

# **1. Introduction**

## **1.1 Research Background**

Web technologies are offering features that help most of the people and provide for them an easy way to deal with these technologies. It also provides new technologies to deal with maps and map services. These technologies allow users to attach their own information to web maps in an easy way and with the maximum of freedom and flexibility. Thus, the web map services shift from developer-centered into user-centered interactive map services **(Hu, S. and Dai, T. 2013)**.

There are some companies such as Google and Yahoo, which have developed easy-to-use mapping platforms for users to add and update information or publish their new map services. Therefore, they give a good opportunity to the uses and researchers to create many applications in different ways with different perspectives using map services. In addition, a new technology like Mashups nowadays are used widely nowadays, in many applications. Thus, almost everything a user needs is available and easy to get anytime. With the increasing need for up-to-date information and online services, as well as needs to represent this information in reality for better understanding, a Geographic Information System seems to be the best way for supporting and to get optimal understanding of the information and its proprietaries, which are all based on map services. This information connects with spatial data which include latitude and longitude. The role of a maps service is to allow users to overlay own information to an online map, to become more clear and, therefore more understandable **(Terumalasetti S., Jalgama R. et al 2013)**.

In this thesis we design a Sudan Geoinformation Application Mashups using Google Maps, which include information about Sudan (localities, population and universities for each state) and then overlay this Geoinformation on Google Maps.

This system includes a database, which has content latitude and longitude for states with their localities and also known universities in each state or city. In addition, it offers population statistics for each state or city.

## **1.2 Problem Statement**

In Sudan, there is no Geoinformation system organized online, especially for delivering correct and enough Geoinformation via Internet. Thus there are many challenges to face with, who search about Geoinformation, which is organized, complete and up-to-date in our country.

## **1.3 Research Hypothesis**

- Using Mashup technology provides the ability to design a Geoinformation systems for Sudan in an easy manner.
- Using API to transform public databases building a Geoinformation system to Sudan.
- Using Google maps to overlay the Geodata on the maps.

## **1.4 Purpose of the Study**

The main idea in this research is to create online Web based application maps for Sudan, including Geoinformation about Sudan in general.

## **1.5 Significance of the Research**

This application gives us great benefits regarding Geoinformation of Sudan to facilitate ways of searching about specific places or Geoinformation about specific places or even about whole States and Cities with localities of Sudan. We will make it as easy as possible; moreover, we will provide Geoinformation applications to help students in their studies at different levels, and also to help visitors and tourists from outside to get information about Sudan.

## **1.6 Research Scope**

This work will implement GeoInformation Systems in different manner for Sudan.

In particular, it includes:

- Khartoum State with its localities and population in each local, as well as public universities.
- The application is online, therefore compatible for mobile and desktop computing facilities.

## **1.7 Research Goals and Objectives**

- Using Mashup technologies to meet the needs of the user.
- Provide a variety of GeoInformation systems for Sudan.
- Provide Geodata and overlay on the maps.
- Improve search manner about Sudan GeoInformation.
- Provide GeoInformation for schools and universities in Sudan.
- Provide GeoInformation for all, in an easy and simple way.

## **1. 8 Research Methodology**

First of all, in this research we aim to design applications for Sudan maps, mainly Khartoum State as case study, including Mashup technology and Google maps with database which contents GeoInformation about Sudan.

This application is an online application, that enables users to visit any place at any time via Internet. Therefore, it enables users to get up-to-date information about geography of Sudan, public universities as well as information about Sudan's population, mainly for Khartoum State.

**The steps for creating the application are:**

- Design the interfaces of the application using HTML and CSS.
- Create the database using SQL.
- Create the PHP script to retrieve data from the database and convert it into XML file.
- Integrate the data which represented as XML file with google maps using JavaScript and google maps API.

**The steps for using the application are:**

- Using any browser to enter the Internet and enter the URL.
- Select one state and then it will show three option localities, population and universities.
- Users can choose what they want to visualize on the Google maps, whether localities, population or universities.
- The information will show according to the user's choice.

**1.9 Expected Results**

- Online Web GeoInformation application specific for Sudan (Khartoum State).
- Organized and correct GeoInformation about Sudan (Khartoum State).
- Providing correct GeoInformation about Sudan (Khartoum State).
- Providing up-to-date data about Sudan.

## **1.10 Organization of the Thesis**

There are seven chapters in this thesis; it is organized as follows:

- Chapter 2- This chapter contains a literature review about GeoInformation, Google maps API and Mashup technology as well as summarizes related work, which are papers regarding this thesis.
- Chapter 3- This chapter describes the methodology and the phases of the application.
- Chapter 4- This chapter contains information about Sudan in general, also GeoInformation about Khartoum State as case study.
- Chapter 5- This chapter concentrates on the description, component and users function of the system. In addition, it includes the result with discussion.
- Chapter 6- This chapter provides conclusions and recommendations for future works with discussion and the references.

## **2.1 Literature Review**

### **2.1.1 Introduction**

In this chapter we concentrate on literature review about technologies we used in our thesis and more explanation about it. This also includes related works that explains what have been done by using these technologies and about the projects carried out. Therefore, there are three papers discussed using three different implementations. Thus, we demonstrate that, these technologies can provide a good application for the users and we can get benefit from maps services, as well as promote good services to the humans in order to enhance their life.

### **2.1.2 Background**

In this section we deliver a brief background about some concepts regarding our thesis, which are helpful to make the topic clearer and better understood. Below are the explanations of these concepts:

#### **2.1.2.1 GIS:**

GIS is an information system or technology which has strong capability to maintain and analyze geographic or spatial data (Luqman, M., Ahmad et al, 2015).

#### **2.1.2.2 Mashup technology:**

The term Mashup is historically rooted in musical style compositions, where recordings from different sources are combined into a new piece. On the Web it means taking information published from multiple sources and integrating it into a new information stream (Li, S. and Gong, J, 2008).

The main characteristics of a Mashup are combination, visualization and aggregation. The usage of the existing data in a more meaningful way for the professional or personal purpose. The basic principle involved in designing Mashups is the creation of new connotation by reusing and combining existing connotation from heterogeneous sources (Terumalasetti S., Jalgama R et al 2013).

### **2.1.2.3 Application Programming Interface (API):**

API is an interface to a software program that allows users to interact and customize the maps.

Google Maps API: allows wrapping up the Google Maps in web pages and customizes the Google maps. The developers can easily customize the Google Maps using the Google Maps API. The API provides the developer with a rich set of applications. The JavaScript is used to embed the maps in to the applications. The maps API web services provides many APIs like the Direction API, Distance Matrix API, Geocoding API, Elevation API, Time Zone API. The API is rich the libraries such as AdSense library, drawing library, Geometry library, Panoramic library, Places library, Weather library **(Google Maps 2017)**

### **2.1.2.4 Google maps**

Google Maps is a web mapping service application and technology provided by Google, that powers many map-based services. Google maps can display map images, topographic maps, satellite images and hybrid images. It can also achieve global location search, classified information access, traffic information queries, driving direction lines and even street scene 3-dimensional view and so on **(Neelu. L, Aruna, K. B et al, 2015)**

## **2.2 Related work**

In this section there are three scientific papers we use as related work in our thesis. All these papers use Google map API to overlay Geoinformation on Google maps, so we summarized these papers briefly to show what have been done. Below is the summation for each one of them.

### **2.2.1 Mashup technology with Google maps and .net Framework:**

**(T. Sailaja, et al, 2013)**

The application discussed in this paper is using Mashup technology with Google maps and .net framework for India's states. The application contents a database built on SQL server. The database which has been created includes two tables - the first table gives details of the location like latitudes, longitude, and the second table gives more details of location, for example which information is available for every specific state of India. The design of this application includes two pages; the first page gives the details of the locations that are available. The user could select the location from the available location on the drop down list. Then, the User can select any one of the available states. The list is available as a drop down list for the easy access of the user. Finally, the lists of states are retrieved from the database. The second page displays the location of state according to the choice of user. Therefore, the user could select location from the drop down list for a particular location to display any state on the map. The main contribution is that they are using map services and Mashup technology to display the states location for India, as well information about it to help people for better understanding to promote their different purposes.



### **2.2.2- Online map application development using Google map API, SQL database, ASP.net:**

**(S. Hu,T. Dai, 2013)**

This paper has demonstrated an online mapping application that was successfully developed using Google Maps API v3, Google Geocoding, Microsoft SQL Server Express database, and Spry Framework for Ajax. The case study presented in this paper provides the advanced functionality to display the locations and state-based summary counts of the United States Department of Agriculture (USDA) thousands of peoples' gardens on the Internet with customized icons and map legend. It also provides the sophisticated functionalities for searching, filtering, and tabbed interface, that offer the user the capability to manipulate the data. At the initial launch of the web page is the display of Google Maps with the number of gardens in each state. This gives the user a clear idea where most of the gardens are concentrated. There are two tabs, Find Gardens by Location and Find Gardens by State. The user can click one of them to perform the search functions. Online mapping from a database being updated in real time can be very useful for many purposes. First, the database can be collected from an online registration process that, along with other information contains locational information such as latitude and longitude or street addresses. This is the way how the USDA people's garden information has been gathered. Such database can be stored on a secure server inside a firewall. Second, once the data has been collected and stored, it can be easily and directly retrieved in full or partially for online mapping application without going through a data format transformation as it has been done in the past (e.g., XML). Third, the backend database can be updated through the database interface and the resulting data changes will be reflected immediately on the web interface. Fourth, complex data manipulation can be carried out using the powerful SQL scripts in the backend databases.

### **2.2.3 Web mapping with Google maps Mashup: overlaying geodata:**

**(I. O. Bildirici et al, 2010)**

In this paper, first of all the Google maps API family is introduced and then the overlay possibility on the map is discussed. Furthermore, they examine KML and XML overlays and propose an XML schema for their application. They have established an application by using XML overlay methodology. The application includes two maps: An earthquake map of Konya and a City map of Konya (turkey). The earthquake map of Konya data includes the date of Earthquake, time of Earthquake, geographical coordinates, magnitude, depth, and place name. The authors developed a program that converts earthquake data into XML format. Attributes such as date and time and magnitude are taken as additional semantics, with which thematic representation are created. By using buttons users can see all Earthquakes occurred, or filter them according to the month. The default view is a physical map. Users can switch to the road map or satellite image. Some information about the road topic is added at the right hand of the web site. Another map is the city map of Konya which is created for visitors of the department of geometrical engineering of Selcuk University. For this purpose, a number of point of interests POI were determined and an XML file was created. The POI, divided into 10 classes for the legend, are classified using for each class customized icons. Furthermore, for each POI an Infowindow is triggered by clicking the defined item, in which the name and description attributes are displayed on the map. All POI are the listed in a drop-down list box at the right side. When an item is selected, the item is centered in the map with a circle around. The content of the drop-down list is filled automatically from the XML file.

### **3.1 Overview**

In the previous chapters we discussed general concepts and related work about different ideas regarding GeoInformation System using Google Maps.

In this chapter we are going to discover more about our research idea and how to plan and implement the system to arrive finally at a Sudan GeoInformation System. First of all, we display the tools and programming language that we are using for the system and technology to be implemented. Furthermore, we are discussing in this chapter the methodology of the system, describing overall the system's structure and how it works.

Finally, this chapter discusses the methodology of research, which is used to create an online system for the geography of Sudan.

### **3.2 Tools and Technology**

In this research we use different tools and technology to implement the application which is called "Sudan GeoInformation System"; that includes different programming languages, GIS systems, a database management system, as well as web technology. Below a brief definition for every component is given:

#### **3.2.1 JavaScript:**

JavaScript is most commonly used in a web browser, and, in that context, the general-purpose core is extended with objects that allow scripts to interact with users, control the web browser, and, alert the document content that appears within the web browser window. It is commonly called client-side. JavaScript is about to emphasize that scripts which are running on the client computer rather than web server (**Flanagan, D., 2006.**).

### **3.2.2 MySQL**

MySQL is one of the most popular database management systems. It is a very fast and easy-to-use system distributed under an open source license by its manufacture **(Williams, H. E. and Lane, D., 2004).**

### **3.2.3 XAMPP**

XAMPP stands for Cross-Platform (X), Apache (A), MySQL (M), PHP (P) and Perl (P). It is a simple, lightweight Apache distribution, that makes it extremely easy for developers to create a local web server for testing purposes **(Walia, E.S. and Gill, E.S., 2014)**

### **3.2.4 PHP**

PHP is an open source product - it is server side scripting language designed specifically for the Web. PHP code is interpreted at the server and generates HTML or other output. PHP has many strength, including high performance interfaces to link many different database systems, is of low cost as well as portable **(Welling, L. and Thomson, L., 2003.).**

### **3.2.5 UML**

UML (Unified Modeling Language) is a standard language for specifying, visualizing, constructing, and documenting the artifacts of software systems. UML was created by the Object Management Group (OMG) and UML 1.0 specification draft was proposed to the OMG in January 1997. It was initially started to capture the behavior of complex software and non-software systems and now it has become an OMG standard. The tutorial ([www.tutorialspoint.com](http://www.tutorialspoint.com) 2017) gives a complete understanding on UML.

### **3.2.6 Enterprise Architect**

Enterprise Architect is a visual platform for designing and constructing software systems, for business process modeling, and for more generalized modeling purposes([www.sparxsystems.eu](http://www.sparxsystems.eu) 2107).

### **3.2.7 GPS**

The Global Positioning System (GPS) is fully operational and meets the criteria established in the 1960s for an optimum positioning system. The system provides accurate, continuous, world-wide, three-dimensional position and velocity information to the user with the appropriate receiving equipment (**Kaplan, E. and Hegarty, C., 2005**).

### **3.2.8 NetBeans IDE**

NetBeans is a free and open source Integration Development Environment (IDE), which complies with multiple programming languages. For a long time, it has been the editor of choice to major developer communities. Along with the growing market demand, NetBeans has integrated the PHP development features since NetBeans 6.5, and nowadays, it has become one of the most popular IDEs for the PHP community ([www.gps.gov](http://www.gps.gov) 2017).

## **3.3 Idea and Methodology:**

The aim of this research provides GeoInformation online and up-to-date to support and help different communities within Sudan and outside, by developing an Application which is called “Sudan GeoInformation System” simply by using Google maps. The research methodology and project planning is carried out in the following steps.

### **3.4 Data collection**

We collected real and up-to-date data and information about geography of Sudan by different data types, which are about localities coordinates, university coordinates and population of Sudan.

All that data and information we gained as PDF file and shape file, and all these files we collected from different foundations which are:

- 1.Center Bureau of Statistics
- 2.Khartoum State of Water Corporation

### **3.5 Data preprocessing:**

As we mentioned the data format is PDF files and Shape files, therefore that format is not compatible with our database, and moreover, not compatible at all with our research ideas. Thus it needs some preprocessing before being used in the database. Here we use ArcMap to preprocess this data in order to make it compatible for our purpose.

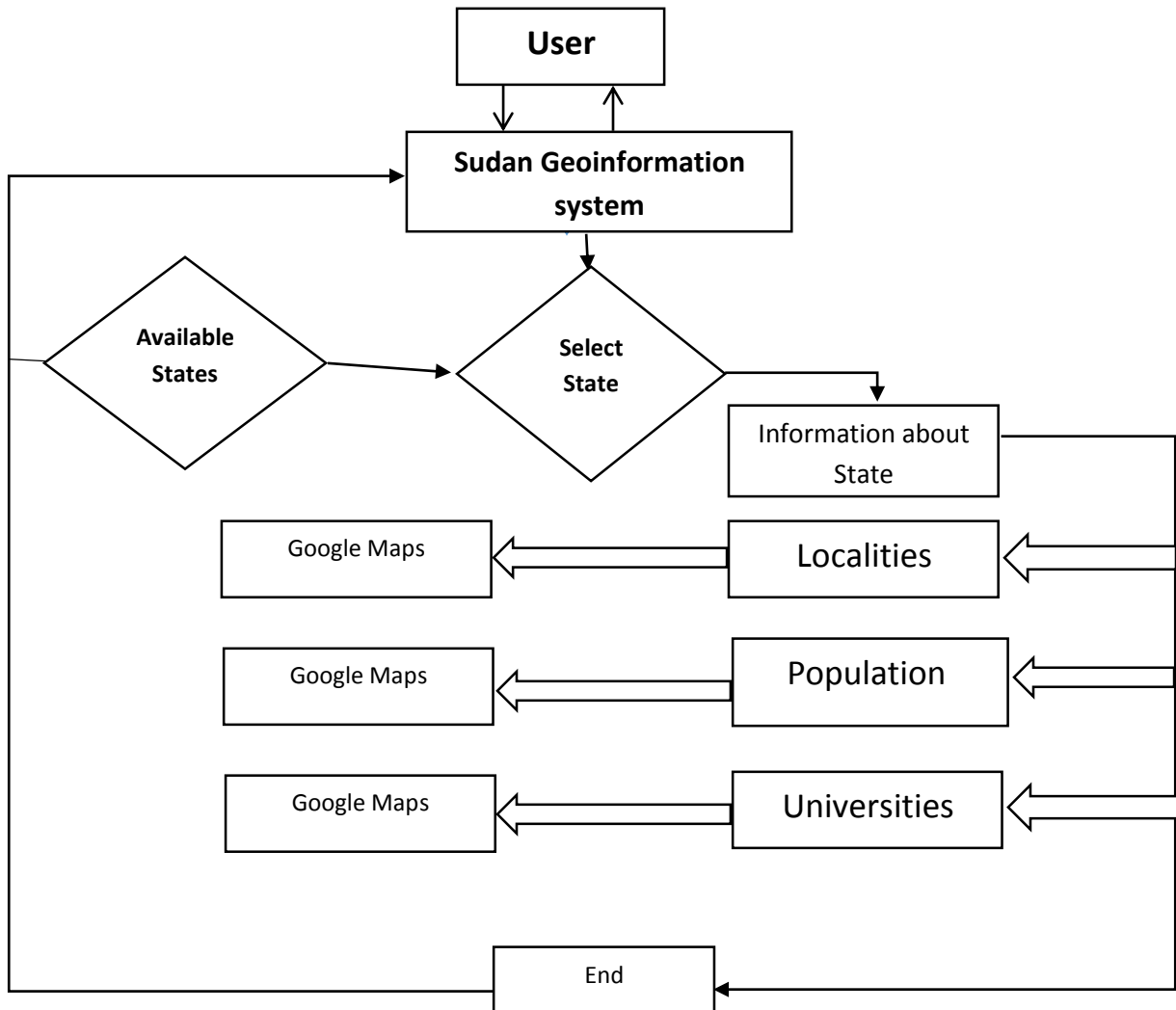
### **3.6 Description of System Structure:**

Sudan GeoInformation System includes two sides, which is the client side and the server side - each one is capable to do some data processing.

#### **3.6.1 Client Side:**

On this side the system enables the user to choose a particular state from the optional Sudan's States to show information about that State. However, there is another option for each state which is localities, population and universities;

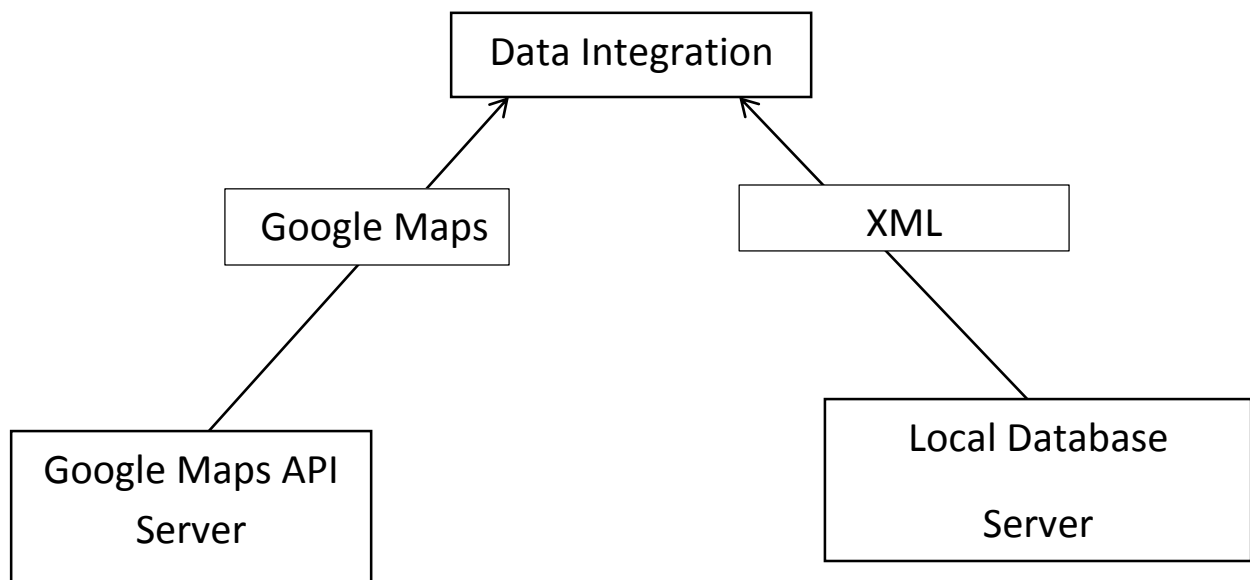
therefore, the user could visualize them on Google Map. The diagram (figure 3.1) below illustrates some data processing within the client side:



**Figure 3.1:** Data processing at the client side

### 3.6.2 Server side:

In this research we have two servers: the first one is the XAMPP Server with its database content representing GeoInformation about Sudan. The second one is the Google maps API Server which has maps; the diagram (figure 3.2) below illustrates data processing within the server side:

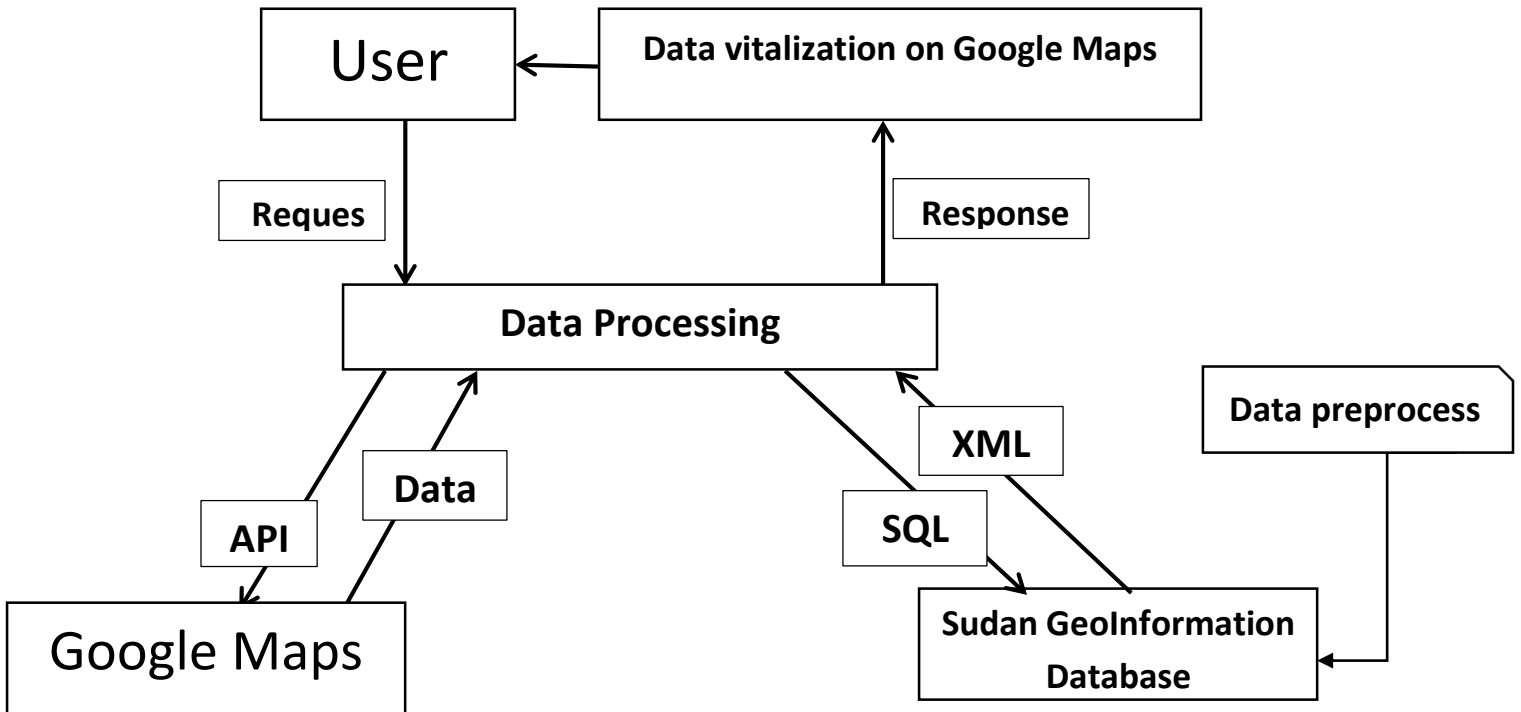


**Figure 3.2:** Data processing within server side

### 3.7 Phases of creating the application

- Design the User Interface by using HTML and CSS.
- Create the Database using MySQL database management system.
- Created the JavaScript files to embed Google maps API as well as the communication with server.
- Create PHP files to communicate with the database in order to return an XML file including coordinates of places as well as information.





**Figure 3.3:** Description of the whole system (Client-side, server-side)

### 3.8 Phases of creating the Database

A database has been created using the MySQL database management system. The database which is called “Sudangis” has two tables. One of them contents information about localities, which is a local table and the second one contents information about universities, which is the university table.

## 4.1 Introduction

In the previous chapters we did discuss the methodologies that we use to create the application, which we call “Sudan GeoInformation System using Google Maps”. In this chapter we are going to highlight some information about geography of Sudan, particularly that of Khartoum State.

**All the information in this chapter is gained from the Center Bureau of Statistics and from Khartoum State of Water Corporation.**

## 4.2 Geography of Sudan

Sudan is the third largest country in Africa. It is located in northeastern Africa and bordered by seven countries, that includes Egypt to the north, Eritrea and Ethiopia to the east, South Sudan to the south, the Central African Republic to the southwest, Chad to the west and Libya to the northwest as well as the Red Sea to the northeast (see figure 4.1). It had been the largest country until the 2011, when the independence of South Sudan was put into force.



**Figure 4.1:** Map of Sudan and neighboring countries

### **4.2.1 Sudan States**

Sudan has been divided into eighteen states. The States are (see figure 4.2):

1. Central Darfur State
2. East Darfur State
3. River Nile State
4. Khartoum State
5. Al-Gazira State
6. Al-Gedaref State
7. Red Sea State
8. The Northern State
9. Kassala State
10. South Darfur state
11. White Nile State
12. Blue Nile State
13. North Kordofan State
14. Western Kordofan State
15. West Darfur State
16. North Darfur State
17. Sennar State
18. South Kordofan State

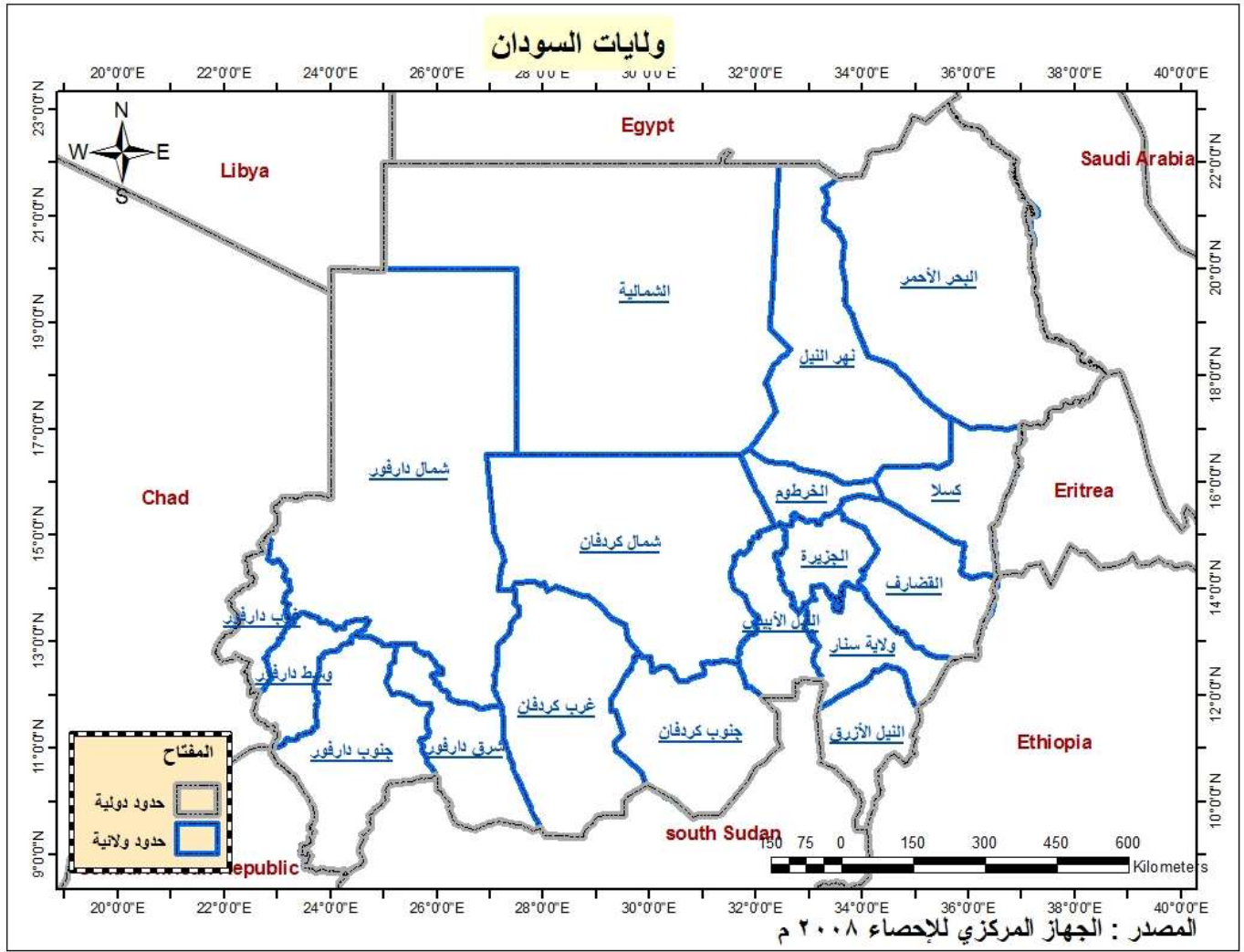
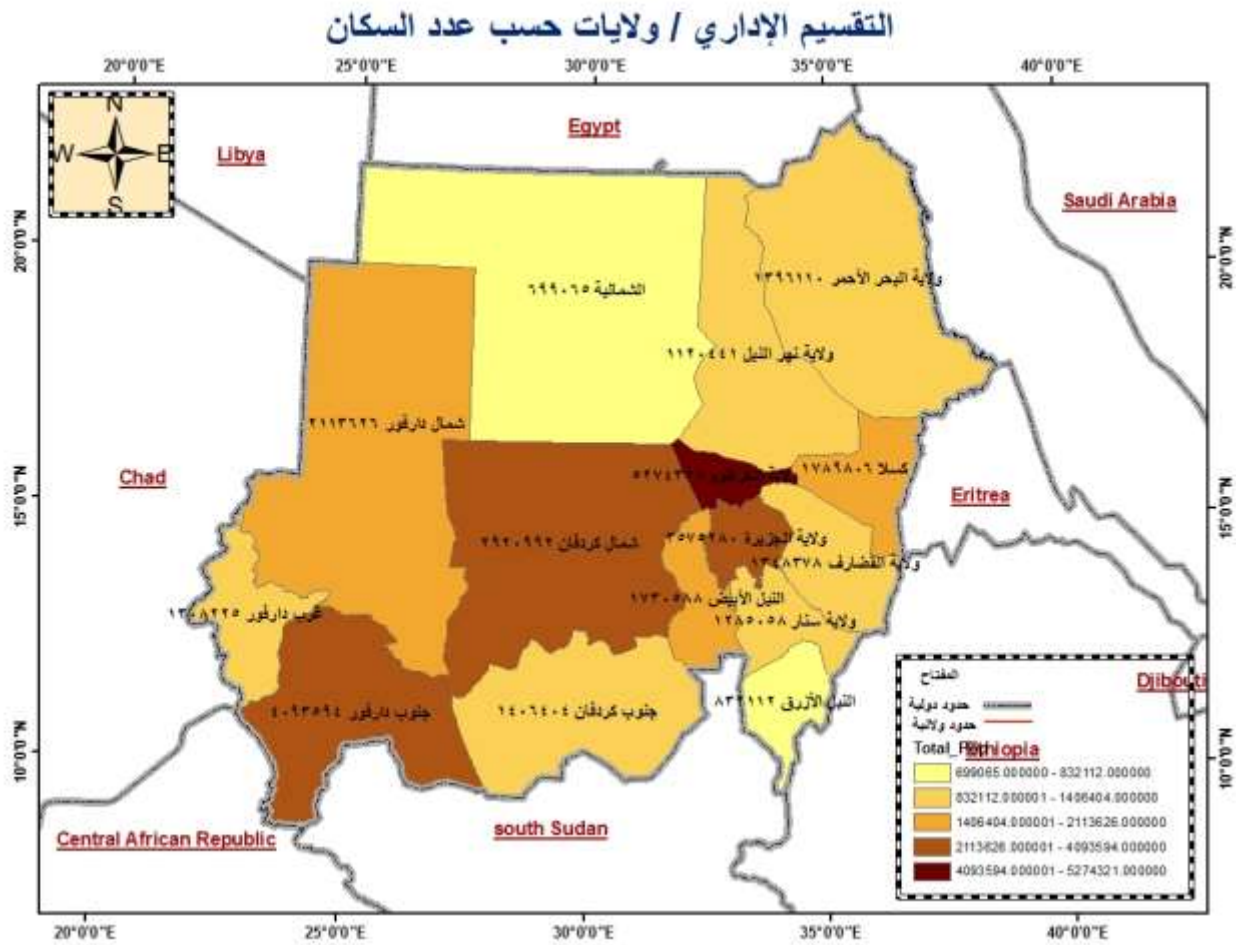


Figure 4.2: Sudan’s States maps

### 4.2.2 Population

The population of Sudan in the beginning of the year 2011 was estimated to be about (33.419.625) persons at a growth rate of 2, 53% annually (see figure 4.3). The population density reaches 14 persons for one square km. The Population of rural areas constitutes 24,6% of the total population. It is comprised from tribes that descend from Arab, African and Nubian origins.

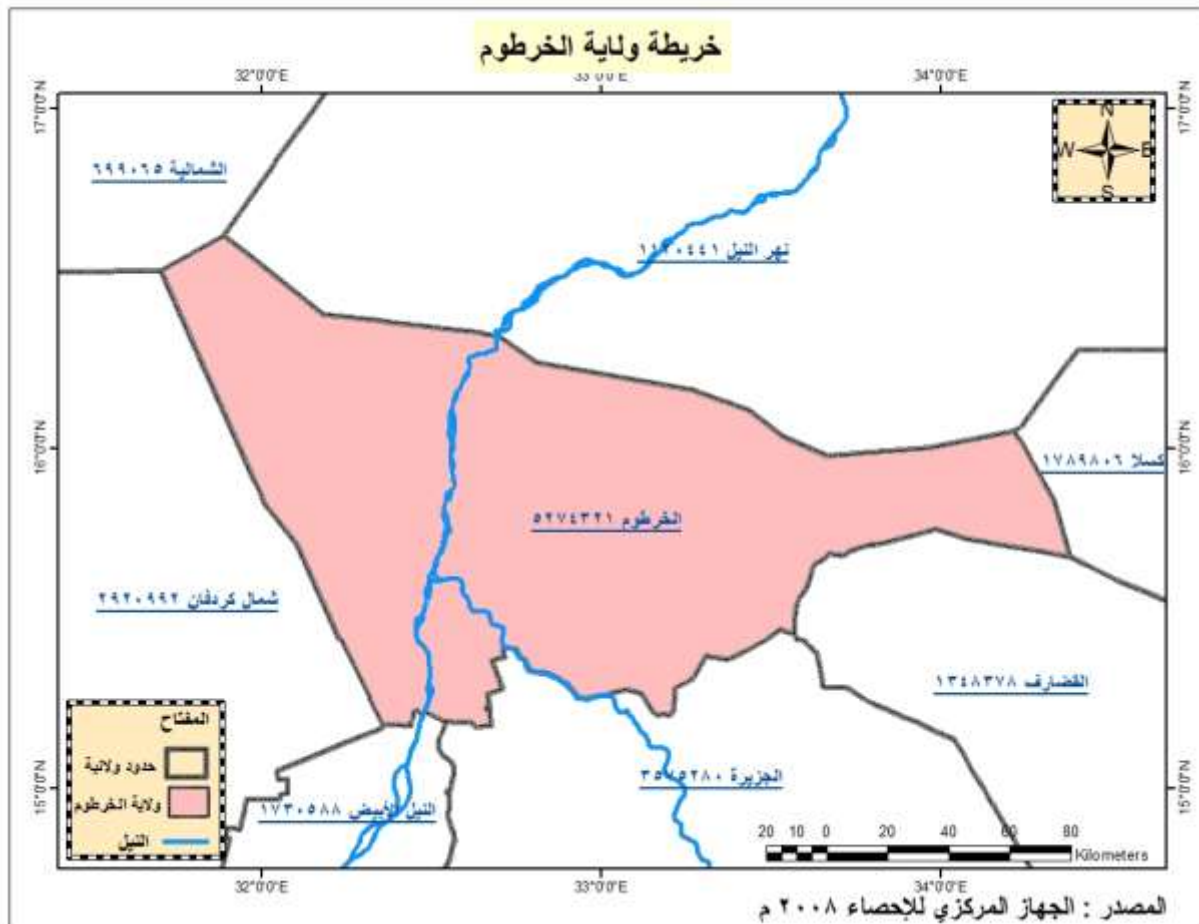


**Figure 4.3:** Sudan’s States according to population

### 4.2.3 Khartoum State

Khartoum State is one of the eighteen states of Sudan (see figure 4.4). Although it is the smallest state by area (22,142 sqkm), it is the most populous (5,274,321 in the 2008 census). It contains the country's largest city by population, Omdurman, and the city of Khartoum, which is the capital of the state as well as the national capital of Sudan. The capital city contains offices of the state, governmental and non-governmental organizations, cultural institutions, and the main airport. The city is located in the heart of Sudan at the confluence of the White Nile and the Blue Nile, where the two rivers unite to form the River Nile. The confluence of the two rivers creates a unique effect. As they join, each river retains its own color:

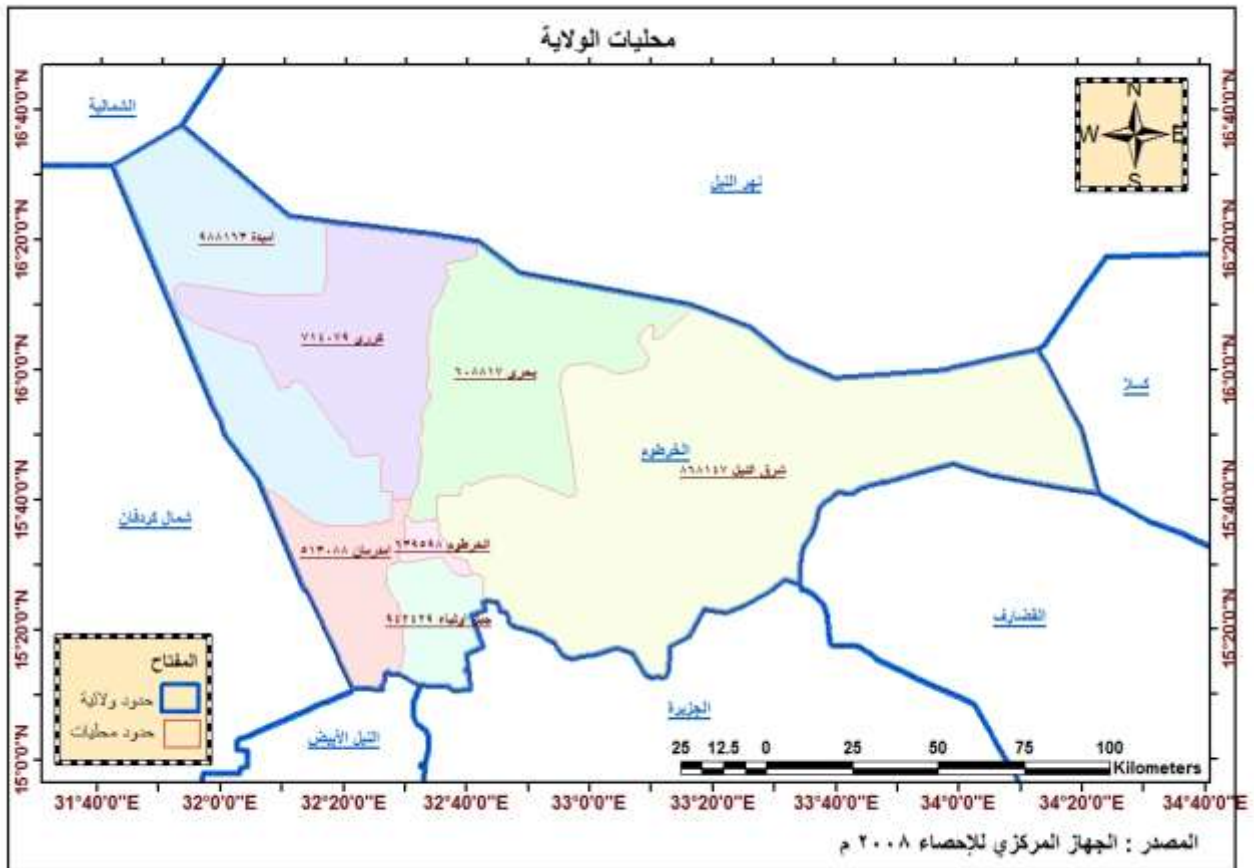
The White Nile with its bright whiteness and the Blue Nile with its alluvial brown color. These colors are more visible in the flood season. The state lies between longitudes 31.5 to 34 °E and latitudes 15 to 16 °N. It is surrounded by River Nile State in the north-east, in the north-west by the Northern State, in the east and southeast by the states of Kassala, Gedaref and Gezira, and in the west by North Kurdufan.



**Figure 4.4:** Khartoum and neighboring states

#### 4.2.3.1 Khartoum's localities (see fig. 4.5):

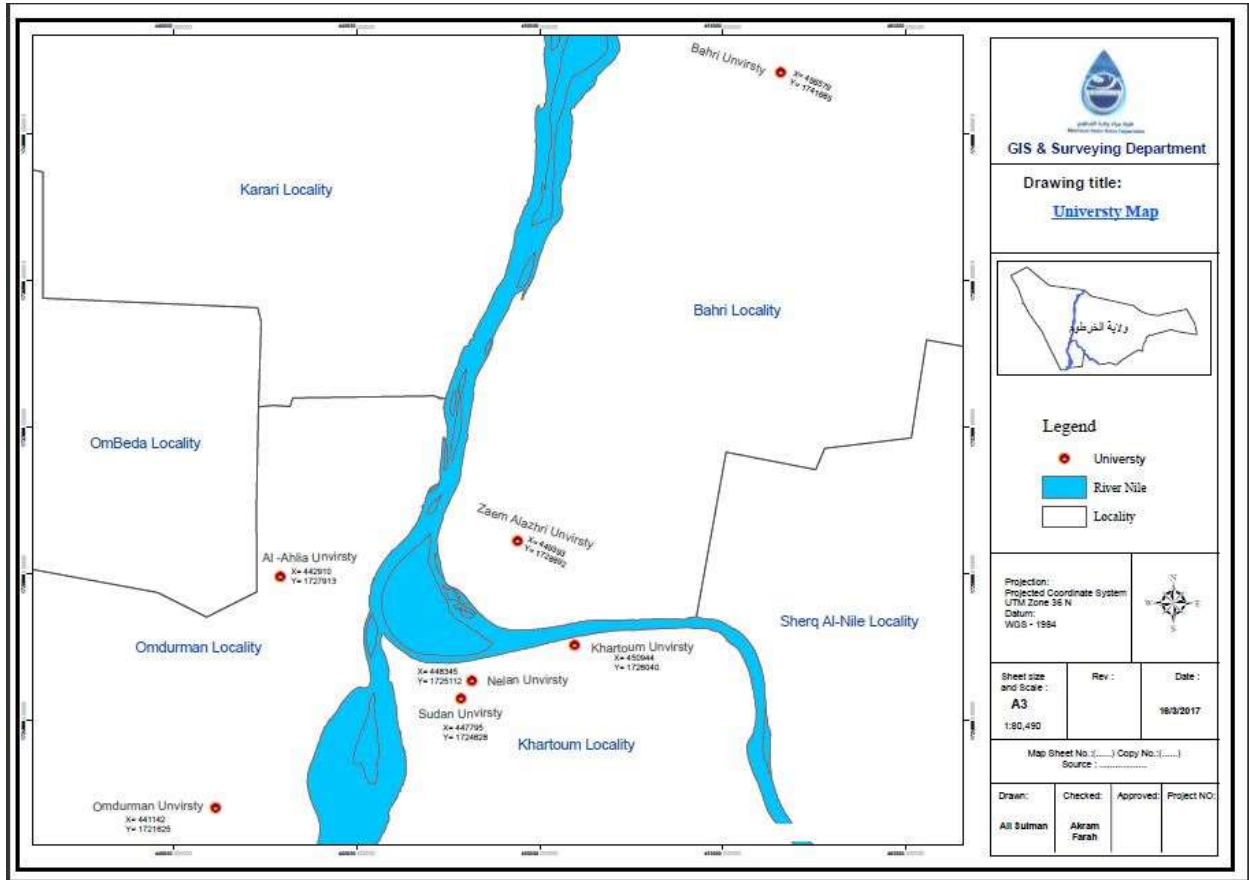
1. Khartoum locality
2. Bahri locality
3. Omdurman locality
4. Jabal awlia locality
5. Karray locality
6. Ombada locality
7. Shargh Elneil locality



**Figure (4.5):** Distribution of localities and Population of Khartoum State

In figure 4.6 the location of some public universities of Khartoum State is presented.





**Figure 4.6:** Some of public Universities in Khartoum State



## **5.1 Introduction**

This chapter presents the description, component, and user function of the application called “Sudan GeoInformation System”. In addition, it discusses the implementation of the application as well as analyses. Moreover, it also introduces an explanation of the application workflow and how users deal with the application. At the end of this chapter, it shows results of our research.

## **5.2 System Description**

The mechanism of the application is based on getting location of specific places, which are the States, localities and universities from the database and then relay it on Google maps. It is also getting the population data from the database and shows it on Google maps, according to the specific State.

### **5.2.1 User of the system:**

Anyone can visit the application online and can look for the content, which is state map, state’s localities, and population without having any authorization for them.

### **5.2.2 Administration of the system:**

One has full authority to access the database and to add information or edit information to the database. Moreover, we offer full authority to add or edit location (longitude and latitudes) of State, local, and university, as well as population.

### **5.2.3 User function**

The user has authority to carry out the functions below:

- Type URL to view Sudan GeoInformation System
- Choose State to view it on the map
- View Localities on the map
- View Population on the map
- View Universities on the map

#### **5.2.4 Administrator function**

The Administrator has authority to carry out the functions below:

- Add/edit State location
- Add/edit local location
- Add/edit population
- Add/edit university location

#### **5.2.5 System function**

- Retrieving results according to the selected data by the user.
- Shows state map on the map.
- Shows localities, population, universities on the map.

### **5.3 Application component**

The application consists of two components: hardware and software

#### **5.3.1 Hardware component**

- The computer works as server and manages the database that has Geodata for Sudan GeoInformation System.
- Google maps API server.

#### **5.3.2 Software component**

This component is divided for two sides:

- **User side:**

Sudan GeoInformation System enables the user to view information, states, localities, population and universities location online on Google maps.

- **Server side:**

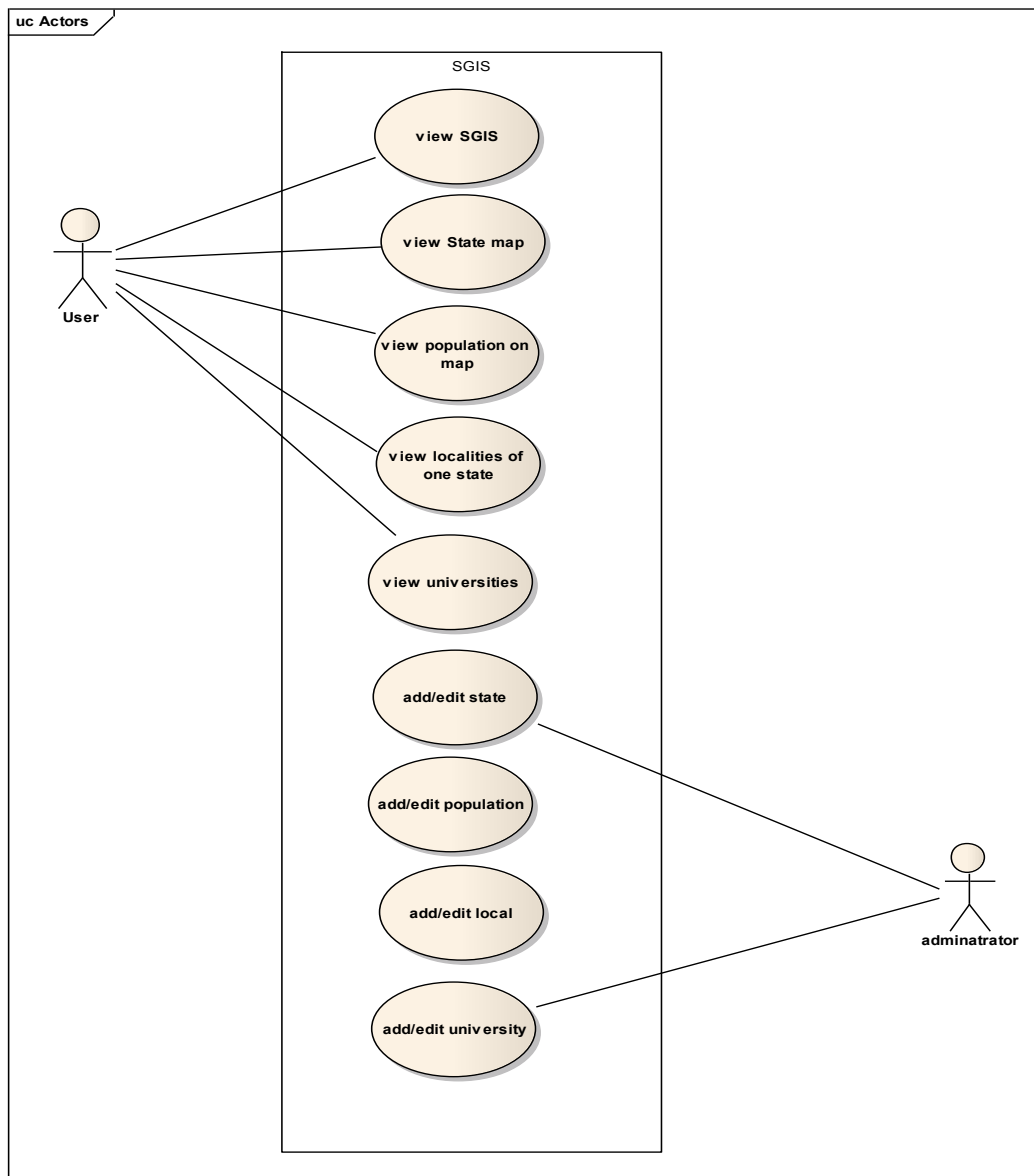
Consists of MySQL database management system which is managing Sudan GeoInformation's database and PHP files.

## 5.4 Analysis of application:

### 5.4.1 Use Case Diagram:

A use case diagram is a schema used to identify the different types of actors and represents their function and interaction with the system.

**Figure 5.1** illustrates the use case diagram of the system and the processes to be carried out.



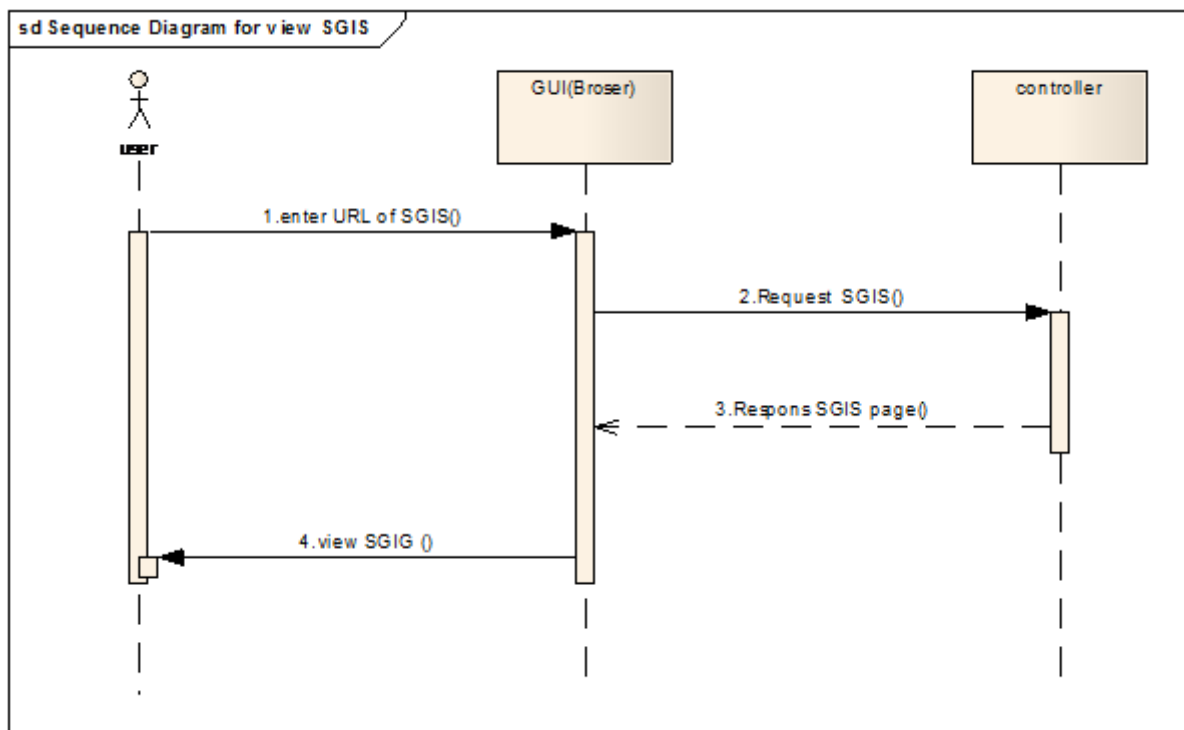
**Figure 5.1:** Use Case Diagram

### 5.4.2 Sequence Diagram

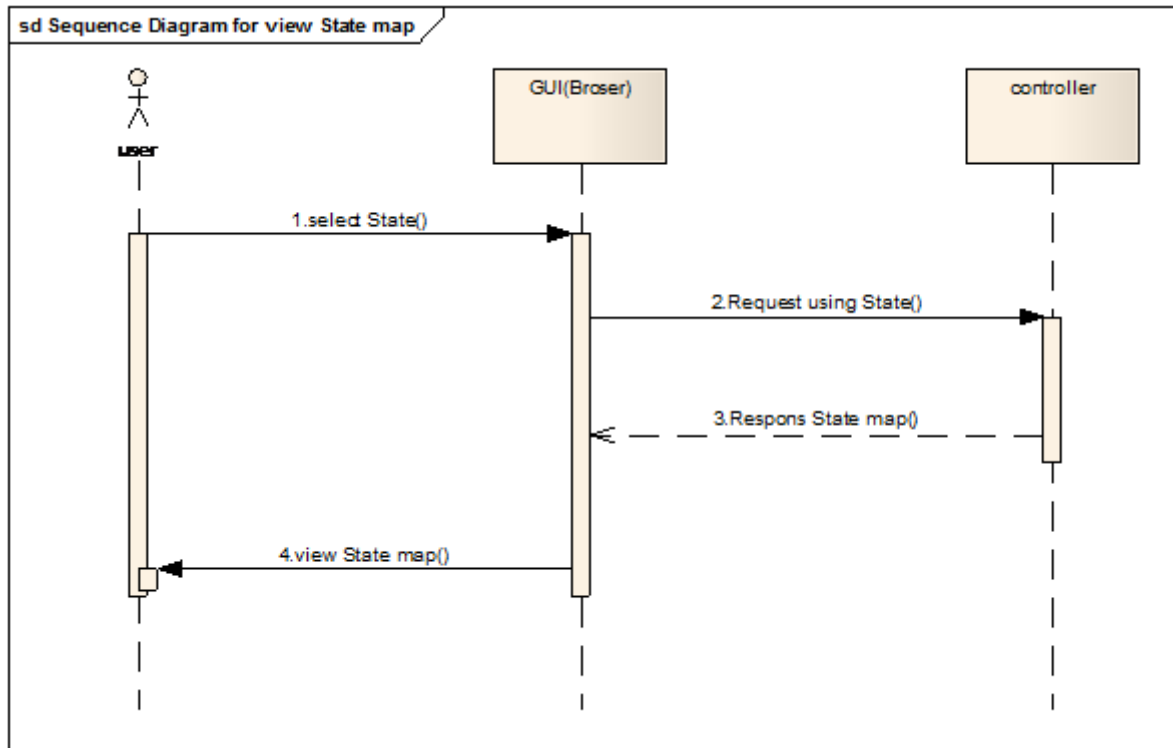
A sequence diagram is a schema to show how the processes cooperate with each other, and in what order they appear. It also shows the flow of data and messages between the various components of the system.

- The horizontal component in the diagram shows the objects in the system.
- The vertical components show the order of messages exchanged.

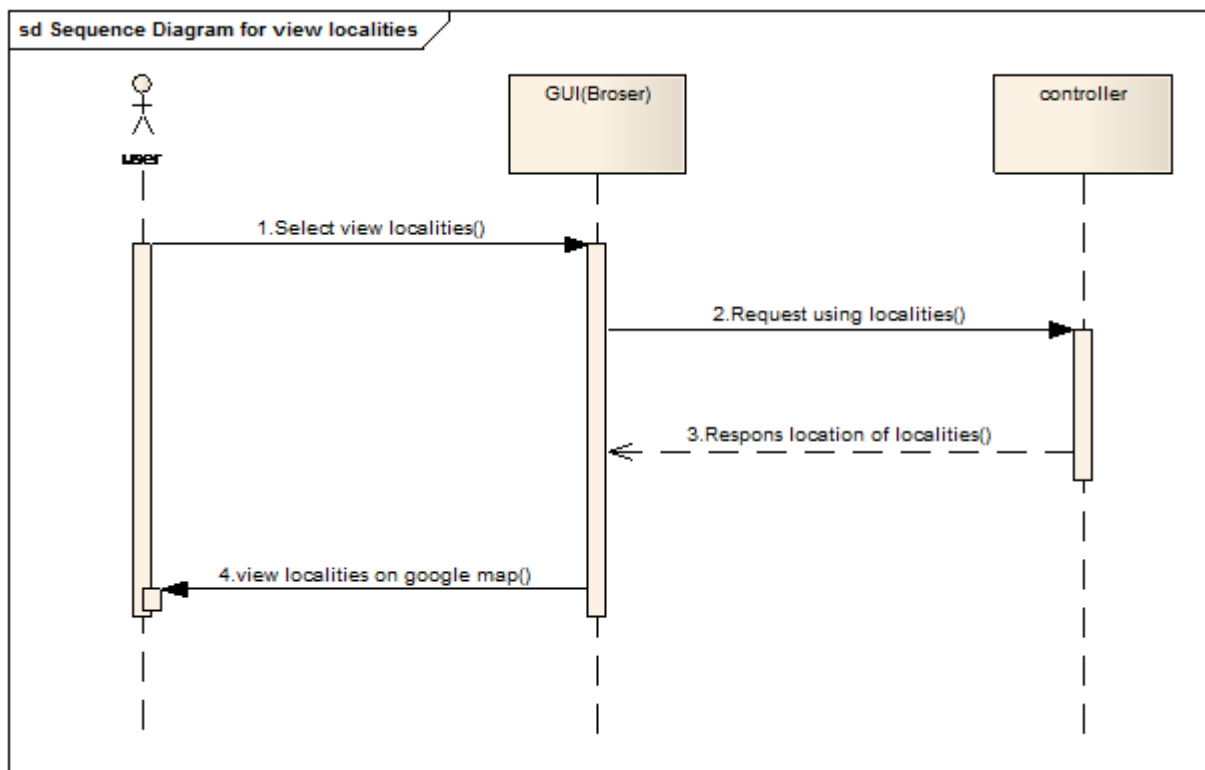
In total eight sequence diagrams for this system are used. Each of them illustrate a function provided by the system, whether to the user system or system administrator.



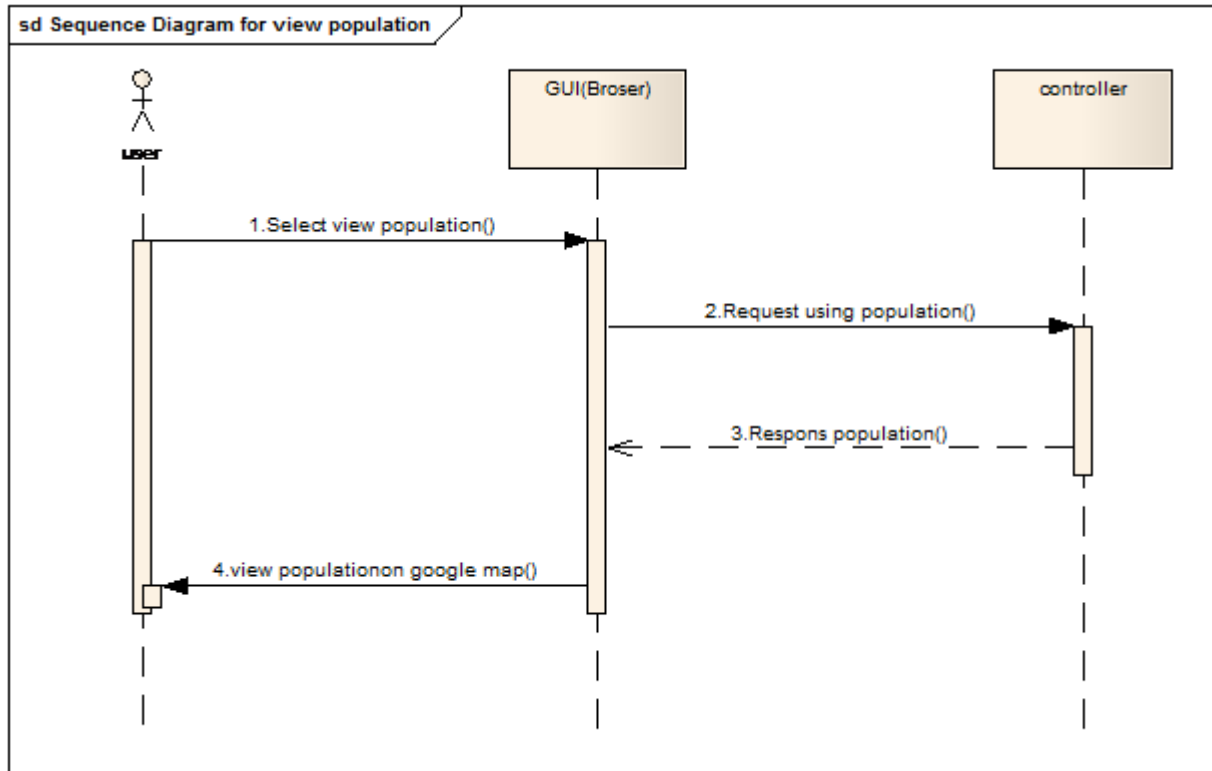
**Figure 5.2:** Sequence diagram for viewing Sudan map



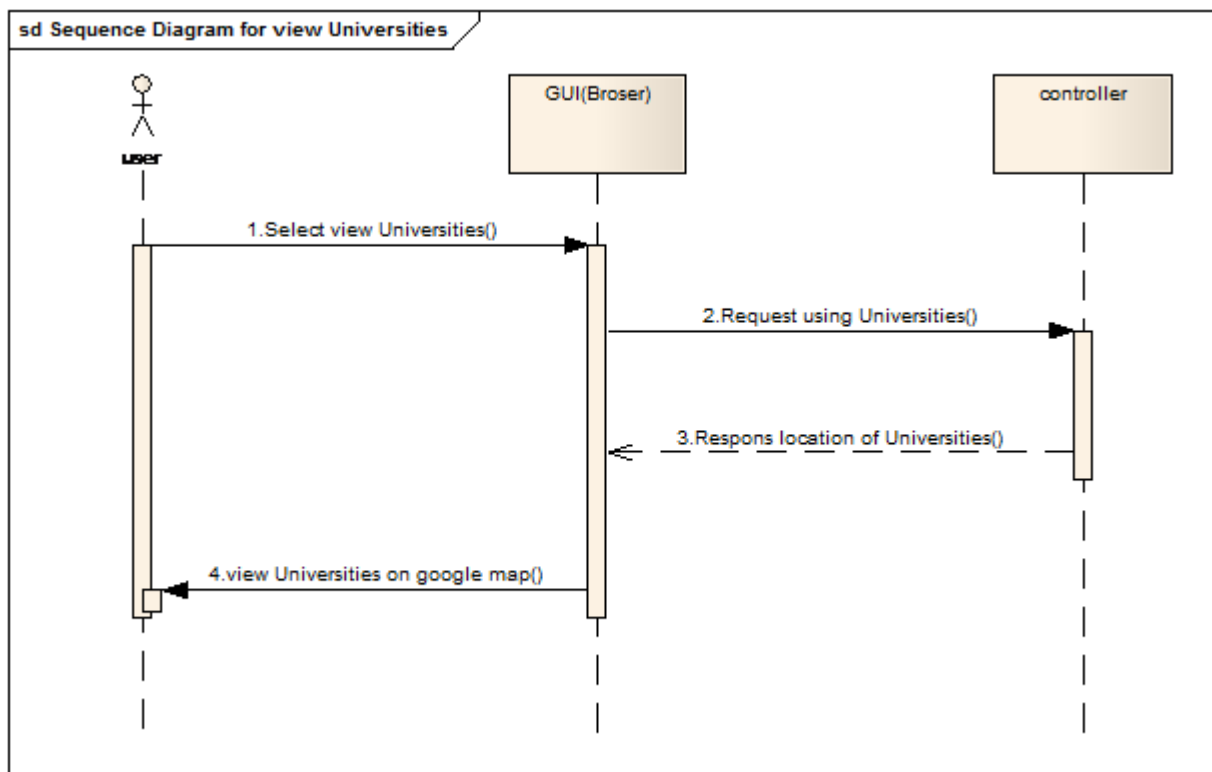
**Figure 5.3:** Sequence diagram for viewing the State map



**Figure 5.4:** Sequence diagram for viewing the localities



**Figure 5.5:** Sequence diagram for viewing the population data



**Figure 5.6:** Sequence diagram for viewing the Universities

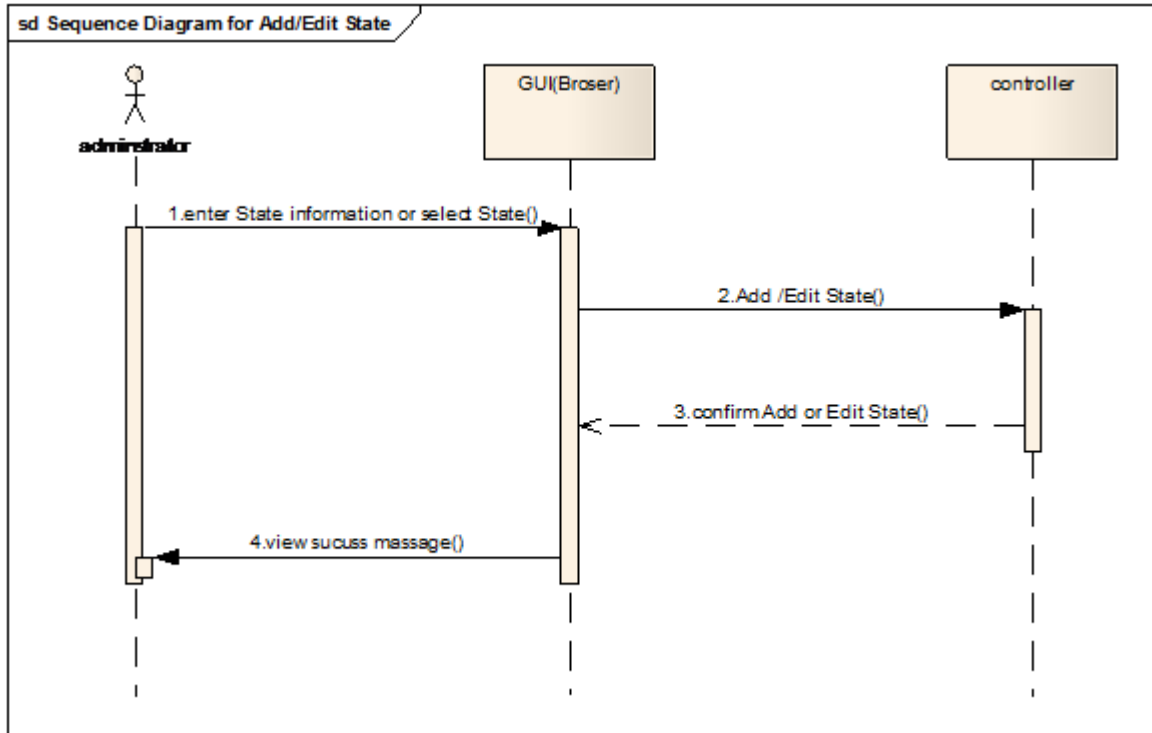


Figure 5.7: Sequence diagram for Add/Edit State

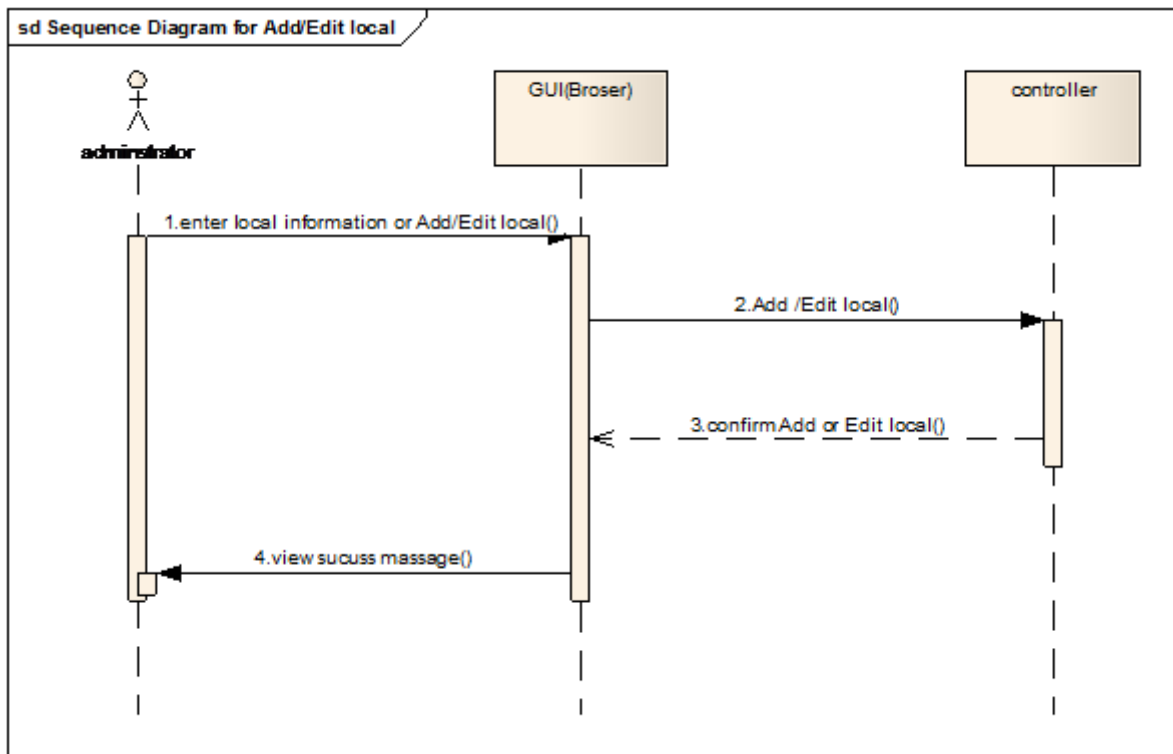


Figure 5.8: Sequence diagram for Add/Edit local

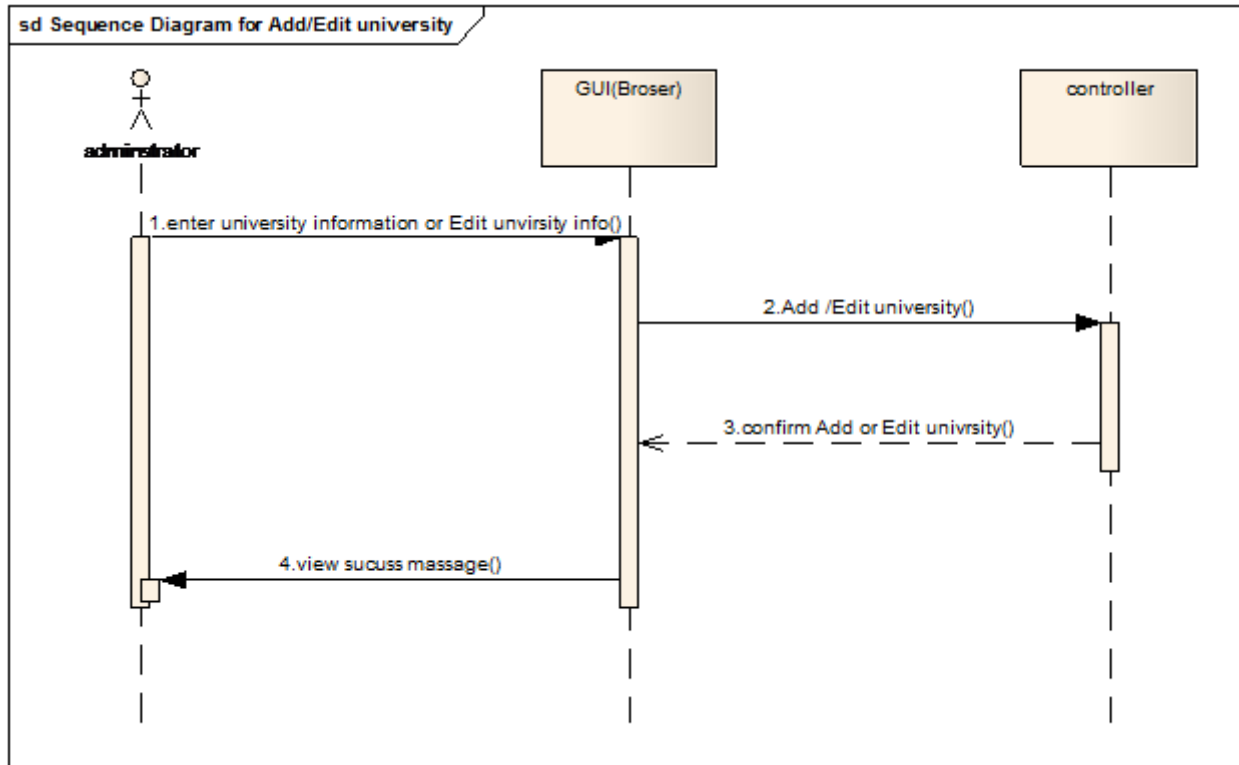


Figure 5.9: Sequence diagram for Add/Edit university

### 5.4.3 Deployment Diagram:

The deployment diagram illustrates hardware and software used in the system and how these components interact with each other.

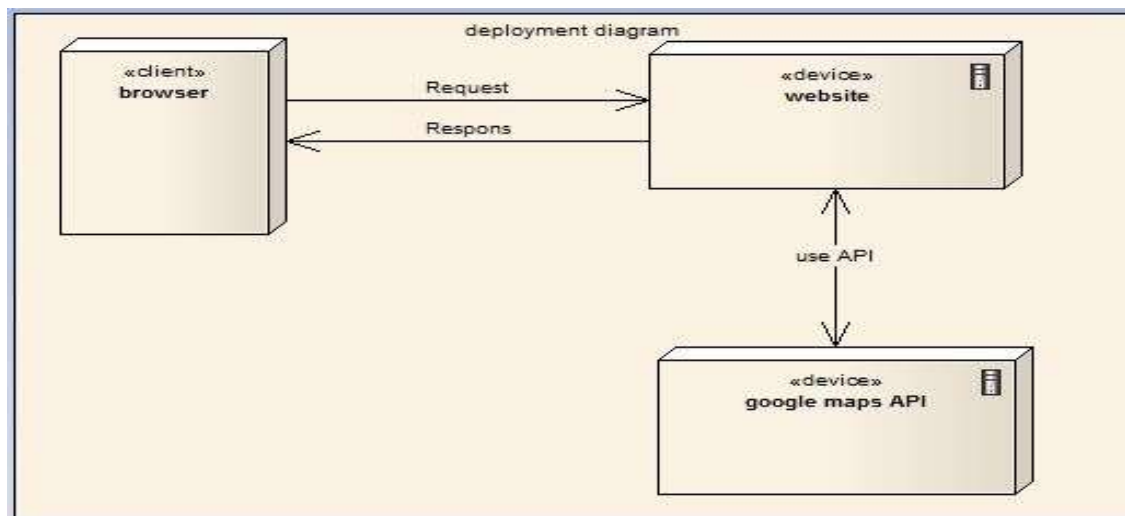


Figure 5.10: Deployment Diagram



## 5.5 Implementation and Application Interfaces:

### 5.5.1 Main page for Sudan GeoInformation system



**Figure 5.11:** Main page for Sudan GeoInformation system

This is the home page of the system; therefore, the user could explore the whole system through the buttons below of the page. It is kept very simple to show localities, population and universities of any state of Sudan according to selected specific state (as it is here only Khartoum state as a case study).

## The selection interface



**Figure 5.12:** The selection interface-1

The figure above shows the marker which was centered on a specific state's location according to the selection of the user. Below are buttons enabling the user to show localities, population, and universities of that State.

## Localities



**Figure 5.13:** The selection interface-2

The figure above shows the markers which are centered on location of localities, according to the selection of the user.

## Universities



**Figure 5.14:** The selection interface-3

The figure above shows the markers which are centered on location of universities. according to selection of the user.

## Population



**Figure 5.15:** The selection interface-4

The figure above shows the markers which are centered on location of localities, in order to show population data.

## The resulted information interface:



**Figure 5.16:** The result of showing specific locality.





**Figure 5.17:** The result of showing specific university.



**Figure 5.18:** The result of showing population data about a specific locality area.

## **5.6 Results:**

After executing the application and carrying out several tests the following results are figured out:

- The application allows the user to overlay information on Google maps
- The application allows the user to view location of localities on Google maps
- The application allows the user to view location of population data on Google maps
- The application allows the user to view location of universities on Google maps.

The tests have proven that the system developed fulfills the requirements given in the system design.



## **6.1 introduction**

In the previous chapters we have discussed the contents of this thesis in many different aspects. As an outcome we have gained nice results, which we have expected before starting work on this thesis. In the following we formulate conclusions for the Master's Thesis, to accentuate clearly what has been done, as well as we give some recommendations for what we expect in the future.

## **6.2 Conclusions**

This thesis has demonstrated a system for Sudan, which is zed "Sudan GeoInformation System". It was successfully developed using Google Maps API v3, Mashup technology, MYSQL database management system, PHP and JavaScript.

After testing the system and showing the results, it provides good information about Sudan via overlaying this information on the Google maps to make it simple to use and easier to read for different users. This system provides support for the users with different purpose, who want to know trustful information and up-to-date geography about Sudan.

The system described in this thesis can be easily modified and updated to meet the requirements of such important tasks

## **6.3 Recommendations**

After the completion of this project and the many tests carried out, we recommend the following to enhance the system and to make it more benefit and more powerful:

1. Adding all states of Sudan for the system to make it an overall system for different users.
2. Adding road maps for the system in order to help people to know the different roads in Sudan.
3. Adding some more geoinformation for the system in order to provide more details for the users.
4. Developing the system further to meet new the technologies, as well as make it properly work on different platforms.
5. Connect the system with Google Earth.
6. Using online ArcGIS to enhance functions of the application.

## References

Bildirici, I.O. and Ulugtekin, N.N., 2010. Web mapping with Google maps mashups: overlaying geodata. In A special joint symposium of ISPRS technical commission IV & AutoCarto in conjunction with ASPRS/CaGIS 2010 fall specialty conference, Orlando, FL, pp. 15-19.

Dincer, A. and Uraz, B., 2013. Google Maps JavaScript API Cookbook. Packt Publishing Ltd.

Flanagan, D., 2006. JavaScript: the definitive guide. " O'Reilly Media, Inc."

Google Maps ,2017, Getting Started: Google Maps JavaScript APIv3 [shttps://developers.google.com/maps/documentation](https://developers.google.com/maps/documentation).

GoogleDeveloper,2017,[shttps://developers.google.com/maps/documentation/javascript/tutorial](https://developers.google.com/maps/documentation/javascript/tutorial)

Gunawan, K. and Purnama, B.E., 2015. Implementation of Location Based Service on Tourism Places in West Nusa Tenggara by using Smartphone. IJACSA) International Journal of Advanced Computer Science and Applications, 6(8)

Hu, S. and Dai, T., 2013. Online Map Application Development Using Google Maps API, SQL Database, and ASP .NET. International Journal of Information and Communication Technology Research.

Kaplan, E. and Hegarty, C., 2005. Understanding GPS: principles and applications. Artech house.

Li, S. and Gong, J., 2008, Mashup: A new way of providing web mapping/GIS services. In ISPRS Congress Beijing.

Luqman, M., Ahmad, S.R., Khan, S., Akmal, F., Ahmad, U., Raza, A., Nawaz, M., Javed, A. and Ali, H., 2015, GIS Based Management System for Photovoltaic Panels. Journal of Geographic Information System.

**Neelu. L, Aruna, K. B, Shashidhar, V, Bharath J, 2015. Location Based Reminder Using Android and Google Maps. International Journal of Innovative Research in Computer and Communication Engineering.**

**sudan.gov.sd, 2017, [sudan.gov.sd /index.php/en/pages/details/74/Sudan%20states#.WOUuZrj\\_rIU](http://sudan.gov.sd/index.php/en/pages/details/74/Sudan%20states#.WOUuZrj_rIU)**

**Terumalasetti S., Jalgama R., Lakshmi, D.R., 2013, A Mashup technology with Googlemaps and .net framework. International Journal on Advanced Computer Theory and Engineering (IJACTE).**

**Tonu, M.H., 2012. PHP Application Development with NetBeans. Packt Publishing Ltd.**

**Walia, E.S. and Gill, E.S., 2014. A framework for web based student record management system using PHP. International Journal of Computer Science and Mobile Computing.**

**Welling, L. and Thomson, L., 2003. PHP and MySQL Web development. Sams Publishing.**

**[www.sparxsystems.eu](http://www.sparxsystems.eu),Enterprise Architect, 2017, <http://www.sparxsystems.eu/start/home/>**

**[www.gps.gov](https://www.gps.gov/),2107 GPS, <https://www.gps.gov/>**

**[www.tutorialspoint.com](http://www.tutorialspoint.com), 2017 ,UML tutorial ,[www.tutorialspoint.com/uml/](http://www.tutorialspoint.com/uml/)**

**Williams, H. E. and Lane, D., 2004. Web Database Applications with PHP and MySQL: Building Effective Database-Driven Web Sites. " O'Reilly Media, Inc."**