ETHIOPIAN INSTITUTE OF ARCHITECTURE, BUILDING CONSTRUCTION AND CITY DEVELOPMENT

Identifying Streets from roads of Addis Ababa

Using Space Syntax Analysis Tool

by

Feven Mulushewa Wondimu

A Thesis submitted to graduate studies of Addis Ababa University presented in partial fulfillment of the requirement for the degree of Master of Science in Urban design and development.

Addis Ababa University

Addis Ababa, Ethiopia

October, 2020

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School of Graduate Studies

This is certifying that the thesis prepared by Feven Mulushewa, entitled *Identifying Streets from roads of Addis Ababa Using Space Syntax Analysis Tool* and submitted to graduate studies of Addis Ababa University in partial fulfillment of the requirement for the degree of Master of Science in Urban Design and Development Compiles with the regulation of the University and meets the accepted standards for originality and quality.

Signed by the Examining Committee:

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Graduate program director: Signature……Date **……**

Declaration

I, the undersigned, declare that this thesis prepared for the partial fulfillment of the requirements for the degree of Master of Science in urban design and development entitled **"Identifying Streets from roads of Addis Ababa Using Space Syntax Analysis Tool"** is my original work and has not been presented for a degree in any other university and that all sources of material used for the thesis have been duly acknowledged.

Feven Mulushewa

Signature: _____

October, 2020

Confirmation

This thesis can be submitted for examination with my approval as a university advisor.

_____

Tibebu Assefa(Assistance professor)

October, 2020

Abstract

Space Syntax analysis is a tool for analyzing the road system of the city and broadly used for modeling vehicular and pedestrian movements, to control traffic pollution and on the processes of route selection. The existing road system of Addis Ababa face different urban problems and it's difficult to have standardized streets so, this study explores how to identify important urban roads that have potential to be converted into the street using space syntax analysis tool based on greater consideration of the needs of people, rather than vehicles since street differs from roads. The study uses Addis Ababa's current and proposed road network for the production of axial line and analysis integration and mean depth at the sub-city level to identify major important roads of Addis Ababa and highly segregated roads, respectively. Integrated streets in a system are assumed to be accessible from all other streets and the value range (0-1) lowest value (0.1 -0.5), mid-value (0.5-0.9), and the highest value (0.9 -1.0). The depth is the smallest number of syntactic steps to reach one space from another so, the deepest street means a highly segregated street. According to this assumption core area of the city which has a highly integrated value (>0.9) covers only 4% of Addis Ababa city, and it laid some parts of Kirkos, Lideta, Arada, and Adiss Ketema sub-cities. Also, 28% covered in integration (0.5-0.9), while the peripheral areas (intermediate and the suburbs) are not integrated. The most segregated area of the city is found around the riversides of the city and it needs urgent intervention. Kirkos sub-city has both highly integrated roads and highly segregated areas.

Key Words: street, space syntax, axial line, integration, mean depth,

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Finally, to all the people who participated in the research process, as their involvement has contributed to the success of this project, and for that I am grateful.

Contents

page

List of Figure Page

List of Table Page

AACPPO	Addis Ababa City Planning Project Office
AARTB	Addis Ababa Road and Transportation bureau
AACRA	Addis Ababa City Road Authority
ADB	Asian Development Bank
CBD	Central Business Center
CES	Consumer Electronics Show
CSA	Central Statistical Agent
ERA	Ethiopian Roads Authority
FDRE	Federal Democratic Republic of Ethiopia
MUDs	Multi User Dungeons
MoFED	Ministry of Finance and Economic Development
OFID	OPEC Fund for International Development
RIBA	Royal institute of British Architects
RSDPs	Road Sector Development Programs
RSDP	Road Sector Development Program

SDSS	spatial decision support systems
SS	Space syntax
UCL	University College London
UK	United Kingdom
UNESCO	United Nations Educational, Scientific and Cultural Organization
USD	US Dollar

List of Acronyms

CHAPTER ONE

INTRODUCTION

1.1. Background

In urban development designing quality street has a great role and its different from road design. Streets connect people for interaction, while roads connect towns and cities for travel (Matt, 2012). The difference is a matter of place and purpose (Moughtin, 2003). Every road can't be a street so there are lists of criteria to choose potential roads that can be converted to the street. The main criteria are scientific analysis of roads.

The city government of Addis Ababa has envisioned "to make the city competitive, livable and model for good urban governance" (Addis Ababa urban design guideline Volume I, 2015). In line with this, a new structure plan is being developed for the city having a mission "to provide a safe & livable environment becoming Ethiopia's hub to ensure the vision of a middle-income country, Africa's diplomatic capital & internationally competitive city by 2023" (A.A city structural pan summary report,2017-2027). To achieve this mission, having a good street design is the main criterion but Addis Ababa has not adequate standardized streets. Also planning authorities are focused on increasing the capacity and building new transport networks, and little attention is given to the structure of the network and miss the scientific analysis of roads.

As a research technique, Space Syntax analysis is a tool for analyzing the road system of the city. This tool is capable for measuring numerous characteristics of road structure. It has a great role

for predicting the effect of the road system on the socio-economic pattern and broadly used for modeling vehicular and pedestrian movements (Hillier et al, 1993), how to control traffic pollution (Penn and Croxford, 1997), the processes of route selection (Peponis et al, 1990) and analysis of anti-social activity (Nubani and Wineman, 2005).

So, this research aims to identify potential roads of Addis Ababa that can be easily changed to the street using space syntax analysis and only using an axial map of city road systems.

1.2 Problem Statement

The existing road system of Addis Ababa face different urban problems like traffic congestion, environmental degradation, safety issue and become unattractive for visitors and inhabitants because of lack of good street design. It is difficult to achieve different socio-economic benefit without having a good street condition. So the urban roads in Addis Ababa should be changed in to street by applying scientifically. But no study has been done in Addis Ababa to identify potential roads that could be changed to the street and fulfill the status of the street.

AACRA has a set of selection criteria when prioritizing between projects for new road constructions and for upgrading existing roads based on their contribution to facilitating connectivity and productivity which means manly consider transportation issues. In another way, Addis Ababa non-motorized transportation strategy 2011-2020 the city locates manly four areas to develop as the vision of the next 10 years such are Piassa, Megenagna, Merkato, and Churchel godana but selection criteria are not supported by the scientific method and also it needs further study to select a specific location where pedestrian road located in the selected area. So this

study strives to address how to select a potential road that can be a street in Addis Ababa city and to select roads that need urgent development due to connectivity issues finally design one selected road as a street to be an example for other street designs in different sub-cities and cities.

1.3 Objective

General objective:

To identify important urban roads that have potential to be converted in to street using space syntax analysis tool.

Specific objectives:

1. To identify and map integration level of Addis Ababa roads.
2. To determine the depth of Addis Ababa roads.

1.4 Research question

1. How to identify integration level of Addis Ababa roads?
2. Where are found deepest roads of Addis Ababa?

1.5 Significance

The study attempted to address the challenge of finding or choosing potential roads to change it to a good street or public space. It has shown the integration level of Addis Ababa and the segregated area of the city. This helps the city administration to improve the dis-connectivity for the ease of mobility of peoples and goods. It also helps to identify the priority for the allocation of potential roads to be changed to the street and the citizen also would be beneficial from the important street. It becomes a springboard for further developments of the street in the city. It

also gives a clue for academicians to conduct a further study for other cities by clearly showing the difference between random developments of street vs systematic focused development of the street.

1.6 Scope

This study was done in Addis Ababa's current jurisdictional boundary (2012E.C.) and focused on the existing street at all levels (from alleys in the residential area to the higher level as boulevards of Addis Ababa) it used axial line only and planned roads are included. The study focused only special parameters of space syntax analysis.

1.7 Limitation

In this research, many constraints were faced from data acquiring to analyze, from these the following is mentioned. To do an axial map of the city first clear line map of the city is very essential but it was very difficult to get a clear line map of the city so the first challenge was creating a clear line map of the total road system of the city in GIS, it takes more time. The second challenge was that searching software for the production of an axial map. However, this Depthmapx software is good enough, it needs also a high-quality supercomputer. So it was challenging to produce an axial map of the total road system of the city at a time. To overs me this bottleneck analyzing each sub-city section by section makes it cumbersome. The other challenge was that after doing an axial map of all sub city's there was a detailed space syntax analysis that helps to know more detail about selected road such analysis like pedestrian count, movement trace, etc... which were complicated by COVED 19 pandemic. Despite all these challenges, the study was done diligently using only the axial map analysis.

1.8 Work Flow

The whole workflow of this study has been shown in figure 1.1 below.

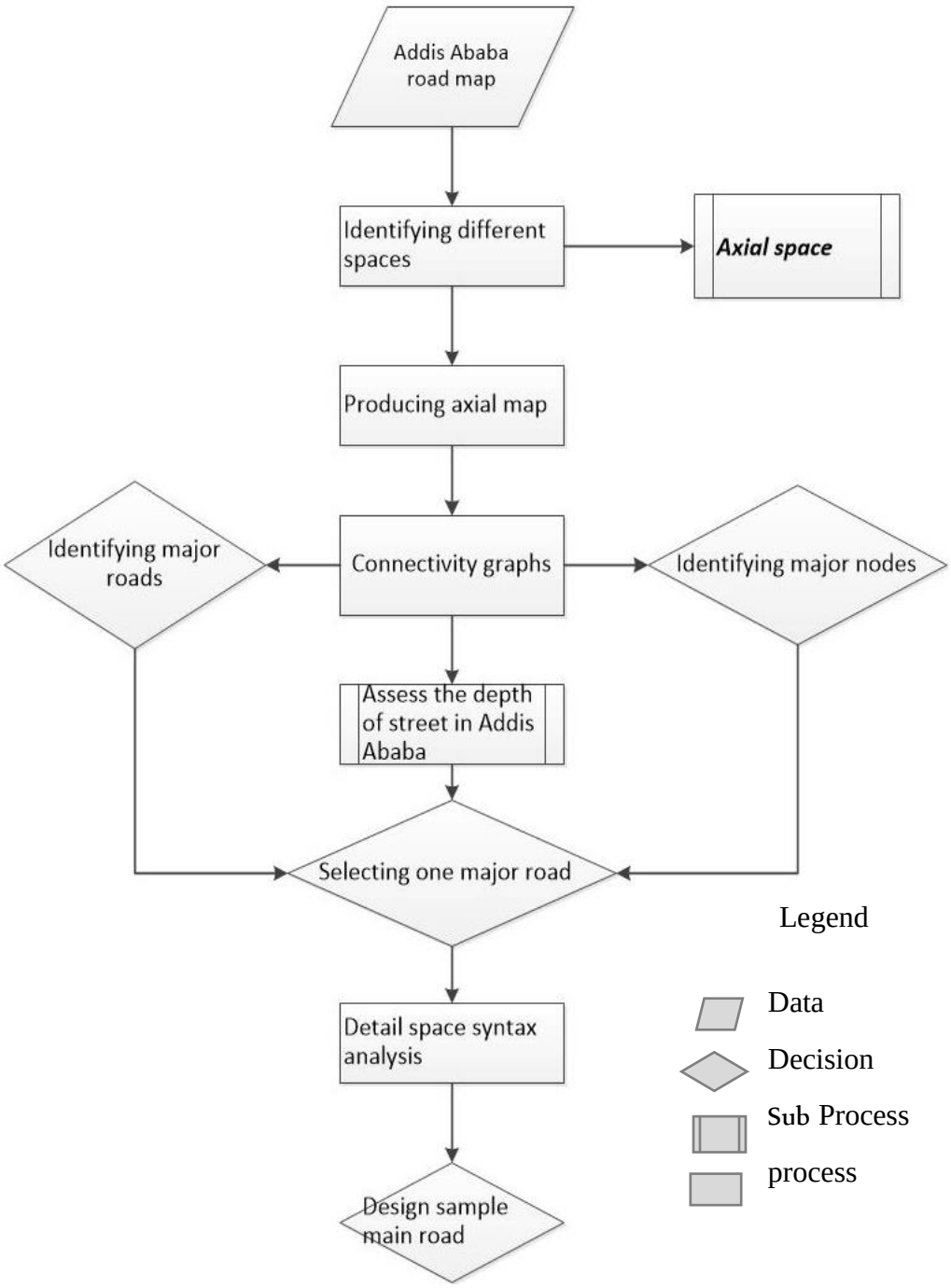

Figure 1.1 Work Flow

CHAPTER TWO

LITERATURE REVIEW

Under this chapter, review of literature on the street, space syntax analysis, application of space syntax analysis in other countries, use of space syntax analysis, and current Addis Ababa road situation is presented. These theories and empirical findings are important to conceptualize the study and are used as supportive ideas in line with the discussion of the findings in this study.

2.1 Theoretical review

2.1.1 Street definition in different professions

Street design mainly converged from two different directions. First, according to transport planner or engineer, struggling to inspire the use of more sustainable transport modes (Moughtin, 2003). The second view is the point of urban designer, conceive ensembles of buildings, sequences of spaces, and their associated functions, one of which is the specialist concern of movement – which becomes a transport 'complicating factor' that gets in the way of designing a good place (Marshall, 2004). Streets connect people for interaction, while roads connect towns and cities for travel (Matt , 2012)

In general, different considerations of street functions affect the kinds of design solution suitable in different contexts(disciplines). The two broad types of street functions are 'Link' and 'Place' according to creating a special road classification (Jones et al, 2008). These types of classification are summarized in Table 2.1.

Table 2.1 Street concept in different disciplines.

	Link	Place
Planning	Transport planner	Urban planner
design	Traffic engineer	Urban designer

(source: Jones et al, 2008)

From the above table explanation, urban design is mainly focused on designing space for peoples. The way how people feel about a place is affected by the quality of the streets, where they live, shop, work, relax, and entertained. An urban design association working party was established to review how streets can be "designed for people". Work began with a survey of local authorities, followed by evidence provided by those involved in this field, both practitioners and academics (Alliance, 2000).

A place for people is a place where people want to be the focus for communities where people feel safe and comfortable in attractive and functional surroundings. It is people-orientated and not traffic dominated. The street fulfills a range of community needs these include social and economic activities and human interaction, areas of peacefulness and tranquility, liveliness and energy, and links between communities and businesses. The street is an important feature of the public realm and is a quality attraction in its own right (Jiang & Jia, 2011).

A new approach to street design, that meets the demands of today and the challenges of tomorrow. According to the concept of quality street, streets are public spaces for people as well as routes for traffic and transportation, this guide focuses on the role of the street as a catalyst for

urban transformation. It cements the tactics and techniques being pioneered by the nation's foremost urban engineers and designers (Moughtin, 2007).

Urban design is the process of making better places for people than would otherwise be produced. This definition asserts mainly the importance of four themes. First, it stresses that urban design is for and about people. Second, it emphasizes the value and significance of 'place'. Third, it recognizes that urban design works in the 'real' world because it influences business activity and political (regulatory) forces. Fourth, it states the importance of design as a process. The idea that urban design is about making better places is unashamedly and unapologetically a normative contention about what it should be, rather than what it is at any point in time (Carmona et al, 2012).

An urban transportation system is too complex to be investigated. On the other hand, the state-of-the-art computers are powerful enough to create a mirror world to carry out simulations, by using different what-if scenarios and testing their feasibility. This simulation technology is commonly known as agent-based modeling or simulation. So geospatial analysis should be used to extract morphological rules from traditional settlements, and the rules can be used to redevelop modern cities to generate suitable cities. One such agent-based modeling or simulation technique is that space syntax analysis (Jiang et al, 2010).

2.1.2 Space syntax analysis

1. The theoretical background of space syntax(SS)

SS theory was developed from the 1970s onwards by a group led by Bill Hillier at UCL in London, England. The theory states that the spatial pattern is a descriptive variable for certain dynamics contained in the relationship between built structures and society. SS is mainly focused on analyzing the spatial configuration of the city and its influence on how the city is working (Medeiros, 2006). SS theory targets to study the social consequences of architectural space in a few words, it aims to launch a relationship between the buildings and spatial structure of cities, broader social variables, and the spatial dimension of social structures.

In general, "the spatial structure of cities" is assumed as an "urban configuration". It includes the totality of relationships between the spatial patterns of barriers and permeability that establish the physical structure of space. This means the city road system provides circulation for pedestrians and/or vehicles to perform their activities. Also, Space syntax analysis explains the configuration of urban structure and describes its role in social activities and human behaviors (Holanda, 2002).

However, what is not yet sufficiently studied is whether the street configuration has a meaningful impact on preferences of residential locations and choices of travel mode (Berhie and Haq, 2017). It starts with a certain explanation of the spatial architecture of buildings and cities. In Space Syntax, spaces are assumed as voids (rooms, squares, streets, parks, etc.). The same description might also apply on an urban scale. (Al-Sayed, 2014).

2. Terminologies in space syntax analysis

In Space Syntax analysis, few key terms need to be clarified. These are axial lines, spatial accessibility, and spatial choice.

(a) Axial line

Spaces are represented by straight lines called ‘axial lines’ drawn between two points (figure 2.1).

(a) (b) (c)

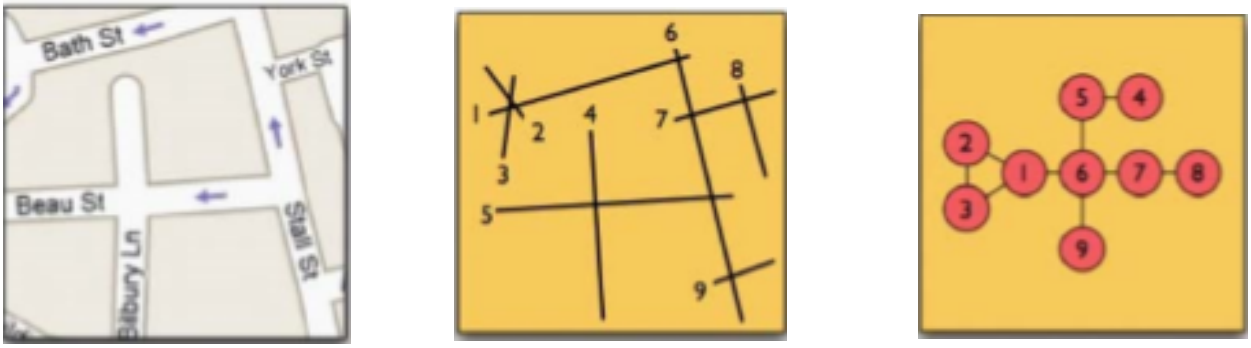

Figure 2.1 (a) map of the city (b) Axial map (C) graph representation. (source: (Berhie 2017).

These lines are based on how far an observer can have an uninterrupted impression of visibility or permeability along the street (Hillier & Hanson, 1984; John et al, 1989). The axial map is the representation of urban space as a matrix of the `longest and fewest’ lines in the system (Hillier, 1999) and is the basis of layout analysis. Each axial line represents a unit of real-world space which is usually a street or part of it. Axial lines are used in space syntax to understand connections between spaces that make up an urban morphology. Accessibility of space or street

is explained by its relative distance to all other spaces. And its spatial relationships are measured through the concepts of ‘integration’ and ‘choice’ of each street (Berhie and Haq, 2017).

(b)Axial Maps

An axial map records the least set of longest and straightest lines of sight and access social coverage of public spaces of the city also link connectivity of the road system(Ahmed et al, 2014). A street map is mainly different from the axial map. Axial map interprets the role of sight, and the expression may link two roads along the same axis into one and break one curvilinear road into several connected lines. In a space syntax method, the properties of street grid configuration are analyzed by a series of measures using axial maps (Ahmed et al, 2014).

(c) Graph

Graph representation is the representation of street intersections as nodes and streets as edges. SS uses the opposite: streets become nodes, and intersections become links. Each street represented as a single node in the graph, irrespective of its location, width, and length. This representation is extremely helpful to identify concrete metrics for each street in a city. This is achieved by carrying out an analysis of the graph and deriving numerous metrics for each node (i.e. street).

(d)Metrics

A city graph can be analyzed in terms of its properties such as the integration of nodes. In SS, the deepness or shallowness of a node to the other nodes in the graph, represent integration. So to have a highly integrated street, there must be fewer changes of direction (change of direction means changing streets). Also, less integrated streets are relatively segregated from other streets

and need more changes of directions to get to them. Typical examples of highly integrated streets are high streets, while cul-de-sacs and alleyways are usually less integrated.

The metric of integration is similar to the traditional graph metrics but it has developed its terminology when referring to them. and, SS researchers have developed new metrics. Table 2.2 shows the most popular metrics used by SS, their conventional name (if one exists), and their definition and description (Jiang et al, 2010).

Table 2.2 Basic space syntax metrics

Space syntax	Graph theory	Description/Definition
Integration	Closeness	The mean distance between an axis and all other axes of the system
Connectivity	Degree	The connectivity of axis i is the number of axes that it intersects.
Choice	Betweenness	The number of times axis i is used when calculating the shortest paths between all pairs of axes in a system.
Control		The degree to which axis I control "access" from and to the axis it intersects.
Global metric		A metric for an individual axis, calculated using the whole metric system.
Local metric		A metric for an individual axis, calculated using the axis' neighborhood (e.g. axes up to three intersections away).

Intelligibility The correlation between axes' connectivity and global integration

(Source: Jiang et al, 2010).

Integration: The most important measure, which is the relative depth or shallowness of any spatial system seen from any particular point within it (Ahmed et al, 2014). Spaces with lower average depth to all other spaces in a street network are said to be 'integrated', and those spaces with higher average depth are 'segregated'. Integrated streets in a system are assumed to be accessible from all other streets. Therefore, they are considered more attractive destinations of movement than segregated ones simply as a result of their configurational position in the network. Thus, integration is said to be a measure of 'to movement' (Hillier et al, 1993). In other words, integrated areas would be a good candidate for the destination of journeys.

Choice: Choice measures the state of betweenness (Varoudis et al, 2013; Narayanan, 2005) it's a measure of 'through movement' (passing by movement) since it is about the spaces between the origin and destination. The higher choice value of a street segment means more movement would be passing through that segment of the street. In other words, there would be busier traffic or pedestrians. Integration and choice measures are calculated on two concepts of distances; topological and angular. The topological parameter depends on the total number of turns between point A and Point B. Angular parameter is calculated based on the total sum of angular turns between origin and destination points (Berhie and Haq, 2017).

Connectivity: is a metric used to describe the number of streets that any particular street intersects. It is the number of axial lines that intersect with or connect to, each line in the system. It is a local static measure. Also, the amount of choice of space is represented by the measure of

local control, also it represents its immediate neighbors as somewhere to go. Thus it gives rise to a local dynamic measure. High values of control indicate a better connection of space in comparison with its neighbors (Ahmed et al, 2014).

2.1.3 space syntax analyzing methods and procedure

Space Syntax Observations are a set of techniques to observe movement flows and patterns of space usage in complex buildings or urban contexts. These techniques are developed specifically for Space Syntax Research.

A Gate counts

Gate counts allow researchers to collect a great deal of data that can be represented graphically and statistically. The method must be applied with rigors and consistency at many locations.

To conduct observations, usually choose several locations that cover an area under study. then choose a reasonable number of 'gate' positions. Each gate can be observed for 5 or 2.5 minutes – depending on how quite a gate is- over regular intervals (i. e. four or five times) during working days and weekends. Observers are to stand at the edge of each gate to maximize their visual field and count people crossing an imaginary line that ideally connects two parts of the built environment e.g. columns, walls (figure 2.2). They may use a stopwatch to perform the counting precisely. Information can be recorded on special tables, where numbers of pedestrians passing by might be logged in addition to special notes on the time, date, weather conditions, and other special factors that might affect the course of observations (figure 2.3).

On the gate count tables, it helps to note categories as accurately as possible. Categories can be delimited by age, profession, status such as students, visitors, tourists, locals, etc. Researchers may aggregate the categories later to inform their investigation (figure 2.4). The counts of movement are usually helpful in understanding the relationship between spatial structure and human behavior (see figure 2.5).

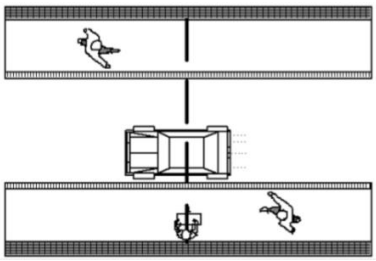

Figure 2.2 Position of observer in relation to the observed gate. (Source: Screens in the Wild @UCL).

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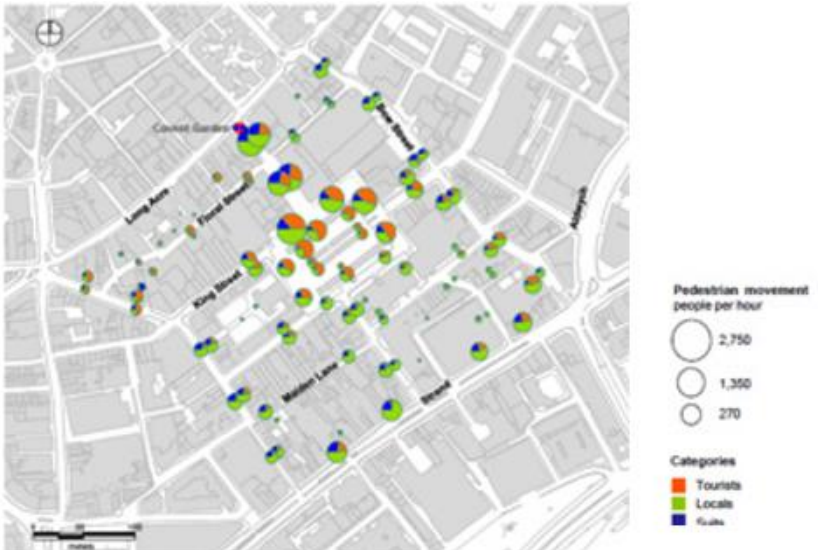
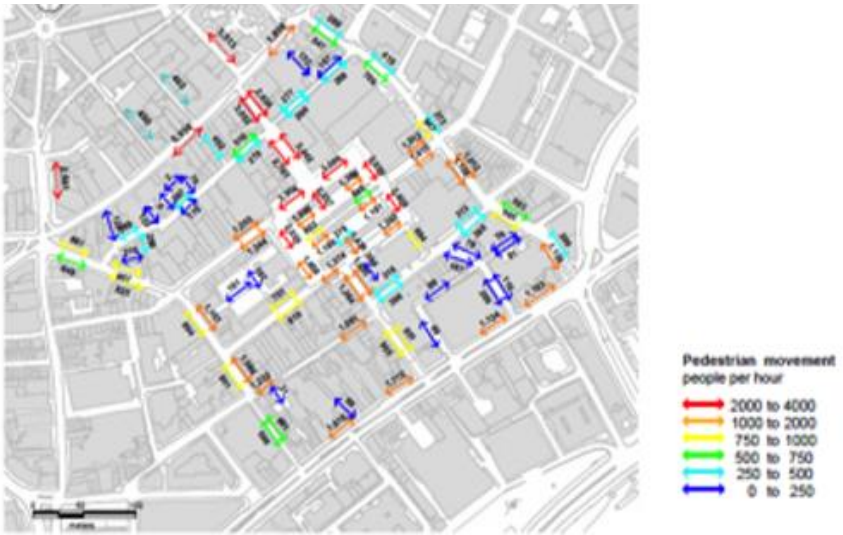


Figure 2.3 A sample of the gate counts table. Source: (Screens in the Wild @UCL).



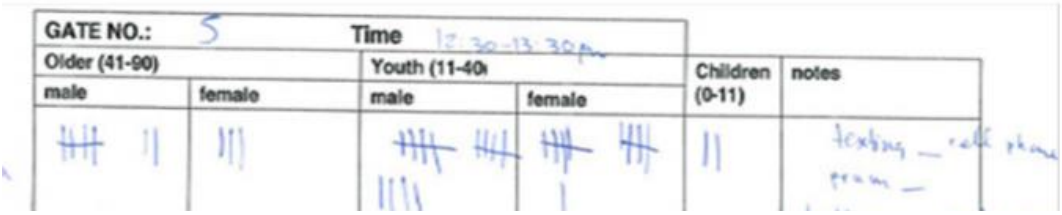


Figure 2.4 A map showing the average number of pedestrians per hour with categories (Source: Screens in the Wild @UCL).

Figure 2.5 A map showing the average number of pedestrians per hour with count movement. (Source: Space Syntax Ltd. 2007).

B, Static snapshots

Static snapshots are conducted to record the use pattern of spaces within buildings or public spaces in an urban context. The method is useful for comparing static activities (standing, sitting) and movement. By tracking and mapping, these activities in time can do outline the patterns of space use in an area and spot the locations where more potential interaction takes place naturally. To conduct snapshots, first, predefine areas that can be easily observed and positions at which an observer could maximize visual exposure to the observed field of study and at the same time minimize his/her visibility to the users. Use a floor plan to note categories and activities (sitting,

standing, moving, interacting) for five minutes over regular intervals during the day. (Al-Sayed, 2014).

C, Movement traces

Movement traces enables tracking and mapping the sum of movement change within a selected area. It helps in understanding movement patterns and where people are likely to enter/exit the area. Observers might also be able to outline islands where no movement traffic is recorded. Similar to snapshots, target areas are normally chosen to have a convex layout that is easy to observe. The observers position themselves in locations that maximize their vision of the layout and record movement for 5 minutes at several time intervals throughout the day. They are encouraged to use colored pens to mark different categories on the layout. Observations are mainly focused on-site to empirically track and map human behavior. They are usually conducted to test the spatial models. (Al-Sayed, 2014).

D, Traces (People-Following)

Three distinct issues can be investigated through the use of this technique: 1) patterns of movement from a specific location; 2) the relationship of one route to other routes; 3) average distance people walk from one location. To trace, first, use the plan of the whole area of interest. In urban contexts, it will be useful to arrange the plan so that the pick-up point is at the center of the plan. The tracing might be stopped either when people leave the area of interest, reach a pre-defined destination, or after a fixed time (e.g. ten minutes). It is important to be discreet in this process – people should not become aware that someone is following them. It is always good to

account for a mix of people (age, gender, other categories of interest) and note details for each trace.

2.1.4 Observation tools

The tool for observing pedestrian interaction in space syntax analysis is manual counting, using Bluetooth devices, People Watcher, and PedCount software (Al-Sayed, 2014).

2.1.5 Software for space syntax analysis

For space syntax analysis, the software has been developed software called depthmapX.

The original concept behind Depthmap X developed from two strands of thought. One was isovist analysis (Benedikt, 1979), and the other space syntax (Hillier and Hanson, 1984) using the axial lines Hillier and Hanson created a graph, that is represented as nodes, and it's considered it intersected when each line was connected to others. From this graph, they calculated how well ‘integrated’ each line was for all the others in the graph and calculated a measure of the average number of steps it takes to get from one line to any other within the axial map (Turner, 2004).

DepthmapX start working by withdrawing all the line through the open space of a plan, which is called an ‘all-line map’, it's drawn in three different way: first by connecting two convex corners, secondly connect one convex and one reflex corner such that the line can be extended through open space past the reflex corner, and by connecting two reflex corners such that the line can be extended through open space past both of them (Penn et al, 1997), then reduce these lines using a

so-called ‘greedy’ algorithm to a near-minimal set of lines that complete all topological loops and fully observe the whole system. This would be the solution to the problem, but their algorithm only works with simplified plans (Batty and Rana, 2002).

2.1.6 Exemplary country that design street using space syntax analysis

1. Trafalgar Square

The network of public spaces in central London between Trafalgar Square and Parliament Square is the heart of the national government and, for many, the heart of London. A masterplan for the area was commissioned in 1996 by Westminster City Council and the Greater London Authority, calling for improvements in the quality of the public realm, which – although of historic importance – was perceived to be unpleasant, unsafe, and dominated by traffic (Jacoby, 2006).

a. Diagnosis – problems, opportunities, and constraints

Form – Spatial accessibility analysis (figure2.6)

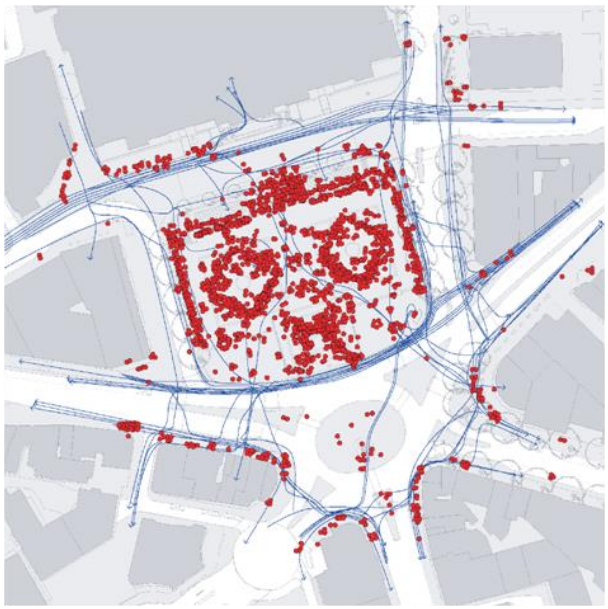
Key spatial issues: Trafalgar Square is not spatially integrated into its surroundings.

Function – Observation study of pedestrian movement and stationary activities (figure2.7)

Key functional issues: Evidence revealed Londoners avoided the center of Trafalgar Square and tourists failed to make the journey between Trafalgar Square and Parliament Square.

Interpretive models– space vs. movement and stationary activities

Define development opportunities and constraints and to provide the evidence for proposing design recommendations.



b. Prognosis – design development and forecast

Space Syntax Limited gave design recommendations including a major new staircase into Trafalgar Square, a selective pedestrian station of the public realm, and the re-connection of Parliament Square to the wider area. Given the historic importance of the context, these solutions required a very convincing technical argument. The interpretive model of space and movement was developed to allow us to quickly test design solutions (Figure2.8) against the diagnosis study and to assemble evidence for that argument.

Figure2.6 Spatial accessibility analysis (source: Jacoby, 2006).

Figure2.7 The pattern of current movement and stationary activities (source: Jacoby, 2006).

c. The outcome

The evidence from Space Syntax proved compelling, and permission to move forward was granted by all bodies concerned. Trafalgar Square is the first element of the masterplan to be completed in 2003 and has been a huge success, with levels of pedestrian movement in the square increasing by thirteen times. Space is now animated throughout the day by tourists and Londoners alike **(**Figure2.9**)**, demonstrating that the UK can create great public spaces to rival those in the rest of Europe.

Figure2.8 Test design recommendation of Trafalgar Square (source: Jacoby, 2006).

Figure2.9 The new central staircase in use Trafalgar Square with its surroundings (source: Jacoby, 2006).

2. The City of Jeddah, Saudi Arabia

Space syntax models of the city of Jeddah, Saudi Arabia. These models have been used as the base layers to inform the Strategic Planning Framework and its showed under figure 2.10. The spatial structure of the city as exists now (a), is compared with what it would be like if the old Local Plan is implemented (b), and what it would become if all strategic transformations proposed by the Strategic Planning Framework are implemented (c).

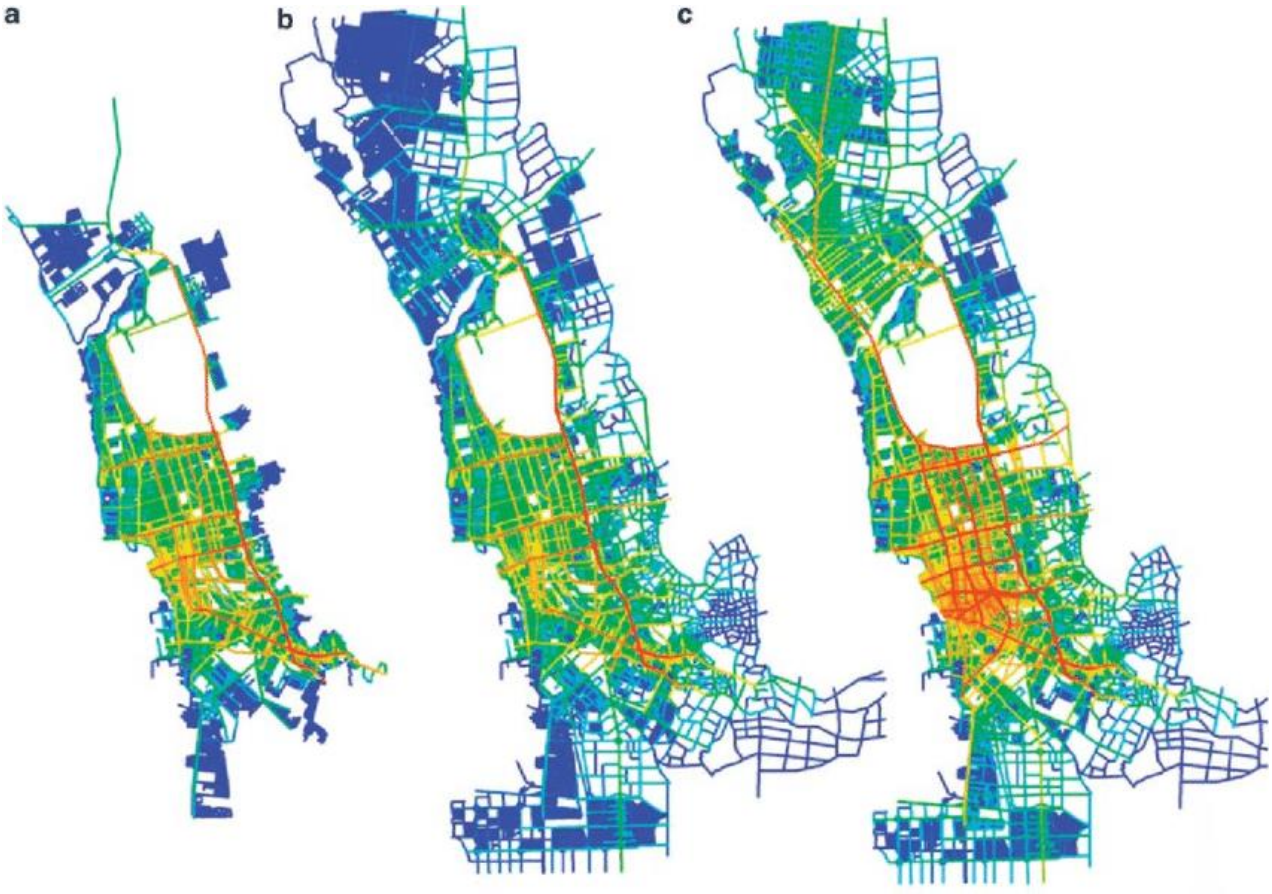


Figure 2.10: Space syntax models of the city of Jeddah, Saudi Arabia. (Source: Karimi, 2012).

These urban transformations were measured by the spatial model on local and global scales. The analysis showed major city-wide improvements compared with the existing city as well as with the proposed local plan, adopted previously by the Municipality. The project then continued further to develop more specific urban design solution options, or assess the impact of the other masterplans developed for different parts of the city, including a masterplan for the vacant Old Airport Site, a masterplan for the Historic core and waterfront, and a series of regeneration and area action plans for the unplanned areas of the city (Karimi et al, 2007; Karimi and Parham, 2012).

In all these projects space syntax methodology was used in the baseline study phase, as well as analytical evaluation phases. In the most recent study of this kind in 2011, a composite model, which takes into account spatial structure, land use, density and road capacity, was used to assess the impact of all masterplans developed for the City Centre of Jeddah on the definition, boundary, movement flows and vehicular traffic of the City Centre. This is a highly advanced tool that could feedback into the design process for each of these projects, as well as to the main strategic plan of the city (Source: Karimi, 2012).

2.1.7 Use of space syntax analysis

Space syntax analysis has a great role in the understanding of the relation between spatial pattern which means road system of the city and peoples activity, using this understanding it can be applied for the developments of the city in a different way some of such applications are presented below.

1.To further influence policy

Space syntax analysis gives a clear image for a policymaker about how special patterns affect accessibility in cities and how accessibility affects movements and hence social and economic activity, so this understanding can be applied to the three policy: crime, health, and social inclusion also, space syntax could have a greater policy influence is economic development (Bolton et al, 2017).

2.Health

Physical activity is frequently associated with proximity to public space, but proximity to public open spaces did not predict pedestrian use, instead, a more sophisticated understanding of how public spaces relate to the street network could predict public health benefits. (Koohsari et al, 2013). Healthy urban design can also be informed by space syntax. At the building scale, developers and landowners may gain commercial advantage from healthier spatial layouts, perhaps in combination with other space syntax evidence on productivity benefits for office design. At the urban and neighborhood scale, work on more sophisticated methods of understanding green space usage would if more widely known, be relevant to many local authorities who are facing budgetary pressures to justify the upkeep and management of parks and green spaces. Space syntax research into the spatial factors influencing the distribution of poverty is historically specific but could be more persuasive if also applied to contemporary data (Choi et al, 2006).

3 Crime and Safety

A study of crime in a London borough, provided detailed findings that could be particularly helpful to policymakers (Hillier and Sahbaz, 2012). According to Hillier and Sahbaz, it's safe in more neighbors on a street segment regardless of street type (Hillier and Sahbaz, 2012). The existence of a local ‘virtual community’ of people who regularly use the same spaces appears to be important in reducing crime risk (Hillier, 1999). busy city streets and its adjacent streets are risky for Street robbery and violent crime. (Hillier and Sahbaz, 2009). Mixed-use streets with few residents are particularly at risk but local movement reduces risk, while larger-scale movement can increase it. For this reason, residential areas need to be designed to structure local

movement, while managing the larger-scale movement and use Safer dwelling types to balance ‘eyes on the street’ with ‘eyes from the street’ (Sahbaz, 2012).

2.2 Contextual Review

2.2.1 Addis Ababa road network system

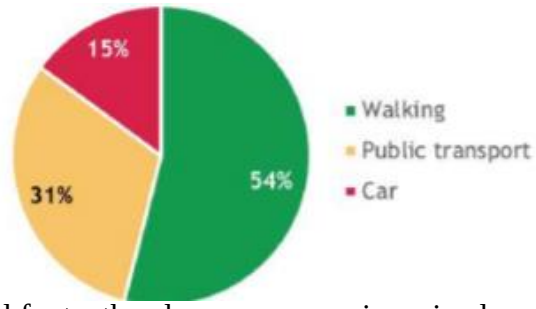
Since its establishment in 1886, Addis Ababa has undergone many changes in terms of its size and demographics, its finance and economic structure, its physical and spatial organization. The spatial development scheme of Empress Taitu had created several localities known as ‘Sefers’ around the houses of the novelty. The first roads served to link Sefers (villages within bigger settlements) by non-motorized modes of transport. The construction of modern roads was intensified during the beginning of the reign of Emperor Haile Selassie (Elias & Laura, 2018). The construction of roads during that period was carried out by the public works department of the municipality of Addis Ababa. The road construction had further been strengthened during and after the brief Italian occupation.

The city currently has mainly radial and orbital road patterns where main roads radiate from the center to the 5 outlets; and the ring road encircles the core and intermediate parts of the city. Walking is the dominant mode accounting for 55% of modal share in 2011. According to travel demand projections, the share of walk trips is estimated to be around 45% in the year 2020 (Mohapatra,2017; Knebel et al, 2009). Cycle transport is negligible; terrain and absence of cycle lanes have contributed to discourage its use. The lack of attention given to this mode by policymakers and planners over the years seems to have shifted since there are now three cycle routes in the city.

2.2.2 Street Concept in Addis Ababa

Walking and public transport are the dominant forms of mobility in Addis Ababa, making up an estimated 85 percent of trips (Figure 2.11). The fraction of trips made by foot varies widely across the city. For example, in the Addis Ketema sub-city, walking accounts for 78 percent of trips, while in Bole sub-city only 40 percent of trips are on foot. The average length for walking trips is 1.5 km. While not captured in official statistics, cycling is also a mode for short-distance trips, primarily among low-income and risk-taking males (Hagos & Adnan, 2020).

Figure2.11Walking and public transport in Addis Ababa. (source: Hagos,2020).



At present, most residents depend on walking. Nevertheless, pedestrians face many challenges, including inadequately sized footpaths, dangerous crossings, inadequate illumination, absence of disability access guidelines, and poorly maintained infrastructure. Going forward, the city seeks to priorities non-motorized transport (NMT), including walking, cycling, and other forms of non-motorized mobility. Greater use of NMT has numerous benefits, such as enhanced public health

due to active lifestyles; better access to jobs and educational opportunities; reduced emissions of dangerous pollutants (Hagos & Adnan, 2020).

According to implementing NMT, AARTB select high-priority locations for pedestrian precincts include Piazza, Megenagna, Merkato, and Churchill south. And there is some practice to change selected roads to street by providing street elements such as street furniture, trash box, public toilets, lighting and so on. Such sites are, around irreecha park and Kirkos sub-city administration office, and around Ethio Cuba park in Churchill road and from Meskel square to Urael site. But, such attempt is not enough for achieving quality street. According to the standardized street concept Addis Ababa city still has not any street so this study contributes in the selection of potential roads for designing quality street using space syntax analysis.

CHAPTER THREE

MATERIALS AND METHODS

This chapter mainly explains how the study was conducted, the applied methods and techniques in data collection, and the reasons as to why they were used according to the research aims and main objectives of the study.

3.1 Study Area description

The study is conducted in Addis Ababa, Ethiopia. It is the capital city of Ethiopia. It lies at an elevation of 2,355 meters (7,726 ft) and is a grassland biome, centrally located at Latitude and longitude coordinates are: 9.005401, 38.763611 and covers an area of approximately 527 km2. The current administration of Addis Ababa constitutes 10 sub-cities, ('Kefle Ketemas') those are Addis Ketema, Arada, Akaki Kality, Bole, Gulele, Lideta, Kirkos, Kolfe- Keranio, Nifassilk Lafto, and Yeka sub cities.

Comparative to other cities in the nation, the greater numbers of motor vehicles are found in Addis Ababa with a total share of 56.1 percent of the total motor vehicles in the nation. Thus traffic problem in the city goes up together with the increase of motor vehicles and population size without having adulate broad system. Moreover, the rise in automobile ownership together with the condition of the roads has resulted in a high level of traffic risk and congestion problems.

This calls for the development of effective traffic management within the city. Therefore, this research mainly focused on the road connectivity of the city. The location of the site is shown in figure 3.1.

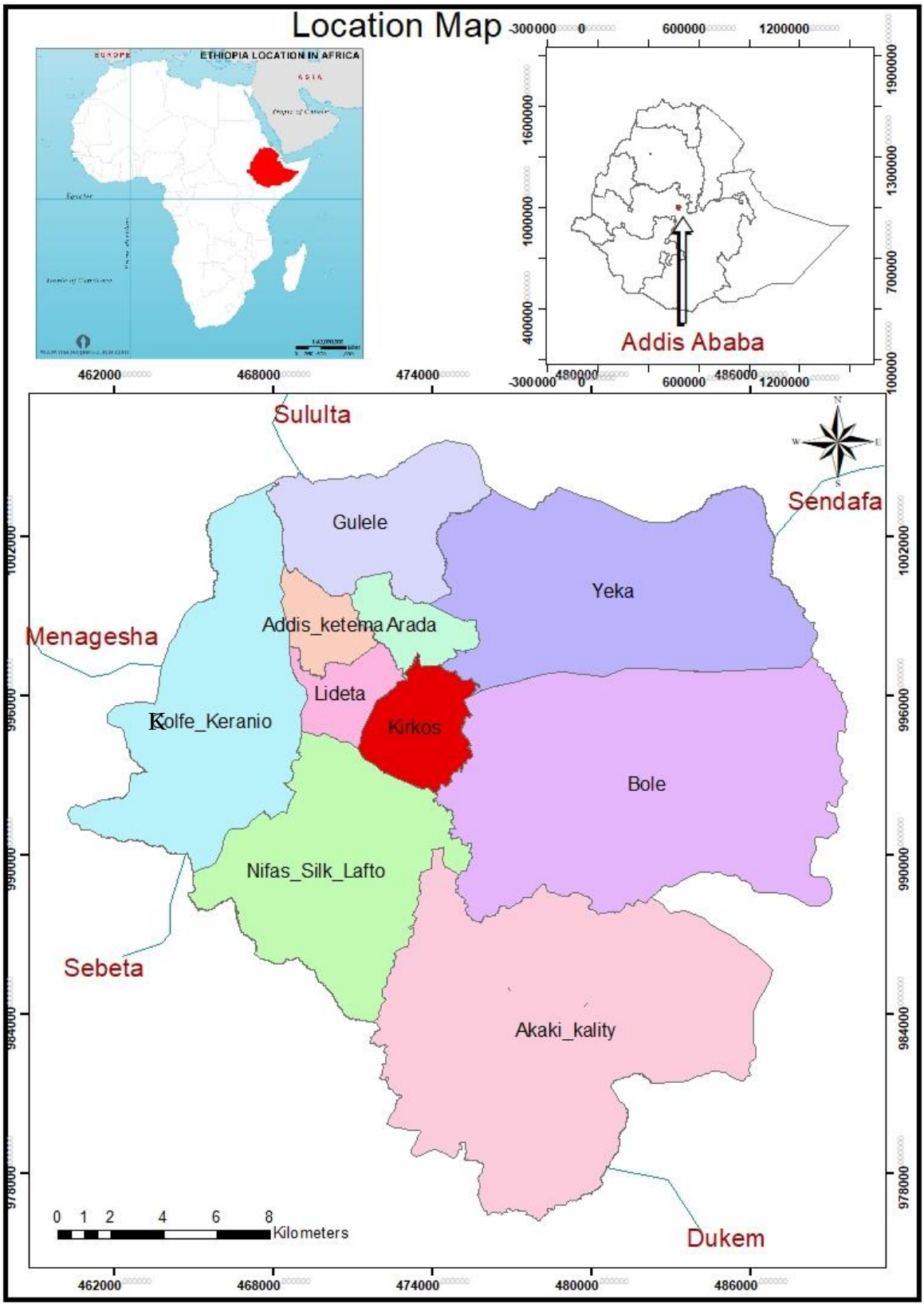


Figure 3.1 Location map

3.2 Data Sources

Most of the data are secondary and collected from government offices like AACRA, Transport office, Traffic police commission, and Master plan office.

3.3 Methods of data collection

All roads from alleys to major arteries are identified using Arc GIS and detail methods of data collection to achieve each specific objective are listed under Table 3.1.

Table 3.1. Data collection methods and tools

No	Specific objectives	Types of data	Source of data	Software used	Analysis
1	Identify and map integration level of Addis Ababa roads.	Road map (clear line map of Addis Ababa city)	Master plan office	Gis, Auto CAD, depth mapX,	Measurement Integration Analysis
2	To determine the depth of the Addis Ababa roads.	Road map	Road Analysis	depth mapX,	Mean depth analysis

3.4 Tool of Data Analysis

Depth mapX software is used to analyze the street network of AA. As the road network is many, the analysis was done for each sub-city part by part.

The whole process of the geographical analysis is shown in the following Figure 3.2

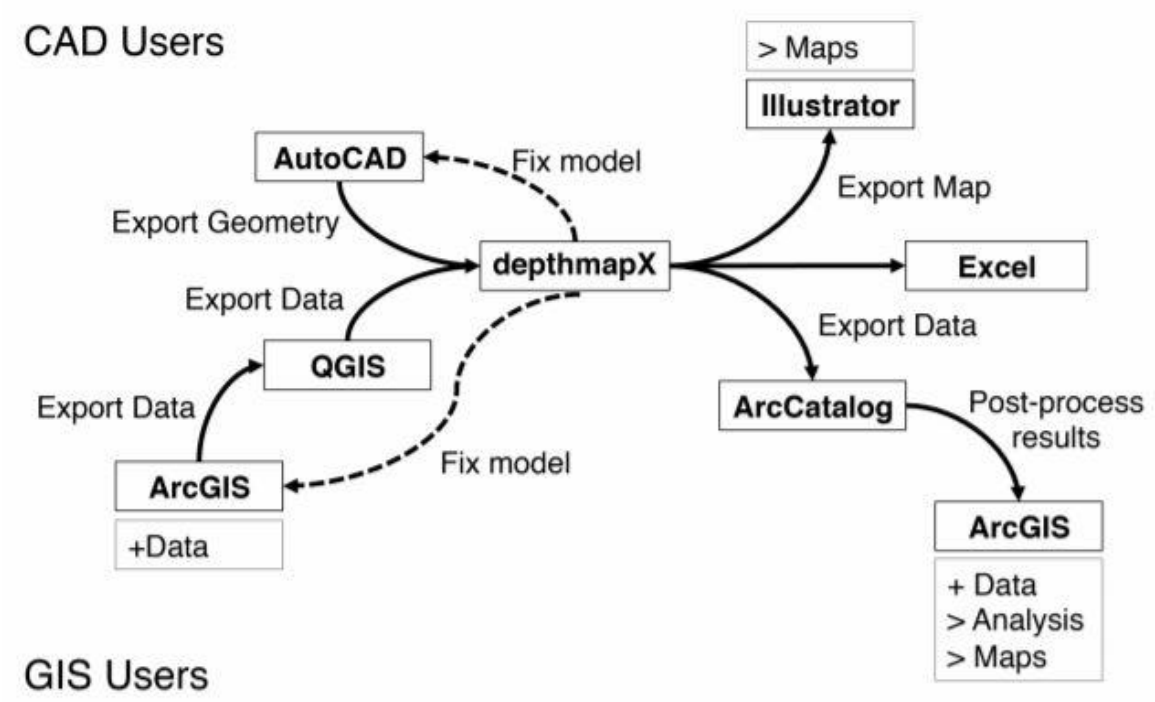


Figure 3.2. The workflow of space syntax analysis using the Depthmap (source: Gil et al, 2015)

3.5 Stages and Operations

Stages and operations of a typical space syntax urban research workflow are explained in Table 3.2. This table explains a detailed procedure of doing space syntax analysis through GIS, AutoCAD, and depth map X software.

Table 3.2 stage and operation of space syntax analysis

Stage	Operations
Data acquisition	Collect base map data
	Convert data formats
	Georeferenced vector and raster data
	User behavior data entry
	Location survey data entry
Geo-processing	Filter, aggregate, and join data based on attributes and spatial relations
	Find the nearest feature
	Transform geometries
	Attributes update and calculation
Network model preparation	Draw map
	Extract map from a larger data set
	Prepare plans
	Generalize road network
	Map verification
	Manage unlinks and links
Network analysis	Analyze network models (space syntax) Post-process analysis results (attribute naming, selection, new calculations)
	Calculate the shortest route and catchment areas

	Street and block morphology
Exploratory spatial data analysis	Interactive visual exploration of results
	Inquiry of individual feature values
	Identify the core of the network
	Spatial analysis (interpolation, hotspots, clustering)
	Terrain analysis
Statistical analysis	Descriptive statistics
	Transform columns
	Interactive charts (histogram, scatter plot)
	Linear regression
	Multivariate regression
	Statistical clustering (PCA, k-means, hierarchical)
	Export data to statistics packages
Reporting and visualization	Create base map compositions for print
	Set output format and resolution
	Standard visualization (color ranges) for screen and print
	Store named views
	Produce map series based on attributes

(Source: Varoudis et al ,2015)

After identifying important roads of each sub city's, all are combined to produce the final major street and choose the one that has high integration value.

3.6 Methods of Data Analysis

Space syntax measures the road as a graph rather than a map (O'Sullivan and Turner, 2001) and calculate connectivity, mean depth, and integration using a "segment map", which segments each axial line at its intersections, allowing an analysis of street segments. Depthmap software calculate connectivity matrix and configurational measures of segment map (Pereira et al, 2001). It is also important to note the two-stage mechanism of the process: map creation, then graph analysis. Indeed, Depthmap works in two separate programs: one to build the network automatically from a set of points, and one to perform the graph analysis (Turner, 2004).

3.6.1 Integration Analysis of Addis Ababa Roads

According to Hillier, there is a strong relationship between spatial integration in the axial map and observed human movement flows in urban areas. A highly integrated road is the grater traffic the one most used by people and also lined with important global function and local shops, which means it has the potential to change to the street easily. According to this, to identify important roads of Addis Ababa city, integration of the road system is calculating under the flowing process and formula.

Integration is a global static measure where every axial line is assigned a value that characterizes its relation to all other lines in the grid, thus providing a global index of relative integration or segregation for that line relative to all others (R = n). Therefore, integration of a line is by definition a value that indicates the degree to which the line is more integrated, or segregated/inaccessible, from a system as a whole.

Hillier's integration measure = (NC * NC) / TD

Integration for angular segment analysis = NC/MD = NC/(TD/NC) = NC * NC/ TD

where: NC – node count

TD – total depth

MD – mean depth (Al-Sayed, K. 2014)

The value of integration is in the range 0–1. The way the scale is allocated can be imagined by thinking of a rule where '0' corresponds to the lowest attribute value and '1' to the highest attribute. Between 0.1 and 0.5, lowest value, the mid-value is between 0.5 and 0.9 and from 0.9 to 1.0 is the highest value (Turner, 2004). However, depending on the size and segments of the axial map, the urban core is formed with 1% to 10% of highest integrated lines of the urban grid (ISPRS, 2014).

Integration is a good predictor of the potentials for each segment within a metric radius to be a highly desired destination. In other words, the measure forecasts the to-movement potentials for each segment when measuring on all the shortest angular paths in the system from all origins to all destinations (Al-Sayed, 2014).

Selection criteria for Sampled Street Design

Selection criteria for choosing one potential road for designing sample street design are listed under the following.

- ✓ Highly integrated road

From Addis Ababa, axial map analysis selects highly integrated roads.

- ✓ Future development opportunity

It’s better to select from those of highly integrated roads, the one that have Future development opportunity

- ✓ Location of international and governmental organization.

For more social and economic activity select the Location of international and governmental organization.

- ✓ Low cost for demolishment

3.6.2 The Depth Analysis of Addis Ababa Roads

One of the most useful configurational methods of analysis is that of angular depth which outlines the shortest angular journeys through the spatial network (Hillier & Iida, 2005). It is important to emphasize that the metric radius of the measure refers to the metric distance from each segment along all the available streets and roads from that segment up to the radius distance. Following this definition, radius ‘n’ means that each segment is related to every other segment in a city without any radius restriction (Al-Sayed, 2014). In this study all the analysis is done with the radius ‘n’. but it can be analyzed by giving fixed radius and all the concept and formulas to calculate depth of the roads is explained under the following.

i. Step Depth

Step depth follows the shortest angular path from the selected segment to all other segments within the system. The weighting used in the angular scale considers 1 step as a 90± angle. Angles are cumulative.

ii. Node Count

Node count is the number of segments encountered on the route from the current segment to all others.

iii. Total Depth

The global measures are derived from the graph topological depth, which accounts for the distance between each axial line and all the others, where the shallowest axial line is the closest to all other axial lines and the deepest is the furthest one. Depth is a topological distance between vertices in the dual graph G. Two open spaces, i and j, are said to be at depth dij if the least number of syntactic steps needed to reach one vertex from the other is dij. The sum of all depths from a given origin is computed as Total Depth;

$$TD_i = \sum_{j=1}^{n-1} d_{ij}, \qquad i \neq j$$

iv. Mean Depth

The angular mean depth value for a line is the sum of the shortest angular paths divided by the sum of all angular intersections in the system rather than the number of lines in the system. Mean depth in general terms is indicative to how deep or shallow a node is in relation to the rest of the graph, a measure defined as centrality.

MD = TD /NC

where: TD – total depth

NC – node count

$$MD_i = \frac{1}{n-1} \sum_{j=1}^{n-1} d_{ij}, \qquad i \neq j$$

or

Depth is counted in a graph and is determined by parameter k. Parameter connectivity considers immediate neighbors and depth considers the neighbors of the k-th degree.

Connectivity and depth measures can be written as a sum:

$$\sum_{s=1}^{m} \text{s x Ns} = \begin{cases} \text{conncectivity iff m} = 1 \\ \text{local depth iff m} = \text{k} \\ \text{global depth iff m} = \text{l} \end{cases} \quad 1 < k < l/local\ depth(until\ k = 3) \quad (1)$$

where: k – parameter,

s – operator (s is an integer),

l – the shortest distance,

Ns – the number of nodes with the shortest distance s.

Where 1 < k < l, usually three steps are adopted for the calculation of local depth, i.e. k is equal to 3 (this means that we consider lines within three steps from an axial line). We can also note that connectivity is equivalent to local depth if k = 1 (Dettlaff, 2014).

3.7 Data Presentation

The analyzed data were presented using statistical tools such as Tables, Graphs, and maps.

CHAPTER FOUR

RESULT

This chapter presents the result part of the research. The study began with the assumption that integrated areas attract retails and commercial activities, which become workplaces for a good number of people. From this point of view, the investigation had to be focused on identifying more integrated roads and segregated areas using Depthmap software.

Depth map displays attributes with a color scale that runs from a blue-tinged magenta for the very lowest value, to blue (through cyan) to green (through yellow) to red, and up to a red-tinged magenta, for the very highest value. The way the scale is allocated can be imagined by thinking of a rule where '0' corresponds to the lowest attribute value and '1' to the highest attribute value. By default, 0.0 is bluish magenta. This slowly changes to pure blue at 0.1. Between 0.1 and 0.5, the blue is slowly faded out and green faded in, so the mid value is pure green. Similarly, between 0.5 and 0.9 green is faded out, and red faded in, so at 0.9 the value is pure red the changes to a reddish magenta at 1.0 (Turner, 2004).

4.1 Potential Roads of Addis Ababa City

This study applies integration analysis to identify major important roads of Addis Ababa using Depthmapx software. But Depthmapx software needs a high-quality supercomputer to produce an axial map of the total road system of the city at a time. So the analysis was done by using each sub-city section by section and the result of each sub cities explained under the following.

N.B: All the maps are not scaled.

1. Potential roads of Addis Ketema sub-city

Addis Ketema sub-city is one of highly integrated sub-city. The integration map of the city is shown in figure 4.1(a) from total roads of Addis Ketema sub-city, three roads are highly integrated those are the road from Kolfe to Piazza, the road from Abinet to Pauster and the road from Addis Ketema to Admas kurs. and presented in figure 4.1(b)

2. Potential roads of Akaki Kality sub-city

From integration map of Akaki Kality sub city (Figure 4.2(a)), three roads are highly integrated those are proposed bridge road between road from Damo's House to Tulu Dimtu Adebabay and Akaki city bus depot site, proposed bridge road between road from Addis Ababa to Dukem and road from Kilinto to Ethio ICT village road and road from Maru metal industry to Akaki city bus depot. This is shown in Figure 4.2(b).

3. Potential roads of Arada sub-city

From integration map of Arada sub-city (Figure 4.3(a)), three roads are highly integrated those are: road from Addisu Gebeya to Minilik square, road from Minilik square to Cherchil view restaurant and the road from Minilik square to Korian monument. This is shown in Figure 4.3(b).

4. Potential roads of Bole sub-city

From integration map of Bole sub-city (Figure 4.4(a)), five roads are highly integrated those are: road from Megenagna to CMC, road from CMC to Summit, the road from Megenagna to Adwa park, road from Lemhotel to Goro square and the road from Goro square to Summit. This is shown in Figure 4.4(b).

Figure 4.1(a) Integration map of Addis Ketema sub-city

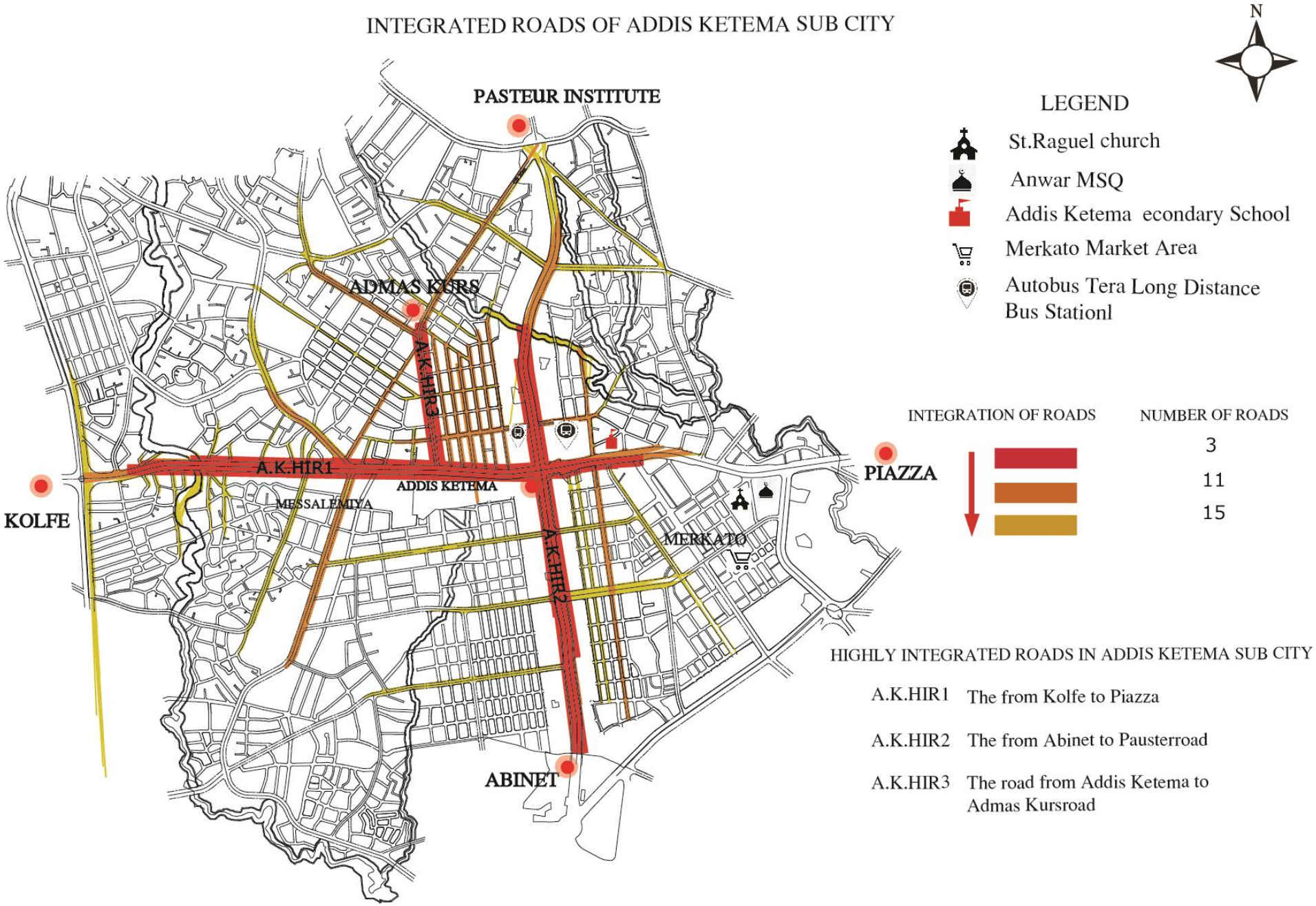


Figure 4.1(b) Integrated roads of Addis Ketema sub-city

2.INTEGRATION MAP OF AKAKI KALITY SUB CITY

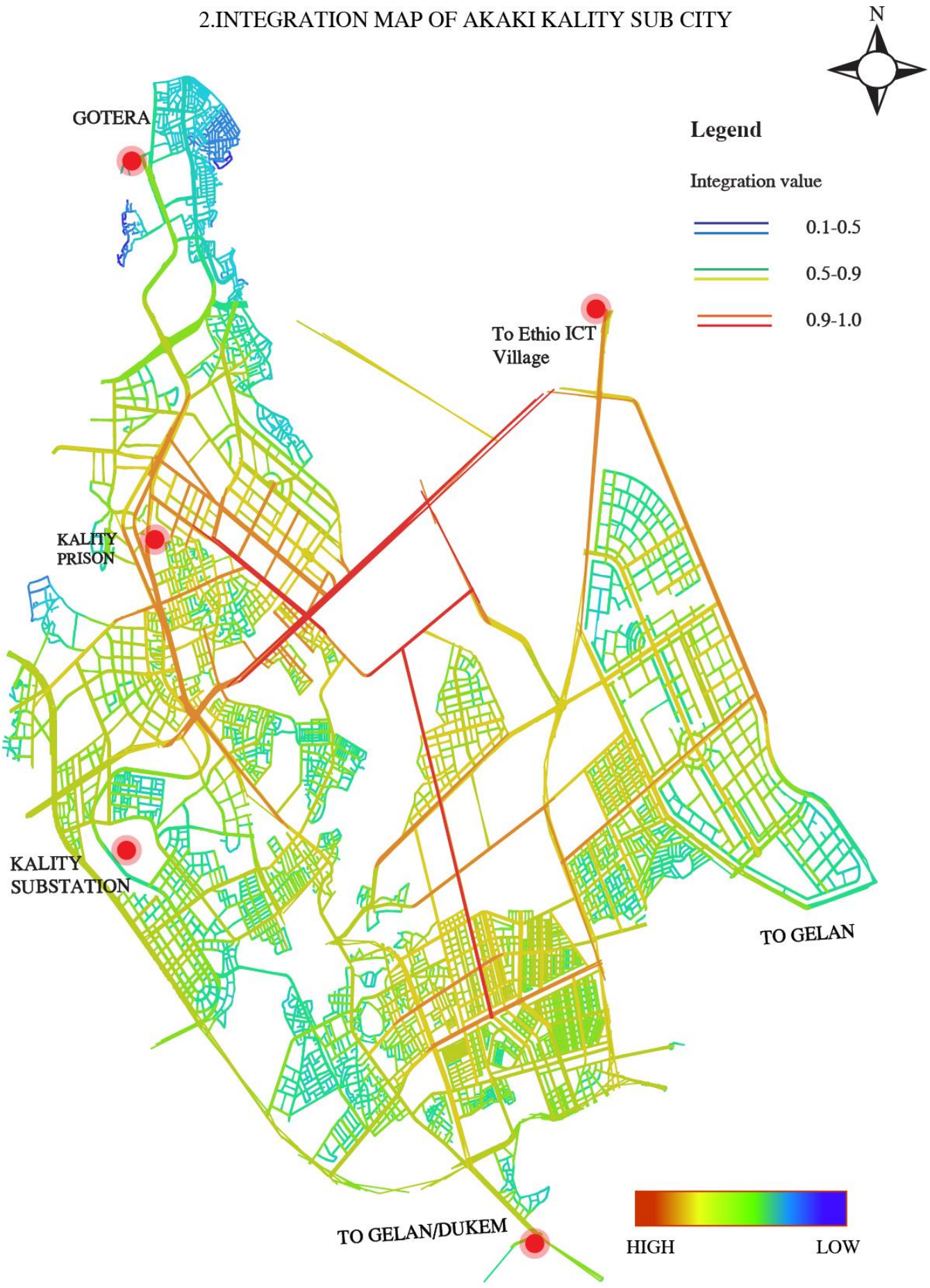


Figure 4.2(a) Integration map of Akaki Kality sub-city

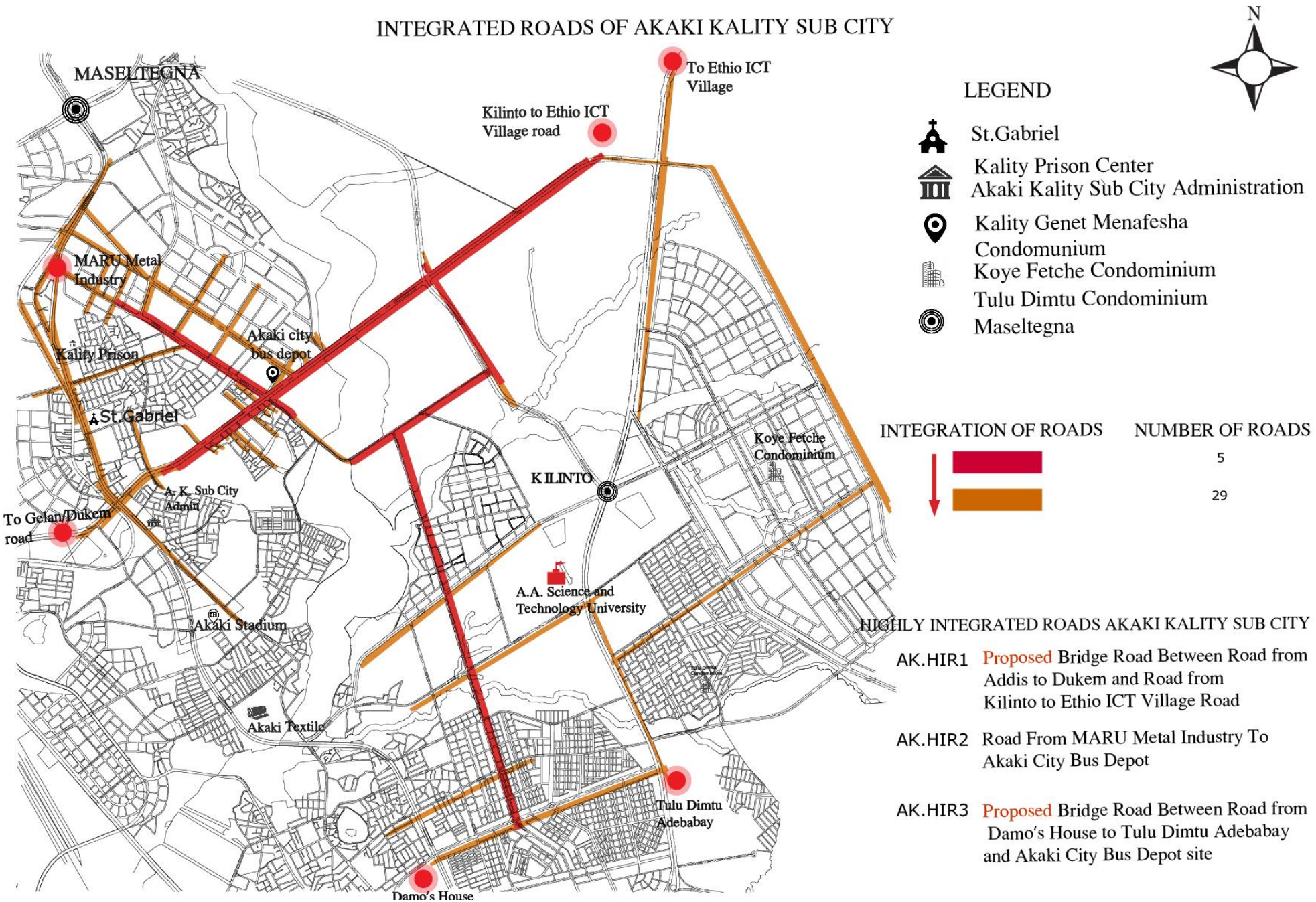


Figure 4.2(b) Integrated roads of Akaki Kality sub-city

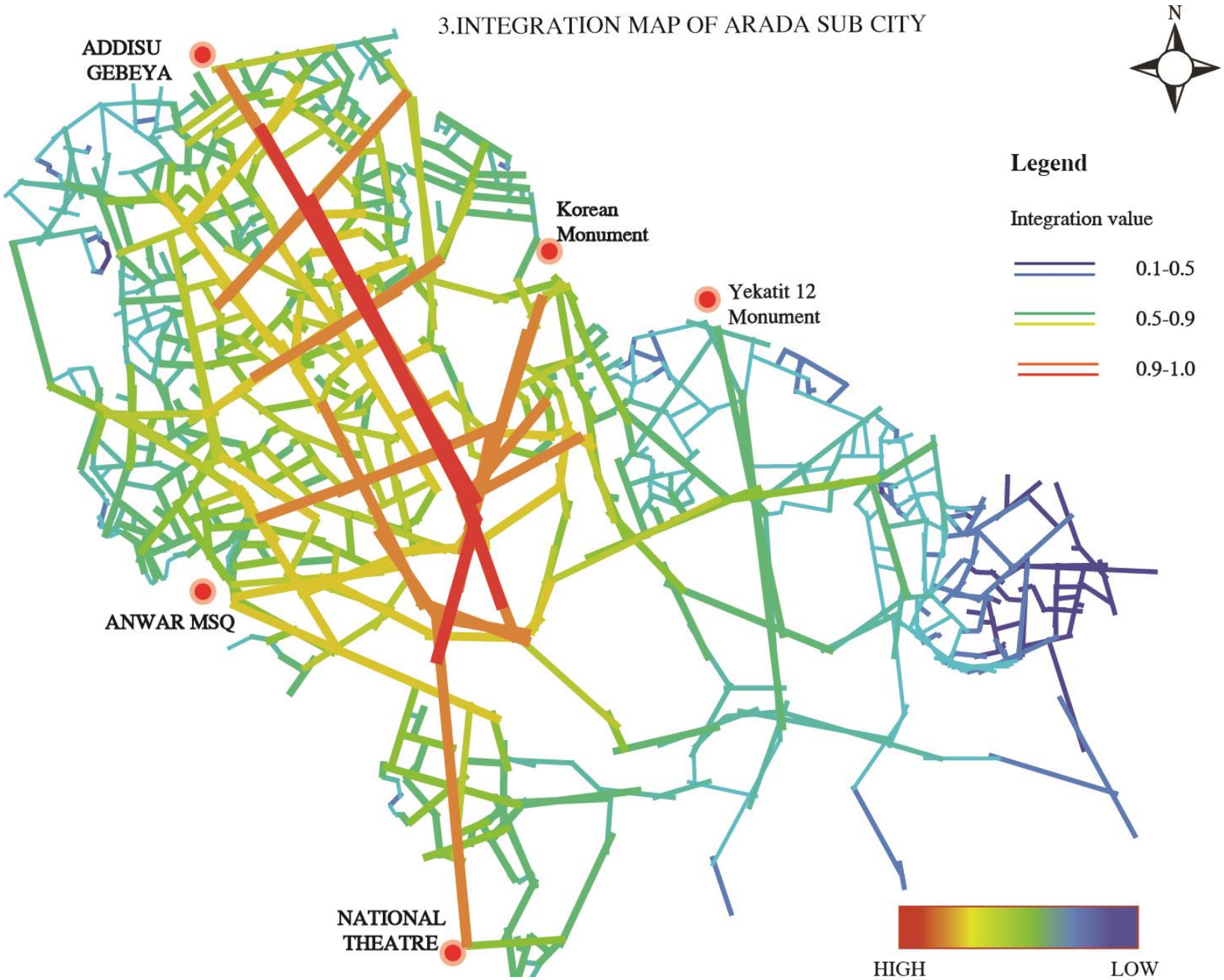


Figure 4.3(a) Integration map of Arada sub city

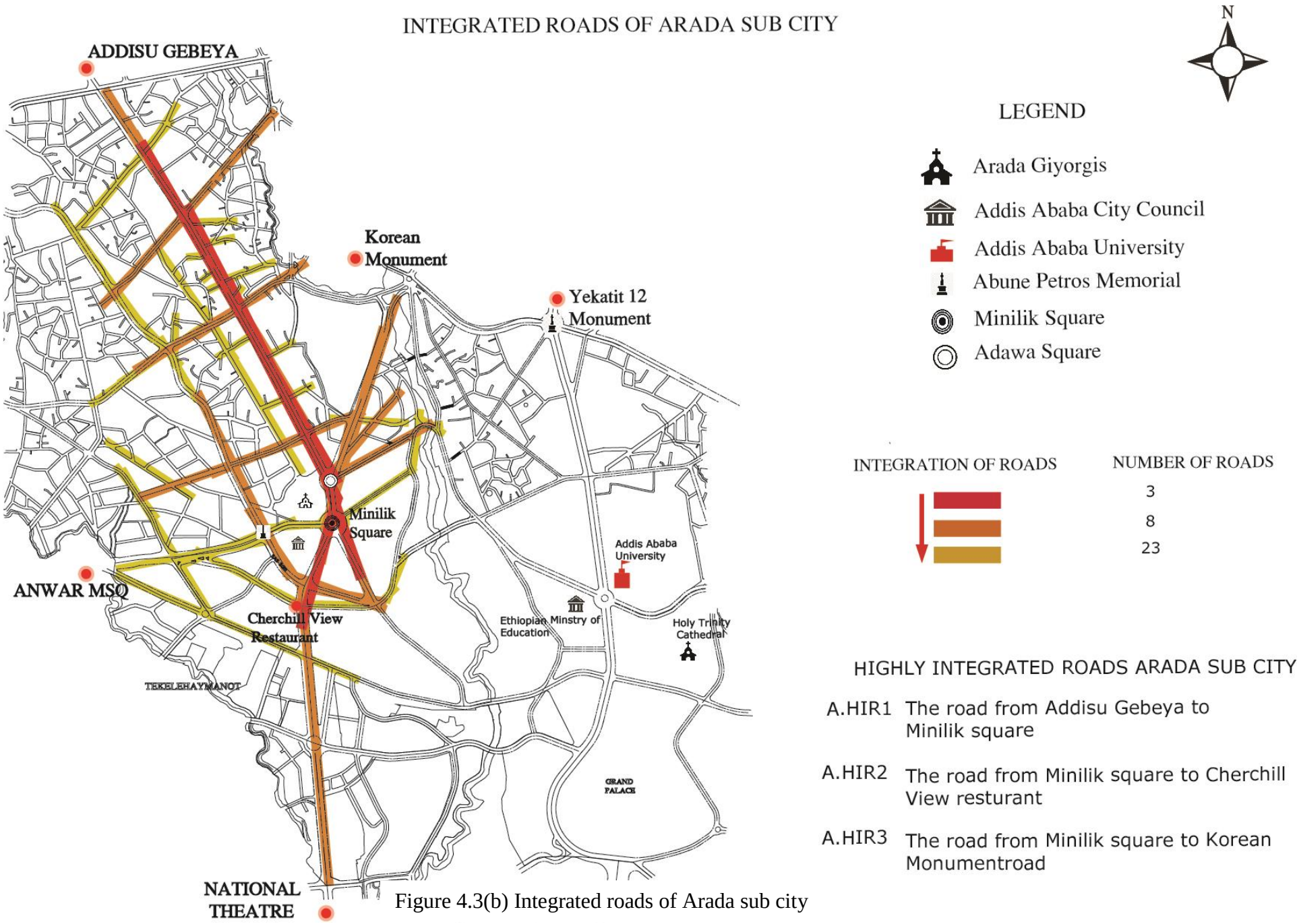


Figure 4.3(b) Integrated roads of Arada sub city

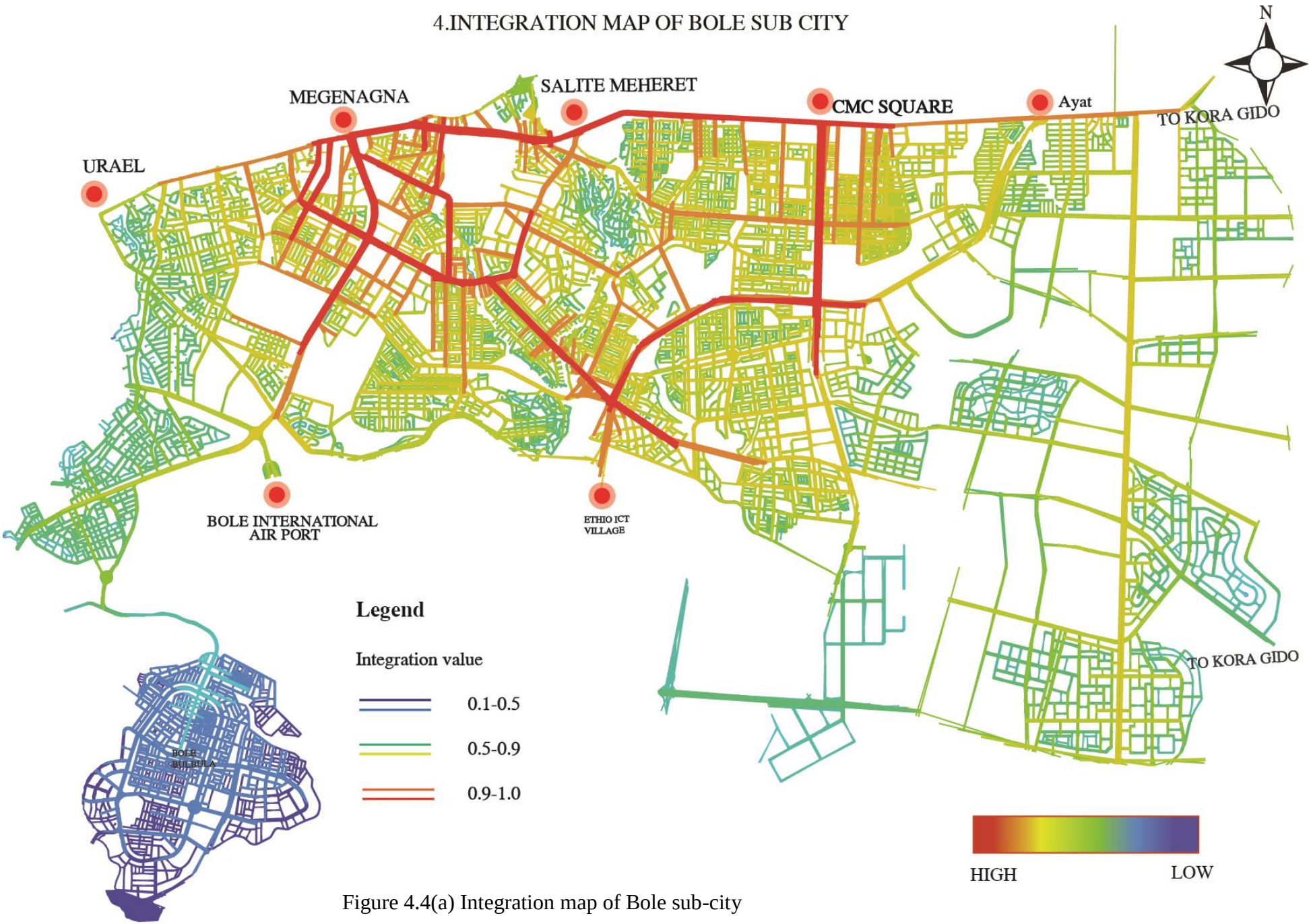
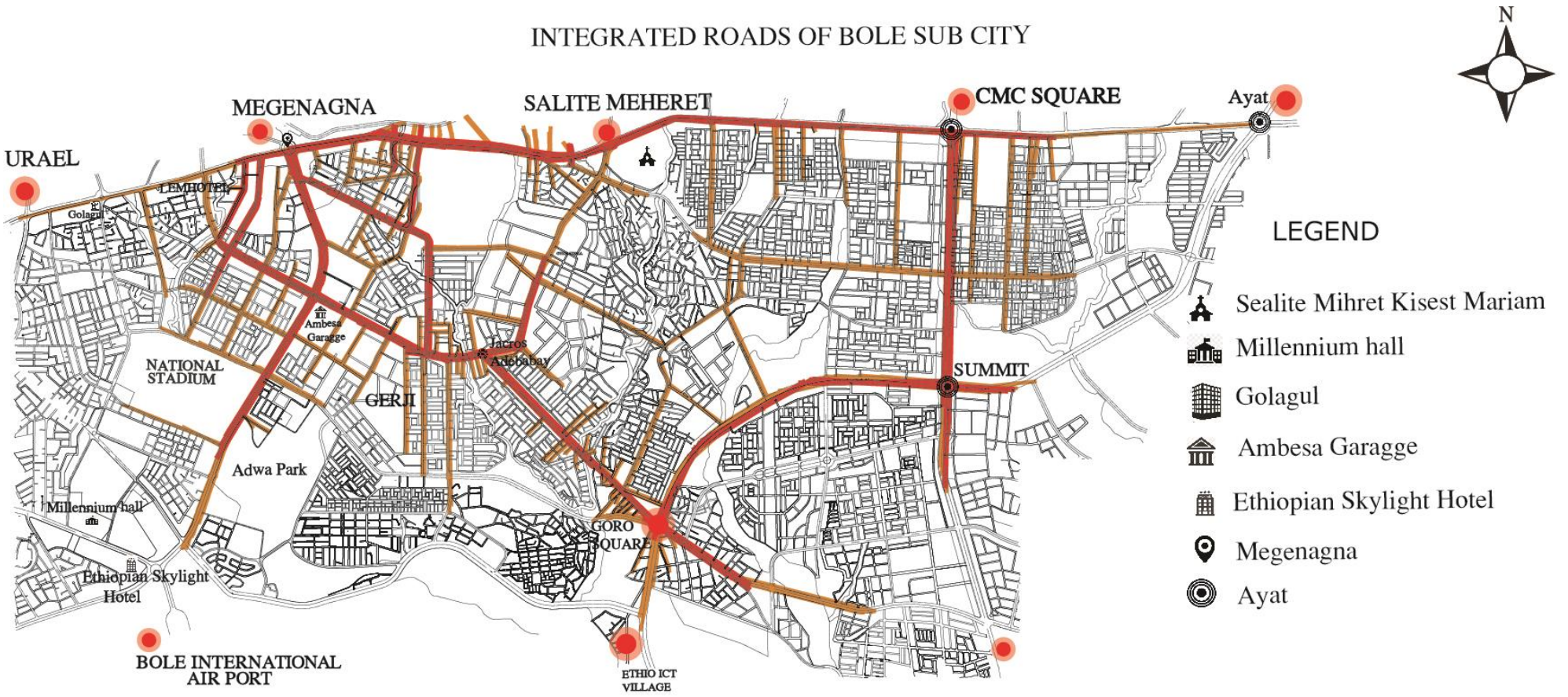


Figure 4.4(a) Integration map of Bole sub-city



HIGHLY INTEGRATED ROADS BOLE SUB CITY

B.HIR1	The road from Megenagna to Cmc
B.HIR2	The road from Cmc to Summitroad
B.HIR3	The road from Megenagna to Adwa Parkr
B.HIR4	The road from Lemhotel to Goro Square
B.HIR5	The road from Goro Square to Summitroad

INTEGRATION OF ROADS	NUMBER OF ROADS
	13
	75

Figure 4.4(b) Integrated roads of Bole sub-city

5. Potential roads of Gullele sub-city

From integration map of Gullele sub-city (Figure 4.5(a)), four roads are highly integrated those are: proposed road from Addisu Gebeya to Kecheni, proposed road from Kecheni to Intoto park, road from Addisu Gebeya to Sheger park and the road from Addisu Gebeya to St Raphael. This is shown in Figure 4.5(b)

6. Potential roads of Kirkos sub-city

From integration map of Kirkos sub-city (Figure 4.6(a)), three roads are highly integratedroad from Mexico to kera, proposed road from AU to Kirkos sub city administration Via Meshualekiya, road from Riche to Meskel square and the road from St. Yared square to Washengton square. This is shown in Figure 4.6(b)

7. Potential roads of Kolfi Keraniyo sub-city

From integration map of Kolfi Keraniyo sub-city (Figure 4.7a)), three roads are highly integrated those are: road from Ampho to Ayer Tena square via Alem bank, road from Rom sefer to Keraniyo Adebabay via Tahibib village and road from Tahibib village to Bethel driving training place.This is shown in Figure4.7(b).

8. Potential roads of Lideta sub-city

From integration map of Lideta sub-city (Figure 4.8(a)), three roads are highly integrated those are: road from Mexico to EiABC, road from Dessie hotel to Mola Maru liquor factory and the road from Mexico to Teklehaymanot. This is shown in Figure 4.8(b).

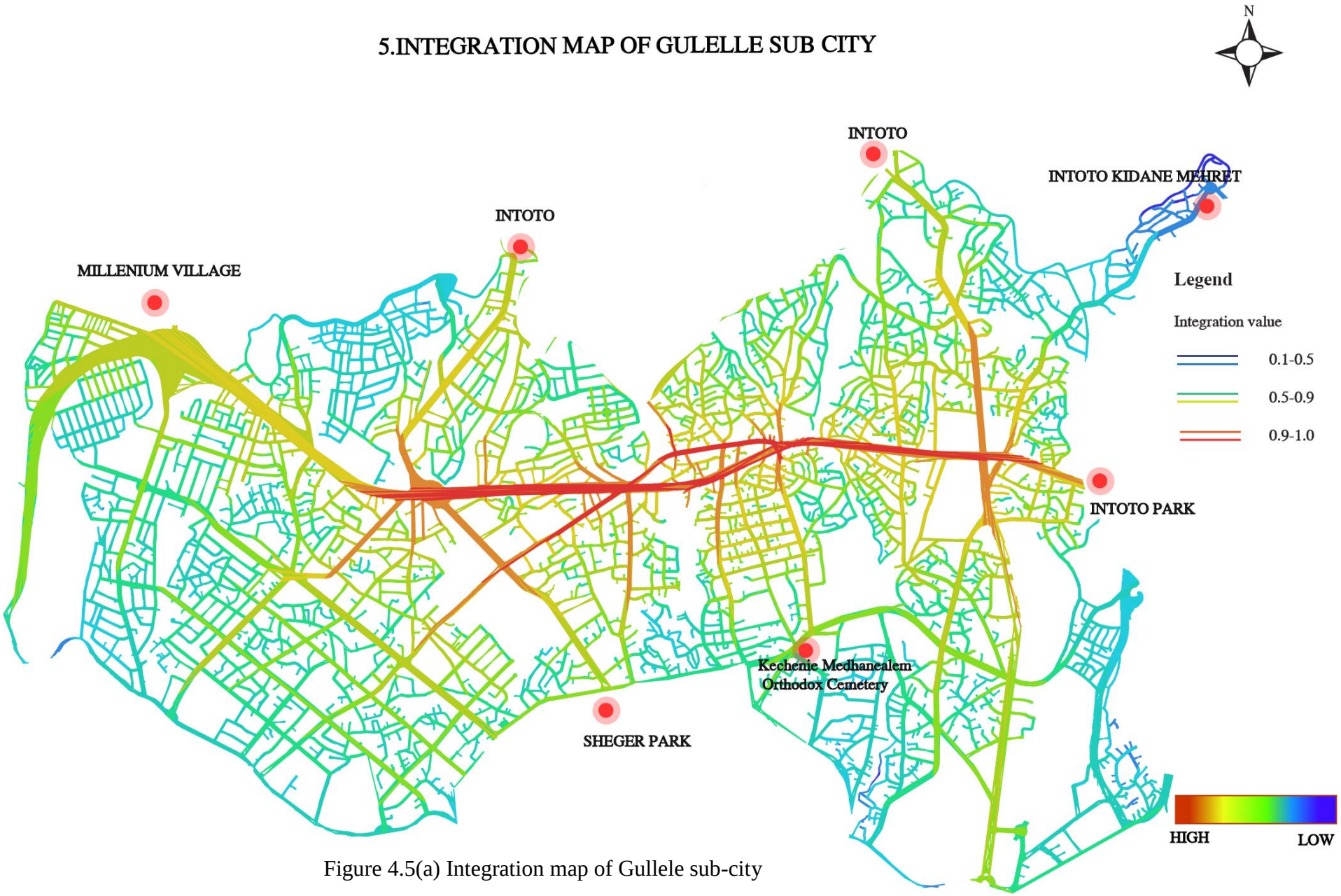


Figure 4.5(a) Integration map of Gullele sub-city

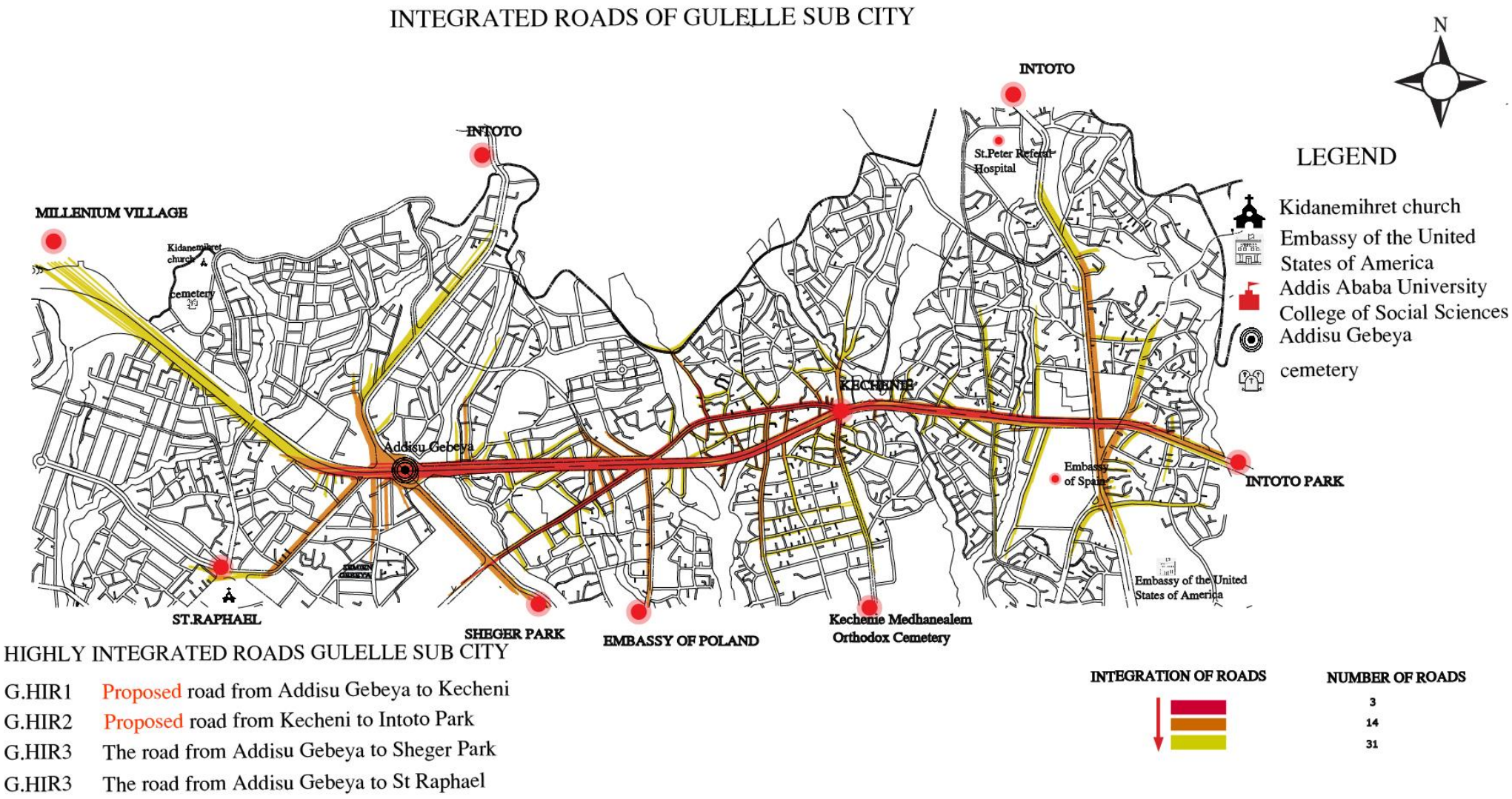


Figure 4.5(b) Integrated roads of Gullele sub-city

Figure 4.6(a) Integration map of Kirkos sub-city

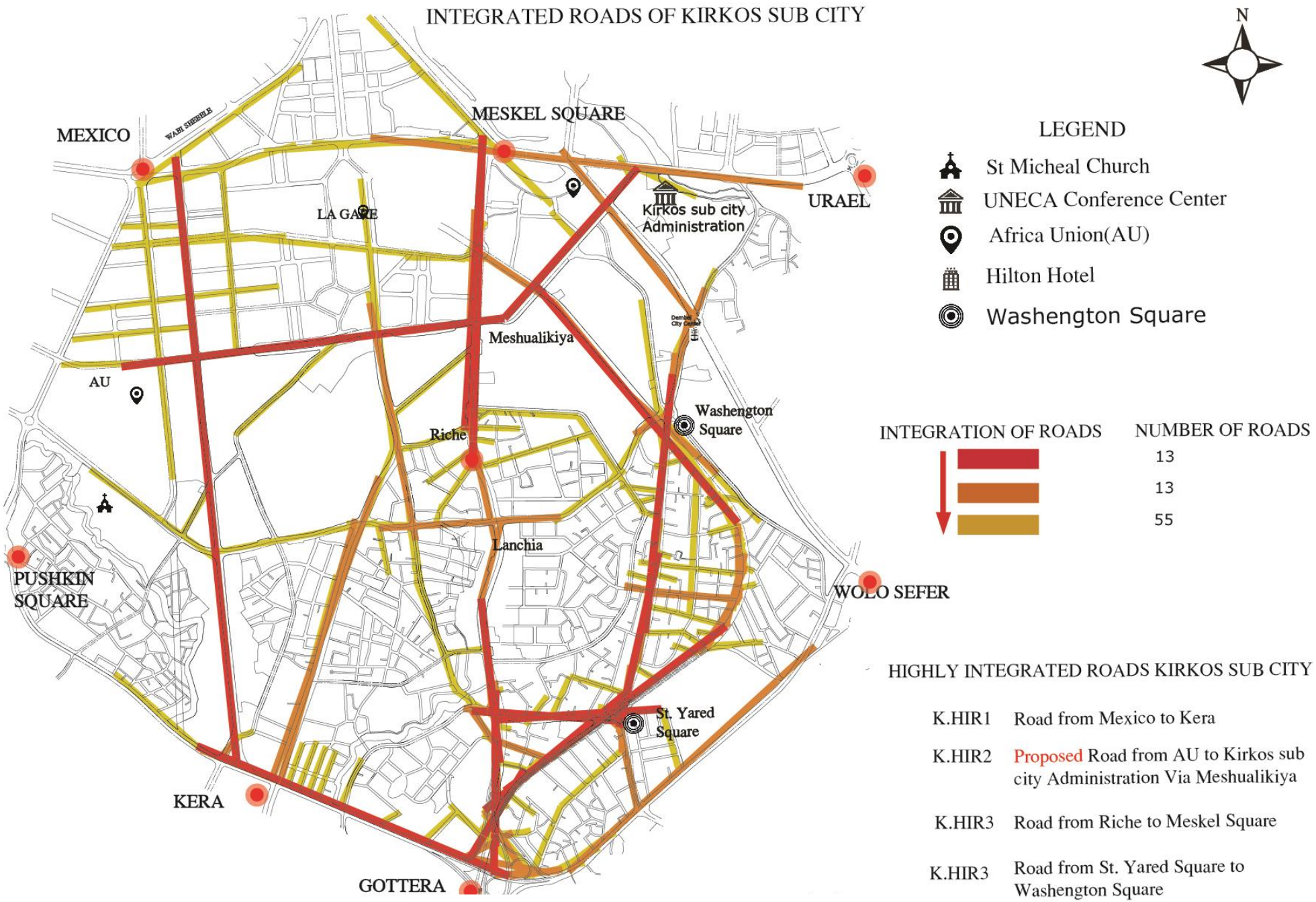


Figure 4.6(b) Integrated roads of Kirkos sub-city

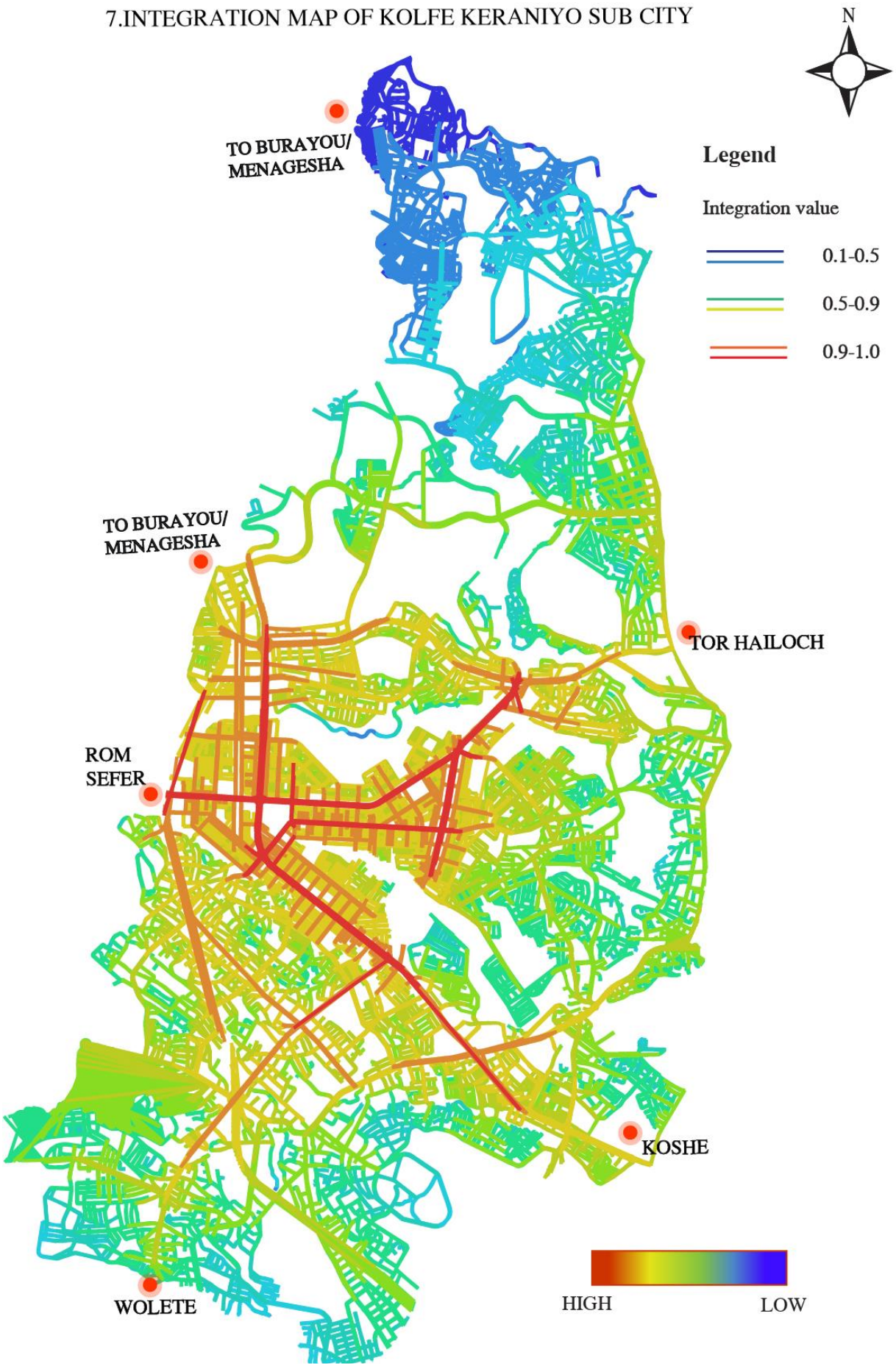


Figure 4.7(a) Integration map of Kolfe Keraniyo sub-city

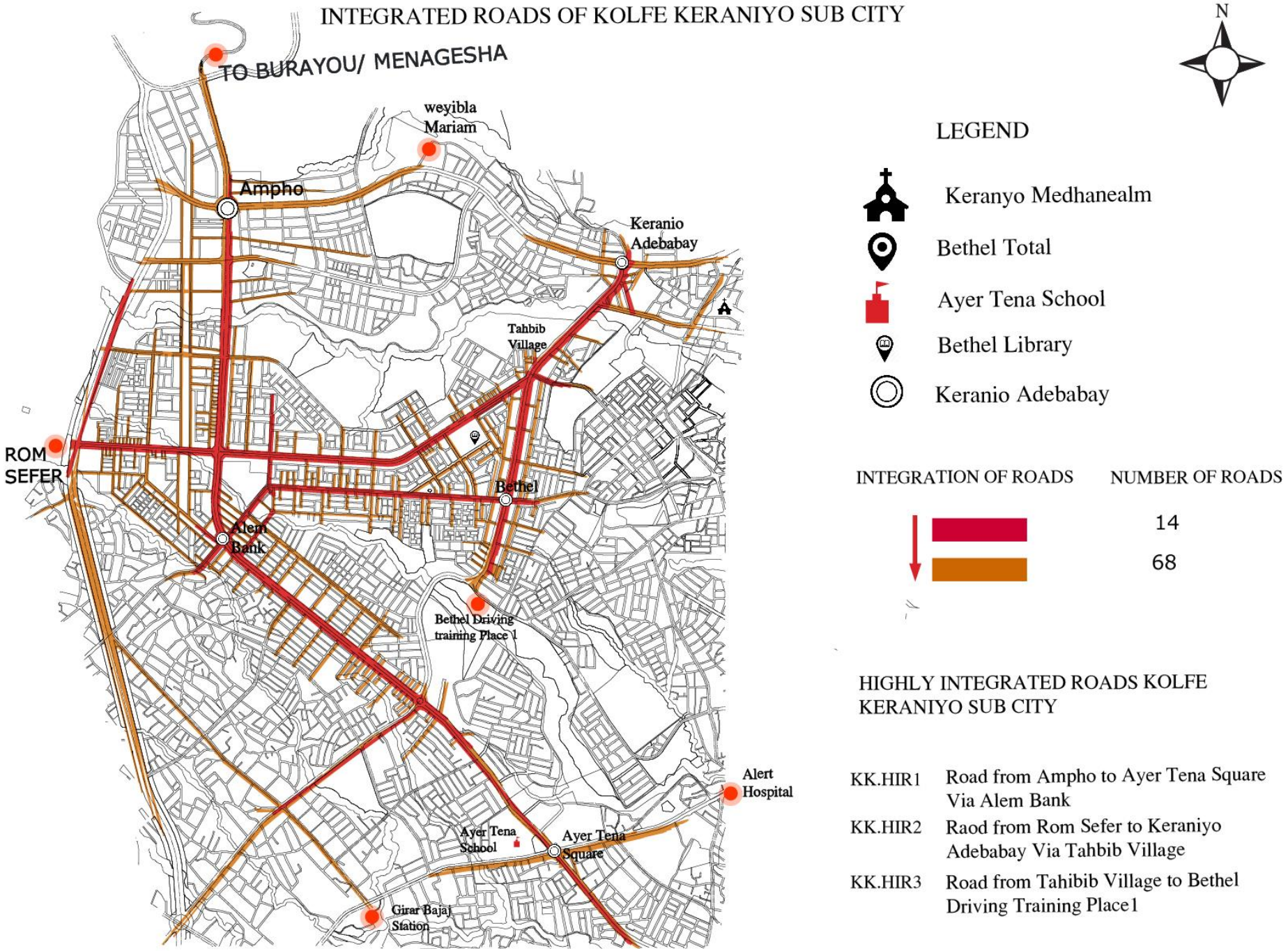


Figure 4.7(b) Integrated roads of Kolfe Keraniyo sub-city

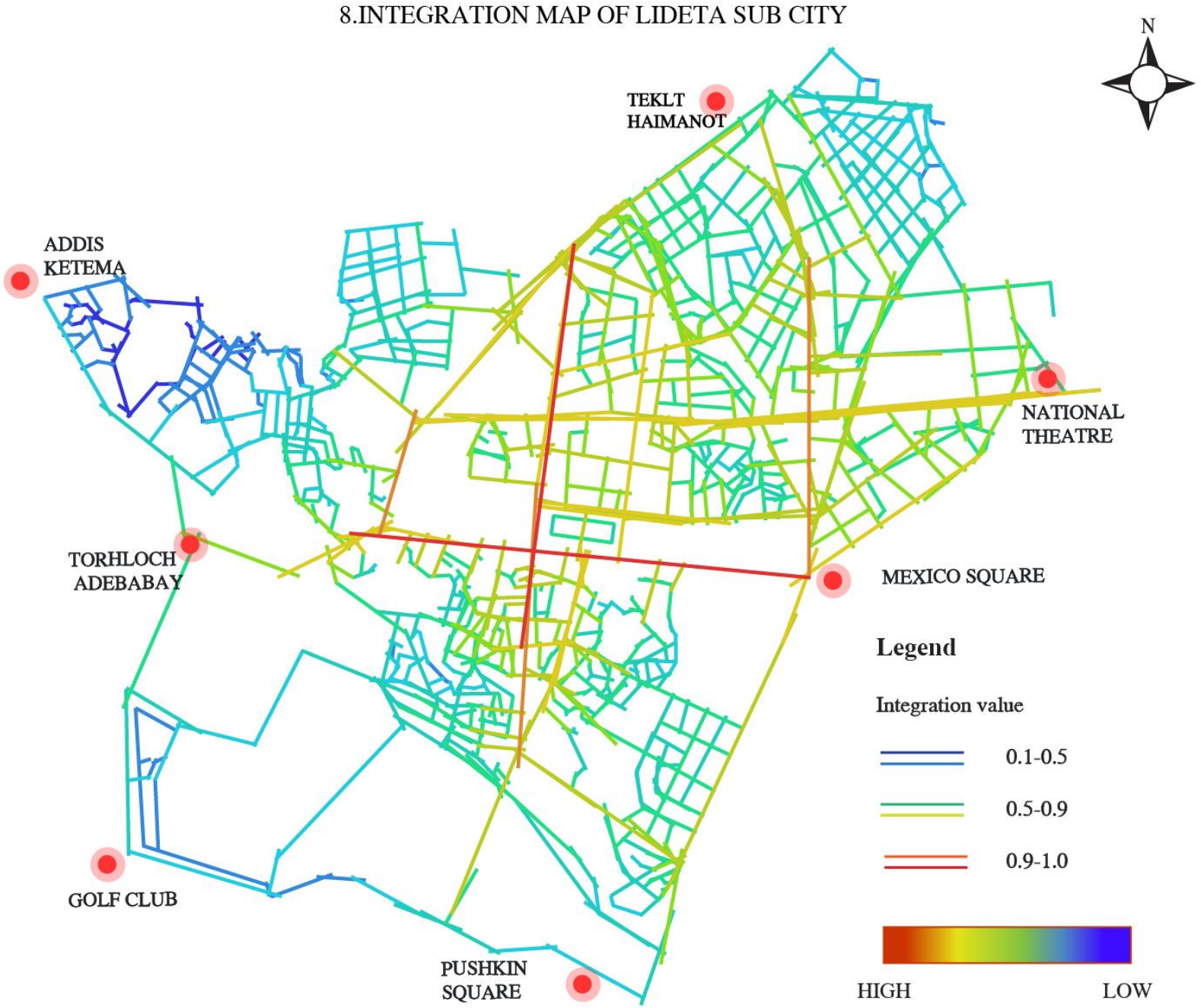


Figure 4.8(a) Integration map of Lideta sub-city

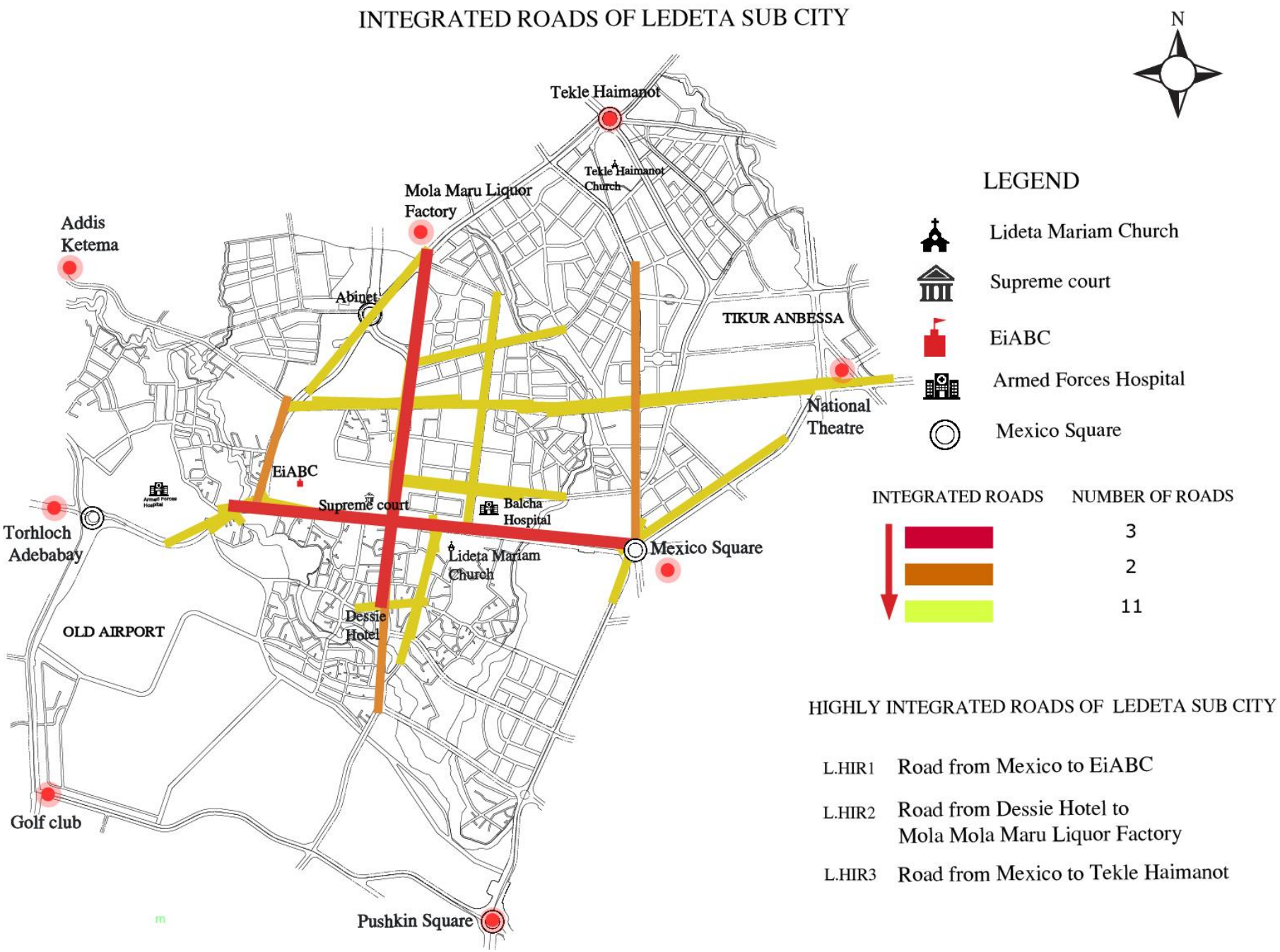


Figure 4.8(b) Integrated roads of Lideta sub-city

9. Potential roads of Nifaslk Lafto sub-city

From integration map of Nifaslk Lafto sub-city (Figure 4.9(a)), three roads are highly integrated: road from mikeal square to Haile garment square via Lebu, road from Gemo to Lebu and the road from Mekanissa to Gofa Gebrial square. This is shown in Figure 4.9(b)

10. Potential roads of yeka sub-city

From integration map of Yeka sub-city (Figure 4.10(a)), three roads are highly integrated those are: road from Ampho to Ayer Tena square via Alem bank, road from Rom sefer to Keraniyo Adebabay via Tahibib village and road from Tahibib village to Bethel driving training place. This is shown in Figure4.10(b).

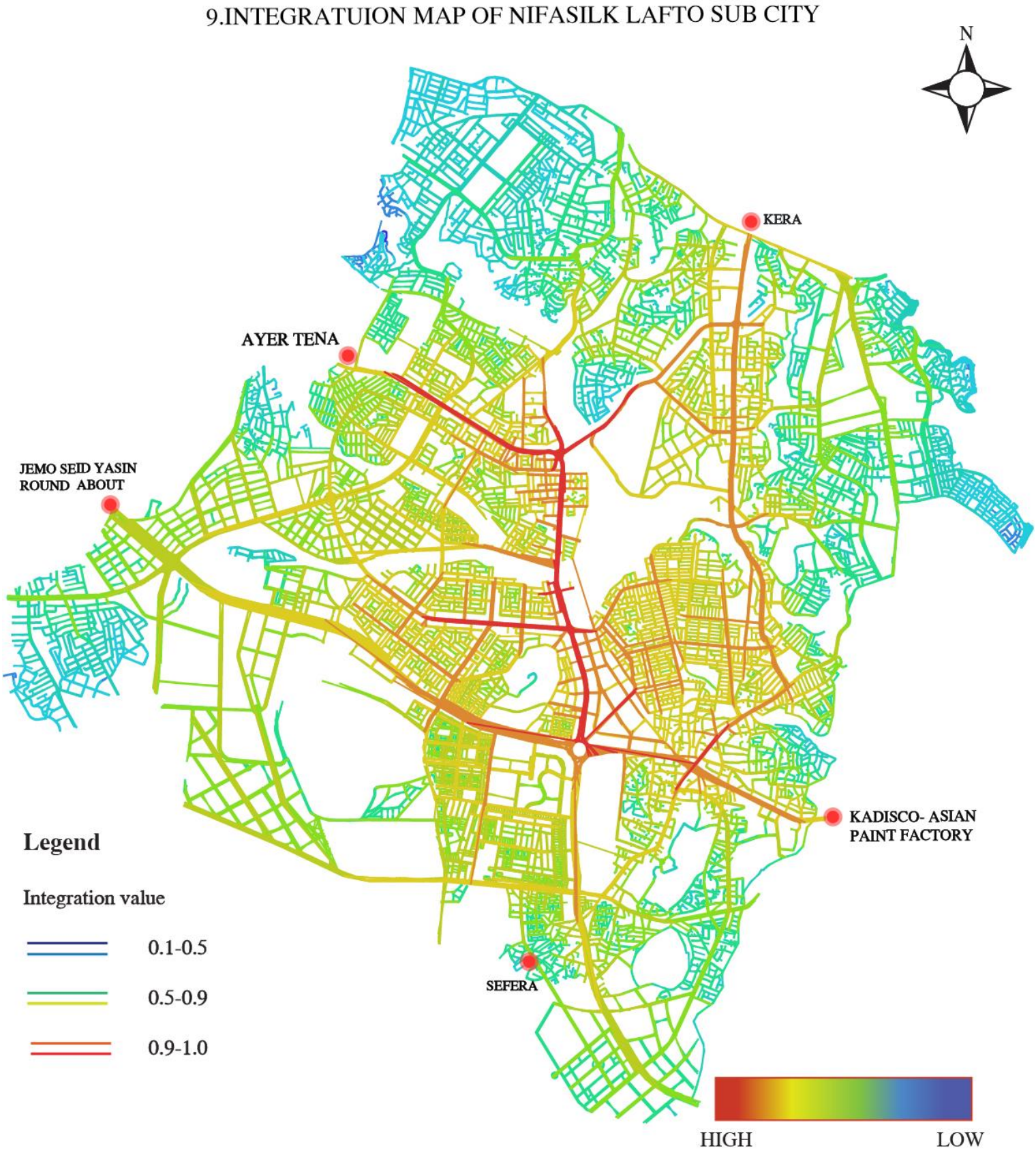


Figure 4.9(a) Integration map of Nifasilk Lafto sub-city

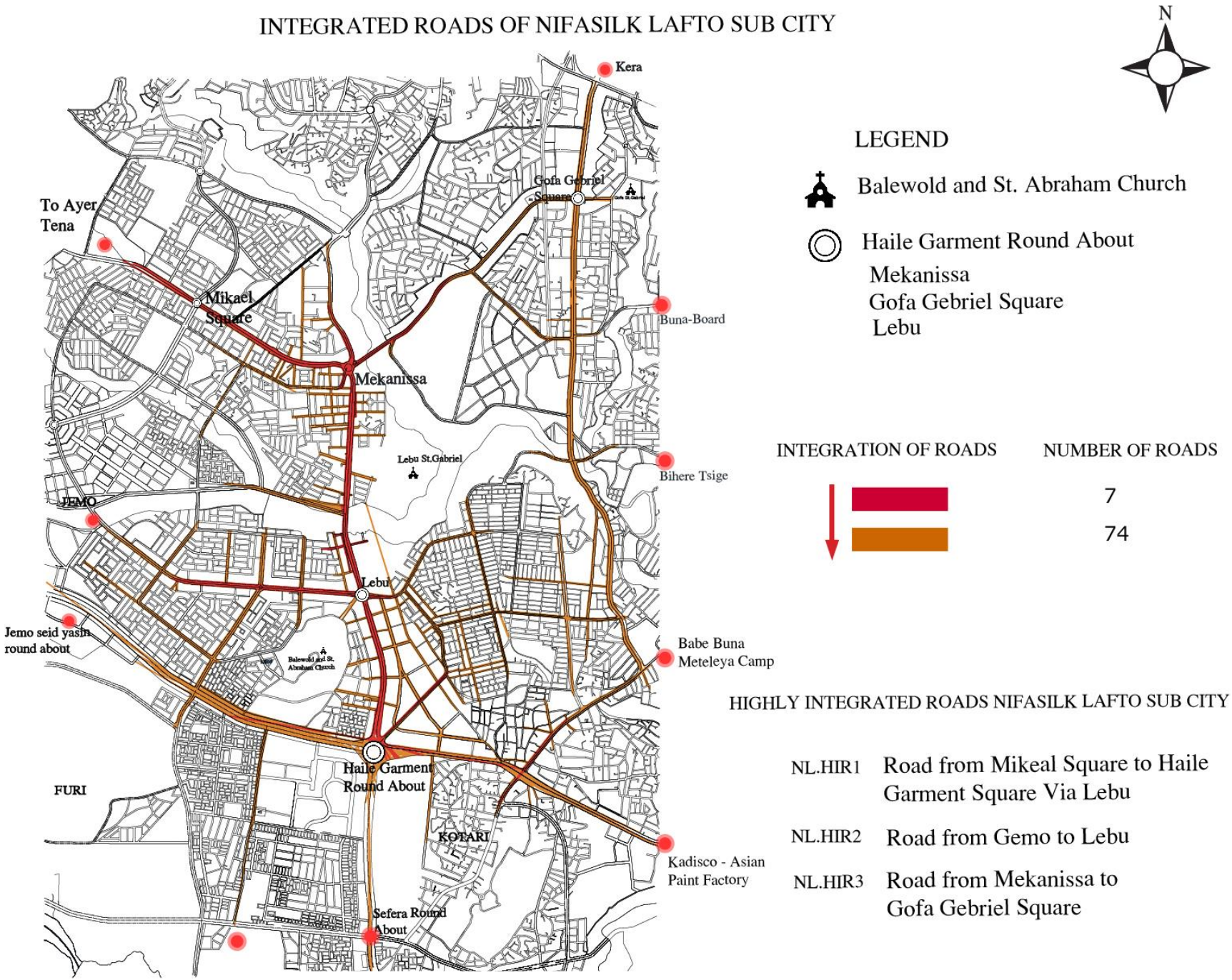


Figure 4.9(b) Integrated roads of Nifasilk Lafto sub-city

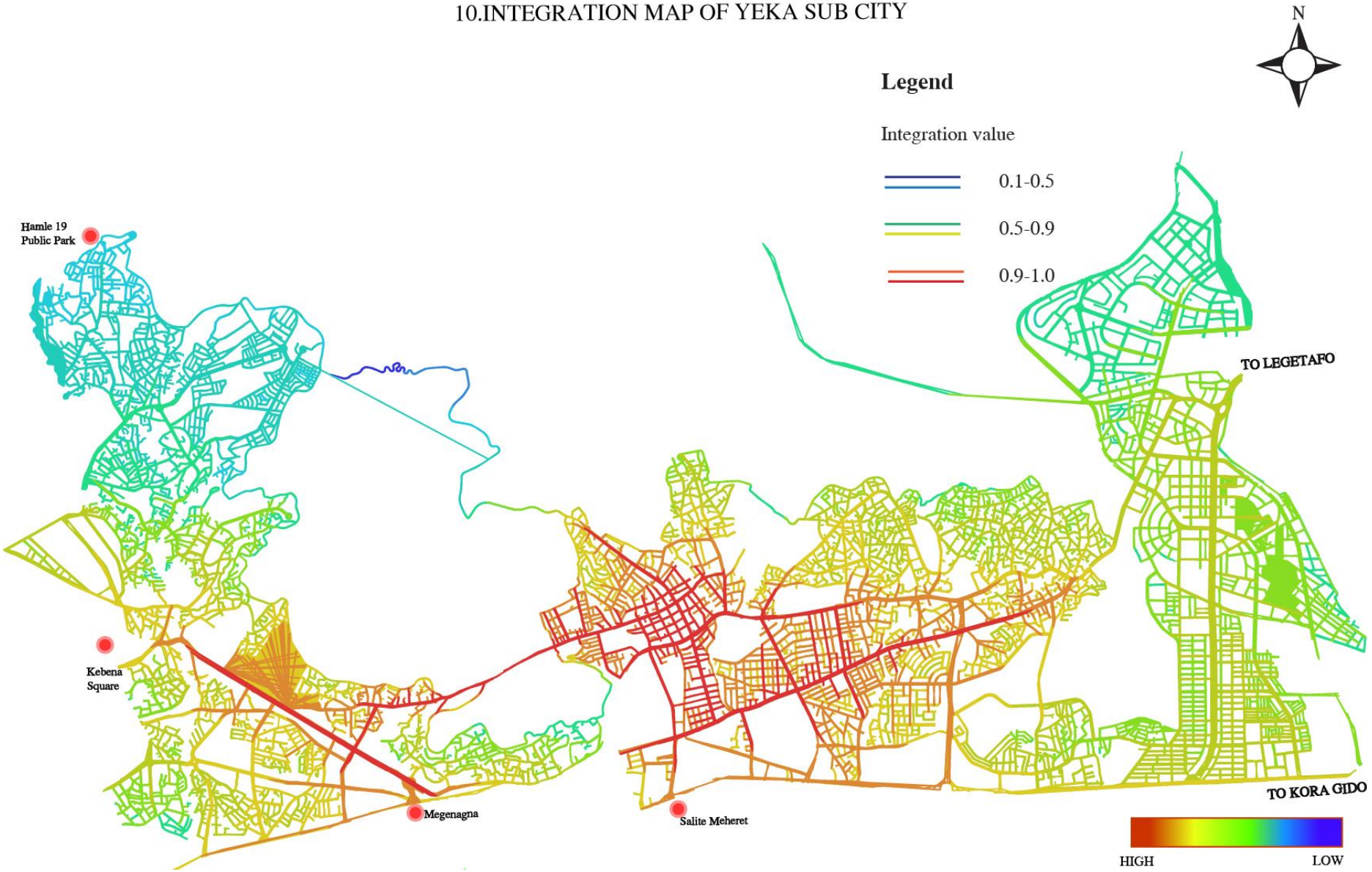


Figure 4.10(a) Integration map of Yeka sub city

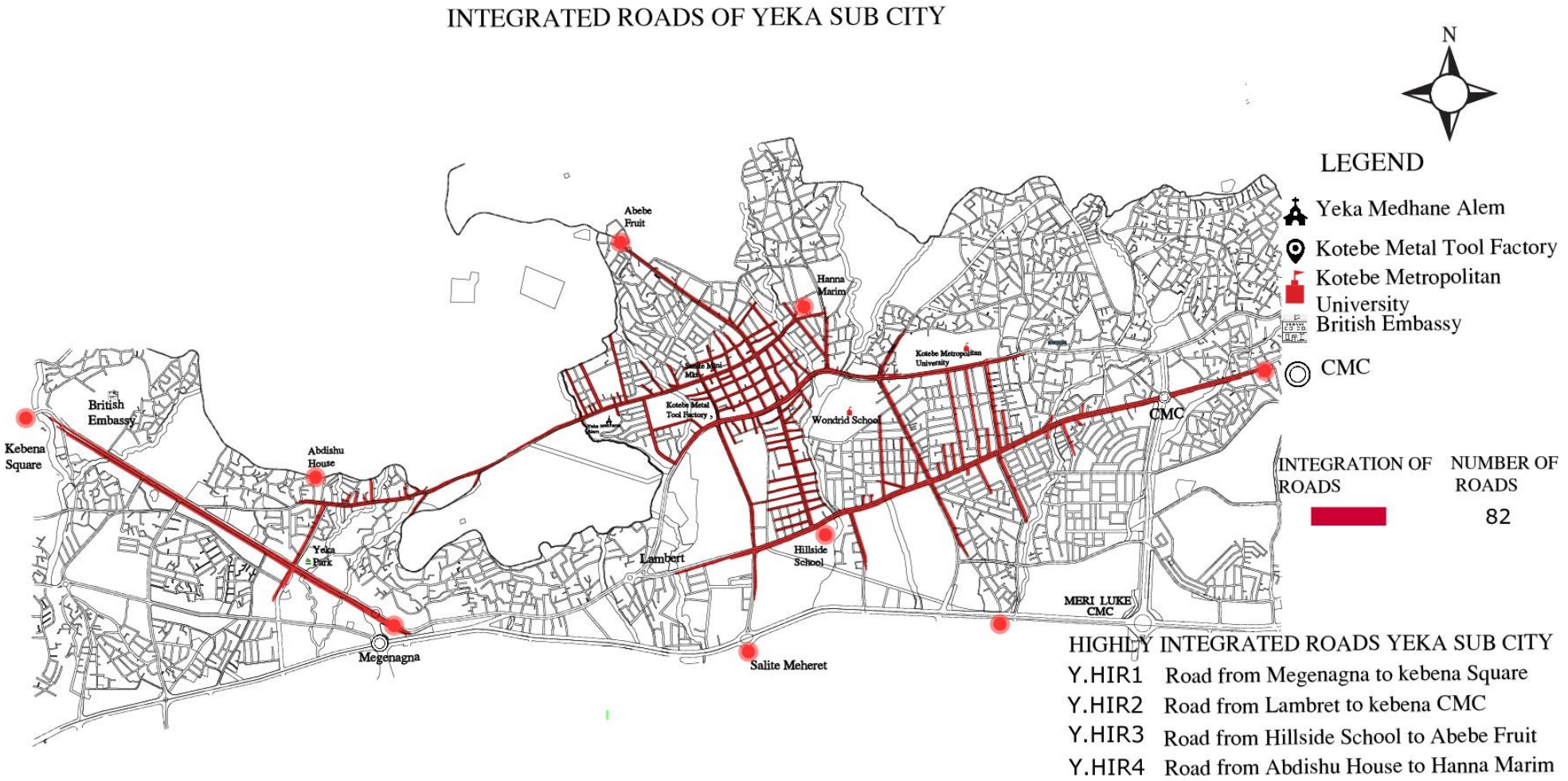


Figure 4.10(b) Integrated roads of Yeka sub city

11. Potential roads of Addis Ababa city.

Addis Ababa is the capital city of Ethiopia. It covers an area of approximately 527 km2. From the total area only 4% of the area covered by highly integrated roads which means core area of the city (Figure 4.11). It covers some parts of Kirkos, Lideta, Arada, and Adiss Ketema sub-cities and 28% covered in integration (0.5-0.9) this is shown in Figure4.12.

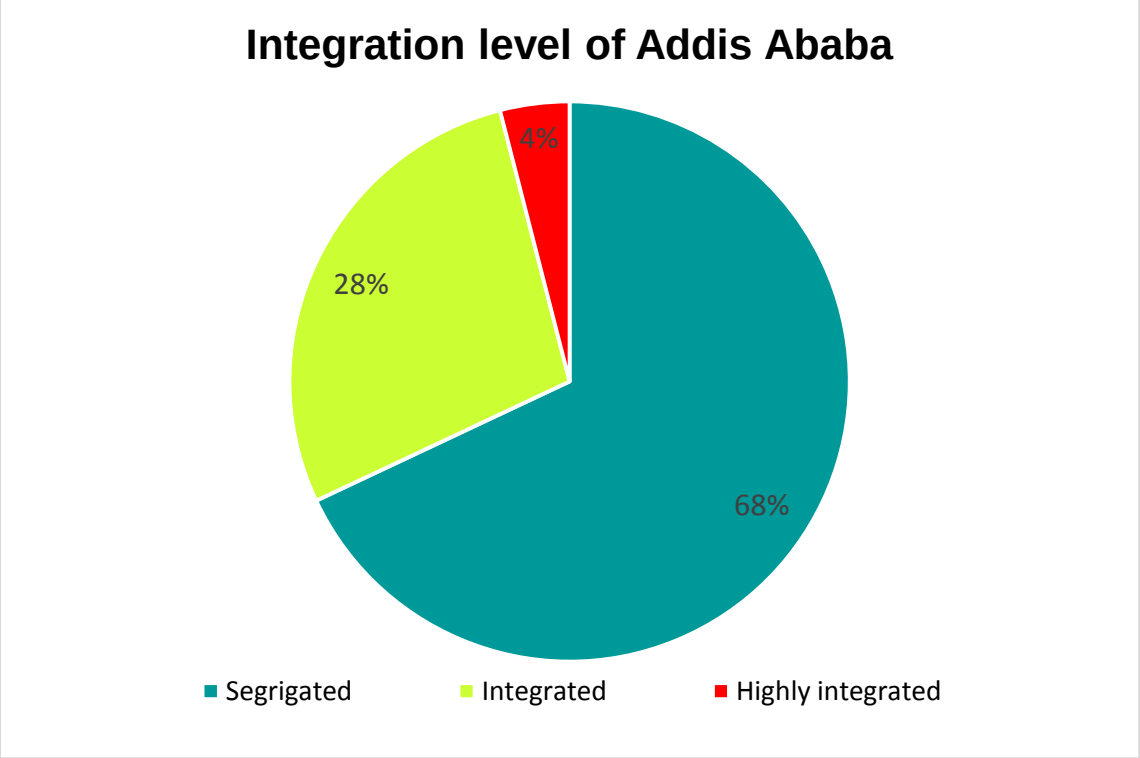


Figure 4.11. Integration level of Addis Ababa

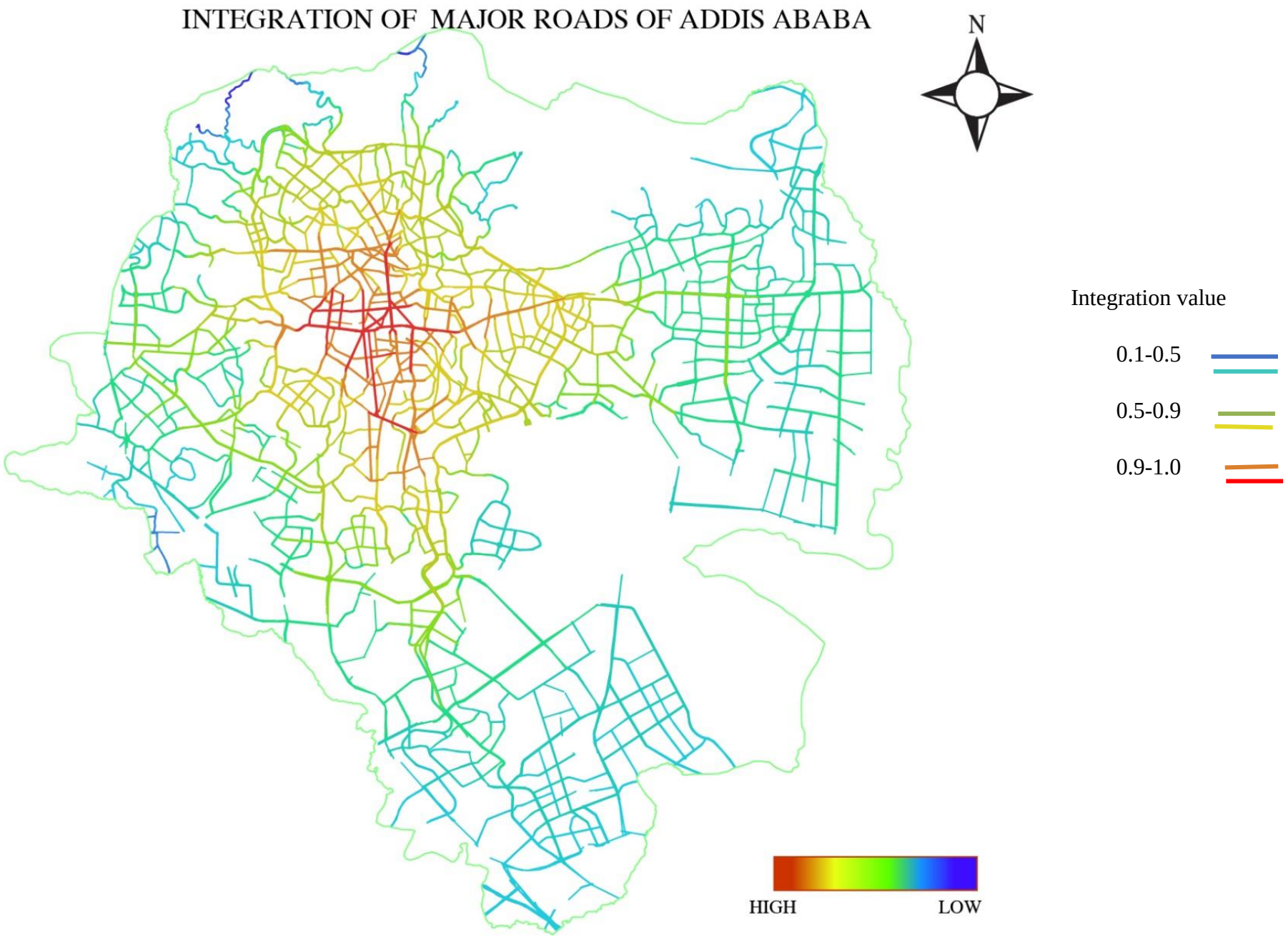


Figure 4.12. Integration map of Addis Ababa city

Sample Street Design for Addis Ababa City

Sample street was selected according to integration map analysis. From total Addis Ababa city Kirkos sub-city is highly integrated and It has majorly four highly integrated roads such are, Proposed Road from AU to Kirkos sub-city Administration Via Meshualikiya, the road from St. Yared Square to Washington Square, the road from Riche to Meskel Square and the road from Mexico to Kera. Finally select the road from Mexico to Kera as a sample potential road that can be change easily to street. And analysis of selected road is shown in figure4.13.

Highly integrated roads have a high degree of accessibility or reachability which is important for creating vital urban centers and generating economic activities within them. So the road from Mexico to Kera shares such benefits to easily change to the quality street since its highly integrated road.

According to Prelovskaya & Levashev study in the Modern approach of street space design, hear it is the indicator for designing street for the attractiveness of people.

- Variety of objects of attraction: more than 5 out of 9 different types of functions are found on the road network site (development of mixed-use)
- Generation of objects of attraction: more than 1158 persons/h by 100 m of street space based on quartiles of the distribution of measurement results
- Availability of street fittings, active ground floors of buildings, architectural and landscape design (Prelovskaya, 2007)

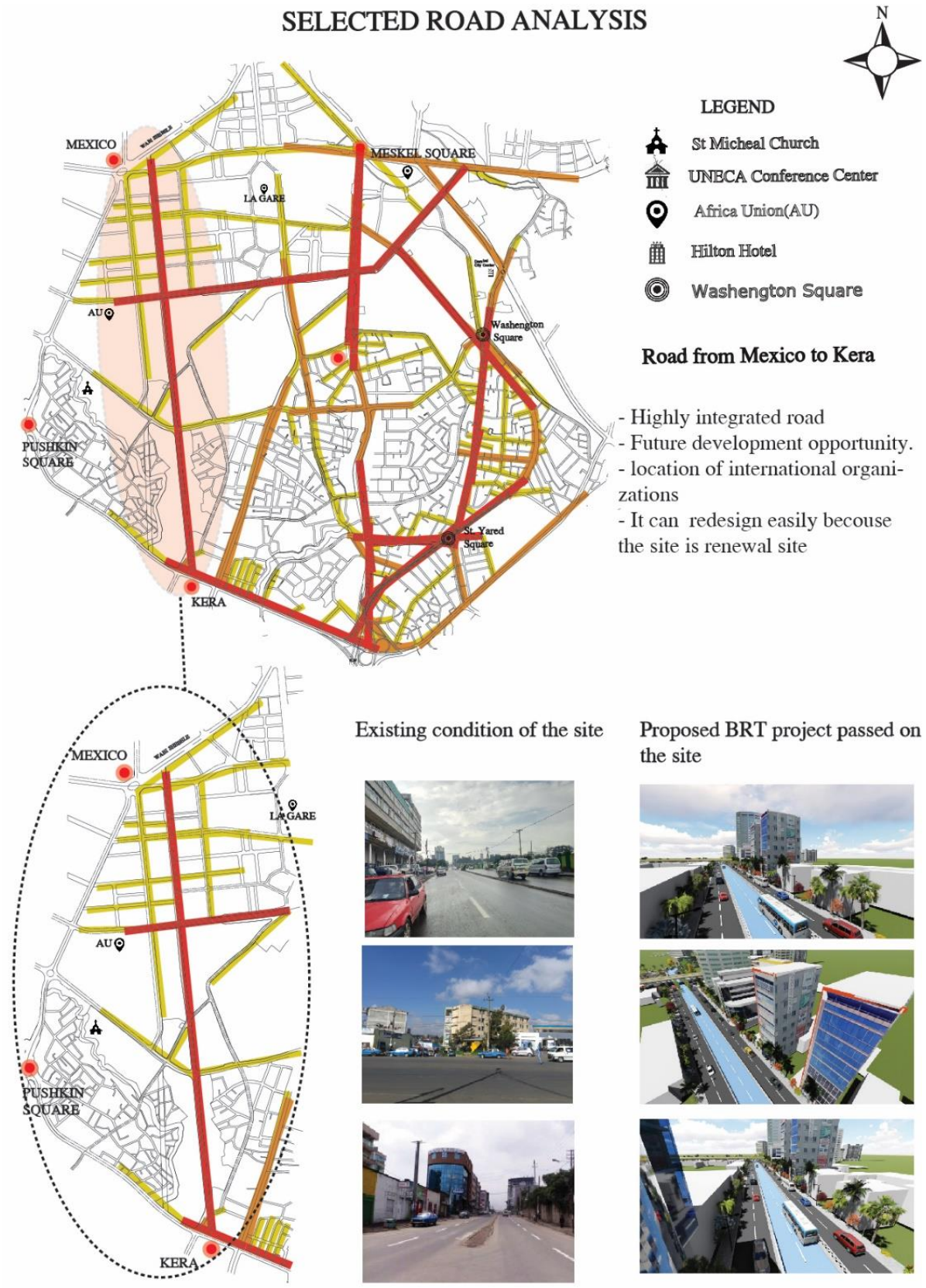


Figure 4.13 Site analysis of selected road

There are also different street design elements for various street user groups to successfully carry out their activities. Examples of the kinds of activities and corresponding infrastructure requirements for street Place users are shown in Table 4.1

Tabel 4.1 infrastructure requirement for various kinds of activities

Place street user group	**Street activity**	**Infrastructure requirement**
Car user, motorcyclists, cyclists	Parking	Parking space Adequate lighting
Van/lorry user	Loading/unloading	Loading provision and Adequate lighting
Bus operators	Boarding/alighting	Protected curbside at bus stops, Easy access for mobility restricted passengers, and Adequate lighting
Bus passengers	waiting	Shelter and seating, Lighting and security, and Service information
Pedestrian (strollers)	Window shopping, Queuing for services, Chatting for friends, Resting and Comfort break	Adequate lighting, Space to carry out their activity, Weather protection, Seating, Public toilet, and Litter bins

(source: Jones et al, 2008)

Using the above table and site analysis of selected road, develop street concept how to change Mexico to kera road to a quality street and its presented in figure 4.14(a) and (b). To creat workable vibrant space the road become devided in three zones and designed having different

activity by concidering currnt and upcoming future of the selected site and its presented in Figure 4.15(a)&(b).

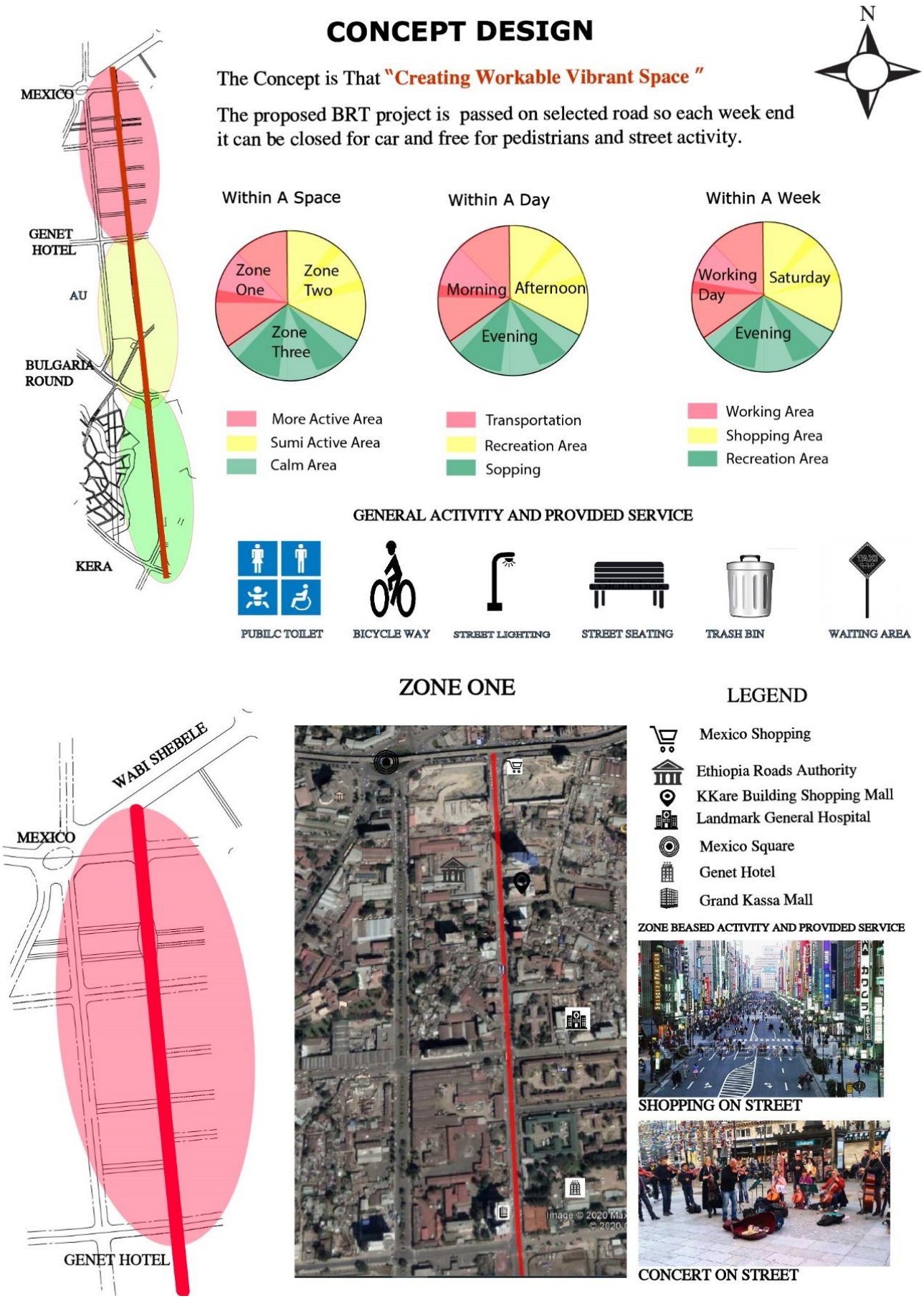


Figure 4.14(a) Concept design (zone one)

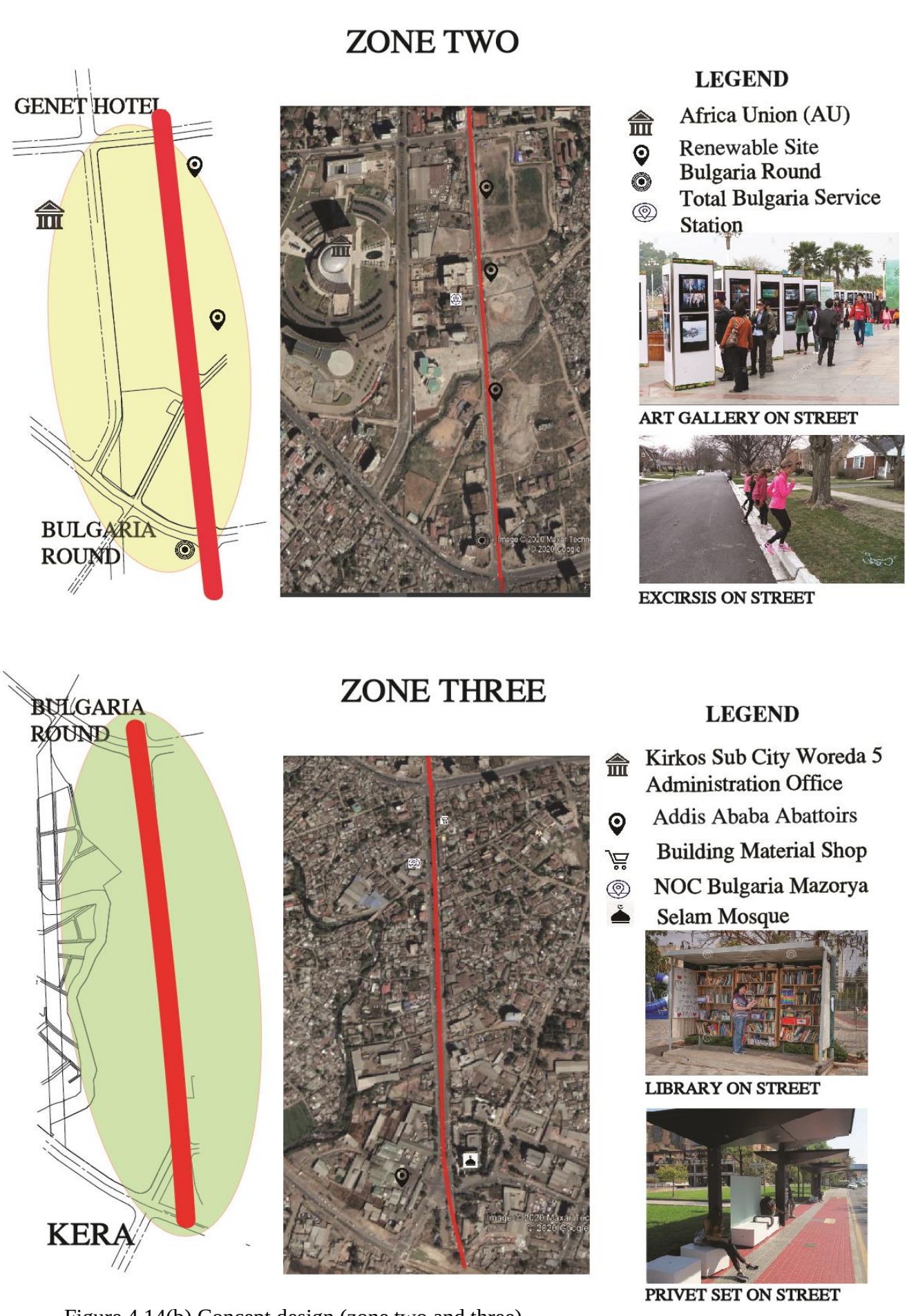


Figure 4.14(b) Concept design (zone two and three)

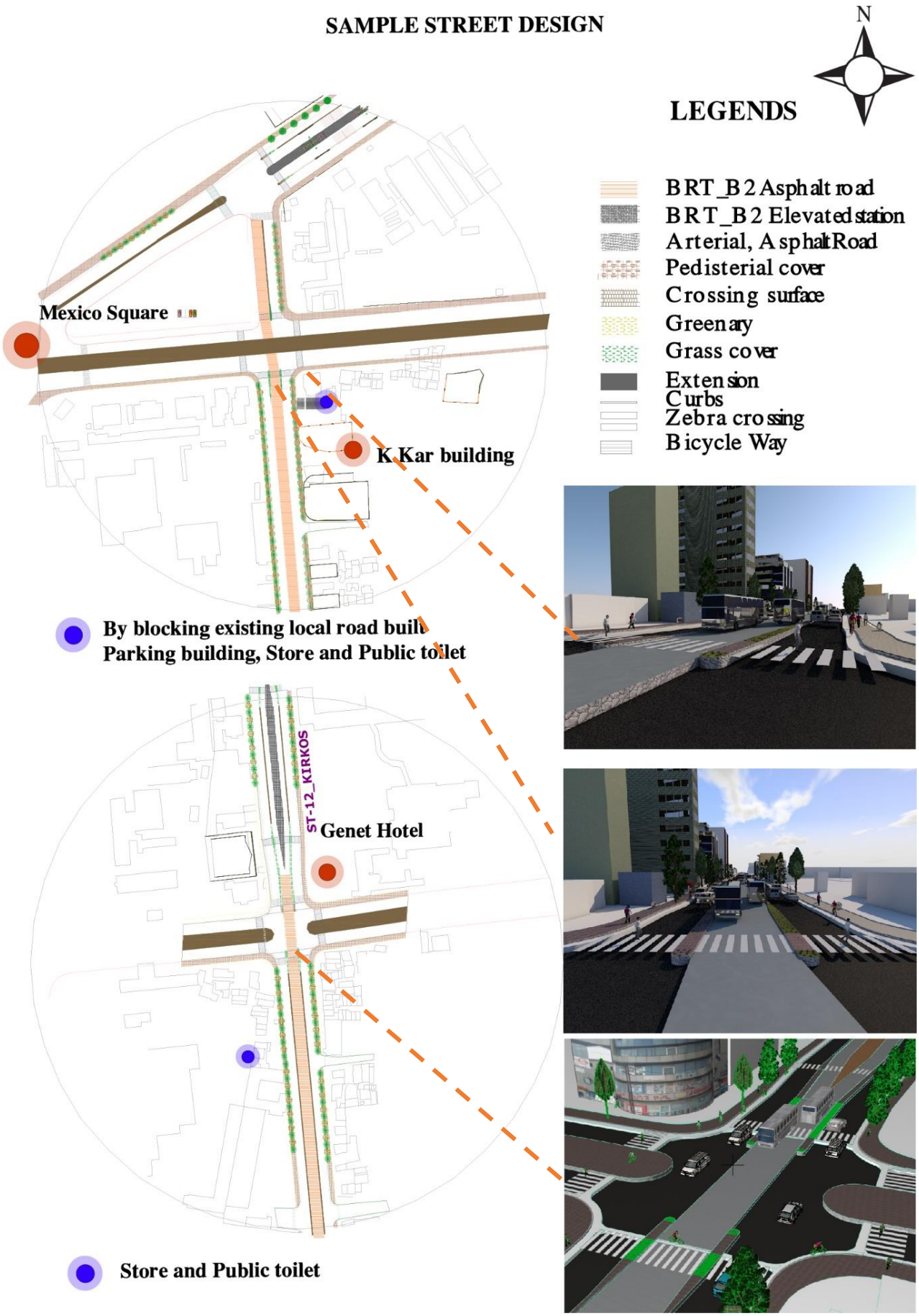


Figure 4.15(a) Sample street design (zone one)

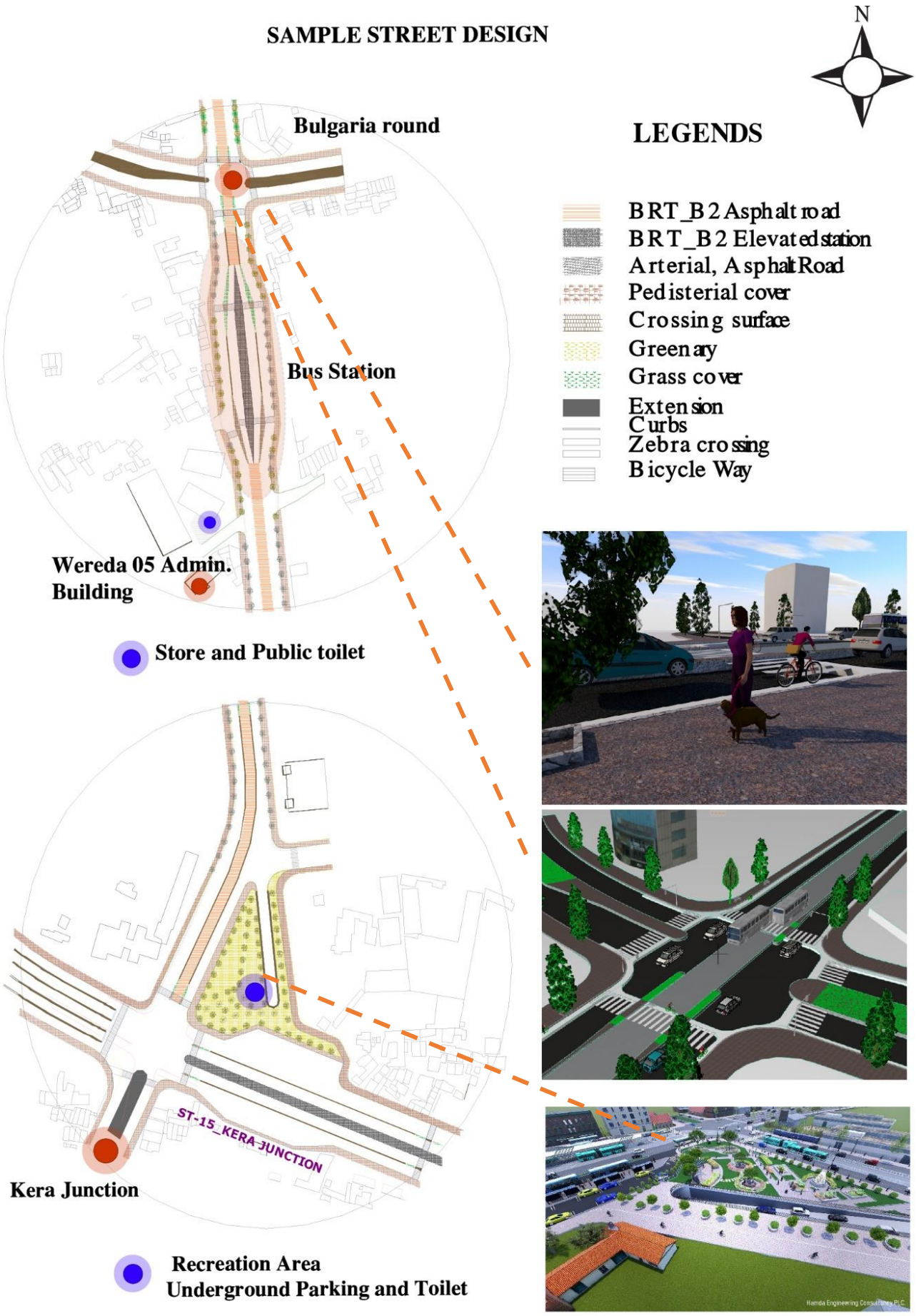


Figure 4.15(b)Sample street design (zone two and three)

4.2 The Depth of Addis Ababa City

The depth of the street indicates how far from the main road (transportation) so; the deepest road means highly segregated road. A general assumption is that highly segregated streets provoke anti-social behavior and criminal activities. These studies identified segregated area of each sub-city that need urgent intervention and presented under the following.

1. Depth of Addis Ketema sub city.

The scatter plot of mean depth versus integration of Addis Ketema sub city is shown in Figure 4.16(a). From the whole mean depth analysis (Figure 4.16(b)), four areas are selected as highly segregated area. Those areas are: the boundary of Tinishu Akaki River from Addis Ketema Park to Zulfa Snak, border of Muslim Grave Yard, from Queen's supermarket to Ethio Tebib general hospital via Yejoka hotel, from General Wingate square to Gullele Via Ethio Tebib General Hospital. Selected segregated areas are presented in Figure 4.16(c).

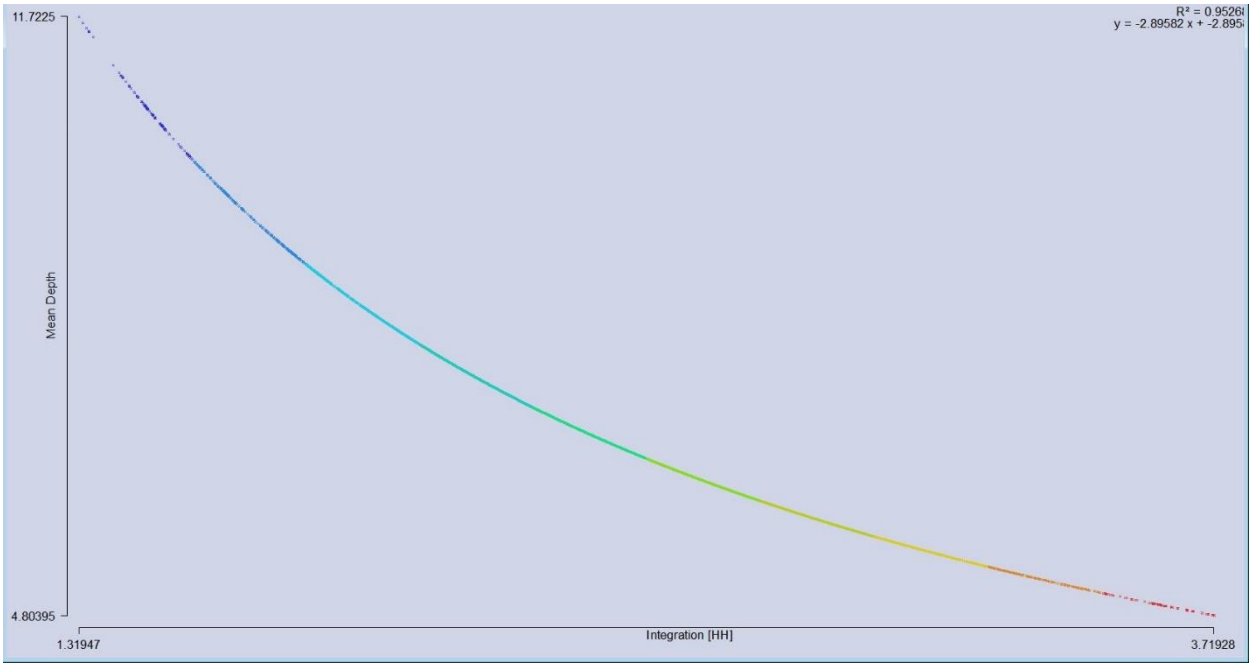


Figure4.16(a) Scatter plot of main depth versus integration of Addis Ketema sub-city

Figure 4.16(b) Mean Depth map of Addis Ketema sub city

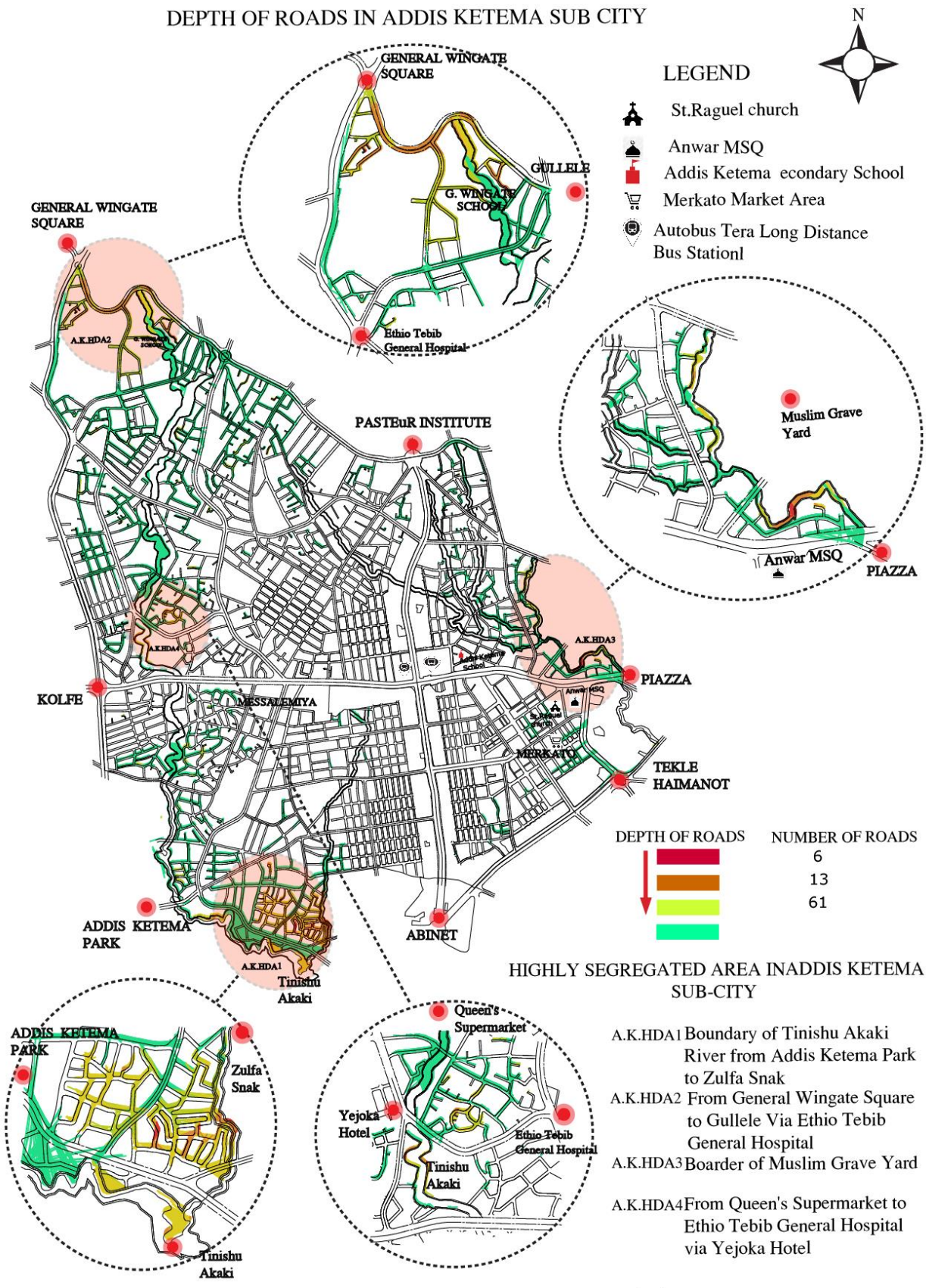


Figure 4.16(c) Depth of roads in Addis Ketema sub city

2. Depth of Akaki Kality sub city.

The scatter plot of mean depth versus integration of Akaki Kality sub city is shown in Figure 4.17 (a). From the whole mean depth analysis (Figure 4.17(b)), six areas are selected as highly segregated area. Those areas are: Edge of Koye Fetche Condominium site, Around Derartu Tulu preparatory school, from Akaki Steel Factory to Akaki Beseka, area of Abebe Mulugeta coffe factory and Mango Mosque, Saris Addisu Sefer and Entrance to Koye Fetche Condominium site. Selected segregated areas are presented in Figure 4.17 (c).

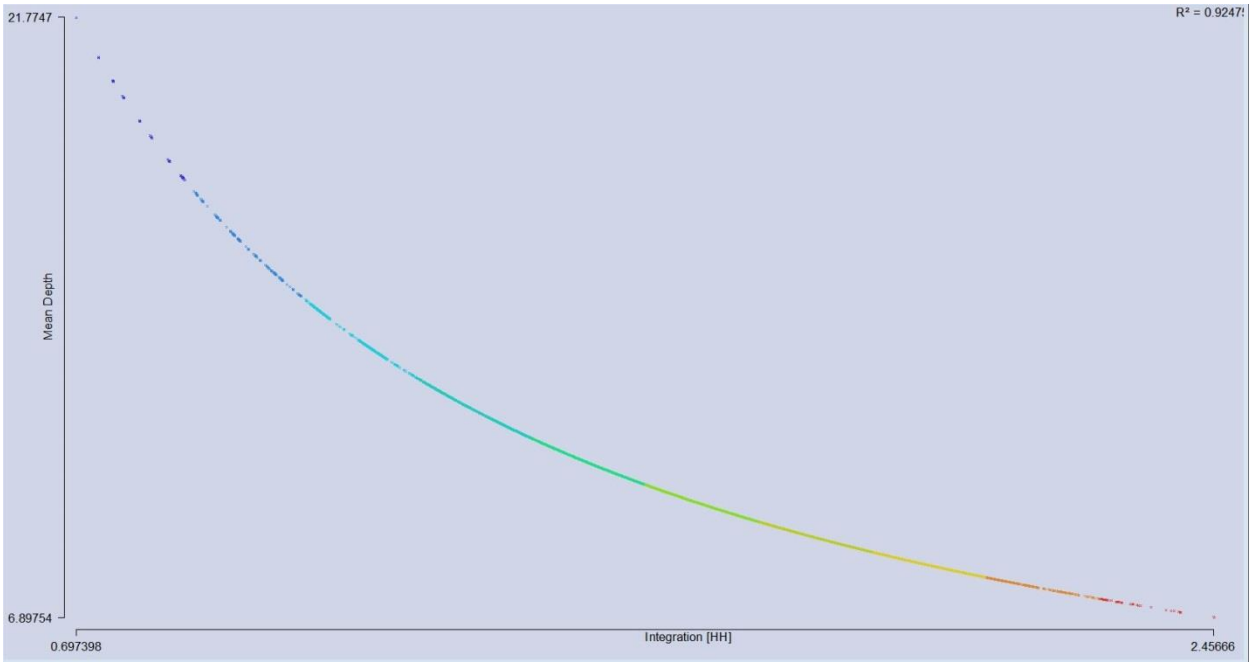


Figure4.17 (a) Scatter plot of main depth versus integration of Akaki Kality sub-city

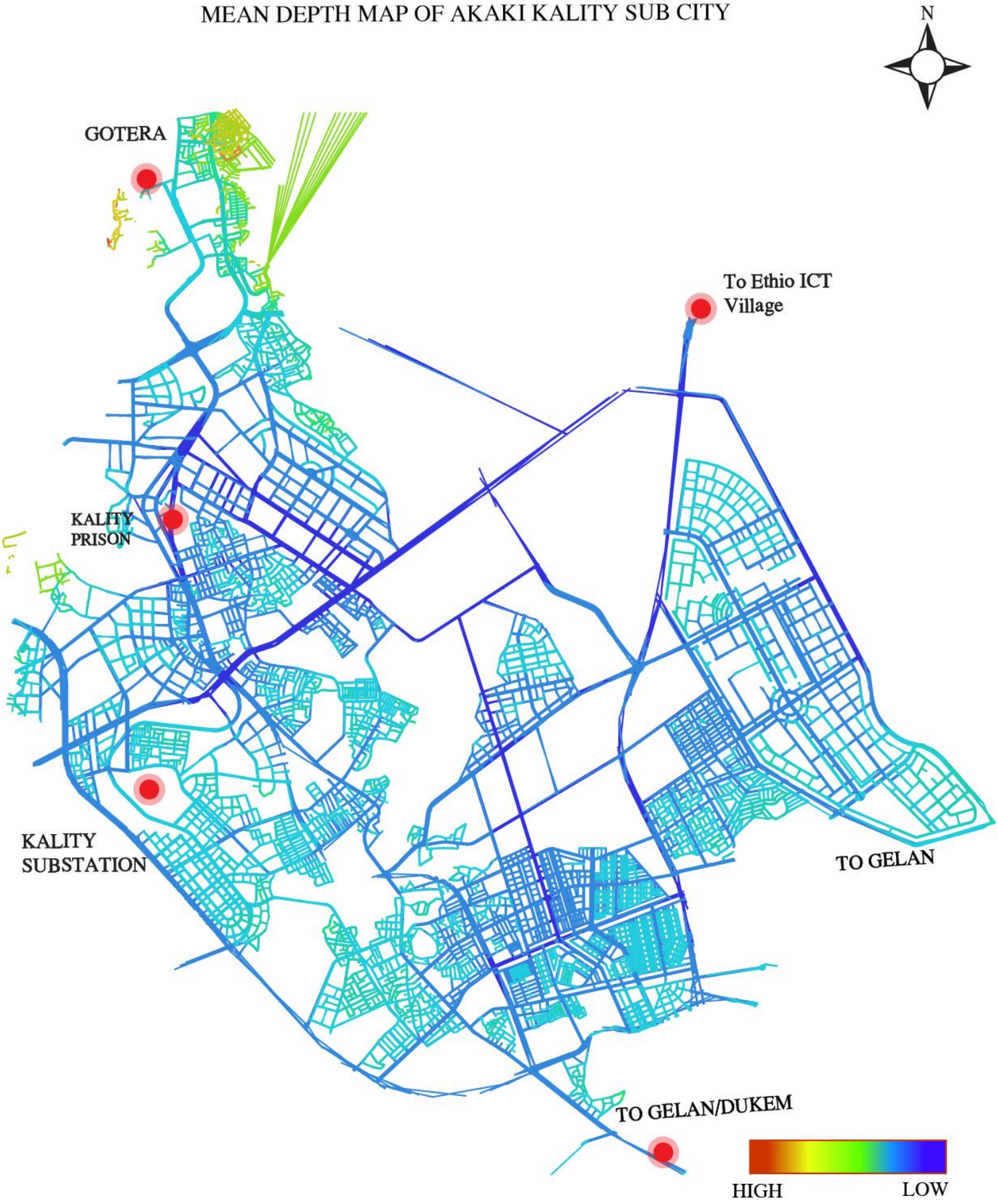


Figure 4.17 (b) Mean Depth map of Akaki Kality sub city

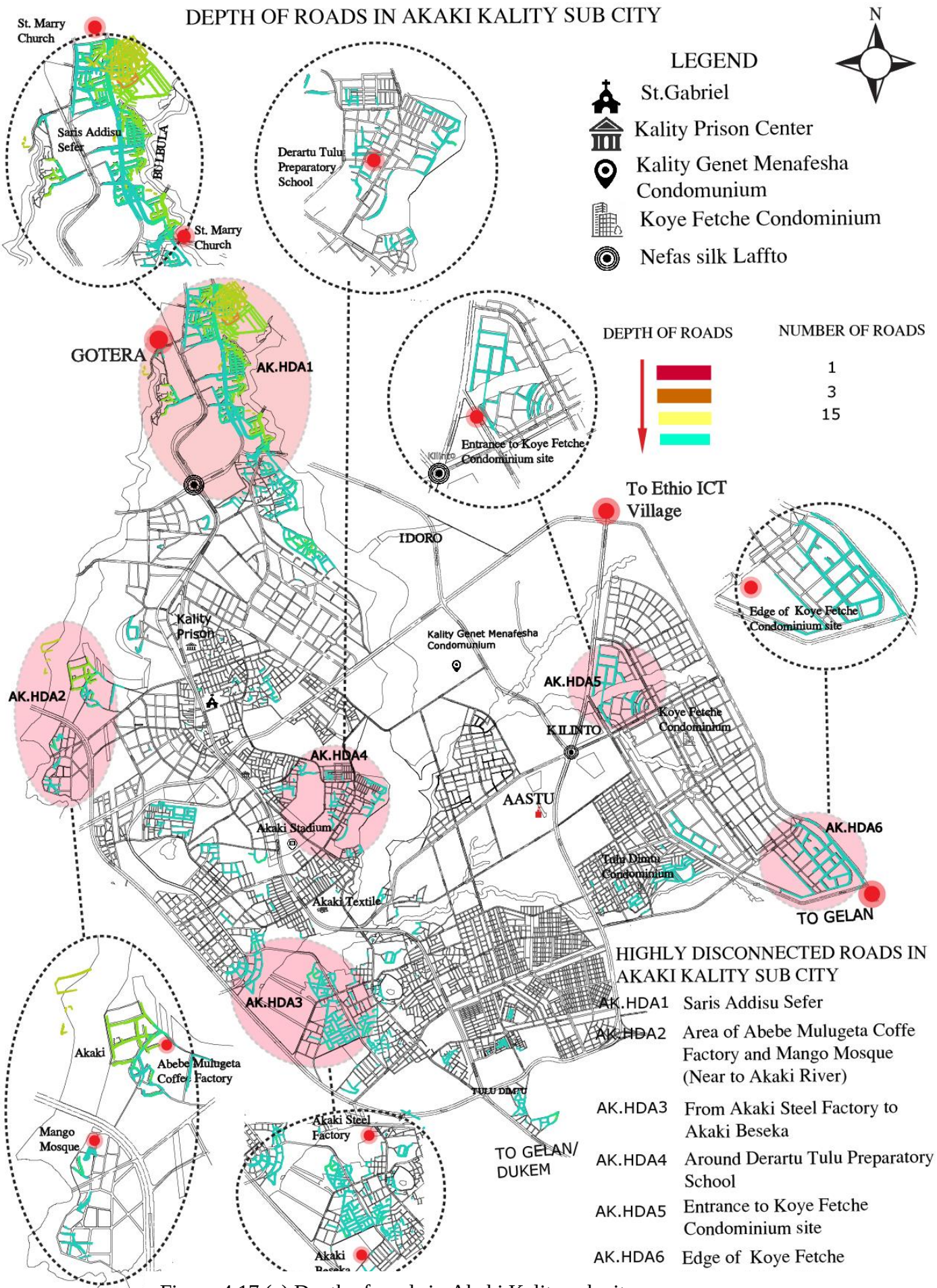


Figure 4.17 (c) Depth of roads in Akaki Kality sub city

3. Depth of Arada sub city.

The scatter plot of mean depth versus integration of Arada sub city is shown in Figure 4.18(a). From the whole mean depth analysis (Figure 4.18(b)), two areas are selected as highly segregated area. Those areas are: The area surrounded by Enkulal Sefer Condominiums, St. Gabriel Catholic Church, and Bethel Mekene Eyesus and the area surrounded by Jan Meda, Menelik II Referal Hospital, Kebena Square, Asra Amest Meda, and Holy Trinity Cathedral. Selected segregated areas are presented in Figure 4.18(c).

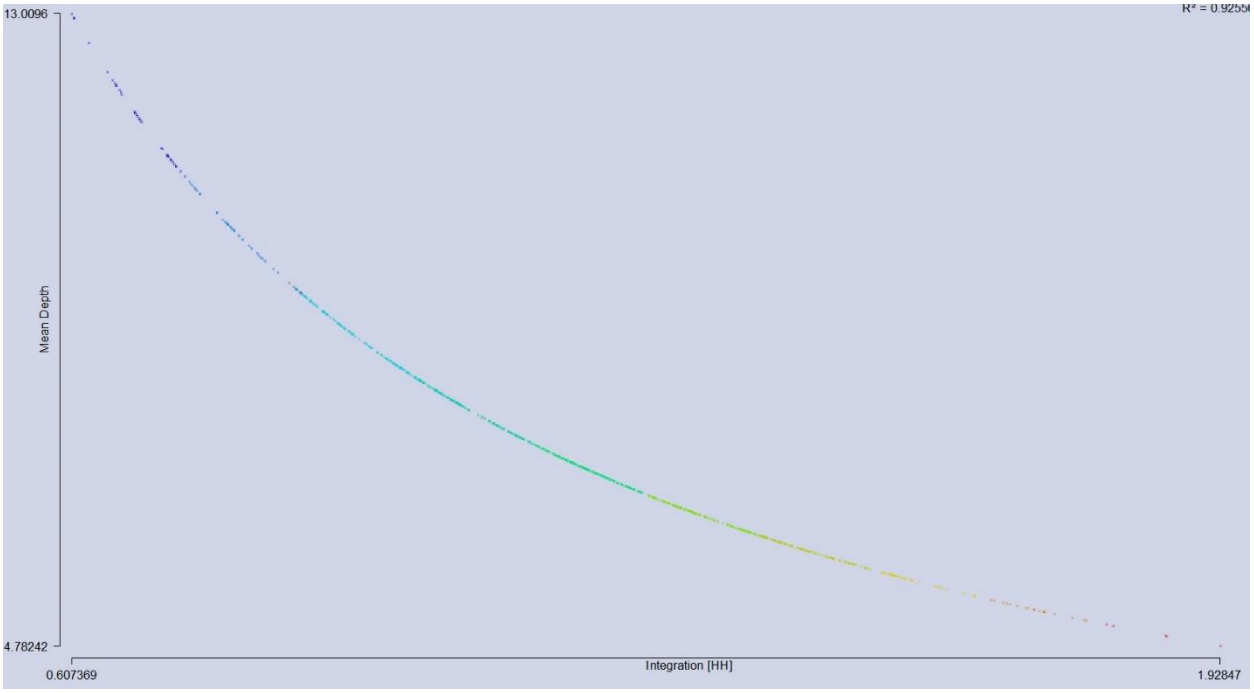


Figure 4.18(a) Scatter plot of main depth versus integration of Arada sub-city

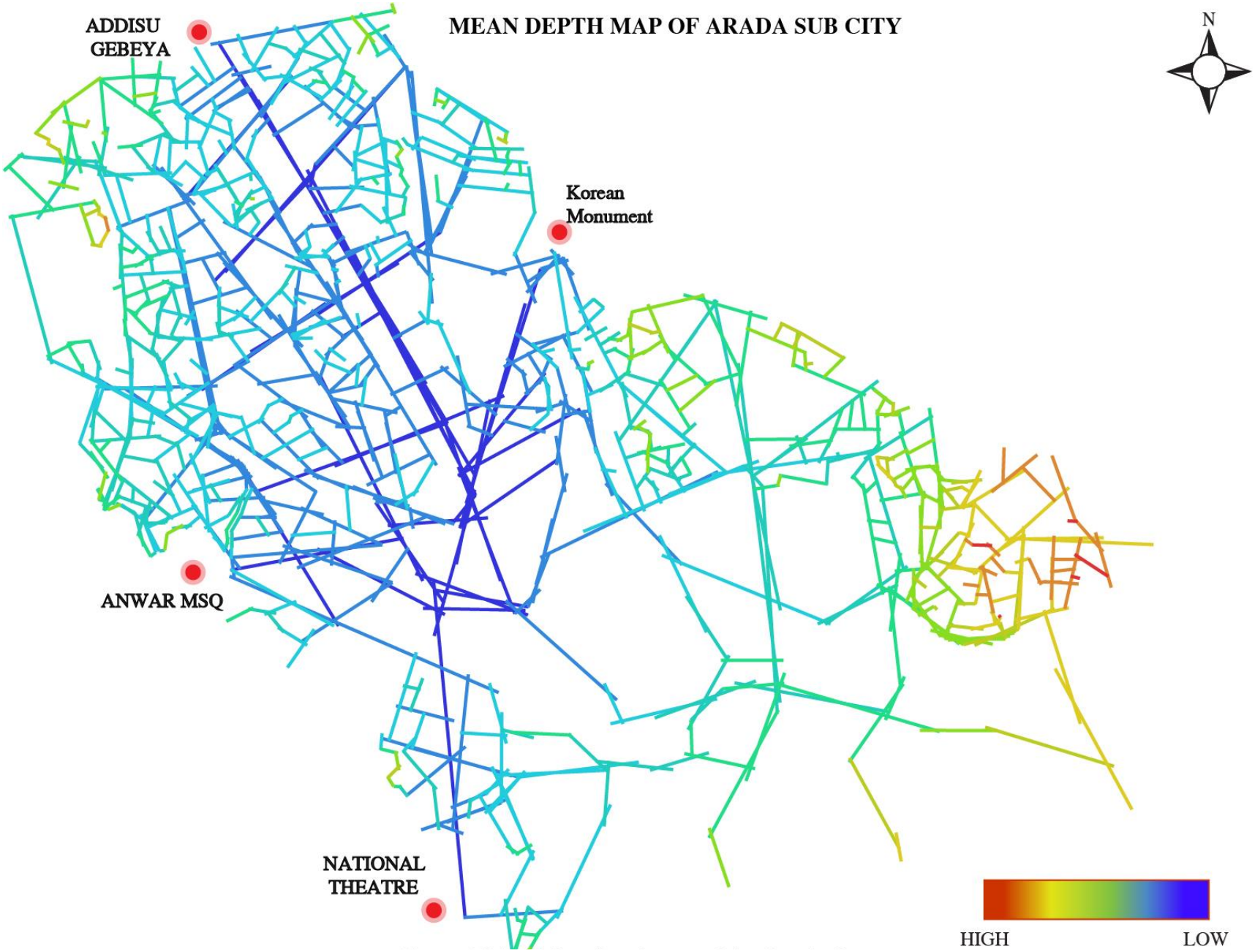


Figure 4.18 (b) Mean Depth map of Arada sub city

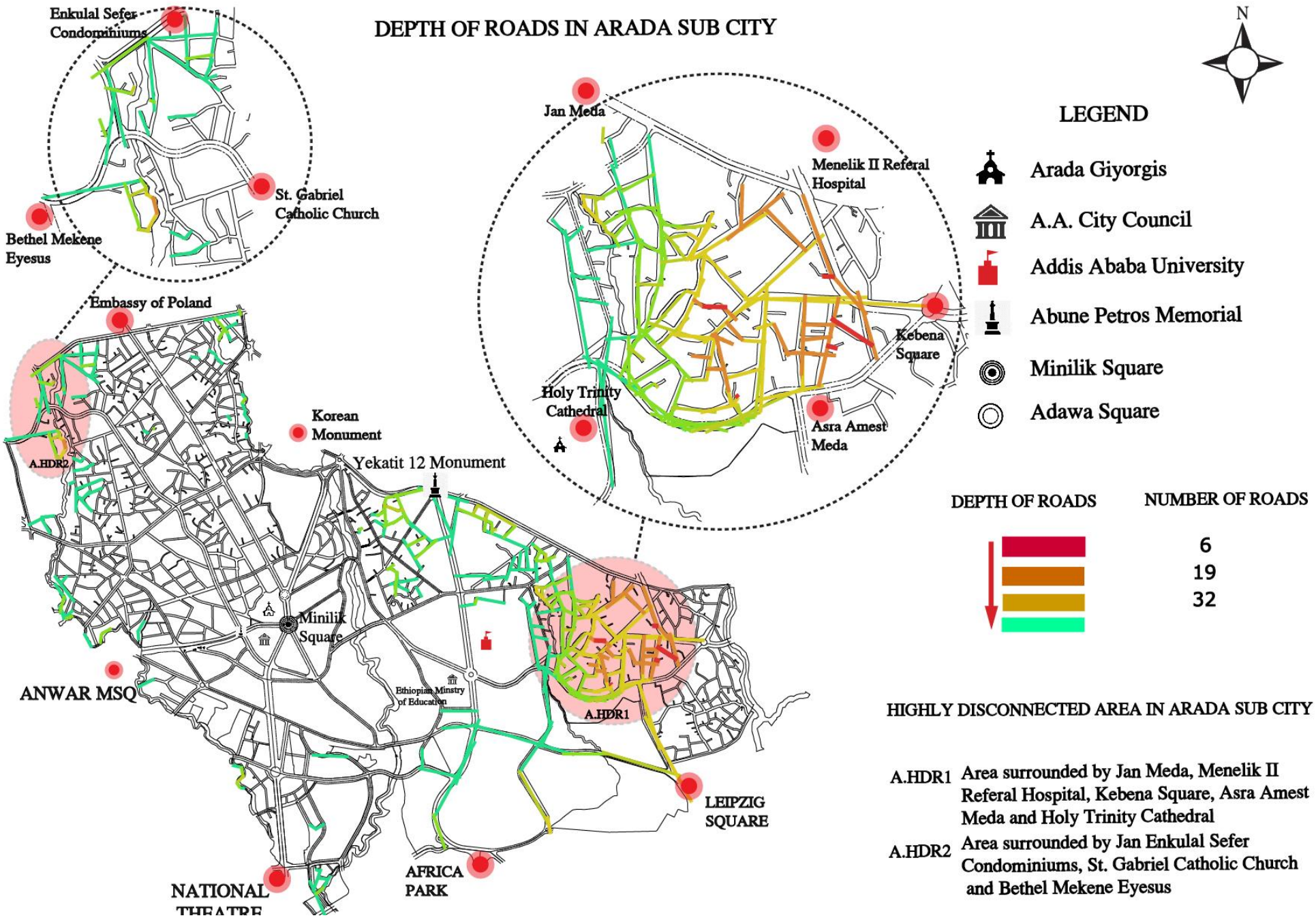


Figure 4.18 (c) Depth of roads in Arada sub city

4. Depth of Bole sub city.

The scatter plot of mean depth versus integration of Bole sub city is shown in Figure 4.19(a). From the whole mean depth analysis (Figure 4.19(b)), four areas are selected as highly segregated area. Those areas are: Bole Bulbula Site. Area Surrounded by Salite Meheret, Exotic Ethiopian Adventure and Selam Sefer, Bashale condominium site. Bole Arabsa Site, and Border of Kebena River from Urael to Welo Sefer. Selected segregated areas are presented in Figure 4.19(c).

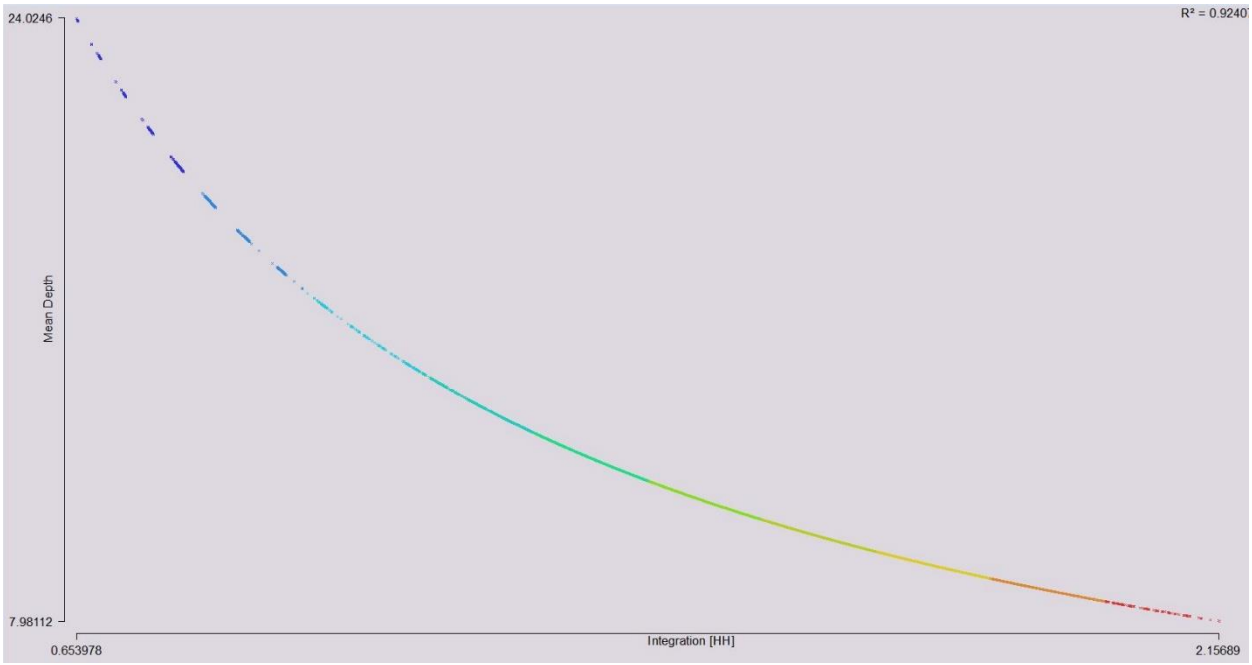


Figure 4.19(a) Scatter plot of main depth versus integration of Bole sub-city

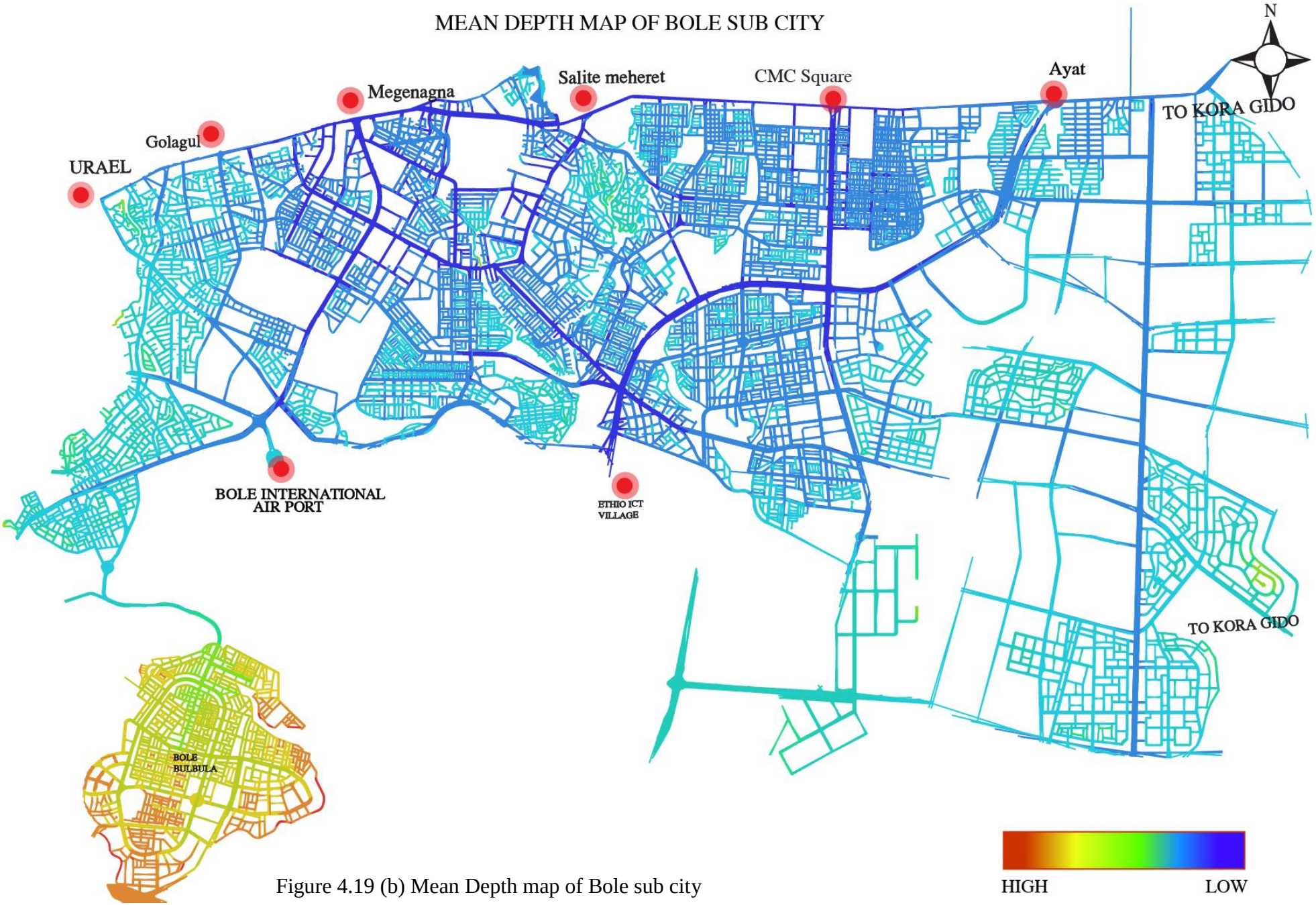


Figure 4.19 (b) Mean Depth map of Bole sub city

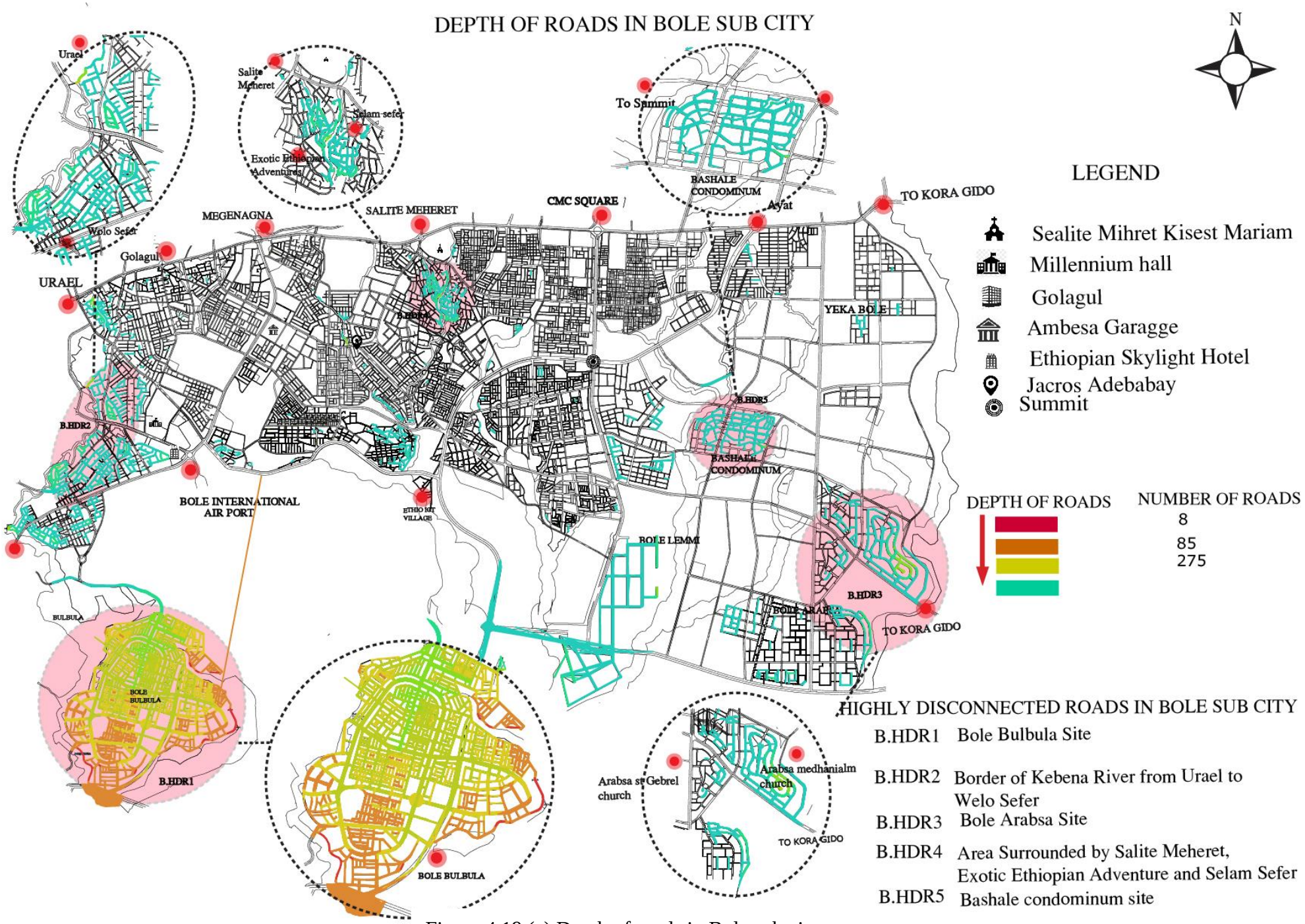


Figure 4.19 (c) Depth of roads in Bole sub city

5. Depth of Gullele sub city.

The scatter plot of mean depth versus integration of Gullele sub city is shown in Figure 4.20(a). From the whole mean depth analysis (Figure 4.20 (b)), six areas are selected as highly segregated area. Those areas are: The area surrounded by Eletel Primary School, Aba-Dula Garage, and Temesgen Dabo Bet. From Medhane Alem Preparatory school to Anbesa bus parking garage via the catholic church. Both side of Bantyketu River from Afencho Ber to Ketchene orphanage cump. Edge of Kebena river from Hamle 19 public park to Jan Meda. From Entoto Kidane Mehret church to St.Peter referal hospital Via Shiro Meda and from Medhane Alem church to Kidanemihret church Via Addisu Gebeya Condominium. Selected segregated areas are presented in Figure 4.20 (c).

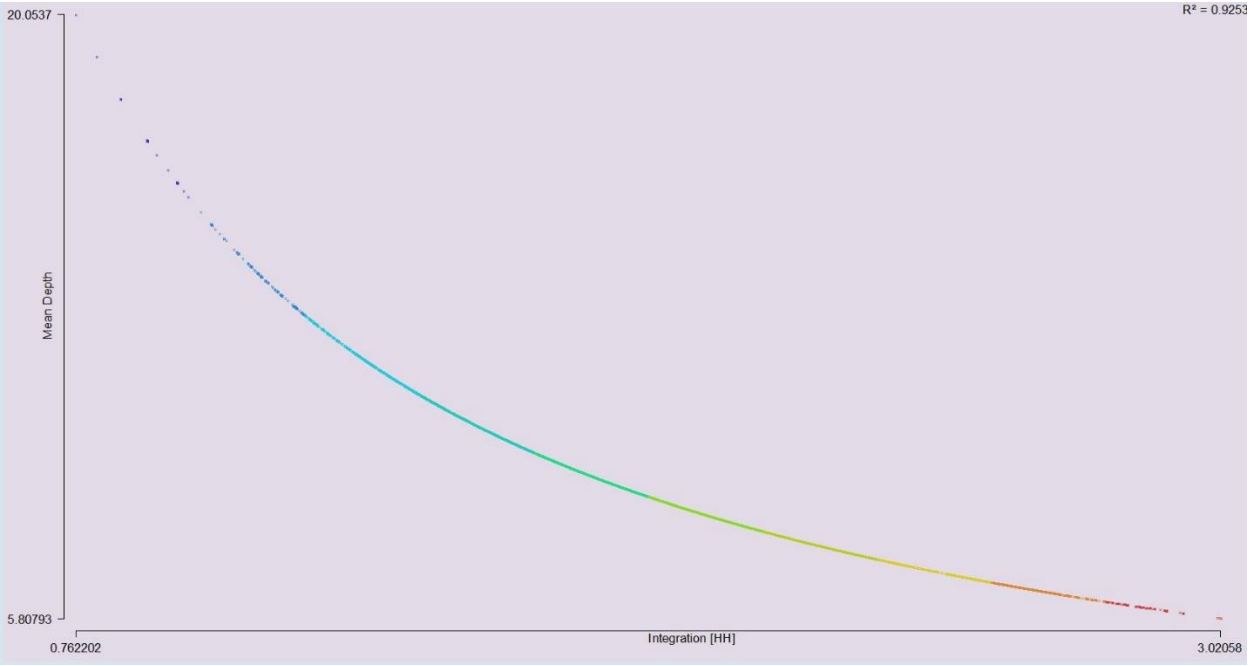


Figure 4.20 (a) Scatter plot of main depth versus integration of Gullele sub-

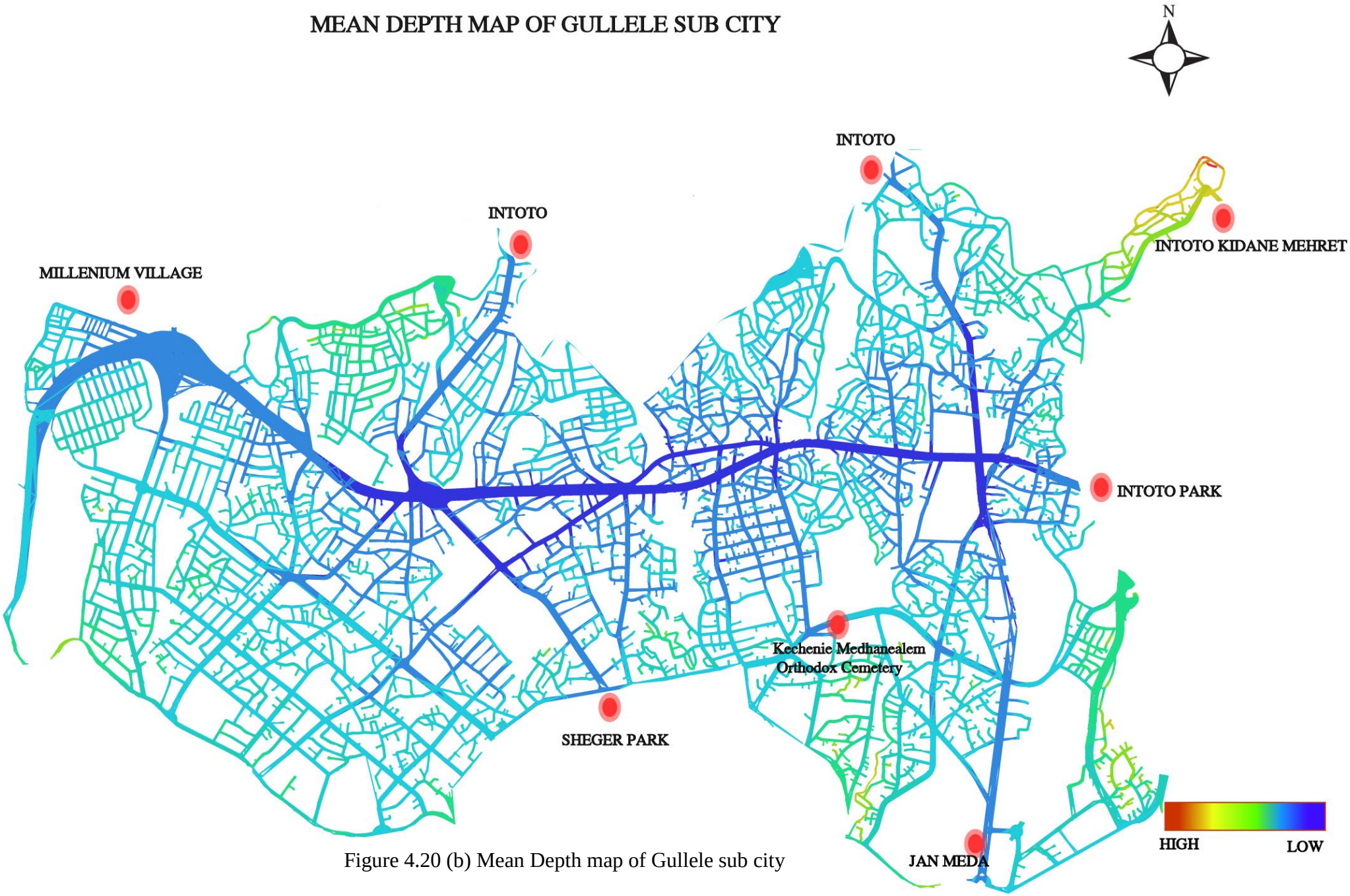


Figure 4.20 (b) Mean Depth map of Gullele sub city

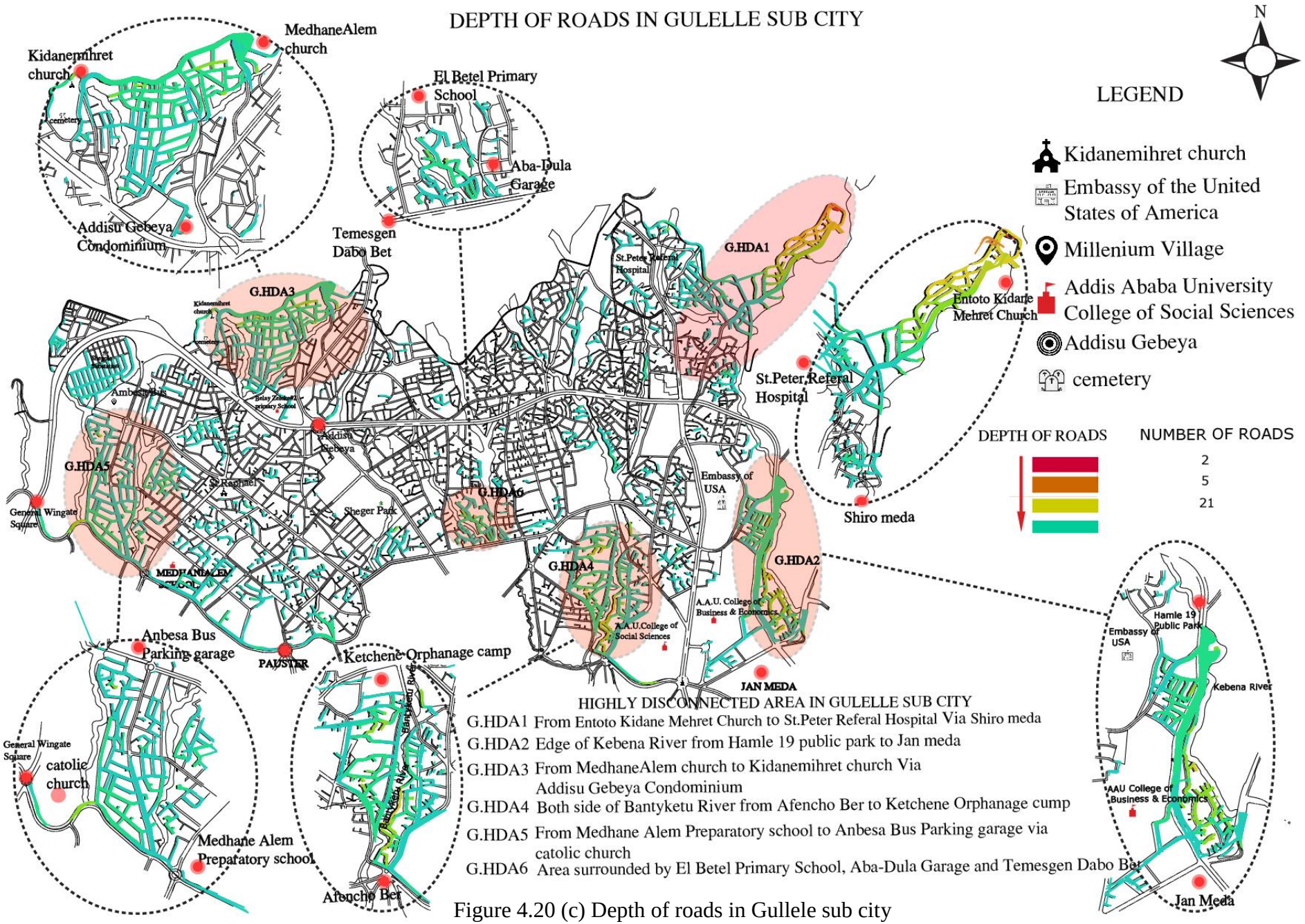


Figure 4.20 (c) Depth of roads in Gullele sub city

6. Depth of Kirkos sub city.

The scatter plot of mean depth versus integration of Kirkos sub city is shown in Figure 4.21(a). From the whole mean depth analysis (Figure 4.21 (b)), five areas are selected as highly segregated area. Those areas are: Border of Tinishu Akaki River from Embassy of Finland to Total Ethiopia ABATTOIRS Via Pushkin Square. Border of Bulbula River from Embassy of Turkey to Riverside Luxury Hotel Apartment Ethiopia. The area surrounded by St Gibi Gebriel, Hilton Hotel, UNECA Conference Center, and Kazanchis(EEPCo). From Lanchia to Zig Zag Hotel and Spa Via Gotera I Light Rail StationKebena River.The boundary from Urael to Enderase Via Kasanches Parking. Selected segregated areas are presented in Figure 4.21 (c).

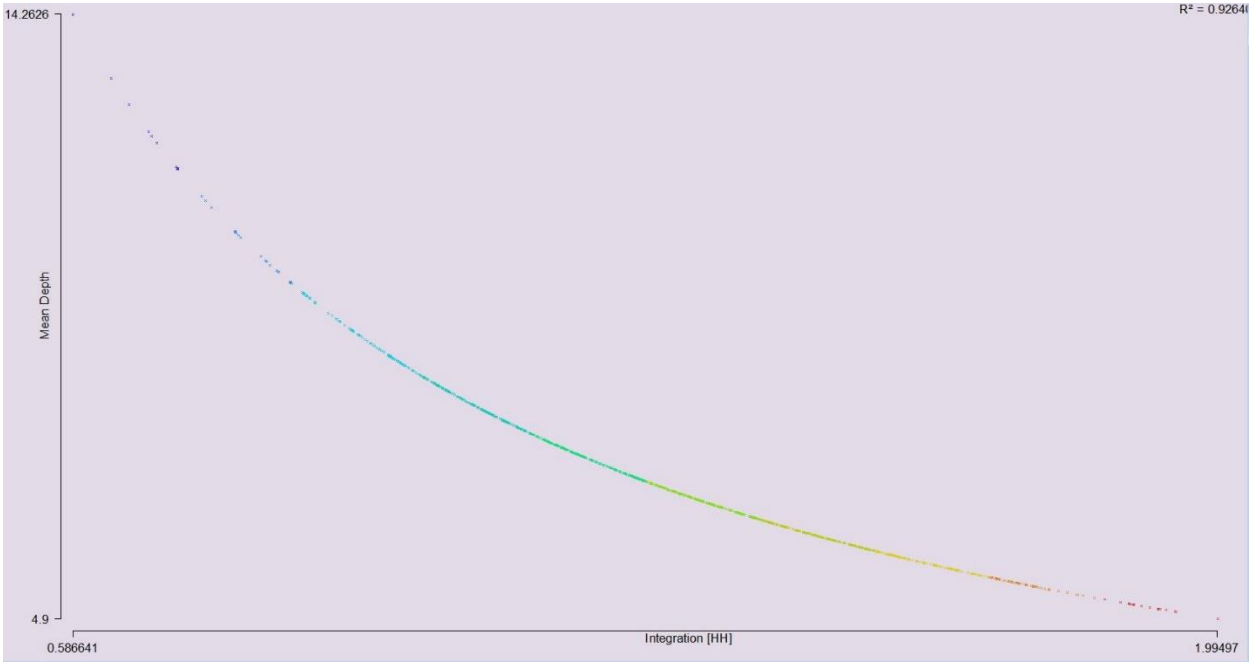


Figure 4.21 (a) Scatter plot of main depth versus integration of Kirkos sub-city

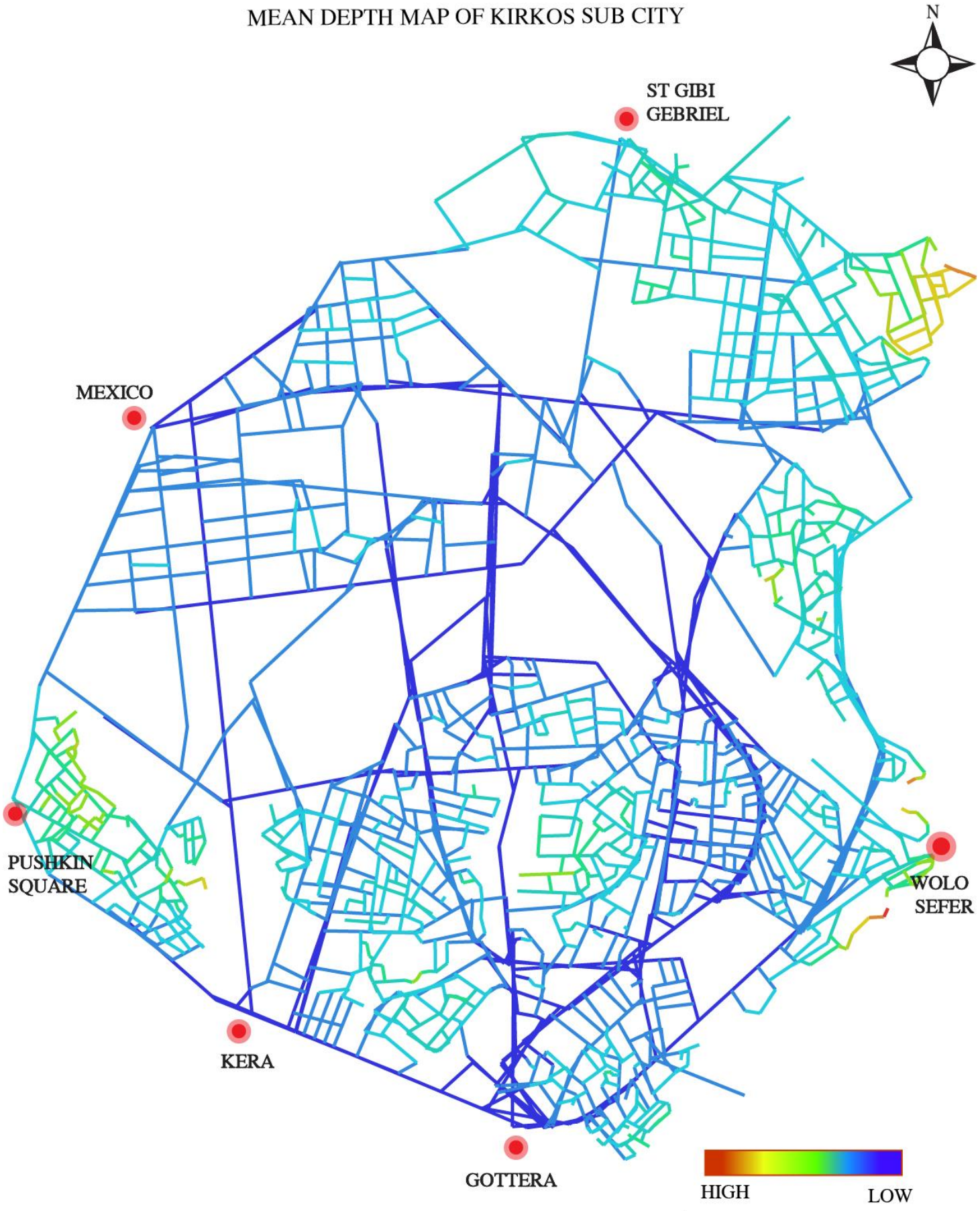


Figure 4.21 (b) Mean Depth map of Kirkos sub city

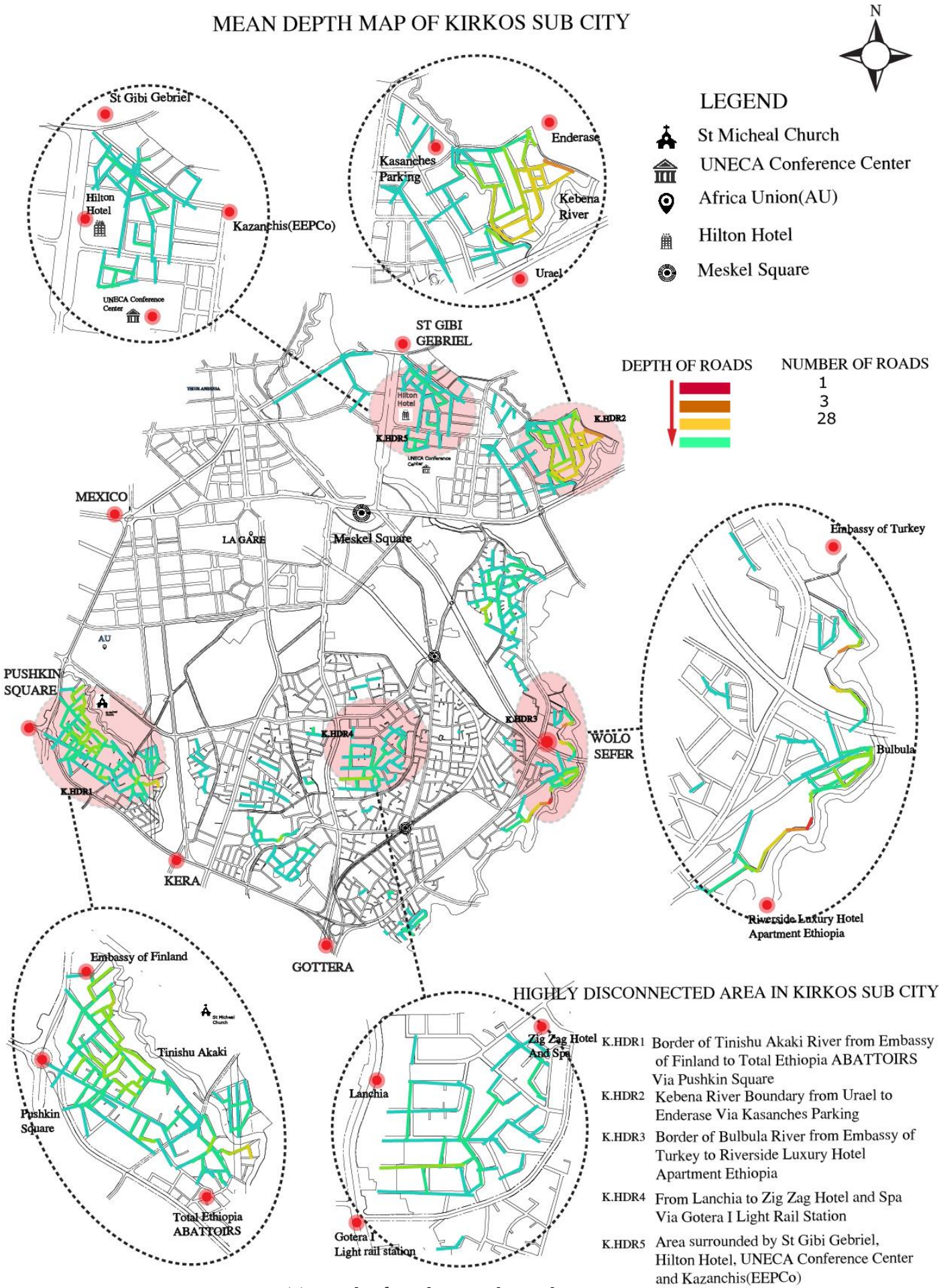


Figure 4.21 (c) Depth of roads in Kirkos sub city

7. Depth of Kolfe Keraniyo sub city.

The scatter plot of mean depth versus integration of Kolfe Keraniyo sub city is shown in Figure 4.22(a). From the whole mean depth analysis (Figure 4.22(b)), two areas are selected as highly segregated area. Those areas are: From Welete Selasi to Jemo Condominium III and The area from General Wingate Square to 18 Mazoriya via Catholic Church and Tizazu sefer. Selected segregated areas are presented in Figure 4.22(c).

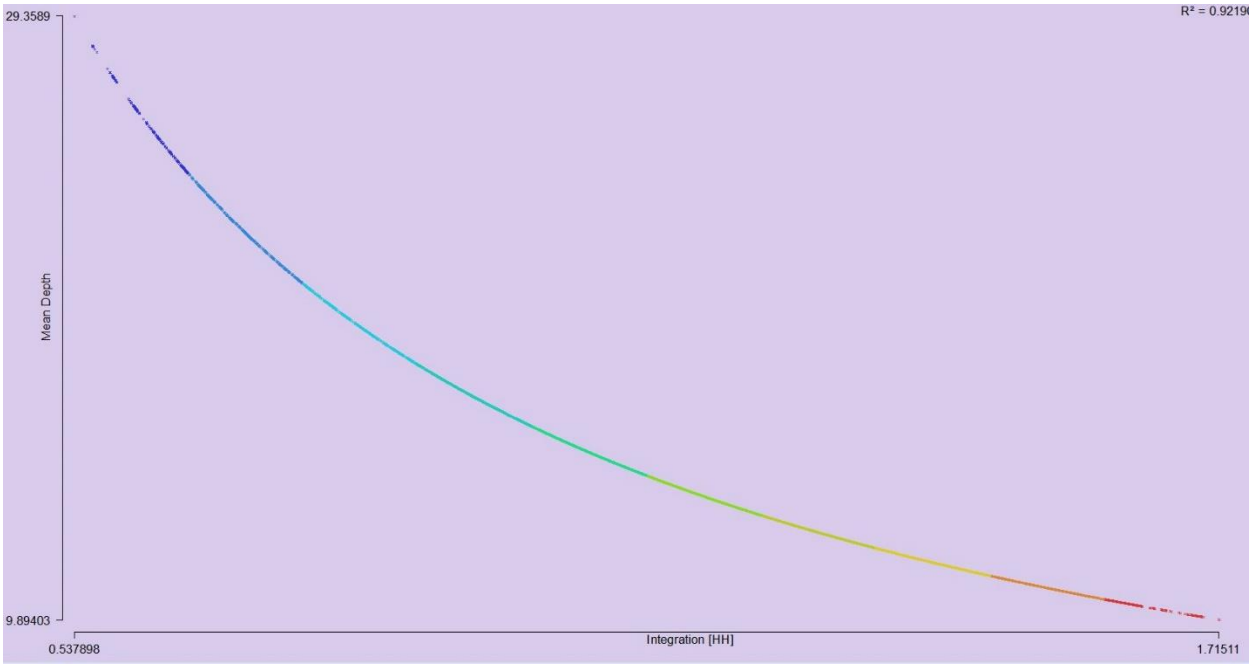


Figure 4.22(a) Scatter plot of main depth versus integration of Kolfe Keraniyo sub-city

Figure 4.22 (b) Mean Depth map of Kolfe Keraniyo sub city

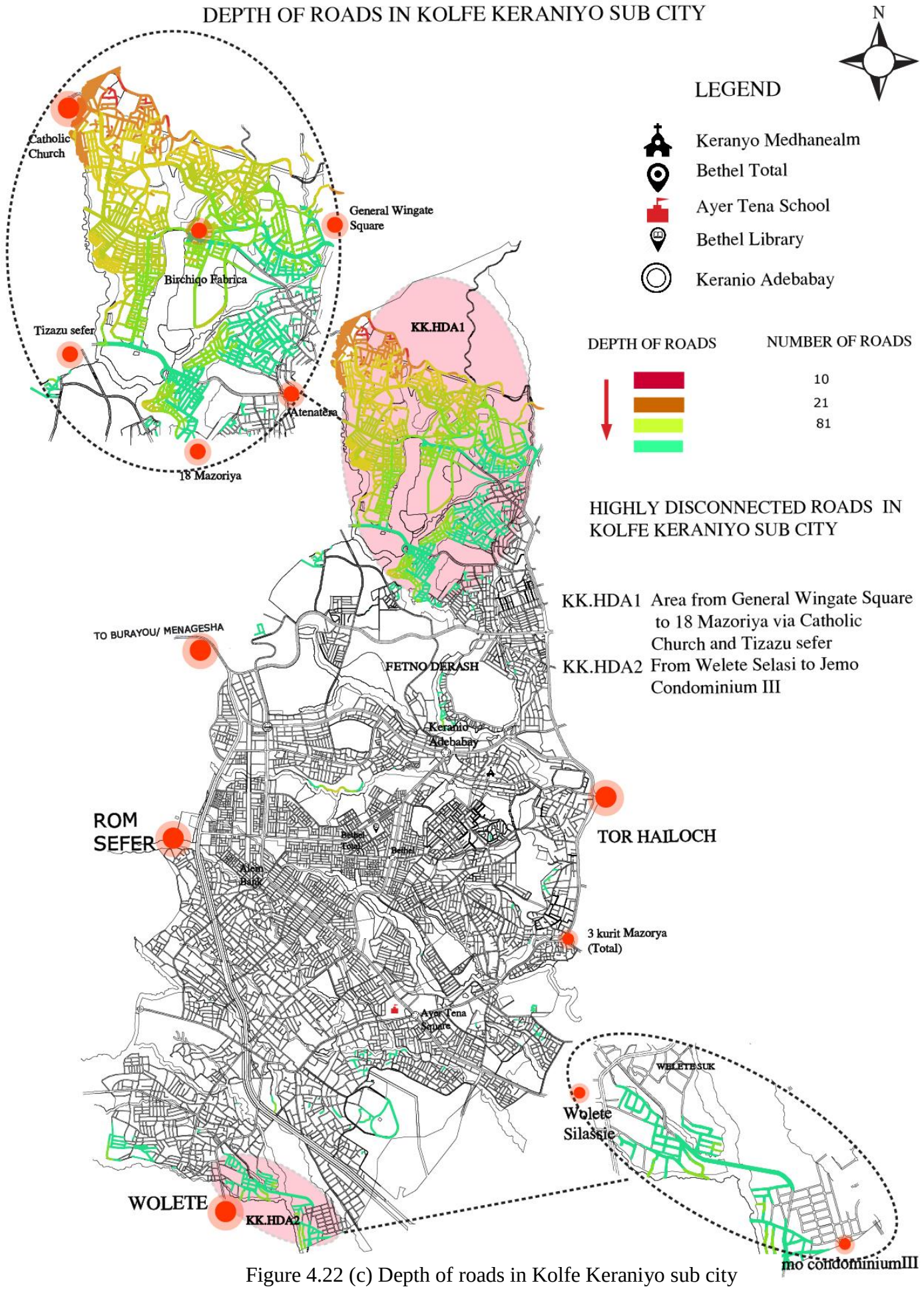


Figure 4.22 (c) Depth of roads in Kolfe Keraniyo sub city

8. Depth of Lideta sub city.

The scatter plot of mean depth versus integration of Lideta sub city is shown in Figure 4.23(a). From the whole mean depth analysis (Figure 4.23(b)), three areas are selected as highly segregated area. Those areas are: Around Gola Mikael. The boundary of Tinishu Akaki from F.D.R.E. Defense Forces Club to Mirut Café and the boundary of Tinishu Akaki from Addis Ketema Park to Coca-Cola Factory. Selected segregated areas are presented in Figure 4.23(c).

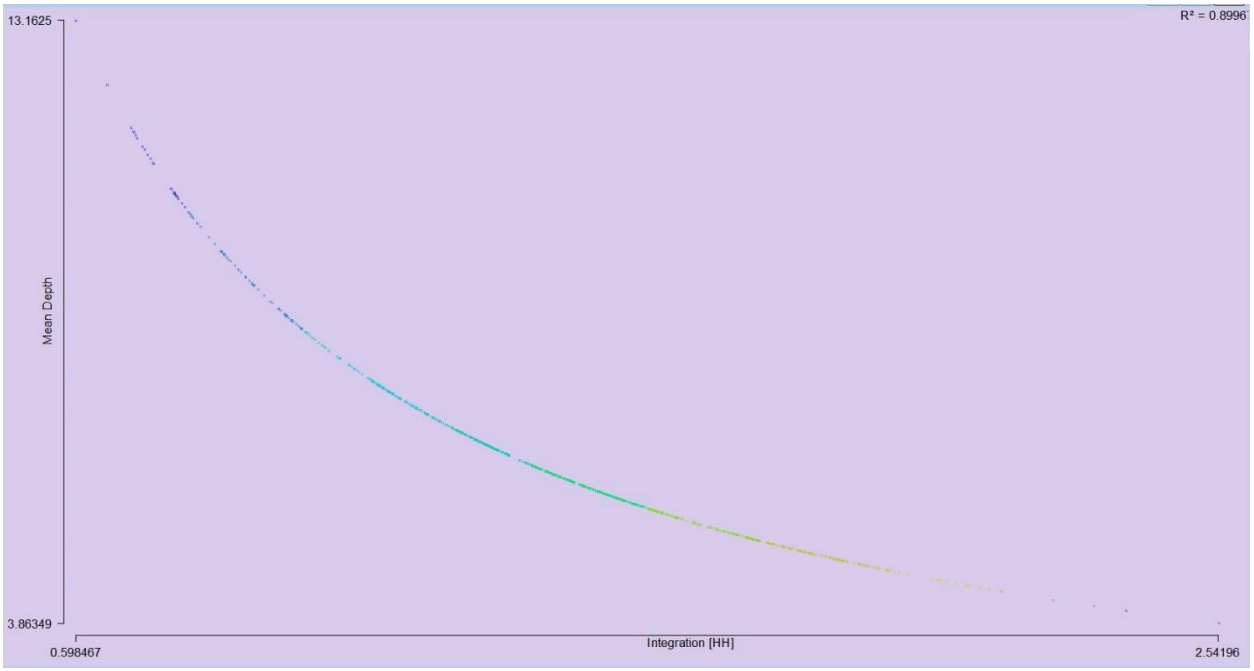


Figure 4.23(a) Scatter plot of main depth versus integration of Lideta sub-city

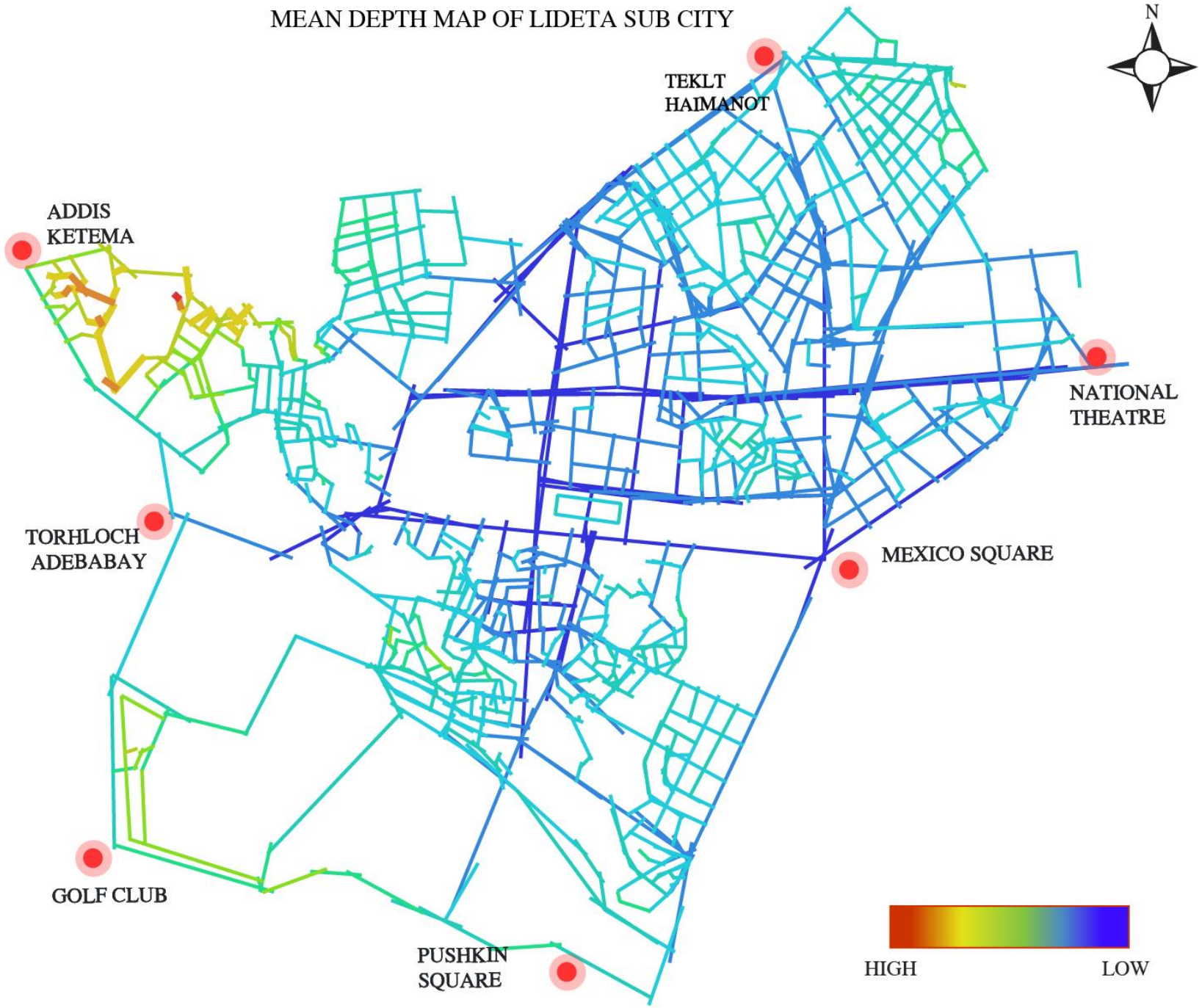


Figure 4.23 (b) Mean Depth map of Lideta sub city

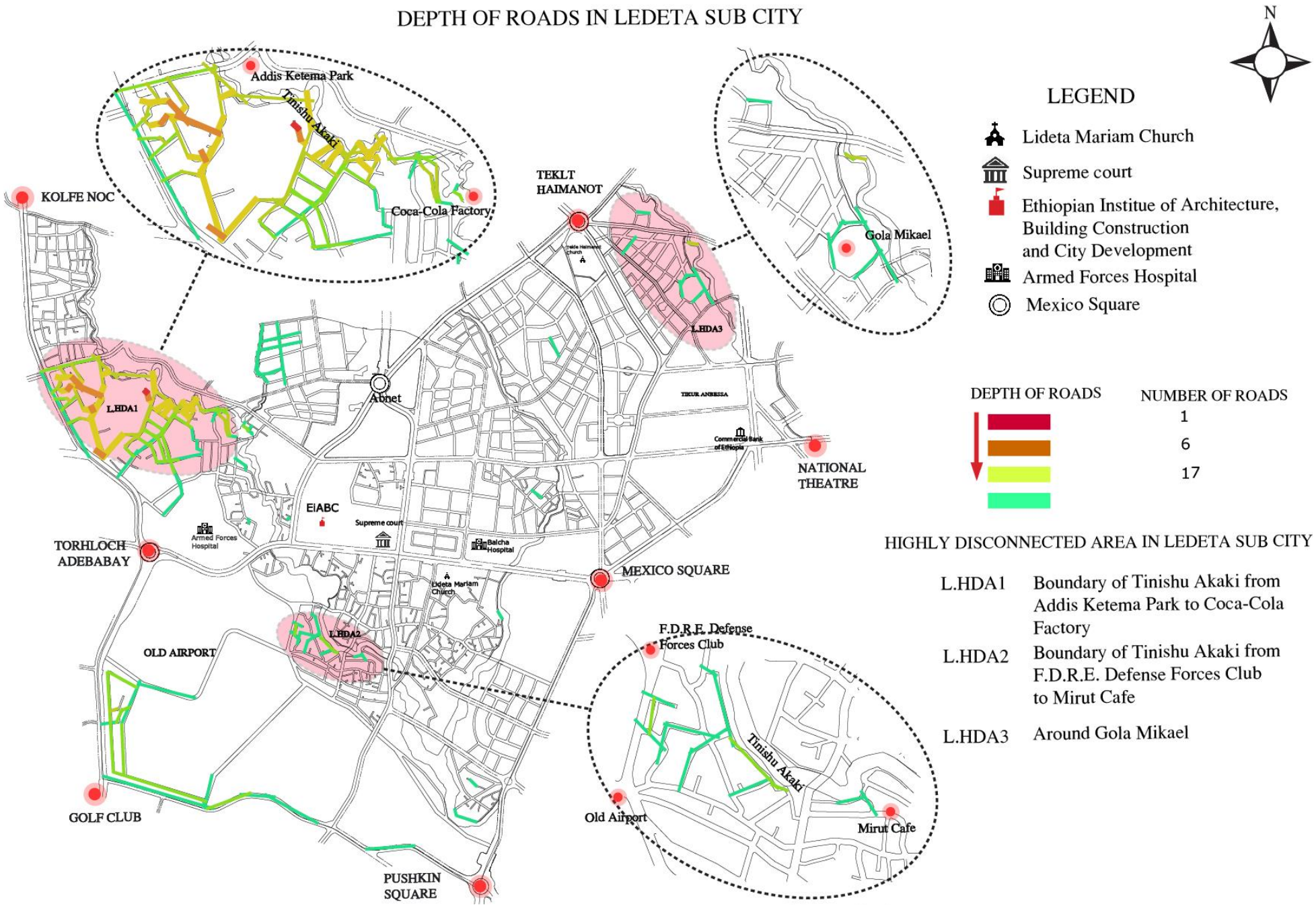


Figure 4.23 (c) Depth of roads in Lideta sub city

9. Depth of Nifaslik Lafto sub city.

The scatter plot of mean depth versus integration of Nifaslik Lafto sub city is shown in Figure 4.24(a). From the whole mean depth analysis (Figure 4.24(b)), four areas are selected as highly segregated area. Those areas are: The area surrounded by Addis International bank - Furi branch, Obte Mobile & MovieElectronics store, H and Y Townhouse complex and Hasan Yasin Real State Furi. Edge of Akaki river from Gofa K/Mihret Church to Avi Pension. Edge of Bulbula river from wolo sefer to Sarris Adisu sefer Gebriel. From Karl Square to Koshe via Embassy of Botswana and 3 kurit Mazorya (Total). Selected segregated areas are presented in Figure 4.24c)

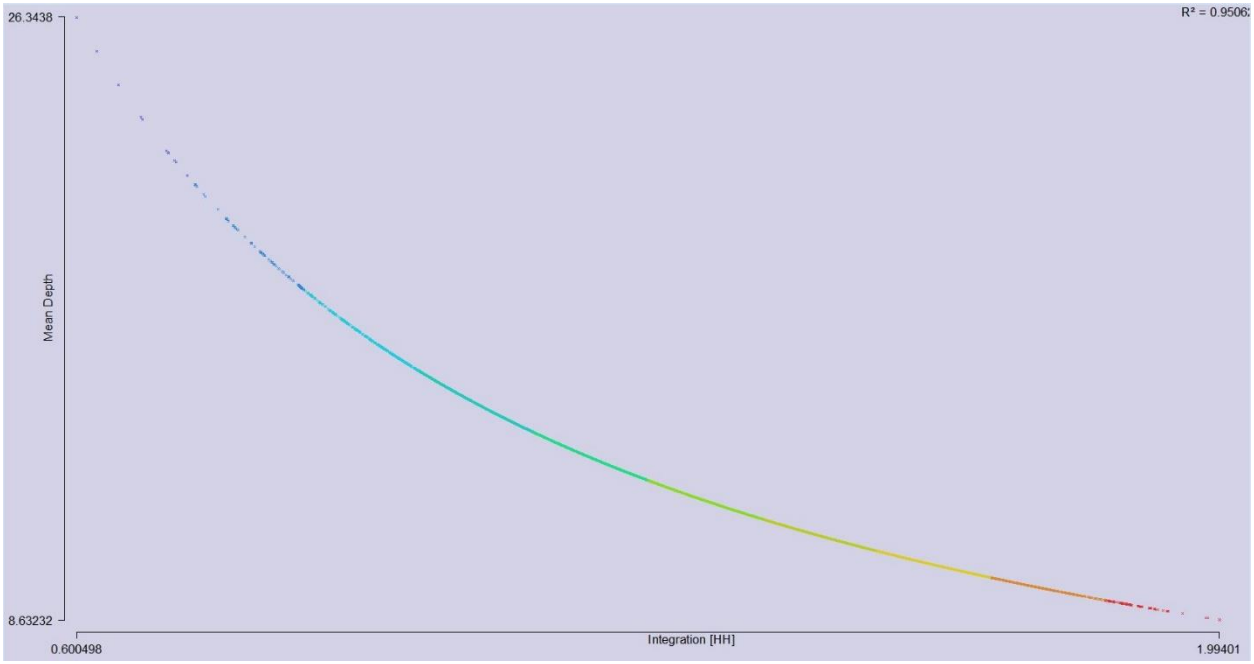


Figure 4.24(a) Scatter plot of main depth versus integration of Nifasilk Lafto sub-city

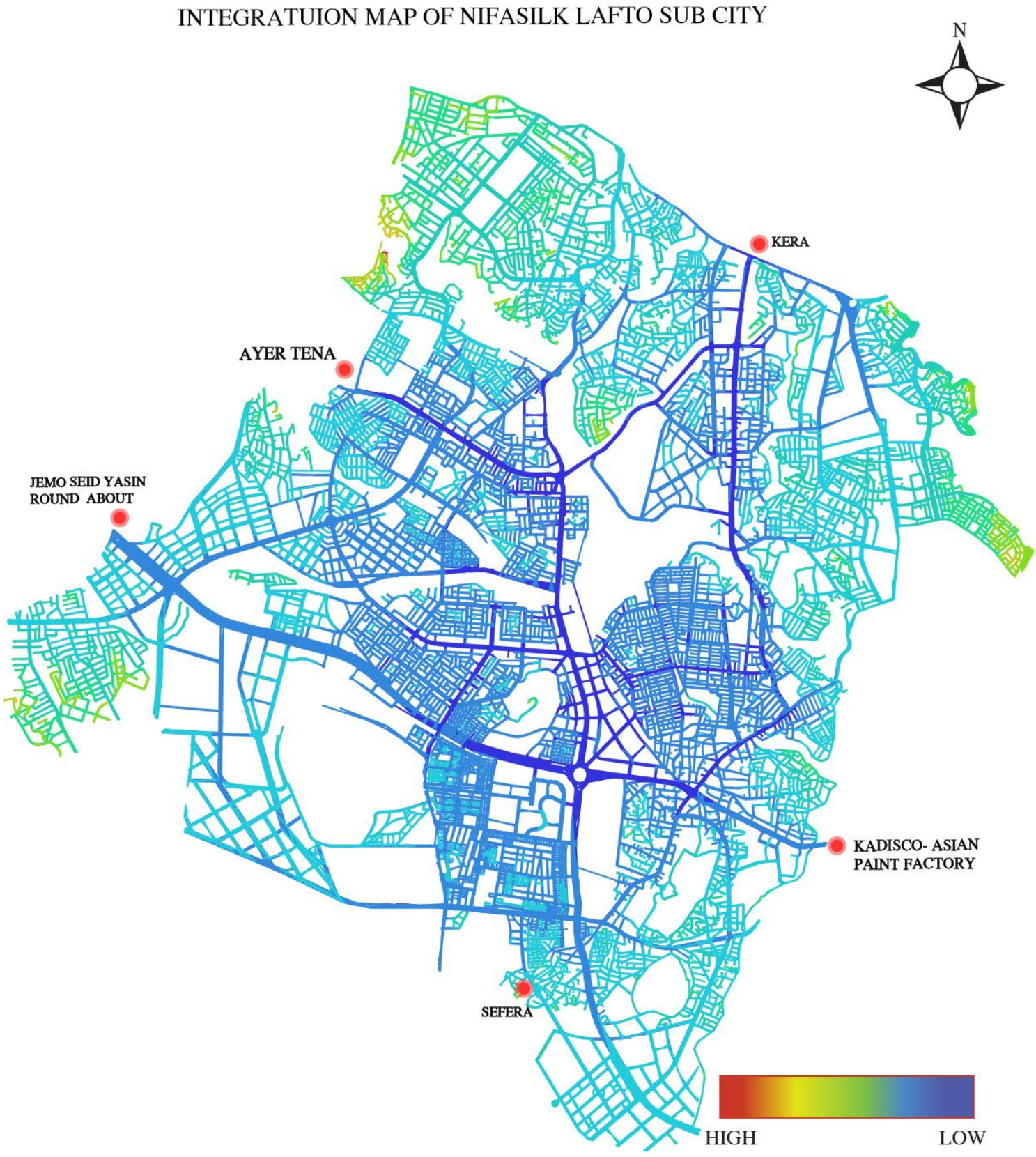


Figure 4.24 (b) Mean Depth map of Nifasilk Lafto sub city

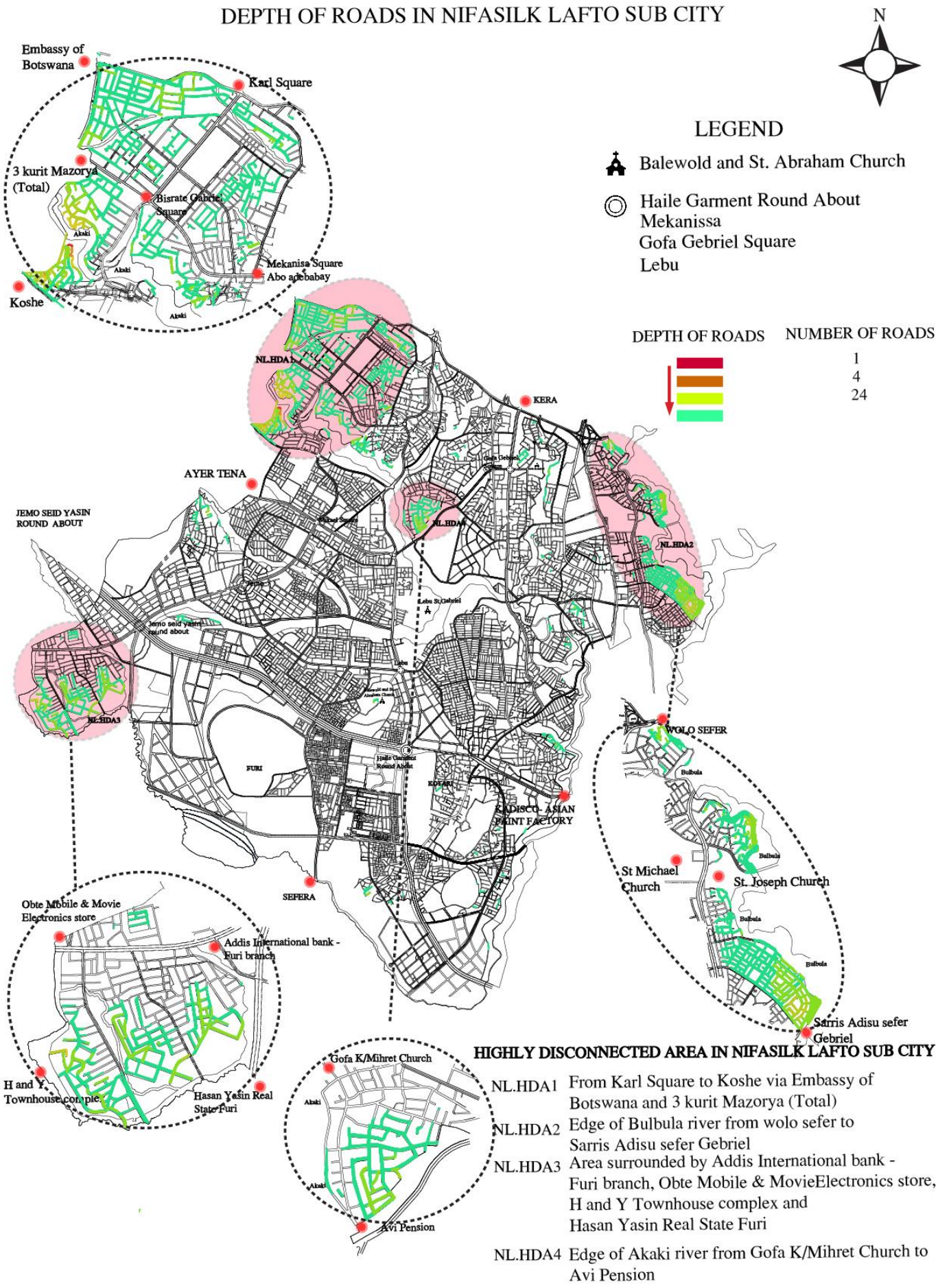


Figure 4.24 (c) Depth of roads in Nifasilk Lafto sub city

10. Depth of Yeka sub city.

The scatter plot of mean depth versus integration of Nifaslik Lafto sub city is shown in Figure 4.25(a). From the whole mean depth analysis (Figure 4.25(b)), two areas are selected as highly segregated area. Those areas are: Yeka Abado Condominiums site and The area surrounded by St. Kidane Miheret, Great Abyssinia Factory, Temkete Bahir Hamle19public Park, and Netsa Art Vilage. Selected segregated areas are presented in Figure 4.25(c).

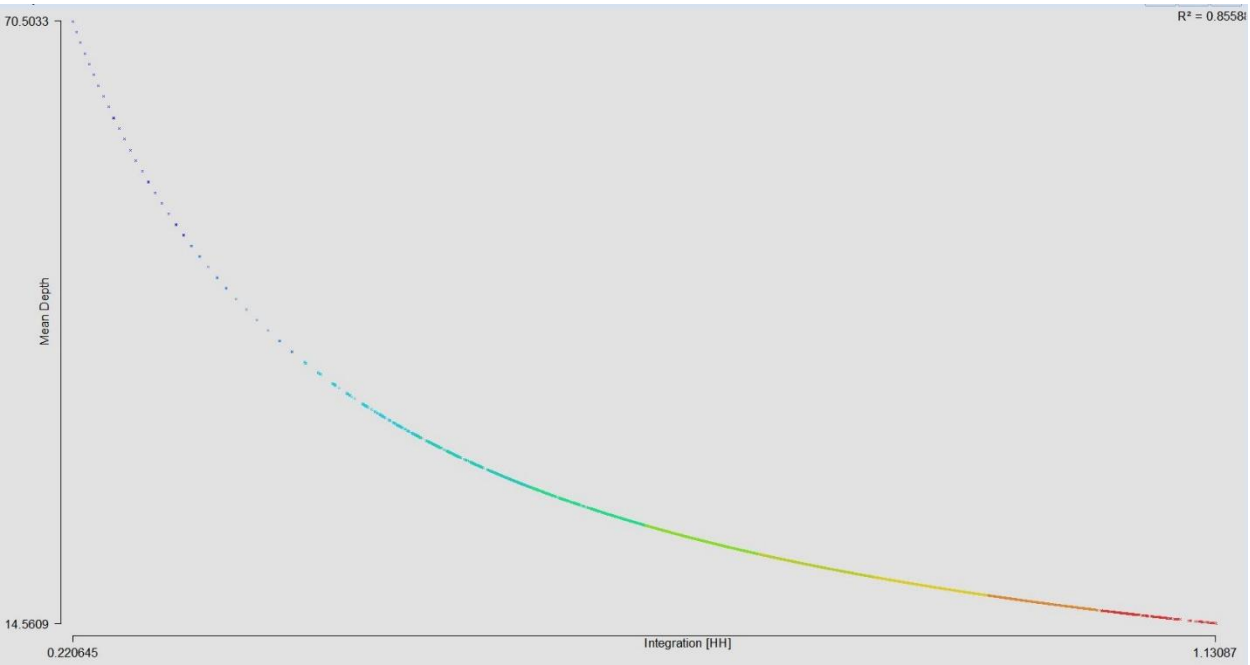


Figure 4.25(a) Scatter plot of main depth versus integration of Yeka sub-city

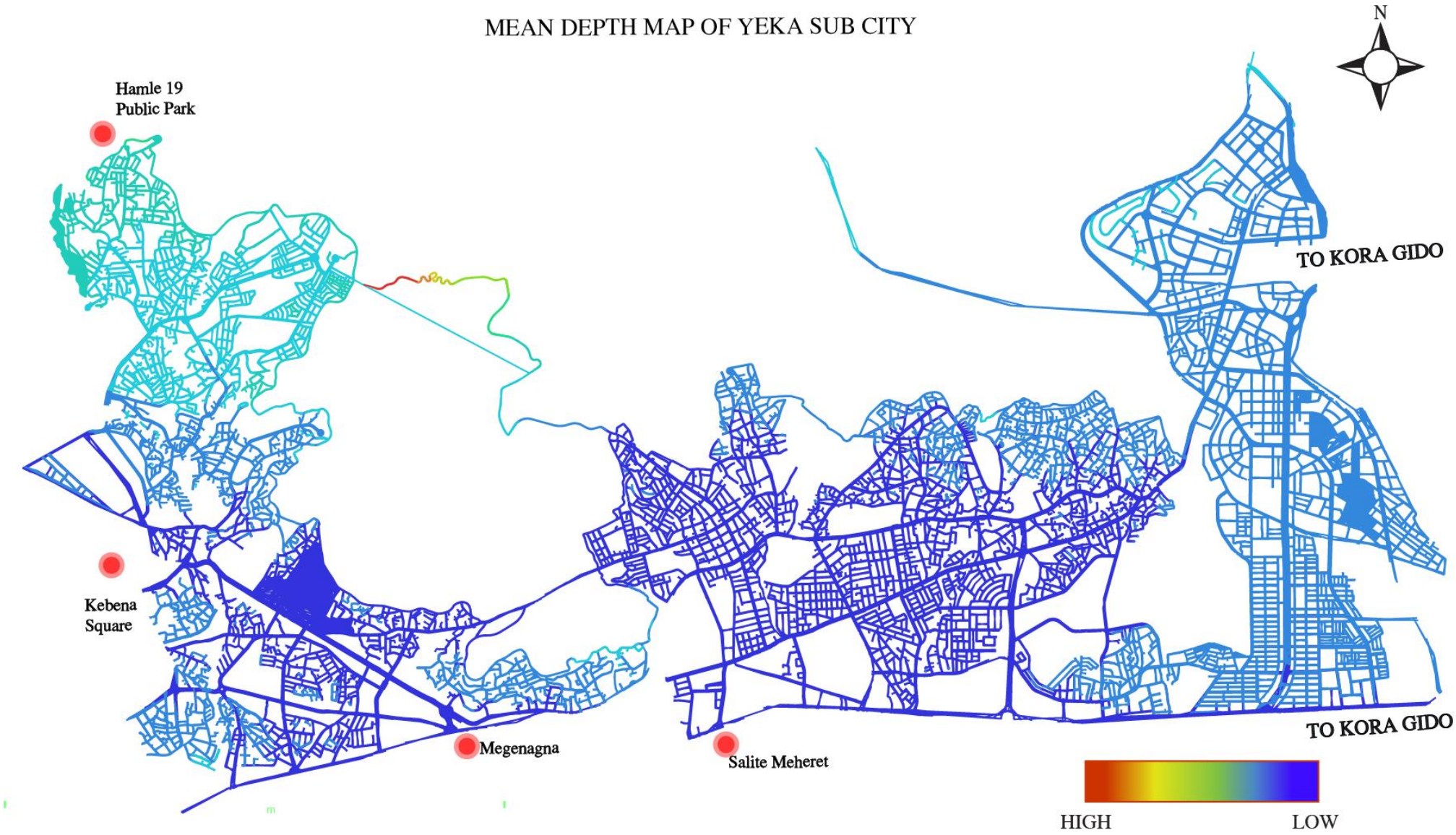


Figure 4.25 (b) Mean Depth map of Yeka sub city

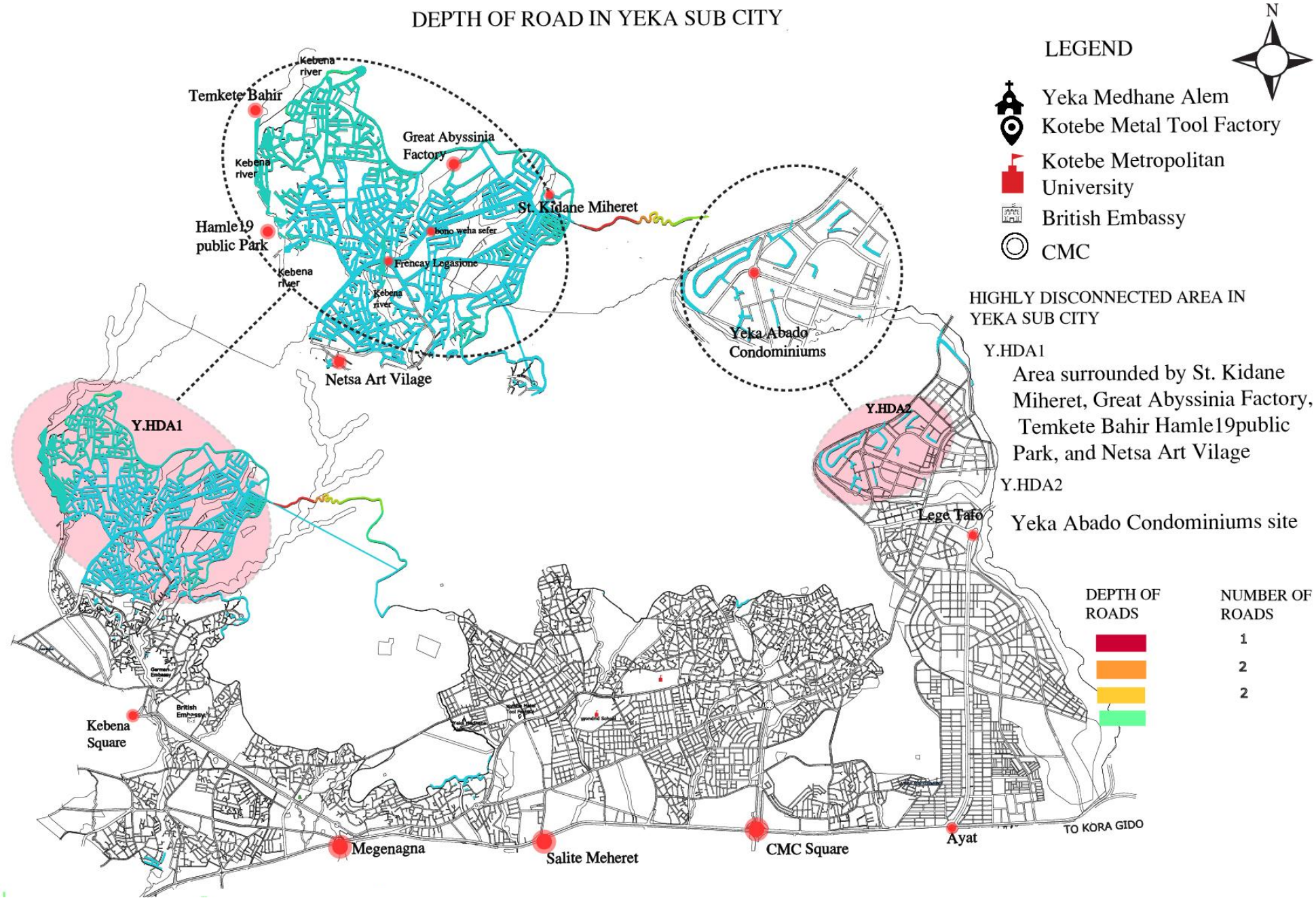


Figure 4.25 (c) Depth of roads in Yeka sub city

11. Depth of Addis Ababa road

Mean depth analysis of the city indicates that the peripheral area of the city has higher depth value in other word there are numerous segregated area in the peripheral area of the city. Most of segregated areas are found in the river side of the city. Mean depth analysis of Addis Ababa city is shown in Figure 4.26.

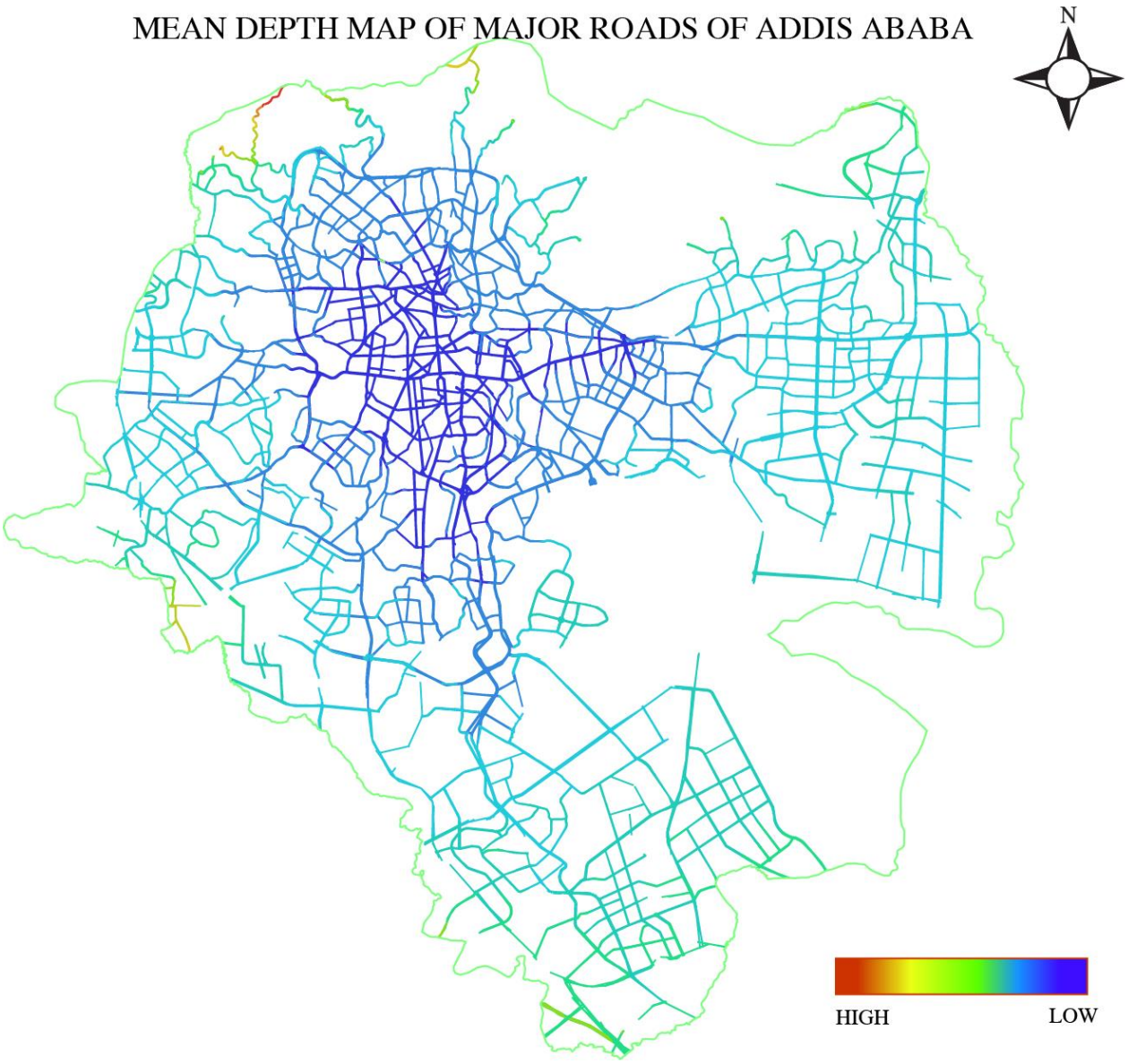


Figure 4.26 Mean Depth map of Addis Ababa city

CHAPTER FIVE

DISCUSSION

This part explains how this paper deffer from other related research or project by compere and contract its methodology and outcome results.

This research is the only one that use space syntax analysis to identify potential roads of Addis Ababa for street design, so it's difficult to discuss from related project or researches but instead of identifying major core area of the city and developed site, Addis Ababa city planning project office prepare one large research. This research covers different issues such as existing and proposed land use, city centers, transport and road network, main city center development, social service, municipal service, housing, and so on. So from those issues select main city center development, transport and road network, issues and try to compare to this research. Also, try to compare to Space syntax models of the city of Jeddah, Saudi Arabia.

5.1 Major Important Roads of Addis Ababa City

Addis Ababa city planning project office, majorly selected major roads and prioritized based on their contribution to facilitating connectivity and productivity. Which means manly consider transportation issues. But this research uses the space syntax analysis method to identify major important roads of Addis Ababa, also the method can briefly illustrate the range of street functions and user needs and shows how classifying streets on this basis leads to a greater consideration of the needs of people, rather than vehicles. And the paper use integration map to select potential roads for street design because highly integrated roads attract many peoples.

From the result perspective, Addis Ababa planning project office decides the city center is around the National Theatre district, Kerkos district, LeGare district, Filwuha - Meskel district since major roads are mainly found in main city centers (it shows under Figure 5.1). The result of this study according to space syntax analysis, the main city center cover 4% of the city and lays in some parts of four sub-cities such are Kirkos, Lideta, Arada, and Addis Ketema. (its shown in figure 5.2) which include the Proposed road network Map of AACPPO Main City Center which means relatively similar result.

Figure 5.1 AACPPO Main City Center Proposed road network Map

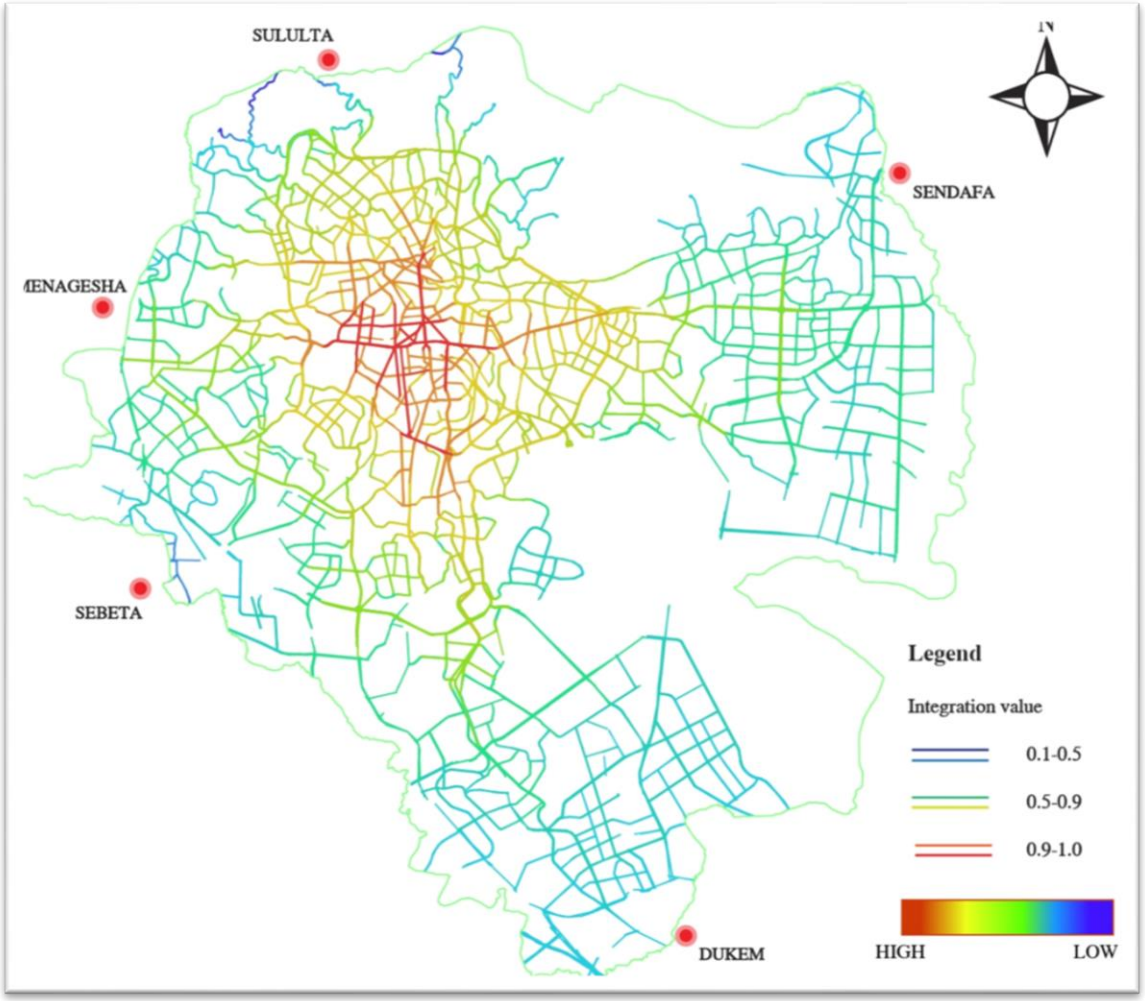


Figure 5.2 Addis Ababa integration map

	AACPPO Main City Center Proposed road	Addis Ababa integration map
Methods	Select based on facilitating connectivity and productivity.	Select using integration map.
Result	The same result.	The same result.

In addition to identifying the major core area of Addis Ababa, this study also identifies major important roads of each sub-city that helps to activate all parts of the city. According to the result, the roads of the city is highly integrated at the center of the city and its cover only 4% of the total city area. The peripherals are not integrated well so, there is more flow of movement from peripherals to the core of the city because, important roads engage more economic activity and attract propels for interaction. Due to this the transportation system of the city affected. So identification of potential roads in each sub-city and changing to the street helps to minimize the negative effect of people's flow by increasing the integration level of the city.

Sample Street Design

Addis Ababa city planning project office, select Churchill street- special corridor as sample street for Addis Ababa city. Churchill street is a corridor to link the historic business center of Arada to the potential new business center of Cherkos through the national theater area (it shows in Figure 5.3). A delicate area where the issues of conservation, history, and development overlap to create a character of transition.

Rationale Churchill being one of the oldest streets in Addis Ababa. It has a great historical value connecting Arada and la Gare, which are two of the three distinctive nods of the city. The assumed city center has been moving southwards through time. Therefore, the Churchill corridor has been the host of multiple developments through time. It is only logical to consider Churchill as a time cord which exhibits timeline developments from the very first to the very 26 presents. The corridor being interrupted by the central park at La Gare will continue anew southwards representing the new trend of development (future). This will be the main axis of the country.

Churchill road

- Highly integrated.
- historical value.
- Fixed land use.
- limitation for walking.

Figure 5.3 MCC districts

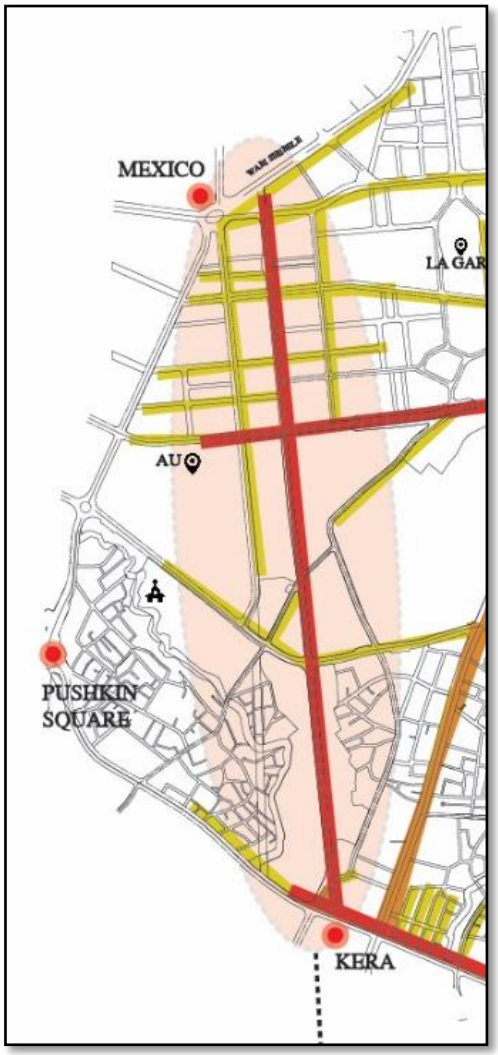


Figure 5.4 Mexico to Kera road

Mexico to Kera road

- Highly integrated.
- Future development
- Renewal site.
- suitable for walking

From the street quality standard, one of the criteria of the street is that the place of people interaction, and mainly peoples interact in more active areas. Active area also describes on its variety of activity (provided service) and its interaction from different roads also, its topology must be suitable for walking. Due to such a parameter, Churchill road fulfills some of them. It has good interaction from different roads (high integration value) and variety of activity (provided service) but due to suitable topology for walking it has some limitation.

One of the criteria for the selection of Churchill road is its historical value connecting Arada and La Gare, but instead of appreciating upcoming development this study selects Mexico to Kera road as a sample important road of the city. Because, Mexico to Kera road fulfills the requirement of a quality street some of those are: highly integrated road, topologically suitable for walking and variety of activity, also it has a good opportunity to design such activities on upcoming projects because the site is identified for urban renewal.

5.2 The Depth of Addis Ababa Road

The depth analysis of Addis Ababa roads shows most of river side areas are highly segregated from main transportation so, it need urgent intervention. A general assumption is that highly segregated streets provoke anti-social behavior and criminal activities because they are visually broken up. Space syntax analysis help to evaluate the city road system for further improvement. For example, Space syntax models of the city of Jeddah, Saudi Arabia have been used as the base layers to inform the Strategic Planning Framework.

These urban transformations were measured by the spatial model on local and global scales. The analysis showed major city-wide improvements compared with the existing city as well as with the proposed local plan, adopted previously by the Municipality. The project then continued further to develop more specific urban design solution options, or assess the impact of the other masterplans developed for different parts of the city, including a masterplan for the vacant Old Airport Site, a masterplan for the Historic core and waterfront, and a series of regeneration and area action plans for the unplanned areas of the city (Karimi, 2012). This is a highly advanced tool that could feedback into the design process for each of these projects, as well as to the main strategic plan of the city and its showed under figure 5.5. The spatial structure of the city as exists now (a), is compared with what it would be like if the old Local Plan is implemented (b), and what it would become if all strategic transformations proposed by the Strategic Planning Framework are implemented (c).

In this study mean depth analysis also help to evaluate the existing road system of the city based on its accessibility and easy for transportation by clearly shown which parts of the city roads are highly segregated (shown in figure 5.6).

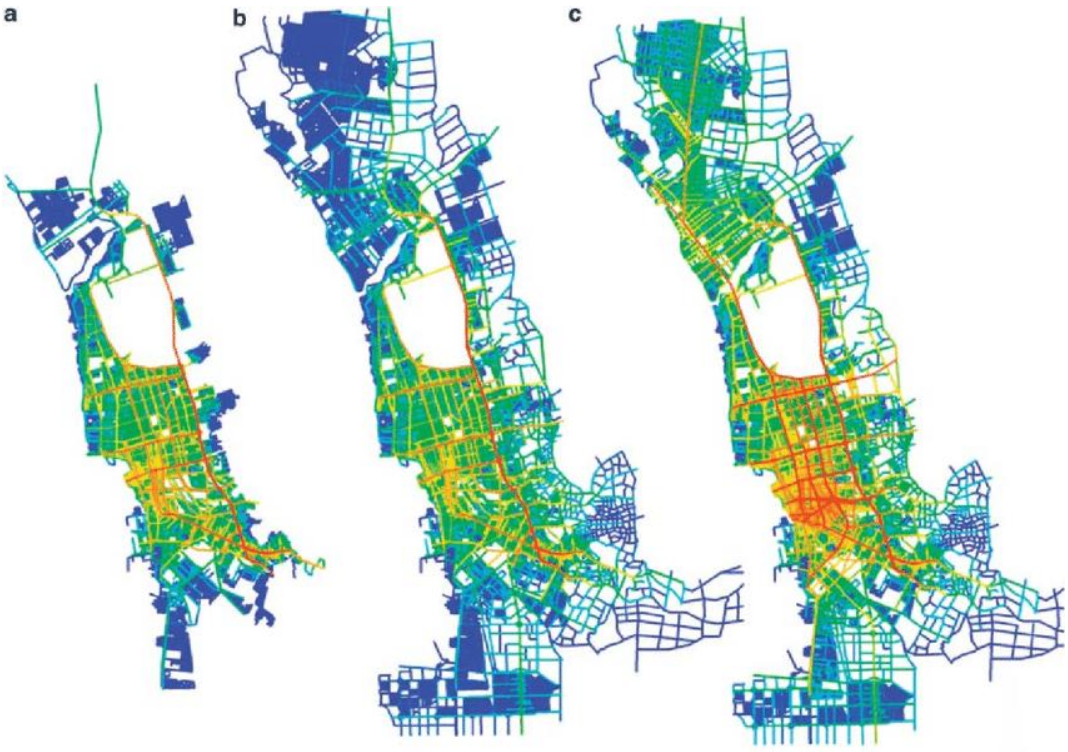


Figure 5.5: Space syntax models of the city of Jeddah, Saudi Arabia. (Source: Karimi, 2012).

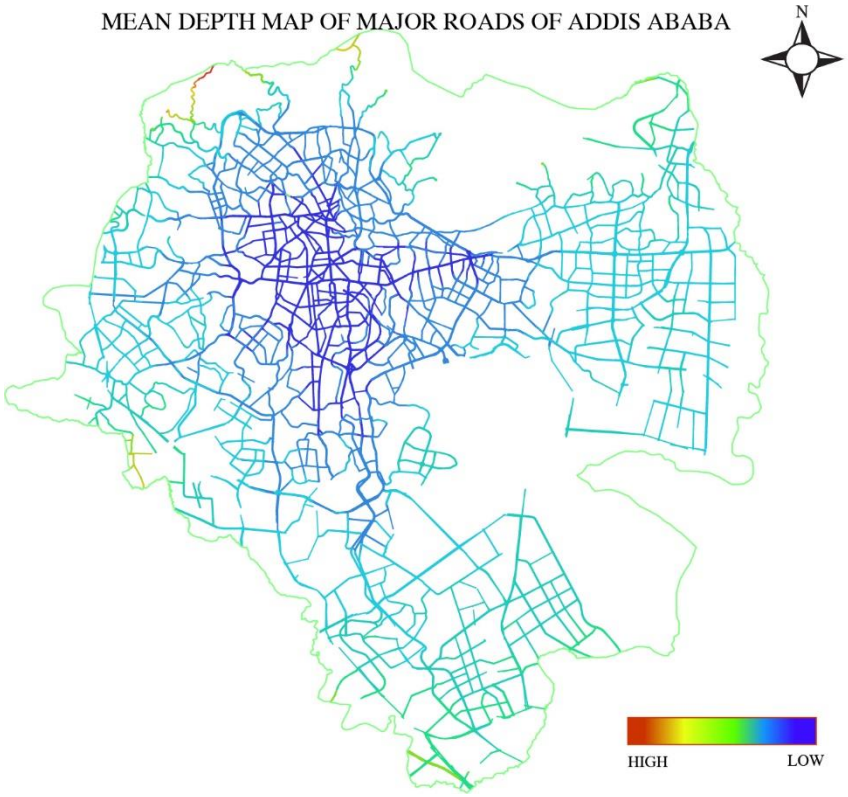


Figure 5.6: mean depth map of Addis Ababa.

CHAPTER SIX

CONCLUSION AND RECOMMENDATION

6.1 Conclusion

In this study, the road system of the city is evaluated according to its integration level using space syntax analysis and identifies the location, where the important roads of the city are found and the study investigates the highly segregated area of the city that needs urgent development.

The research shows the following:

- Addis Ababa city is highly integrated at the center of the city its cover 4% of total area of the city and 28% of the city area somehow integrated.
- At the sub-city level, highly integrated roads are found in four sub-cities such are Kirkos, Lideta, Arada, and Addis Ketema. And the most integrated sub-city is Kirkos sub-city. It has majorly four highly integrated roads which are proposed road from AU to Kirkos sub-city Administration Via Meshualikiya, road from St. Yared Square to Washington Square, road from Riche to Meskel Square and Road from Mexico to Kera. Finally the road from Mexico to Kera is selected as sample potential road to change to the street.

- Some of the highly integrated or potential roads are laid on proposed roads for example in Kirkos sub-city Proposed Road from AU to Kirkos sub-city administration Via Meshualikiya and in Gullele sub-city Proposed bridge road between road from Damo's House to Tulu Dimtu adebabay and Akaki city bus depot site. Proposed bridge road between road from Addis Ababa to Dukem and road from Kilinto to Ethio ICT Village road.

- Highly segregated roads are found in five sub-cities such are Gullele, Akaki Kality, Bole, Kolfi Keranio, and Kirkos
- The most segregated area of the city is found around the riversides of the city. For example, in Addis Ketema sub-city the segregated area is found in Boundary of Tinishu Akaki River from Addis Ketema Park to Zulfa Snak. In Bole sub-city segregated area is found in Border of Kebena River from Urael to Welo Sefer. In Gullele sub-city the segregated area is found in Both side of Bantyketu River from Afencho Ber to Ketchene Orphanage cump and Edge of Kebena River from Hamle 19 public park to Jan Meda. In Kirkos sub-city the segregated area is found in Border of Tinishu Akaki river from embassy of Finland to total Ethiopia abattoirs Via Pushkin square and border of Bulbula river from embassy of Turkey to riverside luxury hotel apartment Ethiopia. In Lideta sub-city the segregated area is found in boundary of Tinishu Akaki from F.D.R.E. defense forces club to Mirut café and boundary of Tinishu Akaki from Addis Ketema park to Coca-Cola factory and in Nifaslik Lafto sub-city the segregated area is found in edge of Akaki river from Gofa K/Mihret church to Avi pension and edge of Bulbula river from Wolo Sefer to Sarris Adisu sefer Gebriel.

6.2 Recommendation

Based on the above conclusions and results of this paper the following recommendations are forwarded:

- The city road authority can use highly integrated roads of each sub-cities as a location of street design and depth analysis for prioritizing roads for improvement.
- The city road authority give attention to those of proposed roads and having high integration value for proposing upcoming land use around that area.
- Highly integrated roads can be the location of shops, retail, national and international firms, and the location of urban centers in general, also, land values and rent processes tend to be influenced by the various integration values of the street net.
- It needs urgent development on those of highly segregated areas especially the riverside area of Addis Ababa those areas are often affected by crime and experience social misuse. because highly segregated streets provoke anti-social behavior and criminal activities.
- It needs further detail space syntax analysis on the existing spaces located for public space, to understand how the people use it and what is the effect of that space on the life of the society this study helps to know what type of improvement is needed and how can upgrade the benefits from quality street and public space.
- For prioritizing roads for development here, it is recommended that three factors are taken into account. The first one is the degree of a problem identified for each indicator (i.e. how far away is its performance from an acceptable level which means 1.49km average walk trip. The other is the relative connection and place status of that street segment and which function has the higher priority.
- land use determination must follow the road structure of the city.

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