# EVALUATION OF SUSTAINABLE URBAN MOBILITY IN THE CITY OF MEK'ELE


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SCHOOL OF CIVIL ENGINEERING

ROAD AND TRANSPORT ENGINEERING STREAM


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The thesis is submitted to School of civil engineering of Mek'ele University in partial fulfillment of the requirement for Masters of Science Degree in Civil Engineering (Road and Transport Engineering Stream)

BY

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# DECLARATION

I certify that this M.Sc. thesis study work titled "**EVALUATION OF SUSTAINABLE URBAN MOBILITY IN THE CITY OF MEK'ELE**" is my own work. The work has not been presented somewhere else for assessment and award of any degree or diploma. Where material has been used from other sources it has been properly acknowledged and referred.

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# Abstract

Currently, cities are looking for all round transport sustainability. Nevertheless, urban transportation can create a problem on economic, social and environmental aspect of the city. Up on observation residents have complaint on the fare for local transportation, vehicles noise disturbance and services provided by public transport. This thesis indexed eleven urban sustainable transport indicators. Based on the indexed results of the tool, SWOT analysis is conducted. The study also sought to identify the remedial measures that should be undertaken to mitigate the problems. The study area is defined to be Mek'ele city.

The sustainable urban mobility indicators are assessed through a procedure that requires various method of data collection and data processing. World Bank backed online software was used after data legitimizing and confirmation was made between Tigray Construction Road and Transport Bureau and the world councils of urban sustainable development headquarter at Geneva, Switzerland. The indicator, access to mobility service, is based on percentage of people living within a radius of 400 meters from a public transport stops. Fatalities were considered as the number of deaths per annum per 100,000 inhabitants. For mobility space usage, area of roads, open parking, service areas and petrol stations were considered. Length of road network with sidewalks, with bike lanes, in zone 30 (km/h) and total length of city road network were served as input for the indicator of opportunity for active mobility .The social aspects such as, access for mobility impaired groups, comfort and pleasure, commuting travel time and security is indexed using structured questionnaire as part of the tool. For noise hindrance, sound measurements were taken. Affordability of public transport for the poorest quartile is measured by GDP and population's lowest quartile income as a data.

The sustainability for Mek'le city transport system is 4.93/10, suggesting weak sustainable mobility conditions for the city‘s transport system. The SWOT analysis has the prospects of being used in policymaking, defining strategic directions and the implementation of measures towards the fulfilment of sustainable urban mobility in the city of Mek'ele.


**KEY WORDS: Sustainable Mobility, Indicators, Parameters, Economy, Social, Environment**

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# List of Acronyms

CSA: Central Statistical Agency

I_SUM: Index of Sustainable Urban Mobility

MMO: Metropolitan Mobility Observatory

MOXE: Mobility Index of Environmental Effect

SMP: Sustainability Mobility Project

UN: United Nations

WBCSD: World Business Council for Sustainable Development

# CHAPTER ONE

# INTRODUCTION

## 1.1. Back ground of the study

Since the publication of "Our shared future on the World Commission on Environment and Development, 1987" (Haghshenas and Vaziri, 2012), sustainable urban mobility has become a major concern for policymakers and planners in both developed and developing countries. Identifying the notion of sustainable urban transport is the first step in addressing major challenges, barriers and points of interest in urban transport. As pointed out by (Zegras, 2005), it is important to clearly identify whether we need to focus on what aspects of interdependence between urban areas, the transport sector and sustainability.

The use of the word sustainable in the transportation sector dates back at least to the late 1980s. As sustainable development entered into the language of mainstream growth and was eventually mainstreamed by governments, international agencies, the private sector and NGOs during the 1990s (Zegras, 2005). Transportation obviously plays an important role in making this progress easier. Transportation clearly plays an important role in making this development easier. At the same time, more production fuels require transport, which in turn creates economic, social and environmental impacts (Zegras, 2005).

One of the subsystems is the network of urban transport, which is the key element in the movement of goods and people within and between cities. So the question arises based on (Szabo, 2012) whether a sustainable transportation system exists, while the city does not? Can a city grow sustainably while its transportation system does not? According to the World Urbanization Prospects Review (UN, 2017), 54% of the world's population live in cities and this number is expected to reach 66 percent by 2050.As a result, more and more people are making daily use of these systems, hence the pressure on the urban transport system is steadily increasing and becoming the major driver of sustainable cities.

Like cities of most developing countries, Mek’ele city’s growth is very fast and this can be demonstrated by looking at the magnitude of population growth and physical expansion trends. According to available information, among major top Ethiopian cities, in terms of population size, Mek’ele in 1984 was found at level 6, but in 2017, Mek’ele stood at second position next to Addis Ababa. Average doubling time for Ethiopian cities population size is estimated to be 23 years; however, in Mek’ele it is estimated to be doubled at 12 years which implies that same scenario is expected Mek’ele city to have enough supply of land size, infrastructure and social services and so forth (Mek’ele University, 2017).

The task of measuring the existing transport sustainability of Mek’ele city is therefore mandatory to develop and provide strategic directions for the delivery of transport services as well as a policy framework which will direct the city’s continuing efforts to maximize value, including the role transport plays in promoting economic development and protecting the social values.

## 1.2 Statement of the Problem

Economic, social and environmental factors have an impact on the sustainable urban development of the city. Nevertheless, up on concern of Mek’ele city, the sustainable urban mobility indicators have never been quantified. The transport urban mobility of the city is not yet ranked according to the standards set by World Bank and European commission.

Hence, to point out which government sector needs attention to sustain the mobility of the city it’s important to measure the sustainability.

## 1.3. Research questions

What are the main sustainable mobility indicators for the city?
What are the indices of the urban mobility indicators quantitatively?
What are the possible solutions to mitigate the transport non-sustainability of the city?

## 1.4. Objective of the Study

**General objective:**

The objective of this thesis is to measure the sustainability of urban mobility in case of Mek’ele city.

**Specific objectives:**

- ✓ Measuring the urban mobility indicators.
- ✓ Conducting SWOT analysis
- ✓ Providing a mitigating measure for non- sustainable concerns.

## 1.5. Limitation of the Research

Due to the nature of data type, it was challenging to collect the accurate data due to the weak way of data handling. The data applicable to calculate the indicator of greenhouse gases is missed from the regional sectors and insufficient budget to measure the emission. With regard to scope of the indicators, air transport was excluded as urban transport of the city. The sustainability aspect of the mode is beyond the scope of the city governance. The indicators were analyzed as values over the 12-months period.

## 1.6. Significance of the Research

Now a day's quantifying cities mobility indicators is essential to maintain its sustainability. Without a doubt, the research on measuring sustainability of urban mobility has a wide range of significance for both the researcher and city administration.

## 1.7. Research Outline

The thesis work is organized in five chapters and associated Annex.

The first chapter is an introduction that includes back ground, statement of the problem, research questions and objectives and significance of the study as well as the overall thesis outline. Chapter two covers the review of the main related facts from references used in the study and review of earlier studies. The various studies conducted in specific parts of the entire study area are well described and used in the study.

Chapter three gives a general description of the study area. This includes location and land use. Also describes data input for analysis used in the study with clear methods of collection. This chapter also briefs the methodology to be followed to address objectives of the study.

Chapter four is about result and discussion. And the last chapter, chapter five, is concerned with conclusion and recommendation.

Finally, annex in the form of tables and figures and serving as a supporting document to this thesis are attached to make the work a complete one.

# CHAPTER TWO

## Literature Review

The literature review is divided into six sections. The first section covers an introduction to the topic, its objectives and importance. The second section conceptualizes to sustainable urban mobility in terms economic, social and environmental aspects. In the third section, the main concepts of indicators and indexes are presented, and in the fourth section, a summary of the literature review on the indexes is covered. On fifth section, previous experiences and expected results from Ethiopia and abroad is presented.

### 2.1. Introduction

The aim of this chapter is to present a review of the literature on urban mobility, on conceptualizing index framework and the methodologies that were used for evaluation of urban sustainable mobility (I_SUM). Likewise, the literature specifies on the approach of urban mobility, urban mobility index and the purpose for which each index is adopted.

Concerns about the evolution of human settlements and the unavoidable impact of social development on the environment were first regarded by the global community as comprising three key dimensions : economic, social and environmental at the Human Environment Conference in Stockholm (United, Conference and Environment, 1972).

Knoflacher (2007) described the results of the city center development in Vienna, where most roads are turned into pedestrian streets, making it one of the most important urban structures in Europe. Two-thirds of people now travel through public transportation, walking and demonstrating the value of conscious decision-making on the regional transportation system to promote urban sustainability.

Alonso et al (2014) concluded that sustainable mobility is a prerequisite for achieving sustainable cities in urban areas where contaminants are present in a concentrated manner and consequently the impacts produced by unsustainable transport system. Shiau and Liu (2013) upheld these statements and defined technological change and reduced demand as acceptable and efficient means of achieving a sustainable transport system. The European Union's White Paper

(European Commission, 2011) offers the key criteria for sustainable urban transport, such as pedestrian and cycling-oriented infrastructure, fewer cars with internal combustion engines, and promotion of public transport.

## 2.2 Sustainable transportation

### 2.2.1. Definition of sustainable mobility

Magagnin and Silva (2008) defines mobility as an attribute that sets out Scroll criteria for different purposes in urban space: going to work, leisure, visiting, studying, etc. So, understand that a long-term strategy for the future development of urban areas, including transport infrastructure and mobility services, can be considered when it comes to sustainable urban mobility. The authors state that a sustainable urban mobility project aims at enhancing connectivity in urban centers and providing high-quality, sustainable mobility and public transport.

From perspective of (Lauwers, 2017), Sustainable urban mobility is the ability to meet society's needs to move freely, gain broad access to desired locations, communicate, negotiate and build relationships without sacrificing other values.

Shiau & Liu (2013) mentioned the definition of transport sustainability of the European Council of Transport Ministers, describing the concept with the following features:

- ✓ A sustainable transport system provides basic accessibility for individuals, businesses and society on the social side and connects present and future generations**.**
- ✓ Improve productivity and regional development from an economic point of view through cheap and efficient operation.
- ✓ Finally, from an environmental point of view, it encourages the use of renewable resources and the reduction of pollution and waste in terms of the planet's absorption potential, and these features can also prevent future negative impacts.

Nevertheless, (Zegras and Gakenheimer, 2006) emphasized mobility as the key feature of sustainable transport and did not provide feasible economic and environmental approaches. Nevertheless, most sustainable transport studies concentrate on the environmental impacts of motorized transport modes (Török, 2014), so it can be seen that sustainable development is only the environmental impacts (Szabo and Varhelyi, 2012). Litman (2014)  described this obstacle, indicating that some of the variables and concepts suggested in different studies represent and track environmental aspects, thus providing ecologically effective but economically ineffective solutions through decision-making processes. Some factors expressed in the economic situation may lead to environmentally counterproductive decisions.

According to (Zito and Salvo, 2011), to achieve sustainable mobility, the following are needed: decreased demand for transportation needs, encouragement of modal shift, decreased travel distance, and incentive for greater efficiency. To avoid arbitrary and unconventional concepts, it is possible to embrace the broadest term of sustainable transport as "satisfying existing transport and mobility needs without undermining the ability of future generations to meet their own needs" (Zito and Salvo, 2011). The definition of this term allows us to take into account the main pillars of sustainable transport such as economic, ecological, social and organizational dimensions. This approach is approved and used in combination with the study of urban-scale indicator selection and the following recommendations in this report.

## 2.3. Index and Indicators

### 2.3.1. Index

Costa (2008) explains that indexes are instruments responsible for aggregating indicators using arithmetic methods to simplify complex parameters. Magagnin and Silva (2008) states that indexes and indicators are commonly used as tools to direct effective policy and decision-making in the field of urban mobility, thus contributing significantly to the development of mobility.

An indicator definition and quantification process enables reliable results to be obtained and temporal comparisons to be appropriated to the geographical indexes. In short, sustainable urban mobility metrics promote the development of management level knowledge and expertise to identify issues and their organizational shortcomings. Thus, indicators of sustainable urban mobility can provide adequate responses to social effects (Frei, 2009).

The indicators should be easy to interpret and indicate the actual situation through a representative picture and make it possible to compare them with other indicators. Be feasible at national level and be linked to objectives and values that can be compared with users (Seabra, 2013).

Faced with the complexities of mobility planning, indices and metrics should be used to track mobility conditions in urban areas ( Miranda, 2012). An example of this is the (Costa, 2008) established I_MUS (Sustainable Urban Mobility Index). This index was applied in certain regions of Brazil .This can be seen in (H. Miranda, 2010). indices were applied in Indonesia in an international context to analyze their transportation and assess mobility situations (Midgley, 2011).

Furthermore, as an example, we can consider the Mobility Index for Environmental Effects (MOXE), which was established in Germany to measure urban sustainability by combining individual indicators to provide a panoramic view of urban mobility issues (Bernhardt, 2010).

### 2.3.2. Using indicators to assess urban transport sustainability

By using indicators or a complete set of indicators (Szendrő et al, 2014), the most professional way to evaluate and measure the viability of a specific transport system in a given city and to support decision-making processes is. Consequently, it can be stated that the collection, use, standardization and revision of used variables depends on the limitations and their availability. Litman (2009) identified the failure of a single indicator as a complex indicator system for better target assessment. There is no consensus on the definition of sustainable urban transport, as can be seen above, so there are different approaches to the collection and analysis of indicators that can calculate it accurately. Toth- Szabo and Varhelyi (2012) clarify that indicators are developed to describe a situation of concern or change over time. Nevertheless, there is an increasing need to develop new and more effective methods of assessment to assist in decision-making processes that are capable of responding to the new challenges of climate change and thus relevant to sustainability. (Zito & Salvo, 2011) stated that there is no internationally agreed standard for the collection, assessment and standardization of indicators, but these steps are crucial in identifying cost-effective and time-efficient indicators.

First, it is extremely important to be able to isolate the boundaries of a given city, the limits of our research. Secondly, the isolation of evaluated systems, such as distinguishing urban transport from larger transport systems or separating the transport system from freight (Zegras &

Gakenheimer, 2006). Because each city is different from each other, it depends on the goals and objectives of a given study. The third step is the classification of the parameters used, and many approaches are recognized worldwide. It may be quantitative or qualitative indicators. They can be used to evaluate the truth in an absolute or relative manner. Effective and useful metrics are: easy to understand, logical, observable, quantifiable, accessible and informative, reflect different aspects of the study, sensitive to changes over time, autonomous, comparative organized, clearly defined and captured long-term processes. The main characteristics of the measures used to describe the sustainable transport environment have been defined (Joumard et al, 2011) as based on measurements, pointing clearly the potentials and being accurate as possible.

Indicators have three primary functions as described by (Toth- Szabo and Varhelyi, 2012): simplification, quantification and communication. The variable requirements suggested are as follows: extensive, high quality of data, small compared, easy to understand and transparent. (Joumard et al., 2011) set standards for evaluation and indicator selection. Criteria relate to the function of measurement and monitoring, and four management criteria have finally been established. From the measurement point of view, indicators should be valid, reliable and sensitive to significant changes. Based on the monitoring function, measurability, data availability, and ethical concerns were identified. Selected indices from the management point of view must be straight forward, interpretable, meaningful and actionable. (Litman, 2009) presents other important considerations in the choice of metrics, namely the importance and quality of the variables. Nevertheless, the urban transportation sector has some global database, but the absence of a comprehensive database prevents the comparison of the sustainability of transportation between different cities.

### 2.3.3. The index of sustainable urban mobility (I_SUM) framework

According to (Costa, 2008), I SUM is an analysis method that can be used to expose the current conditions of urban mobility or to predict the effects of sustainable mobility-oriented initiatives and strategies. The index consists of nine domains covering 37 themes, further subdivided into 87 indicators. It was designed to address both conventional transport problems and concerns related to the new sustainable mobility model. However, as a result of the index's diversified and detailed structure, it is versatile enough to adapt to different urban contexts.

As described in (da Silva, Costa, & Ramos, 2010), the index of sustainable urban mobility was developed in several stages. The first step was to define the concept of sustainable urban mobility that could be adopted in selected Brazilian cities in urban planning and transportation activities. The process involved holding several seminars at the regional or metropolitan level between May 2005 and November 2006 with engineers, planners and decision-makers working for the public administration sector. The outcome of analyzing the issues addressed in the 11 cities where the workshops were conducted was a list of 55 alternatives. They expressed the main areas of concern regarding sustainable mobility.

I SUM's requirements hierarchy started with the fifty-five alternatives identified after successive rounds of analyzes, comparisons, and concept combinations expressing similar ideas. The final outcome of the process was to identify nine teams, named individually to reflect each group's main concept. The new groups originating from the Alternatives were then called Domains, owing to the comprehensiveness of the concepts involved. Consequently, in the I SUM hierarchy of criteria, the ninety-six initial Fundamental View Points obtained during the workshops with a constructivist Multi Criteria Decision Analysis methodology are reduced to thirty-seven themes. Lastly, the I SUM criteria hierarchy was completed by relocating the indicators originally associated with the FPVs in the themes. The selection of indicators to be used in I SUM for tracking each of the topics was based on the evaluation of two sets of information: I a reference framework with approximately 2700 urban indicators compiled by the authors after analyzing experiences produced in Brazil and abroad; and (ii) the complete set of indicators obtained in the workshops conducted in the Brazilian cities. A final set of 87 measures emerged from the process described above. In spite of the large number of indicators, it’s tried to avoid redundancy as much as possible. The process used to define the set of indicators was very helpful in that, because we started with a large number of indicators and then narrowed it down to a final number that was sufficiently large to cover the domains that were considered relevant but not too large that could not be calculated. A guide was subsequently produced providing procedures for their design and implementation (Costa, 2008).

Themes and domains weights are collected through a panel of experts working in the fields of urban planning, transportation planning, mobility and sustainability in Brazil as well as in other countries (Portugal, Germany, USA and Australia). In the case of Themes, the experts were also asked to evaluate their relative contribution directly to each of the three dimensions that are usually regarded as the main components of sustainability. For each theme, the themes ' weights and sustainability dimensions were obtained directly from the experts ' average values. In the case of the Domains, their weights were obtained from the average values of all the subjects that are part of it. The indicators ' weights were equal, and within each theme they had to sum up one. Considering that each indicator can be evaluated in a particular way, it is usually not possible to directly combine the resulting values of different indicators. To overcome this problem, a normalization process for each of the indicators applied in I SUM had to be defined. The suggested process of normalization in the case of I SUM is basically based on a lookup table defined for each indicator. The reference values adopted in the lookup tables are proposed based on either Brazilian or international standards found in the literature or on the experience of index developers who adapted the existing reference values to the scope of Brazilian cities. I SUM's proposed aggregation method was based on a weighted linear combination in which all criteria were combined by a weighted average. This approach allows a total trade-off between parameters. This means that a very bad attribute can be balanced by a number of good attributes, translated as higher scores obtained for some other criteria, translated as a low score obtained for one criterion. According to the adopted Domains, Themes and Indicators structure and the introduction of the Dimensions of Sustainability, the process of aggregation of metrics resulted in a global index and three sector indexes, one for each Dimension.

The proposed framework for I SUM also makes tests based on a reduced number of indicators. This is the case when the data needed to measure all 87 indicators are either not accurate or simply do not exist. However, if a reduced number of indicators are used, the weights of the indicators within each theme need to be redistributed. For Themes and Domains, the same method may be needed to ensure that the weights in each category of hierarchy always sum up one.

The integration of the hierarchical structure created by the classes, themes and indicators with a weighing system makes it possible to classify the relative contributions to the global index of each of these components. This index function can be used to devise strategies that focus exclusively on mobility issues or can be combined with other planning fields, leading to a more fair and effective use of available resources (H. Miranda, 2010). Using the index may help identify critical factors that are likely to have a major impact on global and partial aspects of urban mobility (Costa, 2008).

## 2.4. Measuring sustainability and input data

Some researchers find sustainable transport indicators as decision-making tools that should represent economic, social and environmental impacts (Litman, 2009) while (Nicolas et al, 2003) focus on issues raised by urban resident mobility and consider household transportation surveys as a highly valuable source of data. Ultimately, in terms of efficiency and fair operation, other methods have based their research on policy evaluation.

The Index of Sustainable Urban Mobility requires a significant amount of data and knowledge for applications due to its detailed structure. Such outputs can be collected from many different data sources, but they typically provide most of what is required by the local administrations. Since some data may not be easily obtained anywhere, however, it is important to carry out an earlier analysis of the data required to measure each of the index indicators. If it is not possible to calculate a specific indicator, it must be excluded from the index hierarchical structure and the weights of the remaining indicators must be redistributed within the same theme in order to still sum up one. Clearly, if a large number of indicators are measured, the cumulative index value is more representative.
The data used in the calculation can vary considerably. Some are numerical statistics (e.g., number of inhabitants in a certain area) while others are physical attributes of urban elements (e.g. transit stop location).

Due to the existence of a homogeneous database with a sufficient number of cities, the work to develop a group of indicators in and evaluate the different dimensions of sustainability in urban passenger transport was initially based on Spanish cities. It was decided to include other cities from central and northern Europe in order to achieve a wider scope for comparison and to avoid an overly biased analysis–referring only to cities in southern Europe. There are two groups at European level that collect and publish information on urban transport from a representative group of cities and facilitate the exchange of information and good practices in the area of organization, planning and funding of public transport.

## 2.5. Indicator screening criteria

Indicators constitute part of this process and since their first establishment in 1992 by the United Nations Conference on Environment and development they are being increasingly accepted as a tool for the assessment of the sustainable urban mobility mainly due to their simplicity in communicating complex phenomena. Although sustainability is difficult to be measured directly, it can be evaluated through a system of parameters which reflect its dimensions. Accordingly sustainability is evaluated using a set of measurable indicators to track trends, compare areas and activities, evaluate particular policies and planning options, and set of performance targets Litman (2009).

Litman (2009) prepares a the report of Canadian Victoria Transport Policy Institute (VTPI) and suggests the best practices for selecting indicators to measure transportation performance take into the account of comprehensiveness, data quality, comparability, easiness to understand, accessibility and transparency. These criteria are also acceptable in several past studies.

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According to (Szabo and Varhelyi, 2012) indicators have three main functions**.** These are simplification, quantification and communication. (Haghshenas and Vaziri, 2012) collected requirements for indicators from different international studies.

Litman (2009) provides a consideration regarding indicator selection, namely the cost and the quality of the variables. These are highly relevant, because as (Haghshenas and Vaziri, 2012) mentioned, the lack of databases is one of the biggest difficulty concerning assessing urban transport sustainability.(Joumard et al., 2011), Alonso et al (2014), and ( Miranda, 2012) mentioned Barriers regarding data availability

The EEA states that progress towards targets should be methodologically well founded and the UN organization outlines that indicators should be within the capability of national governments to develop. Timeliness is an important indicator quality criterion for the EU, Eurostat, EEA and OECD. Cost efficiency of indicators plays an important role for the OECD and UN indicator selections.

## 2.6. Methodologies and data collection strategies

You can check a variety of indexes and local applications, highlighting the Sustainable Urban Mobility Index (IMUS), most commonly used and used by authors in the current research. Importantly, the IMUS is defined as capable of assessing the resource and, at the same time, tracking urban mobility, regarded by technicians and managers who use it as easy to handle, allowing the evaluation of existing demands in terms of requirements and impacts suggesting ecological and sustainable urban mobility initiatives (Costa, 2008).

The Imus, developed by (Costa, 2008) using the Multi Criteria Methodology Help Constructivist Decision , comprises of nine fields, more than 37 themes and 87 indicators, all linked to traditional mobility and urban sustainability aspects. It is an important tool for assessing and tracking urban mobility and essential for developing sustainable urban mobility public policies. Despite the different urban contexts, urban mobility analysis tool used by the researchers adapts to local conditions. In short, the index is significant as an aid for urban public administration as well as mobility management and formulation of public policy. (H. Miranda, 2010) used the index as a method for comparing different cities, demonstrating to be very effective and maintaining a consistent calculation framework between cities.

Out of the 87 metrics, 70 are determined using adaptation strategy and implementation to evaluate and pick alternatives to improve urban mobility. These adaptations include the rehabilitation of deteriorated urban areas and already consolidated interventions in urban spaces. The approach has been tested in the city as follows: I diagnosis of current conditions from the calculation of the Sustainable Urban Mobility Index; (ii) implementation strategy capable of identifying alternatives to sustainable improvement, mobility conditions, and (iii) assessment of the influence of urban mobility.

Maia (2013) used the IMUS to evaluate the contribution of the city's large-scale public transportation system to sustainable mobility. A total of 17 public transport metrics have been measured. The research introduces participation as a diagnosis of urban mobility management, limited to Fortaleza and its metropolitan region's public transport system.

The Mobility Impact Index (Camagni et al, 2002) was used. They used it in Milan's metropolitan area to verify that the different trends of urban development can be associated with negative environmental costs, especially for land use and generation of mobility. The methodology used to develop the index was statistical analysis and the study attempted to fix the problem explicitly by developing innovative methods and conducting some initial econometric analysis, carrying out an empirical analysis in the region and identifying the characteristics of urban development and the social costs of urban sprawl over a period of 10 years.

In view of the fact that the city is a guide for good transportation planning, it must be verified by the index implementation. The request will also be used to test the index itself, or the process and reference values underlying the analysis. In short, by taking into account the inherent complexities of urban space, I SUM is a tool for evaluating mobility conditions in any area. I SUM can therefore be used as a tool to support flexibility management and sustainable policy formulation. The requirements index hierarchy was basically organized at the top of a comprehensive set of metrics that can be measured and evaluated relatively easily (da Silva et al, 2010). Moreover, the index covers several aspects related to the new sustainable mobility paradigm while at the same time considering traditional transport planning issues (Miranda, 2012).

Travisi et al (2010) used the Mobility Impact Index (MII) to empirically analyze the complicated relationship between urban development and displacement. A cross-multivariate regression analysis also explored the relation between the effect and certain different aspects of municipalities.

After defining the metrics for assessing sustainability of urban transport, the methodology used to evaluate and compare sustainability of urban transport in selected cities is discussed in this paragraph. First, for each sustainability dimension and each city, the selected indicators are compiled in a single index. These indexes are referred to as composite indicators and are based on a benchmark approach, namely the comparison of cases; values therefore depend on the average performance of the rest for each city. The characteristics values were established that most contribute to achieving a sustainable urban transportation system. In this step, by analyzing Pearson correlation coefficients, current correlations between sustainability scores for all cities and other variables such as volume, wealth or modal share are explored. Finally, we group the cities according to how similar their transport systems are to be financially, socially and ecologically sustainable, using the composite index as variables of classification.

Mendiola (2014) used the mobility impact index to assess whether the variables of land use are the result of various types of development and whether urban factors are linked to patterns of mobility to work, particularly with regard to the impact of relevant travel on the environment. Using methods of spatial econometrics and horizontal spatial data, we used multiple regression assessment to evaluate the impacts of land use factors on mobility's environmental impact.

Miranda and Correia (2007) provided spatial statistical tools to test the spatial structure of the Sustainable Mobility Index in several areas of Belo Horizonte Region. Analyzes were carried out using spatial statistics to confirm the number of sectors that need to go through some sort of action to enhance the mobility level within their local region.

Frei (2009) developed an index of roughly 100,000 to 500,000 residents to synthesize a collection of mobility measures for medium-sized cities. In the city of Assisi, in São Paulo, the author put the Sampling Mobility Map. In such a case, three sections were observed in the index: pedestrians, cars and cycling. The index contains meeting the three sections in this case: pedestrians, cars, and cycling. Eight indicators have been used to measure the index: tour length, go-to-foot, pedestrian traffic lights, bike paths, car occupancy, seat belts, traffic lights and signs respected.

(Bernhardt, 2010) introduced the Environmental Effects Mobility Index (MOXE) to measure sustainable urban mobility in the cities of Kaiserslautern and Tubingen. Comparison was made with previously developed indexes, suggesting that in the planning framework facing mobility, the MOXE findings were close to those of IMUS.

D’Amico et al (2011) used the sustainable mobility index and used it in Naples. In this case, the first step was to define measurement functions in a structured scale for each indicator The next step was weight allocation and final aggregation relating to hypotheses (linear function) for which the Naples region was feasible to apply the index. It picked 22 mobility indicators.

Machado (2010) established the Sustainable Mobility Index (IMS) and implemented it in the Porto Alegre metropolitan area to help understand the impact of mobility on sustainability, i.e. social, environmental, economic and urban quality of life. The index established was important as it offered more detailed knowledge of the basic characteristics of Porto Alegre's urban centers and, through these features, it was possible to identify factors that could be improved in terms of mobility in the search for urban well-being.

Seabra (2013) developed the Strategic Management of Sustainable Urban Mobility Index (IGEMUS, Portuguese acronym) to support strategic decision-makers in the decision-making process. The index allows local interpretation of meeting the goals of urban mobility policies. IGEMUS' development methodology highlights how important it is to identify strategic actors ' views and priorities of each sustainability dimension. Perceptions rely on exogenous factors including geographical location, structure and urban design as endogenous factors, including the uncertainties and risks inherent in the actors ' lack of data, expertise and practices. It is important that the information is shared with all participants in strategic-level decisions during the decision-making process, and the decision-maker must have advance knowledge of all options and the capacity to forward a solution.

Moeinaddini et al (2014) used Hong Kong and Chicago's urban mobility index. The index contains indicators of urban mobility correlated with a percentage of daily trips made through private motorized modes. The approach is aimed at defining existing problems and can be used to propose solutions to reduce the use of vehicles.

The Urban Core Index was used to examine urban mobility for the elderly in Canadian large cities. They identified significant aspects such as the fact that people over the age of 65 have become highly dependent on cars to move around to other locations such as parks and medical services, which, according to the author, leads to their quality of life being reduced. (Patterson et al, 2014), also stresses the importance of planning for future transport systems that meet specific demands and both suburbs as metropolitan areas of Canada, highlighting their implications for future generations ' well-being. (Patterson et al, 2014) also highlights the importance of planning for future transport systems that meet the specific demands and both of the suburbs as the

Canadian metropolitan areas, emphasizing their implications for the future well-being of future generations.

### 2.7. Previous Experiences and expected results

The score (1 to 5) of the indicators are calculated on the basis of the parameter value chosen to describe the indicators based on the research conducted in Addis Ababa city. The results of those 19 representative indicators are shown in the table. With regard to the diagrams given, it can be shown that five out of nineteen indicators get the lowest score (i.e. one) while only one indicator is ranked at the highest. Seven measures yielded a modest result with a 3 average. The environmental category averages 2.33 while the social and economic category ratings are 2.13 and 3.6 respectively.

Table 2. 1 Ranking score of indicators of Addis Ababa city (2019)

| **Indicators** | score |
|---|---|
| Mobility space usage | 4 |
| Affordability of public transport | 3 |
| Traffic safety | 3 |
| Opportunity for active mobility | 3 |
| Availability of public transport | 1 |
| Public transport density per population | 3 |
| Road availability /road network density | 2 |
| Pedestrian infrastructure density | 2 |
| Cycling infrastructure density | 1 |
| Public transport infrastructure density | 3 |
| GHG | 4 |
| Age of vehicle fleet | 1 |
| Engine technology of PT fleet | 3 |
| Share of PT in modal split | 4 |
| Car ownership | 5 |
| Public finance | 2 |

From the research study, the sustainable urban mobility index was selected for use in the analysis of public transport in the Metropolitan Greater Vitoria Region serving seven municipalities covering 46.45 percent of the state's total population.

In the Great Vitoria Metropolitan Region, the index calculation resulting in between 0.00 (zero) and 1.00 (one) values was held for 20 of the 22 indicators that make up the public transport evaluation index structure. The absence of the 2 indicator data did not nullify the calculation; as the weights of the omitted indicators were equally redistributed among the others, enabling the index calculation to remain reliable.

In the Excel spreadsheet, the estimate for Great Victoria was performed with the reliable data available from 20 indicators collected from the Greater Vitoria Urban Transport Company. The calculated value of the Imus Public Transport presented to the Global Dimension was 0.4881, so the optimal value is the result below, which shows that the RMGV public transport requires more attention.

In terms of size, the social area showed the best rating (0.168) and the economic dimension (0.165) followed. A lower figure, equivalent to 0.133, was given by the Environmental Element. Because of this, it is important to note the value of trying to balance the three dimensions and prioritize environmental dimension behavior.

The calculation method defines the high-performance indicators that are associated with the positive aspects of public transport reliability. Of the 22 Imus-TP metrics, 7 (31.8%) had standardized scores of 1.00 (maximum) and 3 (13.6%) were very similar to 1 (0.99 and 0.97). Similarly, the shortcomings that impair public transport reliability and have much to add to urban mobility can be identified. Low performance metrics in the Greater Vitoria metropolitan region clearly show the points that are missing in information that are not measured indicators and referred to as' blank' score (collective transportation x private transportation, non-motorized modes x motorized modes); and those with administrative limitations, i.e. equal to' 0.00' (public transportation routes, passenger per kilometer).

# CHAPTER THREE

## RESEARCH MATERIAL AND METHODOLOGY

The approach in this study includes an evaluation of the study area at the office and field level as well as various methods and techniques used for data collection and analysis. The study methodology also included various materials and methods to achieve the stated goals. This section of the dissertation, therefore, addresses the approach adopted and shows the methods to solve the research issue.

### 3.1. Research Approach

In this thesis the methods followed were designed in such a way that the key questions of the research be answered properly. The research involves both quantitative and qualitative approaches. Both approach of data analysis were used to determine the sustainability indices of the city. As a data source, both primary data or direct field measurements and secondary data were the main sources. Qualitative data from questionnaire were also used to measure the indicators which are qualitative in nature such as comfort and pleasure, quality of public area, security, inclusive access and travel time.

### 3.2. Description of Study Area

As per the data from regional statistical agency, in 2016 the population of Mek'ele was 313,332 which accommodates close to 34% of the urban population in the region (Mek'ele University, 2017).

Urban transport serves as a vein to accelerate industrial, commercial, educational, health and other services developments. According to various studies, Mek'ele, the capital of the Tigray Regional Government, suffers from insufficient road and transportation facilities. Above all, day-to-day transportation operations are tested with complex problems and service users ' complaints are vivid at the moment. To narrow the gap between demand and supply for city transportation and provide the transportation service that can support the socio-economic development effort of the residents.

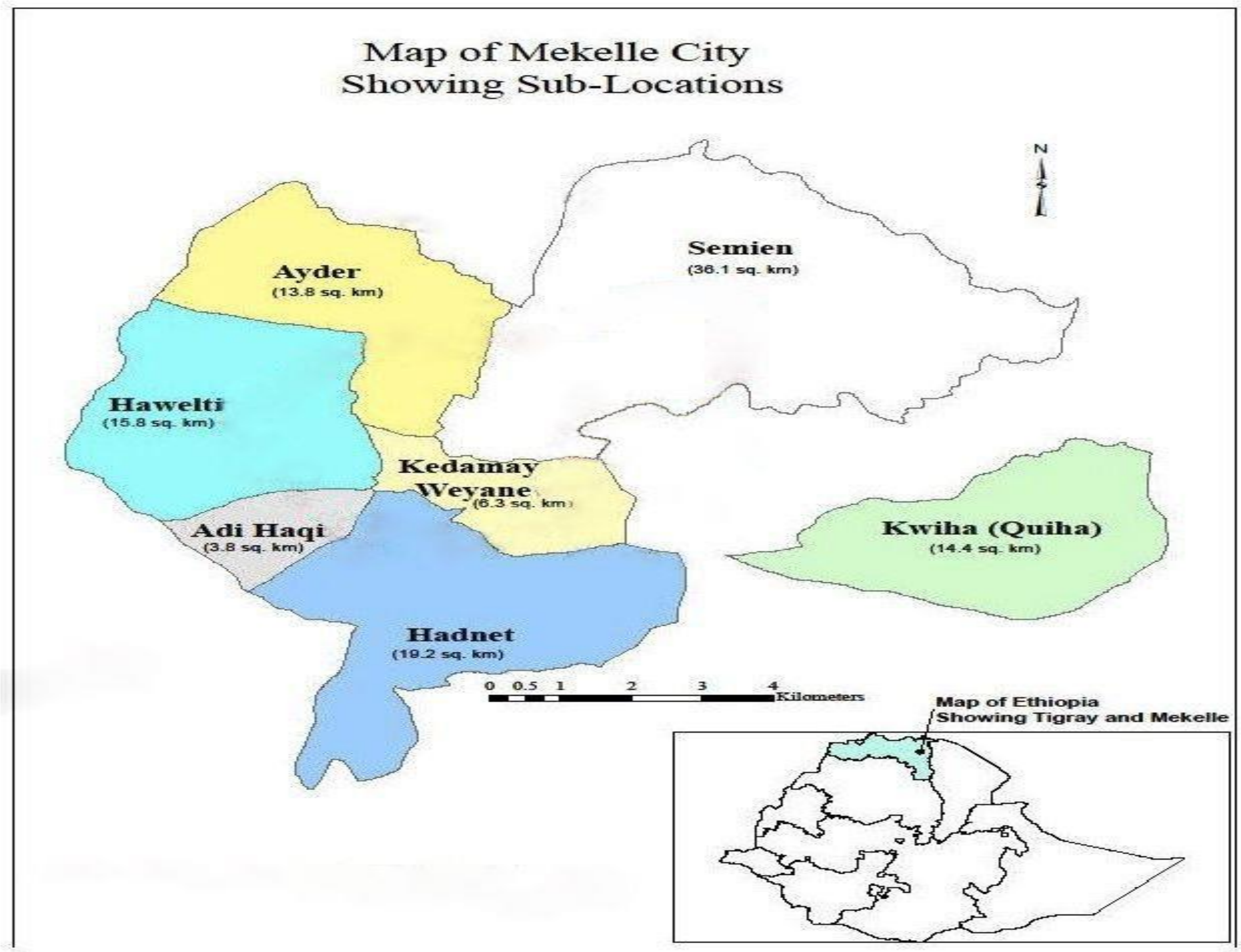


Figure: 3. 1 Map of Ethiopia, Regional state of Tigray and Mek'ele city

## 3.3. Scaling and Valuation of parameters

In order to meet the specific objectives, data has been collected from the primary and secondary sources. For both data sources recommended techniques and steps has been followed to minimize errors.

The primary data were collected through field measures and questionnaires. Questionnaires were distributed by sub-cities for road users such as taxi drivers, private car owners, and public transport users to gather information on the perception of the road users about the general transportation situation in determination of the sustainability of transport of the city.

.

Different types of data were followed different procedure of data collection.

### 3.3.1. **Value and scaling of parameters**

The values of the parameters were expressed in various scientific units (e.g. number of deaths per year per capita). All parameters are recalculated to a scale of 0 (most negative score) to 10 (most positive score) to have a standardized reference value. Data from sub Saharan cities and literature researches inspired the base scaling and calibration of the indicators. A deductive choice and long-term development targets like the Zero Vision of the World Health Organization on deaths that have no casualties due to accidents in the transportation system.

The online software SMP2.0 offers indicators that are not determined by the city's physical characteristics (e.g. population, area ...) but by possible actions for change. These also reveal the city's overall position in the process of becoming more sustainable for a certain indicator.

### 3.3.2. **Indicator score analysis**

From the parameter value calculation, the indicator score is decided from its position between the best (10) and the worst (0) parameter values as recommended by an online SMP2.0 sustainable mobility project software. A score of 10 will therefore indicate a sustainable performance for the city in that aspect.

## 3.4. Indicators selection criteria used

The list of 11 indicators selection are based on economic, social and environmental aspects. As part of the tool, all social and economic issues were considered. Whereas, energy efficiency, air polluting emissions and quality of public areas were excluded due to the non- complaint issue of the public and time and money budget constraints and unrelated Engineering subject matters.

In order to avoid redundancy with in the 11 selected indicators, the following criteria were applied by the selection: Fairness, which includes both positive effects of mobility and negative impacts (e.g. noise hindrance) and mode neutral, which means any mobility mode was not favored.

The following criteria were defined and used to make final selection from the developed list of candidate indicators, taking into account the recommendations from different literature. Work span was also among the criteria for filtering the potential indicators of this work. The issues with the excluded indicators are discussed later on chapter five.

Table 3. 1 Indicators selection criteria and description

| No. | Criteria | description |
|---|---|---|
| 1 | Measurability | A sustainable transport indicator should be capable of being measured in a theoretically sound, dependable and easily understood manner. |
| 2 | Interpretability | An indicator and its calculation should yield clear, unambiguous information that can be easily understood |
| 3 | Target relevance | Each indicator must show one aspect of sustainable transportation |
| 4 | Validity | Indicators must actually measure the issue it is supposed to measure |
| 5 | Ease of availability | It should be possible to easily and at a reasonable cost, collect reliable data on the indicator or calculate/forecast the value of the indicator using accepted models. |
| 6 | Independent/Transport‘s impact isolatable | Indicator should be independent of each other‘s. It should be possible to isolate transport‘s share of the impact that the indicator is purporting to measure. |
| 7 | Level of analysis | If possible, indicators should reflect ultimate impacts of concern rather than intermediary effects. Care is needed to |

| | | |
|---|---|---|
| | | account for possible double counting of impacts, for example, if indicators include both vehicle fuel efficiency and climate change emissions. |
| 8 | Understandable and Useful | Indicators should be understandable to the general public and useful to decision-makers. The usefulness and value of individual indicators may vary in importance among project phases, jurisdictions, and stakeholders. |

## 3.5. Methodologies used for data gathering

The next portion gives a definition for each of the indicators and a parameter to measure its sustainability score. There are three types of variables:

**A**. **Common input variable:** these inputs are variables, such as the number of inhabitants of the city (called 'capita' in the parameter input), that are used in different indicator parameter analysis.

**B. Indicator-specific input variables:** these variables are used in a formula for one of the indicators, for example number of fatalities to calculate the level or transport safety for the indicator describing this aspect of the sustainability of the city transport.

**C. Predetermined values**: intermediate calculation results to be used in later in the indicator calculation process.

As the grouping of data sources in figure 3.1 shows, there are five methodologies for data gathering. The scheme represents the relationship between the input data and data analysis. For the city the most relevant difference between the five types of data sources appears between unprocessed data and processed data. Unprocessed data was obtained directly from existing deposited data, surveys and measurements. Processed data result from the analysis of raw data commonly using GIS.

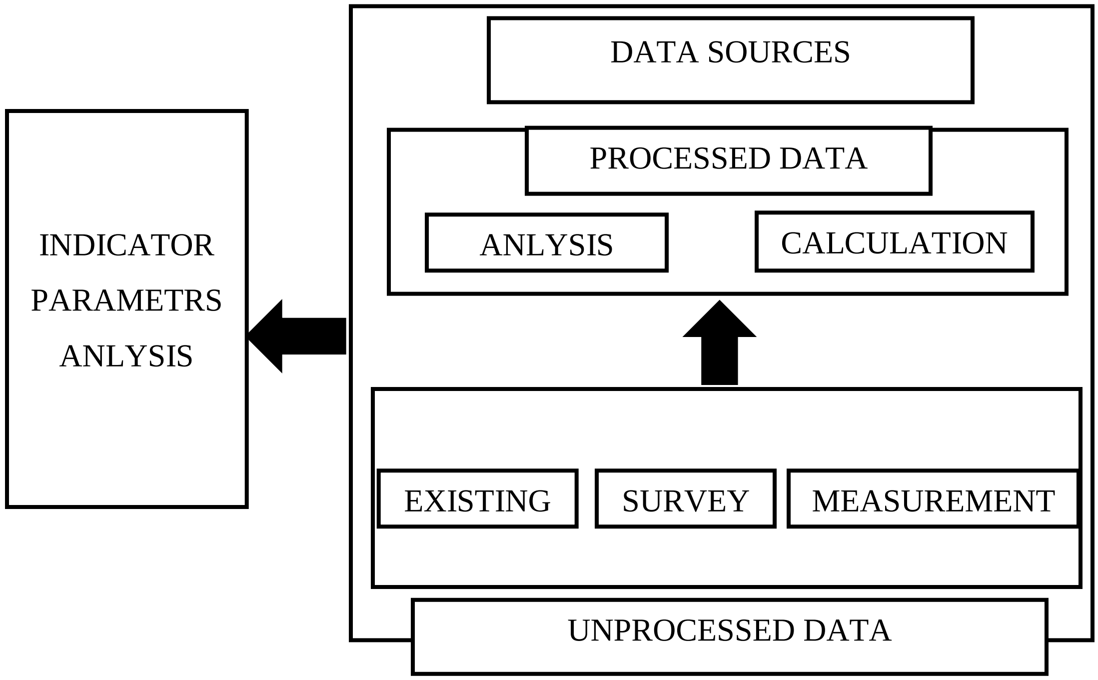


Figure: 3. 2 overview of the typology of input data sources and analysis

### 3.5.1. Using existing database

The indicators below are mainly based on city databases and they are available because they have to be reported in the frame of monitoring the performances of the city.

Data coefficients was found as existing data for some of the indicators. Specific city databases give more relevant figure than national database. The following indicators are partly based on coefficients from regional databases:

- ✓ Affordability of public transport for the poorest quartile
- ✓ Fatalities
- ✓ Noise hindrance
- ✓ Mobility space usage
- ✓ Access to mobility service
- ✓ Opportunity for active mobility
- ✓ Net public finance

The data for the above indicators is grouped in a category referred to further on as existing data.

### 3.5.2. Using Population Survey

A population survey is proposed for the following indicators:

- ✓ Accessibility for mobility-impaired groups which are elderly people (65+), pregnant women, physically disabled, visually disabled
- ✓ Commuting travel time
- ✓ Comfort and pleasure
- ✓ Security

Topics to be covered in the surveys are described later in the individual indicator descriptions and the complete survey questionnaire can be found in Annex D.

For general surveys the sampled populations should have been a mix of inhabitants and commuters that somewhat reflects the dynamics in the city. The sampling for the questions related to the impaired group were inhabitants as per the standard. Most topics were asked to the total population not only inhabitants but also commuters and visitors.

## 3.6. Sampling

To determine the size of the surveying sample, these variables was considered:

- ✓ **Acceptable margin of error E –** is a statistic expressing the amount of sampling error in a survey's results or the amount of error that can be tolerated. A lower margin of error requires a larger sample size, while a margin of error that is too large gives less confidence that the survey reported results are close to the true figures. Five percent (5%) was taken as acceptable margin of error.
- ✓ **Confidence level (c)** – the confidence level is the amount of uncertainty that can be tolerated. This number can be any percentage less than 100%, but the most common levels of confidence are 90%, 95% and 99%. 95% level was applied as most frequently used. Higher confidence levels require a larger sample size.
- ✓ **Response distribution (r)** – a response distribution of 50% was used, which gives a larger sample size.
- ✓ **Size of population (N) –** the population is the complete set of people that one want to understand and therefore the people to choose from the sample.

Size of sample is defined as from the (WBCSD, 2017) document from which the tool is developed

$$n = \frac{N*x}{(N-1)*E^2+x} \qquad (3-1)$$

X is defined as

$$x = Z*(\frac{C}{100})^2 * r * (100 - r) \qquad (3-2)$$

Then Z is the standard score $Z*(\frac{C}{100})^2$ represents the critical value for the confidence level “C”

$$x = 1.96 * (\frac{95}{100})^2 * 50 * (100 - 50)$$

x = 4,422.25

We have N=423,174

$$n = \frac{423{,}174 * 4{,}422.25}{(423{,}174 - 1) * E^2 + 4{,}422.25}$$

“E” can be defined as

$$E = \sqrt{\frac{(N-n)*x}{n*(N-1)}} \qquad (3-3)$$

$$E = \sqrt{\frac{(423{,}174-n)*4{,}422.25}{n*(423{,}174-1)}}$$

$$n = \frac{423{,}174 * 4{,}422.25}{(423{,}174 - 1) * (\sqrt{\frac{(423{,}174 - n) * 4{,}422.25}{n * (423{,}174 - 1)}})^2 + 4{,}422.25}$$

Sample size, n = 385.35

Likewise, from (Cochran, 1963) formula

For a population with:

Marginal error of 5% and confidence level of 95%

$$SS = (Z - score)^2 * \frac{P*(1-P)}{(margineof\ error)^2} \qquad (3-4)$$

For 95% confidence level, Z-score is 1.96

P=50%

Marginal error is 5%= 0.05

$$SS = (1.96)^2 * \frac{0.5 * (1 - 0.45)}{(0.05)^2} = 384.16$$

$$SS\ adjusted = \frac{(SS)}{1} + \frac{\{(SS-1)\}}{Population} \qquad (3 - 5)$$

$$SS\ adjusted = \frac{(384.16)}{1} + \frac{\{(384.16 - 1)\}}{423{,}174}$$

$$\underline{SS\ adjusted = 384.1609 \approx 385}$$

**Questionnaire Execution**

Printed paper questionnaire was used.55 questionnaire for each of the seven sub cities were allocated.

Surveys were not taken place on holidays (e.g. Labor Day, Easter, etc.).Prior to conducting the survey, all relevant local custom regulations was considered (e.g. regulations regarding privacy issues) and surveys adjusted accordingly.

Open questions were not used for the indicator value calculation, but they are valuable for a detailed qualitative explanation of the city situation.

## 3.7. Data and Indicators methodological description

There is specific methodological description for each indicators.

### 3.7.1. **Affordability of public transport for the poorest group**

Affordability of public transport for the poorest group is the share of the public transport cost for fulfilling basic activities of the household budget for the poorest quartile of the population. Affordability index of public transport for the poorest population quartile is based on the relation between the cost for 60 relevant public transport trips and the average monthly household income.

The data were collected from Tigray regional statistical agency and the parameter is based on existing socio-economic statistics to identify the average household budget in the targeted specific group (i.e. the poorest 25th percentile of the population). In this context, affordability is defined as the fare expenditure made by a household as a percentage of its income. Therefore, affordability captures the ability of transportation system users to pay for transportation. A more affordable system is one that consumes a smaller share of users' incomes. The number of trips and the length of the trip are set to be 60 trips of 10 km per month.

Table 3. 2 Affordability of public transport for the poorest

| # | Indicator | variables | | unit | Value |
|---|---|---|---|---|---|
| 3 | **Affordability of public transport for the poorest** | TPT of magic vans | Monthly percentage of PT trips with PT mode magic vans | % | 91 |
| | | F10km of magic vans | Fare 10 km PT trip with PT mode magic vans | Ethiopian Birr | 6.13 |
| | | TPT of three-wheeler Bajaj | Monthly percentage of PT trips with PT mode three-wheeler Bajaj | % | 3 |
| | | F10 Km of magic Vans | Fare 10 km PT trip with PT mode of three-wheeler Bajaj | Ethiopian Birr | 15.25 |
| | | $(MI)_{ave}$ 25% | Average monthly income of poorest population quartile | Ethiopian Birr | 1250 |

### 3.7.2. Noise hindrance

Noise hindrance is the disturbance of population by noise generated through city transport. The parameter is percentage of population hindered by city transport noise based on hindrance factors for noise level measurements.

The indicator was evaluated based on field measurement at locations near a representative selection of city streets. Standard values were used to consider the level of hindrance perceived by the inhabitants.

The measurements are depending on the density of the population in the area concerned. In the methodology proposed, 12 density classes (range of the classes depending on the density range in the city) was defined. The proposed distribution of the classes is listed in the table 3.3 below.

Table 3. 3 Value based on densities in district measurement locations

| Value based on densities in district measurement locations | | | |
|---|---|---|---|
| $MWF_i$ | Dwellings /hectare | | Large attraction schools or enterprises |
| 1 | | ≤15 | No |
| 2 | | ≤15 | Yes |
| 3 | >15 | ≤25 | No |
| 4 | >15 | ≤25 | Yes |
| 5 | >25 | ≤40 | No |
| 6 | >25 | ≤40 | Yes |
| 7 | >40 | ≤55 | No |
| 8 | >40 | ≤55 | Yes |
| 9 | >55 | ≤75 | No |
| 10 | >55 | ≤75 | Yes |
| 11 | >75 | | No |
| 12 | >75 | | Yes |

**Formula & Calculation method**

The formula for sound disturbance calculation from (WBCSD, 2017)

$$NI = \frac{\sum_t (MWF_i * HLFden_i)}{\sum_t (MWF_i)} \qquad (3-6)$$

$$L_{den} = 10 \log[\left(\frac{12}{24}\right) * 10^{\frac{LD}{10}} + \left(\frac{4}{24}\right) * 10^{(LE+5)/10} + \left(\frac{8}{24}\right) * 10^{(LN+10)/10} \qquad (3-7)$$

I = Noise hindrance index [% of population]

i = Measurement number [#]

$MWF_i$= Measurement weight factor i (depending on population density of the area, considering twelve density classes) [#]

$HLFden_i$ = Hindrance factor (part population) at $HLFden_i$ with $HLFden_i$. Some of the values are listed in table 3.4 below.

LD = Noise daily factor (7-19h) or day time value relevant for region [dB (A)]

LE = Noise evening factor (19-23h) or evening time value relevant for region [dB (A)]

LN = Noise night factor (23-7h) or night time value relevant for region [dB (A)]

Upon arrival at a measurement location, the measurement was conducted, whatever the circumstances. It was proposed to execute the measurements near the road, in order to represent as close as possible the noise hindrance inside the houses and other buildings. The measurement took place closer to the road to be noted as a disturbing element.

Table 3. 4 Hindrance factors for respective $L_{den}$values

| Hindrance factor ($HLFden_i$) | $L_{den}$ |
|---|---|
| 1 | 84 dB(A) |
| 0.9 | 81 dB(A) |
| 0.8 | 78 dB(A) |
| 0.7 | 75 dB(A) |
| 0.6 | 71 dB(A) |
| 0.5 | 67 dB(A) |
| 0.4 | 62 dB(A) |
| 0.3 | 57 dB(A) |
| 0.2 | 49 dB(A) |
| 0.1 | 37 dB(A) |

The study undertaken on sound hindrance recording area is listed below as conducted by (Banchirgu, 2018)

Table 3. 5 sound recording sites

| | |
|---|---|
| Adi - Haki region | Dagim amsal Taxi station |
| | 200 m down from Adi Hawsi traffic light |
| | Along Sematat monument |
| Adi- Hawsi region | Around Tombola recreation |
| | Around Adi – Hawsi Condominium |
| | Around Catholic Ayneb |
| Adi – Ha region | Ekram taxi station |
| | Adi – Ha traffic light |

Table 3. 6 data of Sound hindrance

| # | Indicator | variables | | unit | Value |
|---|---|---|---|---|---|
| 4 | Sound | $L_{D1}$ | Noise day factor (7-14hr) or day time value relevant for the region | DB(A) | 73 |
| | | $L_{E1}$ | Noise evening factor (19-23hr) or evening time value relevant for the region | DB(A) | 74 |
| | | $L_{N1}$ | Noise night factor (23-7hr) or night time value relevant for the region | DB(A) | 71 |

| | | | | | |
|---|---|---|---|---|---|
| | **hindrance** | $MWF_1$ | Measuring weight factor, I (depending on population density of the area) | # | 7 |
| | | $L_{D2}$ | Noise day factor (7-14hr) or day time value relevant for the region | DB(A) | 72 |
| | | $L_{E2}$ | Noise evening factor (19-23hr) or evening time value relevant for the region | DB(A) | 76 |
| | | $L_{N2}$ | Noise night factor (23-7hr) or night time value relevant for the region | DB(A) | 70 |
| | | $MWF_2$ | Measuring weight factor, I (depending on population density of the area) | # | 7 |
| | | $L_{D3}$ | Noise day factor (7-14hr) or day time value relevant for the region | DB(A) | 70 |
| | | $L_{E3}$ | Noise evening factor (19-23hr) or evening time value relevant for the region | DB(A) | 71 |

| | | | | | |
|---|---|---|---|---|---|
| | | $L_{N3}$ | Noise night factor (23-7hr) or night time value relevant for the region | DB(A) | 68 |
| | | $MWF_3$ | Measuring weight factor, I (depending on population density of the area) | # | 11 |

### 3.7.3. **Fatalities**

The number of deaths within 30 days after the traffic accident as a corollary of the event per annum caused by urban transport per 100,000 inhabitants was considered.
Raw data from city traffic police indicator is based on the existing databases of statistics of road traffic accidents. Reported data were in the form of annual transportation fatalities. Adjustment of data were needed for the purpose of comparability of data among different days and months.

Table 3. 7 data of Traffic Safety

| # | **Indicator** | **variables** | | **unit** | **Value** |
|---|---|---|---|---|---|
| 1 | **Traffic Safety** | $\sum K_i$ | Total Number of fatalities in altogether transportation modes | # | 40 |
| | | cap | Number of inhabitants | # | 423,174 |

### 3.7.4. **Access to mobility services**

Access to mobility services is the share of population with appropriate access to mobility services. The parameter is Percentage of population living within walking distance of public transport (stop or station).
Spatial data analysis using GIS is proposed for parameter analyses accessibility to mobility

services in terms of the percentage of population living within a public transport service. This is the percentage of people living within a straight-line distance of 400 meters from a public transport stop. Values to define the service area based on real distances to be used are 400 meters from the stations.

The percentage of people living within the service areas was calculated by using spatial data of ArcGIS software.

Table 3. 8 data Access to Mobility Services

| # | Indicator | variables | | unit | Value |
|---|---|---|---|---|---|
| 2 | **Access to Mobility Services** | $\sum PRi$ | Total Number of people living within acceptable radius of 400m of a station (or stop) of public transport | # | 138,251 |
| | | cap | Capita or number of in habitats in the city | # | 423,174 |

### 3.7.5. **Commuting travel time**

**A. Definition**

Commuting travel time is the duration of commute to and from work or an educational establishment.

**B. Parameter**

Average duration of the combined outward journey and return journey to work or an educational establishment expressed in minutes per person per day. The data for commuting travel time is listed in Annex C. The target population is the inhabitants commuting to work or for education purposes.

### 3.7.6. **Net public finance**

The net public finance is net results of government and other public authorities' revenues and expenditures related to city transport. The parameters are net government and other public authorities' revenues from transport-related taxes and charges excluding operational and other costs. As per the nature of the indicator, investments were excluded from the parameter analysis. The data for this indicator were gained from Mek'ele regional finance office.

**Guidance on what should or should not be included:**

The considered revenues were**;** city taxes from city transport services and ownership of a transport equipment.

The excluded revenues were; received subsidies from any authority, collected common fines and gifts by third party not related to transport services offered / to be offered.

The considered costs were**;** energy sources, rental and maintenance of streets under city responsibility**.** Whereas, costs not to be considered are; purchase, other manpower cost, paid fines, retributions to authorities, payback of rent and capital**,** sponsorship, insurance premium for workers and research costs.

Table 3. 9 data of net public finance

| **#** | **Indicator** | **variables** | | **unit** | **Value** |
|---|---|---|---|---|---|
| 7 | **Net Public Finance** | $\sum C_i$ | City government annual revenues from transport related charges | Ethiopian birr | 5,299,719.25 |
| | | $\sum C_i$ | City government annual operational costs related to city transport | Ethiopian birr | 13,359,936 |
| | | GDP | Gross domestic product of the city | Ethiopian birr | 4,420,169,858 |

### 3.7.7. **Mobility space usage**

Mobility space usage is Proportion of land use taken by all city transport modes, including direct and indirect uses. The parameters for this indicator are areas of direct and indirect mobility space usage per capita.

The efficiency of mobility space usage was measured considering the area covered by the city transport modes, including direct and indirect uses. The space usage data were gained from

Mek'ele city infrastructure bureau. This direct land use by city transport refers to the area covered by transport infrastructure such as roads and streets and squares used to move people and for vehicles. Airports were not included as these are outside the administrative jurisdiction of the city.

Indirect land use by city transport refers to land uses such as off-street parking areas, service areas and stations. The considered land uses are listed below.

Direct land use

- roads

Indirect land use

- Open parking
- Service area and petrol stations

Table 3. 10 Mobility space usage

| # | Indicator | variables | | unit | Value |
|---|---|---|---|---|---|
| 5 | **Mobility space usage** | $\sum$ LDi | Direct land use for mobility use for all modes | $m^2$ | 2,294,600 |
| | | $\sum LIi$ | Indirect land use for mobility use for all modes | $m^2$ | 15,990 |
| | | Capita | Number of inhabitants in the city | # | 423,174 |

### 3.7.8. **Opportunity for active mobility**

Opportunity for active mobility options and infrastructure for active mobility, which refers to the use of the soft modes, namely walking and cycling. The parameters for this indicator are the length of roads and streets with sidewalks and bike lanes and 30 km/h zones and pedestrian zones related to total length of city road network.

Only facilities that meet the relevant standards were included to avoid including unpractical sidewalks or bike lanes. The data were collected from Mek'ele city infrastructure bureau and office of traffic police.

Table 3. 11  Opportunity of active mobility

| # | Indicator | variables | | unit | Value |
|---|---|---|---|---|---|
| 6 | **Opportunity of active mobility** | $L_{sw}$ | Length of road network with sidewalks | km | 66 |
| | | $L_{bl}$ | Length of road network with bike lanes | km | 0 |
| | | $L_{Z30}$ | Length of road network in zone 30 (km/h) | km | 34.3 |
| | | $L_{m}$ | Total length of city road network | km | 290.8 |

### 3.7.9. Comfort and pleasure

Comfort and pleasure are the physical and mental comfort of citizens while using the urban transports and services.

Dependent variable for comfort and pleasure of urban public transport includes punctuality, crowding, quality of equipment, services, and availability of information. Comfort for riding and walking includes pavement condition and width of sidewalks. Comfort for car traffic refers to pavement condition of roads, quality traffic management. The overall quality of the transport system and completeness of the connections were also covered by this indicator. The indicator also refers to types or aspects of urban travel considered as enjoyable by the people travelling.

The dependent variable is comfort and pleasure and the independent variables are;
Level of satisfaction with driving aspect in the city; Traffic flow, real time traffic information, signposting of directions and destinations for road users, the lighting of urban streets for driving at night, quantity and location of parking spaces, accessibility of parking spaces by foot (e.g. no barriers like high pavements), quality of road infrastructure, traffic safety and feeling of personal security.

Level of satisfaction with aspect of cycling; availability of dedicated lanes for biking, width of bike lanes, the quality of road surface of the bike lanes, the quality of road surface of the bike lanes, the way other road users treat cyclists when on mixed use roads, signposting of directions and destinations for biking, lighting of biking facilities and urban streets at night, number and the location of bicycle parking facilities in the city and security of the bicycle parking facilities

Level of enjoyment walking in the city; availability of sidewalks in the city, availability of car free streets in the city, signposting of directions and destinations for walking and lighting of sidewalks and urban streets at night.

Level of satisfaction with the aspect of public transport; cleanliness, comfort (seats, noise, temperature), fare, real time information (routes, timetable and delays), the punctuality of the public transport, safe vehicles, feeling secure using public transport

### 3.7.10. **Accessibility for mobility impaired groups**

The parameter for accessibility for deficiency groups to transport and transport services is the questioned convenience of city transport for target groups. The target population is selected groups: 65+ people with visual disabilities or reduced mobility, pregnant women. The identification of these mobility impaired groups was based on international common classifications.

The dependent variable is accessibility for mobility impaired groups and the independent variables are: the issues regarding pregnant women which are availability of parking spaces for expectant mothers, access to the public transport places on foot, availability benches and chairs in stations and at stops, enough seating places in buses.

The concerns  physical mobility issues which are quantity and location of disabled parking spaces, accessibility of the disabled parking places on foot, accessibility of the public transport stops, access of the public transport vehicles at the stops or stations, quality of the sidewalks, provision of space for your wheelchair on public transport, ease of crossing road.

The issues people with visual impairment those are accessibility of the Public transport stops, access of the public transport vehicles at the stops or stations, quality of the sidewalks, guidance and warning systems for visual disabled people along sidewalks.

The concerns about an older traveler among them quantity and location of parking spaces, accessibility of the parking places on foot, accessibility of the public transport stops, access of the public transport vehicles at the stops or stations, quantity of seating places in the public transport, quantity of the Sidewalks are regarded.

The above dependent variables explain the level of accessibility for the mobility impaired group.

### 3.7.11. **Security**

Security is the risk of crime in urban transport. Perception about crime related security in the city transport system including public transport, public domain and roads for car traffic and other facilities such as car parking.

The survey questions have covered perception about crime related security in city transport by general population based on topics such as public transport, in public transport in the evening, walking on the street at night and risk for crime in car theft.

The dependent variable is security and the dependent variables are the way other road users treat cyclists when on mixed use roads**,** waiting for public transport at the stop or at the station during daytime**,** waiting for public transport at the stop or at the station during night time**,** being on board public transport during daytime**,** being on board public transport during nighttime**,** walking during daytime and walking at night.

Apart from the real security also the perceived security is an important issue in the frame of sustainable urban transport because security should give users confidence that they can use transport. The lack of this confidence can lead to non- compliance of mobility needs.

# CHAPTER FOUR

# RESULT AND DISCUSSION

Analysis was done on Mek'ele city using the collected data and results are presented in the following sections.

## 4.1. Questionnaire Responses

As discussed in section 3.4.2, the sort of questions asked are listed later on annexes D, questionnaire was distributed by sub-cities to evaluate the perception of different road users to wards transport sustainability of the city. Out of the distributed 385 questioners all were returned. Table 4.1 shows questioner respondent profile and Figure 4.1 shows age distribution of the respondents.

Table 4. 1 Questionnaire respondents' profile

| | | Number | Percentage |
|---|---|---|---|
| Questioner | Distributed | 385 | 100 |
| | Returned | 385 | 100 |
| **Normal respondents** | | | |
| Sex | Male | 297 | 72 |
| | Female | 133 | 28 |
| | Total | 430 | 100 |
| **Mobility impaired group** | | | |
| | Pregnant | 21 | 38 |
| | Physical mobility impairment | 26 | 47 |
| | Moderate to severe visual impairment | 8 | 15 |
| Total | | 55 | 100 |
| | <15 | 31 | 8 |
| | 15-17 | 27 | 7 |
| | 18-24 | 92 | 24 |

| | | | |
|---|---|---|---|
| Age Distribution | 25-34 | 81 | 21 |
| | 35-44 | 104 | 27 |
| | 45-54 | 23 | 6 |
| | 55-64 | 15 | 4 |
| | 65-74 | 8 | 2 |
| | >75 | 4 | 1 |
| | Total | 385 | 100 |

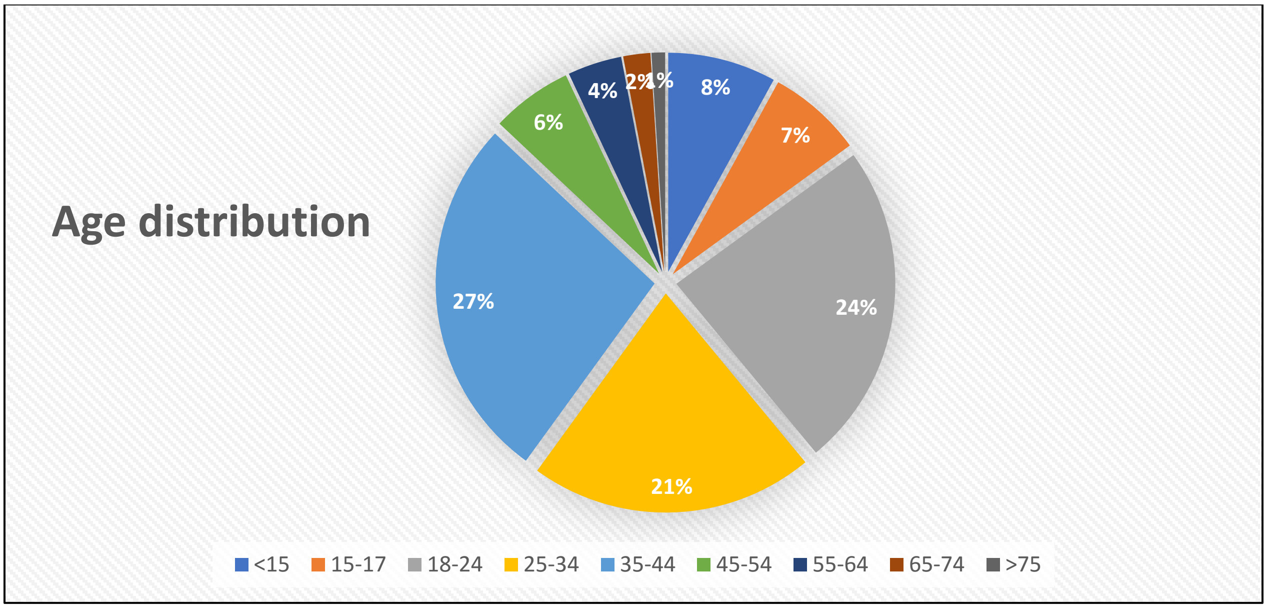


Figure: 4. 1 Age distribution

### 4.1.1. Affordability

Affordability is the cost of a monthly network wide public transport covering all in the city, compared to mean monthly income for the poorest quartile of the population of the Mek'ele city. This indicator is derived from two elements. The first is data on the fare of using public transport and the second is the average monthly income of the poorest part of the population. The data for the lowest income quartile were collected from central statistical agency of Tigray in a regional data break down.

A more affordable system is one that consumes a smaller share of users' incomes. The number of trips and the length of the trip are set to be 60 trips of 10 km per month. The public transports are magic vans taxi and three wheeler bajaj and their fare data from the regional bureau of transport per 10 km of a trip is listed on table 3.2.

The minimum or worst value is 35 percent of income in using public transport. The maximum or best value is 3.5 percent. Per Indicator calculating criteria, a scale of 10 per commute is affordable for 60 trips per month for the poorest quartile. From the analysis the average lowest quartile income of the population is 1250. 35% of survey respondents stated that public transport is expensive and the rest 65% of the respondents says it's too cheap.

Financial costs of transport users should not be excessive. As a general rule, transportation costs should not exceed 20% of household's income (Rand et al., 2004). As shown in the figure below, the parametric value is 33% which is very near to maximum worst value of 35%. So, the current indexed score value is 0.52 which is totally unfordable for the poorest population of the city. Transport costs represent a significant share of the household budget, especially for low income households. The fare harms the poor population in which the Public transport makes up 91% of the transport mode. The third poorest population spends 33.4 % of their salary for public transport. Different income status of the population spends similar fare expense using over public transport.

#### 4.1.2. Mobility impaired group

Among pregnant respondents, more than 67% are dissatisfied with availability of parking spaces for expectant mothers and the availability of benches around the city. Around 45% are satisfied by the on-foot accessibility of parking space and accessibility of public transport stops. 50% of the pregnant mothers have access of public transport vehicles. Only 38 % are satisfied with quantity of benches and chairs in stations and at stops.

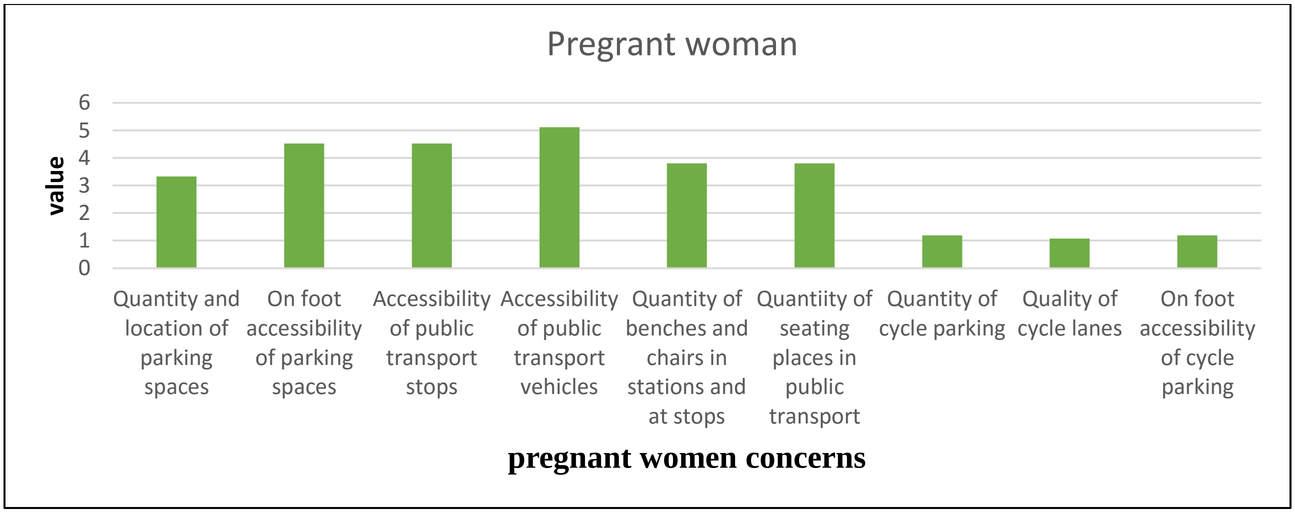


Figure: 4. 2 Response for a pregnant women

Among elderly people, more than 82 % are dissatisfied with availability of parking spaces for older people and accessibility of public transport stops around the city. In the contrary, 80 % of the satisfied are with quantity of seating place in the public transport. Only 20% are satisfied by the on-foot accessibility of parking space and accessibility of public transport stops. 45% of them are happy with the quality of sidewalks. Only 38 % are satisfied with quantity of benches and chairs in stations and at stops.

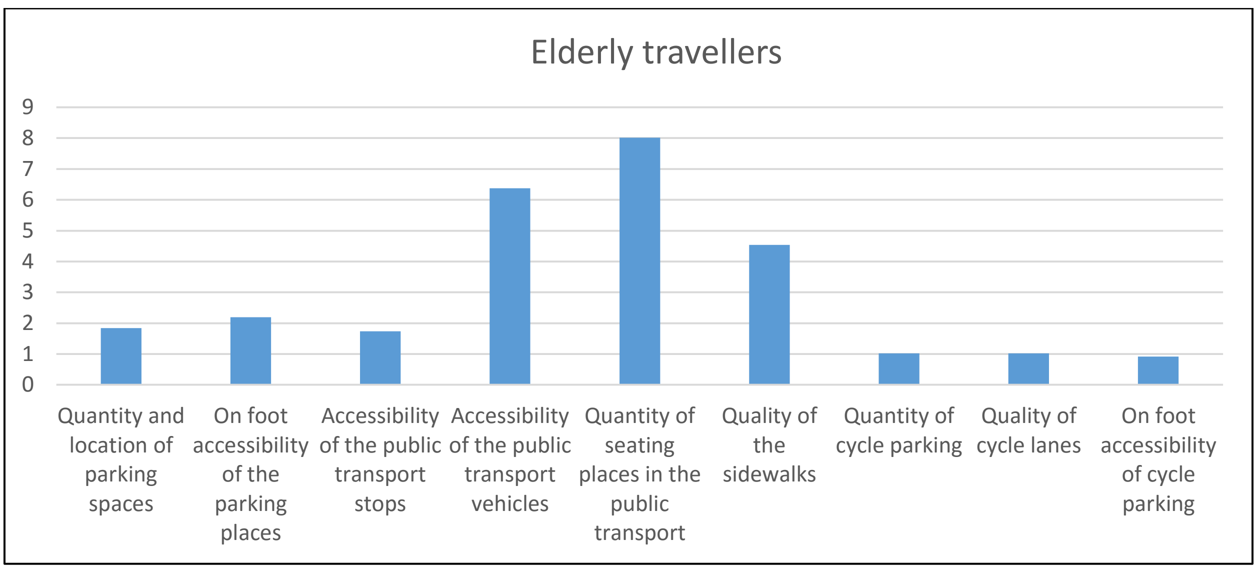


Figure: 4. 3 Response for elderly travelers

Among the people with physical mobility issues, more than 88 % of the respondents are not satisfied with quantity and location of disabled parking space and provision of space for their wheel chair on public transport. Only 35% of the respondents are accessibility of public transport stops.

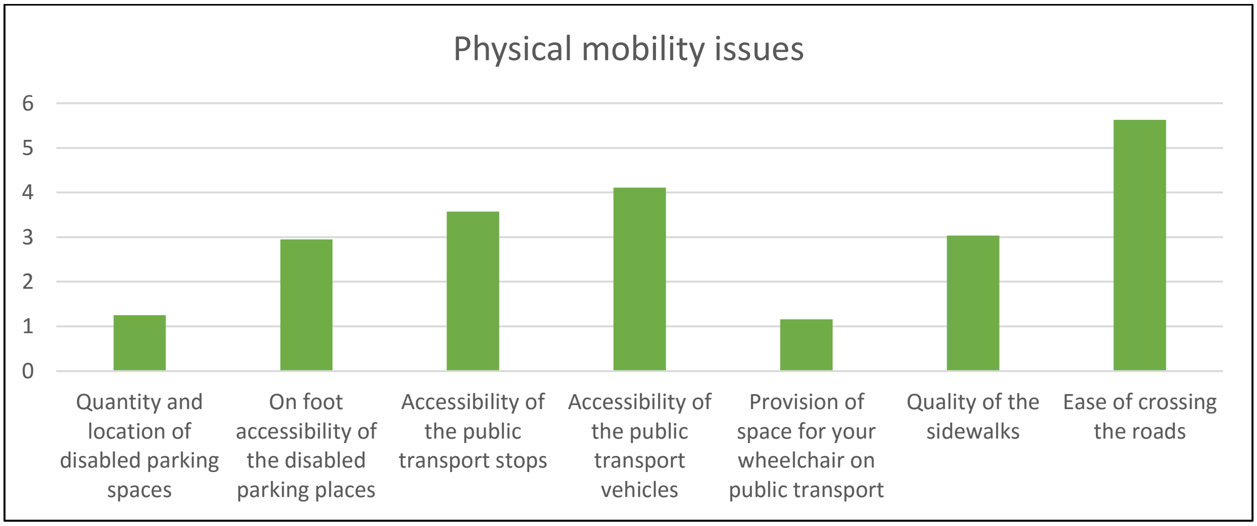


Figure: 4. 4 response for physical mobility issue

Among the visually impaired people, more than 82 % of the respondents are un- happy with accessibility of public transport stops. Around half of the visually impaired people are satisfied with Access of the public transport vehicles at the stops or stations. Less than tenth of the respondents were not aware of the guidance and warning system for visually disabled people along the sidewalks.

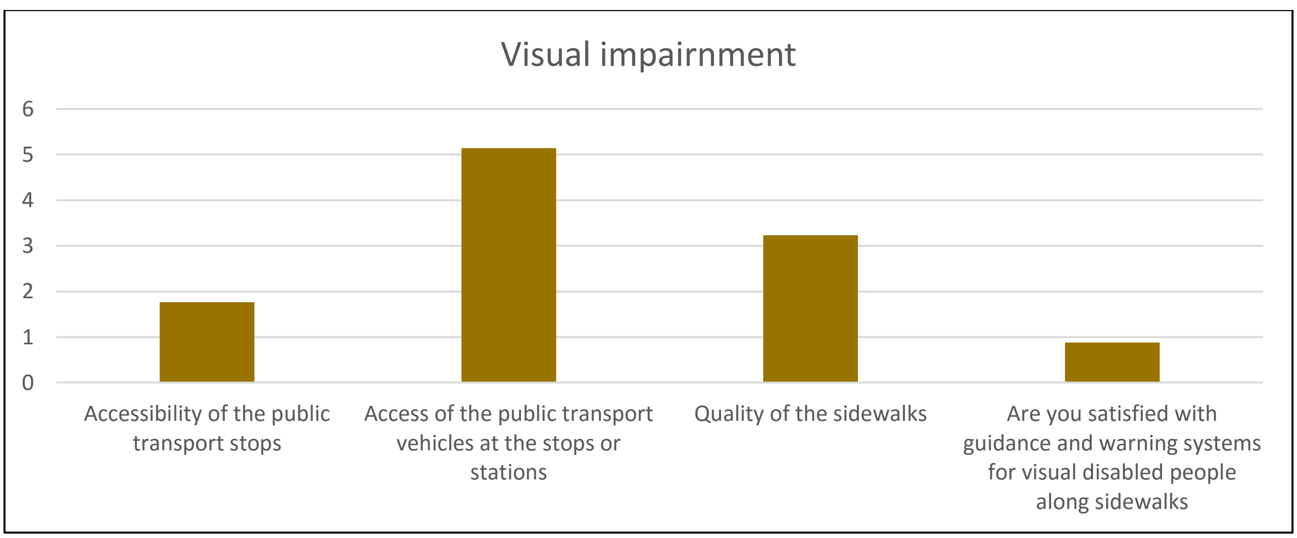


Figure: 4. 5 Response for visual impairment

The index value shown as a figure in annex A for mobility impaired group is 3.20. As per the standard, the transportation system of the city has neglected to address the mobility issue for mobility impaired groups to this extent.

### 4.1.3. Fatalities

As defined by the WHO, a death counts as related to a traffic accident if it occurs within 30 days after the accident. Source was city traffic police.

The minimum level is set to zero fatal accidents while the max is 35 per year. While zero may not seem as an immediately realistic level to achieve, it is increasingly used as a long-term goal among transport authorities around the world and therefore a meaningful lower benchmark.
The severity of injuries sustained ranges from those that can be treated immediately and for which medical care is not needed or sought, to those that result in a permanent disability.
The f scale for fatalities ranges from the worst 35 fatalities per 100,000 to the vision zero of zero fatalities per 100,000 population.

As shown in annex A, the fatality index score for the city is 7.3. This index shows that the city of Mek'ele is doing well. In the year of 2016 the city of Indore India has conducted similar research by the same software has scored 5.4 which is sever than city of Mek'ele. The current population of Mek'ele city is 412,117 and that of city of Indore is 5,245,225. The number of vehicles in city of Mek'ele is 4555 and that of city of Indore was 5664.

"The six evaluated cities so far were surprised by their high score on Fatalities. It is because the scale is representing the extremes observed worldwide. As such most un-developed cities might get a value above 9", WBCSD CEO, Iren.

### 4.1.4. Comfort and pleasure

Among the respondents, around 70% feels personal security. Less than 93 % of the drivers have no idea about real time traffic information. More than 73% of them are unhappy with the quality of road infrastructure.

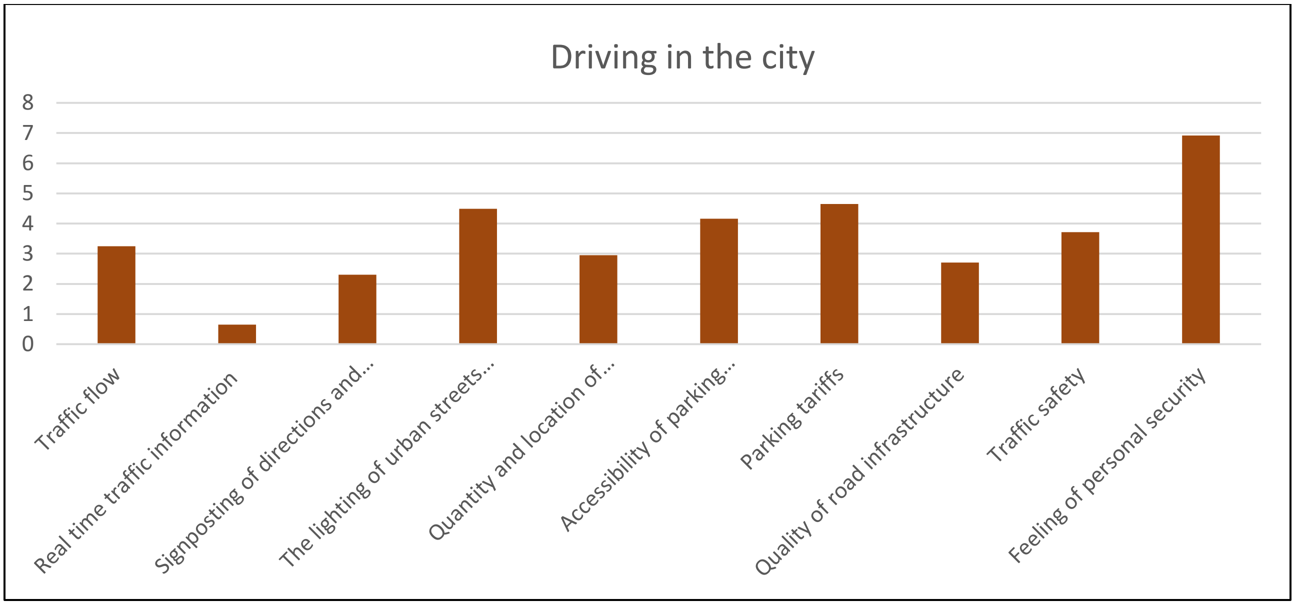


Figure: 4. 6 Response for driving in the city

In the city of Mek'ele, there is no a lane specially allowed only for cyclists. Among the respondents more than 85 % claims there is a problem with availability of dedicated lanes for biking, width of bike lane, the quality road surface of the bike lanes, number and location of bicycle parking facility in the city. Unlike the above entities, more than 75 % are satisfied with the way other road users treat cyclists when on mixed use roads and security of the bicycle parking facility.

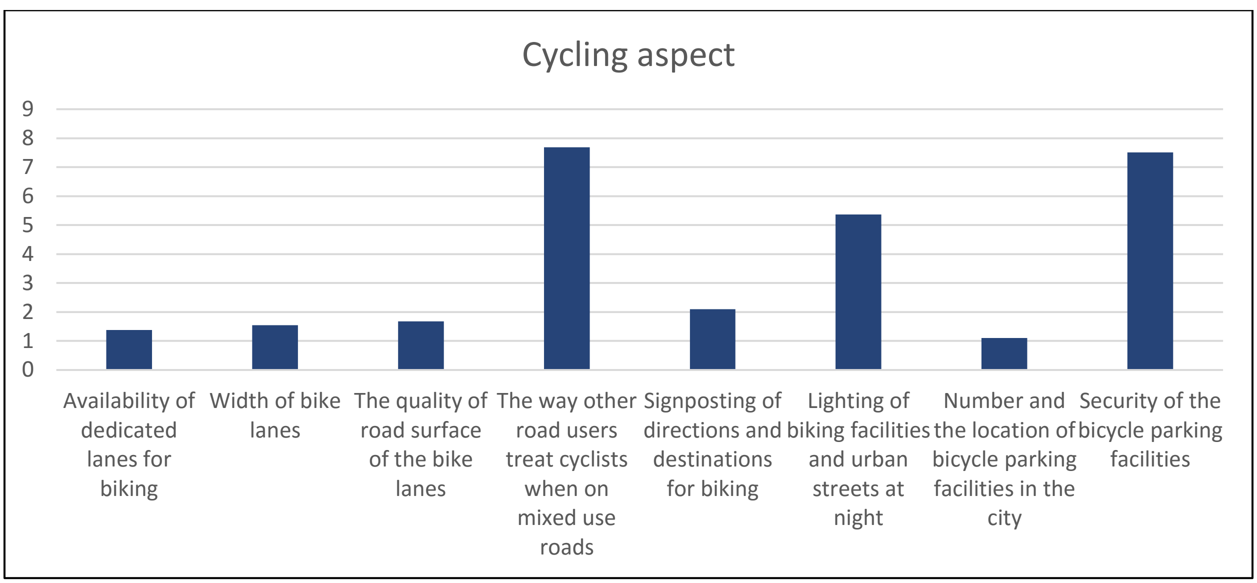


Figure: 4. 7 response for cycling aspect

All of our respondents were not reluctant to respond to their situation while walking across the city. 81 % of the respondents were happy with the availability of car free streets in the city. More than half of the road users were satisfied by the availability of sidewalks in the city.


Figure: 4. 8 response for walking in the city

The response given by the users of the public transport for cleanliness, comfort (seats, noise, and temperature) and fare is less than 25%.

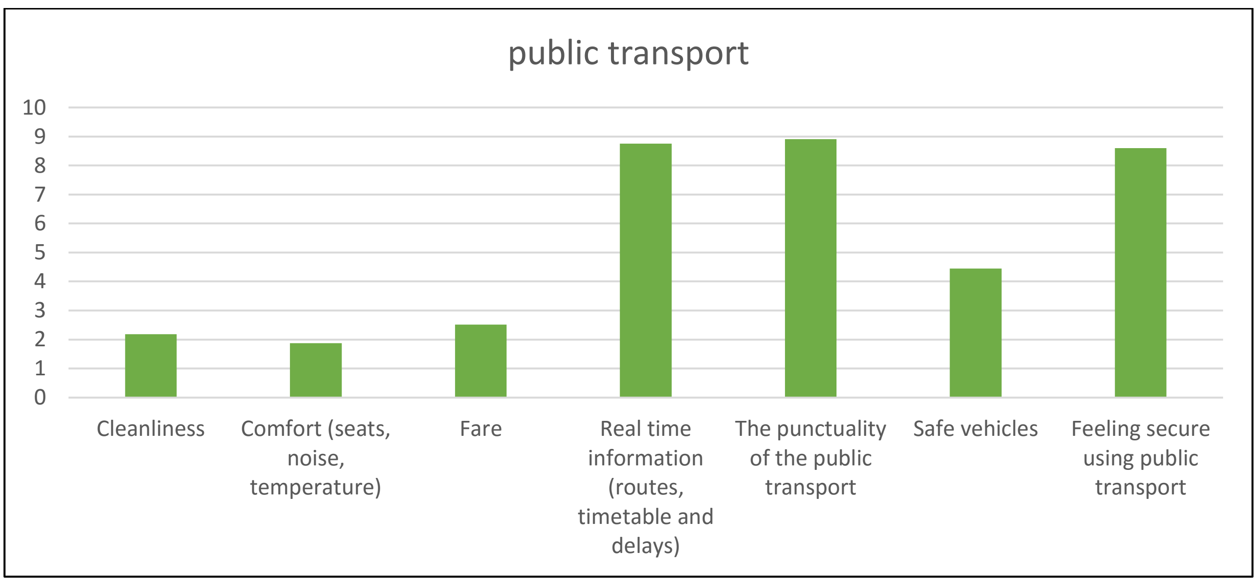


Figure: 4. 9 Response for public transport

As shown in annex A, the indexed score for comfort and pleasure of the city is 4.29. Which means the level of the comfort and pleasure in using urban transportation felt by the residents is around average. The result of the research is the extent to which the level of comfort and pleasure the users deserve.

#### 4.1.5. Access to mobility service

Among the whole population of the city only 138,250 is within the radius of 400 m of the public transport station which comprises 32.6%.

Mek'ele has 20 main so called taxis stations and no formal city bus terminal. The taxi stations are mostly located around Kedamay Weyane building complex (locally known as Dufeo area). Taxis will queue along the roads on different directions and wait for users. There is no defined space or taxi terminal in this or other areas in the city. Taxis stops along the carriage way on one or both sides of roads and wait until they are full and leave for various destinations. The same situations are observed at the end points of trips where sides of roads are used as terminal for back trip from various areas in the intermediate and periphery parts of the city. The following plot shows the main taxis station location.

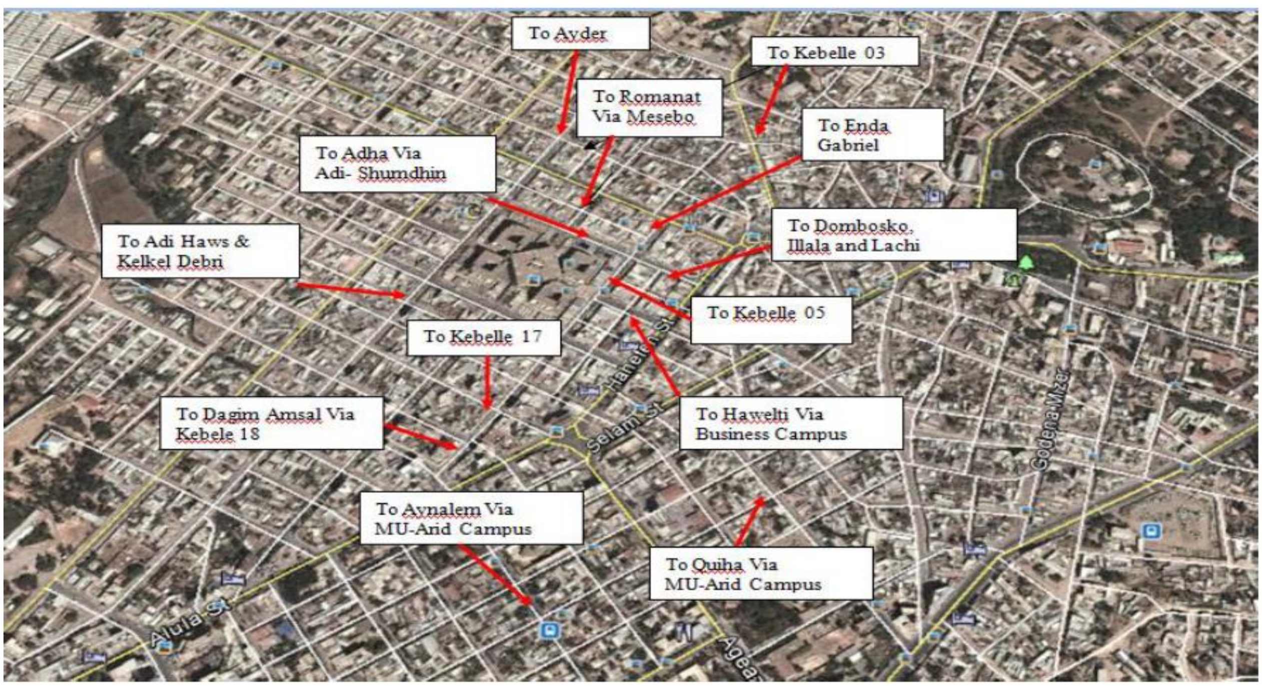


Figure: 4. 10 Mek'ele taxi station location

The present survey conducted shows that currently there are around 550 minibus taxis, 76 small taxis and 2800 bajaj which are registered formally and informally.

As we can see from the city residents' access to mobility service is indexed to be 3.27 which is below average. Most of the residents lives away from the public transport station. More than 66% of the population should have to walk more than 400 m to access the public transport station.

### 4.1.6. Sound hindrance

Sound detector was placed at 3 stations of the city. For Adi – Haki area three specific locations were selected. Those are: Dagim Amsal Taxi station, 200 m down from Adi Hawsi traffic light and Along Sematat monument. For Adi Hawsi area: Around Tombola recreation, Around Adi – Hawsi Condominium and Around Catholic Aynebrhan were selected. And finally, for Adi – Ha: Ekram taxi station and around Adi – Ha traffic light were chosen.

The sound index Value from filed measurement is 0.47. The city of Mek'ele is a very nosiest place. The perceptual response from the comfort and pleasure indicators, noise disturbance entity, of the questionnaire is 1.87. This indicates that the residents have concern about the disturbing noise.

### 4.1.7. Mobility space usage

The data for mobility space usage collected from city infrastructure bureau for the direct land use and filed measurement for indirect land use. Although it shows good score index of 10, Mek'ele would benefit more from balanced planning on efficient land use. There are very few parking places assigned with respect to city area. There is no separate facility for pedestrian/cycle and other vehicles.

### 4.1.8. Commuting Travel Time

Commuting refers to basic activities and travel that are essential for social and economic development. In the frame of this report, the decision was made to focus on commuting travel time to work or educational places because they are the most important trips for people and often the most inflexible ones.

Both the weekly frequency of trips to school or to work has to be taken into account (maximum value = 5) though commuting does not cover all travel in cities, limiting the definition to this travel motive has the advantage that these travel patterns are best documented and sharply defined.

As per the data collected from citizen survey shown in Annex B, people have responded to the question of "What was the average travel distance (one way in km)", "What was the average travel time one way in minute", "What was the average travel time to return home in minutes", "If you have to be certain of being at home or work for important appointment how much extra time will you allow for the journey" and "How many times did you travel last week to Your place of work or study."

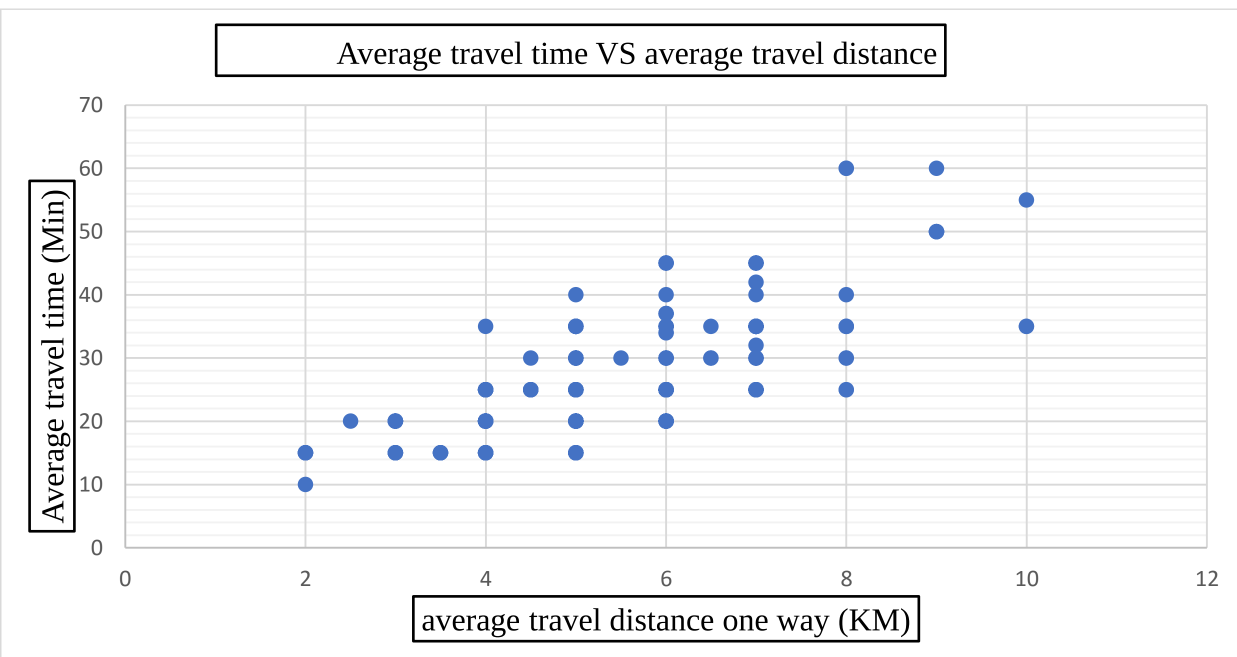


Figure: 4. 11 average travel time vs. average travel distance

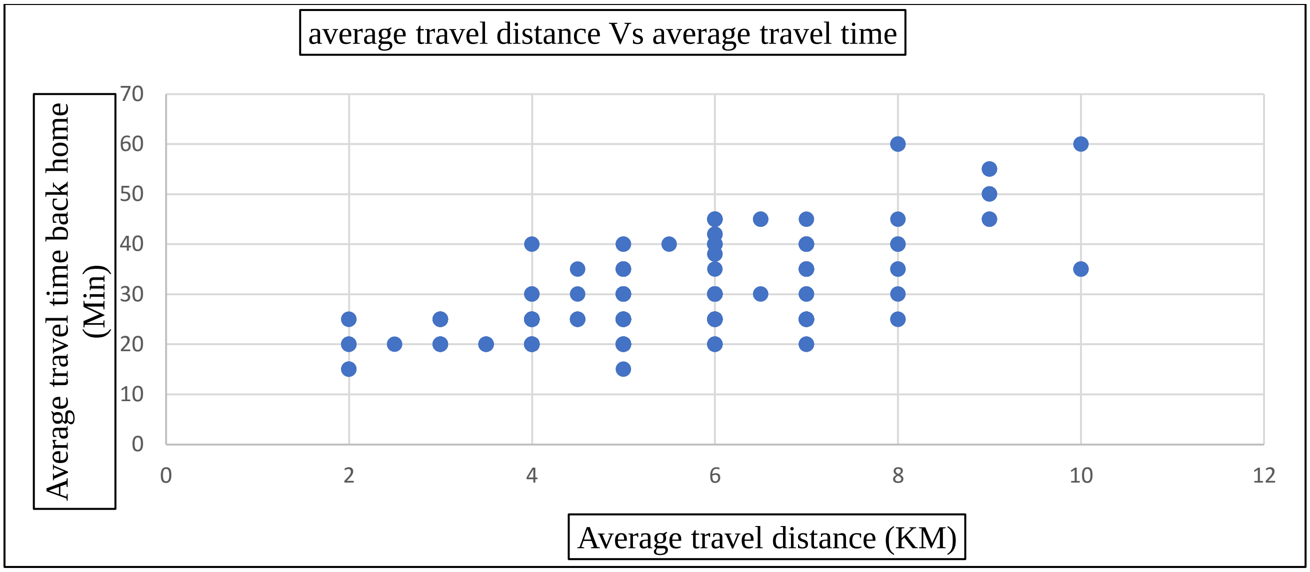

Figure: 4. 12 average travel distance vs. average travel time

As the result shows the score for the commuting travel time is 7.93 which is ranked to be good. This indicates that the current situation is enhancing the economy in case of timely deliverance.

### 4.1.9. Public Finance

During the data collection from the Mek'ele city finance office about net results of government and other public authorities' revenues and expenditures related to city transport, the considered revenues were city taxes from city transport service and on the other hand, received subsidies from any authority and collected common fines were excluded as per the software data collection methodology.

The cost for energy sources and rental expenses to run the transportation sector of the city were included. On the other hand purchases, other manpower cost, paid fines, retributions to authorities, sponsorships, research costs and insurance premium for workers were excluded as costs in the data.

The index value for the indicator of public finance is 9.27 which is very promissory. As the author have later learned, the government has been and is being subsidizing the transport sector.

### 4.1.10. Opportunity for active mobility

Only facilities that meet the relevant standards were included to avoid including unpractical sidewalks or bike lanes. The data were collected from Mek'ele city infrastructure bureau and office of traffic police.

The opportunity for active mobility is measuring the commitment of the city to inspire in using of soft modes such as walking and cycling.

As the index result in Annex "A" shows the score for this indicator is 1.72. The city doesn't own a lane provided only for walking and cycling. The city is not preparing for the overtaking head ache of traffic congestion as other cities of the world are striving to address the congestion issue with walking and cycling

### 4.1.11. Security

In the population survey the public transport safety issues has been addressed by raising the following structured questions: Waiting for public transport at the stop or at the station during daytime, waiting for public transport at the stop or at the station during nighttime, being on board public transport during daytime and night time.

As illustrated in figure 4.13, 89 % feels personal safety while awaiting and on board of public transport. In this case, apart from the real security also the perceived security is an important issue in the frame of sustainable urban transport because security should give users confidence that they can use transport. The lack of this confidence can lead to noncompliance of mobility needs.

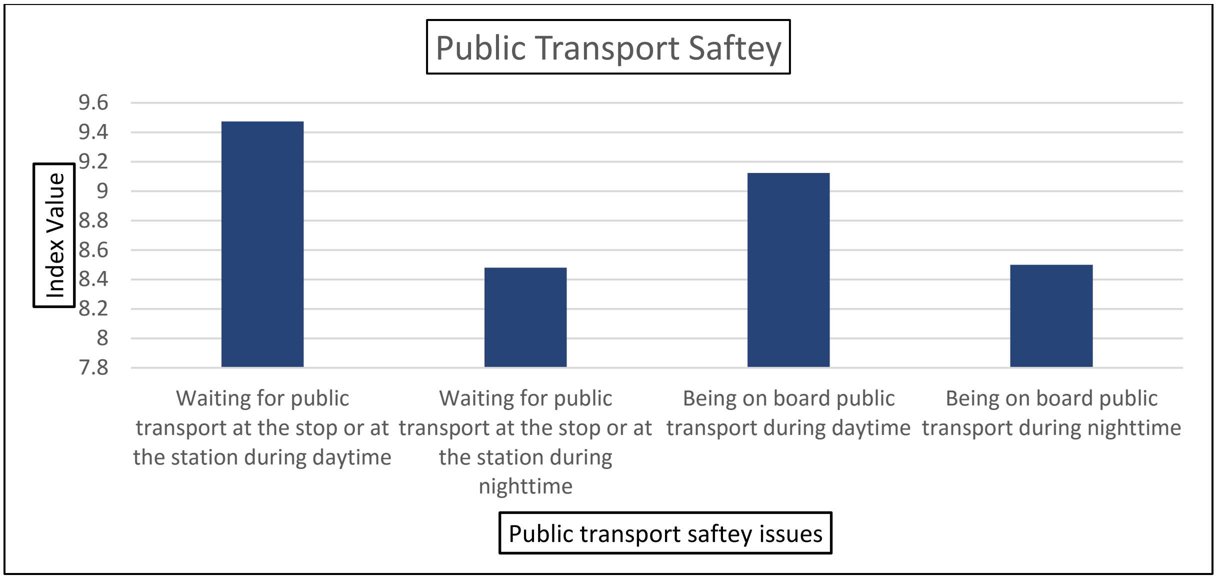


Figure: 4. 13 Public transport safety issues

In the car related safety issue, driving a car during day and at night and car theft was among the structure concerns. 38% expresses their concerns about the security issue.

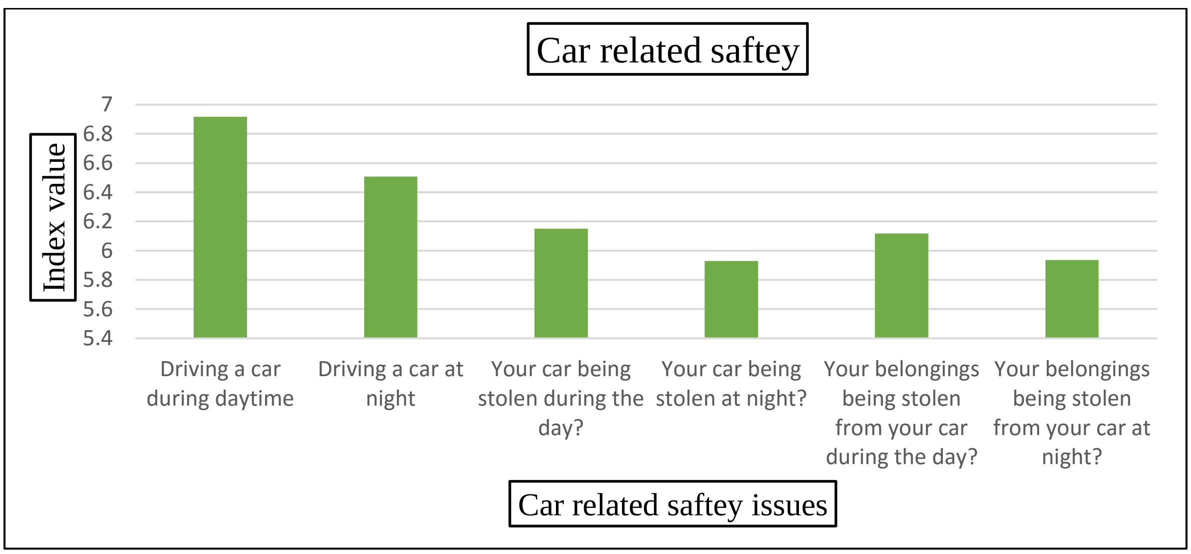


Figure: 4. 14 car related safety issues

Walking safety has an impact on whether to use transportation means or not. As the result shows people feels unsafe during the night that that of day time. They prefer to use mode of transportation during the night time.

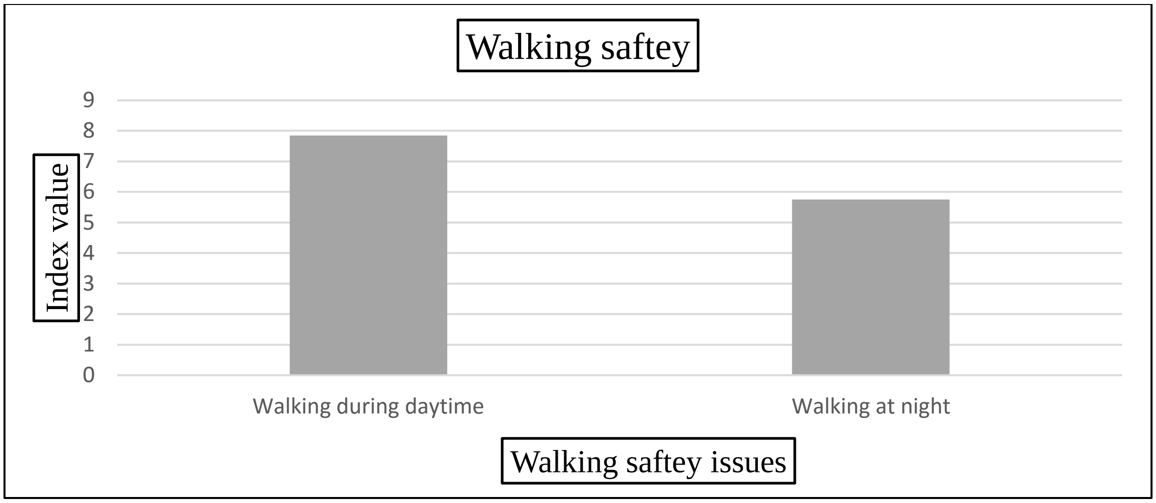


Figure: 4. 15 Walking safety issues

In the survey the respondents have been told that to put into consideration not only the actual security problem but also their personal threat. In general, the concern for security was indexed to be 7.23 and ranked to be good.

The spider chart below shows the sustainable mobility footprint of the city of Mek'ele by giving an overview of how each indicator rates on a scale form 0 (worst) to 10 (best) and the details pertaining to their definitions, parameters and data sources for each of the 11 indicators analyzed for the city of Mek'ele can be referred in the figure 4.16.

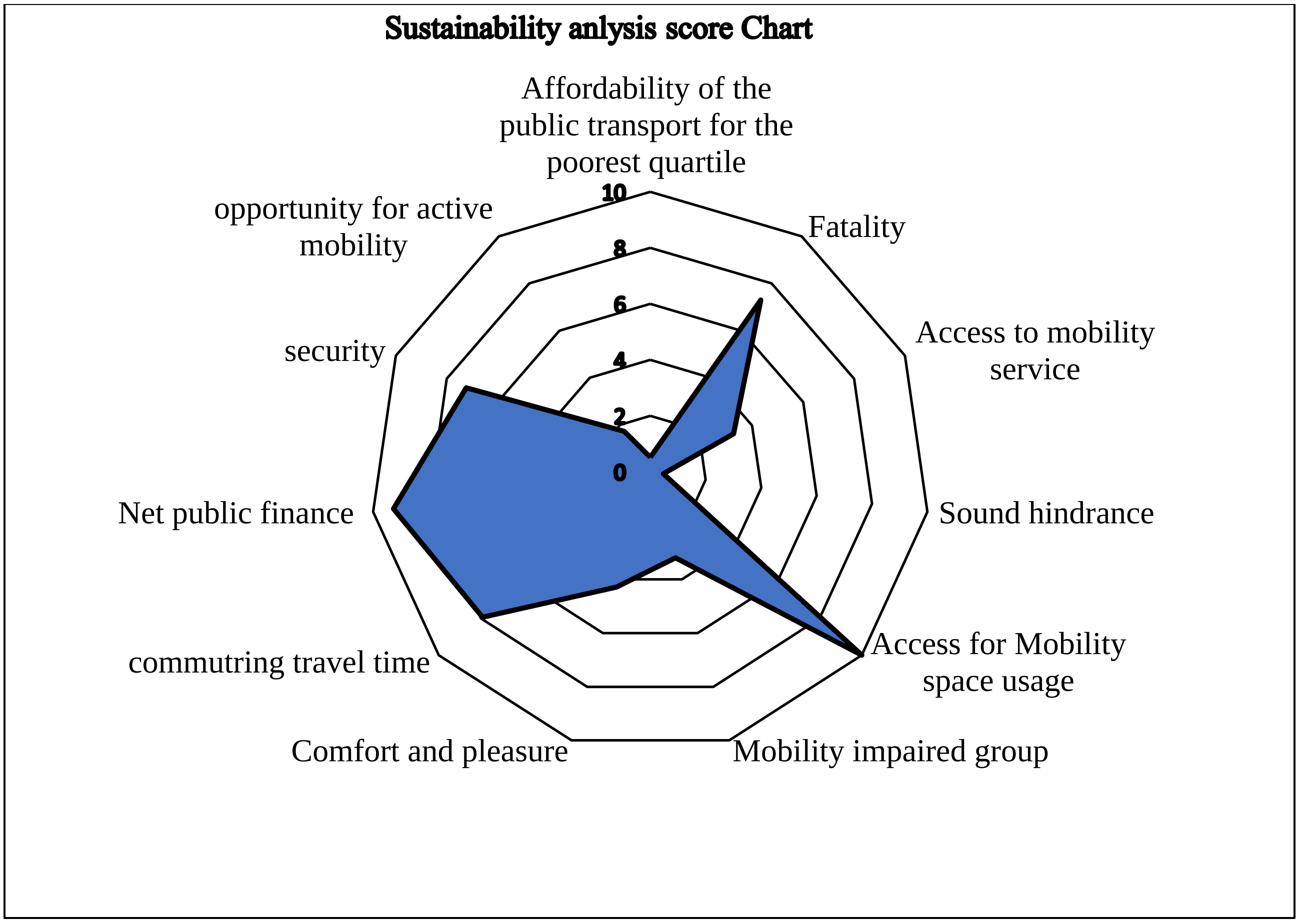


Figure: 4. 16 Urban Transport Sustainability Index

Table 4. 2 Indicator analysis values

| | | | Scale span | | |
|---|---|---|---|---|---|
| **Indicators** | **Parametric Value** | **units** | **Min scale** | **Max scale** | **score** |
| Access to mobility service | 32.67 | | 0 | 100 | 3.27 |
| affordability | 33% | % | 35% | 3.5 % | 0.52 |
| Access for mobility impaired groups | 32 | % score | 0% | 100% | 3.2 |
| Sound hindrance | 0.67 | | 0.7 | 0 | 0.47 |
| Traffic fatalities | 9.45 | Fatality/capita | 35 | 0 | 7.3 |

| | | | | | |
|---|---|---|---|---|---|
| Commuting travel time | 26.57 | | 90 | 10 | 7.93 |
| Mobility space usage | 5.43 | $M^2$/cap | 125 | 25 | 10 |
| Net public finance | -0.18 | % | -2.5% | 0% | 9.27 |
| Comfort and pleasure | 4.29 % | % score | 0% | 100% | 4.29 |
| Opportunity for active mobility | 0.34 | | 0 | 2 | 1.72 |
| Security | 7.23% | % score | 0% | 100% | 7.23 |

A comparison of the Indicator analysis shown in the spider chart to the city's selected priority indicators confirms that indicators are returning low sustainable mobility scores and addressing these indicators could substantially improve the sustainable mobility of the city.

## 4.2. Combined value of Sustainable City Transport

The standardization of the indicators allows the sustainability evaluation of the urban transport network. The initial move towards this aim is to identify the weights assigned to each indicator group in order to reflect the importance of environmental, social and economic sustainability in relation to the ultimate objective of sustainable urban mobility.

In this particular study, the method of equal weighting is chosen to prevent subjectivity, and the following equation was used to calculate:

$$combined = \frac{\frac{\sum i_{s0}}{n_{so}} + \frac{\sum i_{en}}{n_{en}} + \frac{\sum i_{ec}}{n_{ec}}}{n_{tot}} \qquad (4-1)$$

Where, i= score of each indicator

$s_o$ = Social dimension

$s_e$ = Environmental dimension

$e_c$ = Economic dimension

Van Dijk and Mingshun (2005) sets to value the combined sustainable calculation with four different levels of sustainable mobility conditions.

Table 4. 3 range of indicator score with description

| Range of indicator score | description |
|---|---|
| ≥8 | Sustainable |
| 6 - 8 | Moderate |
| 4 - 6 | Weak |
| ≤4 | unsustainable |

The sustainability for Mek'ele city transport system is 4.93/10, suggesting weak sustainable mobility conditions for the city's transport system.

## 4.3. SWOT Analysis and Problem Mitigation measures

The SWOT analysis indicates that the city has a comparable strengths and weakness towards sustainable mobility. These strengths are related with the urban land usage and government annual revenue from transport related charges which shows the government commitment in infrastructure to sustain the mobility. Nonetheless, as it is shown in the analysis below, the fare of public transport is high, the way for soft modes such as walking and cycling is discouraged and there is a limited access to public transport. This are counterparts hindering the sustainable mobility. The public transport administration and office of city infrastructure shall have a joint venture discussing on issues. This would help for decision maker to put direction for sustainability.

Table 4. 4 SWOT Analysis

| Strength | Weakness |
| --- | --- |
| ✓ Adequacy of direct and indirect land use for motorized mode of transportation<br>✓ Good city government annual revenue from transport related charges<br>✓ Good all rounded security | ✓ There is no specially provided lanes for the soft modes of transportation<br>✓ High cost fare of public transport<br>✓ Limited access to public transport within walking distance for majority of the residents |
| **Opportunity** | **Threat** |
| ✓ Newly designed master plan<br>✓ Separate parking is to be allocated<br>✓ Currently imposed Excise tax on a used cars | ✓ Currency devaluation<br>✓ GDP depreciation |

Public transport users make up 91% of the city. Public transport subsidies are widespread in developing countries and are often justified on the grounds of making transportation accessible. Policymakers should be concerned about the level of such subsidies. If the purpose of subsidies is to make transport affordable, the optimum level of subsidies will depend on the source of subsidies, the elasticity of public transport revenues, and the welfare weights that policymakers attach to different income classes.

A significant reduction in noise includes all about of vehicles, such as engines, fuel flow and mechanics, tires, pavements, reducing traffic speed, isolating sources of noise and moving them away from users. It is possible to reduce traffic speed and intensity by adequately routing traffic to the transport network along with the consequent construction of infrastructure.

Improvements shall be on:

- Improvements to infrastructure, like low noise road surfaces.
- Low noise tires.
- Urban planning that limits settlement close to busy roads, layout and acoustic quality of buildings.
- Traffic management, like traffic calming, controlling the speed, low noise operational procedures.
- Restricting access for the noisiest vehicles.
- Noise barriers and improved soundproofing of dwellings.

Proper distribution and control of traffic not only has a positive impact on noise levels, but also on air quality and safety. Reductions in traffic volumes can be achieved by increased use of public transport, encouraging short-distance cycling and walking, parking management, and restricted access to heavy trucks to selected areas. Road identification and bypassing congestion across protected areas are other ways of reducing traffic.

## 4.4. Result comparisons among cities

**Addis Ababa, Ethiopia**

In 2019 a study was conducted to determine Addis Ababa city's sustainability. The indicator score (1 to 5) is determined based on the parameter value chosen for defining the indicators.

Analysis on sustainability is presented using a spider chart. By providing this dis aggregated analysis of the success of sustainable mobility one can recognize strengths and weaknesses. With respect to the diagrams presented, it can be seen that five out of nineteen indicators get the lowest score (i.e. one) while only one indicator is ranked at the highest. Seven indicators yielded a moderate result with a 3 score. The environmental category averages 2.33 while the social and economic category scores are 2.13 and 3.6 respectively as described by (Yodit, 2019).

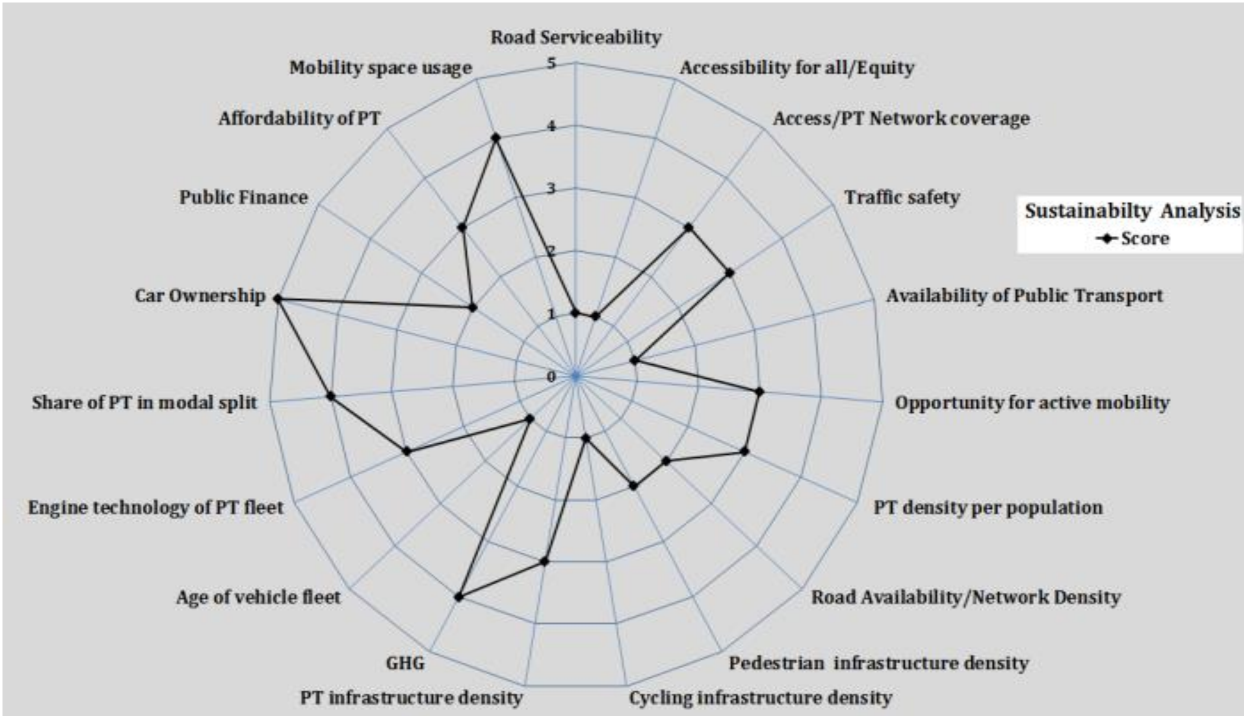


Figure: 4. 17 Ranking Scores of indicators of Addis Ababa city (2019)

Yodit (2019) found the sustainability of the city transport network in Addis Ababa was 2.69/5, indicating poor sustainable mobility conditions for the city's transport network.

**Indore, India**

The spider diagram below shows the city of Indore, India 's sustainable mobility footprint by giving an overview of how each indicator rates on a scale from 0 (worst) to 10 (best).

A comparison of the indicator analysis (pictured below in this Spider Chart, Scale from 0 to 10 with 10 being the most sustainable) with the selected priority indicators indicates that these seven indicators return low sustainable mobility scores and fix these indicators will substantially increase the sustainable mobility of the region (WBCSD, 2016).

Though the calculation shows good score, Indore will benefit from more rational land-use planning. In terms of city area, there are very few parking spaces assigned. There is no separate pedestrian / cycle facility, as well as other vehicles.

More than 80 per cent of pregnant respondents are unhappy with the availability of parking spaces for expectant mothers and the availability of benches across the area. Among older people, 62 per cent are unsatisfied with parking spaces available and located. 73 per cent are unsatisfied with the quality and location of parking spaces for physically disabled people. Among visually impaired, 58% were unsatisfied with the access of public transport vehicles at stations or stops (WBCSD, 2016).

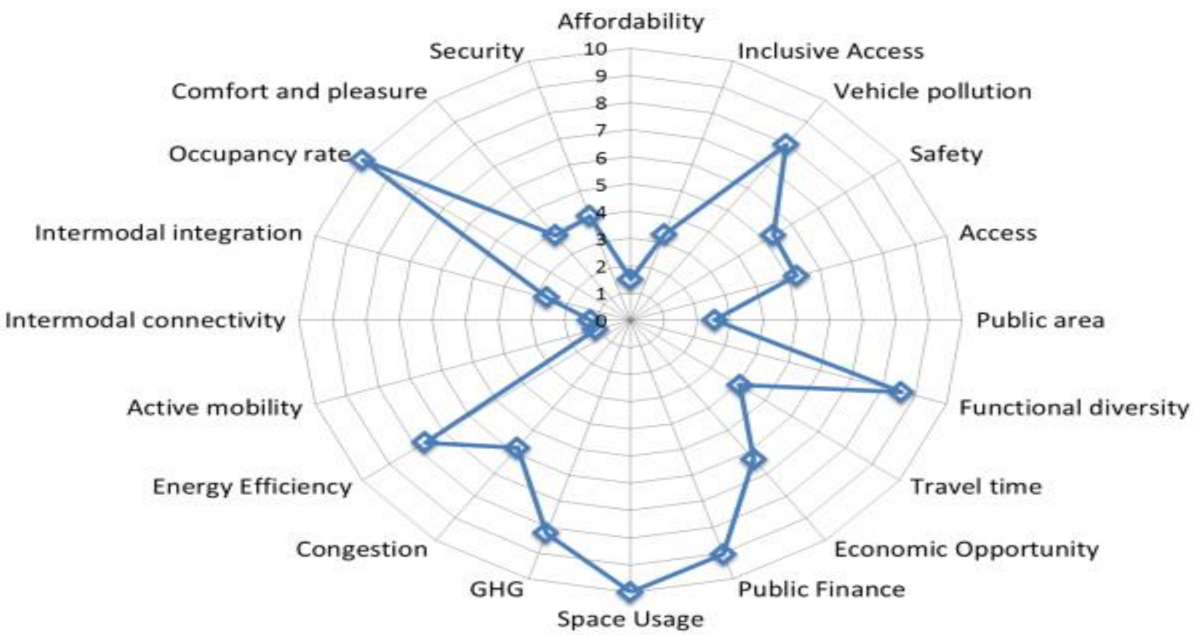


Figure: 4. 18 WBCSD Sustainable Mobility Project 2.0 – Indore City, India (2016)

| Indicators | Values | Units | Scale Span | | SCORE | |
|---|---|---|---|---|---|---|
| | | | Min. Scale | Max. scale | | |
| Affordability | 30% | % | 35% | 3.5% | 1.5 | Affordability of public transport for the poorest people |
| ***Inclusive Access*** | 33% | %score | 0% | 100% | 3.3 | Accessibility for mobility impaired groups |
| Vehicle pollution | 15.23 | $NO_{xeq}$/ cap | 75 | 0 | 8.0 | Air polluting emissions |
| ***Safety*** | 16.42 | atalities/ca | 35 | 0 | 5.3 | Traffic Safety |
| ***Access*** | 53% | % | 0% | 100% | 5.3 | Access to mobility services |
| ***Public area*** | 25% | % score | 0% | 100% | 2.5 | Quality of public area |
| Functional diversity | 0.86 | score | 0% | 100% | 8.6 | Functional diversity |
| ***Travel time*** | 58 | minutes | 90 | 10 | 4.1 | Commuting travel time |
| Economic Opportunity | 11% | % | 0% | 18% | 6.3 | Economic opportunity |
| Public Finance | -0.24% | % | -2.50% | 0.00% | 9.1 | Net public finance |
| Space Usage | 8.13 | $m^2$/cap | 125 | 25 | 10.0 | Mobility space usage |
| GHG | 0.485 | GHG/cap | 2.75 | 0 | 8.2 | Emissions of greenhouse gases (GHG) |
| ***Congestion*** | 1.15 | index | 1.35 | 1 | 5.8 | Congestion and delays |
| Energy Efficiency | 1.20 | energy/km | 3.5 | 0.50 | 7.7 | Energy efficiency |
| Active mobility | 11% | % | 0% | 100% | 1.1 | Opportunity for active mobility |
| ***Intermodal connectivity*** | 0.85 | IC/$km^2$ | 0 | 7 | 1.2 | Intermodal connectivity |
| Intermodal integration | 27% | %score | 0% | 100% | 2.7 | Intermodal integration |
| Occupancy rate | 105% | % | 10% | 65% | 10.0 | Occupancy rate |
| Comfort and pleasure | 38% | %score | 0% | 100% | 3.8 | Comfort and pleasure |
| Security | 40% | %score | 0% | 100% | 4.0 | Security |

Figure: 4. 19 indicators value analysis Indore, India

# CHAPTER FIVE

# CONCLUSION AND RECOMMENDATION

## 5.1. Conclusion

The following conclusions can be drawn from the study:

The index for mobility impaired group is 3.20 which is below the average. As per the standard, the transportation system of the city has neglected to address the mobility issue for mobility impaired groups to this much. The third poorest quartile of the city's population spends 33.4 % of their salary for public transport. Even though the fact that the countries public transport system is highly subsidized, as the value scored is indexed to be 0.52, the city's public transport is totally unaffordable for the poorest not because of the public transport system is un subsidized but due to lowest income of the residents.

The city is doing well with respect to fatalities. In accordance with the goal set by WHO there is a lot more to be done to reach the zero fatality policy.

The current status of the city with regard to sound disturbance is very noisy. Among the 6 metropolitan cities that has been quantified their sustainability with similar software so far, Mek'ele is the nosiest city. The reasons raised for this problem is the outdated status the motor of the vehicles.

The mobility space usage is quite enough to accommodate the traffic passing through. But unless there is wise traffic management, mobility space usage by itself cannot be a solution for traffic congestion. The government is not in aware of future challenges to alleviate traffic congestion by paving the way for soft modes like walking and cycling.

## 5.2. Recommendations

Government intervention for the unaffordable public transport fare is highly recommended. This can be achieved either by special subsidizing the fare for public transport for the poor or by deducting the fare.

Repeating the surveys in different years will depend on the consideration of the expected variation of the results (after implementation of some solution, external changes) versus the survey execution cost. However, cities that prefer to closely monitor the sustainability of urban mobility should repeat the surveys once a year. Target sample size can be modified if the size of the target population has changed since last surveying, but the values for the acceptable margin of error, confidence level and response distribution should be kept in order to ensure comparability of the results.

Regularly assessing the indicators following the same methodology will allow the city to identify its improvements.

This research has been conducted in full collaboration with the Regional bureau of transport starting from data collection until legitimizing the validity of the data so that the word bank backed software can be released upon the recognition of state government. In such an effort, the transport bureau shall be committed to conducted same research in the successive years to come so as to compare the changes and development.

Further research should be conducted to extend all aspects of this research, such as including environmental sustainability. In the environmental sustainability aspect, Energy efficiency and air pollution emission shall be included in the research.

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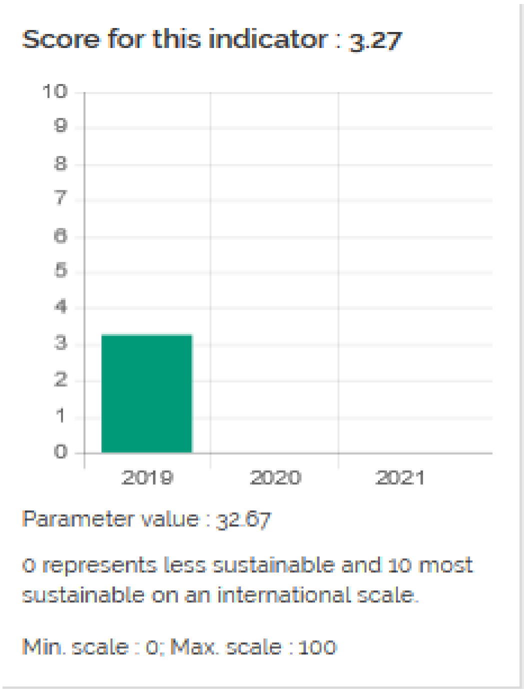
# Annex

## Annex A



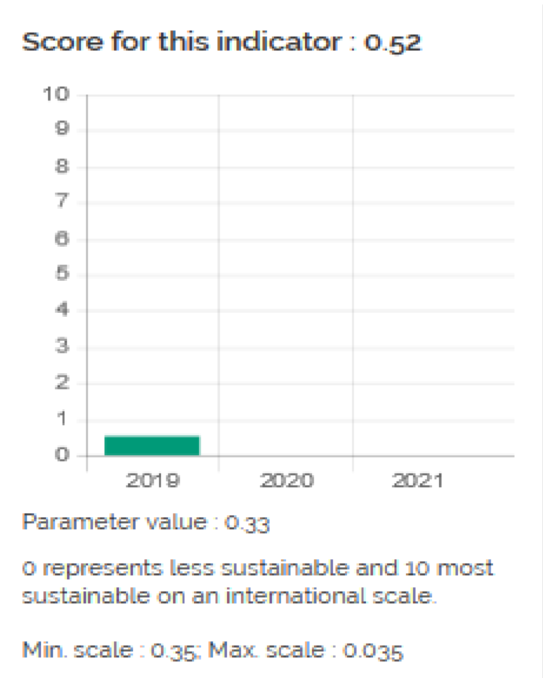
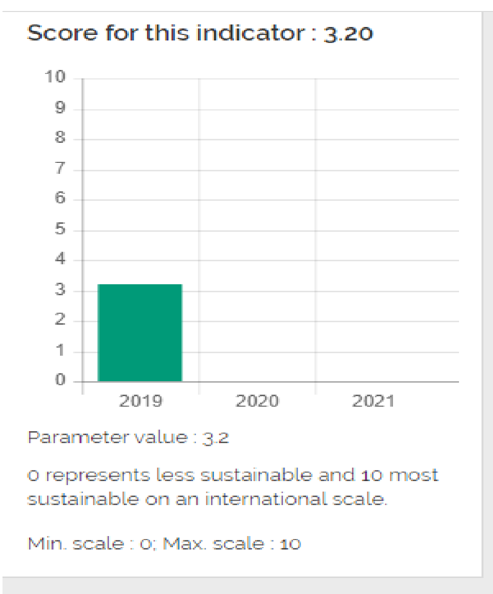




Figure 1: Index score of access to mobility service Snapshot

Figure 2: Index value of Public transport Affordability for the poorest quartile



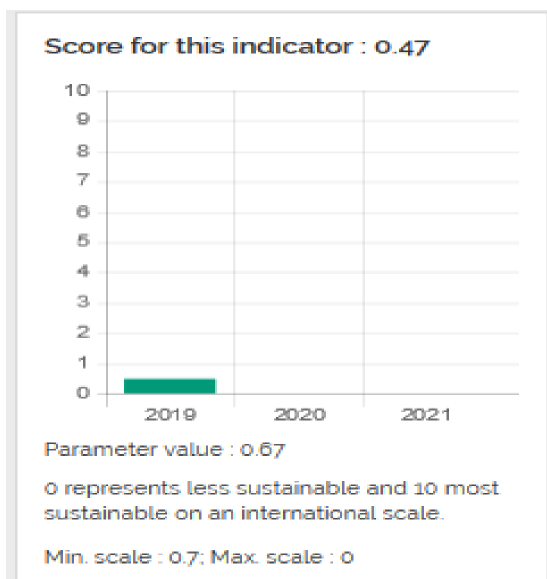




Figure 3: accessibility for mobility impaired groups

Figure 4: Sound hindrance snapshot

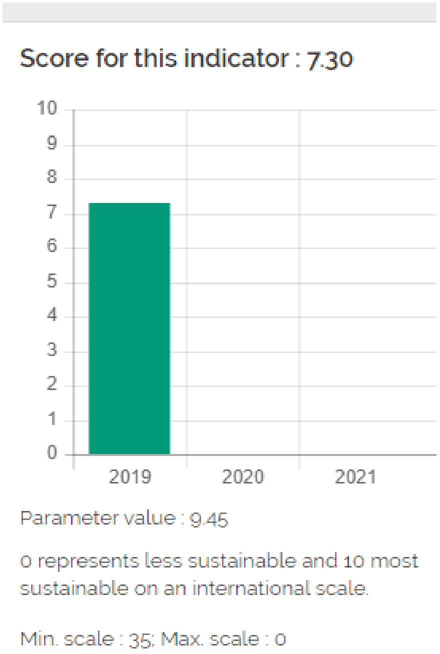



Figure 5: Traffic Fatalities snapshot

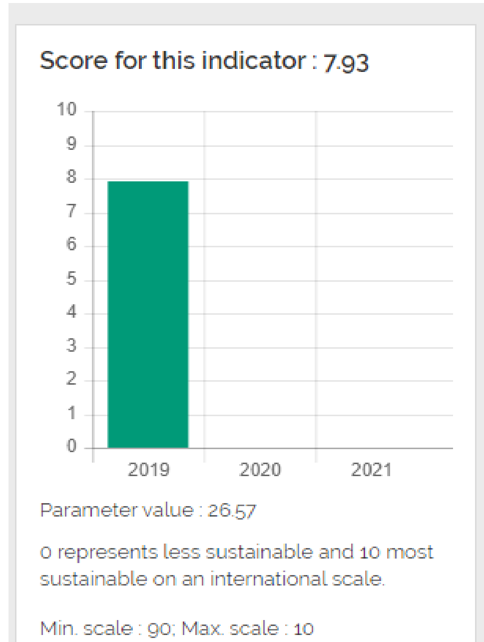
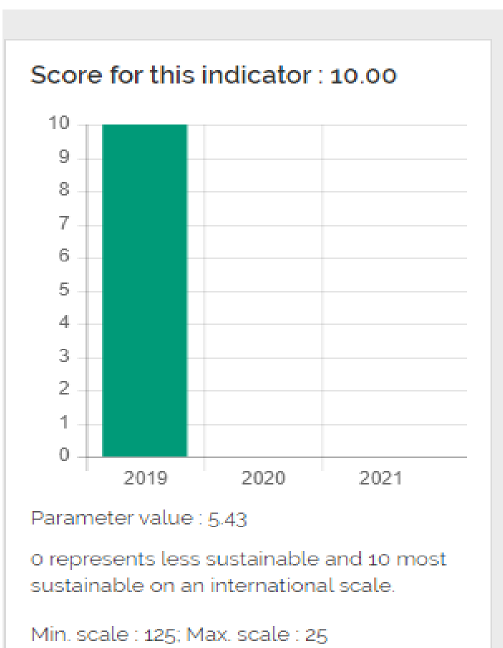



Figure 6: Commuting Travel time snapshot



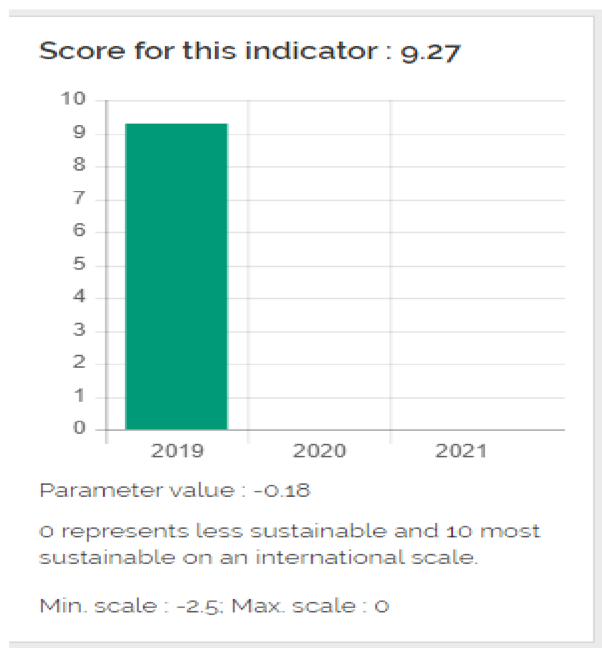
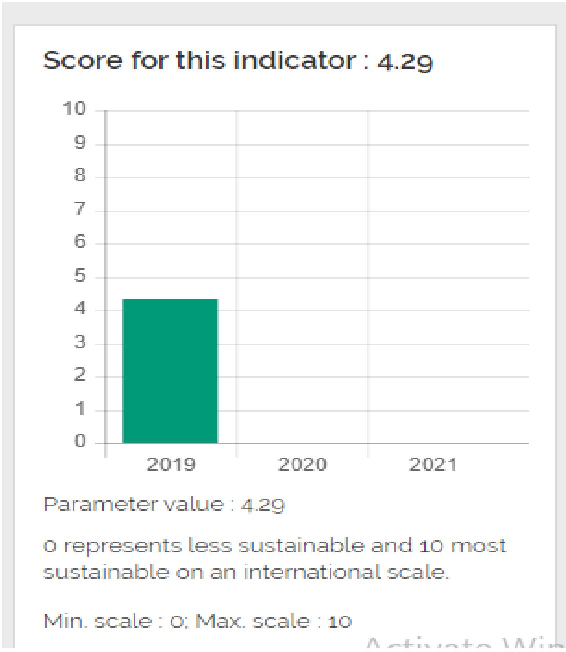




Figure 7: Mobility space Usage snapshot

Figure 8: Net public Finance snapshot



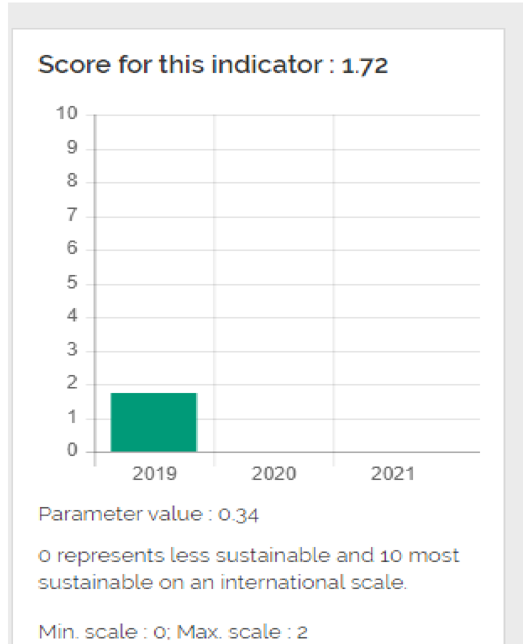




Figure 9: Comfort and Pleasure snapshot

Figure 10: Opportunity for active mobility snapshot

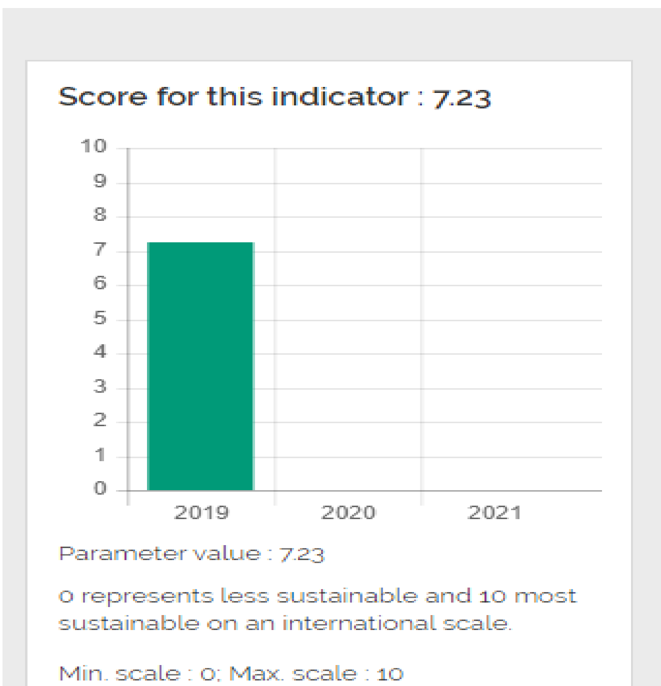



Figure 11: Security snapshot

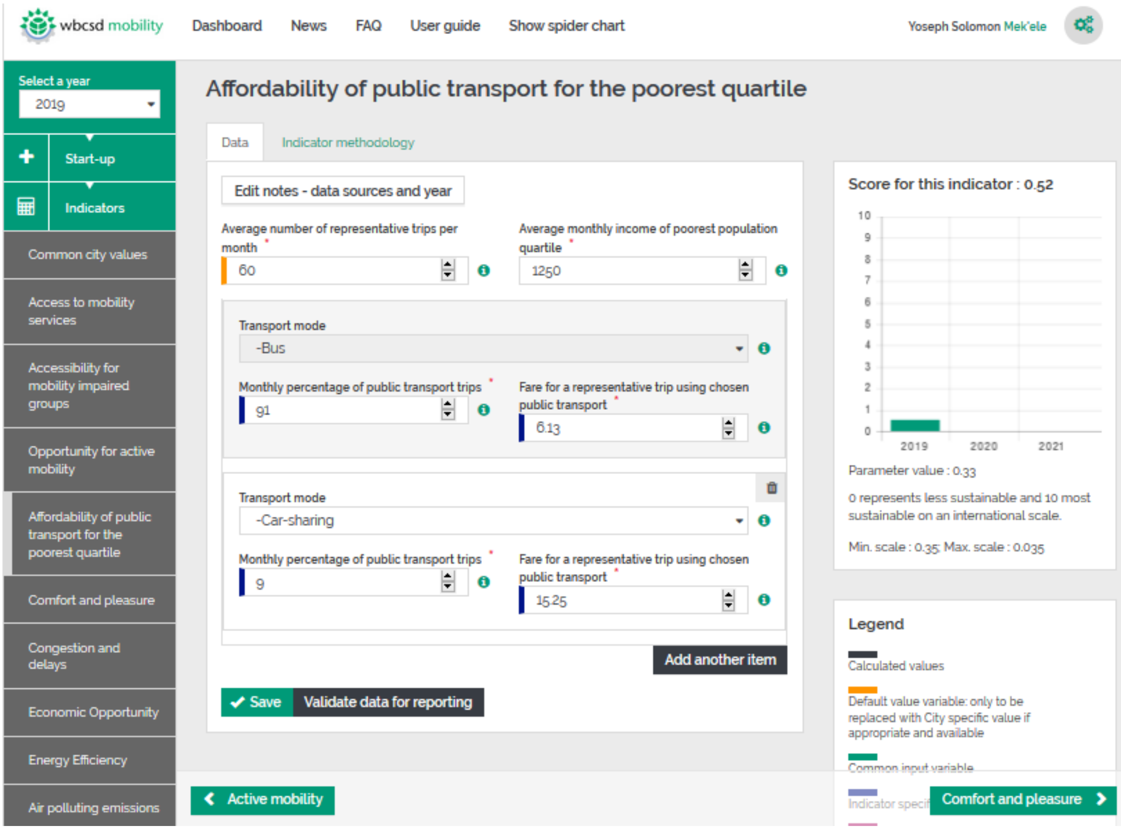



Figure 12: Affordability of Public Transport of the Poorest Quartile snapshot

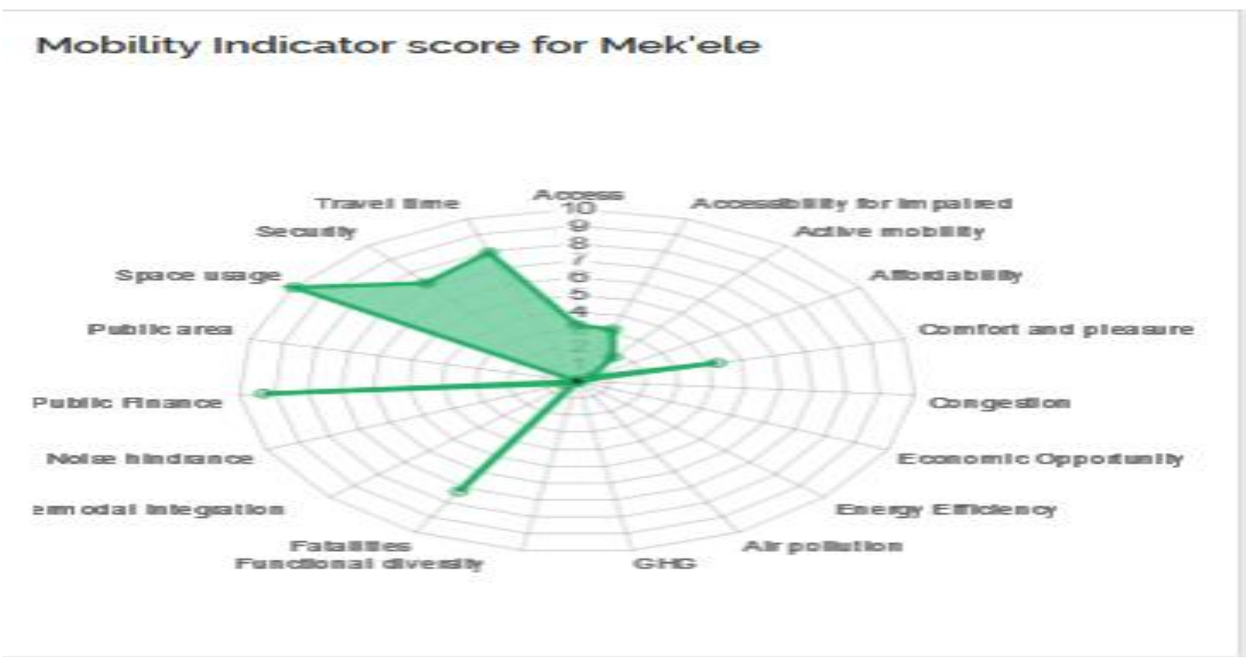
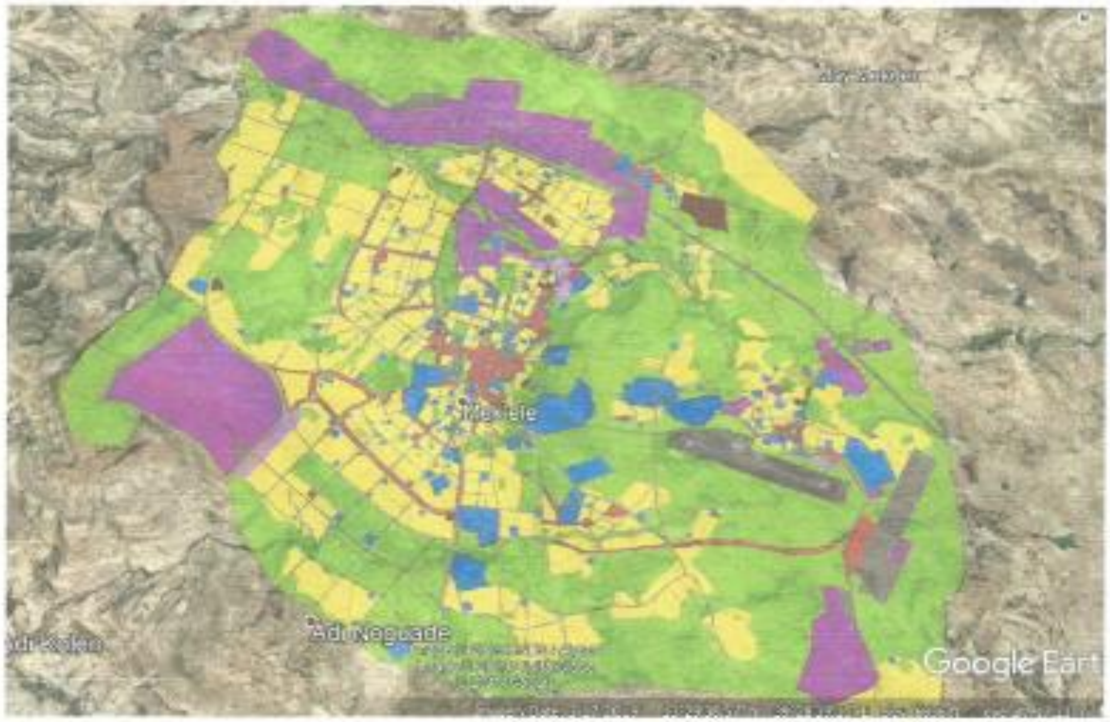



Figure 13: Urban Transport Sustainability Index snapshot

**Annex B**

# SUSTAINABL MOBILITY PROJECT 2.0

## FOR WBCSD MOBILITY




# DATA FOR SUSTAINABLE URBAN MOBILITY INDICATORS OF MEKELE CITY, ETHIOPIA, EAST AFRICA

3rd OF JUNE, 2019

Tigrai Regional National State Brueau of Construction Road And Transport

*Data's for measuring sustainability* *Mekele city, Ethiopia, East Africa*

## Data's for sustainable urban mobility indicators of Mekele city, Ethiopia, East Africa

**NB**

- ✓ Some of the indicators are not included because they are not an issue in our country.
- ✓ The methodologies for data collection are taken from "**SMP 2.0 sustainability mobility indicators 2nd Edition**" and other literatures from **WBCSD.**
- ✓ The variables for the indicators are in a total summation, if detail information is needed, we can provide list of every single detail.
- ✓ the currency is in "Ethiopian Birr"
- ✓ There is no a lane which is only dedicated for bicycle lane, the bicycle users use along with the normal vehicle and pedestrian ways.
- ✓ There is no BRT in the city, there is only magic vans for fare, three wheeler Bajaj and public buses for free (i.e. for government and factory workers).
- ✓ These document contains 22 pages

*Data's for measuring sustainability* *Mekele city, Ethiopia, East Africa*

| | | | | | |
|---|---|---|---|---|---|
| | | TPT of three wheeler bajajs | Monthly percentage of PT trips with PT mode three wheeler bajajs | % | 3 |
| | | F10 Km of magic Vans | Fare 10 km PT trip with PT mode of three wheeler Bajaj | Ethiopian Birr | 15.25 |
| | | Minc 25% | Average monthly income of poorest population quartile | Ethiopian Birr | 1250 |
| 4 | **Sound hindrance** | $L_{D1}$ | Noise day factor (7-14hr) or day time value relevant for the region | DB(A) | 73 |
| | | $L_{E1}$ | Noise evening factor (19-23hr) or evening time value relevant for the region | DB(A) | 74 |
| | | $L_{N1}$ | Noise night factor (23-7hr) or night time value relevant for the region | DB(A) | 71 |
| | | $MWF_1$ | Measuring weight factor I (depending on population density of the area) | # | 7 |
| | | $L_{D2}$ | Noise day factor (7-14hr) or day time value relevant for the region | DB(A) | 72 |
| | | $L_{E2}$ | Noise evening factor (19-23hr) or evening time value relevant for the region | DB(A) | 76 |
| | | $L_{N2}$ | Noise night factor (23-7hr) or night time value relevant for the region | DB(A) | 70 |
| | | $MWF_2$ | Measuring weight factor, I (depending on population density of the area) | # | 7 |

2 | P a g e

Figure 14: Sample of Data sent to the software providers for legitimacy and Validity

## Annex C

| What was the average travel distance (one way in KM) | What was the average travel time one way in minute | What was the average travel time to return home in minutes | If you have to be certain of being at home or work for important appointment how much extra time will you allow for the journey | How many times did you travel last week to Your place of work or study |
|---|---|---|---|---|
| 4 | 20 | 20 | 10 | 5 |
| 2 | 10 | 15 | 15 | 4 |
| 3 | 15 | 20 | 15 | 1 |
| 5 | 15 | 20 | 15 | 5 |
| 3 | 20 | 20 | 10 | 4 |
| 2 | 15 | 15 | 10 | 5 |
| 2.5 | 20 | 20 | 10 | 5 |
| 3 | 20 | 25 | 10 | 4 |
| 4 | 25 | 25 | 10 | 4 |
| 6 | 30 | 25 | 15 | 5 |
| 5 | 30 | 30 | 20 | 5 |
| 4 | 25 | 30 | 25 | 5 |
| 7 | 30 | 30 | 20 | 4 |
| 8 | 25 | 25 | 25 | 4 |
| 10 | 35 | 35 | 20 | 2 |
| 6 | 25 | 25 | 20 | 5 |
| 4 | 20 | 25 | 15 | 4 |
| 3 | 20 | 25 | 15 | 5 |
| 5 | 20 | 25 | 10 | 5 |
| 2 | 15 | 20 | 15 | 5 |
| 3.5 | 15 | 20 | 10 | 5 |
| 4 | 20 | 25 | 15 | 5 |
| 3 | 20 | 25 | 10 | 5 |
| 7 | 25 | 20 | 15 | 5 |
| 8 | 30 | 35 | 10 | 2 |
| 6 | 25 | 30 | 10 | 4 |
| 4 | 20 | 25 | 10 | 5 |
| 2 | 15 | 20 | 10 | 5 |
| 5 | 15 | 15 | 10 | 5 |
| 4 | 20 | 20 | 10 | 5 |
| 6 | 25 | 25 | 15 | 4 |

| | | | | |
|---|---|---|---|---|
| 5 | 25 | 25 | 20 | 5 |
| 6 | 25 | 25 | 25 | 5 |
| 4 | 20 | 25 | 25 | 5 |
| 6 | 25 | 25 | 20 | 5 |
| 5 | 25 | 25 | 20 | 5 |
| 4 | 20 | 25 | 25 | 4 |
| 3 | 20 | 25 | 20 | 1 |
| 3.5 | 15 | 20 | 25 | 5 |
| 4.5 | 25 | 25 | 25 | 5 |
| 4 | 20 | 25 | 25 | 5 |
| 3 | 15 | 20 | 20 | 5 |
| 5 | 20 | 20 | 15 | 4 |
| 5 | 20 | 20 | 15 | 5 |
| 4 | 20 | 20 | 20 | 5 |
| 3 | 15 | 20 | 10 | 5 |
| 3 | 15 | 20 | 10 | 5 |
| 4 | 20 | 20 | 10 | 4 |
| 5 | 20 | 25 | 10 | 5 |
| 6 | 25 | 25 | 10 | 5 |
| 6 | 25 | 25 | 10 | 5 |
| 5 | 20 | 25 | 25 | 5 |
| 6 | 25 | 30 | 20 | 5 |
| 4.5 | 25 | 30 | 20 | 5 |
| 6 | 30 | 30 | 25 | 5 |
| 5 | 25 | 30 | 20 | 4 |
| 5 | 25 | 30 | 20 | 1 |
| 4 | 20 | 30 | 15 | 5 |
| 6 | 25 | 30 | 15 | 5 |
| 6.5 | 30 | 30 | 15 | 5 |
| 4 | 25 | 25 | 20 | 5 |
| 5 | 20 | 25 | 25 | 4 |
| 8 | 30 | 30 | 20 | 5 |
| 7 | 30 | 30 | 20 | 5 |
| 8 | 35 | 40 | 25 | 5 |
| 8 | 40 | 45 | 15 | 5 |
| 6 | 35 | 40 | 10 | 5 |
| 8 | 35 | 40 | 10 | 5 |
| 7 | 32 | 35 | 15 | 5 |
| 5 | 25 | 30 | 10 | 5 |
| 5 | 20 | 25 | 25 | 5 |

| | | | | |
|---|---|---|---|---|
| 4 | 20 | 25 | 20 | 5 |
| 4 | 15 | 20 | 25 | 5 |
| 4.5 | 25 | 25 | 25 | 5 |
| 5 | 20 | 25 | 25 | 5 |
| 4 | 15 | 20 | 20 | 4 |
| 4 | 20 | 20 | 15 | 5 |
| 5 | 20 | 20 | 15 | 5 |
| 4 | 20 | 20 | 25 | 1 |
| 4 | 15 | 20 | 10 | 5 |
| 5 | 25 | 20 | 10 | 5 |
| 6 | 20 | 20 | 15 | 5 |
| 7 | 35 | 25 | 10 | 5 |
| 7 | 45 | 25 | 10 | 5 |
| 7 | 25 | 25 | 25 | 5 |
| 6 | 20 | 25 | 25 | 4 |
| 6 | 25 | 30 | 20 | 5 |
| 4.5 | 30 | 35 | 15 | 5 |
| 6 | 30 | 45 | 25 | 5 |
| 5 | 35 | 30 | 20 | 4 |
| 4 | 25 | 40 | 20 | 5 |
| 5 | 35 | 30 | 20 | 5 |
| 6 | 25 | 30 | 15 | 5 |
| 6.5 | 30 | 45 | 25 | 5 |
| 5 | 35 | 25 | 20 | 5 |
| 5.5 | 30 | 40 | 20 | 5 |
| 10 | 55 | 60 | 25 | 5 |
| 5 | 25 | 25 | 20 | 0 |
| 4 | 20 | 25 | 25 | 5 |
| 4 | 20 | 25 | 20 | 5 |
| 3.5 | 15 | 20 | 25 | 5 |
| 9 | 50 | 45 | 20 | 5 |
| 4 | 20 | 25 | 25 | 1 |
| 5 | 15 | 25 | 20 | 5 |
| 5 | 35 | 20 | 20 | 5 |
| 5 | 20 | 20 | 15 | 4 |
| 4 | 35 | 25 | 20 | 5 |
| 5 | 15 | 20 | 10 | 5 |
| 5 | 15 | 20 | 20 | 5 |
| 4 | 20 | 20 | 10 | 5 |
| 5 | 30 | 35 | 10 | 5 |

| | | | | |
|---|---|---|---|---|
| 6 | 25 | 25 | 10 | 5 |
| 7 | 35 | 40 | 10 | 5 |
| 7 | 25 | 25 | 20 | 5 |
| 4 | 20 | 25 | 15 | 5 |
| 3 | 20 | 25 | 15 | 5 |
| 6 | 37 | 42 | 15 | 5 |
| 2 | 15 | 20 | 15 | 5 |
| 5 | 15 | 20 | 10 | 4 |
| 4 | 20 | 25 | 20 | 5 |
| 6 | 34 | 38 | 10 | 5 |
| 7 | 25 | 20 | 15 | 5 |
| 9 | 50 | 55 | 10 | 5 |
| 6 | 25 | 30 | 20 | 5 |
| 4 | 25 | 25 | 10 | 5 |
| 2 | 15 | 25 | 10 | 5 |
| 6 | 35 | 40 | 15 | 5 |
| 4 | 20 | 20 | 10 | 5 |
| 4.5 | 25 | 25 | 25 | 5 |
| 5 | 20 | 25 | 25 | 5 |
| 6 | 20 | 20 | 20 | 1 |
| 6 | 20 | 25 | 15 | 5 |
| 5 | 20 | 25 | 15 | 5 |
| 4 | 25 | 20 | 25 | 5 |
| 4 | 15 | 20 | 10 | 5 |
| 4 | 25 | 20 | 10 | 5 |
| 6 | 20 | 25 | 15 | 5 |
| 7 | 35 | 35 | 10 | 0 |
| 6 | 45 | 45 | 10 | 5 |
| 7 | 30 | 25 | 25 | 5 |
| 5 | 20 | 25 | 25 | 5 |
| 6 | 25 | 30 | 20 | 5 |
| 5 | 30 | 35 | 15 | 5 |
| 6 | 35 | 45 | 25 | 5 |
| 5 | 35 | 30 | 25 | 5 |
| 5 | 25 | 40 | 20 | 5 |
| 5 | 35 | 30 | 25 | 5 |
| 7 | 42 | 45 | 20 | 5 |
| 6.5 | 35 | 45 | 25 | 5 |
| 5 | 35 | 25 | 20 | 5 |
| 6 | 30 | 40 | 25 | 5 |

| | | | | |
|---|---|---|---|---|
| 8 | 60 | 60 | 25 | 5 |
| 6 | 25 | 25 | 25 | 5 |
| 4 | 20 | 25 | 25 | 5 |
| 6 | 20 | 25 | 20 | 5 |
| 3.5 | 15 | 20 | 25 | 5 |
| 9 | 50 | 50 | 20 | 5 |
| 4 | 20 | 25 | 25 | 5 |
| 6 | 35 | 35 | 15 | 5 |
| 4 | 20 | 20 | 25 | 5 |
| 4 | 15 | 20 | 10 | 1 |
| 5 | 25 | 20 | 10 | 5 |
| 6 | 20 | 20 | 15 | 5 |
| 7 | 35 | 25 | 10 | 5 |
| 7 | 45 | 25 | 10 | 0 |
| 7 | 25 | 25 | 25 | 5 |
| 5 | 30 | 35 | 10 | 5 |
| 6 | 25 | 25 | 10 | 5 |
| 7 | 35 | 40 | 10 | 5 |
| 7 | 25 | 25 | 20 | 5 |
| 4 | 20 | 25 | 15 | 5 |
| 3 | 20 | 25 | 15 | 5 |
| 6 | 37 | 42 | 15 | 5 |
| 4 | 15 | 20 | 25 | 5 |
| 4.5 | 25 | 25 | 25 | 5 |
| 5 | 20 | 25 | 25 | 5 |
| 4 | 15 | 20 | 20 | 5 |
| 4 | 20 | 20 | 15 | 5 |
| 5 | 20 | 20 | 15 | 3 |
| 4 | 20 | 20 | 25 | 5 |
| 4 | 15 | 20 | 10 | 5 |
| 5 | 25 | 20 | 10 | 2 |
| 6 | 20 | 20 | 15 | 5 |
| 8 | 25 | 25 | 25 | 2 |
| 10 | 35 | 35 | 20 | 5 |
| 6 | 25 | 25 | 20 | 5 |
| 4 | 20 | 25 | 15 | 5 |
| 3 | 20 | 25 | 15 | 2 |
| 5 | 20 | 25 | 10 | 5 |
| 2 | 15 | 20 | 15 | 5 |
| 3.5 | 15 | 20 | 10 | 5 |

| | | | | |
|---|---|---|---|---|
| 4 | 20 | 25 | 15 | 1 |
| 4 | 20 | 25 | 20 | 5 |
| 4 | 25 | 20 | 25 | 5 |
| 9 | 50 | 45 | 20 | 3 |
| 4 | 20 | 25 | 25 | 5 |
| 5 | 15 | 25 | 20 | 2 |
| 5 | 35 | 20 | 20 | 5 |
| 5 | 20 | 20 | 15 | 5 |
| 4 | 25 | 25 | 10 | 3 |
| 2 | 15 | 25 | 10 | 5 |
| 6 | 35 | 40 | 15 | 5 |
| 4 | 20 | 20 | 10 | 5 |
| 4.5 | 25 | 25 | 25 | 5 |
| 5 | 20 | 25 | 25 | 5 |
| 6 | 20 | 20 | 20 | 5 |
| 6 | 20 | 25 | 15 | 5 |
| 5 | 20 | 25 | 15 | 0 |
| 4 | 25 | 20 | 25 | 5 |
| 4 | 15 | 20 | 10 | 5 |
| 4 | 25 | 20 | 10 | 3 |
| 6 | 20 | 25 | 15 | 5 |
| 7 | 35 | 35 | 10 | 5 |
| 6 | 45 | 45 | 10 | 5 |
| 6 | 30 | 40 | 25 | 5 |
| 8 | 60 | 60 | 25 | 5 |
| 6 | 25 | 25 | 25 | 3 |
| 4 | 20 | 25 | 25 | 1 |
| 6 | 20 | 25 | 20 | 5 |
| 3.5 | 15 | 20 | 25 | 5 |
| 9 | 50 | 50 | 20 | 5 |
| 6 | 20 | 25 | 15 | 5 |
| 5 | 20 | 25 | 15 | 5 |
| 4 | 25 | 20 | 25 | 3 |
| 4 | 15 | 20 | 10 | 5 |
| 4 | 25 | 20 | 10 | 5 |
| 6 | 20 | 25 | 15 | 5 |
| 7 | 35 | 35 | 10 | 5 |
| 6 | 45 | 45 | 10 | 3 |
| 7 | 30 | 25 | 25 | 5 |
| 6 | 20 | 25 | 20 | 5 |

| | | | | |
|---|---|---|---|---|
| 6 | 25 | 30 | 20 | 5 |
| 5 | 30 | 35 | 15 | 5 |
| 7 | 45 | 25 | 10 | 5 |
| 7 | 25 | 25 | 25 | 5 |
| 5 | 30 | 35 | 10 | 2 |
| 6 | 25 | 25 | 15 | 5 |
| 7 | 35 | 40 | 10 | 5 |
| 7 | 25 | 25 | 20 | 5 |
| 4 | 20 | 25 | 15 | 3 |
| 3 | 20 | 25 | 10 | 5 |
| 6 | 35 | 40 | 15 | 5 |
| 4 | 15 | 20 | 25 | 5 |
| 5 | 25 | 25 | 25 | 5 |
| 4 | 20 | 25 | 10 | 5 |
| 3 | 20 | 25 | 15 | 2 |
| 6 | 37 | 42 | 15 | 2 |
| 3 | 15 | 20 | 10 | 5 |
| 5 | 15 | 20 | 10 | 5 |
| 4 | 20 | 25 | 20 | 5 |
| 7 | 35 | 35 | 10 | 5 |
| 7 | 25 | 20 | 15 | 5 |
| 9 | 60 | 55 | 15 | 5 |
| 6 | 25 | 30 | 20 | 5 |
| 4 | 25 | 25 | 10 | 3 |
| 3 | 15 | 25 | 15 | 5 |
| 7 | 35 | 40 | 15 | 5 |
| 4 | 20 | 20 | 10 | 5 |
| 5 | 25 | 30 | 25 | 5 |
| 5 | 20 | 25 | 25 | 5 |
| 6 | 20 | 20 | 20 | 5 |
| 6 | 25 | 25 | 15 | 0 |
| 8 | 35 | 35 | 10 | 5 |
| 6 | 45 | 45 | 10 | 3 |
| 7 | 45 | 40 | 20 | 5 |
| 6 | 20 | 25 | 25 | 5 |
| 6 | 25 | 30 | 20 | 5 |
| 5 | 30 | 35 | 15 | 5 |
| 6 | 40 | 45 | 25 | 5 |
| 5 | 35 | 30 | 20 | 5 |
| 5 | 40 | 40 | 10 | 3 |

| | | | | |
|---|---|---|---|---|
| 3 | 15 | 20 | 15 | 5 |
| 5 | 15 | 20 | 10 | 5 |
| 5 | 25 | 25 | 25 | 5 |
| 6 | 34 | 38 | 10 | 5 |
| 7 | 40 | 35 | 15 | 5 |

**Annex D**

**Dear Sir/Madam**

I, the researcher, am student in Mek'ele University, currently doing my M.Sc. in Civil Engineering under Road and Transport Engineering at Mek'ele University. I am doing my M.Sc. research/thesis entitled: "**EVALUATION OF SUSTAINABLE URBAN MOBILITY IN THE CITY OF MEK'ELE**" with the aim of quantifying the sustainability urban mobility in Mek'ele city.

Your genuine, honest and prompt response to the questionnaire will have contribution to the Success of the research. Your **response will be kept confidential**, and anonymity will be maintained. Moreover, the information you provide will be **used strictly for academic and governmental purpose**.

Filling the questionnaire will not take more than **15 minutes**. I thank you in advance for the time you devote, effort you make, and consideration you give in filling this questionnaire.

If you have any question concerning the items of the questionnaire, please call on mobile: 0960705931, or e-mail solomonyoseph31@gmail.com

With Great Respect

Yoseph Solomon

## BASIC DEMOGRAPHIC INFORMATION

1. What is your gender? *This question is optional.

- (•) Male
- ( ) Female

2. What is your age?

- ( ) under 15
- ( ) 15-17
- ( ) 18-24
- ( ) 25-34
- ( ) 35-44
- ( ) 45-54
- ( ) 55-64
- ( ) 65-74
- ( ) 75 and over

3. What is the highest level of education you have completed?

- ( ) Did not attend school
- ( ) Technical or vocational college
- ( ) Secondary School
- ( ) High School
- (•) Degree or higher

4. Which of the following categories best describes your employment status?

- (•) Employed
- ( ) Unemployed
- ( ) Student
- ( ) Retired
- ( ) Other

## PHYSICAL MOBILITY

5. Do you suffer from personal physical mobility problems?

- ( ) Heavy
- ( ) Medium
- ( ) Light
- (•) None

## VISUAL IMPAIRMENT

6. Do you suffer from visual impairment?

- ( ) Blindness
- ( ) Severe
- ( ) Moderate
- (•) Mild or None

## COMMUTING

What is your principle mode of transport for your commute? *This question is required.

7. Could you please give us the following details about your main commute that you described above? *This question is required.

Average travel distance (one way) in km [ ]

8. Could you please give us the following details about your commute? *This question is required.

Average travel time to work in minutes [ ]

Average travel time to return home in minutes [ ]

9. Could you please give us the following detail about your main commute that you described above? *This question is required.

How much extra time do you allow for the journey if you have to be certain of being at work/home for an important appointment: [ ]

10. Do you feel restricted in terms of job market access because the mobility network is not connecting the place where you live with the jobs you would like to apply for? *This question is required.

- (•) Yes
- ( ) No
- ( ) Not Applicable

11. Were you restricted in the education choice for your children (primary/high school, university, apprenticeship, etc.) because of the duration of the commute to the university, school, etc.? *This question is required.

- ( ) Yes
- ( ) No
- (•) Not Applicable

## PUBLIC TRANSPORT

We are interested to understand what people see as the most important aspect of public transport - what it is that encourages you to use it or inhibits you from using it.

12. How often do you use public transport? *This question is required.

| (Almost) never | A few times a year | A few times a month | A few times a week | Daily |
|---|---|---|---|---|
| ○ (Almost) never | ○ A few times a year | ○ A few times a month | ◉ A few times week | ○ Daily |

13. Please rank the three most important aspects of using public transport starting with the item which is most important to you. *This question is required.

- ☑ Cleanliness
- ☑ Availability of seats
- ☑ Comfort (seats, noise, temperature)
- ☐ Fare
- ☐ Real time information (routes, timetable and delays)
- ☐ Easy ticketing
- ☐ Luggage/buggy space available
- ☐ Punctuality
- ☐ Comfort of stops whilst waiting (seats, lighting, shelter)
- ☐ Accessibility of the public transport vehicles, stops and stations
- ☐ Safe vehicles
- ☐ Security in public transport

When on public transport how much do you...

14. Enjoy riding the bus *this question is required.

Dislike very much Dislike Neutral Like Like very much

○ Dislike very much ○ Dislike ○ Neutral ○ Like ○ Like very much

How satisfied are you with the following aspects of public transport?

16. Cleanliness *this question is required.

Very Dissatisfied Dissatisfied Neutral Satisfied Very Satisfied

○ Very Dissatisfied ○ Dissatisfied ○ Neutral ○ Satisfied ○ Very Satisfied

17. Availability of seats *this question is required.

Very Dissatisfied Dissatisfied Neutral Satisfied Very Satisfied

○ Very Dissatisfied ○ Dissatisfied ○ Neutral ○ Satisfied ○ Very Satisfied

.

18. Comfort (seats, noise, temperature) *this question is required.

Very Dissatisfied Dissatisfied Neutral Satisfied Very Satisfied

○ Very Dissatisfied ○ Dissatisfied ○ Neutral ○ Satisfied ○ Very Satisfied

19. Fare *this question is required.

Very Dissatisfied Dissatisfied Neutral Satisfied Very Satisfied

○ Very Dissatisfied ○ Dissatisfied ○ Neutral ○ Satisfied ○ Very Satisfied

20. Real time information (routes, timetable and delays) *this question is required.

Very Dissatisfied Dissatisfied Neutral Satisfied Very Satisfied

○ Very Dissatisfied ○ Dissatisfied ○ Neutral ○ Satisfied ○ Very Satisfied

21. Luggage/buggy space available *this question is required.

Very Dissatisfied Dissatisfied Neutral Satisfied Very Satisfied

○ Very Dissatisfied ○ Dissatisfied ○ Neutral ○ Satisfied ○ Very Satisfied

22. Punctuality *this question is required.

Very Dissatisfied Dissatisfied Neutral Satisfied Very Satisfied

○ Very Dissatisfied ○ Dissatisfied ○ Neutral ○ Satisfied ○ Very Satisfied

23. Comfort of stops whilst waiting (seats, lighting, shelter) *this question is required.

Very Dissatisfied Dissatisfied Neutral Satisfied Very Satisfied

○ Very Dissatisfied ○ Dissatisfied ○ Neutral ○ Satisfied ○ Very Satisfied

24. Accessibility of the public transport vehicles, stops and stations *this question is required.

Very Dissatisfied Dissatisfied Neutral Satisfied Very Satisfied

○ Very Dissatisfied ○ Dissatisfied ○ Neutral ○ Satisfied ○ Very Satisfied

25. Safe vehicles *this question is required.

Very Dissatisfied Dissatisfied Neutral Satisfied Very Satisfied

○ Very Dissatisfied ○ Dissatisfied ○ Neutral ○ Satisfied ○ Very Satisfied

26. Feeling secure using public transport *this question is required.

Very Dissatisfied Dissatisfied Neutral Satisfied Very Satisfied

○ Very Dissatisfied ○ Dissatisfied ○ Neutral ○ Satisfied ◉ Very Satisfied

How do you feel about potential physical attacks in the following situations?

27. Waiting for public transport at the stop or at the station during daytime *this question is required.

Very unsafe Unsafe Neutral Safe Very safe

○ Very unsafe ○ Unsafe ○ Neutral ○ Safe ○ Very safe

28. Waiting for public transport at the stop or at the station during nighttime *this question is required.

Very unsafe Unsafe Neutral Safe Very safe

○ Very unsafe ○ Unsafe ○ Neutral ○ Safe ○ Very safe

29. Being on board public transport during daytime *this question is required.

Very unsafe Unsafe Neutral Safe Very safe

○ Very unsafe ○ Unsafe ○ Neutral ○ Safe ○ Very safe

30. Being on board public transport during nighttime *this question is required.

Very unsafe Unsafe Neutral Safe Very safe

Very unsafe Unsafe Neutral Safe Very safe

○ Very unsafe ○ Unsafe ○ Neutral ○ Safe ○ Very safe

## WALKING

31. How often do you walk in the city? ***This question is required.

(Almost) never A few times a year A few times a month A few times a week Daily

○ ○ ○ ◉ ○

32. Please rank the three most important aspects of walking in the city starting with the item which is most important to you ***this question is required.

- ☑ Availability of sidewalks in the city
- ☐ Availability of car free streets in the city
- ☑ Width of sidewalks in the city
- ☐ Quality of the pavement of the sidewalks in the city
- ☐ Signposting of directions and destinations for walking
- ☐ Lighting of sidewalks and urban streets at night
- ☑ Personal security

33. How much do you enjoy walking in the city? *This question is required.

Dislike very much Dislike Neutral Like Like very much

○ Dislike very much ○ Dislike ○ Neutral ○ Like ○ Like very much

How satisfied are you with the following aspects of walking in the city:

34. Availability of sidewalks *this question is required.

Very Dissatisfied Dissatisfied Neutral Satisfied Very Satisfied

○ Very Dissatisfied ○ Dissatisfied ○ Neutral ○ Satisfied ○ Very Satisfied

35. Availability of car free streets *this question is required.

Very Dissatisfied Dissatisfied Neutral Satisfied Very Satisfied

Very Dissatisfied Dissatisfied Neutral Satisfied Very Satisfied

36. Width of sidewalks *this question is required.

Very Dissatisfied Dissatisfied Neutral Satisfied Very Satisfied

Very Dissatisfied Dissatisfied Neutral Satisfied Very Satisfied

37. Quality of the pavement of the sidewalks *this question is required.

Very Dissatisfied Dissatisfied Neutral Satisfied Very Satisfied

Very Dissatisfied Dissatisfied Neutral Satisfied Very Satisfied

38. Signposting of directions and destinations for walking *this question is required.

Very Dissatisfied Dissatisfied Neutral Satisfied Very Satisfied

Very Dissatisfied Dissatisfied Neutral Satisfied Very Satisfied

39. Lighting of sidewalks and urban streets at night *this question is required.

Very Dissatisfied Dissatisfied Neutral Satisfied Very Satisfied

Very Dissatisfied Dissatisfied Neutral Satisfied Very Satisfied

40. Personal security *this question is required.

Very Dissatisfied Dissatisfied Neutral Satisfied Very Satisfied

Very Dissatisfied Dissatisfied Neutral Satisfied Very Satisfied

How do you feel about potential physical attacks in city streets when doing the following?

41. Walking during daytime

*this question is required.

Very unsafe Unsafe Neutral Safe Very safe

Very unsafe Unsafe Neutral Safe Very safe

42. Walking at night

*this question is required.

Very unsafe Unsafe Neutral Safe Very safe

○ Very unsafe ○ Unsafe ○ Neutral ○ Safe ○ Very safe

## NOISE

At the place where you live do you feel personally disturbed by noise from transport during the day?

43. Road traffic

Very much Much Medium Not much Not at all

◉ Very much ○ Much ○ Medium ○ Not much ○ Not at all