ADDIS ABABA UNIVERSITY

ADDIS ABABA INSTITUTE OF TECHNOLOGY

SCHOOL OF CIVIL AND ENVIRONMENTAL ENGINEERING

GEODESY AND GEOMATICS PROGRAM

Web-GIS based electric utility management system: A case of Adama city, Ethiopia

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A Thesis Submitted to the School of Graduate Studies of Addis Ababa University in Partial Fulfillment of the Requirements of the Degree of Master of Science in Geodesy and Geomatics Program (Specialization in Geomatics)

March, 2022

Addis Ababa, Ethiopia

Approved by the Board of Examiners

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DECLARATION

I certify that this research work entitled "*Web-GIS based electric utility management system: A case of Adama city, Ethiopia*" is my own work. The work has not been presented elsewhere for assessment. Where material has been used from other sources, it has been properly acknowledged/referred.

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ACKNOWLEDGEMENTS

First and foremost ‘Glory to God in the highest’, who gave me enormous endurance from the beginning to the end of my task. Second, I would like to thank my advisor Dr. Tulu Besha for his open advice, suggestion and assistances he made during this thesis preparation. My special gratitude expression is also for Dr. Andinet Ashagrie for his kind support in the thesis advice and help. My deepest gratitude goes to mizan -Tepi University for the sponsorship. In addition to this I would like to thank Ethiopian electric utility Adama district and Adama city security office for providing a data necessary in conducting my research work and allowing me to collect field data at that critical time. Furthermore I would like to thank my course instructors during my stay at Addis Ababa University for the past two years, especially for those who delivered the course virtually during the corona virus pandemic. They show us another possibility where everyone can learn by staying at home. Finally I would like to express my great pleasure for my family, friends, classmates and roommates.

I am grateful!

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ABSTRACT

Utilities are very important for smoothing people's daily lives. Public utility authorities are facing significant challenges in developing cost effective business process for managing subsurface, surface and overhead utility infrastructures and assets. People working in utilities need a better understanding of the context of change, what it means, and how to manage current and future utility assets. In Adama city, utility's geospatial data is constantly changing, and geospatial datasets are outdated and poor in data quality, making them unsuitable for decision support, resulting in high maintenance costs. Another big issue is the link between the spatial and non-spatial components of the utility. The objective of this paper is to develop a web-GIS based electric utility management system that addresses these issues. Ethiopian electric utility, adama district is consists 30 service centers, 327 satellite stations, 10 power distributions, 66 outage lines, and more than 200,000 customers. Primary data is collected from the study area using portable GPS. Secondary data is from the Ethiopian electric utility in the Adama area. Accordingly, 660 electric pole data from Angatu kebele (formerly kebele 14), and 2575 district transformer data were collected. Of these 2575 transformers, only 761 are within Adama city boundary. In addition, satellite imagery and existing non-digital sources are used. The developed web-GIS system shows the two data layers (i.e. poles and distribution transformers) overlaid. The system implementation includes the ability to query layer information, split maps, generate reports, and perform spatial operations such as measuring distances and areas, and a mechanism for system administrators to add or remove utilities from specific locations. This work also provides a customer support system that helps customers submit issues and helps managers track down issues for maintenance of the city's utility. This system is especially useful during the maintenance, upgrade, and planning period of the power supply function in the study area.

Keywords: Electric utilities, Internet of things, spatial web service, web-GIS

CHAPTER ONE

1. INTRODUCTION

1.1. Background of the study

A utility is an important service such as water, electricity, or gas that is provided for everyone, and that everyone pays for. Ethiopia has four core public utilities and transportation service providers‟ ethio telecom, Ethiopian Electric Power Corporation (EEPC), Ethiopian Water and Sewerage Authority (EWSA) and Ethiopian Road Authority (ERA) (Mulugeta, 2015). These four utility service providers help the community of the nation by providing telecommunication, electricity, water and sewerage supplies, and transportation services. In order to provide the above services, service providers installed their infrastructure like water pipeline, telecommunication line and electricity line above or below the ground. As other most technologies pipe water supply, electric power and telecommunication utilities initially brought to the country during the period of Emperor Menelik II. As though the city of Addis Ababa firstly got pipe water supply in 1894 while the electric power and telephone begun in the year of 1897 (Addis Ababa Millennium Secretariat, 2007). Later the use of these technologies gradually expanded to different regions in the country. Nowadays, different cities and towns are being provided with different utility networks within them.

Asset management is classified as an important activity in present day electric transmission and distribution system planning and operation (Swasti et al., 2016). The purpose of electricity asset management is to turn assets into a revenue stream, and hence, reducing risk and providing emergency responses (Brown & Spare, 2004). Electricity is a vital aspect of the utility sector that is very necessary to the smooth and meaningful development of any city. It is an important part of any person living both in rural and urban region. It has brought a lot of things that definitely have made many marvels and life would seem so difficult without it (Govindaraj, 2013) After receiving bulk electrical energy from transmission or sub-transmission substations, the fundamental aim of an electricity distribution system is to meet the customer's energy needs (Kinmani, 2014). The complexity of the electrical distribution power system is only one of the reasons for the introduction of new geospatial technologies such as GIS and GPS (Global positioning system), which perform complex power system analyses such as network optimization and load forecasting in a very short time period as and when needed (Parkpoom, 2013). Nowadays, strong approaches that merge traditional data conversion techniques with complex project administration mechanisms to enable effective workflow management and quality control are necessary for generating large-scale electrical network geodatabases (Singh et al., 2016).

Adama city is one of the cities established in 1916. The suitable geographical area nearest to the capital town Addis Ababa and favorable climatic conditions of Adama have contributed to the speedy growth of the City in conjunction with its electric powered and different application networks. Previously any decision-making concerning preservation of Electric cables and road mild poles, substation device, overall performance of device etc. are made on a difficult foundation as statistics are to be had via way of means of studying sheets and regarding antique statistics become difficult. In addition, these maps are rarely updated and there is a lack of linkage between spatial and non-spatial data. Moreover, it is difficult to analyses and manages such utility networks in traditional way without a modern technology aid. In this area, GIS must play an integral role in expanding and maintaining utility infrastructure management and development plans. A few utility and distribution businesses have begun to use GIS or geospatial technologies to increase operational and customer service efficiency (USAID, 2006).

A Geographic Information System (GIS) is developed by bringing together hardware, software, and people, who can capture, store, analyze, manage, and present spatially related data (Bolstad, 2005). GIS does this by keeping accurate records of utilities, with the development of the cities environmental and natural resources, implementation of emergency management processes and assuring the quality of service provided. Spatial and attribute data are integrated in GIS to provide complete information about any feature. Using the GIS technology, complexities of utility network can be simplified and maintenance cost can be reduced to some extent. Moreover, Geographic Information System (GIS) and web

GIS technology can help resource managers in providing improved services. Traditional approaches are very complex to manage utility information which Upswings the need for the development of a Web-GIS based Utility Management System (WGUMS).

In order to utilize the available spatial datasets efficiently and effectively, web GIS has to play a significant role by providing information in decision making processes and it is not just in disseminating the spatial data (Yang, 2005).Web GIS is gaining popularity and it is an important tool to share and interoperate the heterogeneous spatial data. The web based applications consent a new forms of communication as well as information sharing. In essence, Web Services are able to package data without considering the specific application environment at the client end. Different systems can achieve seamless communication, data sharing and interoperation across platforms and languages based on Web Services framework.

Since the advancement of internet and geospatial technologies, various efforts have been made to generate information and utilization of these techniques for the well-being of society. Today in the advancement of Web technology, various management systems have been developed for utility mapping, power distribution, Earth data and planetary data dissemination and archival. Apart from these, Web GIS is also important in decision making process such as urban planning process (Mansourian, 2011), Transport Management System, Emergency Response System, livestock information management system (Otieno, 2014) which has been developed using various tools and technologies.

The Web Map Service (WMS) interface standard provides a simple HTTP interface for requesting geo-registered maps or images from geodatabases configured with PostgreSQL and PostGIS. Application development uses open source technology that complies with the Open Geospatial Consortium (OGC) specification for example, GeoServer, Open Layers, etc. (Green, 2002). Therefore, this study aims to combine modern geospatial technologies with web map services (WMS) and web feature service (WFS) in growing city of Adama to provide instant information access through web GIS technology to all concerned service providers and users. The study comprises two electric utility data layers; pole and distribution transformers, overlaid in a web map with different web map service and web feature service functionality.

1.2. Statement of the problem

Urban centers need an efficient system of electric power supply. But; the deployment and management of this infrastructure is severely restricted by planning, institutional, and technical factors. There is no systematic record of incidental costs at the service provider to make them available for future planning and use. Until now, people have always relied on paper charts and poorly organized databases to manage such facilities. Also, the management of analog and non-spatial data in existing underground and aboveground electrical systems is very cumbersome, clumsy, and almost inaccurate. The lack of web maps and information on the spatial location of underground, above-ground, and above-ground transmission lines caused extensive destruction and damage during excavation for various environmental and construction purposes. In addition, for better and simple user interaction the lack of web map platform remains to be a great problem for quick maintenance of damaged utilities. This problem is more severe in developing countries like Ethiopia where cities are not planned prior to their establishment. Therefore, the problem demands a well mapped electric utility infrastructure that can be accessible through online web GIS technology.

1.3. Objective of the study

1.3.1. General objective

The aim of this study is to produce a well detailed GIS based web map for electric utility in Adama city of Ethiopia using open source geospatial technologies.

1.3.2. Specific objectives

Specific objectives designed to attain the major objective are listed below.

- To identify major drawbacks in the previous electric utility management system.
- To develop electric utility database that can be queried.

- To develop an interactive web-GIS platform using open source geospatial technologies.

1.4. Research questions

In order to solve the current urban electric utility management system drawbacks and to prepare an interactive Web GIS based electric utility management system, the study formulates the following research question.

- What are the major drawbacks of existing electric utility management system?
- How will Web-GIS based utility mapping contributes to proper management and quick maintenance of electric utility?

1.5. Scope of the study

In fact, there are financial and material challenges in mapping all utility networks within a large area and analysis in ArcGIS software will be quite difficult which could have considerable influence on the quality of the work. Therefore, this study will be limited to developing a web map for electric utility networks. The field data collection will be carried out using Hand held GPS as differential GPS is very coasty to rent. The study area is bounded to Adama city, Ethiopia. In addition, the study will not include utilities other than Electric utility.

1.6. Significance of the study

While Web GIS utility management is simplification of a more complex reality, this study will simplify the understanding of this complex network and provide valuable support for providing instant information access through web map technology to all concerned engineers and service providers like Ethiopian electric utility officials .this is essential to minimize time for locating any lines, power restoration, and efficient planning for preventive maintenance. Furthermore, data may be shared and accessed via a variety of devices, including PCs, mobile phones, and tablets. Unlike a standard desktop GIS, which can only be used by one person at a time, the Web GIS produced can be used by dozens or hundreds of people at the same time. Unlike desktop GIS, which are designed for professionals with months of training and experience in GIS, the developed system is simple to use. Web GIS is aimed at a wide range of audiences, including non-GIS experts. The developed system can be accessed by low cost as telecom internet tariff is decreasing. Moreover, this study will also determine the future expansion of the network by using the map as a reference. The ability to manage electric utility networks as regards monitoring, maintaining and updating remotely as well as the ability to plan all future installations of this network meticulously and cost-effectively are the pillars that support the significance for such a system to be in place. This can be concluded on the basis of the following advantages that web based electric asset management solutions should provide.

- Exact geographic location of respective electric assets accelerates the emergency response system
- The system enables Easy updates on existing assets like increase in capacity, Dynamic addition of new assets and deletion of discontinued assets
- Hassle-free replacing of elements which have exceeded their lifespan
- Determining Shortest and most practical route to be chosen
- Measurement of distribution line along the route to be taken for planning new works could Avoid losses /damages due to lack of knowledge of exact routes

1.7. Thesis structure

The preliminary pages of the thesis document consisted of the title page, approval sheet; acknowledgment, abstract, table of content; list of figures, tables and acronyms. **T**he body of the text accounted five chapters, within each chapter there is different but interrelated subtopics. The first chapter contains the introduction part which comprised the background information, problem statement, objectives, Research questions, significance, scope and organization of the thesis. The second chapter consisted review of relevant sources including previous research works, journal articles, books and others. The third chapter is the research material and methods which covers the research methodology, data source, data type, and data gathering tools, software, their purposes and source. The fourth chapter is the results and discussion part of the study which concerned about presentation and discussions of the results. This documented the analysis of the primary and secondary facts of the case study. The last chapter provided the conclusion and recommendation of the study. Finally, list of all sources cited in the main body of the thesis is presented as references and data obtained during field survey that cannot be part of the thesis are attached as appendix.

CHAPTER TWO

2. LITERETURE REVIEW

2.1. Electric utility

Utility is the conduit or 'technological system' which support the rapid movement of energy, water, waste and information upon which their integration together into economic and social structures (Graham & Marvin, 1994). 'The Asset Management of Transmission and Distribution Businesses in an Electricity Market entails the network business's central essential decision-making to optimize long-term earnings while offering excellent service levels to customers while minimizing risk.' (Bartlett, 2002). Utilities are continuously attempting to maximize the use of resources available for maintenance and new projects while ensuring system reliability is within acceptable bounds in order to meet the needs. Transmission and distribution components are capital-intensive assets in the electrical power business, so they must be utilized as efficiently as possible.

One of the most important aspects of a changing electric power business is asset management. Because of technological, socioeconomic, and environmental advances, the electric power business is undergoing substantial changes. Transmission and distribution assets, including as transmission lines, power transformers, underground and overhead electric cables, and poles, have also been prioritized as a result of restructuring and deregulation. The privatization of government-owned utilities, competition for wholesale and even retail consumers, and mergers and acquisitions have all brought new risks to today's utility management. Many electrical, gas, and other industries are focusing on making better use of geographical data. Improved hardware, software, and networking technology have created opportunities for the utility industry to build and benefit from more comprehensive and sophisticated GIS (Meyers). Hence, Utility management procedures are extremely complex and multidimensional, necessitating changes to established methodologies (Ajwaliya et al.,2014).

2.1.1. Utility mapping

Utility mapping means displaying maps of utility service providers' underground and overhead infrastructure using mapping technologies (Adnan et al., 2010). In order to identify one utility underground infrastructure from the other they have the capacity to assign a unique color to represent every utility of different service providers. Nowadays, public utilities are assigned a color in order to uniquely identify their infrastructures. The American Public Works Association encourages government agencies, utilities, contractors, other associations, manufacturers, and others involved in excavation to use the APWA Uniform Color Code for temporary marking and facility identification, which is based on the ANSI standard Z535.1 Safety Colors (American Public Works Association(APWA)). Contractors, excavators, utility companies, municipalities, and others working on or near underground and overhead facilities should use this marking guide to ensure universal use and understanding of temporary marking of surface and subsurface facilities to avoid accidents, damage, or service interruption. Accordingly, electric power lines, cables or conduit, and lighting cables are coded red color.

2.1.2. Geographic data model

The heart of any GIS is its data model (Goodchild et al., 2005). A data model is a depiction of a real-life situation that is used to arrange data in a database. There are three major components in most data models. The first is a set of data objects or entity types that serve as the database's fundamental building blocks. The second component is a set of general integrity rules that limit the number of entities that can lawfully appear in the database to a certain number. The last component consists of operators that can be applied to database entities (Miller et al., 2001).

Data modeling involves three different levels of abstraction: conceptual, logical and physical levels. Conceptual data models describe the service provider of data at a high level of abstraction, without taking implementation aspects into account. A logical data model translates the conceptual model into a system-specific data scheme, while low-level physical data models provide the details of physical implementation (file service provider and indexes) on a given logical data model (Rigaux et al., 2001). The conceptual, logical and physical design phases include the following (Zeiler, 2007).

Conceptual design

1) Model the user's view of data

2) Define geographic data entities

3) Identify representation of entities

Logical design

1) Match to the geodatabase model

2) Organize into geographic datasets

3) Diagram geodatabase model

Physical design

1) Implement the design

2) Design workflows for building and maintaining of layer

3) Design documentation

The most widely used logical data model that supports the node-arc representation of networks is the geo relational model. This model separates spatial and attribute data into different data models. The geometry and associated topological information are kept in relational database management (RDBMS) tables, while the associated attribute information is kept in a logical spatial data model (the vector data model) that encodes nodes and arcs. Each spatial entity (node, arc) has a unique identifier that links to records in the relational database and data about the entity's properties. This hybrid data management technique was created to store and handle attribute data using a relational database management system (Goodchild et al. ,2005). However, this technique prevents relationships between spatial objects and their properties from having their own attributes. Though neither elegant nor stable, the method is functional, and the geo relational model is commonly used in GIS applications.

2.1.3. Geographic data representation

Geographic data may come in vector form, raster form, or in both forms. Spatial objects are said to be in vector form if they are represented by one of the basic discrete entities such as points, lines, and areas (polygons) which are spatially referenced by a Cartesian coordinate system (Gregory et al., 2007) .The same spatial object entities can be represented in raster form if they can be decomposed into pixels. Each pixel is referenced by row and column positions. Representing spatial objects as raster or vector has its advantages and disadvantages. Vector representation easily offers better accuracy than raster representation because entities are represented by exact coordinates in space and do not have their locations generalized to a pixel. Thus, raster provides more approximate positions for the entities being depicted. Further comparisons of these two representations, such as topology handling, are explicitly given in the vector form, which is useful for tasks like network analysis. Geometric data processing, such as coordinate transformation, is complex (and necessitates resampling) in raster format, but simple in vector format.

a. Topological model

All geometric objects and digital map data can be represented by nodes and linkages, according to the topology model (Goodchild et al. 2005). Nodes and connections are recorded in three tables to define the objects' attributes and relationships: a polygon table, a node topology table, a link topology table, and an additional table that gives the objects' geographical coordinates and is saved separately from the attribute data files.

b. Network model

A network model is a graph called a connectivity graph that keeps track of the connections between spatial features with line or point geometry. Edges, junctions, and turns are the essential components of a network model. Lines are represented as one or more edge elements between pairs of junction elements, while features with point geometry are represented by junction elements inside the graph. Network components have no geometrical attributes and are only used to express the connectivity information for the spatial features they represent. If only the topology and connection of a network are considered, it is referred to as a pure network. A flow network is defined as one that is defined by its topology and flow characteristics (such as capacity limitations, path choice, and link cost functions). A utility network is a flow network that represents various underground and above ground utilities such as water, electricity, telecommunications, and gas (Goodchild et al., 2005).

2.1.4. Structure of geographic data

Geodatabase, dataset, object class and feature class are a part of GIS which helps to store and manipulate geographical data. The geodatabase is classified in to two generations (sewiki). In the first generation of geodatabases the spatial data is stored outside the DBMS system in separate files was shown in (Figure2.1).

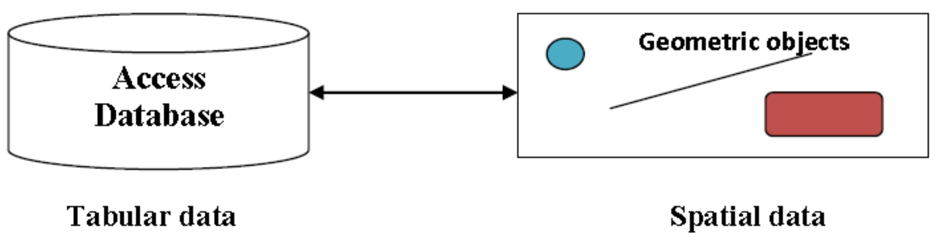

Figure 2.1. First generation geodatabase [Adopted from (Sewiki)]

In the second generation of geodatabases the spatial data is stored inside the DBMS system in a separate column called GEOMETRY. Overall spatial data is linked and stored in the same location in tabular format in DBMS as shown in (Figure 2.2).

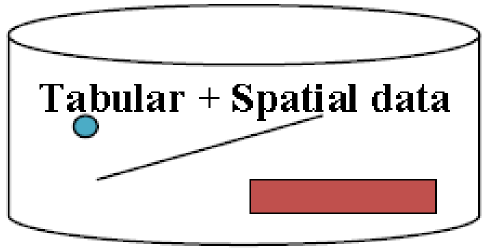

Figure 2.2. Second Generation geodatabase[Adopted from (Sewiki)]

2.1.5. Types of Geodatabase and database management system

There are three different categories of geodatabases, namely: personal, file and ArcSDE. Personal Geodatabase is a database system which used to store small size spatial geometries and non-spatial data whereas File Geodatabase supports single user editing and uses a normal file structure to store medium size spatial information. ArcSDE Geodatabase on the other hand is built on top of RDBMS system as shown in (Figure 2.3). This kind of database is used to provide a multiuser environment via providing central spatial data storage location.

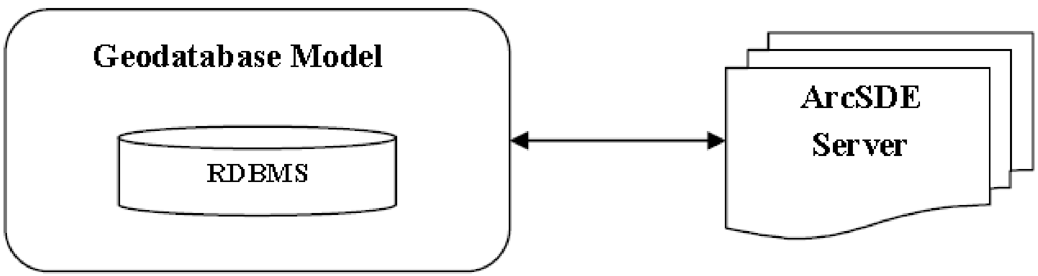

Figure 2.3. ArcSDE geodatabase [Adopted from (ESRI)]

A relational database management system (RDBMS) is a set of applications and features that allow IT professionals and others to develop, edit, administer, and interact with relational databases. To access the database, which is kept in the form of tables, most commercial relational database management systems employ Structured Query Language

(SQL). It is the most widely used database system in the world's enterprises. It provides a reliable method of storing and retrieving large amounts of data, as well as a good combination of system performance and usability. A table will be used to hold data in a relational database management system (RDBMS). Each system will have a different number of tables, each with its own distinct primary key. Each table is then identified using the primary key. There are rows and columns in the table. Records, or horizontal entities, are the rows that carry the information for each individual item. The columns are vertical entities that contain information about a particular field (brush).

The RDBMS must check the following constraints before generating these tables:

- Primary keys -- This is how the table's rows are identified. There can only be one primary key per table. The key must be one-of-a-kind and free of null values.
- Foreign keys -- This is used to connect two tables together. The foreign key is stored in one table and references to the primary key of a different table.
- Not null -- This ensures that no column, such as an empty cell, has a null value.
- Check -- This ensures that each entry in a column or row meets a specific requirement and that each column contains unique data.
- Data integrity -- Before the data is created, the data's integrity must be verified.

PostgreSQL is a strong open source object-relational database system that operates on Linux, UNIX (AIX, BSD, HP-UX, SGI IRIX, Mac OS X, Solaris, Tru64), Mac OS X, Solaris, and Windows. It offers programming interfaces for C/C++, Java, Perl, Python, Ruby, Tcl, and Open Database Connectivity, as well as text, graphics, audio, and video (ODBC). PostgreSQL includes a spatial database extender called PostGIS, which is open source, freely available, and mostly OGC compatible for the PostgreSQL Database Management System. PostGIS is a spatial extension for the PostgreSQL object-relational database that provides support for geographic items and allows SQL-based location queries. It is fairly similar to SQL Server Spatial support, ESRI ArcSDE, Oracle Spatial, and DB2 spatial extension in terms of capability, however it has greater functionality and generally superior speed. PostgreSQL can be used as a backend spatial database for GIS with the PostGIS extension. GeoServer, on the other hand, is an open source Java software server that may be used to generate, share, and manage geospatial data via the internet. Making use of open standards GeoServer makes data from any major spatial data source available to the public (wafaicloud).

2.1.6. Web mapping

“Web mapping is the process of designing, implementing, generating and delivering maps on the World Wide Web.” (Neumann, 2008). “Web mapping is the technique of utilizing maps that are obtained by an information system for spatial and geographical data.” (Techopedia). Apart from the widely accepted scientific and technical definitions, it is also important to consider what is provided by Wikipedia for two reasons: it is a user-contributed definition that anyone can improve and enrich, and it is one of the primary sources of information for many people, including scholars. In actuality, these definitions are reductive, and in order to have a complete explanation, the term web mapping must be placed in the context of the time period to which it belongs. Geo data/ geo information and its visualization (maps), geospatial software, and the World Wide Web, or the Web, are all implied in web mapping (web hereafter).

People prefer to regard the notion of web mapping as distinct from that of Web GIS (even if the distinction is unclear) or to use the two phrases interchangeably depending on whether the emphasis is placed on maps or on technology and the processing of geodata to make maps. For the sake of clarity, we've decided to describe Web GIS as a full-fledged GIS that communicates with its components via web technologies (data, functionality, and interface). Web mapping is a broader notion that focuses on delivering and supporting mapping features for apps and users at various levels of complexity.

There are a few other phrases that are sometimes mixed up with web mapping and web GIS. Internet GIS, GeoWeb (or GeospatialWeb), and Distributed GIS are examples of these (Peng & Tsou, 2003) . The terms Internet GIS and Web GIS are frequently used interchangeably. It's a geospatial Internet application that can access more than just the web. As a result, it has a broader definition of applied technology than Web GIS, but it is not as widely used. The web is, in fact, the most widely used Internet technology, and Web GIS is the most frequent type of online GIS (Fu & Sun, 2011) . As a result, we'll refer to all online GIS as Web GIS. There are two alternative definitions for GeoWeb: the first is the merger of geospatial and non-geospatial data; the second is the combining of geospatial and non-geospatial data (Parker et al., 2008). The latter is a synonym for Distributed GIS, which is a widely distributed geospatial environment that allows interoperable components to be shared.

Even though the term "web mapping" has been used for a long time, the concept and practice of web mapping has evolved dramatically over time as a result of the interaction between mapping data/information, the Internet, the web, the available tools, and citizens'/users' attitudes (Veenendaal et al., 2017). To summarize, web mapping entails the creation of a website with mapping capabilities. The capability has increased throughout time, as has people's interest in using (and, more lately, contributing to) those websites. Web mapping began as a way to disseminate static maps on the Internet, hence the term "static web mapping." We refer to "intelligent online mapping" as the final frontier of web mapping, in which context is fundamental to the interaction between mapping/geographic information and users.

We are better able to address most of the ambiguities surrounding the generic term "web mapping" by following the nomenclature suggested for the eras by other authors. Web mapping is a type of mapping that uses the internet, the world's largest multimedia platform, to produce maps. It largely deals with technology concerns, but it also necessitates more research into cartographic ideas and other topics. This means that web mapping not only adheres to standard Internet protocols, but also makes use of web-specific protocols. It also means that new cartographic ideas and technology are required to build maps for web mapping delivery. Web mapping began shortly after the internet was launched, mostly in the form of publicly available online maps, with the PARC Map Viewer being the first web-based map (Putz, 1994) . Web mapping has come a long way since its inception, but it has now reached a level that could not have been anticipated two decades ago, thanks to developments in web technologies. Time line for significant web mapping events is shown in (Figure 2.4).

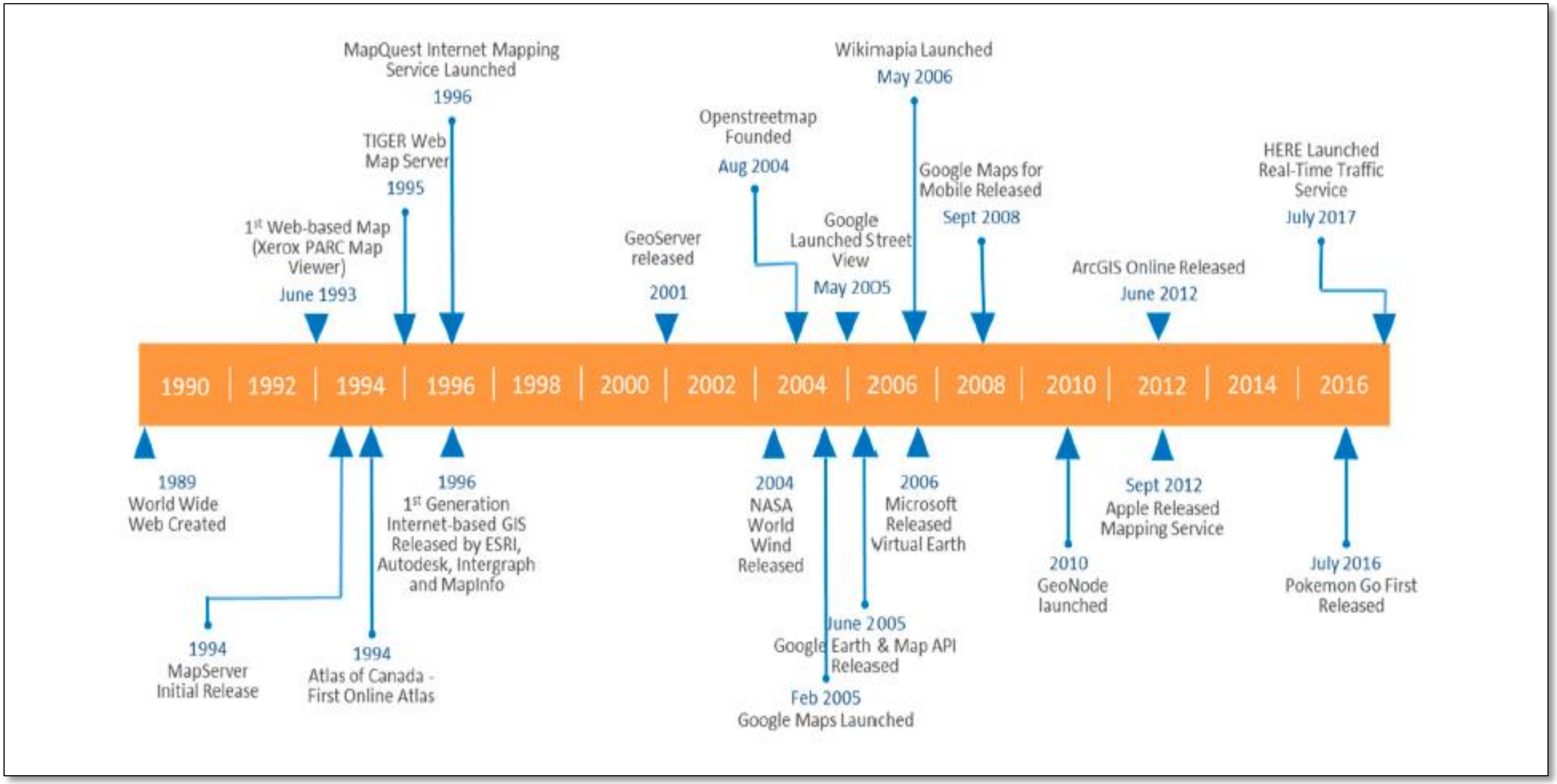

Figure 2.4. Significant web mapping events timeline [Adopted from (veenendaal et al., 2007)]

In terms of its evolution, the web has been classified into four generations by various authors: Web 1.0, Web 2.0, Web 3.0, and Web 4.0 and beyond (Berners-Lee). The major technique of disseminating internet connected information was through HTTP and HTML technologies. Web 2.0, often known as the Social Web, is a read–write web in which users can collaborate to create, modify, and share content (O'Reilly). The Semantic Web, or Web 3.0, focuses on enabling machine understanding of semantically structured data to provide consumers with more meaning and relevant information (Lassila et al., 2001).
Web 4.0 is an ultra-intelligent agent that makes judgments as powerful as a brain in order to facilitate community collaboration (Choudhury, 2014). Although several attempts have been made to describe Web 5.0, some have dubbed it the Sensory and Emotive Web (Colino et al., 2013); it is still largely vague and hypothetical.

Standards for the interchange of geospatial data developed by the Open Geospatial Consortium (OGC) provide a common foundation for the development of geographic information systems (GIS) applications. The Open Geospatial Consortium (http://www.opengeospatial.org/) is a leading organization in GIS standards creation, with members from a variety of scientific disciplines (Open Geospatial Consortium, 2001). The most widely adopted and popular of these is the Web Map Service (WMS), a specification that outlines communication mechanisms that allow disparate software products to request and provide preassembled map imagery ("compiled" map images, which may contain both vector and raster data) to a requesting client. WFS (Web Feature Service) is a similar service that allows clients to obtain vector data in its simplest form (preserving the vector nature of the dataset).

The Web Processing Service (WPS) concept is another service that is gaining traction despite the fact that it is not yet an official specification. This shows how a client can ask for geoprocessing to be done on a server, similar to how ESRITM ArcIMS software allows clients to do GIS processing and analysis over the Internet. While the ArcIMS protocols aren't open to the public, the OGC specifications that specify communications methods are. Software that implements these important criteria (whether client-side or server-side) has the advantage of being compatible with other geospatial software. The University of Minnesota's Map Server is a notable example of this, as it supports both WMS and WFS communication protocols (MapServer, 2006). High-end datacenter servers or even a personal workstation computer can run WMS and WFS. Any client software implementation that supports the specifications, such as Map Window GIS, a client-side application, or the Refractions Research web-based client tool, can consume the data supplied by Map Server via these specifications. Servers may potentially consume data sources from one another, allowing them to create maps based on resources scattered throughout the internet. Map Server is another example: in addition to supplying WMS and WFS data, it may also consume WFS and WMS data from other servers in order to render maps for end users.

2.2. Empirical review

2.2.1. The role of GIS in utility management

A geographic information system (GIS) is a system for creating, managing, analyzing, and mapping various types of data. GIS applications have progressed from their origins in map manufacturing to advanced planning and operations analysis tools. Utilities frequently employ GIS tools for marketing, facility location, and engineering applications (birkin). In the context of GIS, the most generic word for an electrical transmission network is "electrical utility network." The network begins at the source and concludes at the sink. The source is where electricity is generated, and the sink is where the energy is best utilized, which could be an industry or a modest dwelling. This electric utility network is a flow of energy that starts at the source, travels through the grid, and is transmitted to the ends via feeders, switches, and transformers before being connected by cables for energy transfer. (Loganathan, 2015).

GIS can be used in different applications to evaluate the ideal path for transmission lines and locate fault transmissions in order to reduce electric power losses throughout the country and use electricity more efficiently (Gayathri & Kumar, 2016)**.** Furthermore, keeping and updating information on electricity networks has always been a challenge (Kshetri et al., 2020) .A paper by (Ragade et al., 2016) offered an overview of subsurface utilities and how geo-technology can be used to map, monitor, model, measure, and manage existing underground infrastructure. This study emphasizes underground utilities such as oil pipelines, gas pipelines, residential waste water, non-residential waste water, drinking water pipelines, and so on. As a result, the three major approaches for mapping subsurface utilities have been identified: EMI (Electromagnetic Induction), GPR (Ground Penetrating Radar), and GPS (Global Positioning System) (Global Positioning System). in a similar manner, (Singh et al., 2016) In Bhadohi, Uttar Pradesh, India, used emerging technologies such as GIS (Geographic Information System) and GPS (Global Positioning System) to conduct power system analysis such as load flow analysis, load movement, electrical line (HT/LT) changes, and electric asset management system using the ArcGIS 10.1 platform. High-resolution remote sensing data was utilized to create several thematic layers, such as settlement, transportation network map, and other land base, as well as conduct a survey of Bhadohi's electrical asset data, which was then incorporated into a GIS platform. During the field survey, information such as the number and types of electric poles, pole IDs, distribution transformers (DTRs), and the length of HT/LT lines is collected. Each distribution transformer's physical location in the study region was determined using GPS and mapped in hard copies of satellite data. While 433 distribution transformers were discovered in 2015, only 336 were discovered in 2011.

The application of GIS and other geospatial technologies is not restricted to features found above ground; it also includes subsurface utilities. According to (Fenais et al., 2019) using a mobile device, created an integrated augmented reality (AR)-geographic information system (GIS) for mapping and recording underground utilities. Using a custom-built platform dubbed the extended reality geographic information system, the integration of AR with GIS has been developed and evaluated from a technical performance standpoint (XR-GIS). Virtual, augmented, and mixed reality systems are all included in the term extended reality (XR). This study used a design science (DS) research approach to attain its goal. A cloud-based solution allows data to be shared instantly with other stakeholders. Augmented reality (AR) has been recognized as a technique that could increase information availability and use by enhancing information extraction from the virtual world to the real world. A viable platform for AR development was offered by Unity3D and ARKit. To store and manage data, XR-GIS use the Google Earth platform and Amazon Web Services (AWS). A focus group discussion as well as a questionnaire was used to validate the XR-GIS. According to the findings, 86 percent of the participants approved of the system's ability to adapt to the underground construction. The authors finally concluded this research has produced an efficient solution for data collection and sharing among stakeholders in the underground construction industry.

2.2.2. Web GIS based utility management system

Geographic Information System (GIS) and web GIS technology can help resource managers in providing improved services. The use of a web-based geographic information system (GIS) is critical for water utility management (Okello, 2017). These problem upswings the need for the development of a Web-GIS based Utility Management System (WGUMS) system. Several studies have been conducted all around the world on the application of Web GIS technology in utility management and control. The same authors published a journal article in September 2014 in which they presented a conceptual design model for a GIS [Geographic Information System] based Utility Management System for DOS Housing Colony, Vikramnagar, Ahmedabad, India, with the goal of developing a Utility Management System based on GIS and GPS-GLONASS observations, as well as a data visualization, query, and analysis application. The input data acquired from the field, CAD map, and existing paper maps were used to execute the GIS-based utilities management project. The complete database was then transformed to spatial format and geo-referenced in the next stage. The final phase explains how to integrate collateral data into a GIS database and create a web GIS application using Visual Basic 6.0 and Map Object 2.1. This system allows for the updating of utility maintenance schedules, user and service provider interaction on the built web application, and so on.

In the water distribution industry, GIS has shown to be a useful and strong tool. According to the American Water Works Association (AWWA), 90 percent of water agencies were utilizing GIS to help with applications in 2002 (Shamsi & Uzair, 2005). Another study at Copperbelt University in Zambia reported the usage of a web GIS system for water utility management (Okello, 2017). The disadvantages of paper-based utility maps have been investigated, and a better system based on geographical data organization, manipulation, and display has been developed to overcome them. The usage of GIS decreases overall maintenance costs and provides end-users with a web-based centralized system with correct and up-to-date information, according to the findings. Using PostGIS, QGIS, and GeoServer, the researchers were able to construct an effective and efficient web GIS water management utility system. The web GIS framework was designed to provide a centralized system with web-based access to accurate and up-to-date utility spatial information across the university. The study's findings revealed that the PostgreSQL/PostGIS database was successfully integrated with QGIS for desktop mapping and GeoServer for web mapping. These tools allowed users to create patterns and relationships from a variety of data sources using both visualization and analytical functions.

On the other hand, a framework for developing a 3D utility data model was proposed, with the goal of bridging the gap between underground utility surveying and data management. The two primary components of this framework are a 3D utility network data model that seeks to convert utility survey data to 3D geospatial information and a 3D utility cadastral data model that supports utility ownership management (Yan, 2018). This data model has two primary applications. One is for government agencies, stakeholders, and other users to share data. The other is to assist with underground utility network cadastral administration. The collection of spatial data by survey crews takes time and can be erroneous.

In surveying and mapping, photography is used to determine the distance between objects. Photogrammetry is a way for creating a three-dimensional representation of an exposed subterranean utility. The model yielded an absolute coordinate. And The GIS Database is retrieved and updated using a graphical user interface for 3D visualization. 3D modeling and hydraulic modeling are used to model subsurface pipelines. The system was monitored by employing either an operator monitoring system or a remote sensing data monitoring system to detect water loss by deploying wireless sensor networks (WSN) with acquisition data from sensing technologies such as moisture, sound, and pressure sensors. GIS and remote sensing were given the management role for this system. The final conclusion was that with these strategies, infrastructure could be converted to smart infrastructure.

According to Kshetri et al. (2020) presented web-GIS based utility management system to address issues such as the absence of effective utility network planning that takes into account other utility networks in the area. The system includes all utility layers, such as transmission lines, drainage, and water supply, in a web-map, as well as the functionality of querying the layer's information, sharing maps, and generating reports, as well as some spatial operations, such as distance and area measurement, and the mechanism for system administrators to add or remove utilities at specific locations. The information was gathered using GPS, a drone survey, and non-digital sources. With the help of GIS desktop software, collected data from various sources was organized and layers of various utility components were constructed. PostgreSQL's relational database system was used to manage the data. After that, the utility layers are integrated into a web platform. Hypertext Markup Language (HTML), Cascading Style Sheets (CSS), and javascript are used to create the frontend. Django, an open-source Python framework, was used to create the backend. Zooming in/out, panning, adding markers, distance calculation, area calculation, and other mapping functions are developed using the javascript package Leaflet. The method is particularly useful when it comes to the upkeep, updating, and planning of any utility features in the region of interest.

2.2.3. Web-GIS based electric utility management system

GIS is a computer-based platform capable of handling spatial data that represent real world feature transmission lines, in the form of digital maps and attributed geo-relational database. This model allows new methods to be used and provides high-quality presentation of processed data and decision making tool in situations when data relevant to a decision include a spatial component. Nowadays, utility companies are discovering the advantages of GIS technology in automated mapping. As a result, GIS has emerged as a critical tool for electrical utilities and operations such as utility asset management, maintenance planning, outage management, and network planning, particularly in the distribution planning area. These facts should be accurately stored and kept as up-to-date as possible in GIS to aid in the provision of vital information for the construction of an electrical network that ensures the network's growth and reliability (Meehan, 2013). All the equipment involved in electric transmission network has got some limited time period on its durability. To keep the electrical network up to code, this equipment must be changed on a regular basis. So, by geographically managing these with a temporal dimension, the system will be able to automatically signify the time limit for each and every piece of equipment within a threshold time limit, reducing the frequency of power outages in an electrical network.

Web GIS system is employed to provide the information system on electrical assets for the electricity board users through Geographic Information Systems to implement this, the survey work was done using GPS and mapping process using GIS. The applications can be developed with GIS capabilities using the JAVA Web ADF [Application Developer Framework] provided by ArcGIS. This will be available for tracking any asset over the full network of a particular town or towns via a query. Users can search for a substation by name, capacity, kind, section name, and so on. They can also search for HT, LT Lines, DTR's, and Poles according on the variables and values they choose. According to the user's preferences, the system will also generate reports for the substation, DTR, and Substation Elements. The search in this system is essentially non-graphic, and the final result will be displayed on a GIS map (Gayathri & Kumar, 2016).

In the context of GIS, the most generic word for an electrical transmission network is "electrical utility network." The network begins at the source and concludes at the sink. The source is where electricity is generated, and the sink is where the energy is best utilized, which could be an industry or a modest dwelling. This electric utility network is a flow of energy that starts at the source, travels through the grid, and is transmitted to the ends via feeders, switches, and transformers before being connected by cables for energy transfer. The Aggregate Technical and Commercial Loss (AT&Closs) accounts for roughly 25% of the total loss in our country, totaling 700 billion rupees. Identifying the loss pocket is the first step in reducing the loss. The function of GIS is to spatially map the entities, to perform the process in real time, and to disseminate data across all verticals using Arc GIS or Quantum GIS, and to pinpoint the loss pockets (Loganathan, 2015).

According to Bharathi and Sundara (2015) the impact of GIS integration with the Transmission Asset Management System (TRAMS) of Kerala State Electricity Board (KSEB) was analyzed. As a consequence, a Web GIS application is developed and made use for the KSEB personals using Open Geo Suite package. Open geo suite architecture is shown in (Figure 2.5) .The Open Geo Suite is one of the open source GIS packages having required components to create a web GIS application.

User interface framework: GeoExt / ExtJS&OpenLayers

Application cache: GeoWebCache tile cache

Application server: GeoServer map/feature server

Storage: PostGIS/PostgreSQL spatial database

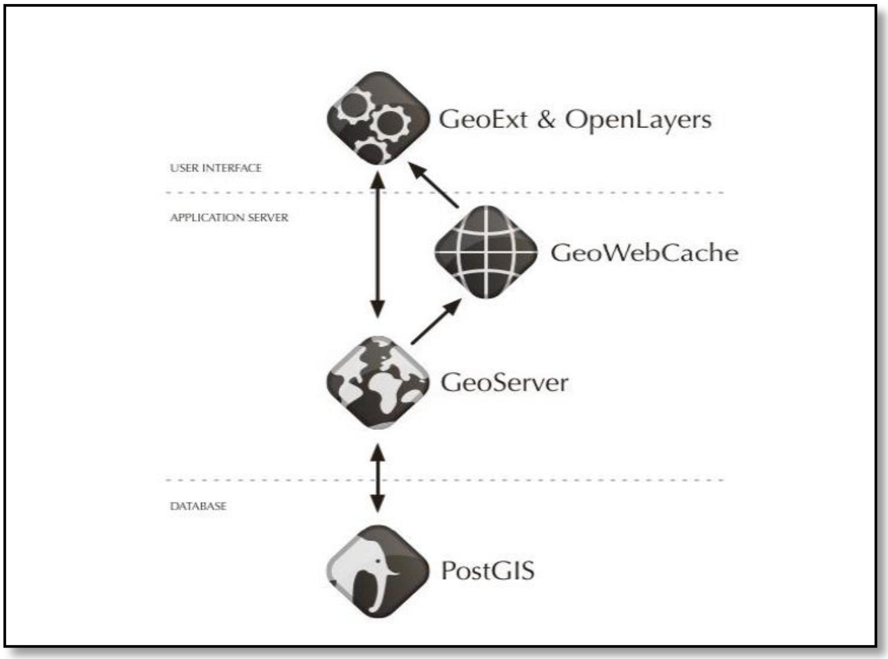

Figure 2.5. Open geo suite architecture[Adopted from (Open source community, 2010)]

(Ajwaliya et al., 2017) Illustrates architecture of the developed application in figure, where user can send data request from a web browser as HTML/JavaScript and they can get response from server in HTML/ JavaScript client node. Web server Apache is handling the request from client and the same is passed to Geo-server which is used as map server; from map server, request has been responded to the client in form of spatial data or query results in tabular form.

CHAPTER THREE

3. MATERIALS AND METHODS

3.1. Description of the study area

Adama is a city in Ethiopia's central Oromia Region. Adama is part of Oromia's Special Zone and is surrounded by the East Shewa Zone. It spans $8^{o}26'15''-8^{o}37'00''$N latitude and $39^{o}12'15''-39^{o}19'45''$E longitude, covering a total area of 134.11 km^2 and at an average elevation of 1712 meters above mean sea level (Figure 3.1). To the west, the city is at the base of an escarpment, and to the east, the Great Rift Valley. Since its founding in 1916, the City's quick progress, as well as its infrastructure, has been aided by its good geographical location, which is close to the capital city of Addis Ababa, and its pleasant climatic conditions.

The Awash Valley's economic potential and future development are also important aspects in the city's growth and development, as well as the surrounding region as a whole. Furthermore, Adama was given a new status in August 2000, when it became the seat of the National Regional State and the capital city of Oromia, Ethiopia's largest Regional State. As a result, the City's rapid development was slowed somewhat. There are fourteen Kebeles in the administrative area of the city. The lowest level of city governance is the Kebele, and there are six Kebeles in the central section of the city, covering 5.8 square kilometers. The remaining eight Kebeles, which have an area of 127.9 square kilometers, are located on the outskirts. In 2017, the city was restructured into six (6) sub cities: Aba geda, Danbala, Bole, Dabe, Lugo, and Boku. These 14 kebeles were distributed to each sub city. Siqqee Street, Karayu Street, Mamo Mazammir Street, Atlet Wami Birratu Street, Alamayehu Atomsa Street, Ali birra street, Elemo kiltu street, Adama butta street, and Abba gada street are the city's principal streets. The importance of street name has been discovered to be critical for effective property location, and the planning and provision of infrastructural utilities like power.

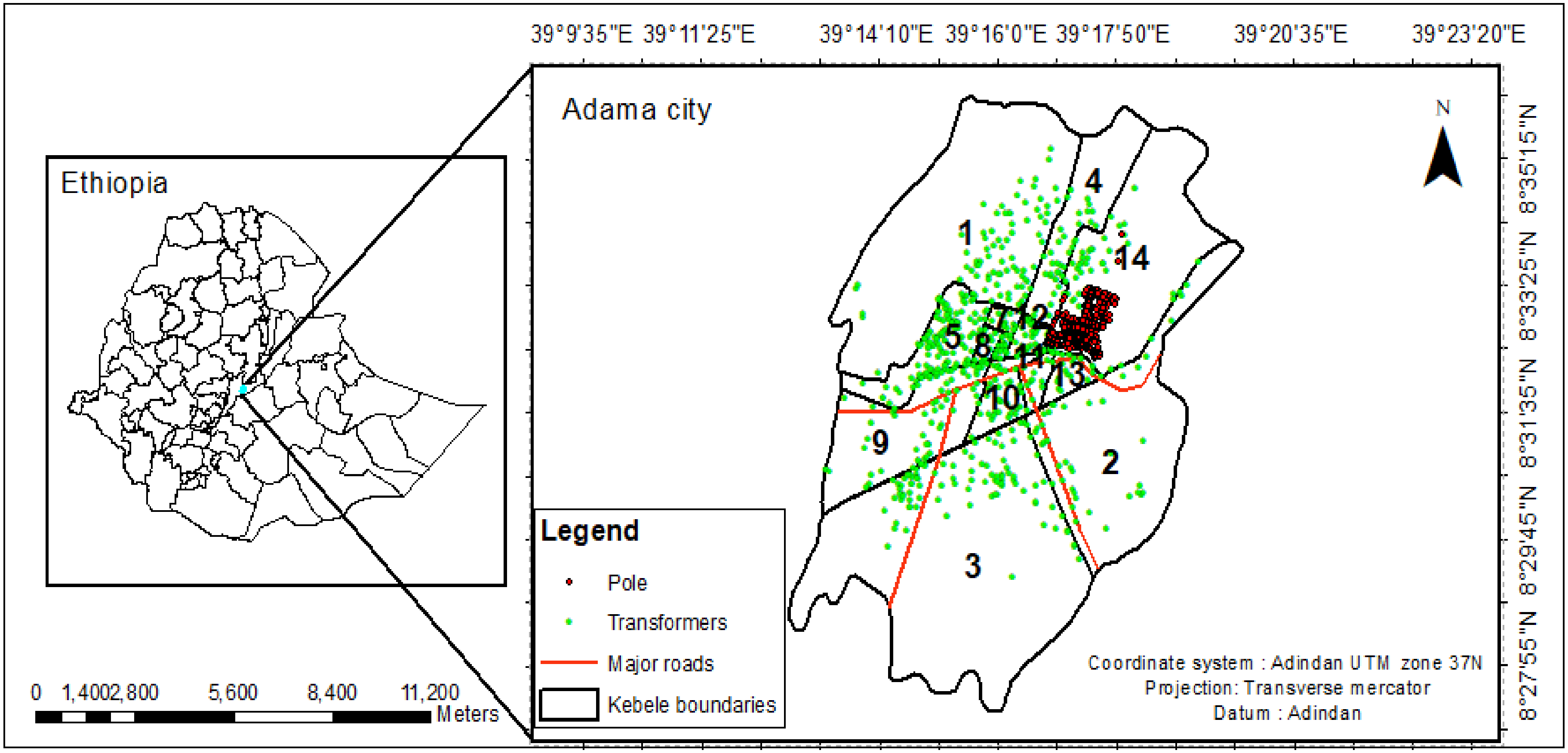

Figure 3.1 Location map of the study area

3.2. Population distribution by kebele

Information on the size of the population of a region has become a very important tool on various grounds. This is mostly due to the fact that population has a direct link to any development effort. Data on the quantity and structure of a population is required for planning and implementing development initiatives in health, education, and infrastructure provision such as water, roads, power, and housing. The city's total population in 2006 was 356, 304 (Adama Science and Technology University(ASTU), 2016) up from 127,842 in 1994.

Population distribution by Kebele presented in (Table 3.1) showed that the population of the City is unevenly distributed. Kebele 11 accounts the highest population size making 14.7 % of the total urban population followed by Kebele 10 (13.24%); Kebele 09 (9.26%) and Kebele 16 (6.54 %). On the other hand, Kebeles accounting less than 3% of the total population are Keble 05 (2.03 %); Kebele 08 (2.36 %) Kebele 18 (2.75%) and Kebele 19 (2.78%). The most of the Kebeles account less than the average (5%) of the total urban population (Central Statistical Agency(CSA), 2021) .

Table 3.1. Population distribution of Adama by kebele in 1994

Kebele	**Population**			
	Population distribution(No.)	**Population distribution (%)**	**Male**	**Female**
1	3744	2.93	1807	1937
2	4672	3.65	2102	2570
3	4895	3.83	2420	2475
4	4747	3.71	2177	2570
5	2595	2.03	1562	1033
6	4117	3.22	2089	2028
7	4251	3.33	2170	2081
8	3014	2.36	1473	1541
9	11838	9.26	5633	6205
10	16930	13.24	8459	8471
11	18843	14.74	9171	9672
12	5473	4.28	2508	2965
13	5671	4.44	2722	2949
14	5744	4.49	2665	3079
15	5886	4.6	2586	3300
16	8360	6.54	4180	4180
17	4297	3.36	2077	2220
18	3519	2.75	1528	1991
19	3548	2.78	1692	1856
20	5698	4.46	2944	2754
Total	**127842**	**100**	**61965**	**65877**

Source: - (CSA, 1994) census

Previously there were 20 kebele in the city, this restructured into 14 kebeles. In 2013, kebele boundary of the city is structured in new kebele boundary, and the populations of the city in the new kebeles are mentioned in (Table 3.2).

Table 3.2. Population and population density per kebele in the year 2013

No	Kebele name	Population	Population density
1	01	12,580	0.0017
2	02	15505	0.0036
3	03	9364	0.0069
4	04	15757	0.0095
5	05	11501	0.037
6	06	13534	0.025
7	07	11883	0.014
8	08	18960	0.038
9	09	18981	0.0049
10	10	18127	0.0023
11	11	18209	0.0037
12	12	13737	0.0033
13	13	12401	0.0066
14	14	17577	0.0036
Total		**208,116**	

Source: - Computed from document of AMPPD , 2003

As of 2021, the total population of the city was estimated to be 435,222 with 212,991 being male and 222,231 female (Central Statistical Agency(CSA), 2021).

3.3. Data types and source

The primary data of the study area is collected using hand held GPS (GARMIN, ETREX 32X) which is obtained from Addis ababa institute of technology. The GPS point data depicted a detailed geographic location of each and every electric asset within the study area. The point data was then imported to ArcGIS environment and assigned appropriate symbol. Secondary data used as a reference to compare the previous system with the current one include existing analogue and digital electric utility map of Adama city which is obtained from Ethiopian electric utility(EEU) ,Adama district. To prepare the location map of the study area, the shape file data of Adama city showing all kebeles is collected from Adama Municipality office. The data, their types and sources used for this study are shown in (Table 3.3).

Table 3.3. Data and source

S.No	Data	Format	Source
1	GPS point data	Way points(.gpx)	Field survey
2	Electric distribution Transformer data	Ms. Excel workbook(.xlsv)	Ethiopian electric utility
3	Shape file data	Shapefile(.shp)	Internet and adama city administration
4	images	Raster	USGS and google earth

3.4. Software application, purpose and sources

Software applications used in this study are selected based on the availability and capability to work on the existing problems in achieving the predetermined objectives. The summary of all software applications used in this study are depicted in (Table 3.4).

Table 3.4. Software application and source

Software (Application with Specification)	Purpose	Source
Microsoft office 2010(word,excel,power point)	• Report writing • To Make graphs • Thesis presentation	*Microsoft® Inc.*
ArcGIS 10.4	• To load existing shapefile data • To map gps point data • To manage geodatabase	*ESRI® Inc.*
Apache tomcat 9.0	• Serves as java HTTP web server	http://tomcat.apache.org
Open layers 6	• For making interactive web maps viewable in nearly any web browser	http://www.openlayers.org/
PostgreSQL 9.3	• For database storage and transaction	http://www.postgresql.org.
PostGIS 3	• A middle ware between postgreSQL and GIS engine	"http://www.postgis.net/
Geoserver	• For publishing layers to web	http://geoserver.org
Wonder share Edraw max	• To draw flow chart and diagrams	*Edraw®*
JQuery,Bootstrap,layer switcher,open layers	• Java script and CSS codes	*Google*
Visual studio code editor	• To edit wms/wfs code	*Visual studio*

3.5. Methodology

The methodology adopted for this study is shown by flow chart in (Figure 3.5). Development of Web-GIS based electric utility management system comprised 4 steps: initially ground survey was made to collect pole electric utility. Distribution transformers data on the other hand is obtained from Ethiopian electric utility, Adama district office. Following field data collection, data preparation was made by considering the two data layers pole and distribution transformers in Arc GIS. Based on this 660 poles and 2575 distribution transformers were mapped in ArcGIS. Database preparation is done for the two feature classes in Arc GIS. Later, the two feature classes are imported to postgre SQL free RDBMS software for better data management and manipulation. Postgis a postgre SQL database extension was utilized to import these shape files to open source, free web server called Geoserver. The layers were fetched to the developed Web page by using HTML, CSS and JavaScript codes in visual studio code editor. The full steps of followed methodology have been briefly described in the following subsequent sub-sections.

3.5.1. Field data collection

The data required for conducting the research was collected using different techniques like GPS surveying and digitization technique. Using GARMIN ETREX 32X hand held GPS which have accuracy up to 3m depending on satellite signal strength, the ground survey of each electric pole points were conducted. GPS-GLONASS observations technique is used during data collection. As a result 660 high tension and low tension electric poles were found during field survey. The collected points were assigned a code which will later help in identifying the features during digitization. Accordingly, electric poles are given a WP and CP in a note section of waypoints which indicates wooden pole and concrete pole respectively. Each transformer is assigned DTR, meaning distribution transformers. The collected field data is provided in Appendix-1 of this document.

The Global Positioning System (GPS) and GLONASS (Global Navigation Satellite System) are satellite navigation systems that enable precision and flexibility in determining the location of stationary and moving objects. Navigation, surveying, remote sensing, mapping, and geodetic positioning are some of its applications. Geodetic placement can be calculated in reference to a well-defined coordinate system, usually using three coordinate values, or in relation to other points, using one point as the local coordinate system's origin. GPS is a global positioning system that employs satellites and computers to calculate positions anywhere on the planet. Finding the location of any object in an electrical power distribution system, such as buildings, roads, pump houses, wells, trees, electric cables, substations, route and street light pole tracking, and so on. It displays the location in latitude and longitude, which may be simply imported onto a computer screen. GPS is quickly becoming one of the most effective techniques for capturing GIS data. With the right software, the GPS can be simply connected to a laptop or a computer in the field. Users can also have all of their data on a single platform with minimal distortion.

3.5.2. Importing points to ArcGIS

The field survey data then downloaded to personal computer using GARMIN USB cable and with the aid of dnrgps software by specifying the correct coordinate properties (Adindan UTM zone 37N).the data can be downloaded in different format options. To follow clear and easy steps .gpx and .txt tab delimited format is preferred. After having all the data on the computer, the tab delimited text file was copied to the Microsoft excel work book with the format .xlsv format and saved. The excel data was imported to ArcGIS by specifying projected x and projected y as x field and y field respectively. The coordinate system is set to projected Adindan UTM zone 37N. Finally, the imported excel file is exported to shapefile which enables feature editing after creating a certain geodatabase in ArcGIS. With the help of GIS desktop software, the acquired data from various sources was organized and the layers of electric utility components were constructed.

3.5.3. Database preparation

The research and design of a geodatabase is a critical stage in ensuring its effectiveness and proficiency. If the design is incorrectly implemented, as the current experience of Ethiopian electric utility, the organization’s utility database will not function to its full potential, essentially creating problems for the users. The main theoretical approaches within this study is to develop a proficient database model design to accommodate the electric utility data needs of the Adama city, while using all necessary database functionality. Therefore, this section outlines the conceptual design phase which addresses the research conducted, and the logical and physical design phase which illustrates the resulting to create a comprehensive electric utility database model using entity relationship model. Symbols and notations used in entity relationship diagram are shown in (Figure 3.2).

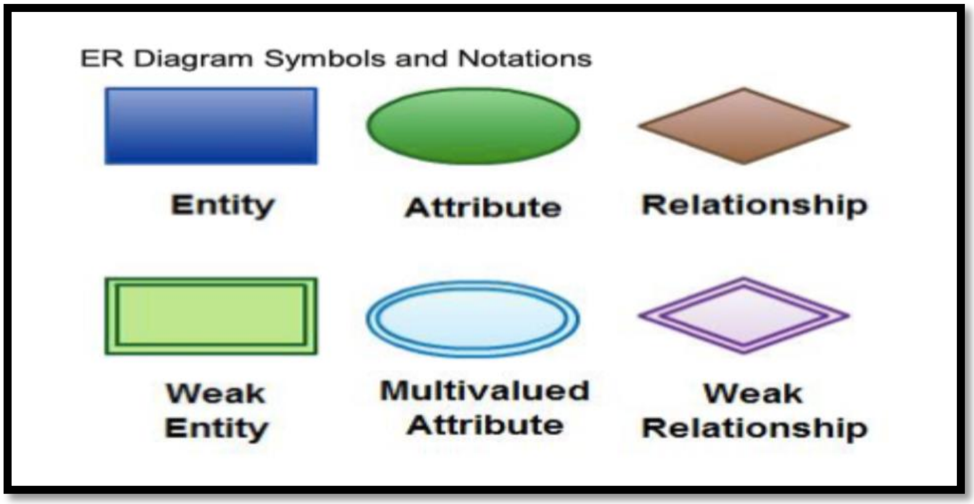

Figure 3.2 Symbols and notations of entity-relationship diagrams

After creating a geodatabase, the data was maintained using PostgreSQL's relational database architecture. The database aids in the connection and correlation of each layer's geometry with its attribute information. PostgreSQL 13 (PostgreSQL) is installed with the default program files directory and port 5432, as well as a database super password to use when opening the PostgreSQL database. Using the PgAdmin user interface, a new database is created in PostgreSQL. PostGIS 3 bundle is also installed, and a database connection to the installed PostgreSQL is established by entering the login, password, and port that were specified during the PostgreSQL installation. Importing shape files into PostGIS utilizing the shape file import/export manager plugin allows converting shape files to PostgreSQL database tables. The database is published to geoserver after it has been configured and designed in PostgreSQL as required.

3.5.4. Publishing layers to geoserver

The general workspace of geoserver was run after installing apache tompcat 9 and deploying geoserver inside it with default port number localhost: 8080 the credentials were set by admin. The interface of installed geoserver is shown in (Figure 3.3).

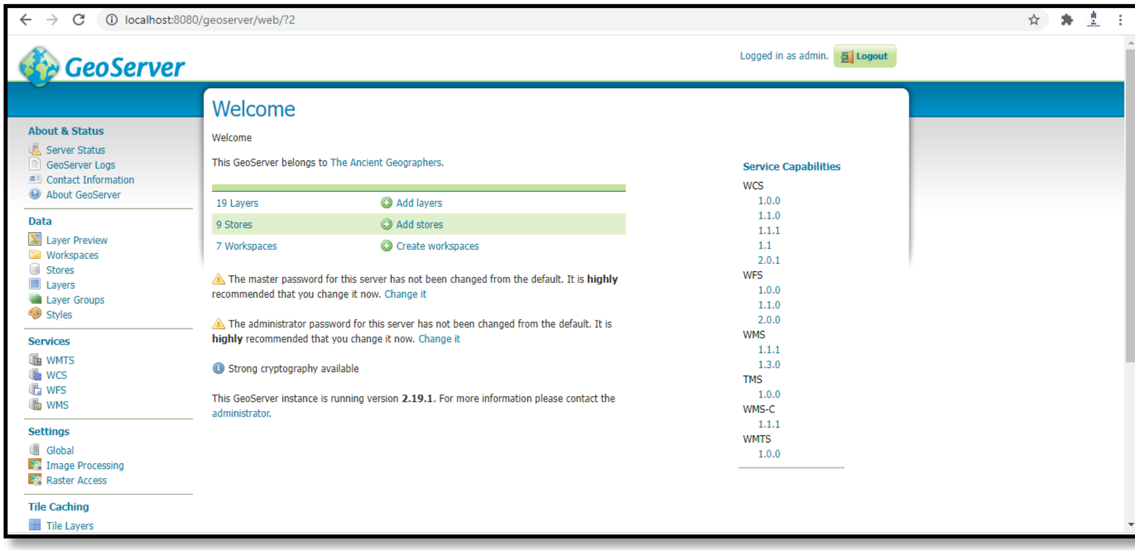

Figure 3.3. Geoserver interface

Workspace is the name of a fictitious container used to group similar data. A workspace consists of a name and a namespace URI (Uniform Resource Identifier). The workspace name cannot contain spaces. This study creates a new GeoServer workspace and eventually sends the name and namespace URIs as WGEUMS and WGBEUMSM, respectively. Under workspace name the newly created workspace presented in (Figure 3.4).

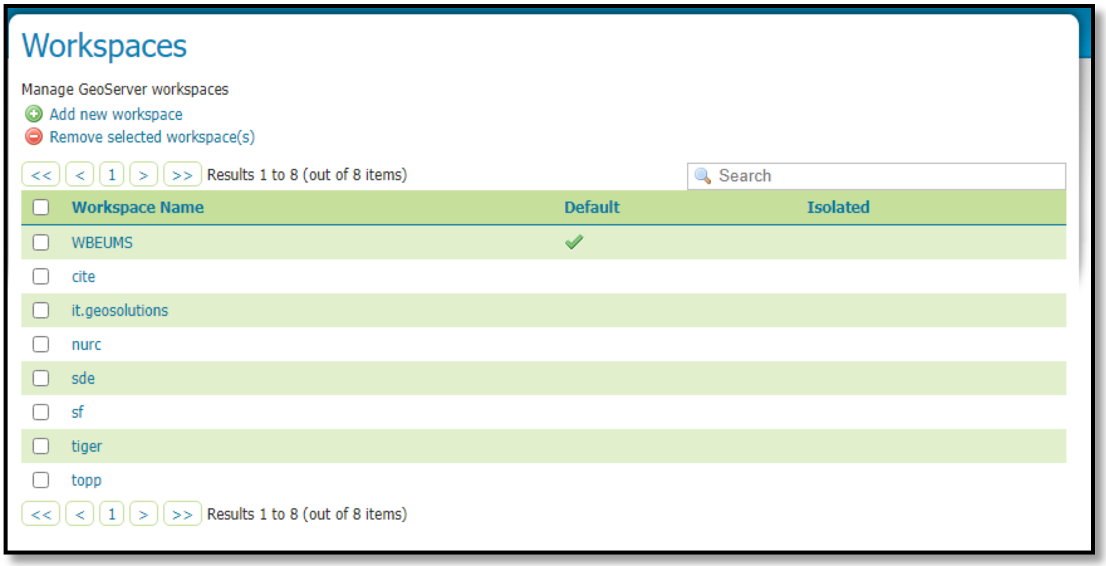

Figure 3.4.Geoserver workspaces

Converting a shapefile to a PostgreSQL database table is done by importing the shapefile into PostGIS using the Shapefile Import / Export Manager Plugin. The resulting table contained all the attributes of the shapefile, such as the coordinates and geometry that define each feature. This process is repeated for each vector layer created within the scope of the study. After the database is configured and designed in PostgreSQL as needed, the database is published to Geoserver by creating a new Postgis store in Geoserver.

3.5.5. Web interface development

The process of developing web based electric utility management system is started by downloading various open source software and libraries, which are directly involved in web application, while many other desktop GIS applications are used in preprocessing of spatial database and advanced analysis. PostgreSQL is a database server for storage and transaction management. In the developed application, the open source database PostgreSQL with PostGIS extension supported spatial features very well. PostGIS is a middleware between PostgreSQL and Geoserver (Figure 3.5).

GeoServer is an open source software server written in Java that allows users to share and edit geospatial data and is used for interoperability and publishing Open Geospatial Consortium (OGC) web services. Java development kit is required to run and develop Java application on the computer system. So it is downloaded from http://www.oracle.com. The Apache Tomcat9 server was obtained from tomcat.apache.org. The GeoServer package is deployed on Apache Tomcat. Open Layers is an open source client-side JavaScript library for creating interactive web maps that can be viewed in almost any web browser. Open Layers makes it easy to add dynamic maps to any web page. In addition, open layer javascript libraries such as jquery and bootstrap have also been downloaded and copied to the Apache Tomcat library. After having all open source libraries and software, web interface was developed using HTML, CSS and JavaScript codes in visual studio code.

HTML is used to define the building blocks of the web page like head, body etc. The style was created using CSS for map element by defining size and aspect in html page. CSS is used in styling web page and make it beautiful by defining position, color, size of different web elements. The code used to style the map is as follows.

```
#map{
    position: absolute;
     top: 4%;
     left: 20%;
    width: 80%;
     height: 96%;
     overflow: scroll;
     border: 0.5px solid #4CAF50;
   }
```

A reference and links to each and every open layers and java script libraries was created to access open layers service by using the following html code in the head section.

```
<!doctype html>
<html lang="en">
 <head>
   <link rel="stylesheet"
href="http://localhost:8080/webgis/libs/v6.5.0/v6.5.0/v6.5.0/css/ol.css" type="text/css">
```

```
<link rel="stylesheet"
href="http://localhost:8080/webgis/libs/v6.5.0/v6.5.0/v6.5.0/examples/resources/layout.css"
type="text/css">
    <link rel="stylesheet" href="http://localhost:8080/webgis/libs/ol-layerswitcher-
master/dist/ol-layerswitcher.css" />
```

Java script is a programming language used to add different functionality to web page. Variables are declared with a var keyword in java script tag section.

```
<script type="text/javascript">
    var map, geojson, layer_name, layerSwitcher, featureOverlay;
  var container, content, closer;
```

A base layer open street map (OSM) is added with the title OSM

```
var base_maps = new ol.layer.Group({
            'title': 'Base maps',
            layers: [
                new ol.layer.Tile({
                title: 'OSM',
                type: 'base',
                visible: true,
                source: new ol.source.OSM()
              })
            ]
        });
```

Vector layers namely pole and transformers are fetched using the code below from geoserver to web page. The web pages GET the layers in geojson format from geoserver through GET JavaScript command. geojson is an open standard vector file format representation in geoserver.

```
var overlays = new ol.layer.Group({
            'title': 'Overlays',
            layers: [
   new ol.layer.Image({
```

```
  title: 'pole',
     // extent: [-180, -90, -180, 90],
      source: new ol.source.ImageWMS({
        url: 'http://localhost:8080/geoserver/wms',
        params: {'LAYERS': 'WBEUMS:pole'},
        ratio: 1,
        serverType: 'geoserver'
      })
    }),
new ol.layer.Image({
  title: 'transformers',
     // extent: [-180, -90, -180, 90],
      source: new ol.source.ImageWMS({
        url: 'http://localhost:8080/geoserver/wms',
        params: {'LAYERS': 'WBEUMS: transformers'},
        ratio: 1,
        serverType: 'geoserver'
      })
    })
]
});
  var map = new ol.Map({
    target: 'map',
  view: view,
overlays: [overlay]
    });
map.addLayer(base_maps);
map.addLayer(overlays);
```

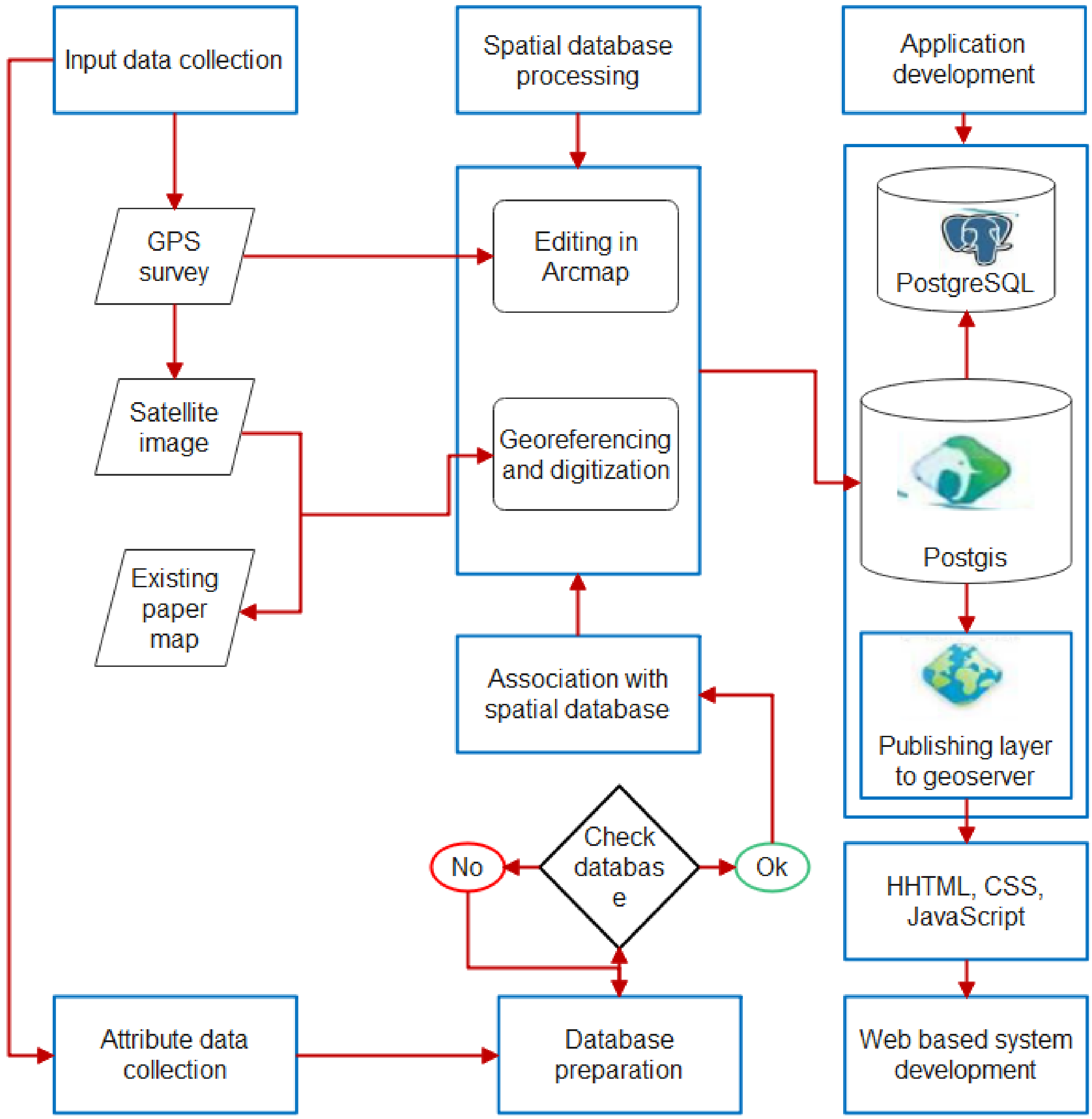

Figure 3.5 Methodology flowchart

CHAPTER FOUR

4. RESULTS

4.1. The previous electric utility management system

The data obtained from Ethiopian electric utility, Adama district during data collection is in Microsoft excel format. In fact it is possible to import this excel data to ArcGIS but the data handling system is meant for Ethiopian electric utility officials and technical experts as it is complicated and abbreviated. Besides there is only transformer data and other electric utilities are not included. As it is reveled while site survey, some poles and electric cables haphazardly placed either inside or over the existing street network or in built up area of the city (Figure 4.1).

Figure 4.1 A sample photo showing over crowded electric poles in the study area

This implies that there is a high possibility of destruction of the utilities by transportation vehicles, during road infrastructure upgrading or other utility maintenance. The outcome result of this problem is below standard of services, impact on the development of the city, vulnerable to high cost of compensation and visual obstruction on human activities and walking. The usual work of overhead electric power provision made using a simple kind of field sketching techniques. Furthermore utility poles usually installed in haphazard locations without the consent of the city administration. According to the result of the primary data, here the most distressing issue is that when the city administration need to develop the area (need to mad redevelop in the area) it faces so complicated and bureaucratic problems. Such problems might happen due to most of utility authorities may not easily able to relocate utility lines and poles. This problem might not occur if there was a utility web map developed earlier. Previously, there is no utility data disseminated to users online that enables user to query and extract important information about the utilities.

The following are some other draw backs in the previous electric utility management system observed from the data obtained.

- Users were limited to access the utility information pertaining to electricity by analogue methods.
- Even though there exist poorly mapped and not well organized databases, it is not exposed to the users by any means.
- The database is not managed and obtained in the form of information where decision makers and users can extract information regarding electric utility.
- The mapping of electric utility was limited to station, substation, transformers and main distribution lines.
- Normally all the maps available with the department are either outdated or rarely updated.
- Lack of interactive web based system for providing instant information to users and departmental engineers.

4.2. Electric utility database model

The fundamental principles behind planning a successful database are based on an attempt to discover its real purpose, and decide what output and information is needed. The electric utility database conceptual, logical and physical design phase results are presented based on two main electric assets: pole and distribution transformers. The database is stored and managed using RDBMS software postgreSQL.

4.2.1. Conceptual design phase of electric utility

A conceptual data model is a view that organizes database concepts and their relationships. The purpose of creating a conceptual data model is to specify entities, their attributes, and their relationships. The 3 basic tenants of Conceptual Data Model are:

- **Entity**: A real-world thing
- **Attribute**: Characteristics or properties of an entity
- **Relationship**: Dependency or association between two entities

Accordingly

- Pole and transformers are the two entities.
- FID,OBJECTID,shape,type,latitude,longitude,y_proj,x_proj,comment,altitude are attributes of pole.
- FID,OBJECTID,no_,csc,tg_no,specific_area,substation,line_voltage,trafo_rating,erection_status,feeder-name,x,y are attributes of transformers.
- A pole supports transformers which are pole mounted and this is the relationship between the two entities.

Defining the geographic data entities requires a transformation from the ideas and needs into the creation of concrete feature classes or object classes. The geographic entities are broken down further in this stage to represent points, lines, polygons, or tables (object classes). The objective of this phase is to determine how data is grouped and represented in the geodatabase model by classifying entities according to their type of representation (Table 4.1).

Table 4.1.Geographic data entities and representation of electric utility

Layer	Data model		
	Point	Line	Polygon
Pole	✔		
Transformers	✔		

4.2.2. Logical design phase of the electric utility geodatabase

The logical phase illustrates the complexity of the geodatabase including all design elements required to establish a proficient geodatabase. All design elements are based on previously identified data requirements outlined at the conceptual stage of the design. The logical data model adds more information to the conceptual data model elements. The advantage of using this data model is that it provides the basis for forming the basis of the physical model. However, the modeling structure remains common. No primary or secondary key is defined for this level of data modeling. This level of data modeling requires reviewing and adjusting connector details previously configured for relationships in terms of data types, record lengths, field descriptions, subtypes, and domains Tables (4.2 and 4.3).

Table 4.2 Pole feature class data specification

Field name	Data type	Length	Domain	Description
FID	Short integer	Default	---	Feature ID number
OBJECTID	Short integer	>>	---	Object ID number
Shape	Geometry	>>	---	Geometric shape
Latitude	Float	>>	---	Lat in decimal degree
Longitude	Float	>>	---	Long in decimal degree
Y proj	Float	>>	---	Y location
X proj	Float	>>	---	X location
Pole_type	Text	>>	WP/CP	Wooden/concrete pole
Altitude	Double	>>	---	Height above msl

NB: Default field length is set to 50

Table 4.3.Transformer feature class data specification

Field name	Data type	Length	Domain	Description
Feature ID	Short integer	Default	---	Feature ID No.
Objected ID	Short integer	>>	---	Object ID No.
Shape	Geometry	>>	---	Geometry
No.	Short integer	>>	---	Random no for transformers
Csc	Text	>>	---	Transformer protection
Tag nunber	Text	>>	---	Tag number
Specific area	Text	>>	---	Name of the area
Substation	Text	>>	---	Name of substation
Line-voltage(Kv)	Short integer	>>	---	Power capacity
Trafo rating	Short integer	>>	---	Transformer rating
Erection-status	Text	>>	---	Pole mounted or other
GPS point north	Float	>>	---	Decimal degree
GPS point east	Float	>>	---	Decimal degree
Feeder-name	Text	>>	---	Name
Easting	Float	>>	---	X location
Northing	Float	>>	---	Y location

NB: Default field length is set to 50

4.2.3. Physical design phase of the electric utility geodatabase

In the physical design phase, the procedure of building the geodatabase is described in terms of applying the specifications identified in conceptual and logical design phases. The feature classes were established according to the structure mentioned in the conceptual and logical design phases. In addition, the valid data types and domains are associated to the features and attributes. The database are populated for each entity or feature class in ArcGIS according to data needs, specifications, types, domains were saved as shapefiles to local machine. Finally, database is created in postgreSQL and these shapefiles are imported through Postgis spatial extension for better data management and relationships are defined.

Entities, attributes, key attributes and relationships of the developed WBEUMS database are depicted in (Figure 4.2).

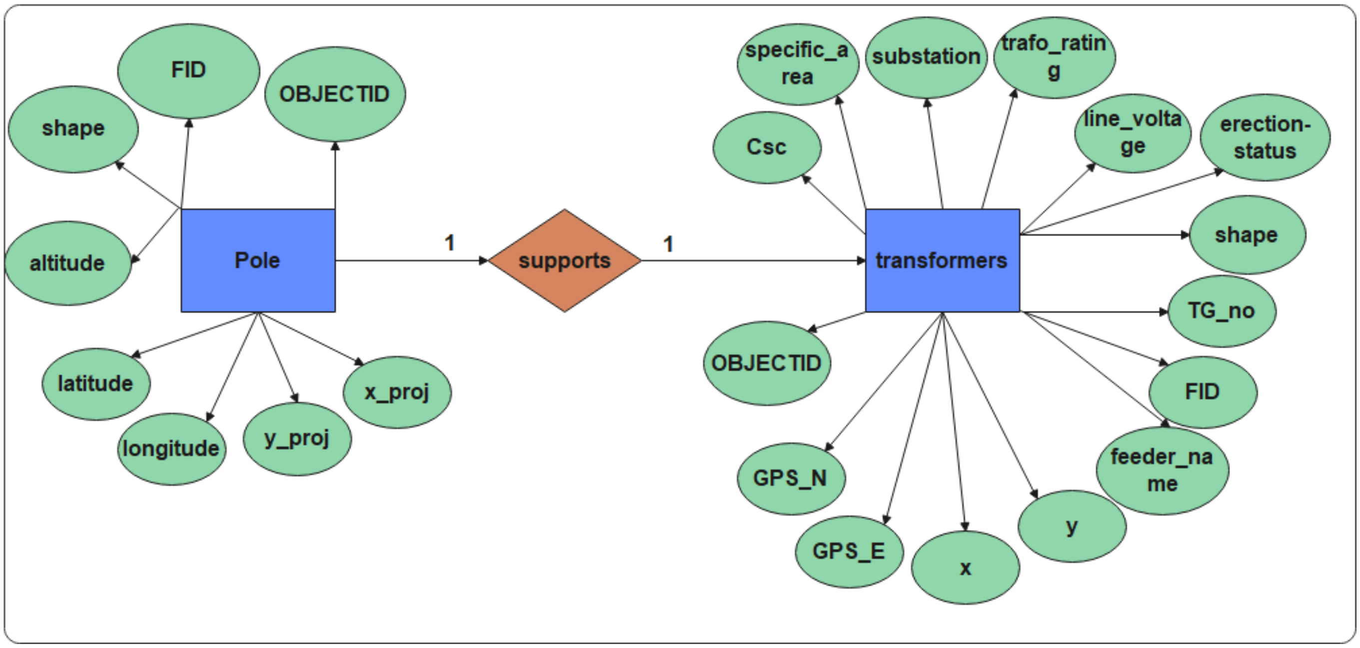

Figure 4.2.Entity relationship diagram

4.3. Web-GIS based electric utility management system

As seen in 4.1 one of the major draw backs of the previous electric utility management system was lack of properly mapped and well organized database which is prepared in 4.2. This problem will be solved most likely by employing a modern Web-GIS based electric utility management system. Subsequently, 660 electric pole point data which is collected during field survey and 2575 distribution transformer data layers were published to geoserver using the procedure specified in section 3.5.4 of this thesis. The preview of the published layer is seen under layer preview in data section of geoserver (Figure 4.3).

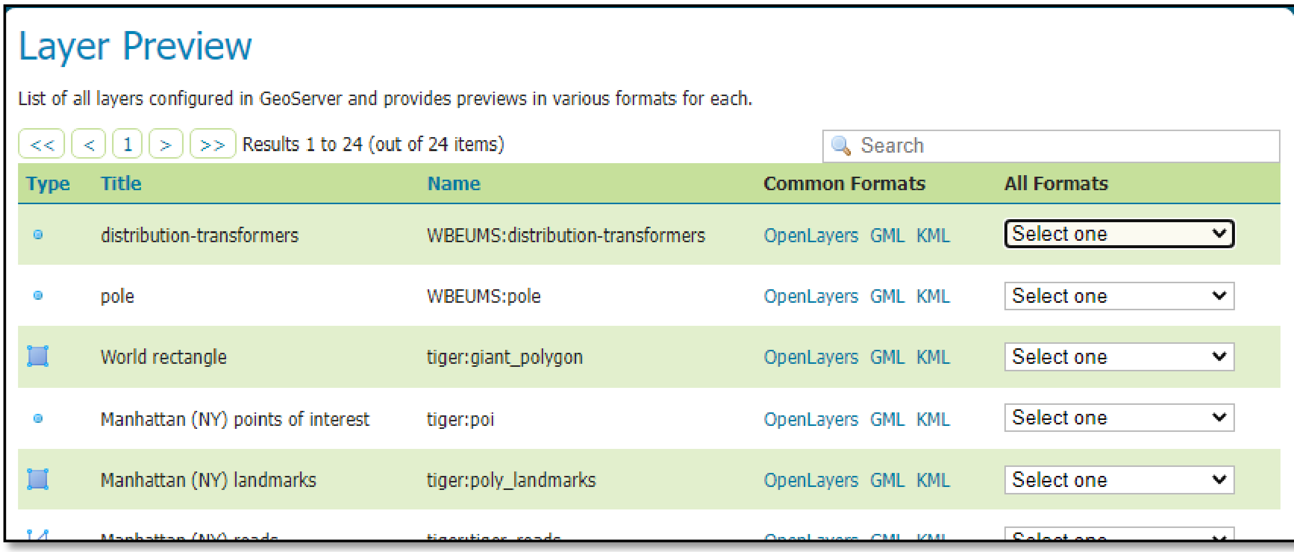

Figure 4.3 Layer preview in geooserver

'**OpenLayers**' is selected from the down drop list against to the **'pole**' by click on '***Go***' '***pole'*** layer will be viewed in a new browser window as shown in (Figure 4.4).

Figure 4.4 Electricity poles layer preview in geoserver

Transformers layer was published similarly but with different style created as transformers style to identify from pole by assigning different symbol.

The developed Web-GIS application incorporates web mapping service and web feature services like get feature info, get capabilities, fetching available web map service layers, query panel, customer support center and many more. The web map service WMS includes services like get capabilities, get map, get feature info and so on whereas web feature service allows a client to perform data manipulation/query operations on one or more geographic features. In this study, web map service/web feature service implementations functions are developed by using java script. JQuery is mainly used to add different web map functionalities like legend function, dropdowns, queries, operators, get info, wms layers and popups through GET function by AJAX method. AJAX stands for Asynchronous java script and xml. It is a set of web development technologies that uses various technologies on the client side to create asynchronous web applications. With AJAX, it is possible to update parts of web pages without reloading the whole page. Finally, the interface of developed web based electric utility management system (WBEUMS) for Adama city is shown in (Figure 4.5).

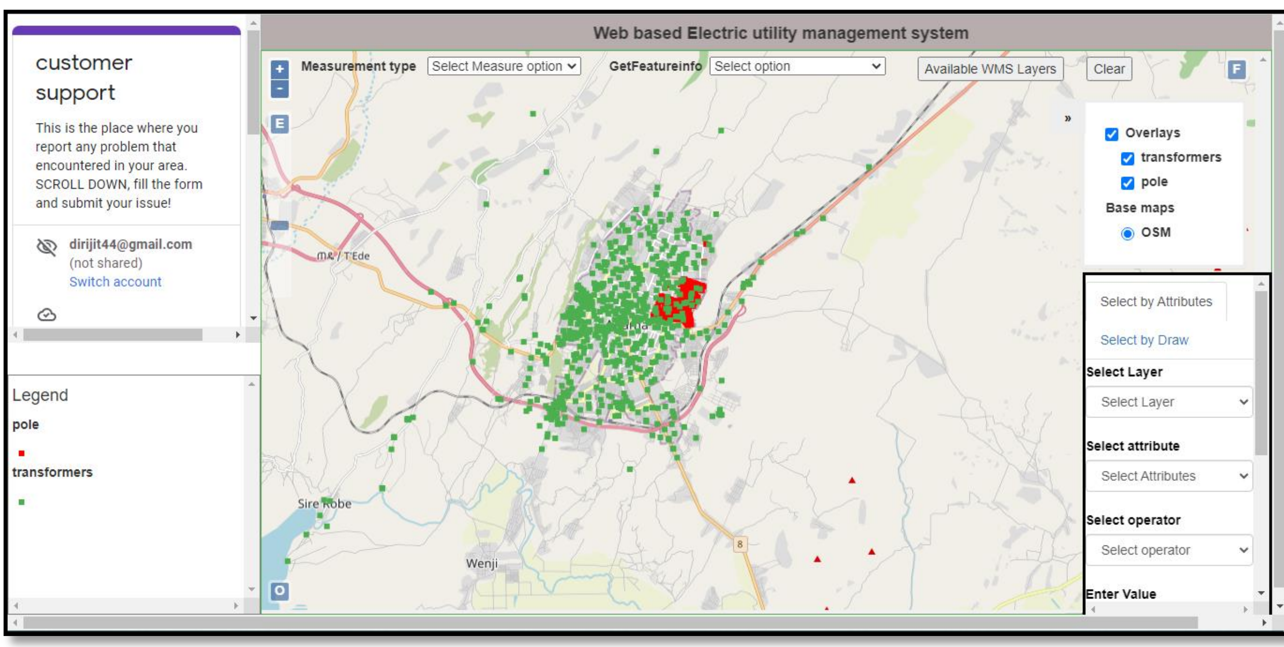

Figure 4.5 Developed interface of Web-GIS electric utility management system

CHAPTER FIVE

5. DISCUSSION

This section reviews the work accomplished in this thesis, by examining the initial problems faced by the electric utility management. The study research questions are restated below in section 5.1 and 5.2, in order to verify their realization and state the discussion drawn from the associated research questions. The theoretic approach is discussed to demonstrate the need for effective electric utility management system development. The software approach is discussed to identify how results of the system were formed, and how the goals were reached.

5.1. Major drawbacks of previous electric utility management system

Traditional approaches of utility management are very complex to manage utility information, due to a number of reasons (Ajwaliya et al., 2017). Analogue methods are used to maintain all utilities information pertaining to the civil utility, electrical utility, mechanical equipment, and nursery, which includes specifications of pump houses, Sewage Treatment Plant (STP), lifts, buildings, roads, and various features such as water supply, sewage line, fire line, electric line, substations, High Tension (HT) / Low Tension (LT) distribution, street lighting, and service connection of each quarter, among others. In addition, it is very difficult to update paper maps timely in traditional methods.

Ajwaliya et al. (2017) added that traditional systems do not manage and maintain databases in the form of information from which decision makers can extract data on buildings for plastering, painting, road maintenance, pump houses, well locations, trees, electric cables, street light poles, substation equipment, LT panels, feeders, and fault logging, among other things. The data may not be available for common customers to examine through a web map to view their utility information. Based on the data obtained during data collection from Ethiopian electric utility, Adama district, some draw backs of the previous system was identified and pointed out in section 4.1 of this thesis. The impacts of those drawbacks are discussed as below.

- There is only transformer data available which makes difficult to carryout overlay analysis and establish relationship between different electric utility data layers.
- In fact there was a distribution transformer data mapped to ArcGIS desktop which is only accessible by company experts, but other users are limited to access the information by analogue methods which mean performing spatial query and measurement is not possible. On the other hand engineers, town planners and contractors may face difficulties in finding where utilities are laid and taking necessary pre cautions during excavation.
- The fact that maps which are already available are outdated or rarely updated might lead to wrong information which can cost a lot. This can also affect measurement and selection of the shortest and most practical way for laying new distribution line.

Generally, bulleted points above are the problems this research aimed to solve by preparing web-GIS based electric utility management system which is discussed in the sub section 5.2.

5.2. Web-GIS based electric utility management system

Today in the advancement of web technology, various management systems have been developed for utility mapping, power distribution, earth data, and planetary data dissemination and archival (Ajwaliya et al., 2017). The utility network's complexity can be decreased, and web GIS can help with resource management (Kshetri et al., 2020).

According to Singh et al. (2016) focuses on the use of emerging technologies such as GIS (Geographic Information System) and GPS (Global Positioning System) to perform power system analysis such as load flow analysis, load movement, electrical line (HT/LT) changes, and electric asset management system using the ArcGIS 10.1 platform. According to the authors, high-resolution remote sensing data is used to prepare various thematic layers, such as settlement, transportation network map, and other land base, as well as conduct a survey of electrical asset data, all of which are then integrated into a GIS platform. The study was found to be capable of performing the above-mentioned analyses and electric asset management system using ArcGIS software, but it lacked a web-based management technique.

Utility Management System using GIS software has been developed by (Ajwaliya et al., 2014) after creation of shape files and the database using Arc Map using Visual basic 6.0 and accessing Map Object 2.1. The frontend is designed using Hypertext Markup Language (HTML), Cascading Style Sheets (CSS) and javascript (Kshetri et al., 2020). The backend is designed using Django (Aratyn, 2018), an open-source python framework. The javascript library Leaflet (Maclean, 2014) is used for the development of mapping functionalities like zoom in/out, panning, adding marker, distance calculation, area calculation, etc. According to (Kshetri et al., 2020), The web based utility management system provides all the utility networks overlaid with base layers like OpenStreetMap (OSM), Mapbox, and Dark map. Adding different utility layers like road network, transmission line, water supply network, sewer line, drainage network, telephone and television network, street light, building footprint, plot, housing boundary, temple, park and swimming pool on the system helps to analyze two or more layers at the same time and is useful for overlay analysis. The developed system contains basic map functions like zooming in/out, zooming to layer, expanding to full screen, adding marker, adding vector layers, measuring distance and area, printing maps, sharing them and generating reports.

This study confirms that mapping all utility layers in one web-GIS platform is helpful in overlay analysis but as it may degrades quality of the work, this thesis strongly suggests that focusing on a single theme is quite important. The developed Web-GIS based electric utility management system provides electric utility networks overlaid with base layer Open Street Map (OSM). The utility layers available on the system are electric pole and distribution transformers. The individual layers are visualized along with their attribute information. This system helps to analyze the two electric utility layers at the same time and is useful for overlay analysis. The developed system contains basic map functions like zooming in/out, zooming to layer, expanding to full screen, adding marker, adding vector layers, measuring distance and extracting attribute information.

The web feature service standard and specification have been developed by the open geospatial consortium (OGC).it allows a client to perform data manipulation operations on one or more geographic features. Data manipulation operation includes the ability to get or query features based on spatial and non-spatial constraints, create new feature, modify feature or delete a feature. The developed WFS include elements of a feature type service, a feature query service by attributes and by shapes. WFS specifies 11 different operations grouped as recognition operations, query operations, locking operations, transaction operations, and operations for managing stored parameterized query expressions. The discovery operation involves getting the feature and describing the feature type. Spatial and non-spatial query operations include getting property values, getting properties, and getting properties using locks (query and lock operations). The lock operation, on the other hand, allows you to request a lock on one or more instances. Map acquisition and functional information acquisition provide users on the Web with an interoperable way to display a combination of map images from various sources, and the functional information acquisition interface is simple for these users. Display with mouse click.

In general, WMS allows clients to overlay to display map images provided by several web map services (often called mashups) on the Internet. Similarly, WFS allows clients to retrieve and update open-layer encoded geospatial data from multiple web feature services.
The default interface is intended for clients. The system administrator is provided with their respective user data for authentication. This system provides administrators with general controls such as adding, updating, and removing utility layers. The admins have privilege access to the main admin dashboard where they can view a summary of the data, and track issues of the clients for which they can take necessary action. The users are limited to the functionalities of viewing the layers and performing basic query.

The fact that preparing a web map of a single theme of utility increases quality of the work, it has also some limitations. First, the study considers only electric utility due to financial and time constraints. This affects the study that, it is difficult to know the relative position of electric utility with respect to other utilities like road, drainage, water and sewerage. Besides, this study is bounded to one particular city. Hence, further studies need to be conducted with maximum possible advancements in geospatial and web mapping technologies to regional or country level by correcting shortcomings of this thesis.

CHAPTER SIX

6. CONCLUSION AND RECOMMENDATIONS

6.1. Conclusion

The existing electric utility geo-database lacks some attributes and feature classes. Thus poor management system.in this study all required electric utility feature classes and attributes were identified. Based on the literature review and ESRI's geo-database design manual, these requirements are specified. Additionally, the entire geo-database spatial data elements and their representation were specified. The obtained requirements aid to resolve the existing electric utility geo-database drawbacks as well as input for the designing of new electric utility geo-database model

Two main data sources were used to prepare digital electric utility map. The first was the electric pole data collected during field survey using handheld GPS and the second was distribution transformer data which is obtained from Ethiopian electric utility, Adama district. The above mentioned data were obtained in Microsoft excel CSV comma delimited format which was later imported to ArcGIS and exported as shape file. The exported shape files are then imported back to the created electric utility database as a single feature class each. Adindan UTM zone 37 N was selected as a projection system and some map layouts were also added.

Web-GIS based electric utility management system helps in identifying electric assets for better understanding and management. From the present development, it can be concluded that this is an attempt to develop a Web-GIS based electric utility management system for spatial planning in the field of utility management. However there are scopes for future advancement in the system capability by adding some advanced functions and modules in account to lodge users compliant, further administrator or manager can track the registered compliant weather it is attended by concerned technician and regularly updated. This paper provided a practical web-GIS frame work combined with latest web service technology and open source projects. Based on this solution and spatial data service were developed to access and publish spatial data. The spatial data management and visualization system was developed to provide a new solution for public to share geospatial data on the web. The Web-GIS based system is developed for visualization and analysis of electric assets. The developed system contains the facility to interactive visualization of spatial data. The system is useful for planning, maintenance and improvement of information standard and decision making processes. There is the scope for future advancement in the system capability by adding some advanced geospatial technologies in account to decision making process for utility management.

6.2. Recommendations

The research and development stages presented here, and methods and techniques applied are recommended to use ultimately to continue the development of the web map for the other utilities and infrastructures. The study concentrated on the particular data needs necessary to develop effective Web-GIS based electric utility management system for the Adama city, Ethiopia. The instrument used for field data collection in this study is handheld GPS with positional error up to 3m.Therefore positional error up to 3m should be considered tolerable however it is recommended to use differential GPS to get exact or nearly exact positional accuracy for works apart from research.

According to the tasks and techniques implemented, this system will improve the major drawbacks in previous utility management sector.it is recommended that the developed web GIS based system can be extended for civil, electric, water and sewerage or other infrastructures and utility mapping in Ethiopia with maximum possible geospatial technology advancements. The system provides structural integrity, manageability, data integrity and query. The study suggestion in regards to designing a regional or country wide utility management system is to start at one particular city and adequately design all necessary data. Next, move from one city to another, modifying the data design, while standardizing similar needs. Almost all cities share a common electric utility dataset and close to one another. It is anticipated that all cities utility data will only change slightly, while some cities may require minor transformations.

A development of country wide scale web based utility management system is recommended to conduct by other scholars. Accordingly, the scholars possibly will refer the current study method and techniques or results as a base for their future attempts in the area of the current application. The developed electric utility management system described in this study, the methods, techniques, objectives will ultimately change over time with advancements in geospatial technology.

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APPENDIX 1-GPS POINT DATA

TYPE	NO.	LAT.	LONG.	NORTHING	EASTING	DESCR.
WAYPOINT	1	9.039962	38.76304	999278.7	473957.5	WP
WAYPOINT	2	8.544265	39.28568	944479.6	531438.1	WP
WAYPOINT	3	8.544095	39.28715	944461	531600.7	WP
WAYPOINT	4	8.544107	39.28703	944462.3	531586.8	WP
WAYPOINT	5	8.544206	39.28685	944473.2	531567.2	WP
WAYPOINT	6	8.544186	39.28638	944471	531515.5	WP
WAYPOINT	7	8.544293	39.28616	944482.8	531491.8	WP
WAYPOINT	8	8.544232	39.28605	944476	531479.8	WP
WAYPOINT	9	8.544269	39.28575	944480.1	531446.8	WP
WAYPOINT	10	8.544321	39.28578	944485.8	531449.2	WP
WAYPOINT	11	8.544327	39.28554	944486.5	531423.5	WP
WAYPOINT	12	8.544278	39.28531	944481	531397.6	WP
WAYPOINT	13	8.544427	39.28533	944497.5	531399.6	WP
WAYPOINT	14	8.544421	39.28522	944496.9	531387.6	WP
WAYPOINT	15	8.544312	39.28518	944484.8	531384	WP
WAYPOINT	16	8.544368	39.28488	944491	531350.5	WP
WAYPOINT	17	8.544418	39.28462	944496.5	531321.5	WP
WAYPOINT	18	8.544496	39.28446	944505.1	531304.5	WP
WAYPOINT	19	8.544427	39.28439	944497.4	531296.2	WP
WAYPOINT	20	8.544469	39.28409	944502.1	531263.8	WP
WAYPOINT	21	8.544357	39.28406	944489.7	531260	WP
WAYPOINT	22	8.544504	39.28381	944505.9	531232.5	WP
WAYPOINT	23	8.544615	39.28378	944518.2	531229.7	WP
WAYPOINT	24	8.544592	39.28371	944515.6	531221.8	WP
WAYPOINT	25	8.544621	39.28342	944518.8	531190.4	WP
WAYPOINT	26	8.544471	39.28323	944502.2	531168.6	WP
WAYPOINT	27	8.544634	39.28265	944520.2	531104.7	WP
WAYPOINT	28	8.544856	39.28238	944544.7	531074.9	WP
WAYPOINT	29	8.54496	39.28209	944556.2	531043.4	CP
WAYPOINT	30	8.544876	39.28201	944546.9	531034.8	CP
WAYPOINT	31	8.54496	39.28182	944556.2	531014.1	CP
WAYPOINT	32	8.545059	39.28197	944567.1	531029.9	WP
WAYPOINT	33	8.545132	39.28134	944575.1	530960.4	TR
WAYPOINT	34	8.545242	39.2811	944587.3	530934.5	WP

WAYPOINT	35	8.545336	39.28117	944597.7	530941.8	CP
WAYPOINT	36	8.545373	39.2808	944601.7	530901.2	WP
WAYPOINT	37	8.545519	39.28041	944617.9	530858.2	WP
WAYPOINT	38	8.54566	39.28044	944633.4	530862	WP
WAYPOINT	39	8.545371	39.28028	944601.5	530843.9	LP
WAYPOINT	40	8.5451	39.28017	944571.5	530832.6	LP
WAYPOINT	41	8.545027	39.28019	944563.4	530834	WP
WAYPOINT	42	8.544684	39.28004	944525.5	530818.2	WP
WAYPOINT	43	8.544521	39.27992	944507.5	530804.4	WP
WAYPOINT	44	8.544233	39.27983	944475.6	530795	LP
WAYPOINT	45	8.543914	39.2797	944440.4	530780.9	LP
WAYPOINT	46	8.543689	39.27963	944415.5	530772.5	CP
WAYPOINT	47	8.543621	39.27952	944407.9	530761.1	LP
WAYPOINT	48	8.5435	39.27951	944394.6	530759.7	WP
WAYPOINT	49	8.543341	39.27943	944377	530750.6	LP
WAYPOINT	50	8.543146	39.27938	944355.4	530745.4	WP
WAYPOINT	51	8.543007	39.27931	944340	530737.2	LLP
WAYPOINT	52	8.542869	39.27928	944324.8	530734.9	CP
WAYPOINT	53	8.542806	39.27956	944317.8	530765.4	CP
WAYPOINT	54	8.542789	39.27978	944316	530789.4	TR
WAYPOINT	55	8.542816	39.27984	944319	530796.4	CP
WAYPOINT	56	8.54275	39.28013	944311.7	530827.7	CP
WAYPOINT	57	8.542694	39.28059	944305.5	530878.2	CP
WAYPOINT	58	8.542659	39.28103	944301.7	530927.1	CP
WAYPOINT	59	8.542795	39.28117	944316.8	530942.8	CP
WAYPOINT	60	8.542846	39.28123	944322.4	530948.8	TR
WAYPOINT	61	8.543156	39.28132	944356.7	530958.6	CP
WAYPOINT	62	8.543563	39.28148	944401.7	530977	CP
WAYPOINT	63	8.543838	39.28158	944432.1	530987.2	CP
WAYPOINT	64	8.54386	39.281618	944434.5	530991.7	CP
WAYPOINT	65	8.544068	39.28164	944457.5	530994	CP
WAYPOINT	66	8.54446	39.28187	944500.9	531018.8	WP
WAYPOINT	67	8.544427	39.28247	944497.3	531085.7	CP
WAYPOINT	68	8.544395	39.28254	944493.8	531093.4	CP
WAYPOINT	69	8.543825	39.28247	944430.7	531085.3	CP
WAYPOINT	70	8.543826	39.2824	944430.8	531077.3	CP
WAYPOINT	71	8.543271	39.2823	944369.5	531066.4	CP
WAYPOINT	72	8.543267	39.28228	944369	531064.7	TR
WAYPOINT	73	8.543246	39.28239	944366.7	531077.1	CP
WAYPOINT	74	8.54256	39.28224	944290.9	531060.5	CP
WAYPOINT	75	8.542545	39.28233	944289.2	531070.6	CP

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WAYPOINT	77	8.542496	39.28223	944283.8	531059	LP
WAYPOINT	78	8.542385	39.2832	944271.6	531165.6	CP
WAYPOINT	79	8.542379	39.28366	944271	531216.1	CP
WAYPOINT	80	8.542331	39.28411	944265.7	531266	CP
WAYPOINT	81	8.542279	39.28477	944260	531338.2	CP
WAYPOINT	82	8.542259	39.28456	944257.8	531315.2	CP
WAYPOINT	83	8.542683	39.2849	944304.7	531353.1	WP
WAYPOINT	84	8.542731	39.28481	944310	531342.9	CP
WAYPOINT	85	8.543145	39.28501	944355.8	531365	WP
WAYPOINT	86	8.543609	39.28503	944407.1	531367.4	CP
WAYPOINT	87	8.543613	39.28512	944407.5	531377.4	WP
WAYPOINT	88	8.544283	39.28534	944481.6	531401.2	WP
WAYPOINT	89	8.544319	39.2852	944485.6	531385.5	WP
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WAYPOINT	91	8.543708	39.28679	944418.2	531560.5	WP
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WAYPOINT	94	8.543003	39.28668	944340.2	531548.9	WP
WAYPOINT	95	8.542789	39.28667	944316.5	531548.2	WP
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WAYPOINT	97	8.542598	39.28666	944295.4	531546.9	WP
WAYPOINT	98	8.542642	39.28641	944300.3	531519	TR
WAYPOINT	99	8.542638	39.2862	944299.8	531495.9	WF
WAYPOINT	100	8.542738	39.28525	944310.8	531391.7	WP
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WAYPOINT	121	8.540358	39.29138	944048.2	532066.6	LP
WAYPOINT	122	8.540109	39.29153	944020.7	532083.1	LP
WAYPOINT	123	8.539849	39.2917	943991.9	532101.6	LP
WAYPOINT	124	8.539588	39.29187	943963.1	532120.4	LP
WAYPOINT	125	8.539287	39.29204	943929.8	532138.8	LP
WAYPOINT	126	8.539624	39.29199	943967.1	532132.9	WP
WAYPOINT	127	8.539928	39.29172	944000.7	532104.1	CP
WAYPOINT	128	8.540361	39.29145	944048.5	532074.1	CP
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WAYPOINT	134	8.541763	39.2895	944203.3	531859.7	CP

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WAYPOINT	136	8.541864	39.28812	944214.4	531706.9	CP
WAYPOINT	137	8.54199	39.28725	944228.3	531612.1	CP

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WAYPOINT	143	8.54245	39.2879	944279.2	531682.6	WP
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WAYPOINT	166	8.543963	39.28922	944446.5	531828.5	WP
WAYPOINT	167	8.543875	39.2893	944436.8	531836.7	WP
WAYPOINT	168	8.54384	39.28975	944433	531886.1	WP
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WAYPOINT	179	8.542275	39.28956	944260	531865.8	WP
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WAYPOINT	181	8.542346	39.28895	944267.8	531798.1	WP
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WAYPOINT	186	8.542104	39.29053	944241.1	531972.4	WP
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WAYPOINT	190	8.541405	39.29045	944163.8	531963.3	WP
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WAYPOINT	196	8.541176	39.29228	944138.7	532165.3	WP
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WAYPOINT	203	8.541678	39.29285	944194.2	532228.4	WP
WAYPOINT	204	8.542233	39.29273	944255.6	532214.9	WP
WAYPOINT	205	8.543564	39.29242	944402.7	532180.8	WP
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WAYPOINT	207	8.543586	39.2921	944405.1	532145.5	WP
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WAYPOINT	215	8.544784	39.29175	944537.5	532106.8	WP
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WAYPOINT	218	8.54486	39.29219	944546	532155.1	WP
WAYPOINT	219	8.545141	39.29171	944577	532102.4	WP
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WAYPOINT	227	8.546351	39.29118	944710.7	532044	WP
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WAYPOINT	229	8.546098	39.29134	944682.8	532061.5	WP
WAYPOINT	230	8.54631	39.29149	944706.2	532077.8	WP
WAYPOINT	231	8.546266	39.29174	944701.4	532105.2	WP
WAYPOINT	232	8.546178	39.29176	944691.6	532107.9	WP
WAYPOINT	233	8.546152	39.29182	944688.8	532114	WP
WAYPOINT	234	8.545989	39.2917	944670.7	532100.5	WP
WAYPOINT	235	8.545886	39.29171	944659.4	532102	WP
WAYPOINT	236	8.546226	39.29186	944697	532118.2	WP
WAYPOINT	237	8.546078	39.29216	944680.6	532151.2	WP
WAYPOINT	238	8.546789	39.29096	944759.1	532019.3	WP
WAYPOINT	239	8.546944	39.29107	944776.3	532031.2	WP
WAYPOINT	240	8.547302	39.29118	944815.9	532044	WP
WAYPOINT	241	8.547344	39.29111	944820.5	532036.4	WP
WAYPOINT	242	8.547224	39.29164	944807.3	532093.9	WP
WAYPOINT	243	8.547088	39.29187	944792.3	532119.1	WP
WAYPOINT	244	8.546947	39.29192	944776.7	532124.9	WP
WAYPOINT	245	8.547176	39.292	944802	532133.5	LP
WAYPOINT	246	8.546985	39.29269	944780.9	532209.9	WP
WAYPOINT	247	8.546689	39.29372	944748.3	532323.4	WP
WAYPOINT	248	8.547266	39.2916	944811.9	532089.6	LP
WAYPOINT	249	8.547321	39.29133	944818	532060.2	LP
WAYPOINT	250	8.547376	39.2911	944824	532034.7	LP
WAYPOINT	251	8.547433	39.29088	944830.3	532011.1	LP
WAYPOINT	252	8.547505	39.2906	944838.2	531980.1	LP
WAYPOINT	253	8.547536	39.29041	944841.7	531959	CP
WAYPOINT	254	8.547334	39.29032	944819.3	531948.7	CP
WAYPOINT	255	8.547574	39.29032	944845.9	531949.3	LP
WAYPOINT	256	8.547649	39.2901	944854.1	531924.7	LP
WAYPOINT	257	8.54765	39.29001	944854.2	531915.1	CP

WAYPOINT	258	8.547648	39.28988	944854	531900	DTR
WAYPOINT	259	8.547768	39.28957	944867.2	531866.1	LP
WAYPOINT	260	8.54776	39.2895	944866.3	531858.7	WP
WAYPOINT	261	8.547839	39.2893	944875.1	531836.2	LP
WAYPOINT	262	8.547974	39.28878	944889.9	531779.5	LP
WAYPOINT	263	8.548034	39.28856	944896.6	531755	LP
WAYPOINT	264	8.548034	39.2885	944896.6	531748.5	CP
WAYPOINT	265	8.548105	39.28829	944904.4	531725.5	LP
WAYPOINT	266	8.548093	39.28818	944903.1	531713.8	WP
WAYPOINT	267	8.547755	39.28808	944865.7	531702.7	WP
WAYPOINT	268	8.54739	39.28798	944825.3	531691.2	WP
WAYPOINT	269	8.546759	39.2878	944755.5	531671.7	WP
WAYPOINT	270	8.547845	39.28812	944875.6	531707	MSJID
WAYPOINT	271	8.548163	39.28804	944910.8	531697.6	LP
WAYPOINT	272	8.548209	39.28776	944915.8	531667.7	LP
WAYPOINT	273	8.548231	39.28767	944918.3	531657.3	WP
WAYPOINT	274	8.548355	39.28724	944931.9	531610.4	LP
WAYPOINT	275	8.54838	39.28708	944934.7	531592.3	LP
WAYPOINT	276	8.548385	39.28707	944935.2	531591.5	WP
WAYPOINT	277	8.54842	39.28696	944939.1	531579.4	LP
WAYPOINT	278	8.54852	39.28674	944950.1	531554.5	LP
WAYPOINT	279	8.54857	39.28656	944955.7	531534.8	WP
WAYPOINT	280	8.548696	39.28623	944969.6	531498.6	LP
WAYPOINT	281	8.548771	39.28596	944977.8	531468.8	WP
WAYPOINT	282	8.548862	39.28575	944987.9	531446.3	LP
WAYPOINT	283	8.548941	39.28548	944996.6	531416.7	WP
WAYPOINT	284	8.549028	39.28525	945006.2	531390.6	WP
WAYPOINT	285	8.548992	39.28525	945002.2	531391.1	DTR
WAYPOINT	286	8.549077	39.28521	945011.6	531387	LP
WAYPOINT	287	8.549165	39.28497	945021.3	531360.5	WP
WAYPOINT	288	8.549246	39.28481	945030.3	531342.5	LP
WAYPOINT	289	8.549304	39.28451	945036.6	531309.3	WP
WAYPOINT	290	8.549397	39.28429	945046.9	531285.5	LP
WAYPOINT	291	8.549499	39.28404	945058.2	531257.6	LP
WAYPOINT	292	8.54962	39.2836	945071.5	531208.9	WP
WAYPOINT	293	8.549672	39.28353	945077.2	531201.5	LP
WAYPOINT	294	8.549754	39.28326	945086.3	531172.2	LP
WAYPOINT	295	8.549842	39.28299	945096	531142.2	LP
WAYPOINT	296	8.549915	39.28276	945104	531117.3	WP
WAYPOINT	297	8.549968	39.28272	945109.9	531112.6	LP
WAYPOINT	298	8.550114	39.28232	945126	531068.1	LP

WAYPOINT	299	8.550145	39.28227	945129.4	531063	WP
WAYPOINT	300	8.55015	39.28219	945130	531054	LP
WAYPOINT	301	8.549846	39.28205	945096.4	531039.1	LP
WAYPOINT	302	8.549552	39.28194	945063.8	531026.1	LP
WAYPOINT	303	8.549266	39.28182	945032.2	531012.9	LP
WAYPOINT	304	8.548992	39.28177	945001.9	531007.5	CP
WAYPOINT	305	8.548933	39.28172	944995.4	531001.9	LP
WAYPOINT	306	8.548685	39.28163	944968	530992.9	CP
WAYPOINT	307	8.548277	39.28147	944922.9	530974.9	CP
WAYPOINT	308	8.548253	39.28145	944920.2	530973.1	LP
WAYPOINT	309	8.547719	39.28124	944861.1	530949.3	LP
WAYPOINT	310	8.547414	39.28115	944827.4	530939.8	CP
WAYPOINT	311	8.547391	39.28113	944824.9	530937.4	LP
WAYPOINT	312	8.547115	39.28105	944794.4	530928.5	LP
WAYPOINT	313	8.547064	39.28103	944788.7	530926.4	DTR
WAYPOINT	314	8.546536	39.28078	944730.3	530898.9	LP
WAYPOINT	315	8.54645	39.28078	944720.8	530898.7	WP
WAYPOINT	316	8.546261	39.28067	944699.9	530887.4	LP
WAYPOINT	317	8.546104	39.28062	944682.5	530882.1	CP
WAYPOINT	318	8.546059	39.28065	944677.6	530885	DTR
WAYPOINT	319	8.545902	39.28106	944660.2	530929.8	CP
WAYPOINT	320	8.545975	39.28054	944668.3	530873.2	LP
WAYPOINT	321	8.545678	39.28044	944635.4	530862	WP
WAYPOINT	322	8.545642	39.28041	944631.5	530858.4	LP
WAYPOINT	323	8.545341	39.28118	944598.2	530943.6	CP
WAYPOINT	324	8.54464	39.28298	944520.9	531141.3	WP
WAYPOINT	325	8.544594	39.28371	944515.9	531221.7	WP
WAYPOINT	326	8.545093	39.28377	944571	531228.8	WP
WAYPOINT	327	8.545201	39.28355	944582.9	531204.1	WP
WAYPOINT	328	8.545175	39.28338	944580.1	531184.9	WP
WAYPOINT	329	8.545633	39.28388	944630.7	531240.2	WP
WAYPOINT	330	8.545843	39.28388	944654	531240.2	WP
WAYPOINT	331	8.5458	39.28424	944649.2	531280	WP
WAYPOINT	332	8.546363	39.28394	944711.4	531246.5	WP
WAYPOINT	333	8.547043	39.28402	944786.6	531255.2	WP
WAYPOINT	334	8.547201	39.28345	944804.1	531193.3	WP
WAYPOINT	335	8.547273	39.28413	944812.1	531267.8	WP
WAYPOINT	336	8.547601	39.28425	944848.3	531280.6	WP
WAYPOINT	337	8.547645	39.28425	944853.2	531281.1	WP
WAYPOINT	338	8.547776	39.28377	944867.6	531228.3	WP
WAYPOINT	339	8.547934	39.28361	944885.1	531211	CP

WAYPOINT	340	8.547748	39.28412	944864.6	531266.4	CP
WAYPOINT	341	8.547584	39.28447	944846.5	531305.3	WP
WAYPOINT	342	8.547417	39.28505	944828.1	531369.4	WP
WAYPOINT	343	8.547462	39.2851	944833	531374.4	WP
WAYPOINT	344	8.547416	39.28543	944828	531410.5	WP
WAYPOINT	345	8.547303	39.28586	944815.5	531458	WP
WAYPOINT	346	8.547648	39.28604	944853.7	531477.8	CP
WAYPOINT	347	8.548139	39.28613	944908	531488	CP
WAYPOINT	348	8.547156	39.28592	944799.3	531464.3	CP
WAYPOINT	349	8.546811	39.28581	944761.1	531452.9	WP
WAYPOINT	350	8.546749	39.28578	944754.3	531449.2	WP
WAYPOINT	351	8.54672	39.28578	944751.1	531449.2	CP
WAYPOINT	352	8.546711	39.28592	944750.1	531464.4	WP
WAYPOINT	353	8.546619	39.28589	944739.9	531461.4	WP
WAYPOINT	354	8.546632	39.28576	944741.3	531446.9	WP
WAYPOINT	355	8.546702	39.28546	944749	531414.4	WP
WAYPOINT	356	8.546766	39.28533	944756.1	531400.4	WP
WAYPOINT	357	8.546834	39.28501	944763.6	531364.3	WP
WAYPOINT	358	8.546888	39.2847	944769.6	531330.2	DTR
WAYPOINT	359	8.547012	39.28422	944783.2	531278.1	WP
WAYPOINT	360	8.546249	39.28581	944699	531452.4	WP
WAYPOINT	361	8.545885	39.28571	944658.7	531442.1	WP
WAYPOINT	362	8.545588	39.28563	944625.9	531432.8	DTR
WAYPOINT	363	8.544946	39.28538	944554.9	531405.3	CP
WAYPOINT	364	8.544752	39.28543	944533.5	531411.3	WP
WAYPOINT	365	8.544511	39.28528	944506.8	531395	CP
WAYPOINT	366	8.544416	39.28534	944496.3	531401.6	WP
WAYPOINT	367	8.544635	39.28655	944520.6	531534.5	WP
WAYPOINT	368	8.545061	39.28665	944567.7	531545	WP
WAYPOINT	369	8.545169	39.28662	944579.7	531541.6	WP
WAYPOINT	370	8.545404	39.28666	944605.6	531546.8	WP
WAYPOINT	371	8.545576	39.28673	944624.7	531554.5	WP
WAYPOINT	372	8.545865	39.2868	944656.6	531562.1	WP
WAYPOINT	373	8.545981	39.28647	944669.4	531525.7	WP
WAYPOINT	374	8.545891	39.28694	944659.5	531577.1	WP
WAYPOINT	375	8.545736	39.28742	944642.4	531629.5	WP
WAYPOINT	376	8.545688	39.28756	944637.1	531645.3	WP
WAYPOINT	377	8.545657	39.28772	944633.7	531663.2	WP
WAYPOINT	378	8.545582	39.28805	944625.4	531699.7	WP
WAYPOINT	379	8.545414	39.28857	944606.9	531756.6	WP
WAYPOINT	380	8.545347	39.28886	944599.5	531788.1	WP

WAYPOINT	381	8.545351	39.28901	944600	531805.4	WP
WAYPOINT	382	8.545218	39.2894	944585.3	531848.4	WP
WAYPOINT	383	8.545153	39.28969	944578.1	531879.9	WP
WAYPOINT	384	8.545086	39.28967	944570.7	531877.9	WP
WAYPOINT	385	8.545035	39.2899	944565.1	531902.7	WP
WAYPOINT	386	8.545032	39.29014	944564.8	531929.1	WP
WAYPOINT	387	8.544909	39.29014	944551.2	531928.9	WP
WAYPOINT	388	8.544503	39.29	944506.3	531913.5	WP
WAYPOINT	389	8.544341	39.28994	944488.4	531907	WP
WAYPOINT	390	8.544119	39.2899	944463.8	531902.5	WP
WAYPOINT	391	8.543962	39.2898	944446.5	531891.5	WP
WAYPOINT	392	8.543897	39.28978	944439.3	531890.2	WP
WAYPOINT	393	8.545374	39.29076	944602.7	531997.7	WP
WAYPOINT	394	8.545447	39.29053	944610.7	531972.5	WP
WAYPOINT	395	8.545404	39.29041	944606	531959.2	WP
WAYPOINT	396	8.545629	39.28979	944630.8	531890.6	WP
WAYPOINT	397	8.545681	39.28961	944636.5	531871	WP
WAYPOINT	398	8.545701	39.28945	944638.7	531853.3	WP
WAYPOINT	399	8.545895	39.28939	944660.2	531846.7	CP
WAYPOINT	400	8.546284	39.28948	944703.2	531856.7	CP
WAYPOINT	401	8.54617	39.28964	944690.6	531874.7	WP
WAYPOINT	402	8.546199	39.28965	944693.8	531875	WP
WAYPOINT	403	8.546088	39.29004	944681.5	531918.1	WP
WAYPOINT	404	8.545983	39.29029	944670	531945.9	WP
WAYPOINT	405	8.545841	39.2908	944654.3	532001.9	WP
WAYPOINT	406	8.546666	39.28962	944745.4	531872.5	CP
WAYPOINT	407	8.546932	39.28978	944774.8	531890.1	CP
WAYPOINT	408	8.547179	39.28988	944802.1	531900.5	CP
WAYPOINT	409	8.545983	39.28889	944669.8	531792	CP
WAYPOINT	410	8.546245	39.28803	944698.7	531696.7	CP
WAYPOINT	411	8.54635	39.28764	944710.3	531654.6	WP
WAYPOINT	412	8.546373	39.28762	944712.9	531651.8	WP
WAYPOINT	413	8.546698	39.28768	944748.8	531658.3	WP
WAYPOINT	414	8.546765	39.28779	944756.2	531670.4	WP
WAYPOINT	415	8.546743	39.28788	944753.8	531680.3	CP
WAYPOINT	416	8.54663	39.28824	944741.3	531719.9	CP
WAYPOINT	417	8.546623	39.28833	944740.6	531729.8	WP
WAYPOINT	418	8.546986	39.28838	944780.7	531735.5	CP
WAYPOINT	419	8.546585	39.28846	944736.4	531744.1	CP
WAYPOINT	420	8.546411	39.28898	944717.2	531801.2	CP
WAYPOINT	421	8.546327	39.28704	944707.7	531587.8	WP

WAYPOINT	422	8.546447	39.28657	944720.9	531535.9	WP
WAYPOINT	423	8.546578	39.28602	944735.4	531475.7	WP
WAYPOINT	424	8.546507	39.28661	944727.6	531541.2	WP
WAYPOINT	425	8.546798	39.28761	944759.8	531651.3	WP
WAYPOINT	426	8.547135	39.28603	944797	531476.5	WP
WAYPOINT	427	8.547215	39.2861	944805.8	531485.1	WP
WAYPOINT	428	8.547122	39.28637	944795.6	531514.4	WP
WAYPOINT	429	8.547113	39.28647	944794.6	531525.3	WP
WAYPOINT	430	8.547401	39.2865	944826.4	531528.2	WP
WAYPOINT	431	8.547685	39.28655	944857.8	531533.7	WP
WAYPOINT	432	8.547977	39.28667	944890.1	531547	WP
WAYPOINT	433	8.548242	39.28672	944919.4	531552.6	WP
WAYPOINT	434	8.548411	39.28679	944938.1	531560.4	WP
WAYPOINT	435	8.547548	39.28671	944842.7	531551.5	WP
WAYPOINT	436	8.547469	39.28687	944834	531568.8	WP
WAYPOINT	437	8.547407	39.28708	944827.1	531592.3	WP
WAYPOINT	438	8.547263	39.28748	944811.2	531636.5	WP
WAYPOINT	439	8.547583	39.28762	944846.6	531651.8	WP
WAYPOINT	440	8.547663	39.28754	944855.5	531643	WP
WAYPOINT	441	8.547922	39.28778	944884.1	531669.7	WP
WAYPOINT	442	8.548177	39.28787	944912.3	531679.1	WP
WAYPOINT	443	8.547117	39.28744	944795.1	531632.6	WP
WAYPOINT	444	8.546873	39.28739	944768.1	531626.7	WP
WAYPOINT	445	8.546864	39.28731	944767.1	531617.6	WP
WAYPOINT	446	8.547015	39.28675	944783.8	531555.9	WP
WAYPOINT	447	8.546833	39.28733	944763.7	531620.1	WP
WAYPOINT	448	8.546829	39.28745	944763.3	531632.9	WP
WAYPOINT	449	8.546458	39.29368	944722.8	532318.9	LP
WAYPOINT	450	8.546212	39.29361	944695.6	532310.8	LP
WAYPOINT	451	8.545766	39.29332	944646.2	532279	LP
WAYPOINT	452	8.545287	39.29313	944593.2	532258.3	LP
WAYPOINT	453	8.544688	39.29307	944527	532251.3	LP
WAYPOINT	454	8.544143	39.2931	944466.8	532254.7	LP
WAYPOINT	455	8.543761	39.29313	944424.5	532258.9	LP
WAYPOINT	456	8.543608	39.29315	944407.6	532260.9	LP
WAYPOINT	457	8.543088	39.2932	944350.1	532266.6	LP
WAYPOINT	458	8.542541	39.29328	944289.7	532275.2	LP
WAYPOINT	459	8.541996	39.29335	944229.4	532282.7	LP
WAYPOINT	460	8.541465	39.29342	944170.7	532290.2	LP
WAYPOINT	461	8.540932	39.29348	944111.8	532297.4	LP
WAYPOINT	462	8.540391	39.29358	944052	532308.4	LP

WAYPOINT	463	8.539893	39.29376	943997	532327.7	LP
WAYPOINT	464	8.539442	39.29388	943947.1	532341.9	LP
WAYPOINT	465	8.538888	39.29385	943885.9	532337.9	LP
WAYPOINT	466	8.538382	39.29371	943829.9	532323.2	LP
WAYPOINT	467	8.538036	39.29363	943791.6	532313.6	LP
WAYPOINT	468	8.546905	39.29394	944772.2	532347.2	LP
WAYPOINT	469	8.546847	39.2938	944765.8	532332.2	CP
WAYPOINT	470	8.547117	39.29289	944795.5	532232.1	CP
WAYPOINT	471	8.547224	39.29242	944807.3	532180.2	CP
WAYPOINT	472	8.547289	39.29194	944814.5	532126.8	LP
WAYPOINT	473	8.547441	39.2913	944831.2	532056.7	CP
WAYPOINT	474	8.547567	39.29089	944845.1	532011.5	CP
WAYPOINT	475	8.54759	39.29079	944847.7	532000.7	CP
WAYPOINT	476	8.547789	39.29005	944869.6	531918.8	CP
WAYPOINT	477	8.547924	39.28951	944884.5	531860.2	CP
WAYPOINT	478	8.54813	39.28868	944907.2	531768.2	CP
WAYPOINT	479	8.548366	39.28786	944933.2	531678.1	CP
WAYPOINT	480	8.548554	39.28702	944953.9	531585.3	CP
WAYPOINT	481	8.548766	39.28649	944977.3	531527.3	CP
WAYPOINT	482	8.549081	39.28565	945012.1	531435.1	CP
WAYPOINT	483	8.549358	39.28486	945042.6	531347.9	CP
WAYPOINT	484	8.549648	39.28398	945074.6	531251.4	CP
WAYPOINT	485	8.549817	39.28355	945093.3	531203.7	CP
WAYPOINT	486	8.550107	39.28276	945125.3	531116.4	CP
WAYPOINT	487	8.550168	39.28276	945132	531116.5	DTR
WAYPOINT	488	8.550252	39.2823	945141.3	531066.5	CP
WAYPOINT	489	8.550326	39.28219	945149.4	531054.4	04MAFI BURGER
WAYPOINT	490	8.547995	39.291	944892.5	532023.3	CP
WAYPOINT	491	8.548522	39.29118	944950.7	532043.3	CP
WAYPOINT	492	8.548828	39.29137	944984.6	532064.8	DR
WAYPOINT	493	8.548971	39.29188	945000.4	532120.4	WP
WAYPOINT	494	8.549131	39.29214	945018.1	532148.7	WP
WAYPOINT	495	8.549153	39.29234	945020.6	532171.6	DTR
WAYPOINT	496	8.549243	39.29266	945030.6	532206.4	WP
WAYPOINT	497	8.549391	39.29299	945047	532242.1	WP
WAYPOINT	498	8.5494	39.29299	945048	532243	WP
WAYPOINT	499	8.549392	39.29308	945047.1	532252.9	WP
WAYPOINT	500	8.54965	39.29368	945075.6	532318.4	WP
WAYPOINT	501	8.549664	39.29381	945077.2	532333.2	WP
WAYPOINT	502	8.54975	39.29415	945086.7	532370.1	WP
WAYPOINT	503	8.549695	39.29437	945080.7	532394.4	WP

WAYPOINT	504	8.549597	39.29489	945069.9	532452.2	WP
WAYPOINT	505	8.549485	39.29496	945057.5	532459.3	LP
WAYPOINT	506	8.549095	39.29482	945014.4	532444	LP
WAYPOINT	507	8.54877	39.29463	944978.4	532422.7	WP
WAYPOINT	508	8.548594	39.29462	944959	532422.1	LP
WAYPOINT	509	8.548138	39.29437	944908.5	532395	DTR
WAYPOINT	510	8.548053	39.29431	944899.1	532388	WP
WAYPOINT	511	8.548183	39.29394	944913.5	532347.5	WP
WAYPOINT	512	8.548506	39.29399	944949.2	532352.5	WP
WAYPOINT	513	8.547637	39.29367	944853.1	532317.1	WP
WAYPOINT	514	8.548115	39.29391	944906	532343.9	WP
WAYPOINT	515	8.54786	39.29433	944877.8	532390	LP
WAYPOINT	516	8.547595	39.29415	944848.5	532370.9	WP
WAYPOINT	517	8.547167	39.29404	944801.2	532358.4	LP
WAYPOINT	518	8.546859	39.29384	944767.1	532336.9	WP
WAYPOINT	519	8.548735	39.29074	944974.2	531994.8	CP
WAYPOINT	520	8.548221	39.29057	944917.4	531976.7	CP
WAYPOINT	521	8.548654	39.29021	944965.2	531936.7	WP
WAYPOINT	522	8.548973	39.29031	945000.5	531948.1	CP
WAYPOINT	523	8.549617	39.29057	945071.7	531976.5	CP
WAYPOINT	524	8.550159	39.29043	945131.6	531961	CP
WAYPOINT	525	8.550361	39.29053	945154	531971.6	CP
WAYPOINT	526	8.550909	39.2906	945214.6	531979.7	CP
WAYPOINT	527	8.551138	39.29071	945239.9	531991.4	CP
WAYPOINT	528	8.551643	39.29086	945295.8	532007.9	CP
WAYPOINT	529	8.55166	39.29089	945297.6	532011.3	WP
WAYPOINT	530	8.551426	39.29157	945271.8	532085.9	WP
WAYPOINT	531	8.551139	39.29236	945240.2	532173.5	WP
WAYPOINT	532	8.550829	39.29314	945205.9	532259.4	WP
WAYPOINT	533	8.550279	39.29297	945145.1	532240	WP
WAYPOINT	534	8.550156	39.29293	945131.5	532235.7	WP
WAYPOINT	535	8.549909	39.2923	945104.2	532167	WP
WAYPOINT	536	8.550526	39.29391	945172.5	532344.3	WP
WAYPOINT	537	8.550078	39.29506	945123.1	532470.7	WP
WAYPOINT	538	8.549982	39.29516	945112.5	532481.1	LP
WAYPOINT	539	8.550288	39.29465	945146.3	532425.7	WP
WAYPOINT	540	8.55058	39.29397	945178.5	532350.6	WP
WAYPOINT	541	8.551944	39.29451	945329.3	532409.2	WP
WAYPOINT	542	8.551689	39.29437	945301.1	532394.5	WP
WAYPOINT	543	8.550828	39.29406	945205.9	532360.4	WP
WAYPOINT	544	8.550774	39.29354	945199.9	532302.8	WP

WAYPOINT	545	8.551637	39.29391	945295.3	532343.9	WP
WAYPOINT	546	8.551965	39.29406	945331.6	532360.5	DTR
WAYPOINT	547	8.552556	39.29429	945397	532385.8	WP
WAYPOINT	548	8.552844	39.29448	945428.8	532406.4	WP
WAYPOINT	549	8.552634	39.29515	945405.7	532479.9	WP
WAYPOINT	550	8.552456	39.29554	945386	532523.1	DTR
WAYPOINT	551	8.553273	39.29466	945476.3	532425.9	WP
WAYPOINT	552	8.553603	39.29472	945512.8	532432.6	WP
WAYPOINT	553	8.554707	39.29517	945634.9	532482.4	WP
WAYPOINT	554	8.554593	39.29554	945622.3	532522.4	WP
WAYPOINT	555	8.554441	39.29589	945605.5	532561.5	WP
WAYPOINT	556	8.554109	39.29679	945568.9	532660.1	WP
WAYPOINT	557	8.553941	39.2968	945550.3	532661	WP
WAYPOINT	558	8.553503	39.29671	945501.9	532651.8	LP
WAYPOINT	559	8.553428	39.29662	945493.6	532642.2	WP
WAYPOINT	560	8.552994	39.29654	945445.6	532632.5	LP
WAYPOINT	561	8.552499	39.29629	945390.8	532605.7	LP
WAYPOINT	562	8.552045	39.29608	945340.6	532582.2	LP
WAYPOINT	563	8.551305	39.29571	945258.8	532542.1	LP
WAYPOINT	564	8.551598	39.29474	945291.1	532434.5	WP
WAYPOINT	565	8.551749	39.29406	945307.7	532360	WP
WAYPOINT	566	8.551147	39.29255	945241.1	532193.8	WP
WAYPOINT	567	8.551488	39.29262	945278.8	532201.9	WP
WAYPOINT	568	8.552168	39.29283	945354	532225.3	WP
WAYPOINT	569	8.552857	39.29316	945430.2	532261	WP
WAYPOINT	570	8.553278	39.29339	945476.7	532286.3	WP
WAYPOINT	571	8.553849	39.2936	945539.9	532309.2	WP
WAYPOINT	572	8.554357	39.2938	945596	532331	WP
WAYPOINT	573	8.555082	39.29409	945676.2	532363.2	WP
WAYPOINT	574	8.555112	39.2941	945679.5	532364	WP
WAYPOINT	575	8.555083	39.29428	945676.3	532384.3	LP
WAYPOINT	576	8.55489	39.29477	945655.1	532438.1	LP
WAYPOINT	577	8.554841	39.29487	945649.6	532448.6	WP
WAYPOINT	578	8.554682	39.29528	945632.1	532494.7	LP
WAYPOINT	579	8.554514	39.29575	945613.6	532546	LP
WAYPOINT	580	8.554396	39.29605	945600.5	532579.2	LP
WAYPOINT	581	8.554934	39.29444	945659.9	532401.4	WP
WAYPOINT	582	8.554028	39.2941	945559.7	532364.6	WP
WAYPOINT	583	8.553007	39.29324	945446.7	532269.8	WP
WAYPOINT	584	8.551133	39.29235	945239.5	532171.6	WP
WAYPOINT	585	8.551307	39.29209	945258.7	532143.9	WP

WAYPOINT	586	8.551796	39.29081	945312.7	532002.6	CP
WAYPOINT	587	8.551856	39.29063	945319.3	531983.2	CP
WAYPOINT	588	8.551864	39.29035	945320.1	531951.9	CP
WAYPOINT	589	8.550513	39.29003	945170.8	531917	CP
WAYPOINT	590	8.549814	39.29007	945093.5	531921.3	CP
WAYPOINT	591	8.548725	39.28971	944973.1	531881.9	CP
WAYPOINT	592	8.547996	39.2895	944892.4	531858.9	CP
WAYPOINT	593	8.548278	39.28859	944923.5	531758.7	CP
WAYPOINT	594	8.548643	39.28868	944963.9	531768.8	CP
WAYPOINT	595	8.549765	39.28907	945088	531810.9	CP
WAYPOINT	596	8.550569	39.28932	945176.9	531838.5	CP
WAYPOINT	597	8.551681	39.2896	945299.8	531869.4	CP
WAYPOINT	598	8.551865	39.28913	945320.2	531817.5	CP
WAYPOINT	599	8.551985	39.28998	945333.5	531911.3	DTR
WAYPOINT	600	8.550853	39.28968	945208.3	531878.3	CP
WAYPOINT	601	8.552029	39.28987	945338.3	531899	WP
WAYPOINT	602	8.552185	39.28999	945355.6	531912.3	CP
WAYPOINT	603	8.553406	39.29022	945490.6	531937.4	CP
WAYPOINT	604	8.553335	39.29069	945482.8	531988.9	CP
WAYPOINT	605	8.553747	39.29076	945528.4	531997	CP
WAYPOINT	606	8.554149	39.29088	945572.8	532010.3	CP
WAYPOINT	607	8.554552	39.29116	945617.4	532040.7	CP
WAYPOINT	608	8.555036	39.29152	945670.9	532080.8	CP
WAYPOINT	609	8.555601	39.29196	945733.4	532128.8	CP
WAYPOINT	610	8.555815	39.29208	945757.1	532141.6	WP
WAYPOINT	611	8.555831	39.29222	945758.9	532157.7	LP
WAYPOINT	612	8.555717	39.29253	945746.3	532191.5	WP
WAYPOINT	613	8.555567	39.29293	945729.7	532236	LP
WAYPOINT	614	8.555384	39.29347	945709.6	532295.5	LP
WAYPOINT	615	8.555158	39.29402	945684.6	532355.1	LP
WAYPOINT	616	8.555442	39.29304	945715.9	532248.1	WP
WAYPOINT	617	8.554788	39.29276	945643.6	532216.4	WP
WAYPOINT	618	8.554112	39.2925	945568.8	532188.4	WP
WAYPOINT	619	8.554398	39.29255	945600.5	532194	WP
WAYPOINT	620	8.554933	39.29276	945659.6	532217	WP
WAYPOINT	621	8.556143	39.29148	945793.3	532076.3	LP
WAYPOINT	622	8.5563	39.29109	945810.6	532032.7	LP
WAYPOINT	623	8.555637	39.29063	945737.3	531982.5	CP
WAYPOINT	624	8.55532	39.29111	945702.3	532035.2	CP
WAYPOINT	626	8.556392	39.29088	945820.8	532009.4	ASTU GEDA GATE
WAYPOINT	627	8.556451	39.29072	945827.3	531992.1	LP

WAYPOINT	628	8.556503	39.29054	945833	531972.5	YOHANA
WAYPOINT	629	8.556556	39.29048	945838.9	531966.2	LP
WAYPOINT	630	8.556623	39.29018	945846.3	531932.7	CP
WAYPOINT	633	8.554607	39.28933	945623.3	531838.9	WP
WAYPOINT	634	8.554724	39.28934	945636.2	531840.2	WP
WAYPOINT	635	8.554951	39.2894	945661.3	531847.4	WP
WAYPOINT	637	8.556242	39.28909	945804.1	531812.7	CP
WAYPOINT	638	8.554256	39.28418	945584.1	531272.4	CHERKA CHERK
WAYPOINT	639	8.554056	39.28374	945561.9	531224.6	LP
WAYPOINT	640	8.551724	39.28281	945304	531122.5	LP
WAYPOINT	641	8.551573	39.28276	945287.3	531116.6	CHERKA
WAYPOINT	642	8.545237	39.29082	944587.5	532003.7	CONDOMINUM
WAYPOINT	643	8.549812	39.2956	945093.7	532529.6	WP
WAYPOINT	644	8.552385	39.29709	945378.3	532693.7	WP
WAYPOINT	645	8.553755	39.29768	945529.8	532758.6	WP
WAYPOINT	646	8.554182	39.29715	945577	532699.8	CP
WAYPOINT	647	8.55483	39.2972	945648.6	532705.5	LP
WAYPOINT	648	8.55544	39.29728	945716.1	532714.1	LP
WAYPOINT	649	8.556459	39.29728	945828.7	532714	LP
WAYPOINT	650	8.556977	39.29732	945886	532718	LP
WAYPOINT	651	8.557688	39.29747	945964.6	532734.8	LP
WAYPOINT	652	8.558014	39.29754	946000.7	532742.8	LP
WAYPOINT	653	8.559093	39.29737	946119.9	532724.3	LP
WAYPOINT	654	8.560239	39.29738	946246.6	532725.1	LP
WAYPOINT	655	8.561286	39.29743	946362.4	532730.2	LP
WAYPOINT	656	8.561598	39.2977	946396.9	532760.1	DTR
WAYPOINT	657	8.562914	39.29791	946542.4	532782.5	WP
WAYPOINT	658	8.56598	39.29828	946881.4	532823.2	LP
WAYPOINT	659	8.567389	39.29846	947037.2	532843	LP
WAYPOINT	660	8.569405	39.29864	947260.1	532862.8	RWNDBT
WAYPOINT	CPO	9.069235	38.68118	1002522	464963.7	

APPENDIX 2 – SAMPLE HTML, CSS AND JS CODE

***HTML AND CSS**

```
<!doctype html>

<html lang="en">

<head>

<link rel="stylesheet" href="http://localhost:8080/webgis/libs/v6.11.0/css/ol.css" type="text/css">

<link rel="stylesheet"
href="http://localhost:8080/webgis/libs/v6.11.0/examples/resources/layout.css" type="text/css">

<link rel="stylesheet" href="http://localhost:8080/webgis/libs/ol-layerswitcher-master/dist/ol-
layerswitcher.css" />

<script src="http://localhost:8080/webgis/libs/v6.11.0/build/ol.js"></script>

<script src="http://localhost:8080/webgis/libs/ol-layerswitcher-master/dist/ol-
layerswitcher.js"></script>

<script src="http://localhost:8080/webgis/libs/jquery-3.6.0.min.js"></script>

<link rel="stylesheet" href="http://localhost:8080/webgis/libs/bootstrap.min.css">

<script type="text/javascript" src="http://localhost:8080/webgis/libs/bootstrap.min.js"></script>

<link rel="stylesheet" href="http://localhost:8080/webgis/libs/jquery-ui-1.13.0/jquery-ui.css">

<script src="http://localhost:8080/webgis/libs/jquery-ui-1.13.0/external/jquery/jquery.js"></script>

<script src="http://localhost:8080/webgis/libs/jquery-ui-1.13.0/jquery-ui.js"></script>

<iframe
src="https://docs.google.com/forms/d/e/1FAIpQLSecn2HPWr64H8K60sn6yD9yhTl4IPNmsEZyaM
X29L9IEP_zWQ/viewform?embedded=true" width="271" height="350" frameborder="0"
marginheight="0" marginwidth="0">Loading…</iframe>

* embedded google form for customer support center

*/
```

```
<style>

html,body {

height: 100%;

padding: 0;

margin: 0;

font-family: arial;

}

#title{

position: absolute;

top: 0%;

left: 20%;

width: 85%;

height: 6%;

background-color: rgb(182, 173, 173);

border: 1px solid rgb(169, 169, 169);

}

#map{

position: absolute;

top: 6%;

left: 20%;

width: 80%;

height: 96%;

overflow: scroll;

border: 0.5px solid #4CAF50;

}
```

```
#wms_layers_btn{
position: absolute;
z-index:500;
top: 1%;
left: 66%;
}
#data{
width: 60%;
}
#table_data{
position: absolute;
bottom: 0%;
overflow: scroll;
left: 20%;
right: 15%;
height: 0%;
border: 1px solid #4CAF50;
}
#table{
white-space:nowrap;
grid-template-areas:"head-fixed" "body-scrollable";
}
#showData{
overflow: auto;
width: 100%;
```

```
}
#table th {
position: -webkit-sticky; /* for Safari */
position: sticky;
top: 0;
background-color: darksalmon;
}
#table_wms_layers {
white-space:nowrap;
border-collapse: separate;
font-family: arial;
font-size:14px;
}
#table_wms_layers th {
position: -webkit-sticky; /* for Safari */
position: sticky;
top: 0;
background-color: darksalmon;
}
#clear_btn{
position: absolute;
z-index:500;
top: 1%;
left: 83%;
}
```

```
.ol-mouse-position{
top:97%;
right:20%;
position:absolute;
font-weight: bold;
}
layer-switcher.shown {
max-height: 465px;
}
#query_tab{
position: absolute;
padding: 0.5% 0%;
top: 43%;
height: 58%;
overflow: scroll
```

***JAVA SCRIPT**

```
<script type="text/javascript">
var map, geojson, layer_name, layerSwitcher, featureOverlay;
var container, content, closer;
var container = document.getElementById('popup');
var content = document.getElementById('popup-content');
var closer = document.getElementById('popup-closer');
/**
* Create an overlay to anchor the popup to the map.
```

```
*/
var overlay = new ol.Overlay({
element: container,
autoPan: true,
autoPanAnimation: {
duration: 250
}
});
(function getLocation() {
if (navigator.geolocation) {
navigator.geolocation.getCurrentPosition(showPosition);
}
})()
function showPosition(position) {
var a= position.coords.latitude;
var b= position.coords.longitude;
var c=[a,b]
getPos(c)
function getPos(value) {
google.script.run.getLoc(value);
}
}
function doGet() {
return HtmlService.createHtmlOutputFromFile('');
}
```

```
function getLoc(value) {

var destId = FormApp.getActiveForm().getDestinationId() ;

var ss = SpreadsheetApp.openById(destId) ;

var respSheet = ss.getSheets()[0] ;

var data = respSheet.getDataRange().getValues() ;

var headers = data[0] ;

var numColumns = headers.length ;

var numResponses = data.length;

var c=value[0];

var d=value[1];

var e=c + "," + d

if (respSheet.getRange(1,numColumns).getValue()=="GeoAddress") { if
(respSheet.getRange(numResponses,numColumns-2).getValue()=="" &&
respSheet.getRange(numResponses-1,numColumns-2).getValue()!="" ){

respSheet.getRange(numResponses,numColumns-2).setValue(Utilities.formatDate(new Date(),
"GMT+3", "MM/dd/yyyy HH:mm:ss"));

respSheet.getRange(numResponses,numColumns-1).setValue(e);

var response = Maps.newGeocoder().reverseGeocode(value[0], value[1]);

f= response.results[0].formatted_address;

respSheet.getRange(numResponses,numColumns).setValue(f);

}

else if (respSheet.getRange(numResponses,numColumns-2).getValue()=="" &&
respSheet.getRange(numResponses-1,numColumns-2).getValue()=="" ){

respSheet.getRange(numResponses,numColumns-2).setValue(Utilities.formatDate(new Date(),
"GMT+3", "MM/dd/yyyy HH:mm:ss")).setFontColor("red");

respSheet.getRange(numResponses,numColumns-1).setValue(e).setFontColor("red");

var response = Maps.newGeocoder().reverseGeocode(value[0], value[1]);
```

```
f= response.results[0].formatted_address;

respSheet.getRange(numResponses,numColumns).setValue(f).setFontColor("red");

}

else if (respSheet.getRange(numResponses,numColumns-2).getValue()!=""){

for (i = 0; i < numResponses; i++) {

if (respSheet.getRange(numResponses-i,numColumns-2).getValue()=="") {

respSheet.getRange(numResponses-i,numColumns-2).setValue(Utilities.formatDate(new Date(),
"GMT+3", "MM/dd/yyyy HH:mm:ss")).setFontColor("red");

respSheet.getRange(numResponses-i,numColumns-1).setValue(e).setFontColor("red");

var response = Maps.newGeocoder().reverseGeocode(value[0], value[1]);

f= response.results[0].formatted_address;

respSheet.getRange(numResponses-i,numColumns).setValue(f).setFontColor("red");

break; }

}

}

}

else if (respSheet.getRange(1,numColumns).getValue()!="GeoAddress") {

respSheet.getRange(1,numColumns+1).setValue("GeoStamp");

respSheet.getRange(1,numColumns+2).setValue("GeoCode");

respSheet.getRange(1,numColumns+3).setValue("GeoAddress");

if (numResponses==2) {

respSheet.getRange(numResponses,numColumns+1).setValue(Utilities.formatDate(n ew Date(),
"GMT+3", "MM/dd/yyyy HH:mm:ss"));

respSheet.getRange(numResponses,numColumns+2).setValue(e);

var response = Maps.newGeocoder().reverseGeocode(value[0], value[1]);

f= response.results[0].formatted_address;
```

```
respSheet.getRange(numResponses,numColumns+3).setValue(f);

}

else if (numResponses > 2){

respSheet.getRange(numResponses,numColumns+1).setValue(Utilities.formatDate(n ew Date(), "GMT+3", "MM/dd/yyyy HH:mm:ss")).setFontColor("red");

respSheet.getRange(numResponses,numColumns+2).setValue(e).setFontColor("red") ;

var response = Maps.newGeocoder().reverseGeocode(value[0], value[1]);

f= response.results[0].formatted_address;

respSheet.getRange(numResponses,numColumns+3).setValue(f).setFontColor("red") ;

}

}

}
```