Web Based GIS Application for Borehole information Management System: The case of Addis Ababa city, Ethiopia

Samuel Zewdu Mekonnen

A Thesis submitted to the Department of Geomatics Engineering
School of Civil Engineering and Architecture

Presented in Partial Fulfillment for the Requirement for the Degree of Master's in Geo-Informatics

Office of Graduate Studies
Adama Science and Technology University

June , 2021
Adama, Ethiopia

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APPROVAL SHEET

I/we, the advisors of the thesis entitled “Web Based GIS Application for Borehole information Management System: The case of Addis Ababa city, Ethiopia” and developed by Samuel Zewdu Mekonnen s, hereby certify that the recommendation and suggestions made by the board of examiners are appropriately incorporated into the final version of the thesis.

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We, the undersigned, members of the Board of Examiners of the thesis by Samuel Zewdu Mekonnen s, have read and evaluated the thesis entitled “Web Based GIS Application for Borehole information Management System: The case of Addis Ababa city, Ethiopia ” and examined the candidate during open defense. This is, therefore, to certify that the thesis is accepted for partial fulfillment of the requirement of the degree of Master of Science in Geo-Informatics, the Graduate program of the department of Geomatics Engineering.

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DECLARATION

I hereby declare that this Master Thesis entitled "Web Based GIS Application for Borehole information Management System: The case of Addis Ababa city, Ethiopia" is my original work. That is, it has not been submitted for the award of any academic degree, diploma or certificate in any other university. All sources of materials that are used for this thesis have been duly acknowledged through citation.

Samuel Zewdu	______________________	_______________
Name of the student	Signature	Date

RECOMMENDATION

I, the advisor of this thesis, hereby certify that I have read the revised version of the thesis entitled "Web Based GIS Application for Borehole information Management System: The case of Addis Ababa city, Ethiopia" prepared under my guidance by Samuel Zewdu Mekonnen submitted in partial fulfillment of the requirements for the degree of Mater's of Science in Geo-Informatics, the Graduate program of the department of Geomatics Engineering. Therefore, I recommend the submission of revised version of the thesis to the department following the applicable procedures.

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Co-Advisor	Signature	Date

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LIST OF ABBREVIATIONS AND ACRONYMS

AAWSA	Addis Ababa Water Sewerage Authority.
API	Application Programming Interface
ASP	Active serve page
AWS	Amazon web service
BSD -	Berkeley Software Distribution
DBMS	Data base management System
DXF	Document exchange Format file
ESRI	Environmental Research Institute
FOSS	Free open-source soft ware
GIS	Geographic information System
GML	Geography Mark-up Language
HTML	Hypertext markup language
HTTP	Hypertext transfer Protocol
IIS	Internet Information Service
JSP.	Java server page
KML -	Keyhole Markup Language,
LAN	Local area network
ORDBMS	Object-relational database management system
OGC	Open Geospatial Consortium
OSM	Open Street map
PHP	Hypertext pre processor
REST -	Representational State Transfer Requests
SDI	Spatial data infrastructure
WFS	Web feature service
WMS	Web map service
WAN	Wide area network

ABSTRACT

Reliable information is of utmost importance for planning and decision making. Various challenges face the water resources management sector in regard to water resources information management. The main challenges include lack of well-defined processes of information flow between various organizations and different storage formats hindering proper information sharing resulting to duplication of information. At present Addis Ababa Water Sewerage Authority (AAWSA) uses analogue form which presents a challenge of data retrieval, information analysis and decision making though there are on-going efforts to digitize them into Ms Excel format. The objective of this Study is to develop web-based GIS application borehole information management system that will enable efficient and effective decision making. Stand-alone GIS systems are limited in data sharing abilities towards the public. Web-based GIS platforms provide resourceful means of data sharing and analysis The study sort to address this problem by developing a web based GIS borehole information management system .The web application was developed using free and open-source (FOSS) web development tools, These tolls were used to create and deploy a web application that will provides a better option for water sector stake holders in Addis Ababa to quickly access information about the borehole information data in the office or the field without referring to a paper document., The output was a fully functional web-based GIS application borehole information management system in Addis Ababa, this web mapping application that can be utilized by all stakeholders includes Addis Ababa water and sewerage Authority (AAWSA) and other water related governmental and nongovernmental organization, Driller Company and researcher. The web application provides a user-friendly interface that provides quick answers about borehole location and other information's with in a fraction of minute.

Keywords: - borehole, Free open-source software, Geographic information system, Addis Ababa water and sewerage Authority.

CHAPTER 1: INTRODUCTION

1.1. Background of the study

Groundwater is the primary source of domestic, Agricultural, and industrial use in many regions of the world (Tolche, 2021). Groundwater has been found to be a more preferred resource due to its less susceptible contamination than surface water It can be considered as the largest single fresh- water source in many parts of the world, especially during prolonged dry periods (Tolche, 2021).

Accurate and reliable groundwater resource information is critical to planners and decision-makers. Huge investment in the areas of groundwater exploration, development and management at state and national levels aims to meet the groundwater requirement for drinking and irrigation and generates enormous amount of data. We need to focus on improved data management, precise analysis and effective dissemination of data.(Kumar, 2011).

Data is the "life blood" of an organization, for as it flows between systems, databases, processes, and departments, it carries with it the ability to make the organization smarter and more effective.(Boissier et al., 2014) The highest performing organizations pay close attention to the data asset, not as an afterthought but rather as a core component in defining, designing, and constructing their programs. Data is essential to making well-informed decisions that guide and measure the achievement of the organizational strategy (Wielki, 2013) Decision-makers at all levels need data: data sustain the continuous management of water resources. How an organization uses and manages its data is just as important as the mechanisms used to bring them into the environment. Possessing the right data of appropriate quality enables an organization to perform processes well and determine which processes have the greatest impact. The highest performing organizations ensure that their data assets are accessible to the processes and individuals who need them, are of sufficient quality and timeliness, and are protected against misuse and abuse.((Khine & Shun, 2017).

The tremendous growth in popularity of the internet and the growing public interests in accessing online geo-spatial information have given a move to develop web mapping applications. The web is playing a huge role in spatial application development mainly because of advantages such as platform independency, reduction in distribution costs and maintenance problems, ease of use and widespread access.(Verma et al., 2012).

The most important power of web-based spatial application is the capability to publish and share geo-spatial information on the web which jointly allows information to be exchanged in a rapid and efficient manner thereby helping individuals make important decision quicker. The geo-spatial information not only includes maps or locations of landmarks, but multiple attribute data, socioeconomic data, aerial photographs, satellite images, etc., which may have static or dynamic characteristics (Kuria et al., 2019).

Current advances in computational speed, storage, World Wide Web and software provide great opportunities to develop decision and management support systems with the advantage of information dissemination for decision-makers. Geographic Information Systems (GIS) have had a profound effect on water resource management. Various GIS tools are now commonly used for data preparation and developing water resource management systems. There have been various systems developed in different parts of the world using geospatial technologies. They vary in terms of the approaches adopted and also on the capabilities of the resulting systems. Integrated (Magondu et al., 2013).

A search for existing literature shows very little research focusing on the usability of web GIS application for borehole information Management system in Ethiopia, this study examined the web GIS application for borehole information management system a Proto type sample for Addis Ababa city by using open-source of software. As a result, this thesis intends to contribute to the further technical development of the usability of system development.

1.2. Problem of statements

The existing way of data storage regarding ground water data in Addis abaca city is largely still manual and analogue involving lots of hardcopy maps and sheets. Data analysis in such a situation is quite difficult if not impossible. , Most of the time data, particularly those collected in Addis Ababa water related sectors in the past, are in the form of static data reports that describe the stratigraphy and the related characteristics; these data types are generally available as paper documents, or static files like excel spreadsheet format and pdf formats while very informative, these documents are not searchable, not interoperable and not re-usable the data, this certainly improves the find-ability of the data and its accessibility but still do not address the interoperability requirement and therefore, combining data from different sources remain a problematic task,

The Ministry of water irrigation and Energy in Ethiopia and Addis Ababa Water sewerage Authority are responsible to manage and monitoring borehole data in the city respectively, However, there is no standard format and well-organized database management system and web mapping technology handling the water resource data, lack of skilled in human power in web mapping technology and shortage of man power in the field of Geo-spatial Technology. (AAWSA, 2021) .

Addis Ababa water and sewerage Authority is in the process of digitizing the borehole records though the digitization process is still at basic levels of capturing data in formats such as MS Excel in scattered form in different professional. (AAWSA, 2021).

Geo-technologies offer the solution to this in an effective and cost-efficient way compared to old-style methods. This in turn results in better data storage and retrieval, enhanced decision making through visualization and spatial analysis and the availability of open-source software provides accost effective way of making and developing mapping application that can be used to manage borehole data, the study focuses how to use free open source software (FOSS) to Create, share, visualizing and publishing borehole data belonging to Addis Ababa city improved service delivery to the public ,The study developing a web-based GIS application for borehole information management system in the case of Addis Ababa city, using free open-source software (FOSSS).

1.3. Objective

1.3.1. General Objective

To develop a web-based GIS borehole information Management system using open-source software such as Quantum GIS, Q GIS 2web plug in and Q GIS cloud for the case of Addis Ababa city the users that allow a spatial and non-spatial data in web plate form.

1.3.2. Specific objectives

- To demonstrate spatial and non-spatial borehole data of the study area
- To Design an interactive borehole web map application
- To demonstrate remote access of borehole information

1.4. Research Questions

The study was conducted answer the following questions

- In what way to demonstrate the spatial and non-spatial borehole data of the study area?
- How to Design an interactive borehole web map application
- How to demonstrate remote access of borehole information?

1.5. Significance of the study

Web GIS provide many more opportunities to provide broader access to the authoritative GIS data, enabling you to move your system of record to system of engagement that facilitates everything from self -service mapping to making better decision. it makes GIS more accessible, more affordable, more pervasive. The easy-to-use nature of web GIS, low-cost barrier of entry, flexibility, promotion of cross team collaboration and effort required to publish and share maps empower organization to become more efficient productive and reactive to their spatial data. The result of this study is expected to have the following significance for water related sectors

- Establish a common language between stakeholders
- Enhance the exchange, the usage and quality of the data
- Its easiest way to improve internal and external communication among water sectors.
- Eliminating time efforts and expense of customization
- Managing huge volume of borehole information data in a single place.
- Facilitating collaboration across government and non- government organization and Private Enterprise.

1.6 Scope of work

The scope of this Thesis is to develop a web-based GIS application for Borehole information management system that will enable various stakeholders to be able to access information about boreholes in a quick and easy manner. The study area is limited to Addis Ababa administrative city. The city was chosen because most of the borehole data in the county is found in Addis Ababa city.

1.7. Limitation of the study

All efforts were made to perform the present study in a systematic and logical manner; however, these efforts were made under the constraints of limited restricted resources, financial support and lack of spatial data infrastructure (SDI) and some of limitation of free open source of software (FOSS.) such as Q GIS 2 web plug in and Q GIS cloud.

1.8. Organization of the research

There are five chapters included in this thesis. Chapter one introduces the back ground of the study, described problem of the statement, objectives, research questions, significance and limitation of the study. Chapter two deals with review literature describe theoretical background of web mapping, and its components, web GIS Architecture web GIS technologies, open standard software, and web mapping technology. The third chapter is the general description about the study area with detailed explanation and describes data Source and materials method of data collection method of data analysis and Methodology used in the implementation of the prototype. Chapter four deals with result and discussion phase. The last chapter deals with the conclusion and recommendation.

CHAPTER 2: LITERATURE REVIEW

2.1. Concept of water bore hole (water wells)

Water well is a hole, tube or excavation used for the purpose of extracting ground water from the subsurface. Water may flow to the surface naturally after excavation of the hole or shaft. Most wells are vertical tube, but they may also be horizontal or at an inclined angle. Some wells are used for purposes other than obtaining ground water, investigation of subsurface conditions, shallow drainage, artificial recharge and waste disposal. The location of any borehole (well) is mainly based on the underlying purpose which is an important consideration. The hydrogeological assessment should be done by qualified professional drillers. The determination of the suitability, availability of sufficient ground water and appropriate quality, are dependent on several factors. These factors include the knowledge of the system of the ground water, experience in similar areas and diverse array of information such as land surface topography, local vegetation, rock fracturing (location dependent), geophysical measurements among other factor .(Okwere, L. hart and Jacson , 2015.).

Generally, the main thrust of the design and construction of water bore hole is to create a structurally stable, long lasting, efficient well that has enough space to have pumps or other extraction devices. it will ensure that ground water move effortlessly and sediment – free from the aquifer in to the well at the desired volume and quality and prevents bacteria growth and material decay in the well (Nussbaumer et al., 2016).

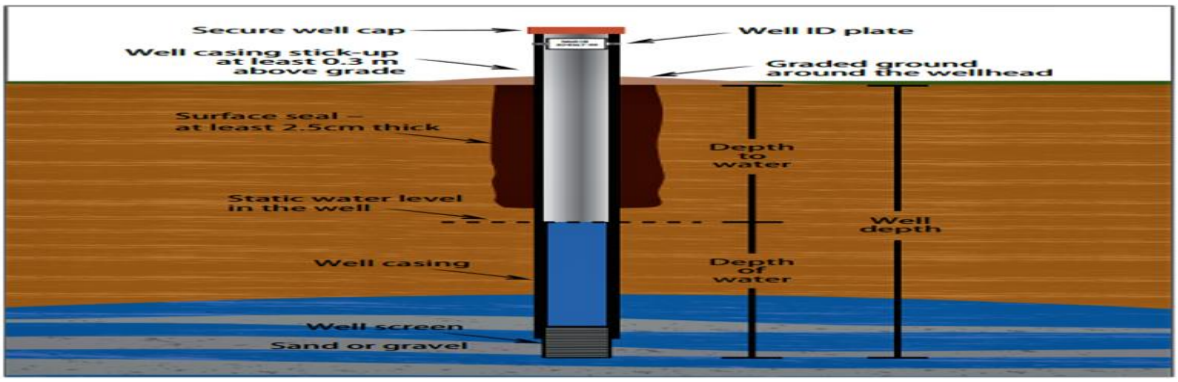

Figure 1 - Underground water Borehole and Aquifer layers source (Okyere ,2015)

2.2. Web Mapping and Web GIS

Web mapping is a form of distributed computing based on the client-server architecture. It affords the benefits attributed to distribute computing. In principle, in web mapping any user With internet connectivity can benefit from web mapping services.(Kraak et al.,2014). Notably, it is not required that a user be a GIS expert in order to benefit from web mapping services. Nonetheless, web mapping services are faced with several challenges some of which arise from the distributed nature of web mapping services while some are due to the nature of geographic data.

Web GIS is the process of designing, implementing, generating and delivering maps on the World Wide Web. Web mapping looks similar to web GIS but web GIS deals with processing of geo-databases, analysis, exploratory issues (Kraak and Stephen Sande ,2014). The web mapping basically deals with technical issues, web based cartography, theory and social issues and usability of maps. It is the presentation media for web maps and gaining more analytical capabilities. GIS integrates and relates data with spatial component and supports GIS integrates and relates data with spatial component and supports users to view in proper format which provides support in making complex spatial decisions through visualization, interactive modeling and analysis environments. GIS is utilized in understanding of spatially distributed phenomena in many areas of decision making and evaluating problems (Sakamoto and Fukui 2004).

Generally, Geographical Information System was considered as monolithic and platform-dependent applications (Wong et al., 2002). The development and rapid growth of web and web-based application created a new platform for traditional GIS to grow and spread. Unfortunately, not everyone has access to GIS, nor would be able to spend time necessary to use it effectively.

Web GIS became a cheap and easy way of disseminating geospatial data and processing tools (Alesheikh et al, 2002). Web GIS have the highest number of users, although typically Internet users focus on simple display and query tasks. (Goodchild et al, 2005). The capability of Web GIS for interacting dynamically in distributed environment from cross platform to client/ server computing system made it more interesting to develop and use for accessing spatial information. The major development of cartography is using the web as a distribution medium. By the means of web, now it has opened the possibility of the availability of real-time maps, cheaper maps sharing, more frequently updated database sources and cheaper software and hardware requirement. There are some problem and difficulties to full development of web mapping. Some technical difficulties such as bandwidth, lower resolution of image are common. Reliability issues and security issues have limited the expansion of web mapping. The development of web cartography and GIS is steady compared to web technologies. Web 2.0, a new generation of Internet services and technology (Deshpande et al, 2006) support user interaction significantly. This evolution leads GIS away from data browsing, analyzing and managing for individual decisions, and more towards group participating and communicating on social decision issues (Carver and Stephen Sande 2014). As Craig et al. (1999) describe the Public Participation GIS principles as accessibility, understand ability, and accountability, Web GIS continues to draw attention as a public participation tool (Sakamoto et al 2004).

Nowadays, Google Maps, Google Earth, Open Street Map, Yahoo Maps, Microsoft's Live Search Maps and other many commercial as well as non-commercial applications provide many kinds of geographical related information such as detailed maps, satellite images and terrain maps covering all over the world and allow users to use their APIs (Zhelu, 2009).

2.3 .Evolution of web GIS from Desk top to web GIS and web mapping

A geographic information system (GIS) is a type of information system that that utilizes the spatial data and attribute data (Non –spatial data) in sense that allows capture, storage, manipulation, analysis, management and provision of actionable spatial data to the end users, The GIS users, the GIS application is made of tools that allows users to make interactive quires, perform spatial analyses, edit maps data and finally generate reports from operations. Modern GI|S technologies consists of computer hard ware and software user, procedures and data, A fully functional GIS uses digital spatial information to produce results.(Verma et al., 2012).

The definition of Geographic information system (GIS) technology originate from the 1960s and it was necessary due to the increase in need for Geographic or spatial information and the appearance of the computer as well most GIS are operated on desk Top computer and are called desk GIS (Mwangi et al., 2017). recently with the advancement and rapidly development of the internet and world wide web and more and dynamic GIS related application are available on line or web site, the increase in computing capabilities and function automation of GIS related analysis has led to up rise web mapping and web GIS has rapidly developed as well gained popularity with the advances made through web 2.0.

2.4. Web mapping components

It is composed of client (presentation), server (application) and data (database) tiers. This architecture preferred over other architectures because it allows developers to develop, maintain, upgrade or replace any tier independently without affecting the other tiers. The client sends a request to the server which in turn processes and executes the query and directs it to the database. The database returns the result which is fetched by and processed by the server and delivered to the client (.(Stephen Sande, 2014).

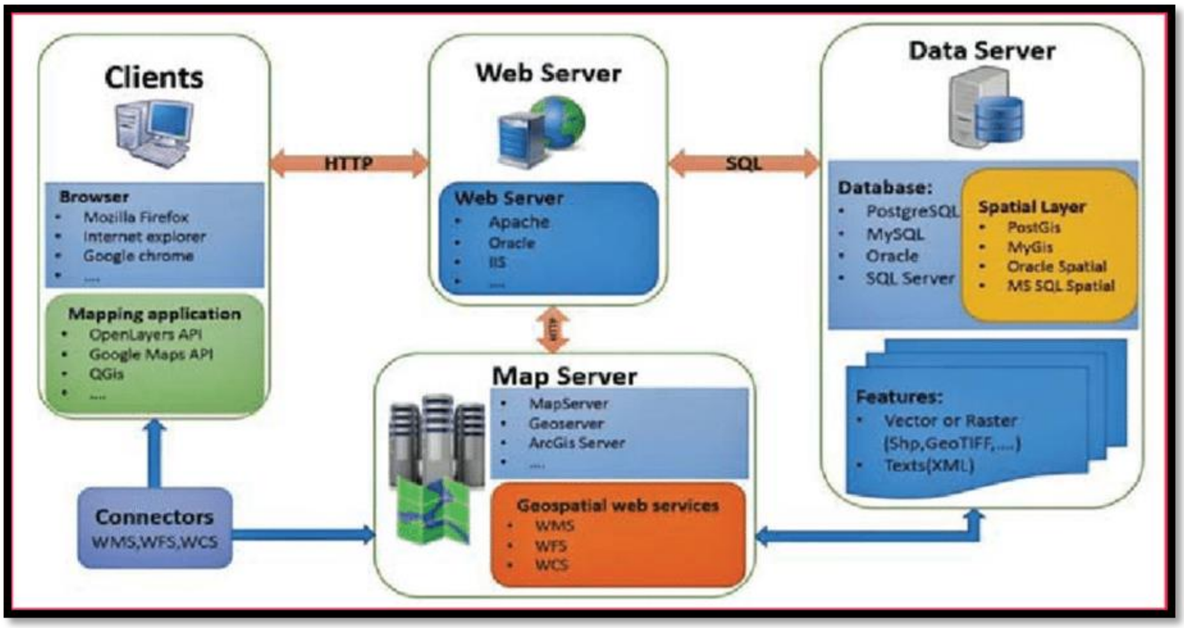

Figure 2-Components of Web mapping (Rouhollah,2021)

2.4.1 Presentation tier

The presentation tier contains a number of client-side environments. This side takes input from The users and is responsible for displaying maps. It includes a number of web browsers linked with the world. Web browser is presentation tier of the web mapping architecture which involves mainly for finding the right web page and then making sense of its content (Dzbor et al., 2003). Uniform Resource Identifier (URI) identifies the information resource and may be a web page, image, video or other piece of content (Veenendaal, Brovelli, & Li, 2017).

2.4.2 Open Layers

Open Layers is used in the presentation/client tier for rendering maps. Open Layers is an OS Geo supported project and works in browser (JavaScript/AJAX) application for accessing and Displaying map tiles, features and markers from different and wide range of data sources. Open source JavaScript library is released under a Berkeley Software Distribution (BSD) style license for displaying a dynamic map in web browsers and provides the functionality of managing and manipulating data in the browser.(Saputra, 2019) It is open source hence it can be used for re-development, re use and updating.

It supports different data formats and web services which includes Keyhole Markup Language (KML), Geography Mark-up Language (GML), Web Map/Feature Services (WMS/WFS), Representational State Transfer Requests (REST), Geographic JavaScript Object (Geo JSON), Geo RSS, Tile Cache web accessible caches and other many commercial and free web map services like Google maps, Yahoo! Maps, Microsoft Bing map, World Wind, etc. Open Layers allows using JavaScript to display feature information on a map. This feature information might come directly from a UI, Geo JSON feed, originate from a GML or KML data source (Ganesan, 2009). Open Layers was chosen for the project because it offers quite a rich library that can be used to enhance map functionality.(Markos , 2012).

2.5 Logic tier

Logic tier consist of web server, application code and web GIS server. Web server takes user request and transfer output map result to the clients. Users request information is transferred to the application code where the request of user is compiled; it detects the user required information and sends the information to the map server. The map server detects which map is requested and sends information to the database(Umoh et al., 2012). After receiving map data from database server, the map is processed. Editing, map processing and generating an output map are done in this tier. Output maps are sent to the client web browser through the Internet. Web servers connect different software components with a scripting language. Web server applications can communicate with the API of a GIS, web server and with the spatial database of other applications. These Web servers are also very useful when developing complex web mapping applications, real time web maps or Web GIS. The two main types of web server are Internet Information Service (IIS) and Apache. Internet Information Service is a high- Performance Web Server from Microsoft which is proprietary software. Apache is open-source software and can be installed on almost all operating systems including Linux, Unix, Windows, FreeBSD, Mac OS X and more. Due to these reasons, Apache was used in the implementation of this project. (Berhanu et al., 2017).

2.6. Database tier

GIS and geospatial data are growing in importance for the Community, because they allow users to examine new types of information in new ways (Meyer, 2004). The Database tier is responsible for keeping map data in organized way. Relational database model is responsible for making relational database table for efficient retrieval of data. It sends and receives instruction and information through maps server and application code compiling center. Map file stores the whole map in a file which is accessed by map server. (Umoh et al., 2012).

2.6.1. Postgress

Postgres, also known as PostgreSQL, is an open-source, object-relational database management system (ORDBMS) that is not owned or controlled by one company or individual. PostgreSQL software is open-source, and it is managed mostly through a coordinated online effort by an active global community of developers, enthusiasts and other volunteers. First released in themid-1990s, Postgres SQL is written in C. Its primary competitors include Oracle DB, SQL Server and MySQL (Cory Janssen, 2014).

2.6.2. Post GIS

PostGIS turns the PostgreSQL Database Management System into a spatial database by adding support for the three features: spatial types, indexes and functions. Because it is built on PostgreSQL, PostGIS automatically inherits important “enterprise” features as well as open Standards for implementation. Spatial data types refer to shapes such as point, line, and polygon; multi-dimensional spatial indexing is used for efficient processing of spatial operations while spatial functions, posed in SQL, are for querying of spatial properties and relationships (Boundless, 2014). Postgres and PostGIS were the preferred choice because of their open-source nature and efficiency in handling spatial datasets.

2.7. Web GIS Architecture

The basic approach for deploying Web GIS application depends on the user requirements that have to concern with which web GIS packages are suitable to accomplish their objectives (Raghavan & Santitamnont, 2004) Developments of web GIS are changing as fast as internet and Web technologies. Because one depends on the other. According (Markos, 2012) there are basically two types of architectures for developing web-based GIS applications client side, and server-side.

2.7.1. Server-side strategy

In a server-side web GIS application, a Web browser is used to generate server requests and display the results on client-side browser. A web GIS server usually combines a standard Web (HTTP) server, GIS application server, and the GIS databases and functionalities that reside completely on the server.

As it is shown in figure 2 users interact with the client machine and type the address they are looking for (the request), which is transferred to the Web server. The Web server passes the request to the GIS application server, which runs an address matching routine, generates a map graphic, convert the graphic to Web format, wraps the image in HTML and sends it back to the Web server, which then returns the response to the client as a standard Web page. Map data transmitted to a Web client are in standard HTML formats that can be accessible through any Web browser, creating significant positive implications for performance, reliability and size of user base. Because of the entire complex and proprietary software, as well as the GIS databases resides on a server, it is easier for simplified application development in Server-side applications for deployment and maintenance of data. But server-side solutions are primarily associated with poor performance and limited user interface and interaction.(Berhanu et al., 2017).

2.7.2 Client-side strategy

Client-side Web GIS applications can provide full GIS analysis and management support to specific users within business, government or public sectors. In a client-side Web GIS application, users are required to install a complete client application. In such systems, either a substantial amount of GIS functionality is moved to the client, or only the user interface is enhanced slightly to enable specific user interaction. In either case client-side application require software of some kind (other than browser) to be transferred to the user. In client-side Web GIS, the client system should be enhanced to support GIS operations. That is, to implement client-side solutions, software must be transferred to the client (Dang, 2000). in client-side Web GIS, the main tasks will be processed in the server, which is basically delivering files. The server receives request from the client and starts to communicate to the database and retrieves attributes of the map stored in the database. The GIS application server has also direct access to the map file. The map files could be SHP, DXF, etc. and used to create map files like lines, point, area and labels. The server provides the client with raw data map and HTML image. The primary advantages of client-side solutions are improved performance.(Adnan et al ., 2010).

2.8. Available Web Mapping Technologies

Web mapping, being one of the newest fields in Geographic Information System, different Commercial as well as open-source software and technologies are being developed. For commercial purposes, commercial companies develop software's which are well documented and contain advance features but the price for that technology is high while open-source system is developed by communities and can be used free of charge but they may contain poor Documentation though the open-source system is developing rapidly with the involvement of a large number of peoples. The major technologies involved in the realm of web mapping today are (Detwiler et al, 2009).

I. Commercial: ArcGIS Server by Environmental Research Institute (ESRI), Geo Media Web Map by Intergraph, Map Xtreme by MapInfo and Map Guide by Auto desk.
II. Open source: Geo Server, Map Server, Open Layers, Scalable Vector Graphics (SVG), Adobe Flex (part open, part proprietary).
III. Public APIs: Google Maps, Yahoo! Maps, Microsoft Virtual Earth (2D), MapQuest's Open API
IV. Globes: Google Earth, Microsoft Virtual Earth (3D), ArcGIS Explorer, NASA.

2.9. Web server

A web server accepts HTTP requests and serves the contents of web pages to the client in the Form of text, image, style sheet and scripts. There are different types of web server developed by different companies like IIS by Microsoft, Apache Tomcat, Sun Java system web server etc, but Apache Tomcat is popular and widely used (Mwangi et al. 2017).

2.10. Geo server:

Geo server is a Java based server that can allow map creating and data sharing. It is completely open source and work under OGC standards. It can allow display/sharing the well-spatial data to the world through the web. Geo server comes with a WMS that can fit into other Java applications like Open Layers and can create maps of different formats. It comes with inbuilt "Geo tools" which is an open-source Java GIS toolkit that allows GIS operations on the map. Geo server can display data on the any popular modern mapping applications like "Google Maps", "Google Earth", "Yahoo Maps" etc.; even it can connect to the traditional desktop GIS tools like ESRI ArcGIS. Complete instruction of the Geo server installation is provided in the appendix of this report (Cignetti et al., 2019).

2.11. Scripting language and JavaScript

A scripting language allows controlling one or more software application. Scripts are different from core programming language often interpreted from source code and embedded in other applications. In web-based application scripts are embedded in HTML code. Clint side Scripting are executed in client-side by web browsers whereas server-side scripting the scripts runs on server side or application servers. The popular server-side scripts are PHP, ASP and JSP. JavaScript is a client-side object-oriented scripting language which is popular for developing client-side application. It is developed by Netscape in 1995 and closely related with Java programming language and influenced with other programming languages but easier to program(Stephen Sande, 2014).

2.12. API

Application Programming Interface (API) which constitutes a language and message format is a set of data structures, routines or protocols used by an application to communicate with other Control program, communication protocol or operating system. Almost every application depends on the APIs of the underlying operating system to perform such basic functions as a accessing the file system (Orenstein, 2000). APIs are implemented by writing function calls in the program, which provide the linkage to the required subroutine for execution. An API entails program module in a computer to perform the operation or links to the existing program to perform the tasks. Based on functions and interactions, the API also differs in the implementation in that Environment. Generic APIs are full set of APIs included in library of programming languages.

API interacts with operating system, DBMS and other applications and facilitates Interaction between users and the computers. Specific API like yahoo and Google only address defined specific problems. Language specific API operate in a specific language Using syntax and components of that language whereas language independent APIs can operate in different application and programming language. This feature of language independent APIs is a required feature of service-oriented API which doesn't limit on specific system, process or platform and useful for web services. (Ananthi & Hariganesh, 2015) The API itself is largely abstract in that it specifies an interface and the behavior of the objects Specified in that interface. The API acronym may sometimes be used as a reference not only to the full interface but also to a single function or even a set of multiple APIs provided by an organization. Thus, the scope is usually determined by the person or document that communicates the information. Based on the API documents, the user could learn and combine existing functions in the application more easily and efficiently..

2.13 Cloud computing

Nowadays, computing resources are moving from the desktop PC to the cloud. Cloud computing involves distributed computing over a network, where a program or application may run on many connected computers at the same time. It specifically refers to a computing hardware machine or group of computing hardware machines commonly referred as a server connected through a communication network such as the Internet, an intranet, a local area network (LAN) or wide area network (WAN).(Prasad et al., 2013) Any individual user who has permission to access the server can use the server's processing power to run an application, store data or complete any other computing task. Therefore, instead of using a personal computer every-time to run the application, the individual can now run the application from anywhere in the world, as the server provides the dealing out power to the application and the server is also associated to a network via the Internet or other connection platforms to be accessed from anywhere. Some of the advantages of using the cloud are maximizing the effectiveness of the shared resources through economies of scale, elasticity of cloud resources and on-demand nearly instant access to resources. Some of the cloud vendors include Google, Amazon, IBM, Oracle Cloud, Rackspace, Sales force, Zoho and Microsoft Azure (Vaquero et al, 2009). Amazon web services (AWS) was the preferred choice amongst the vendors because of their low upfront costs and versatility in the cloud resources they offer. The main cloud services that were utilized from Amazon web services were Amazon Elastic Compute Cloud (Amazon EC2) and Amazon Simple Storage Service (Amazon S3). Amazon Elastic Compute Cloud (Amazon EC2) is a web service that provides resizable compute capacity in the cloud. It is designed to make web-scale computing easier for developers. Amazon EC2 allows one to obtain and configure capacity with minimal friction. It provides you with complete control of your computing resources and lets you run on Amazon's proven computing environment.

Amazon EC2 reduces the time required to obtain and boot new server instances to minutes, allowing you to quickly scale capacity, both up and down, as your computing requirements change. Amazon EC2 changes the economics of computing by allowing you to pay only for capacity that you actually use. Amazon S3 provides a simple web-services interface that can be used to store and retrieve any amount of data, at any time, from anywhere on the web. It gives any developer access to the same highly scalable, reliable, secure, fast, inexpensive infrastructure that Amazon uses to run its.(Prasad et al., 2013).

2.14. Google maps and Open Street map (OSM)

Worldwide coverage capacity of Google maps being maps and open street maps (OSM) provide the most useful and freely accessible web-based mapping system for locating places and services for users Google satellite image provides clients with the most up to date imagery with a spatial resolution of 1 meter this when over laid with accurately accurate way of visualization physical location of particularly phenomenon on earth. (Stachowicz , 2004).

Open street maps are crowd sourced maps which are regularly up dated. This OSM are produced through crowd sourcing and this has been done for over 15 years. the main factors driving this paradigm shift in map production not only being the rapid development of web 2.0 but also a combination of varieties of available high band width of internet and set of well – developed collaborative tools for both geo spatial and non geo spatial professionals. Notably OSM has a vast number of users and contributors continue to grow as well. OSM had more than 33,000 registered system users and more than 3500 active contributors to the system; in 2020 this number is expected to have tripled, therefore with large number of users and dedicated contributors. OSM is up dated regularly and provides aver accurate source for on line geographical information that is accessible to large varieties of users. (Hakaly et al., 2008).

Google maps also use the Google map maker plat form to engage users for regularly up date of places and man-made features on Google plat form , hence also provides a up to date source of place names and features on Earth , conclusively both OSM and Google maps are constantly up dated and this has revolutionized the on line Geo spatial data to provide up to date source of free and Accessible data and information such as information may include Business names , Property boundaries , street maps , location based services for web mapping since the information and details accessible on this plat form is accurate and legal representation of the available feature in an area of interest by users.(Amil et al., 2020).

2.15. Web Mapping with QGIS2Web

Web mapping is a great medium to publish your GIS data to their web and make it accessible by other users. Creating a web map is a very different process than creating one in a GIS. GIS users are typically aren't web programmers and it presents a challenge when one needs to create a web map that is of the same quality as a map creating in a GIS. Fortunately, there are tools available to easily translate your work in QGIS to QGIS2Web plugin to create a web map using Open Layers or Leaflet libraries from your QGIS project. (Dhungel, 2012).

2.16. Leaflet

is a popular open-source Java script library for building web mapping applications. Q gis2 leaf plugin provides a simple way to export your QGIS map to a functioning leaflet-based web map. This plugin is a useful way to get started with web mapping and create an interactive web map from your static GIS data (Veenendaal ,. 2017).

2.17. Open Layers library

Using the Open Layers, the library provided tools that would enhance visualization. These included providing for Google maps to act as a base layer whilst boreholes, roads and administrative units act as overlay layers. Furthermore, zoom in and zoom out tools were incorporated to enhance interactivity with the map. QGIS2web generates a web map from your current QGIS project, either as Open Layers, Leaflet, or Map box. It replicates as many aspects of the project as it can, including layers, styles (including categorized and graduated), and extent. No server-side software required.(Dhungel, 2012).

GIS, Open Layers, and Leaflet are all different mapping technologies. This means that their respective functionality differs in many ways. Qgis2 web does its best to interpret a QGIS project and to export HTML, Java script, and CSS to create a web map as close to the QGIS project as possible. However, many elements of a QGIS project cannot be reproduced, and many are only possible in either Open Layers or Leaflet. Qgis2web tries its best to produce a publish-ready map, but you can always manually edit the output code to achieve what qgis2web cannot.

2.18. QGIS Cloud

QGIS Cloud is powerful Web-GIS platform for publishing maps, data and services on the internet. Create and edit professional maps with all the capabilities from QGIS. With only a few short mouse-clicks you can share your work on qgiscloud.com with the public. QGIS Cloud is personal and public spatial data infrastructure (SDI) on the internet. Publish QGIS projects as maps and data. Share spatial data with others. And all this very easily, without server, infrastructure or expert knowledge. If you know QGIS Desktop, then you know QGIS Cloud. Simply install the QGIS Cloud plugin from the official QGIS plugin repository and you are ready to go. Publish as many maps as you want (Endalew et al., 2019).

2.19. Advantages of QGIS cloud

Create maps: create complex maps with QGIS desktop, using any of the styling possibilities offered by QGIS desktop, QGIS desktop simply publish data and maps with the QGIS Cloud plugin. All this in just a few minutes, it's as simple as it gets. (https://www.qgiscloud.com).

Manage data: QGIS Cloud gives you a full- featured Postgre SQL databases, extended with Post GIS 2. Create new databases directly from the QGIS Cloud plugin with just a click. Manage your databases with any compatible management tool, such as pgAdmin3, the QGIS Browser or the QGIS DB-Manager. You have full access to all features of a Postgr SQL/Post GIS database.

Share information and data:- Share your maps and data over OGC (Open Geospatial Consortium) compliant web services. Display your maps via WMS, or download the data via WFS. With WFS-T, you can edit your data directly over the web service. Or use the QGIS Cloud Web GIS and Mobile Client integrated in QGIS Cloud. If your information and data should not be publicly accessible, QGIS Cloud pro allows you to restrict access by protecting the resources with a password. (https://www.qgiscloud.com).

Print maps:-Offer high quality maps via WMS for printing. Just create as many print compositions as you please with QGIS Desktop, with all the options it offers to you. Compose maps for arbitrary paper formats, with printing resolution up to 1200 dpi.

Security:-the data is stored in the cloud in Postgre SQL databases. Access to the databases is protected with a password, and accessed through SSH. If you want to share your services only to a restricted group of people, then you can limit access to the resources. For this, you'll need QGIS Cloud Pro. With QGIS Cloud Free, all QGIS Cloud services are openly accessible.

2.20. Related research work.

According to (Chang and Park, 2004) developed a web-based GIS for the management of borehole data. They used a standardized format for storing borehole data in a database. Their system allows web clients to search the archived borehole database and perform statistical functions. The system contains information on more than 10,000 bore holes in Korea, which is effective for those requiring use of that particular database. It would be difficult for an individual user to add data or to supplement the database with samples stored in a different format.

According to (Stephen Sande et al., 2012) was to develop a web-based GIS borehole information management system that enabled efficient and effective decision making. Stand-alone GIS systems are limited in data sharing abilities towards the public. Web-based GIS platforms provide resourceful means of data sharing and analysis. The system was based on open-source applications. Programming languages such as HTML and JavaScript were used in defining elements within the system; Postgres was used to manage the database. Open Layers was used for map rendering and display. The output was a fully functional web-based GIS borehole information management system in which information relating to boreholes was held and various query and analysis can be done.

As described by (Fajuyigba, 2007) the tourism industry in Nigeria is growing one but it Suffer from lack of appropriate promotion. To overcome this problem the researcher uses a web based GIS approach. In order to provide enhanced cartographic representation, the Researcher develops the digital maps using Arc view GIS software. The developed maps Were putted on the internet using an interactive user interface web page.

According to (ch Dodo et al., 2004) one of the problems encountered in the tourism Industry is the need for quick update and maintenance of the voluminous tourism data. In Zimbabwe, tourism authorities are continuously collecting data on tourist facilities. At the Zimbabwe Tourism Authority, most of this information is stored in hardcopy format. Some of the information gets lost after some time. The researcher uses arc view version 3. 2 and visual basic programming language to overcome the problem.

The problem of tourism development in Addis Ababa city, Ethiopia was identified. According to (Mesele, 2009) the main problem for the development of Addis Ababa tourism is lack of appropriate promotion. He uses web based GIS application using open sources software for promoting the tourism facilities of the city on the internet. The problem of ecotourism in Sundarbans Bangladesh was identified by (Azizur, 2010). He uses GIS Organize structured information about Ecotourism to planners and developers, to utilize and find location suitability under conflicting demands and facilitate monitoring and controlling of ecotourism activities.

According to (Angelina, 2008) she used GIS for bringing the geo referenced data (spatial and non-spatial) of geographic location Zlatibor and Zlatar of her study area into digital maps. Each object is assigned to a thematic layer. Each layer combines related objects like roads, building, protected areas or watercourses. In this research the author used GIS in three types of applications such as inventory, analysis and evaluation of plan based on tourism development.

Web based GIS approach for disseminating the spatial and non-spatial tourism Information of East Java Indonesia on the internet was done by (Tran, 2006). In order to achieve his objective the researcher develops a spatial and non-spatial data base. He uses my sql DBMS for storing the non-spatial data and the spatial data were stored as ESRI shape files. Finally he develops an interactive user interface by using different web site developing programming languages and he connects the developed spatial and non-spatial data base with the website.

CHAPTER 3: MATERIALS AND METHODS

3.1 Study Area Description

3.1.2. Location and Topography

Addis Ababa the capital city of Ethiopia is located between 8°49` 55.929`` and 9° 5` 53.853`` North latitude and between 38° 38` 16.555`` and 38°54` 19.5 47`` East longitudes. Highest peak at mount Entoto which is 3041 m to 2051 mean above sea level at lower Part of Akaki plain. The topography is un adulating and form plateau in northern, western and south western parts of the city is characterized by gentle morphology and flat, The city located in central high lands of Ethiopia covering an area extent about 527 Km2 (Doyle et al., 2020).

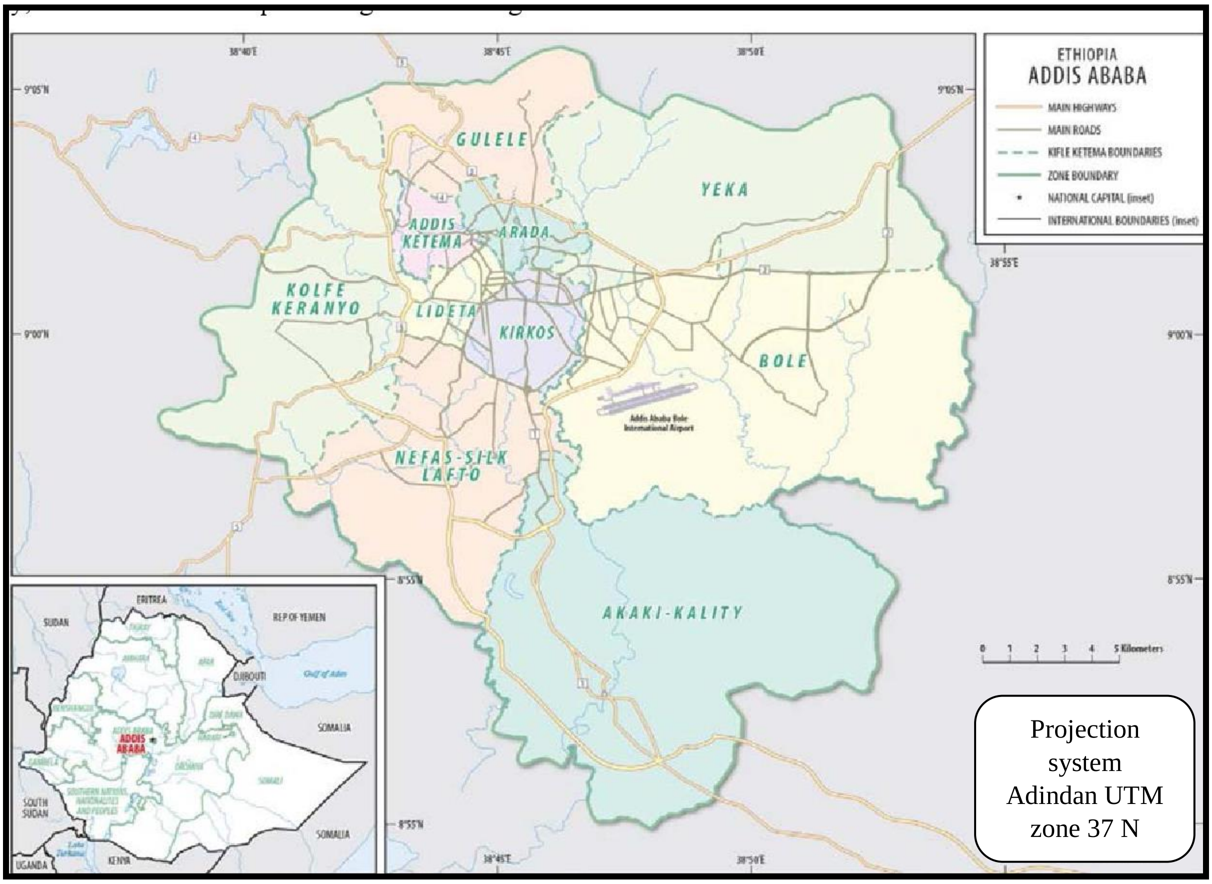

Figure 3 –Location Map of the study Area

3.1.3. Climate

The long-term mean annual rainfall observed at Addis Ababa Observatory is 1254mm. The maximum temperature varies on average between 20° C in the wet season and 25° C in dry season, while the variation of minimum temperature falls in the range of 7° C to 12° C throughout the year. Wind speed is generally moderate in the area, taking average values in the range of 0.5 to 0.9m/s. Average daily sunshine hours as high as 9.5 hours are observed in November and December, and this figure falls to 3 hours or less in July and August. Monthly pan evaporation records, obtained from documents of previous studies, reveal that the average monthly pan evaporation during the dry season (November) at Addis Ababa Observatory is about 180 mm and this value falls to about 75 mm in wet season July .(Feyissa et al., 2018).

3.1.4. Temperature

Long term annual average temperature of Addis Ababa is 16.75 and summer temperature is 16.28 and during winter(dry)season is 17.21 and maximum temperature had been recorded in May 21.4 and minimum also in August 11.31 ◦C.

3.1.5. Geology

The largest part of Addis Ababa is covered with volcanic material. The hill chain (Intoto) in the northern part of Addis Ababa is composed of basalts, called Intoto Cilcic and it is covered with volcanic topsoil materials of about one to two meters thick. The urban area is composed of youngest basalts called “Addis Ababa basalts” which are also covered with volcanic topsoil materials. The western part belongs to the younger age stratum; the northern part is mainly composed of Trachey basalts. In the Bole area, a kind of basalt, called Ignimbrites, is partly found. The topsoil materials in the western part are thick and soft compared to those of the northern and eastern parts. (Walker et al. ,2019).

3.1.6. Hydro Geological setting

The aquifers of northern and central part of Addis Ababa city and in the mountain, area is largely due to weathered and fractured volcanic rock with minor sediments deposited between different series of lava flows. The aquifers at the southern part of the city (Akaki well field) are mainly young volcanic rocks of lava flow and tectonic fractures. (Tadesse et al., 2010) in general, the aquifers are complex and highly variable.

3.2. Data Source and Materials Used

This section encompasses gathering both spatial and non-spatial secondary sources of data from the concerned government Authority.

3.2 1. Data source

The data set used to implement for this study consisted of Borehole data, world street map, boundary of administrative city of Addis Ababa, and Digital Elevation model and Road access of Addis Ababa city.

Table 1. Data sources

S/No	Data	Source	Data type
1	Borehole data	AAWSA ,Ministry of water ,irrigating and Energy and Oromia Engineering Corporation	Excel sheet
2	World street map	Down load from Google	Tiff.
3	Boundary of Administrative city of Addis Ababa	Central statistics Agency (CSA)	Shape file
4	Dem (30m)	Down load from USGSC	Tiff
5	Road	Addis Ababa Road Authority	Shape file

3.2.2 Characteristics of the data

Borehole data: this was point data collected from Addis Ababa water supply Authority (AWSA) and Oromia Engineering Corporation excel format for all the boreholes in Addis Ababa together with their attribute information. The attributes were field number (FID), shape, object Id number (ID), Northing , Easting water point, local name, Elevation, well depth, Discharge, draw down, specific capacity and Transitivity.

Administrative Boundary: this vital data was obtained from CSA. The attributes in this dataset were the names of administrative units and their size in square kilometers this vital data was obtained from CSA. The attributes in this dataset were the names of administrative units and their size in square kilometers ,the Administratve Boundary of Addis Ababa was Georferenced in Q GIS Environment.

World street map : this data Down load Q GIS Vector till from OSM Environment the Road and Building and settlement network is critical in showing accessibility to services and the attributes in this dataset were the various road classes and their respective lengths, OSM also Geo rferenced and the projection system converted in to Adindan zone 37 N or EPGNS 2017 using Q GIS environment .

Degital Elevation Model (DEM) :this data set down load fromGooogle with the 30 m resolution , it is very important for to demonstrate the spatial Distribution of Borehole in the city to describe in relation of Elevation.

Road : This data set collected from Addis Ababa Road Authority in the form of shape file , the data is essential to identify the the relation ship among Road access with borehole site and settelment .

3.3. .Materials used.

The tools used to implement this study included hard ware, software and networks they are described as the following.

Table 2- The types of Material used to in the study.

No	Material	Description	Purpose
1	Quantum GIS 3.18	Free open-source GIS soft ware	Data processing (Geo referencing, Digitizing and projection change
2	Arc GIS 10.8		Preparation of Map lay out
2	Quantum GIS 2 web plug in	Web map server	Design interactive web mapping
3	Open layer and leaf let plug in	Design HTLM, CSS and Java script	Representing geospatial feature
4	Post GIS	Data base and data base manager	Manage the data base
5	Q GIS cloud	Free open-source web based Plat form	Publishing, sharing, Editing and managing data
6	Micro soft word and excel data		Integrating attribute data Compositing final thesis
7	Visual studio code	Source code editor	Scripting
8	Note pad	Word processor	Scripting

3.4. Data Collection Methods

To achieve the objective of this research, secondary data like borehole data, boundary of Addis Ababa city, world street map and digital elevation model were collected from the above concerned source. Additionally, previous reports and documents, various journal papers, thesis, textbooks, and the internet were also used as secondary data.

3.5. Data Analysis Methods

3.5.1. Data Preparation

Stage 1- Organizing and verifying borehole data

The purpose of data verification is to ensure that data that are gathered are as accurate as possible, and to minimize human and instrument errors including those which arise during data processing. The simplest way to describe data verification is the process of checking data for accuracy. There are basically two types of data verification. Full verification means that all data contained in a database is checked for accuracy. Sampling verification is used to check a small sample of data for verification. When data is verified, it is reviewed for everything from spelling errors to inaccurate numbers. It also checks for data loss after a data migration, for this study I used sampling verification to check the borehole data of Addis Ababa.

Table 3- sample of Organized and Verified well Data

ID	Region	Local Name	Water Point	UTME	UTMN	Elv	year of drilling	Description	Driller	Well depth	SWL	DWL	WellType	Geologi
379	AA	Akaki Ethio-Fiber-1	AdBh0495	477400	979500	2080			AID BANK	96.0	27.4		Cased	Basalt
503	AA	Akaki Garment Factory	AdBh0651	477800	979500	2085				99.2	0.0		Cased	
577	AA	AA-Water Ⅲ Testwell-B5	AdBh0753	481200	980000	2150			WWDA	150.0	11.0		Cased	
581	AA	AA-Water Ⅲ Testwell-B9	AdBh0757	481600	982900	2205			WWDA	120.0	35.1		Cased	
585	AA	AA-Water Ⅲ Testwell-T1	AdBh0761	481200	980000	2151			WWDA	173.0	8.9		Cased	
586	AA	AA-Water Ⅲ Testwell-T5	AdBh0762	481600	982900	2205			WWDA	120.0	37.3		Cased	
587	AA	AA-Water Ⅲ Testwell-B13	AdBh0763	479400	981400	2133			WWDA	100.0	2.7		Cased	
589	AA	AA-Water Ⅲ Testwekk-T2	AdBh0765	479400	981400	2134			WWDA	74.0	2.8		Cased	
590	AA	Akaki Water Supply Test Well EP-1	AdBh0766	479340	981400	2131			WWDA	108.7	0.7		Cased	
591	AA	Akaki Water Supply Test Well EP-2	AdBh0767	481600	982850	2204			WWDA	136.0	33.5		Cased	
592	AA	Akaki Water Supply Test well Ep-3	AdBh0768	479740	981400	2134			WWDA	126.0	3.4		Cased	
624	AA	Akaki Water Supply Well EP-5	AdBh0802	478450	979950	2100			WWDA		55.8		Cased	
628	AA	Akaki kebele 06 Kilento	AdBh0807	477900	982875	2130				52.0	20.0		Cased	
629	AA	Akaki Kebele 06 kilento	AdBh0808	478775	983133	2165				50.0	24.0		Cased	
647	AA	Akaki Lesperance school	AdBh0862	478425	981350	2110				50.0	0.0		Cased	
681	AA	Micky Layland Children's Home	AdBh0902	482400	983000	2230			AID BANK	83.3	56.2		Cased	Basalt
782	AA	AAWSA F7 at Koye	AdBh1068	481337	982304	2190				135.0	23.4		Cased	Basalt
783	AA	AAWSA F3 at Fanta	AdBh1069	479700	981700	2135				116.0	20.0		Cased	
784	AA	AAWSA F1 at Fanta	AdBh1070	479000	981400	2120				120.0	10.0		Cased	
801	AA	AA-Bole Lem-2-99	AdBh1110	482896	991871	0		Bole Lemi-7	Al-Nile	205.0	14.4		Cased	Basalt
802	AA	AA-Bole Lemi-5-99	AdBh1111	484152	989566	0		Bole Lemi-5	Al-Nile	182.0	0.0		Cased	Tuff
803	AA	AA-Bole Lemi-1(Hanku)-99	AdBh1112	481230	992312	0		Bole Lemi-1	Al-Nile	200.0	22.3		Cased	Basalt
805	AA	AA-Bole Lemi-Lideta-1-99	AdBh1114	484900	990700	0		Bole Lemi-Lideta-17	Al-Nile	177.0	4.3		Cased	Basalt
829	AA	AA-Bole Lemi-99	AdBh1139	482850	989900	0				168.0	0.0		Cased	
43	AA	S Ayat	SANFTW-1	477891	987018	0			CGCOC	411.0	8.9	80.08		
44	AA	S Ayat	SANFTW-2	484001	987465	0			CGCOC	442.0	0.4	41.52		

Stage 2-Geo referencing, Projection conversion and digitizing the study area

The processing of the spatial data includes geo referencing, on screen digitization, map visualization. The download Google image was imported into Q GIS environment were the reference system was defined, in this study the projected reference system, WGS 84, UTM zone 37N was defined. The next operation was geo referencing which involve the aligning of geographic data to a known coordinate system so it can be viewed, queried, and analyzed with other geographic data. Geo referencing may involve shifting, rotating, scaling, skewing, and in some cases warping, rubber sheeting, or ortho-rectifying the data. The four corners of the imagery of which their coordinate was captured from Google earth and were used as input in geo referencing process. The geo referenced tool in Q GIS 3.18 was turn on. The four (4) edges (corners) coordinates of the map were selected as the control for the geo referencing. The geo referencing tool in Q GIS 3.18 was deployed to carry out the geo referencing operation. The add control tool was used to register the map.

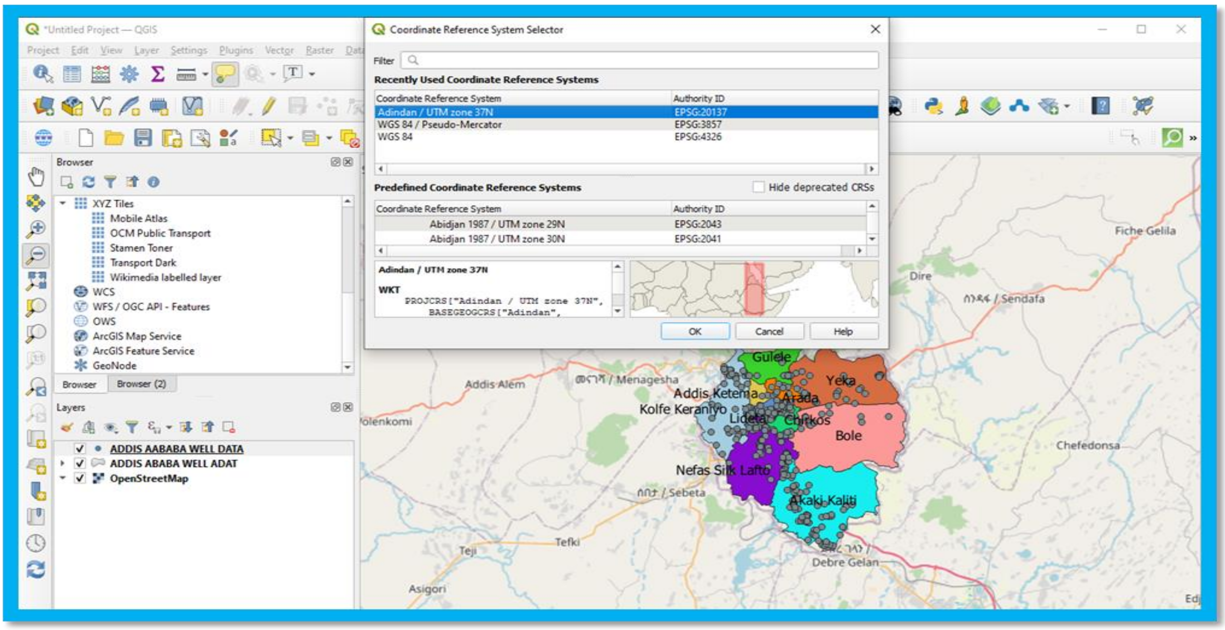

Figure 4 -The Geo referenced and Projection conversion of The study area

Stage 3-Demonstrate the spatial distribution of borehole data

The spatial distribution of the existing boreholes was displayed in ARCGIS environment and Q GIS Environment. The collected well data from the concerned Authority organized, checking and verified and converted to text file and were added to excel. In arc catalogue the create feature from x, y was used to display the GPS point into Arc GIS environment and Q GIS Environment and as the base line digital elevation model of Addis Ababa.

3.6. Methodology

The knowledge of the location of the borehole is very use full to decision makers to make informed decision concerning the type of information that feed on the attribute table. Other information that can be obtained from this web application included to know the spatial distribution of bore hole on the study area, this information has to be accessed through Quires.

3.6.1. Steps include Methodological flow chart

The steps include

1) The user requirements are the location of borehole and other related information such as location, local name, discharge, Yield, Specific capacity, Transmitivity, draw dawn..etc.
2) Data collection (secondary data from the concerned government bodies)
3) Organize and verifying the collected data in Excel spread sheet and CSV format convert in to standard borehole Data format.
4) Data Processing using Q GIS environment Geo-referencing, conversion of projection system and digitizing of the study area boundary, world street map, Google map and borehole data
5) Demonstrate the Spatial distribution of Borehole in the study Area
6) Create web mapping Application using Q GIS 2 web using Open layer
7) Creation of Geo-Json layer form shape file to integrate borehole data in vector format with web mapping Application code
8) Development of web mapping code.
9) Publishing web –mapping using Q GIS cloud.
10) Using QGIS cloud with Post GIS extension manage the data base
11) Test the web application to determine is it satisfies the users objectives efficiently and
12) Use the application to search for borehole data on the web site using view location, view attribute information, view the spatial distribution of borehole data in relation to the road access,

3.6.2 Methodological flow chart

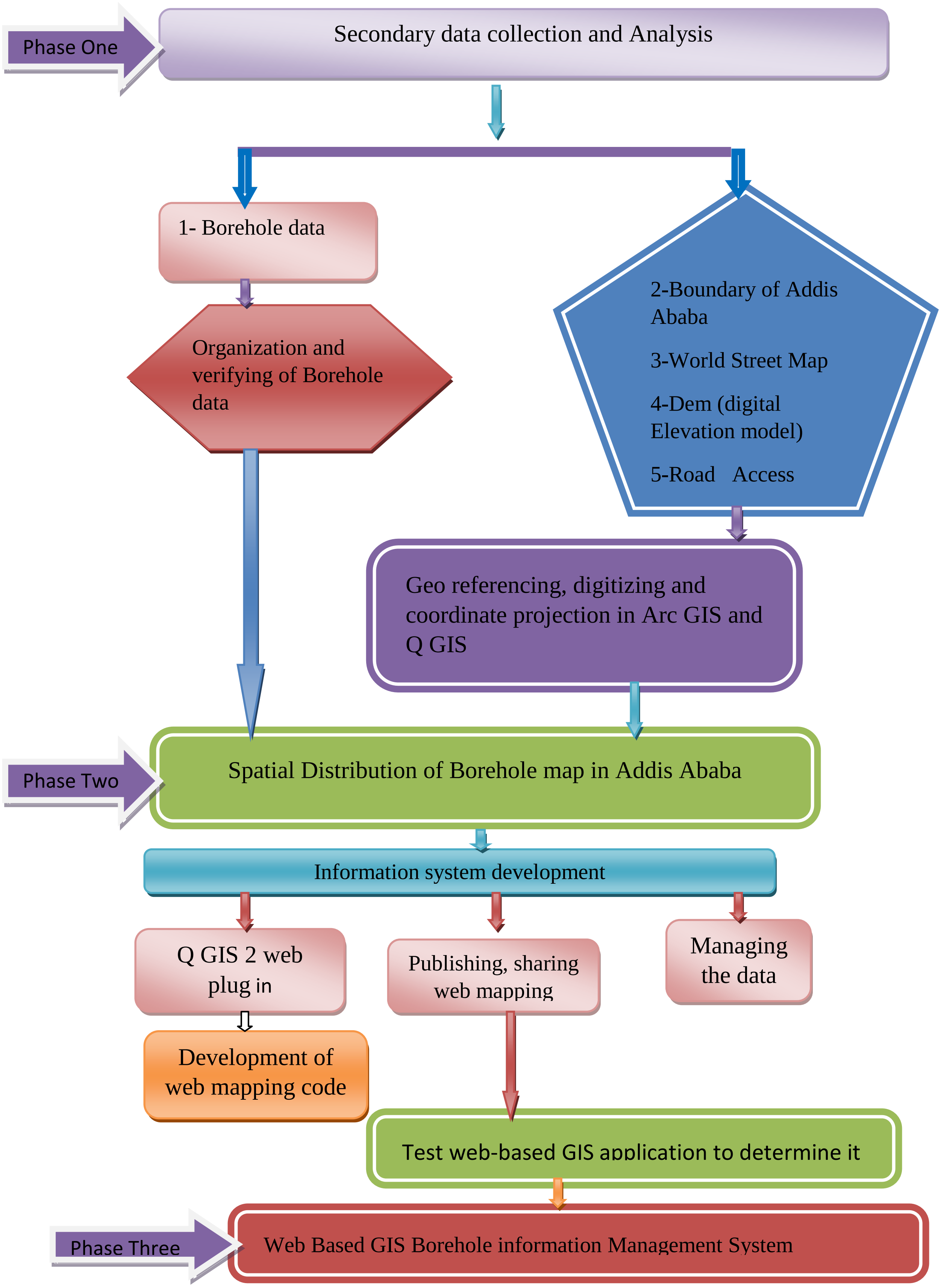

Figure 5 -Methodological flow chart

3.7. Information system Development for design of interactive Web Mapping

Web mapping is a great medium to publish your GIS data to their web and make it accessible by other users. Creating a web map is a very different process than creating one in a GIS. GIS users are typically aren't web programmers and it presents a challenge when one needs to create a web map that is of the same quality as a map creating in a GIS. Fortunately, there are tools available to easily translate your work in QGIS to web maps. The folowing Steps Designed interactive Web Mapping with QGIS2 web for development of web based GIS Application

3.7.1- Web Mapping Plugin installing

QGIS2web Plugin which will export map layers in QGIS canvas in to web page. Therefore firstly we have install plugin. To install QGIS web plugin can be done as follow

1-in the tool menu .open plugin >mange and Install plugins

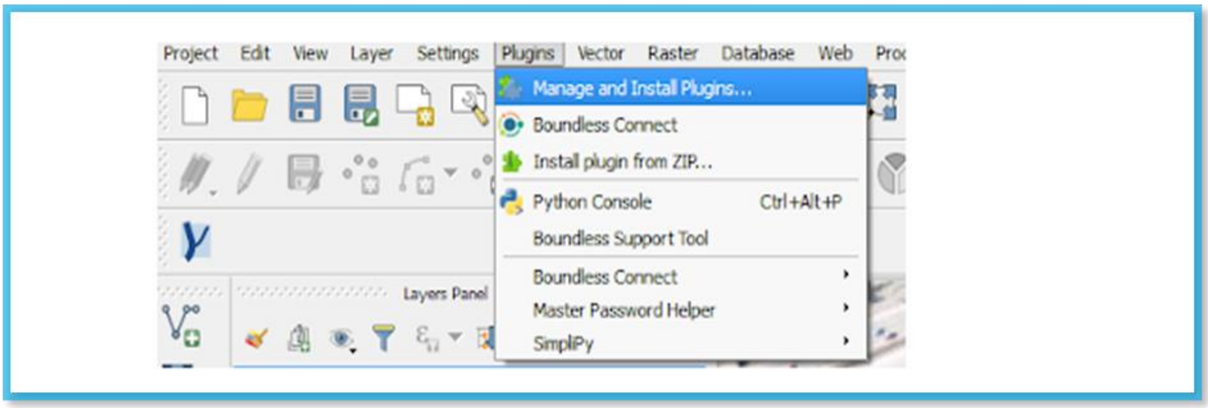

Figure 6- Manage and Installing web mapping Plug in

2. In the search tool bar, type QGIS 2 web .The plug in will appear and then check it .

Click Install plugin at the right bottom of plugins windows

Figure 7 - Installing Q GIS 2web

3.7.2 - Add data to QGIS Map.

In this study, I used borehole data of Addis Ababa, Addis Ababa boundary can be collected from the concerned government Authority in. Add CSV the data in to QGIS map Canvas

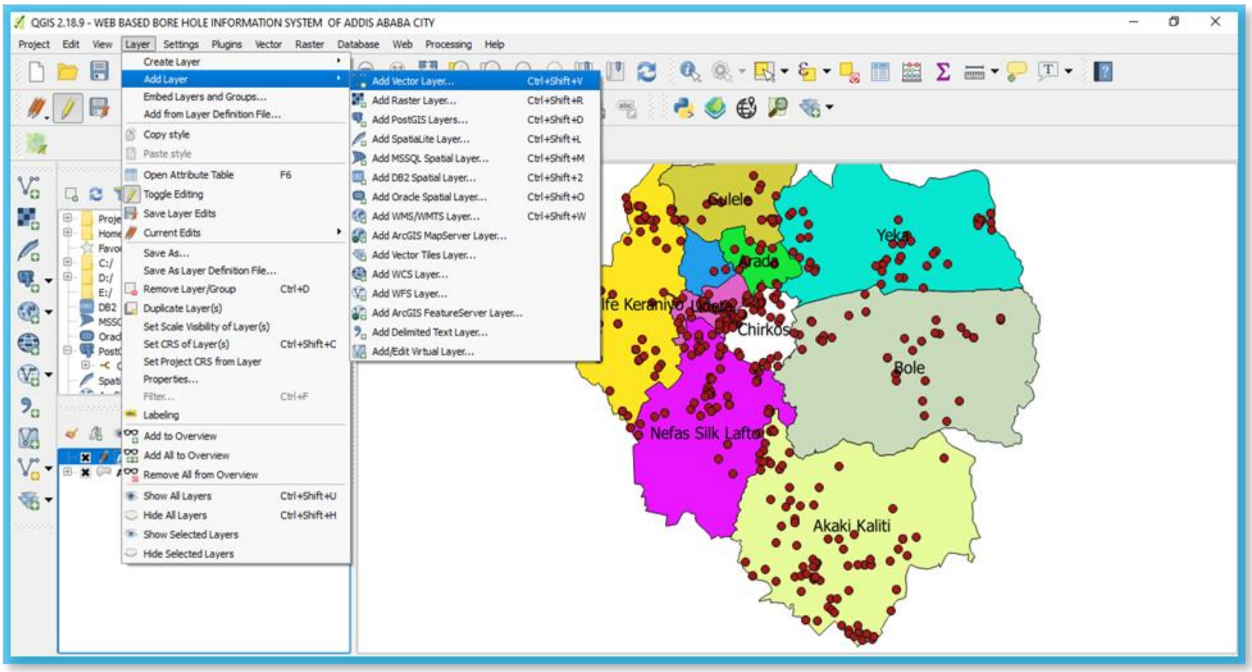

Figure 8 -Add Data to QGIS Map

The map is ready now. Time to save our work go to Project > Save. Enter name of the project you want to give

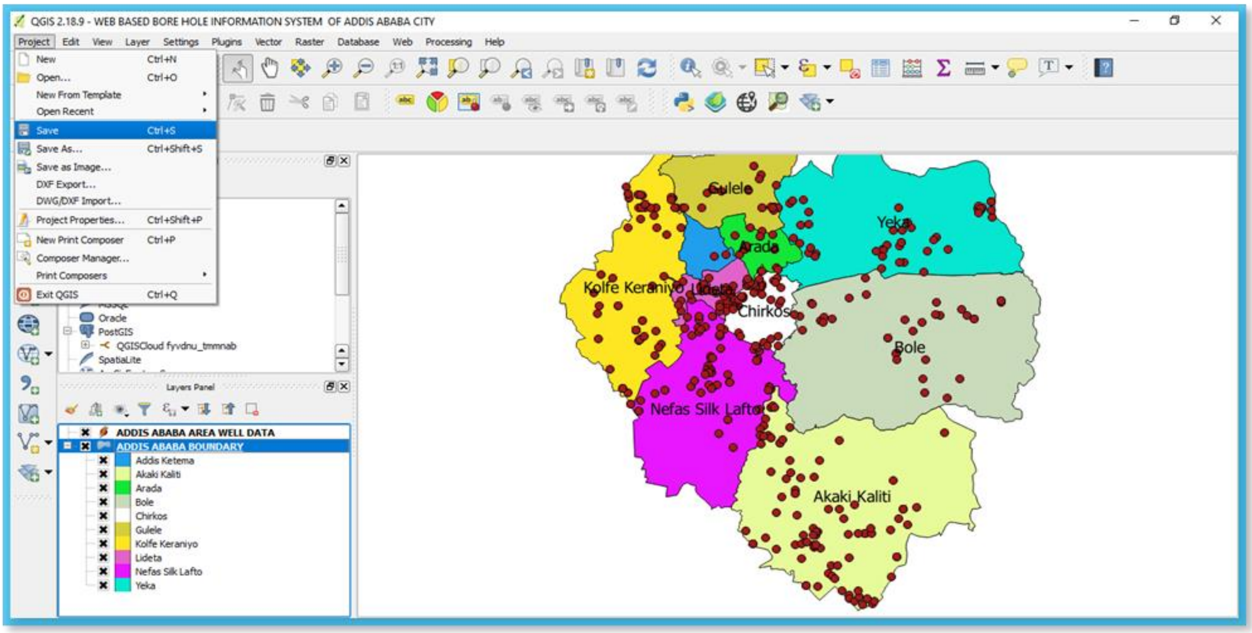

Figure 9- Save enter name of the project in Q GIS

3.7.3 -Creating Geo Json from shape file

The borehole shape file in GIS environment converted into simple web format For GIS data known as Geo-Json , the Geo json files are simple web application file formats that can be easily integrated with a web mapping code . Geo-Json is an open standard formats design for representing simple geographic features, along with their non –spatial attribute s it is based on the Geo json format.

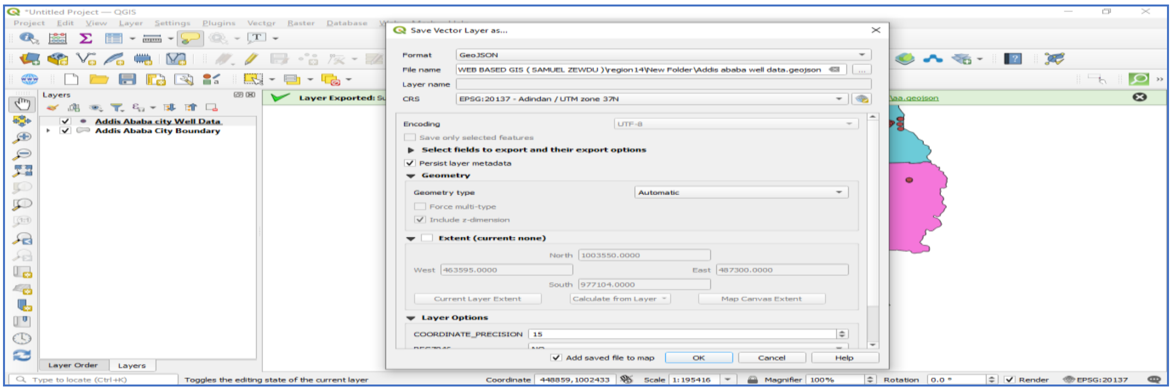

Figure 10- Creating GeoJson file from Borehole shape file

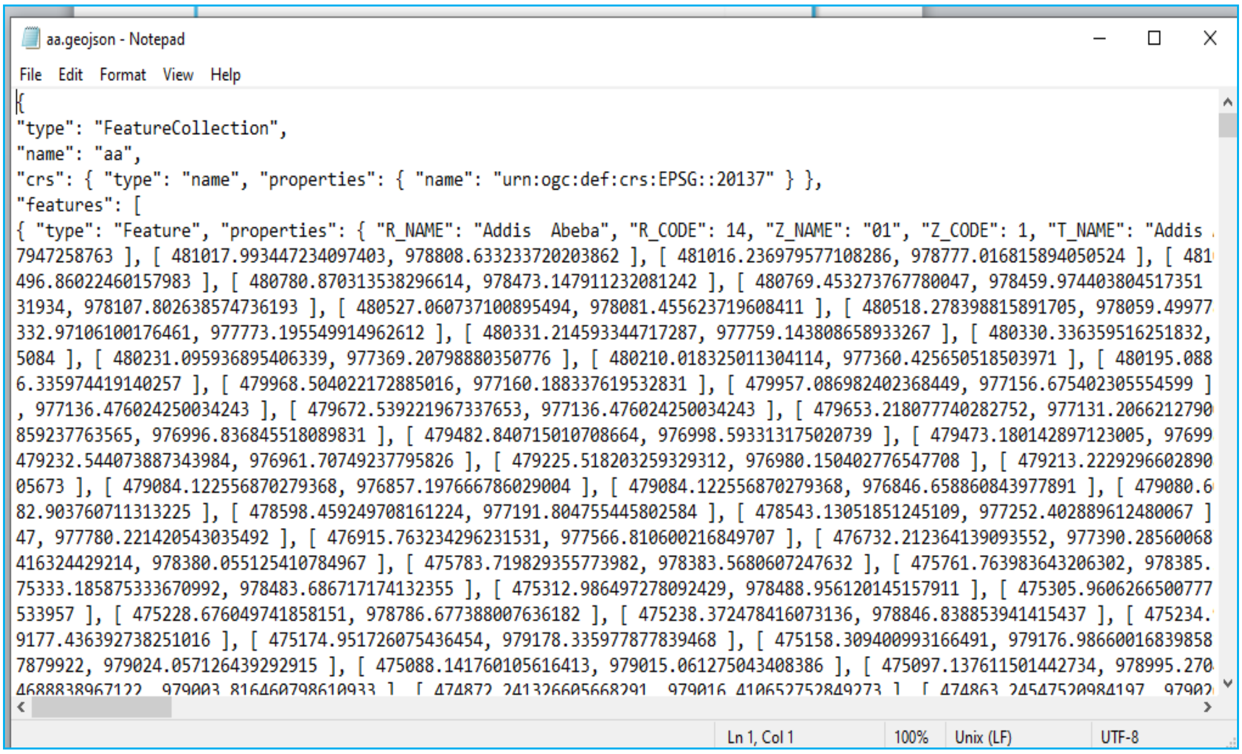

Figure 11- Geo Json file viewed on Note pad ++

3.7.4. Create Q GIS 2web map

Web based GIS borehole map is now to be converted in to HTLM map with QGIS 2web. Qgis2web reads QGIS layers and their style and converts them in to HTLM, JavaScript, and CSS files that can be viewed from the browser. Once the plugin is installed, Create a web map, go to web >qgis 2web >create a web map

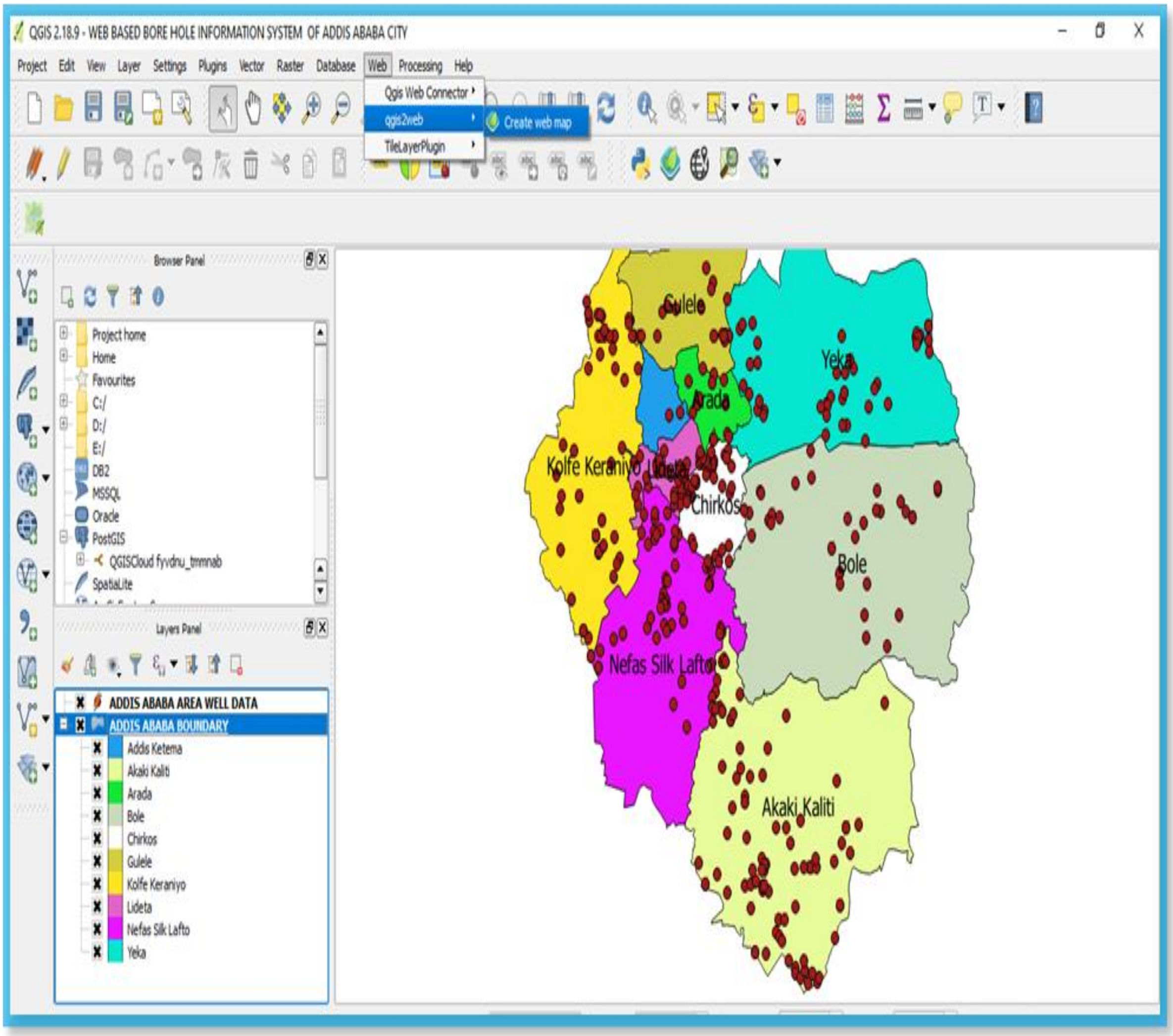

Figure 12 - Q GIS 2web create web map

3.7.5. Create HTLM, Java script and CSS using Open Layers

Using the Open Layers library, the library provided tools that would enhance visualization. These included providing for OSM/Google maps to act as a base layer whilst boreholes, roads and administrative units act as overlay layers. Furthermore, zoom in and zoom out tools were incorporated to enhance interactivity with the map.

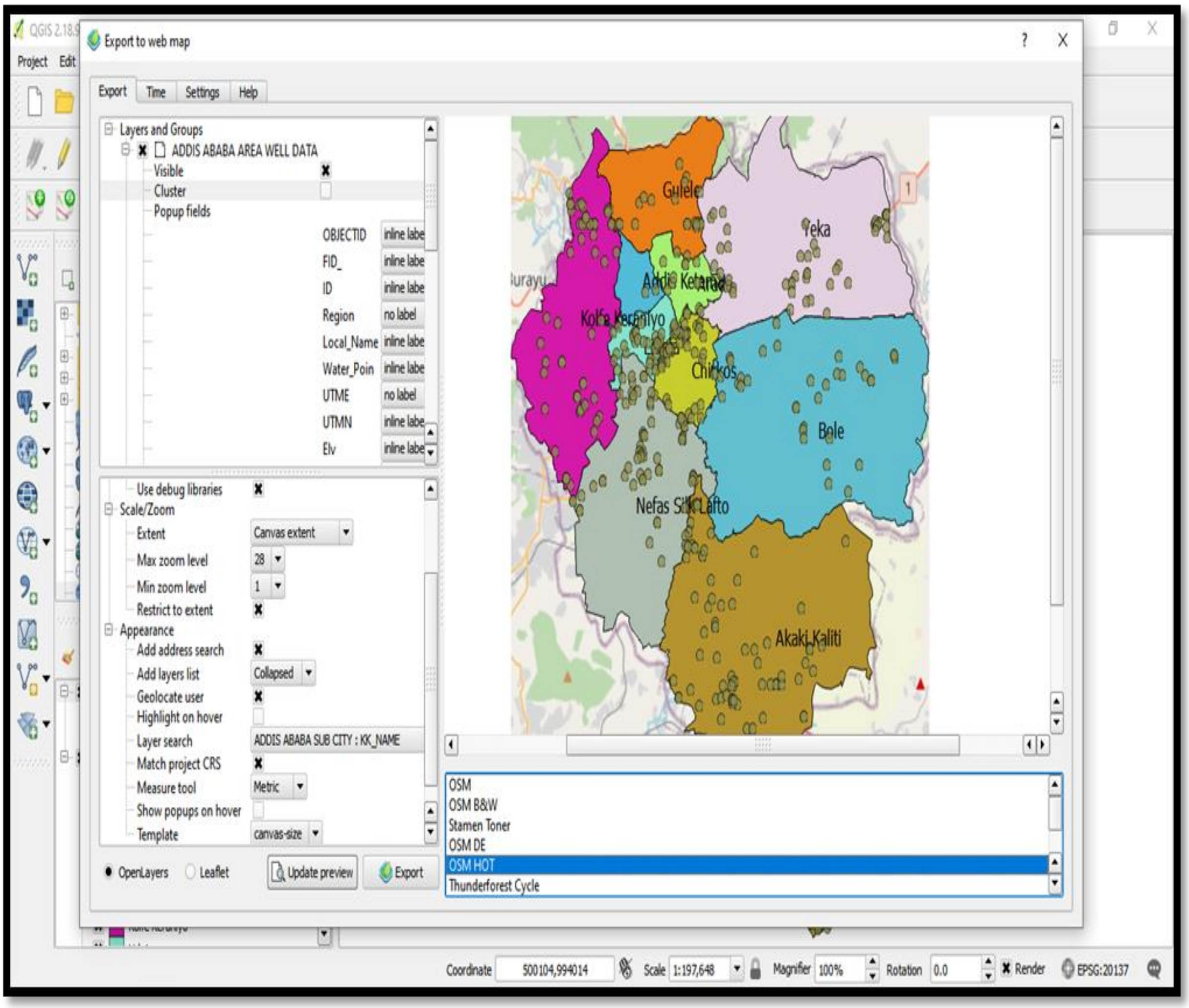

Figure 13 -Created Web mapping using open layer

in the Export web map dialog selects how you want the popups to be labeled in the web map in upper panel.

Pressing the Export button in QGIS2Web generates an index.html file and three folders with associated Java script and CSS files.

If you want to publish this map online, you would need to get a web hosting account and simply upload the index.html file and the three associated folders to the main public html directory. Visiting the URL of Q GIS website would then show the map in the browser.

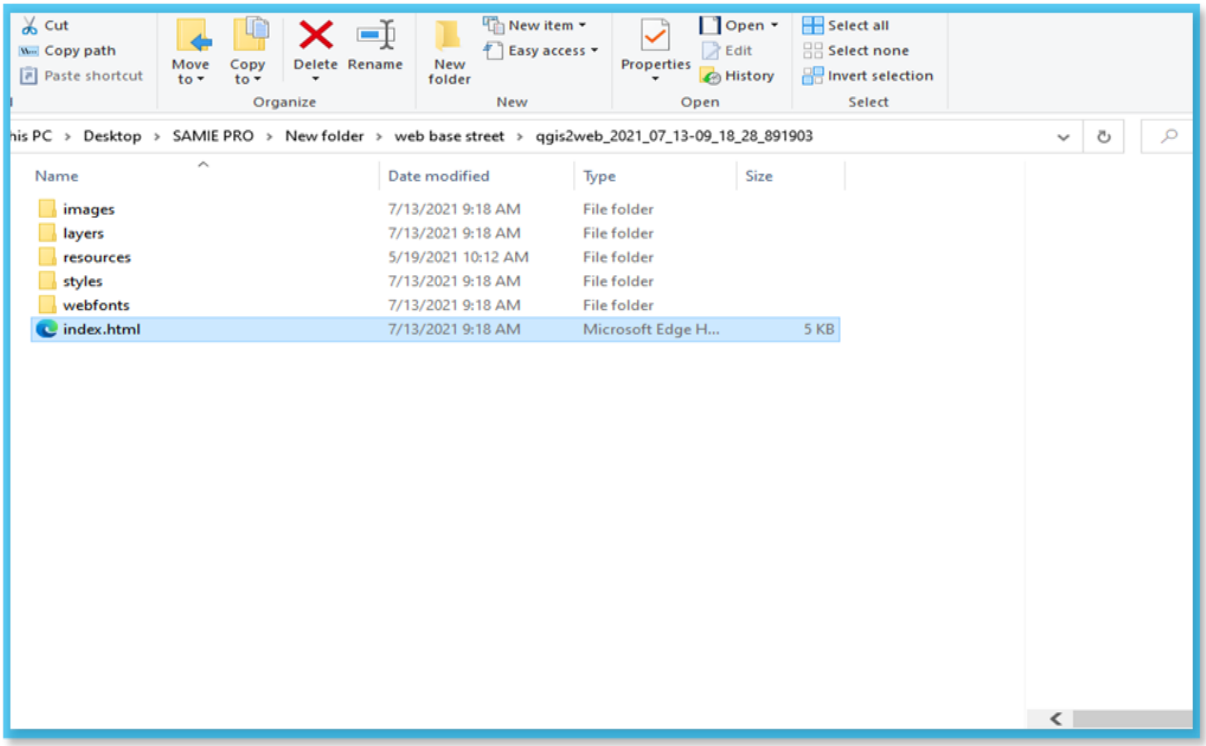

Figure 14 -Exported index html

3.7.6. . Development of web mapping code

Web programing involved creation of web page that would used to display the web map contents as a part of web site, this was done using HTLM. The next step involved adding base map elements added was the bounding box which conformed to OGC ; s web map services standards.

Elements are added were the coordinate reference system , layer , scale and company logo in addition to that , built in capabilities such as Pop ups-zoom and p and were included lastly the inclusion of the data set to dis play on the web map these are PNG and Geo Json files , CSS as to achieve style sheet on the web map, these determined colors , position and orientation of the map objects, Java Script was objectify the web map using object oriented Programing .

Web Programing Code

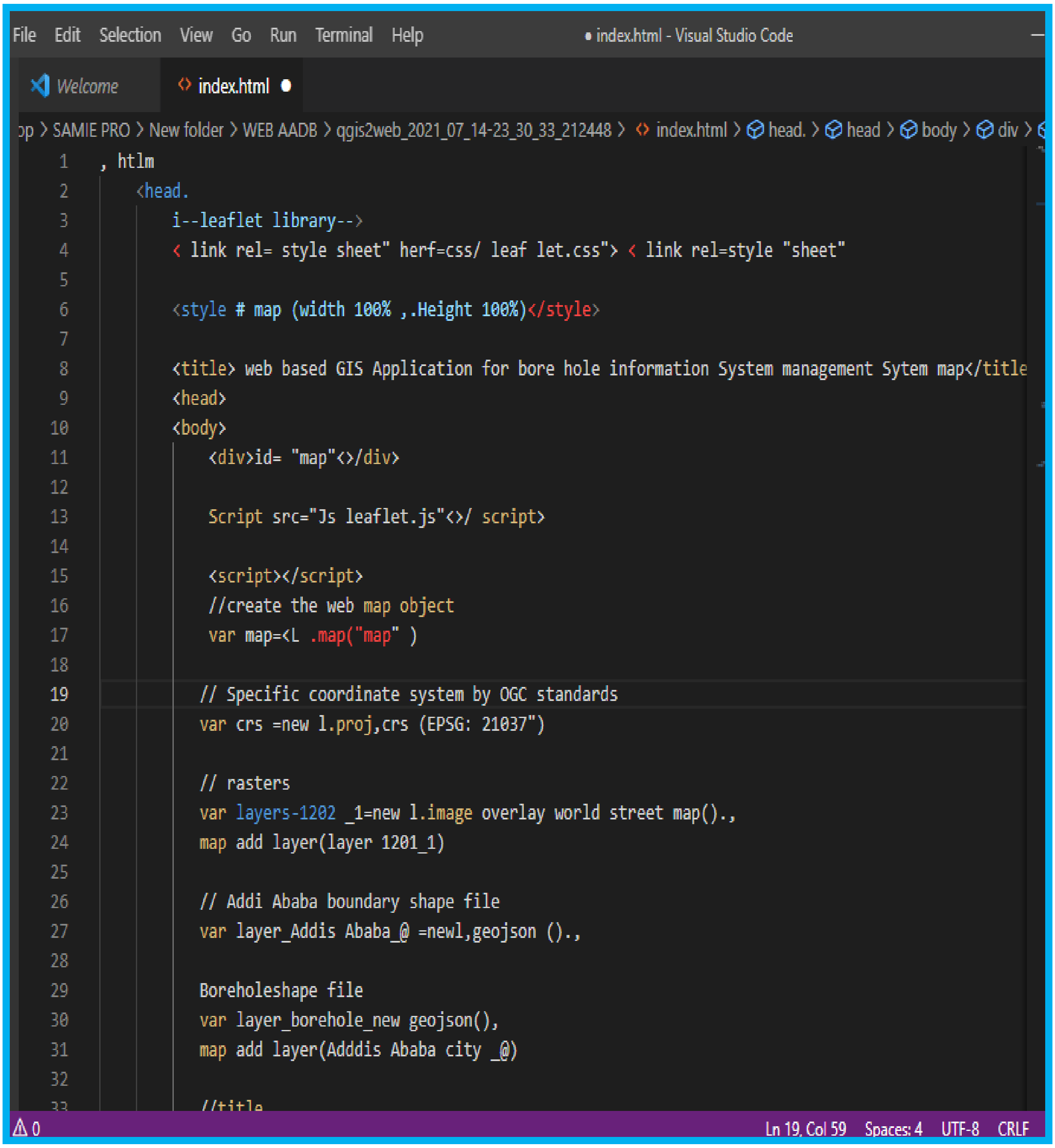

Figure 15- Web mapping code using Visual studio code

3.8. Publish QGIS maps in the web with QGIS Cloud

QGIS cloud is a free plate form to up load on line and share the web GIS based application for borehole information map of Addis Ababa with any one. QGIS advantage is to have the chance of preparing borehole map using Q GIS and up load them on line in to create a Q

GIS cloud account (free simple quick) and installed the QGIS cloud plug in with in Q GIS version , Created my QGIS cloud account Go to http://qgiscloud.com/.

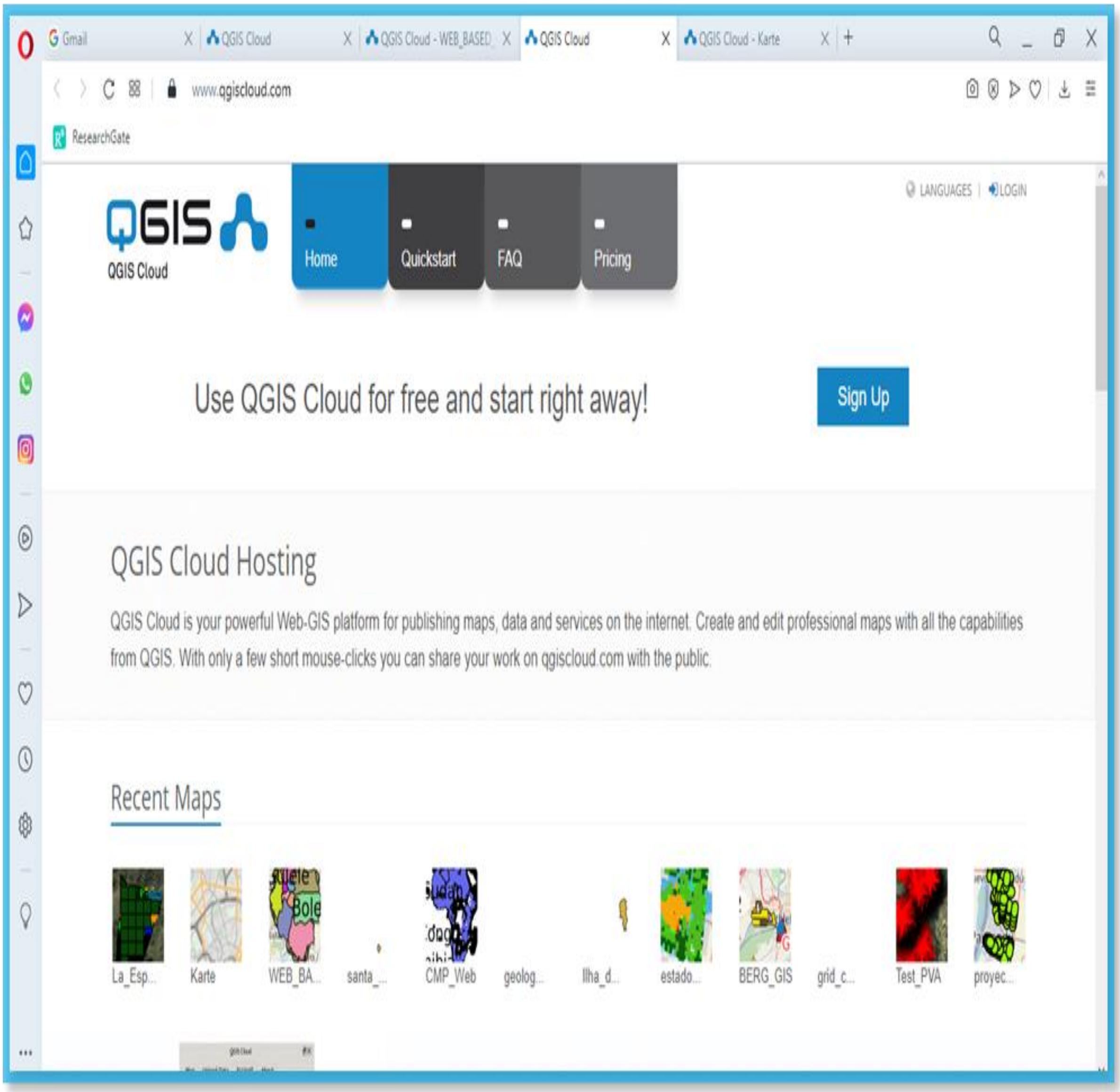

Figure 16 -Q GIS Cloud Web interface Source**(**http://qgiscloud.com)

Click on Sign Up and fill your account parameters

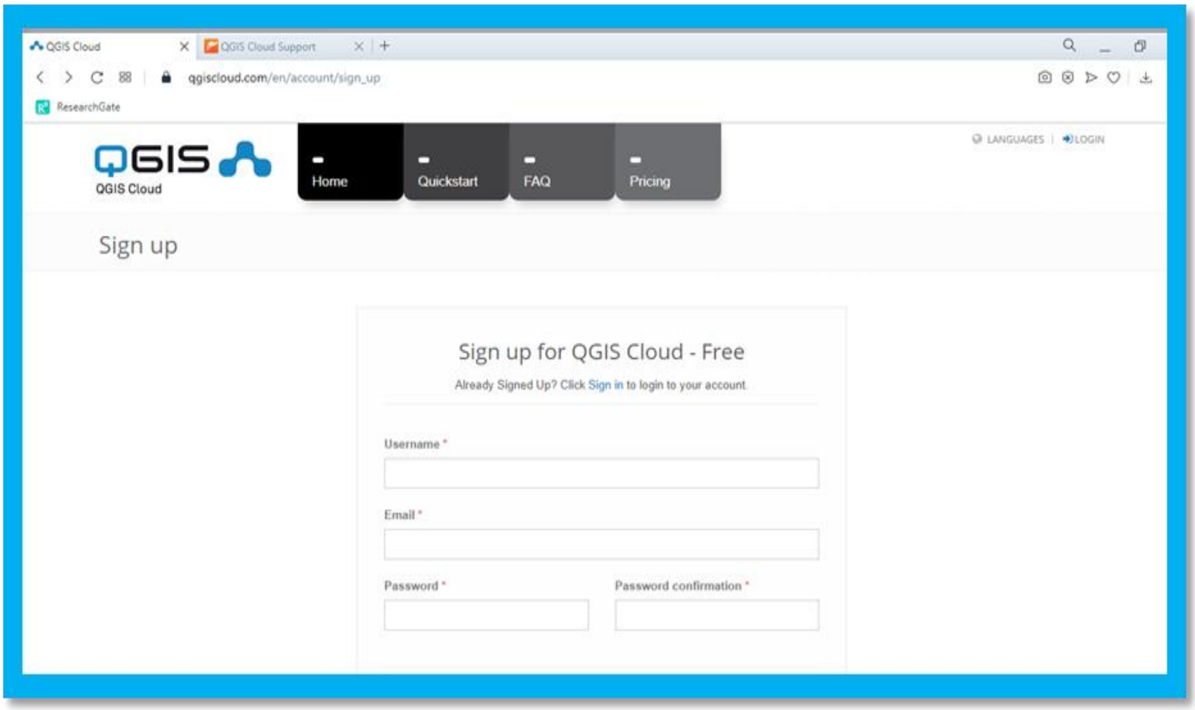

Figure 17- Sign up for QGIS cloud– free Source (http://qgiscloud.com/)

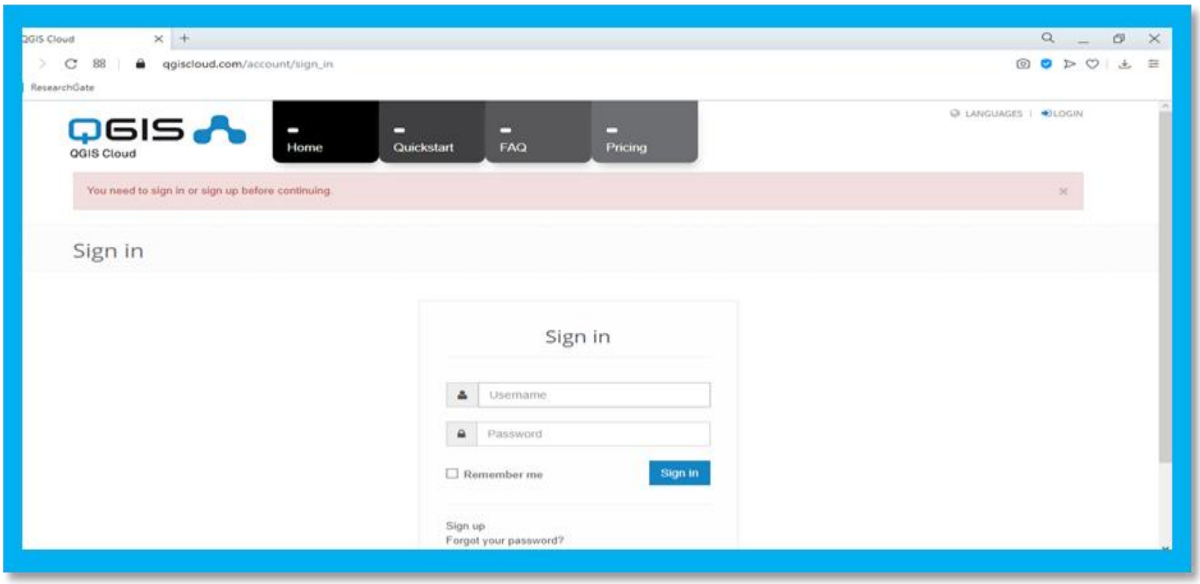

Figure 18 - Sign in Q GIS Cloud Free(http://qgiscloud.com/)

Install the QGIS cloud plugin In Q GIS, go to Extension -> Install / Manage extensions look for the QGIS Cloud plugin and click Install extension

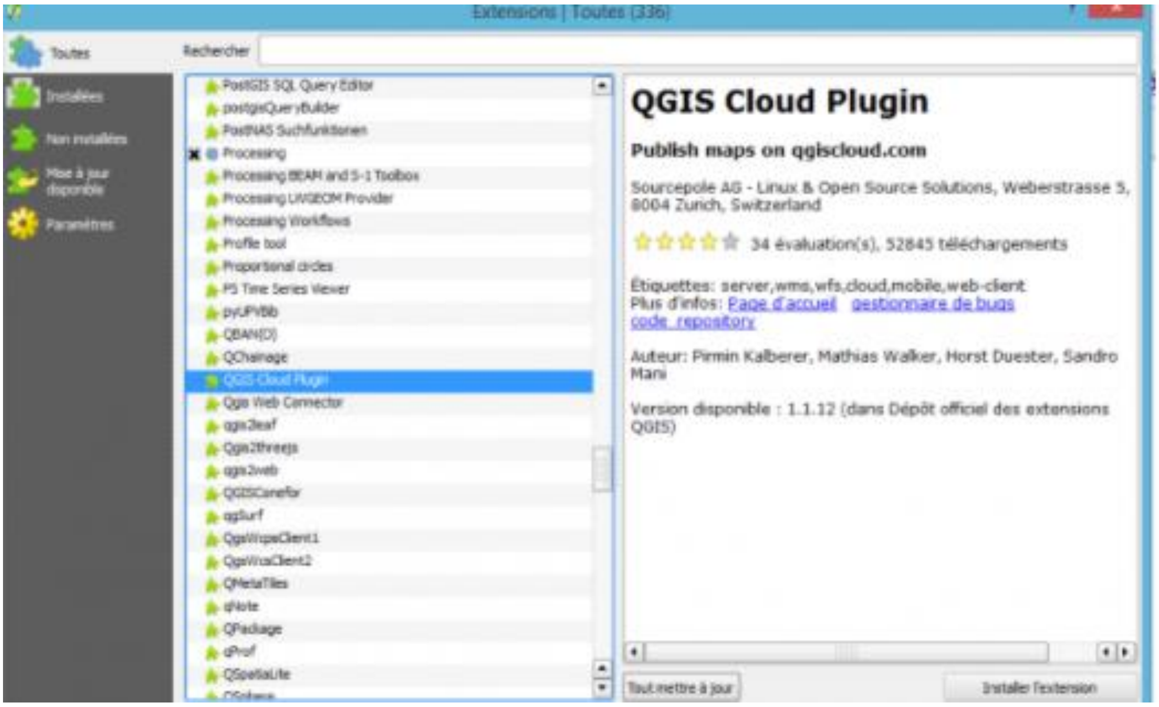

Figure 19- Q GIS cloud Plug in

You will a new a new item in the menu as Extension

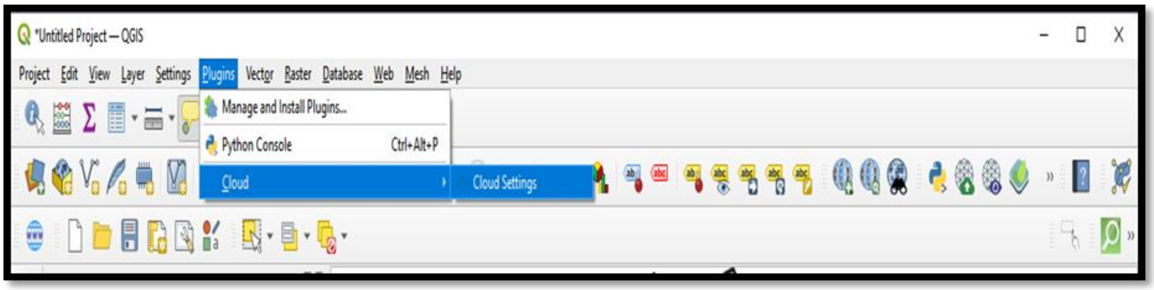

Figure 20 -Extension of cloud setting

By clicking on Cloud settings (Extension -> Cloud -> Cloud settings) we get the following window:

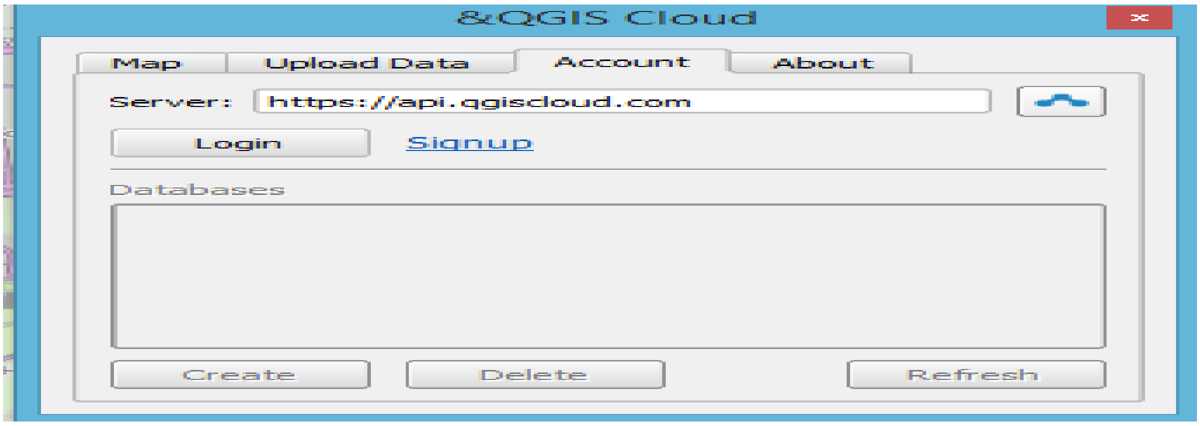

Figure 21- log in in and sig up account Q GIS cloud

Click Login and fill my QGIS Cloud account. I created a database in the name of Web based GIS Application for borehole information System managment cloud to store the data of my projects.

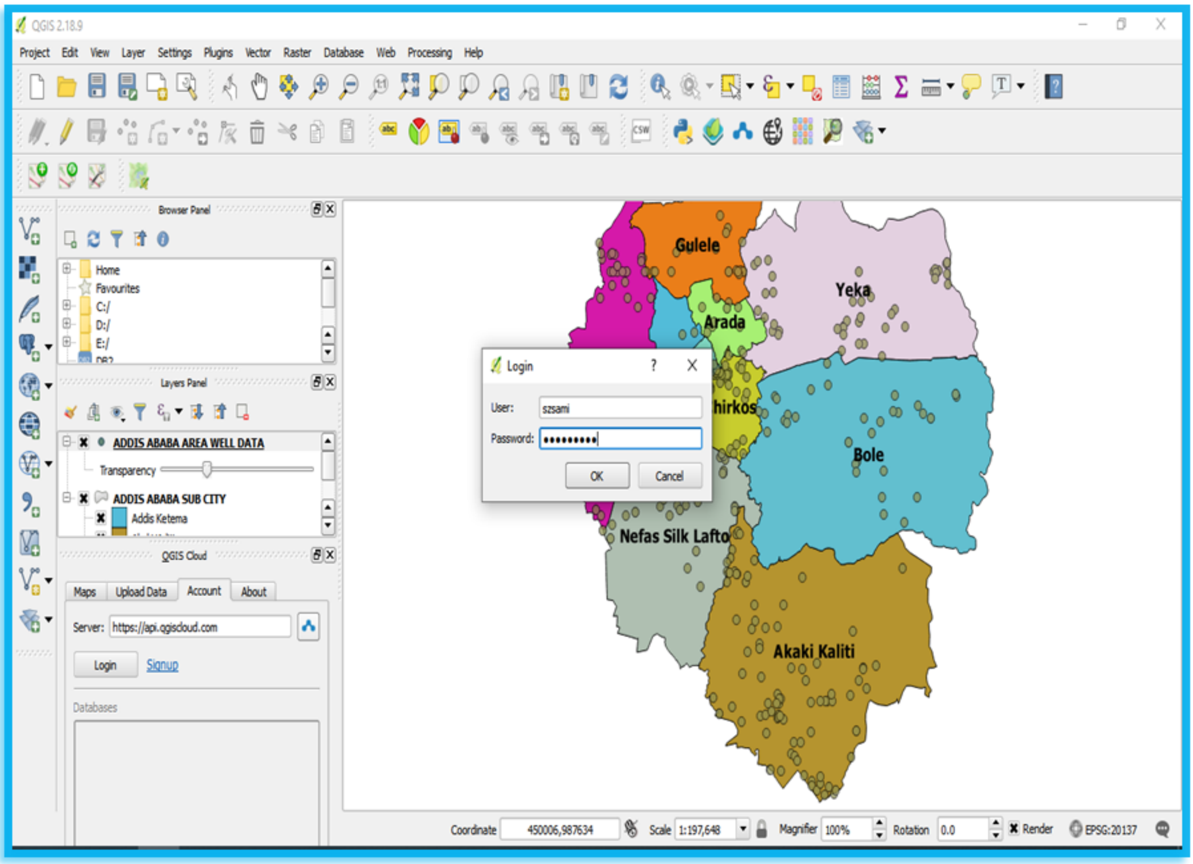

Figure 22- Click Login and fill QGIS Cloud account

Go to the Account tab. Click the Create button to create a database. Once the base is created or selected. I load the data present in the QGIS project. Go to the Upload Data tab. select the layers and click Upload data.

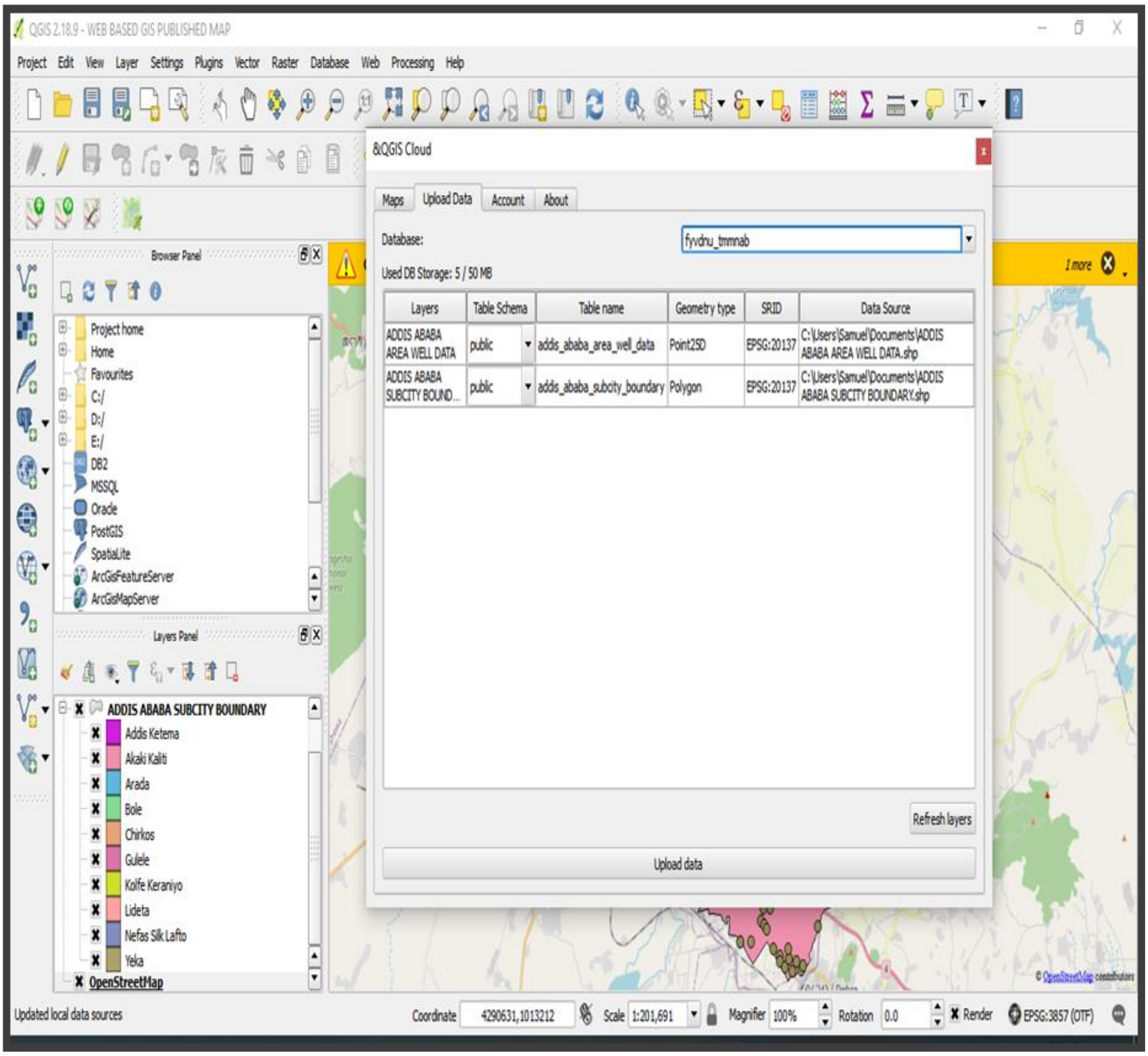

Figure 23 -Select the layers and click Upload data

To publish web based application borehole information map, go to Map. There are two buttons. The first one allows choosing a background map for your map. The second publishes the map in the cloud To set the base map, click Add background layer

Figure 24- The buttons that allows choosing a background map and publishes the map in the cloud

3.9. Manage Data using Post GIS

Spatial Databases allow the storage of the geometries of records inside a Database as well as providing functionality for querying and retrieving the records using these Geometries. In this figure shows Post GIS, an extension to Postgre SQL, to show how to setup a spatial database, import data from shape files into the data base.

QGIS Cloud gives you a full-featured Postgre QL databases, extended with Post GIS. Create new databases directly from the QGIS Cloud plugin with just a click. Manage your databases with any compatible management tool, such as pgAdmin3, the QGIS Browser or the QGIS DB-Manager. You have full access to all features of a PostgreSQL/Post GIS database and make use of the geographic functions that Post GIS offers.

If you want to manage PostGIS database similar like pgA dmin, and visualize SQL results (in the QGIS, click ‘Database’ drop-down menu, and open “DB Manager”, which should have similar interface and function like PgAdmin.

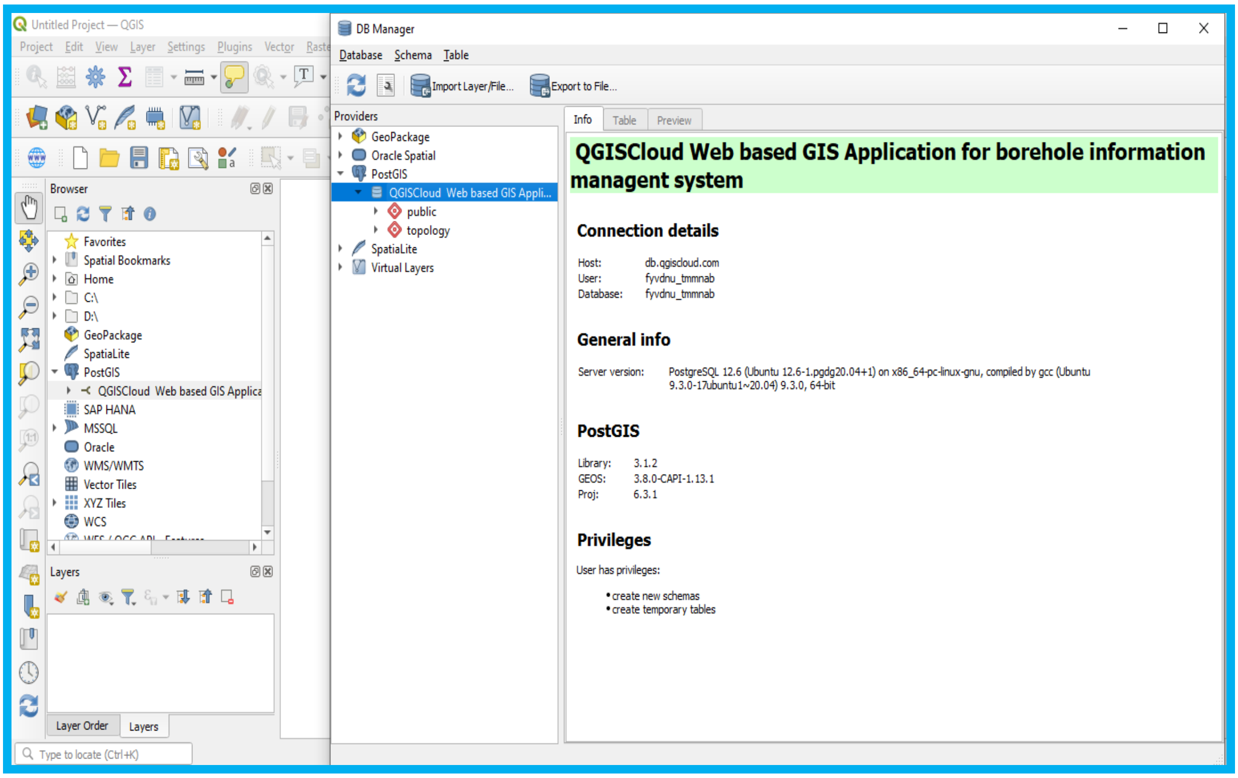

Figure 25 -Data base Manager of Q GIS cloud

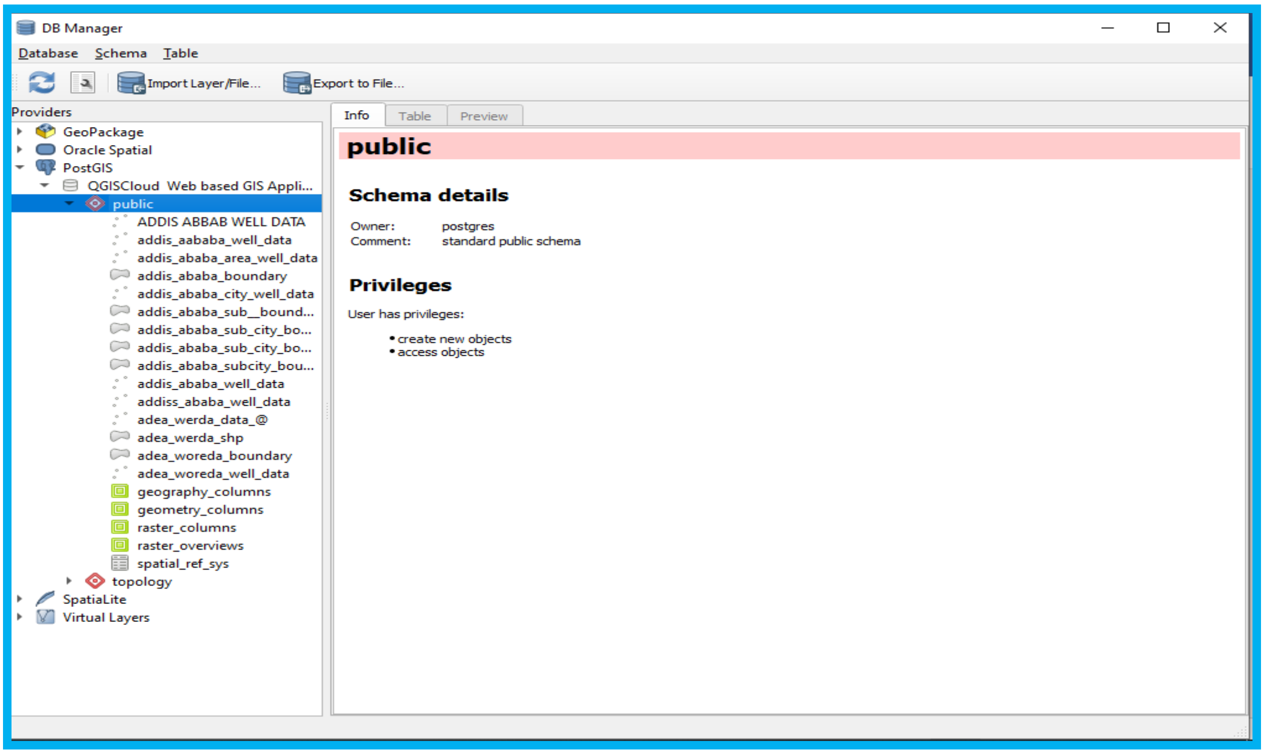

Figure 26 -Data Base Manager Q GIS cloud public schema

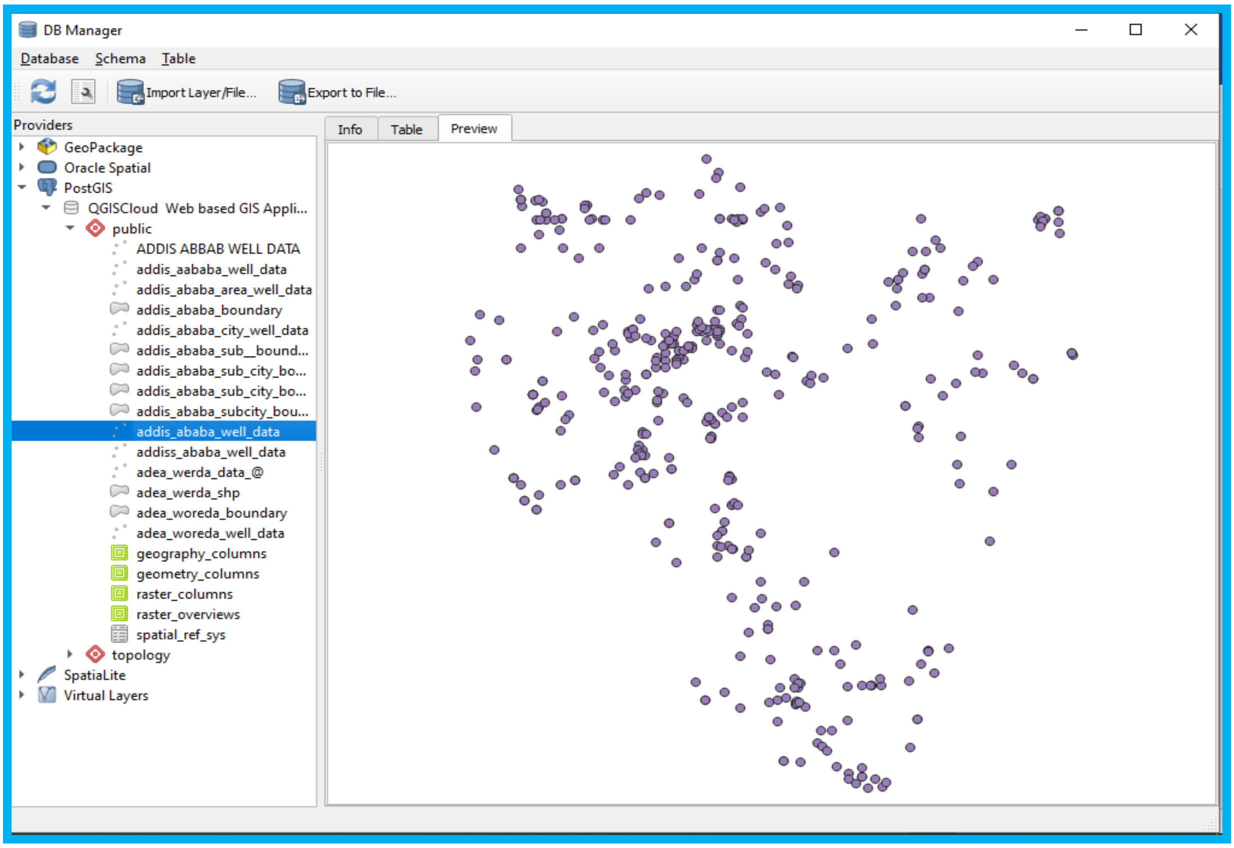

Figure 27- Q GIS cloud Data Base Manager Borehole Distribution

CHAPTER 4: RESULT AND DISCUSSION

4.1 Result

4.1.1. Demonstrate of the spatial Distribution of Borehole map of Addis Ababa

The purpose of most GIS is to function as decision support systems in the specific environment of an organization. Maps are important tools in this process. They are used to visualize spatial data, to reveal and understand spatial distributions and relations.

ADDIS ABABA AREA WELL DISTRIBUTION MAP

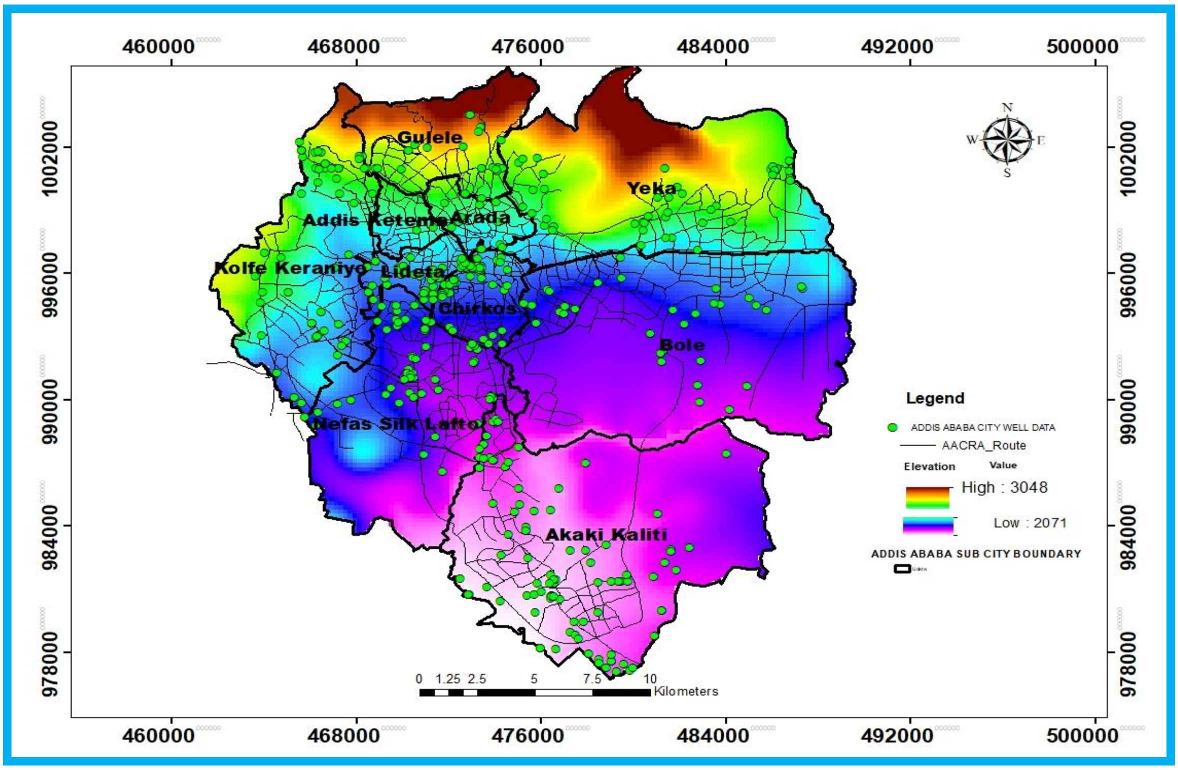

Figure 28 -The spatial distribution of well in Addis Ababa

Figure 28, Can be seen from Table below the most dominant water point in the study area and its surrounding are boreholes. However, the spatial distribution indicated they are not fairly distributed but randomly aligned and concentrated along the settlements and development areas.

4.1.2. Design an interactive borehole web-map application.

The interface for the interactive web-based GIS borehole information management system developed using Q GIS 2 web using Open layer Q GIS2 web does its best to interpret a QGIS project and to export HTLM, Java script, and CSS to create a web map and enhanced the performance the interface the exported HTLM index and could be improved using the web mapping programing code in Figure 31 show that simple developed web mapping that show the spatial distribution of Addis Ababa area bore hole data

Querying additional information about Borehole data :Some of the non -spatial information of about the borehole data is very important and this information helps in decision making, all the non-spatial information was added the attribute table and a tool was developed so that on the web site once a user click on a bore hole the user can see information about the bore hole

Components of the web mapping: the mapping component had various the user in map viewing and navigation that included: Zoom to full extent ; this tool was used to view the whole map at the default minimum scale, Back and forward ; allowed one to move back or forward to previous zoom and hence help to locate point of interest on the map and out ; these are tools to allow one to increase or reduce the scale of the map so as to ease in locating features of interest Pan ; this tool aid in navigating on the map ; tool used to make the map fresh again by removing selection.

On the mapping component also we had various capabilities that were added according to evaluation of user needs. Data retrieval capability enables the user to obtain the information associated to various water resources and other features on the map. User is able to use the identify tool or the select tool to extract specific data related to a given feature. nThe identify tool is used on a single feature while select tool is used when one wants to retrieve information of several features at same time

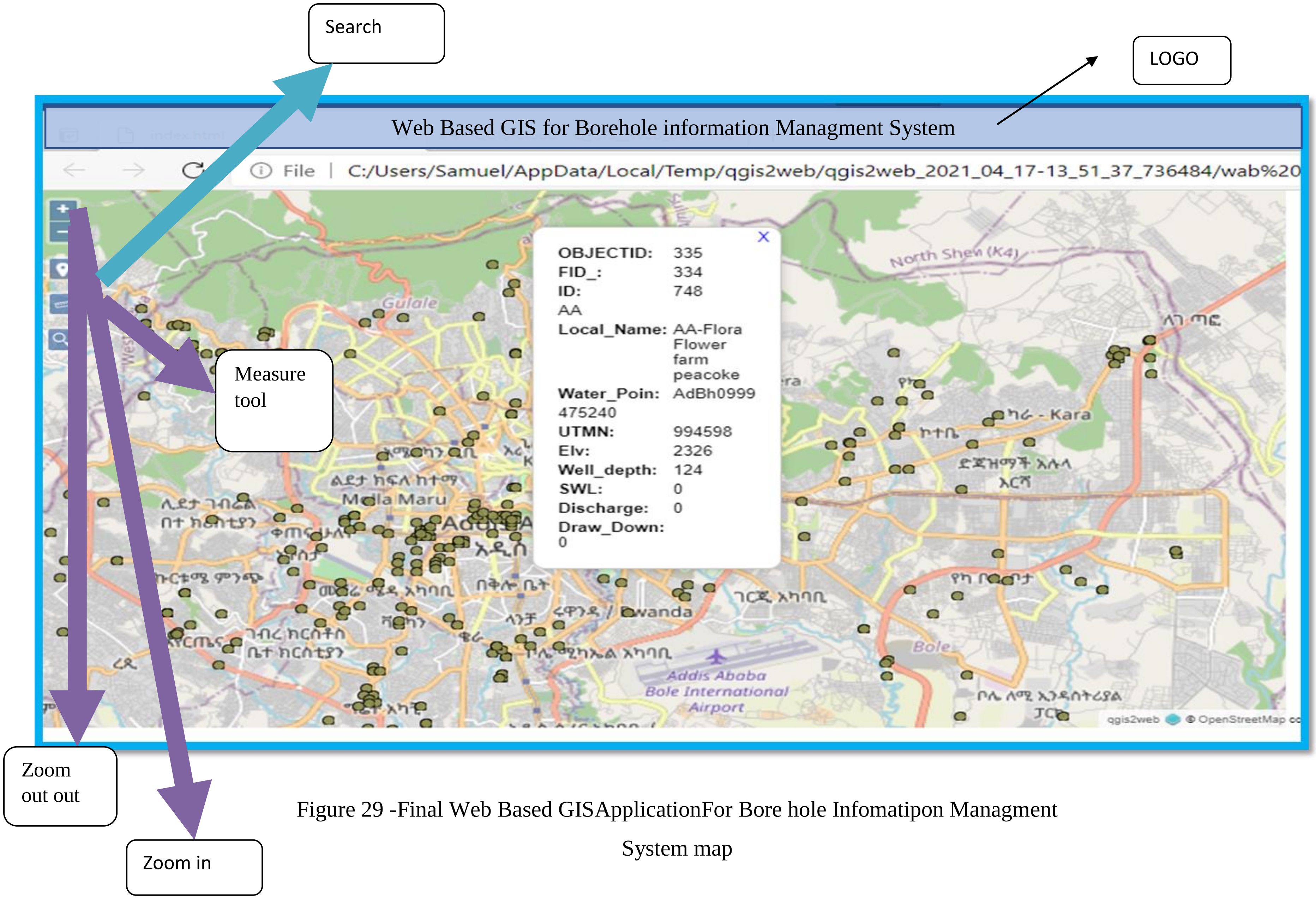

Figure 29 -Final Web Based GISApplicationFor Bore hole Infomatipon Managment System map

4.1.3 .Demonstrate remote access of the borehole information.

The interface for the interactive web-based GIS borehole information management system Running on a device is shown in Figure 32; This enable users who are accessing the application from mobile devices such as tablets and smartphones to enjoy the same services just like those who are accessing the same from a personal computer or laptop. This is through The web addres obtained http://qgiscloud.com/ szsami/WEB__BASED BORE HOLE_INFORMATION MANAGENT SYSTEM OF ADDIS ABABA CITY

Figure 30- Published maps of Web based GIS Boreholeinformation System Management

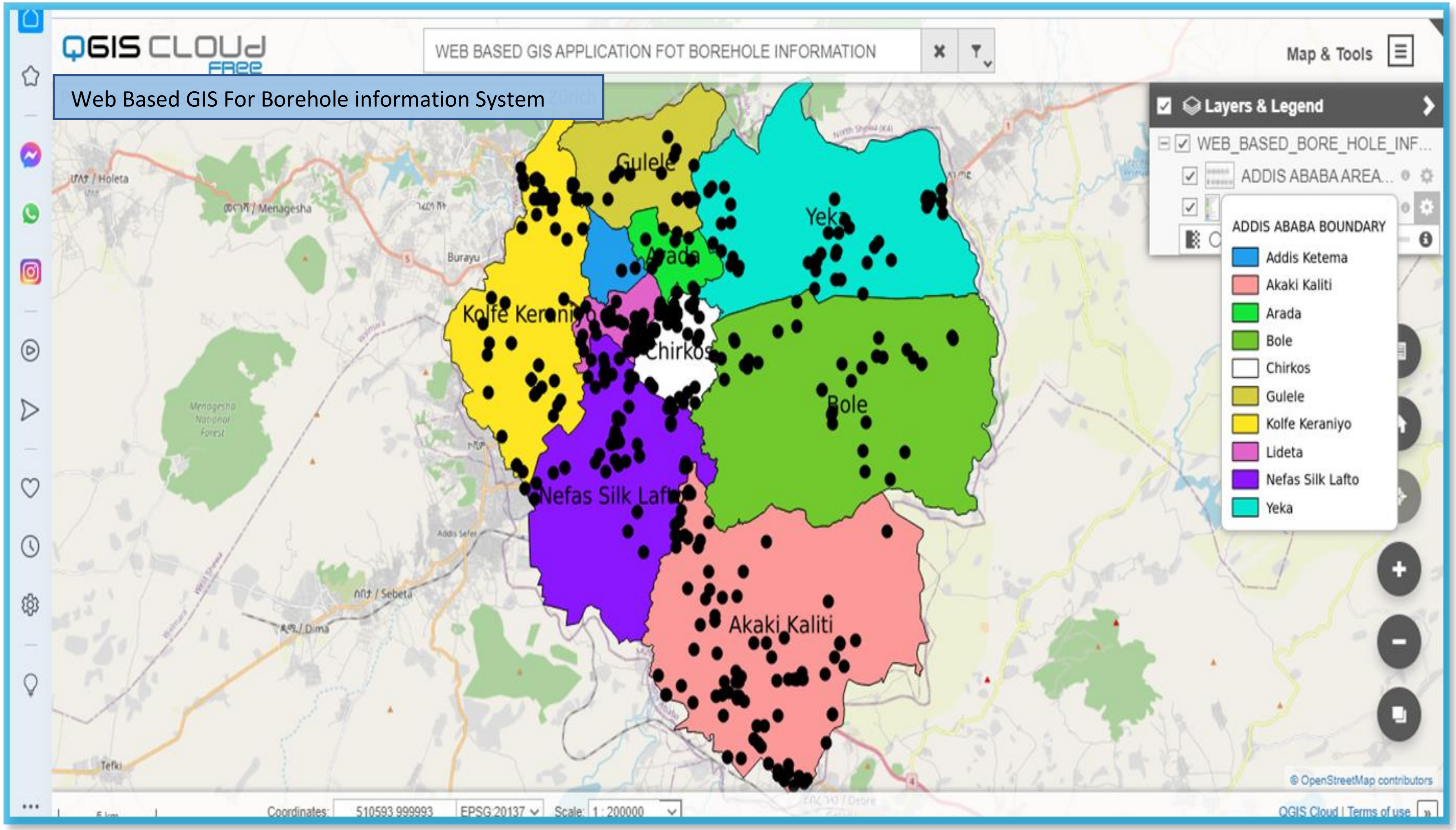

Figure 31 -Published web mapping using Q GIS cloud

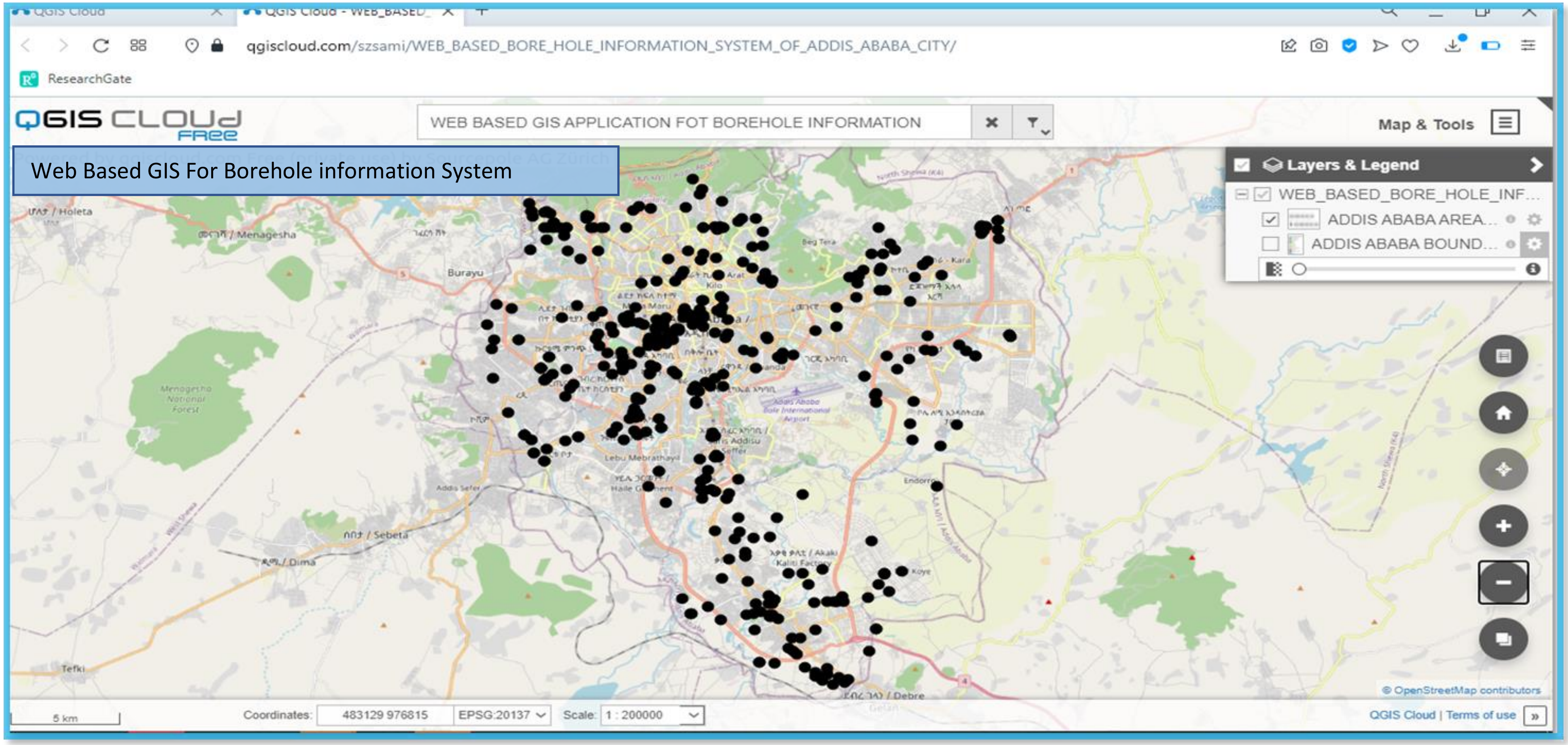

Figure 32 -Published web mapping over laid on open street map

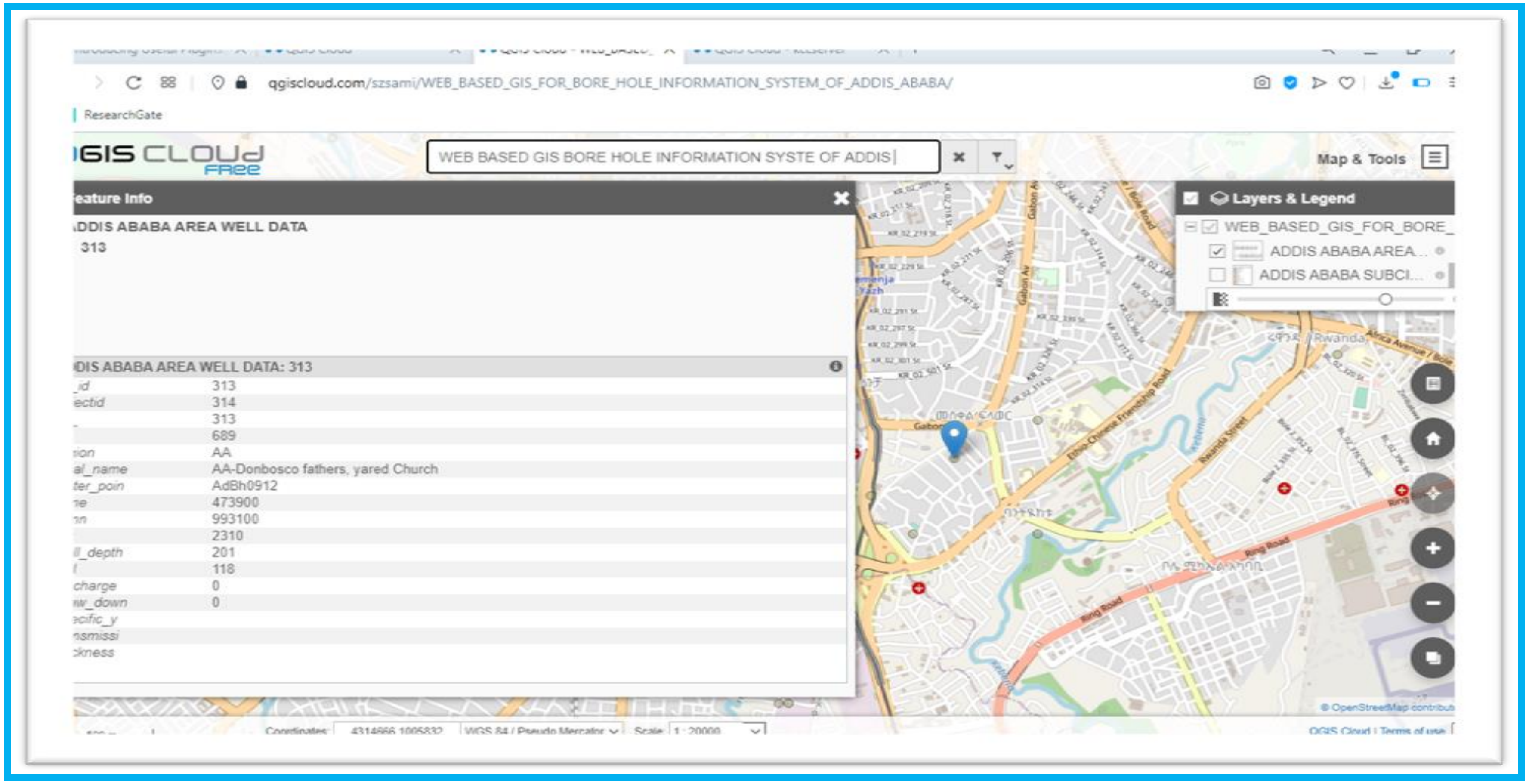

Figure 33 -Published web mapping over laid on street line with querry information

4.1.4. Manage Data using Post GIS

Spatial Databases allow the storage of the geometries of records inside a Database as well as providing functionality for querying and retrieving the records using these Geometries. In this figure shows Post GIS, an extension to Postgre SQL , to show how to setup a spatial database, import data from shape files into the data base.

QGIS Cloud gives you a full-featured PostgreSQL databases, extended with Post GIS. Create new databases directly from the QGIS Cloud plugin with just a click. Manage your databases with any compatible management tool, such as pgAdmin3, the QGIS Browser or the QGIS DB-Manager. You have full access to all features of a PostgreSQL/Post GIS database and make use of the geographic functions that Post GIS offers.

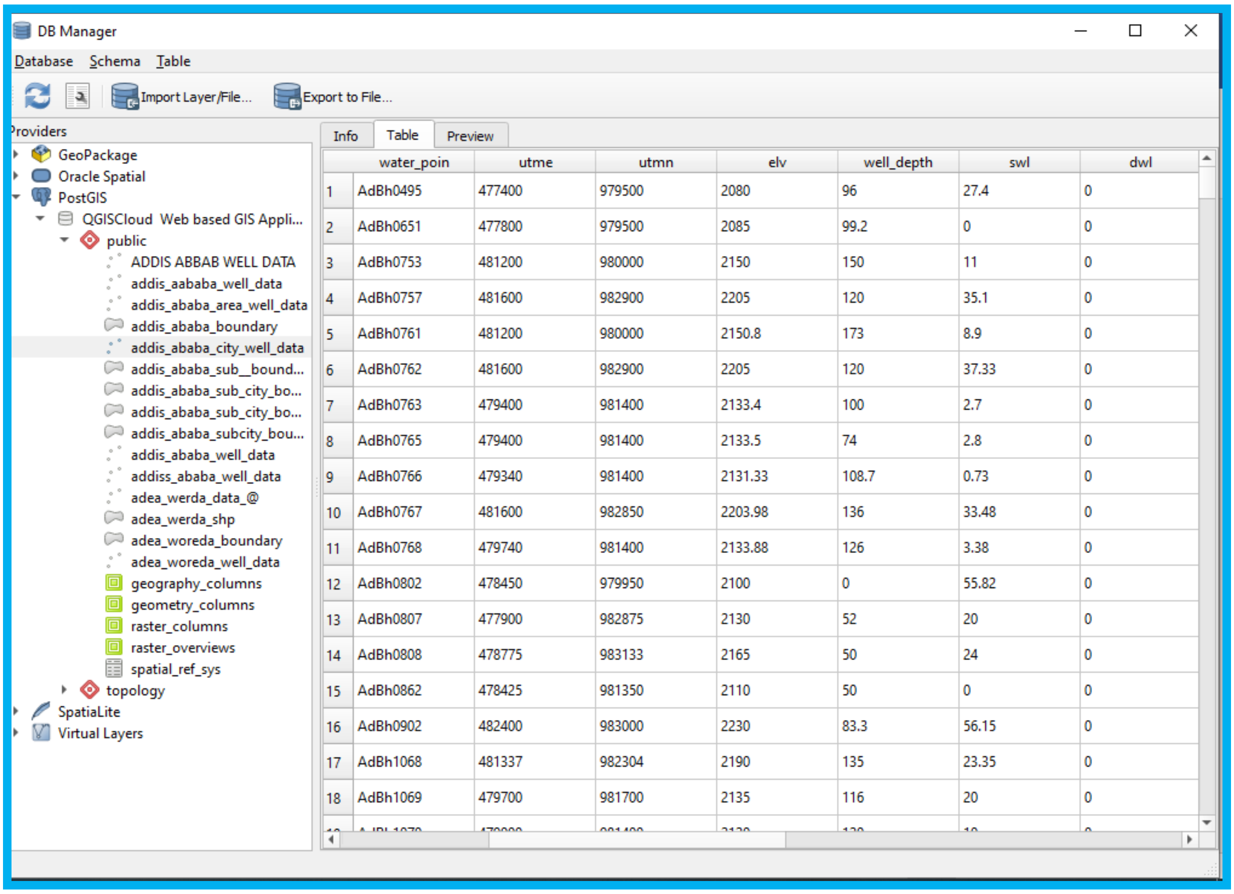

Figure 34 -PostGIS tables displayed

4.2. Discussion

The study was implemented using open-source software using QGIS 2web and QGIS cloud web based plate form; the application allows a user to formulate a query/carry out analysis e.g. a query to find out the number of operational boreholes being used in the city of Addis Ababa.

web- based GIS is a GIS application made available through a common web browser for easy, fast and cost-effective dissemination, sharing, displaying and processing of spatial information. Together with the use of the World Wide Web, GIS could be further developed to allow many more people to have access to GIS functionality and to enhance community participation in planning.

The study was carried out an effective Web based GIS borehole information management system that allows effective storage, management and retrieval of spatial data for water related sectors in Addis Ababa, any government and non-government sectors can access this cloud based web plate form because it is very important to get reliable data in a quick and on time bore hole data without referring a paper document.

The spatial distribution of Borehole data in Addis Ababa indicated they are not fairly distributed but randomly aligned and concentrated along the settlements and development areas.

The designed an interactive borehole web-map application. Using qgis2web open layer and leaf let plug in qgis2web generated a web map from Addis Ababa borehole data in QGIS project, Open layers library provide tools that would enhance visualization. These include providing for world street map to act as a base layer whilst boreholes, road and administrative units act as over layers. Furthermore, zoom in zoom out tools were incorporated to enhance interactivity with the map.

Q GIS cloud is powerful Web-GIS platform for publishing maps it is public and personal spatial data infrastructure (SDI) on the internet. Publish QGIS projects as maps and data. Share spatial data with others. And all this very easily, without server, infrastructure or expert knowledge., the researcher Published and share link the web based GIS application for borehole information management system plat form using QGIS Cloud.

QGIS Cloud with full-featured Postgre SQL databases, extended with Post GIS. Created new data bases directly from the QGIS Cloud plugin with just a click. Manage your databases with any compatible management tool, such as pg Admin, the QGIS Browser or the QGIS DB-Manager. You have full access to all features of a Pos tgre SQL/Post GIS database.

Some of the non-spatial information about borehole data was very important and this information helps in decision making, some of the non-spatial information was added in the attribute table using tools on the web site once a user click on the borehole data and the user can see the attribute information on line

CHAPTER 5: CONCLUSION AND RECOMMENDATION

5.1. Introduction

This chapter discusses the conclusion of the project whose aim was to develop web-based GIS for Borehole information system in Addis Ababa city, and creates a few map applications that can make the web application provide timely and efficient answers to all potential users of Borehole data in the city, the conclusion is a brief explanation of the project achieved and recommendations which also high light further areas of the study of the project..

5.2. Conclusion

This thesis was to create a web-based GIS Borehole information system in the case of Addis Ababa that could be accessed anywhere by all users to retrieve information about borehole data in an efficient and time-saving way. The first step was to collect the spatial and non-spatial data from the concerning government Authority, the second step was Data preprocessing such as data organization. Checking, verification, Geo-refencing, coordinate projection conversion, and the third step was a web map application was developed used by Q GIS 2 web with open layer and leaf let plug in library and a base layer also used Open Street map, finally the web map published. visualized, share and managed by using Q GIS cloud plug in, this web-based GIS application was developed with a purpose of dissemination and managing of Borehole information in Addis Ababa city, this web application used Q GIS cloud interface that the users can search and view location of Bore hole on OSM (Open street map) a web map layer or Base layer, query the attribute information and be able to view associated non-spatial information about borehole data ,The information disseminated through this application can be used by borehole drillers, the public and other decision makers.

From the study one can draw conclusions that Web-based GIS is a prospective application in GIS and represents an important advancement over the traditional desktop GIS. Its application

Eliminates duplication and inconsistency and makes location information conveniently and intuitively accessible across organizations, at a lower cost per user. Internet provides a medium for processing geo-related information and spatial information to users at an amount larger than traditional GIS. The study lays the foundation of proper management of the water resources especially for ground water resource management.

5.3. Recommendation

The current traditional and analogue form of handling borehole data in the city is characterized by Exceled spread sheet in order to improve the system web based reliable information and efficient retrieval of information is crucial for planning and development of water resource management. and the Web GIS is online application with a web-based map interface that enables users to interact with spatial information and create customized maps.

The following needs to be implemented, so as to further improve the application;

a) Further development of the application to allow it to have an interface where by hard copy borehole data can be fed into the database.

b) Further development of the application to allow it to have a web site interface whereby using other advanced open source of soft ware

c) Further development of the application to allow borehole data collected in the field using applications running on a mobile device to be populated in the database in real time (or near real time) using 3G mobile

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7. APPENDICES

Appendix I- Borehole inventory data of Addis Ababa City

Table 1- Borehole inventory data from Oromia Engineering Corporation and AAWSA)

NO	Local Name	Water Point	UTME	UTMN	Elevation	Well depth	SWL	Discharge	Draw Down	Specific yield
1	Akaki Ethio-Fiber-1	AdBh0495	477400	979500	2080	96	27.4	2.5	44.7	0.06
2	Akaki Garment Factory	AdBh0651	477800	979500	2085	99.2	0	4.17	0	
3	AA-Water lll Testwell-B5	AdBh0753	481200	980000	2150	150	11	3	18.2	0.16
4	AA-Water lll Testwell-B9	AdBh0757	481600	982900	2205	120	35.1	3	1.6	1.88
5	AA-Water lll Testwell-T1	AdBh0761	481200	980000	2150.8	173	8.9	1.5	25.3	0.06
6	AA-Water lll Testwell-T5	AdBh0762	481600	982900	2205	120	37.33	3	11.07	0.27
7	AA-Water lll Testwell-B13	AdBh0763	479400	981400	2133.4	100	2.7	4	0.5	8
8	AA-Water lll Testwekk-T2	AdBh0765	479400	981400	2133.5	74	2.8	11.7	1.5	7.8
9	Akaki Water Supply Test Well EP-1	AdBh0766	479340	981400	2131.33	108.7	0.73	26.5	12.78	2.07
10	Akaki Water Supply Test Well EP-2	AdBh0767	481600	982850	2203.98	136	33.48	11.1	5.52	2.01
11	Akaki Water Supply Test well Ep-3	AdBh0768	479740	981400	2133.88	126	3.38	9.5	41.42	0.23
12	Akaki Water Supply Well EP-5	AdBh0802	478450	979950	2100		55.82	12.5	2.28	5.48
13	Akaki kebele 06 Kilento	AdBh0807	477900	982875	2130	52	20	0	0	
14	Akaki Kebele 06 kilento	AdBh0808	478775	983133	2165	50	24	0	0	
15	Akaki Lesperance school	AdBh0862	478425	981350	2110	50	0	0	0	
16	Micky Layland Children's	AdBh0902	482400	983000	2230	83.3	56.15	0	0	

	Home									
16	AAWSA F7 at Koye	AdBh1068	481337	982304	2190	135	23.35	40.88	9	4.54
17	AAWSA F3 at Fanta	AdBh1069	479700	981700	2135	116	20	8	0	
18	AAWSA F1 at Fanta	AdBh1070	479000	981400	2120	120	10	40	6	6.67
19	AA-Bole Lem-2-99	AdBh1110	482896	991871	0	205	14.4	13.1	1.2	
20	AA-Bole Lemi-5-99	AdBh1111	484152	989566	0	182	0	17.4	9.7	
21	AA-Bole Lemi-1(Hanku)-99	AdBh1112	481230	992312	0	200	22.3	14.78	25.6	
22	AA-Bole Lemi-Lideta-1-99	AdBh1114	484900	990700	0	177	4.3	17	4.7	
23	AA-Bole Lemi-99	AdBh1139	482850	989900	0	168	0	20	0	
24	S Ayat	SANFTW-1	477891	987018	0	411	8.91	34.98	71.17	0.49
25	S Ayat	SANFTW-2	484001	987465	0	442	0.35	52	41.17	1.26
26	S Ayat	SANFTW-3	481012	984597	2192	440	29.8	50	45.7	1.09
27	Hana Mariam AKV-2	AA038	477248	982879	2059	228	0	25	48.9	
28	Fanta valley 1	AA046	480847	981623	2202	256	17.62	32	51.91	
29	Akaki	AA051	478130	982300	2175	258	5.75	10	158.33	
30	East bole	AA056	481165	992219	2253	270	27.59	19	68.38	
31	Fanta valley III	AA058	481828	981943	2064	194	29.46	7	146.44	
32	Bole Lemi,SMV 19	AA059	482757	990710	2227	274	0	32	33.25	
33	East Bole EBV 22	AA067	481213	991853	2250	250	25.52	16.5	53.62	
34	AA-Fanta Well field F7	AdBh0176A	481337	1001017	2646.9	135	23	0	0	
35	AA-Ethiopian Metal Tools Factory	AdBh0525	480400	998500	2455	47	30.1	0	0	
36	Legadadi Bh4	AdBh0536	486200	1001042	2475	100	17.76	0	0	
37	Kotebe , Selam Childeren's Village No.2	AdBh0611	481650	997725	2406	145	42.79	0	0	

38	kotebe Berta Well	AdBh0636	482770	997150	2388	136.5	34.75	0	0	
39	Kotebe metal Tools Factory	AdBh0708	480629	998771	2471	96	13.6	6.3	8.5	0.74
40	AA-EELPA,Kotebe	AdBh0722	480431	998457	2452	181	15.4	12	9.2	1.3
41	AA-Water lll Testwell-B4	AdBh0752	486200	1001042	2450	100	10	1.5	7.8	0.19
42	AAWSA/Kotebe Kara	AdBh0855	484190	998500	2480	140	45.02	19	16.21	1.17
43	Legadadi-Day light	AdBh0856	485925	1000975	2482	200	7.59	0	0	
44	Legadai-Gedera 2	AdBh0857	486000	1001115	2482	130	9.8	0	0	
45	Kotebe, Selam Vocational School No.1	AdBh0860	482070	999823	2526	117	79.56	2.5	8	0.31
46	Legadadi-Bekele eshete Park	AdBh0874	486075	1000865	2480	21	0	0	0	
47	Legadadi-Ato Abebe Workiye	AdBh0875	486089	1000950	2480	23	0	0	0	
48	AA-Ato Zena Gessesse, kotebe Gabriel	AdBh0924	483550	999250	2510	80	0	0	0	
49	AAWSA Near kotebe EELPA	AdBh0935	480395	998100	2440	0	8.51	0	0	
50	AA-Jehova Witness Kotebe Well No.1	AdBh0978	483350	999064	2487	116	59	6	0.43	13.95
51	Kotebe Selam vocational Training No.3	AdBh1030	481878	1000148	2546	140	75.95	5.3	19.9	0.27
52	Legadadi-Dini Heriakos	AdBh1047	486000	1000707	2485	54	12	1.2	36.44	0.03
53	AA-Anokorcha-99	AdBh1129	480029	998401	0	144	20	10	0	
54	AA-Dagmawi School-99	AdBh1131	486712	1001378	0	133	0	20	19.4	
55	AA-Wondrad School-99	AdBh1132	481365	998698	0	0	0	0	0	
56	Salayish	AA005	480999	999648	0	228	0	22	22.42	

57	Ankorcha-2	AA019	481462	998906	0	200	0	32	18.18	
58	Luke Stream	AA020	482994	998429	2434	203	0	34	3.79	
60	Lege Tafo-4	AA025	486775	1000441	2414	270	0	0	0	
61	Selam Technique	AA029	481519	999648	0	200	5	20	37.25	
62	New Kara Road-Ararat	AA034	480321	997370	2399	180	0	47.38	18.11	
63	kotabe	AA044	481462	998906	0	0	0	0	0	
64	Legetafo	AA047	486723	1000881	2517	236	32	32	48.98	
65	Legetafo	AA050	486738	1001391	0	218	5.91	28	48.98	
66	Legatefo	AA055	486738	1001391	2455	0	8.14	28	0	48.98
67	New Kara Road WNDV-3	AA064	481368	997713	2317	260	88.37	16	47.68	
68	AA-Ayer Tena	AdBh0355B	466050	993650	2371	137	71.28	0	0	
69	AA-Hope Enterprise -1	AdBh0597	466200	993000	2343	120	0	0	0	
70	AA-Hope Enterprise-2	AdBh0598	466300	993100	2317	112	60	0	0	
71	Repi Soap factory	AdBh0600	466250	993050	2335	142	50	1.75	0	
72	Voice of Revolutionary Ethiopia	AdBh0601	467200	993600	2320	84	48	1.67	0	
73	Militatry Food Kichin	AdBh0650	466050	993650	2371	140	71.28	0	0	
74	Voica of Gospel	AdBh0699	467500	992800	2280	33	0	0.35	0	
75	AA-Darge-Suq,WSSA	AdBh0726	464300	990600	2290	52	14.4	4.4	31.1	0.14
76	AA-Water lll Testwell-B11	AdBh0759	466200	988800	2246	100	0	4	20.2	0.2
77	Rahima Dairy	AdBh0876	467350	992610	2305	100	0	0	0	
78	AA-Alert Abune Yosef School	AdBh0887	467150	992150	2275	94	29	0	0	
79	W/ro Martha kebede, Ayer Tena	AdBh0925	466550	993300	2340	99	0	0	0	

80	AAWSA Repi behind Roll Soap factory	AdBh0932	463850	993100	2400	150	83.71	0	0	
81	AAWSA Ayer Tena near kidanemeheret	AdBh0933	466050	993650	2360	136	71.28	0	0	
82	AA-Repi Enyi General Business Group	AdBh0994	464538	991302	2300	94	5.33	4.7	9.39	0.5
84	AA-Kidane Mihret-99	AdBh1108	466050	993650	0	200	71	20	11.3	
85	AA-Mekanisa-99	AdBh1113	467135	989840	0	213	3	25	93.8	
86	AA-Repi-99	AdBh1118	465741	989188	0	134	3	30	32.8	
87	AA-Mekenisa Harbu-2-99	AdBh1123	467723	990028	0	161	4	20	7.77	
88	AA-Repi-Harbu-5-99	AdBh1125	465591	989872	0	257	7.79	30	59	
89	AA-Repi-1-99	AdBh1126	465295	990132	2282	200	9.8	20	22.3	
90	AA-Repi-new-99	AdBh1127	463985	991540	0	185	24.8	20	10.1	
91	AA-Repi-Dertu-99	AdBh1140	466308	989421	0	185	4.2	15	0	
92	AA-Repi-Alem Gena-99	AdBh1141	466200	988800	0	100	0	5	38.1	
93	Kolfie Well no 32	AA001	465295	990132	0	200	9.78	20	21.11	
94	Lebu site # 28	AA004	467723	990028	0	121	2.65	20	7.77	
95	Kolfie well no 33	AA006	465295	990132	2282	188	0	20	9.41	
96	Repi-23	AA027	465741	989188	2274	135	3	20	32.8	
97	Ayrtena	AA	466050	993650	2360	201	70.5	20	11.81	
98	Alem bank,Kidane Mihert	AA041	466430	994219	2367	250	250	2	147.25	
99	Alem Bank, Kidane Mihiret	AA069	466430	994219	2367	250	250	2	147.25	
100	AA-American Embassy-2 (Ambasador Residence)	AdBH0393A	474125	1001050	2564	154.2	28	0	0	
101	Tikur Abay Shoe Factory	AdBh0395A	466200	1001008	2562	53	22.6	2.9	0	

102	AA-Gulele	AdBh0396A	467200	1001017	2538	152	35.25	0	0	
103	AAWSARas Kassa Sefer/Ferensay	AdBh0403A	475000	1001300	2542	168	73.54	18	4.92	3.66
104	AA-AAU	AdBh0404A	473400	999600	2490	57.9	21	0	0	
105	AA-Anwar Mosque	AdBh0410A	471300	998200	2445	87.5	16.5	0.5	43	0.01
106	AA-American Embassy(Marine old)-1	AdBh0501	473900	1001050	2564	200	14.55	2	128.45	0.02
107	AA-Amaha Desta School2	AdBh0504	473400	1001014	2562	88	0	0.58	0	
108	AA-Amaha Desta School-3	AdBh0505	473400	1001013	2562	84	0	0.69	0	
109	AA-French Embassay	AdBh0507	474300	1001005	2523	83	22	0	0	
110	AA-Glass and Bottle Factory	AdBh0509	467200	1001017	2517	150	35.3	4.54	64.7	0.07
111	AA-Anbessa Transport Garage	AdBh0510	468400	1001016	2580	192	3	1.5	47.2	0.03
112	AA-Women's Rehabilitation Center	AdBh0511	466600	1001003	2500	153	22.6	0	0	
113	AA-General Winget School	AdBh0512	468300	1001003	2525	63	41	2.5	0	
114	AA-Ethio-Marble industry-1	AdBh0513	468800	1001007	2529	42	18	0	0	
115	Aa-Ethio-Marble Industry-2	AdBh0514	468900	1001007	2540	116	72	0	0	
116	St.Poulos Hospital	AdBh0515	469900	1001000	2525	80	7	1.6	0	
117	Total Sidist Kilo	AdBh0518	474000	999400	2473	50	6.8	1.33	0	
118	AA-Yekatit 12 Hospital-1	AdBh0522	473300	999300	2482	27	18	0	0	
119	AA-Yekatit 12 Hospital-2	AdBh0523A	473300	999300	2480	100	0	1.5	0	
120	AA-West German Embassy	AdBh0524	475600	998900	2420	90	20	0.6	0	
121	AA-British Embassy-1	AdBh0526	476500	998250	2425	57.5	22	2.5	0	
122	AA-British Embassy-2	AdBh0527	476450	998100	2420	85	11	1.1	0	

123	AA-Belgian Embassy	AdBh0528	476100	998300	2440	54	17.4	0.5	0	
124	AA-Islam Mosque	AdBh0533	472100	998200	2430	70	0	1.56	0	
125	Mercato privavte well	AdBh0535	470600	998100	2450	38	0	0	0	
126	Akaki Koye Defence Gulele	AdBh0660	465600	1001855	2554	83.3	56.15	0	0	
127	AA-Kality Fafa	AdBh0675	465243	1003393	2634	115	26.17	0	0	
128	Minilik Hospital	AdBh0676	475200	999200	2440	51	39	0.12	0	
129	Queen's Palace	AdBh0679	474300	1001014	2500	108	0	0.46	0	
130	Menilik School	AdBh0682	474100	998500	2440	41	0	0.23	0	
131	Private Well	AdBh0683	472400	998500	2450	43	5	0	0	
132	AAWSA Asko Borehole	AdBh0694	465507	1002282	2555	178	1.95	6	73.79	0.08
133	AA-Gulele Glass-Factory-3	AdBh0711	466900	1001005	2517	150	20.4	2.5	105.9	0.02
134	AA-American Embassy-3 Near Garage	AdBh0728	474050	1000875	2550	156	14.6	2	128.4	0.02
135	Kokebe Thebah School	AdBh0748	476200	998600	2410	66	10	0.7	0	
136	Kuskuam St. peter Hospital BH2	AdBh0838	473350	1003000	2625	150	10.05	0	0	
137	Kuskuam St. peter Hospital BH1	AdBh0839	473250	1002750	2650	12	0	0	0	
138	AA-Asco, Black Lion Shoe Factory	AdBh0863	466175	1001800	2560	0	25.6	0	0	
139	Sansuzi, AAWSA	AdBh0864	465900	1002875	2600	110	15.75	8	17.63	0.45
140	AA-Burayu, Ethio-brick Factory	AdBh0865	465550	1003250	2620	72	0	0	0	
141	San Francisco,Asco	AdBh0878	466440	1001760	2560	66	17.7	0	0	
142	AA-Bingham Acadamy, kolfe	AdBh0898	468650	999800	2460	172	68.5	0.5	93.4	0.01

143	AA-Gulele Soap Factory, Asco	AdBh0899	466300	1001825	2560	72	0	0	0	
144	AA-Glass Factory BH2,Asco	AdBh0900	467100	1000550	2515	142	12	0	0	
145	AA-Dire Tannery BH1, Gulele	AdBh0905	468200	1001600	2578	150	45.9	3.8	54.75	0.07
146	AA-Apostlic, Tero, Kolfe	AdBh0917	467250	999800	2510	70	58.79	0	0	
147	Nigeria Embassy, Afinchober	AdBh0920	472700	999800	2485	120	11.7	1.5	82.3	0.02
148	AA-Bela-Italian Embassay	AdBh0927	476105	1000050	2455	105	50.2	0	0	
149	AAWSA Shegole	AdBh0931	468100	1001625	2585	150	31.69	12	70.64	0.17
150	AAWSA Kuskuam	AdBh0937	472900	1003550	2720	0	4	0	0	
151	AA-Gulele Misionery of Charity No.1	AdBh0946	465651	1001575	2540	76	7.3	6.7	10.21	0.66
152	AA-Gulele Misionery of Charity No.2	AdBh0947	465600	1001855	2545	104	13.2	8	5.52	1.45
153	AA-Kolfe, Catholic	AdBh0961	467853	999379	2445	0	3	0	0	
154	AA-Tikur Abbay Shoe Factory(Asko Well No.2)	AdBh0979	466350	1001000	2550	153	15.65	4	33.93	0.12

Appendix II- HTLM and XML file document

Table 2- Show style information for the design of the web based GIS application for borehole information management system, the case of Addis Ababa.

WMS_Capabilities xmlns:qgs="http://www.qgis.org/wms" xmlns="http://www.opengis.net/wms" xmlns:sld="http://www.opengis.net/sld" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" version="1.3.0" xsi:schemaLocation="http://www.opengis.net/wms http://schemas.opengis.net/wms/1.3.0/capabilities_1_3_0.xsd http://www.opengis.net/sld http://schemas.opengis.net/sld/1.1.0/sld_capabilities.xsd http://www.qgis.org/wms http://wms.prod.qgiscloud.com/szsami/WEB_BASED_GIS_APPLICATION_FOR_BOREHOLE_INFORMATION_SYSTEM_MANAGMENT?SERVICE=WMS&REQUEST=GetSchemaExtension">
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</Service>
<Capability>
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<GetCapabilities>
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<DCPType>
<HTTP>
<Get>
<OnlineResource xmlns:xlink="http://www.w3.org/1999/xlink" xlink:type="simple" xlink:href="http://wms.prod.qgiscloud.com/szsami/WEB_BASED_GIS_APPLICATION_FOR_BOREHOLE_INFORMATION_SYSTEM_MANAGMENT?"/>
</Get>