

Masters Program in **Geospatial Technologies**



A web based geospatial application for disaster preparedness in Uganda

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**A web based geospatial application for disaster
preparedness in Uganda**

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ABSTRACT

The power of Geospatial technologies in first world countries is increasingly being harnessed to manage disasters; this is not the same case for Uganda a disaster prone country in East Africa. For regions in the blankets of Mt. Rwenzori in the west and Mt. Elgon in the east, every year brings with it new challenges in the field of disaster management. When disasters happen in Uganda, government agencies and different Humanitarian Organizations run to the aid of the affected, relief is provided and rehabilitation activities carried out, but there remains little usable GI of the affected areas (Farthing & Ware, 2010). If disaster preparedness and management is dependent on accurate analysis and mapping of vulnerability and susceptibility of communities to risk (Office of the Prime Minister, 2010) and there exists data gaps and challenges (NEMA/UBOS, n.d.) in the country, how then can disaster managers carry out vulnerability assessment of communities? This thesis examines the possibility of providing disaster managers the means to assess the vulnerability of communities to risk by suggesting a solution for data acquisition and developing a web application based on interoperable modular components to act as a platform where this analysis can be performed.



KEY WORDS

Disaster preparedness

Floods

Modular design

Visualization

Vulnerability Assessment

Web application



ACRONYMS

- API**-Application Programming Interface
- EPSG**- European Petroleum Survey Group
- GDACS**- Global Disaster Alert and Coordination System
- GI**- Geographic Information
- GIS**- Geographic Information Systems
- GT**- Geospatial Technologies
- HTTP**- Hyper Text Transfer Protocol
- IDE**- Integrated Development Environment
- Java EE**- Java Platform, Enterprise Edition
- JRC**- Joint Research Centre (European Commission)
- JSP**- JavaServer Pages
- JSTL**- JavaServer Pages Standard Tag Library
- NGO**- Non Government Organization
- OGC**- Open Geospatial Consortium
- OLAP**- On-Line Analytical Processing
- QIVA**- Query Insert Visualize Analyze
- SOLAP**- Spatial On-Line Analytical Processing
- UNOSAT**- United Nations Operational Satellite Applications Programme
- Virtual OSOCC**- Virtual On-Site Operations Coordination Centre
- WFS**-Web Feature Services
- WMS**-Web Map Services



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1 INTRODUCTION

This chapter introduces the reader to the thesis detailing its motivation and contributions alongside the main objectives. The reader will realize the need for geospatial technologies in the event of natural disasters and why these tools are not being utilized in Uganda for disaster management.

1.1 Background

For countries known as first world, technology is a big part of managing, planning and mitigating response to natural disasters. In Uganda, a disaster prone country in East Africa, computer use is existent but the power of computer technology is not being harnessed to the maximum (Farthing & Ware, 2010). Such power lies in the use of Geospatial technologies and this is lacking in Uganda disaster management.

When disasters happen in Uganda, government agencies and different Humanitarian Organizations run to the aid of the affected, relief is provided and rehabilitation activities carried out, but there remains little usable GI of the affected areas (Farthing & Ware, 2010). The aftermaths of these events leave the economy drained (Raddatz, 2009) and the affected areas more vulnerable to the coming disasters. One of the reasons why GIS tools are not widely used in the disaster scenario is the lack of disaster data to feed them and if it exists, getting one's hands on it is very costly (Farthing & Ware, 2010). On the other side of things, the media always provides the status of emerging events in news affairs. This disaster information can be mined from various press resources like newspapers and broadcasts, Non Government Organization (NGO) state of emergency reports and websites such as Relief Web 1 and GDACS2.

"All preparedness activities must be based on knowledge about hazards [...]" (Sutton & Tierney, 2006). This disaster preparedness planning involves many categories ranging from Hazard Knowledge tasks which entail hazard

¹ <http://reliefweb.int/>

² <http://old.gdacs.org/index.asp>



Identification and Risk, Impact, and Vulnerability Analysis to Life and Property protection tasks.

1.2 The Problem

The problem to address in this thesis concerns with Vulnerability Assessment (Kent, 1994) a dynamic process that assesses hazards and risks, establishes a data base that focuses upon the likely effects of potential hazards and anticipates relief needs and available resources.

For disaster managers to identify entities susceptible to damage from the effects of natural disasters as is required by vulnerability analysis, they need access to disaster data. Inderjit (Inderjit, 2007) makes clear the need for data in disaster management; however, this is not possible in Uganda due to the existing data gaps and challenges (NEMA/UBOS, n.d.).

Among the challenges raised, Lack of modern and efficient data collection equipment, computing facilities for digitizing the data, Limited or no data both old and new, Limited incentives to collect data and Lack of standardization and harmonization of data leading to unreliability, non uniformity and conflicting data sets present great difficulties in the disaster management field. The frequency of disaster events also sidetracks the possibility of knowledge discovery activities to be performed using the accumulated data.

Disaster preparedness and management is dependent on accurate analysis and mapping of vulnerability and susceptibility of communities to risk (Office of the Prime Minister, 2010). These analysis tasks are stated to involve geo-referencing, mapping and livelihood zoning of communities. How this study proposes to solve the stated problem follows next in the objectives.



1.3 Objectives

The aim of this study is to examine the possibility of providing disaster managers the means to assess (analyze and map) vulnerability of communities to risk.

To fulfill the above aim, the following objectives need to be addressed;

1.3.1 Determine community risks.

It was highlighted in section 1.2 that disaster managers need access to data and yet this data is not (easily) available. As part of this task, this thesis suggests a way to collect, store and maintain information about community risks in answer to the data problem.

1.3.2 Provide a platform for mapping and analysis of community vulnerability to the risks identified.

A probable method to deal with this task is to design and implement a web application based on interoperable and modular components to act as the platform for mapping and analysis of community vulnerability to the said risks. The usability of this application for vulnerability assessment is then examined in a user scenario.

Modularity is a concept that goes back as early as (Parnas, 1972). The author discusses modularization as a mechanism for improving flexibility and comprehensibility of a system. The basic idea behind modular design is to organize a complex system as a set of distinct components that can be developed independently and then plugged together (Hill, 2011).

1.4 Scope

1.4.1 Geographic scope

The East and Western parts of the country have a long history of natural disasters. These regions are under the blankets of Mt Rwenzori in the West and Mt Elgon in the East. For this study, a small section of Eastern Uganda (figure 1) is studied. The region is mostly swampy and a basin for rains from the Elgon mountain. This fact means the whole area is flood prone. Flood events are intensified by the rise in water levels of the various water features in the area once the rains begin.

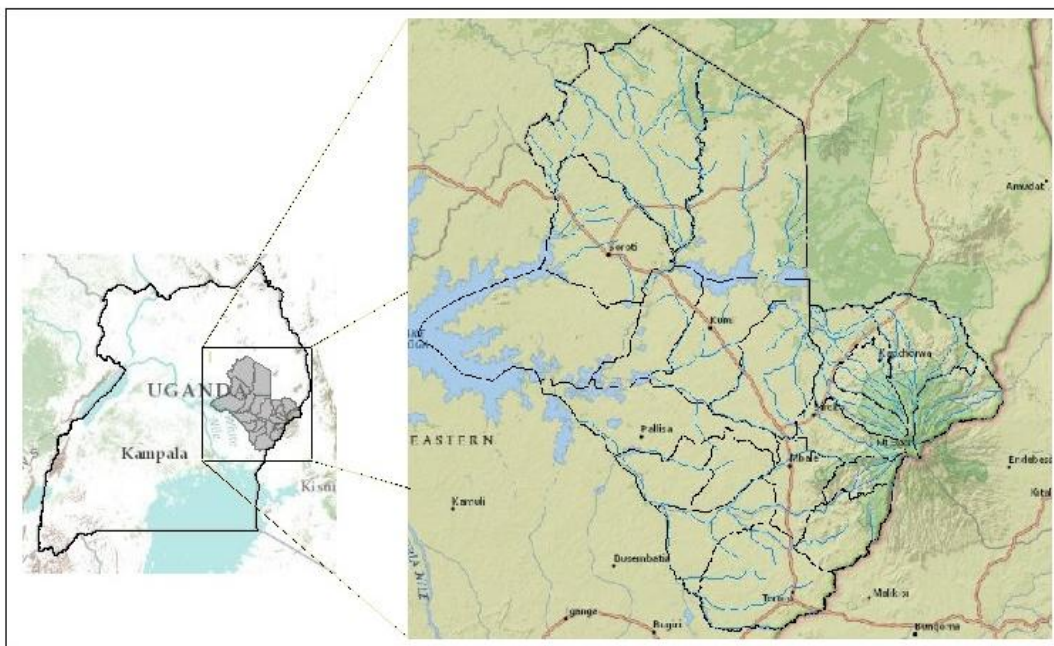


Figure 1: Study Region

The scope of this study focuses on floods as the risk in the Eastern sub regions of Uganda, the Teso and Elgon consisting of 20 districts (Appendix 1) also known as communities. Flood occurrences are considered from the year 2006.



1.4.2 Project scope

To fulfill objectives 1.3.1, data which is freely available online is used as groundwork for this study. The process involved in bringing together the data necessary to carry out the task of determining community risks is described in chapter 4.

Objective 1.3.2 requires designing and developing an application for data creation and storage, which data is then used for queries and visualization in the same application to assess the vulnerability of communities. The application is called the 'Qiva' platform for Query, Insert, Visualization and Analysis.

All calculations and spatial elements are considered in a 2 dimensional scale. Even though height is a fundamental element for flood management, the scope of this study does not involve the height aspect and therefore reference to flood depth is out of this study scope. Focus is put on flood visualization and mapping on a 2 dimensional scale.

The time devoted to this project is limited to within a period of 6 months, Appendix 2 is an illustration of the work plan the project was following.

1.5 Contributions

Section 1.3 gives an introduction to the contributions of this thesis, these contributions are described below.

The first contribution of this thesis is a web application that can be used to create and store data about flood events. This data can be used in analysis of community vulnerability to flood disasters.

The application can be used both for experts to report floods, and also for citizens to validate or also insert data about flood events.



The second contribution is a platform where community vulnerability to flood events can be assessed. By knowing how recent floods occurred and their impacts, a disaster manager can quickly access the vulnerability of a known community.

The third contribution is an application design based on interoperable and modular components. This design facilitates re-use of components since each component can operate independently to serve a unique purpose.

1.6 Thesis Structure

The structure of the thesis follows the process undertaken in carrying out the project. Chapter 1, the Introduction has included the general description of the project and below is a brief description of the chapters to come.

Chapter 2, the theoretical framework describes the current state of the art in the area concerning this project. The chapter covers the background knowledge on which this study is undertaken.

Chapter 3 covers the methodology and design choices used in this project. The methodology section focuses on analysis the identified objectives in chapter 1 while the design section describes the modular design chosen for the proposed platform.

Chapter 4 deals with the processes involved in acquiring and preparing data for use in the study. Chapter 5 focuses solely on the implementation of the proposed platform as described in chapter 3, the next chapter 6 elaborates on usage scenarios, testing and evaluation of the prototype platform. The last chapter 7 looks back on the thesis with limitations and future works as the concluding chapter of the thesis.

2 THEORETICAL FRAMEWORK

2.1 Geospatial Technologies for disaster management

Geospatial technologies (GT) involve the use of Geographic Information Systems (GIS), Global Positioning Systems (GPS) and Remote Sensing (RS) to support decision making and perform sophisticated analyses on information with a spatial component in the geographical sense. The global trend of disasters (figure 1) recognizes the need for GT tools and hence their rise in demand where disasters are concerned.

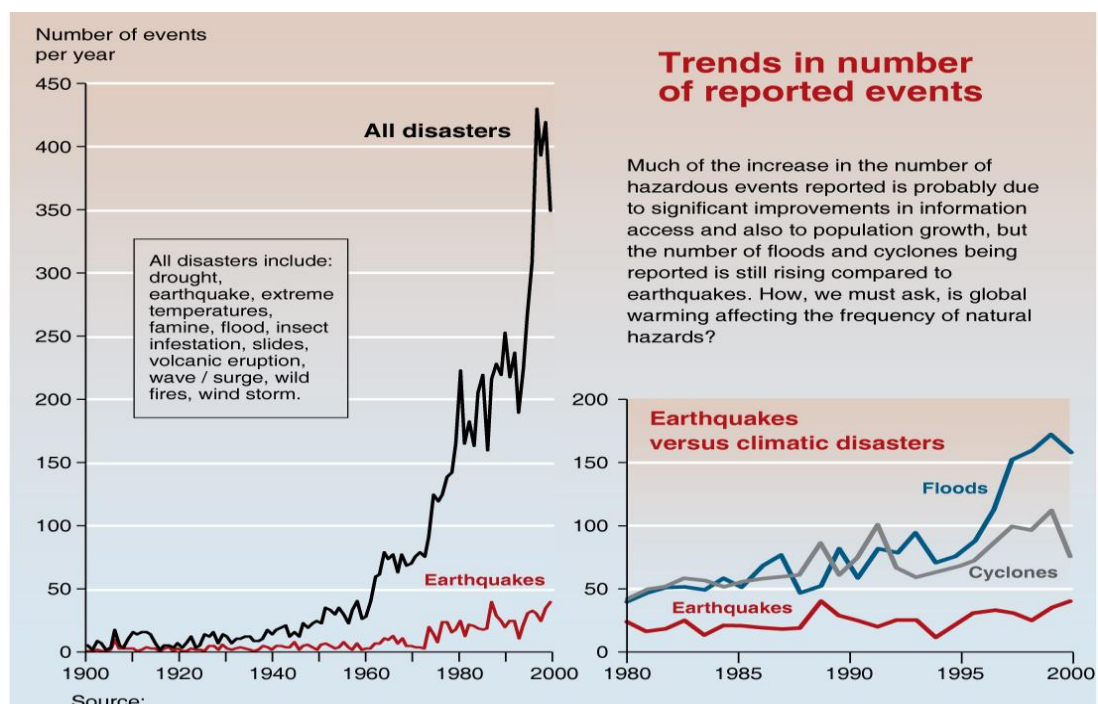


Figure 2: trends_in_natural_disasters (Bournay (UNEP/GRID-Arendal), 2005)

Geospatial technologies support decision making in all phases of the disaster management cycle (Warfield, 2012). In this section, an overview of how these tools are used to perform a variety of functions to aid flood disaster management is illustrated and the conceptual relation to the proposed application made clear.



(Tran et al., 2009) discuss one of the many ways to involve GT in flood management relevant to this study. The authors use Geographic Information System (GIS) at the local level and express the need for integrating modern technology and indigenous knowledge into disaster management. Some of the reasons for the integration are that hazard maps play a key role in disaster risk identification, and hazard maps play an effective tool in making local knowledge visible. Another reason directly linked to this project is that local knowledge is essential for disaster risk management. Involving the community to provide such data as population counts and active routes is beneficial for creating update knowledge for use in a GIS.

Using daily passive microwave observations to achieve his objectives, (De Groeve, 2010) presents a clear example of the need for real time data for flood detection, mapping and flood sizing both for the purposes of global humanitarian organizations and national hydrological services. But even if not in possession of this kind of data (microwave observations), flood extents can be determined from volunteered information (Goodchild M. , 2007) on cell phones and GPS (Parkinson & Spilker Jr., 1997) if a system exists to consume this data. The daily availability of such data allows for experts to understand the dynamic aspects of floods and their nature (De Groeve, 2010).

(De Groeve, Vernaccini, & Annunziato, 2006), 2009 and (De Groeve, Zsofia, & Robert, 2007) introduce the theories behind the Global Disaster Alert and Coordination System. GDACS is a framework between the United Nations, the European Commission and disaster managers worldwide. It provides real-time access to web-based disaster information systems and related coordination tools. One of the key features of this system is the ability to provide instant alerts and automatic impact estimations for response planning.

Another initiative like the above is described in (Herold & Mouton, 2011). Using a method based on large rivers peak flow estimates derived from mean



monthly discharge time-series, the authors create a world map of flooded areas for a 100 year return period to represent flooding that affects large river floodplains, but not events triggered by specific conditions like coastal or flash flooding for instance.

The use of Remote Sensing (Wang, Colby, & Mulcahy, 2002) is increasingly becoming a popular means of flood risk and hazard mapping. Even when remote sensing is out of the scope of this study, it is worth noting that it is a relatively cheap and rapid method of acquiring up-to-date information over a large geographical area.

2.2 Web visualization

With globalization (Stromquist & Karen, 2000) comes the need for everything to be available online, the advantage for this is that information can be accessed from anywhere. For this reason many attempts have been made to provide web visualization (Brodie, 1997) for disaster management. In this part of the chapter, visualization techniques relevant to this thesis are reviewed.

Some tools provide flat-map or globe views for the world. Their basic functionality is to allow creation of basic maps that one can plot data on top of and share the resulting maps online. These mapping applications provide basic display and share functionality for geographic data but they don't allow for in depth data analysis (O'Sullivan & Unwin, 2002). Examples of these tools are GoogleMaps³, VirtualEarth⁴, GoogleEarth⁵ and OpenStreetMaps⁶.

The availability of applications such as the above has made research possible in the area of disaster management. A number of researchers have utilized them to visualize disaster events and also use them for developing tools to

³ <http://maps.google.com/> ,

⁴ <http://www.viawindowlive.com/Resources/VirtualEarth.aspx>],

⁵ <http://www.google.com/earth/index.html>

⁶ <http://www.openstreetmap.org/>



aid disaster management. An example, (Manful, et al., 2010) uses Google maps as a base map to communicate flood forecast products effectively to end-users.

Integrating such tools with other technologies results in products like the web-based SOLAP tool (Martino et al., 2011) developed by integrating Google Earth with Mondrian (Theus & Urbanek, 2008) an OLAP engine to allow decision makers to perform exploration and analysis of spatial data.

Non-interoperability impedes sharing of data and resources, the Open Geospatial Consortium (OGC) interoperability initiatives have resulted in standards that are now the basis to successfully deploy seamless, distributed information infrastructure for the geosciences (Percivall, 2010). These standards support interoperable solutions that "geo-enable" the Web, wireless and location-based services. The OGC Standards most relevant to this study are the Web Feature Services (WFS) and the Web Map Services (WMS).

Web Map Services (de la Beaujardiere, 2004) produce 'maps' rendered in pictorial formats such as PNG, GIF or JPEG. This International Standard defines three operations: one returns service-level metadata, another returns a map whose geographic and dimensional parameters are well-defined and an optional third operation which returns information about particular features shown on a map. Web Map Service operations are invoked using a standard web browser by submitting requests in the form of Uniform Resource Locators (URLs).

Web Feature Services on the other hand allow a user to interact with the data behind a map. The WFS operations support Insert, Update, Delete, Lock, Query and Discovery operations on geographic features using HTTP as the distributed computing platform (Panagiotis, 2005).



The role of these two standards in eliminating time-consuming data translation and facilitating reuse of existing geospatial data over the web is increasingly making them popular. In time-critical applications, the two services may present more advantages once adapted (Zhang & Li, 2005).

The need for guidelines and standards in map symbology for hazard and emergency maps is one of the hindrances for information sharing during crucial emergency situations by emergency managers and people responding to disasters (Dymon, 2003). A study examining the comprehension of the FGDC HSWG Emergency and Hazard Management Mapping Standards point symbology resulted in 22 of the 28 symbols tested not achieving the 85 percent comprehension level necessary to meet the standard. The results portray the difficulty in implementing symbology standards (Akella, 2009).

The principles of map design (Peterson, 2009), (Krygier & Wood, 2005) have many dimensions, from knowing the map's audience to choosing map symbols to choosing map types and design. It is critical as a map developer to know how best to manipulate the symbology of a map to portray information in the best way most perceivable to the target audience.

2.3 Web technologies

There are four design models for developing Web applications using Java technologies: Model 1, Model 2, Struts, and JavaServer Faces (Kurniawan & Xue, 2004). The model relevant to this study employs a series of Java Server Pages (JSP). This JSP Model 1 architecture allows the JSP page to handle all the processing of the request and is responsible for displaying the output to the client (Cavaness, 2002).

JSP pages support both scripting and access to the full Java language and can be extended through the use of custom tags. JSTL is a tag library support developed to plug the missing capabilities (Chopra et al., 2005) frequently needed by JSP developers. It is composed of an expression language, a



standard action libraries and tag library validators (Geary, 2002) providing an effective way to embed logic within a JSP page without using embedded Java code directly.

To use JSP, one must make sure a proper Java platform is available. Java has the Micro Edition (ME), Standard Edition (SE) and the Enterprise Edition (EE) platforms. One of most interest to this study is the Java EE platform (Sun Microsystems, 2007). Following (Heffelfinger, 2010), a user can develop Java EE 6 applications using GlassFish and deploy them to a server.

A discussion about developing applications for the Internet and the web (Deitel & Deitel, 2007) covers all the skills and tools needed to create dynamic Web-based applications and the fundamentals needed to program on the Internet providing in-depth coverage of introductory programming principles, various markup languages (XHTML, Dynamic HTML and XML), several scripting languages (JavaScript, PHP, Ruby/Ruby on Rails and Perl); AJAX, web services, Web Servers (IIS and Apache) and relational databases (MySQL/Apache Derby/Java DB).

A technology in the above discussion of particular interest is scripting languages (Ousterhout, 1998). It is a form of high-level programming language that gets interpreted into computer commands while a program runs. Scripts add interactivity to otherwise static Web pages. Web browsers interpret scripts along with Hypertext Markup language (HTML), the language in which Web pages are written.

The key scripting language to note is JavaScript (Flanagan, 2006). This language became the default language of the Web when Java applets failed (Crockford, 2008), making its popularity almost completely independent of its qualities as a programming language. The good parts of JavaScript that make it a good object-oriented programming include functions, loose typing, dynamic objects, and an expressive object literal notation.



JavaScript has become the choice language for Application programming Interfaces (APIs). APIs allow programs to talk to each other, just by this fact, their use is rapidly growing. API examples based on JavaScript are ArcGIS JavaScript API, Google Maps JavaScript API and OpenLayers JavaScript API.

ArcGIS JavaScript API is a browser based API for developing high performance, easy to use mapping applications (Curdt et al., 2011). The API is a quick way to take full advantage of powerful mapping, editing, geocoding, and geoprocessing services hosted by ESRI⁷ on ArcGIS Online and is available for free use. ArcGIS JavaScript API allows easy embedding of maps in Web pages.

Unlike other JavaScript APIs that allow connecting only with their map servers back end, OpenLayers is an open source API that is not tied to any proprietary technology or company (Hazzard, 2011). It can consume data from any source.

Two back end data providers related to this thesis are ArcGIS Online and GeoServer. The ArcGIS Online belongs to the ESRI family Products. It is a cloud-based geospatial content management system for storing and managing maps, data, and other geospatial information (Shanks, Kensok, & Freitag, 2008). It allows users to create, access, share and manage geographic content shared and registered by Esri and GIS users around the world.

GeoServer is the reference implementation of the Open Geospatial Consortium (OGC) Web Feature Service (WFS) and Web Coverage Service (WCS) standards, as well as a high performance certified compliant Web Map Service (WMS) (Deoliveira, 2008). GeoServer forms a core component of the Geospatial Web. It is free, open source and highly interoperable.

⁷ <http://www.esri.com/>



2.4 Data management

Spatial data is what drives a GIS; this data is commonly referred to as layers by many applications. Layers (Malczewski, 1999) represent features about the surface of the earth. Depending on the features they represent, these layers are one of the two types, either Vector or Raster data (Goodchild, 1991). While Vector data represent features as discrete points, lines, and polygons, Raster data represent the landscape as a rectangular matrix of square cells. In this study, vector data is used for data representation.

The proposal for vector modeling (Tang, Adams, & User, 1996) was prompted by the general negligence of Semantic relations and intrinsic interrelations of the features while all geographic features were being represented as geometric objects with associated topological relations and classification attributes. The advantages of using vector modeling can be pointed out in the comparison of data models in (Peuquet & Dodge, 2011).

Spatial data has components; some of these are metadata, data dictionary and the attributes which add value to the data. Metadata (Federal Geographic Data Committee, 1998) contains such information as the coordinate system, data creation date, last modified date, who created it and how to contact them and definitions for any of the code attribute data.

Spatial data is stored in many formats. Among these are shape files and spatial databases. A shape file (Esri, 1998) is a format developed and regulated by Esri as mostly an open specification for data interoperability among Esri and other software products. In (Güting, 1994), a spatial database system is defined as a database system that offers spatial data types in its data model and query language, and supports spatial data types in its implementation, providing at least spatial indexing and spatial join methods. A key database management system to note is PostgreSQL (Obe & Hsu, 2011).



3 METHODOLOGY AND DESIGN

3.1 Methodology

This section describes the steps followed in achieving the objectives listed in chapter 1 section 1.3, each objective is reviewed and tasks involved along with their requirements are noted. A small introduction to the final product testing and evaluation is presented.

Developing the proposed application requires that tasks necessary to fulfill the objectives raised in section 1.3 be determined, below is the break down.

Objectives;

3.1.1 Determine community risks

Determining community risks requires that communities can be identified, once this is possible the potential risks in the communities can then be noted. The risk in focus for this study is floods, therefore there is need to identify flood occurrences in the identified communities. Tasks involved in this activity are;

- a. Identify Communities
- b. Identify features of value surrounding the communities
- c. Name and identify past flood events
- d. Determine the extent of the flood events
- e. Identify surrounding features which may add or help reduce community vulnerability to floods

With the above tasks clear, requirements to fulfill the objective are explainable. Table 1 elaborates on the above tasks and their requirements in terms of data. An elaboration on the acquisition and processing of the above data is found in chapter 4.



Task	Data requirements
Identify Communities	Populated places: these are classified into; <ol style="list-style-type: none"> 1. Administrative levels; district, county, sub-county, parish. 2. Towns, villages and administrative centers
Identify features of value surrounding the communities	These features are infrastructure like health centers, schools, road networks and bridges
Record and store past flood events	Flood history of the study area
Determine the extent of the flood events	Place names affected by the floods in the past
Identify surrounding features which may add or help reduce community vulnerability to floods	Surrounding features like water bodies- lakes and rivers

Table 1: Objective 1 Tasks And Data Requirements

3.1.2 Provide a platform for mapping and analysis of community vulnerability to the risks identified.

As introduced in section 1.3.2, this objective requires designing and implementing an application to act as the platform where vulnerability assessment of communities can be done. This design process is described in section 3.3 of this chapter. The proposed application design is based on the principles of modular design (Hill, 2011).

3.2 Testing and evaluation

The Qiva platform is evaluated on functionality, how easy it is to accomplish the tasks identified in section 3.1.1. An evaluation is carried out by users in the disaster management field through a questionnaire. The results are discussed in the evaluation section of chapter 6. To determine if this application can be useful to disaster managers for response preparedness, the platform needs to achieve at least 70% success in the evaluation.

3.3 Design

This section explains the data model and system design chosen for the application. The system design is based on a modular design introduced in section 1.3.2.

3.3.1 Data Flow Model

Figure 3 represents the data flow model chosen for the platform.

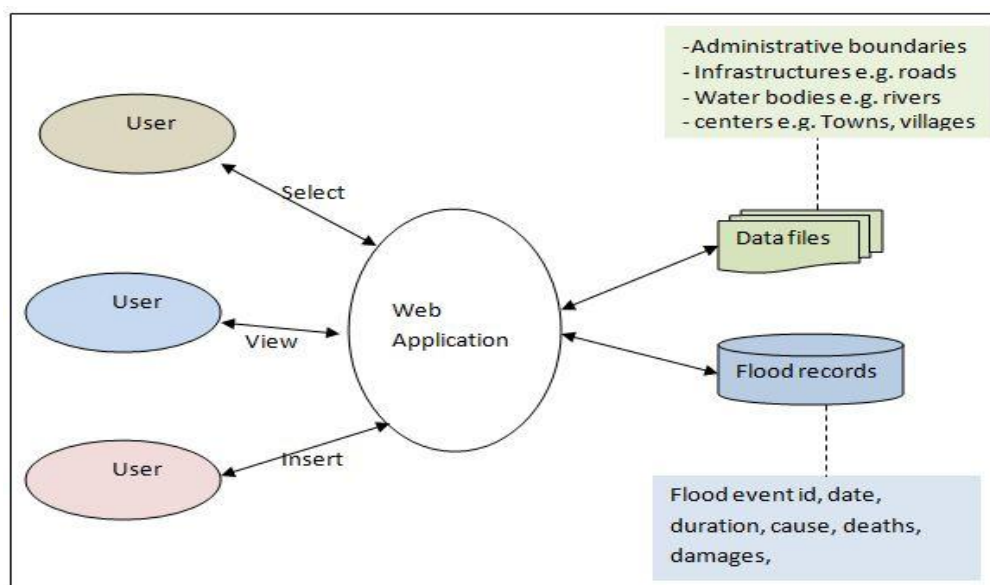


Figure 3: Data Flow Diagram

Flood events as records in a database are stored or retrieved by the web application. Using a database is an ideal choice for this data model because databases offer reduced data entry, storage, and retrieval costs (Beynon-Davies, 2004).

The model has data files; one would ask why not store all the data in the database but depending on the purpose and the format in which the data is acquired, there may not be need to tamper with it. This improves data credibility.

In the model, communication between the data files and the web application is possible; this is explained in detail in section 3.3.2. Using the application may require a user to perform some tasks which include being able to view,

insert and select/query some items on the application. The arrows represent the direction in which data flows through the system. In this model, all entities involved have a two way communication.

3.3.2 System Architectural design

The proposed system consists of a web application, a service layer and a data layer the typical multi-tier architecture of many web geospatial applications as illustrated in figure 4.

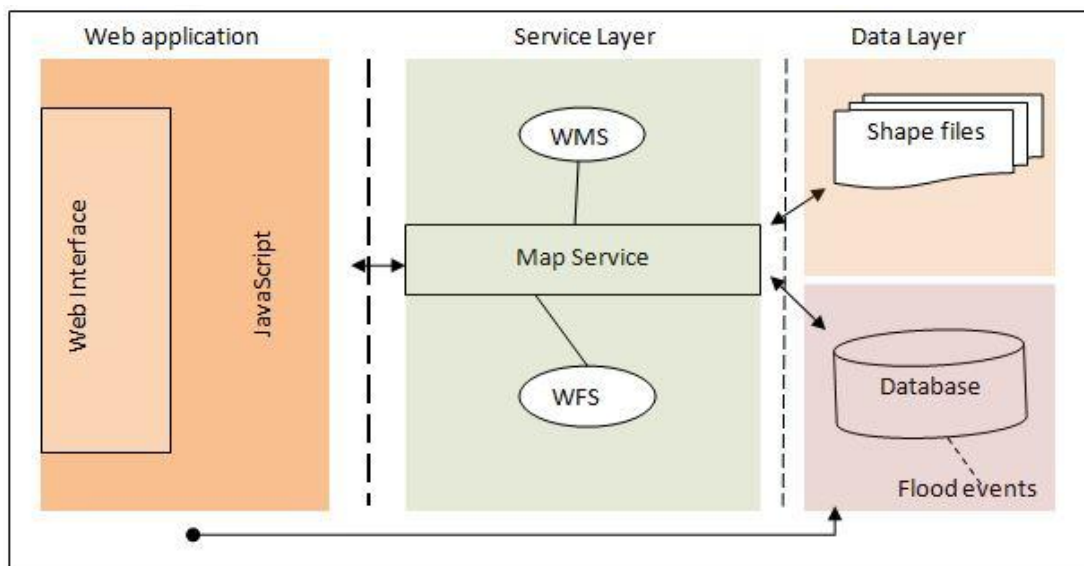


Figure 4: System Architecture

3.3.2.1 Web application layer

The web application layer in charge of presentation tasks consists of a Web Interface responsible for data entry, visualization and manipulation tasks powered by JavaScript libraries. The use of JavaScript was introduced in chapter 2 and basically being a de facto language for web scripting, the language is chosen for use in this design.

3.3.2.2 Service Layer

The Service layer consists of a map service provider responsible for servicing map data to the web application. The map servers functions include being



able to service data in form of Web Feature Services and Web Map Services earlier introduced in Chapter 2.

The map service layer is tasked with data transaction services to the data layer, choice of a map server to use in this design depends on their capability to consume data from shape files and records from the database.

3.3.2.3 Data Layer

The data layer is the core of this design, it provides all the data needs of the service layer and is a repository of data from the web application. In this design two data components have been chosen. The shape files repository and flood records stored in a database.

The shape file repository has been included in the design to represent the scenario where shape files do not need to be transformed and can be used in their original data format. This is so to maintain data integrity.

The database is where all flood related data is stored and for this case, the database must have spatial data management capabilities. The web application sends flood events directly to the database but the database does not serve any data to the web application directly; this function is performed by the map service provider.



4 DATA PREPARATION

This chapter describes the processes involved in preparing data for use in the research. It includes both the data collection and transformation of data referred to as background data in this study and flood events.

4.1.1 Background data collection

Background data is all the necessary data that can be used for analysis but not directly linked to flood events. This data is for example, administrative boundaries like districts, sub-counties, counties, towns, villages. The term is also used to imply geographic features such as water bodies and roads that surround populated places.

Thanks to the internet and a global need to share data, the sources of this data are map library⁸, gadm⁹, and mostly humanitarian response¹⁰. This data (table 2) is not up to date but is enough for illustration in this research. This data is obtained as shape files, the format most acceptable by ArcGIS desktop software (education edition) installed on the local computer.

Data type	Data name	Year represented
Administrative	District, sub-county, parish.	2010
Populated places	Towns, villages	2009
Infrastructure	road networks	2009
Geographic	Lakes and rivers	2005

Table 2: Data acquired for the Application

⁸ www.maplibrary.org

⁹ www.gadm.org/

¹⁰ <http://cod.humanitarianresponse.info/country-region/uganda>

4.1.2 Background data transformation

4.1.2.1 Re-projecting and adding projections

To make use of data from different sources, EPSG: 4326 (World Mercator) and EPSG: 900913 (Google Mercator) are chosen as the standard geographic coordinate reference systems in this study, if the data is not in the same projection, chances are the data layers will not align spatially for them to be accurately analyzed. For this reason when working with various spatial tools, the available data is re-projected to the mentioned standards. Some data may have projected coordinate systems but not geographic coordinate systems and therefore need to be transformed.

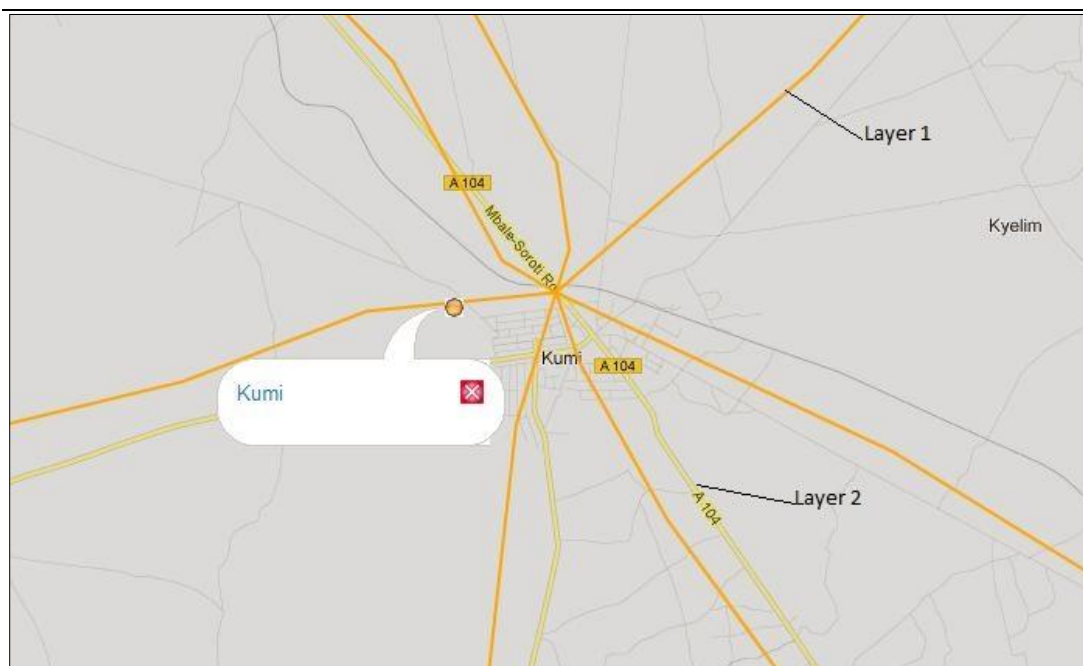


Figure 5: Non Overlapping Data Layers

Figure 5 illustrates the need for projecting data layers to a standard coordinate reference system. Steps to perform the transformation are detailed in appendix 3. Layer 1 and layer 2 are layers representing the same features but in this figure, it is impossible to think so, the layers are so far apart (they don't overlay) and this can be solved by reprojecting one into the other's reference system.

4.1.2.2 Clipping

In the project scope, this study considers only a small region in Eastern Uganda with 20 districts (Appendix 1); this means that using all the countries data is not necessary. It is also important to reduce the number of features since some services do not accept more than a specific number of features.

To solve this, new data files with only the 20 selected districts are created by a process known as clip analysis. Clip analysis (Ormsby, Napoleon, & Burke, 2004) is the function of using the extent of one geographic layer to cut out the extent of another geographic layer. The Steps to do this function are described in Appendix 4. To perform clipping, a feature layer for reference is created and in this thesis, this layer is called district_selection.

Figure 6 is an example of a layer clipped using the layer with the 20 districts (Appendix 1).

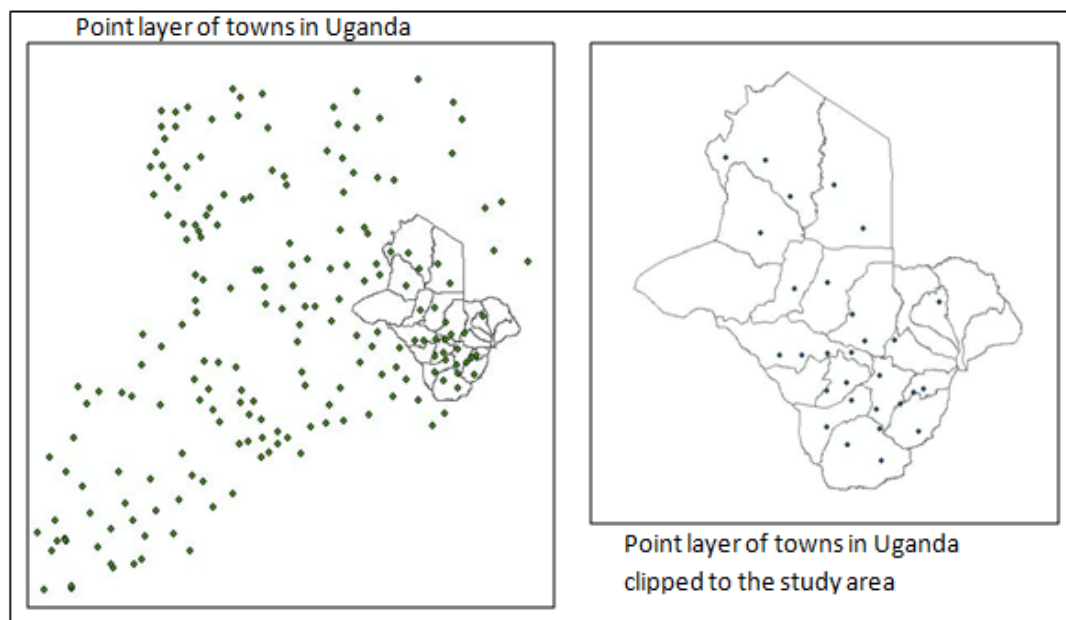


Figure 6: Clipping Example

The layer on the left has very few features compared to the layer on the right, using all the features in the left layer would require more resources than the clipped layer.



4.1.3 Flood events data collection

Flood events data is much harder to come by than the background data. Data for flood events is extracted from information of real events that have happened in the studied area from many newspaper archives, reports, disaster related websites and statements.

Obtaining this data involves finding flood events that have occurred in the chosen region since 2006 by using search phrase like 'floods in eastern Uganda' and following links to find useful information, browsing humanitarian sites; gdacs¹¹, relief web¹², Uganda clusters¹³, earth observatory¹⁴ and Dartmouth¹⁵ for real events, browsing newspaper achieves of the Uganda new vision¹⁶, Uganda monitor¹⁷ and the weekly observers¹⁸ and browsing through the Red Cross¹⁹ state of emergency reports hosted on their websites. Sample data archive for flood events in Appendix 5 and 6.

The information is cross checked with other sources and if more than 3 sources record the same information, it is considered correct. If one source declares a different date and another a different one, 3 more sources will be referenced for a date to be decided on, if two dates are different by one day, the earlier date is taken. Cross checking with records from earth observatory and gdacs for the major events also gives the information more ground. Sample archive for an event from Dartmouth in Appendix 5.

¹¹ <http://old.gdacs.org/index.asp>

¹² <http://reliefweb.int/>

¹³ <http://www.ugandaclusters.ug/>

¹⁴ <http://earthobservatory.nasa.gov/>

¹⁵ <http://www.dartmouth.edu/~floods/Archives/>

¹⁶ <http://www.newvision.co.ug/Archive.aspx>

¹⁷ <http://www.monitor.co.ug/page/search/DailyMonitor/>

¹⁸ http://www.observer.ug/index.php?option=com_content&view=archive&Itemid=96

¹⁹ <http://www.redcrossug.org/reports.html>



4.1.4 Flood events data transformation

Flood events are collected with an identification number, affected districts, start date, end date, duration, water bodies involved (any rivers or lakes that could have accelerated the flooding), cause (what triggered the flood event), death counts, number of displaced persons, most affected place names, affected household counts, affected area in square kilometers, severity and magnitude as used in gdacs, after event speculation and losses (damaged property and anticipated issues like malnutrition, droughts), the date of data capture and source of the same (Appendix 7).

The crucial fields for data transformation are the affected districts and affected place names. Each affected place name requires a translation of the place names to their geometry. To do this involves finding the highest level of administrative level (admin level) available, in this case the parish level also known as administrative level 4. For every village and sub-county listed in the flood event information, parish names which coincide with this place are put on a list of parishes for a given event to make the event extent.

An example to create an extent for a case event with flood district Tororo and place name Bumanda Primary School in Iyolwa sub-county follows. Determining if Iyolwa is a county, sub county or village; in this case Iyolwa is admin level 3. In Iyolwa, there are two parishes; Magola and Poyemi. To find which parish to list, search online and determine if the school is in Poyemi or Magola, for this case, the school is in Poyemi. Poyemi is added to the event extent. Figure 7 is a result with the translation described above in ArcMap 10.

The flood events records are imported into Postgres Database as a flood events table. Using the shp2pgsql tool that ships with Postgres database, the event geography (geometry) is imported into Postgres as tables as well. These tables are named after their event codes. A geometry column is added on the flood events table to allow storage of geometry type data.

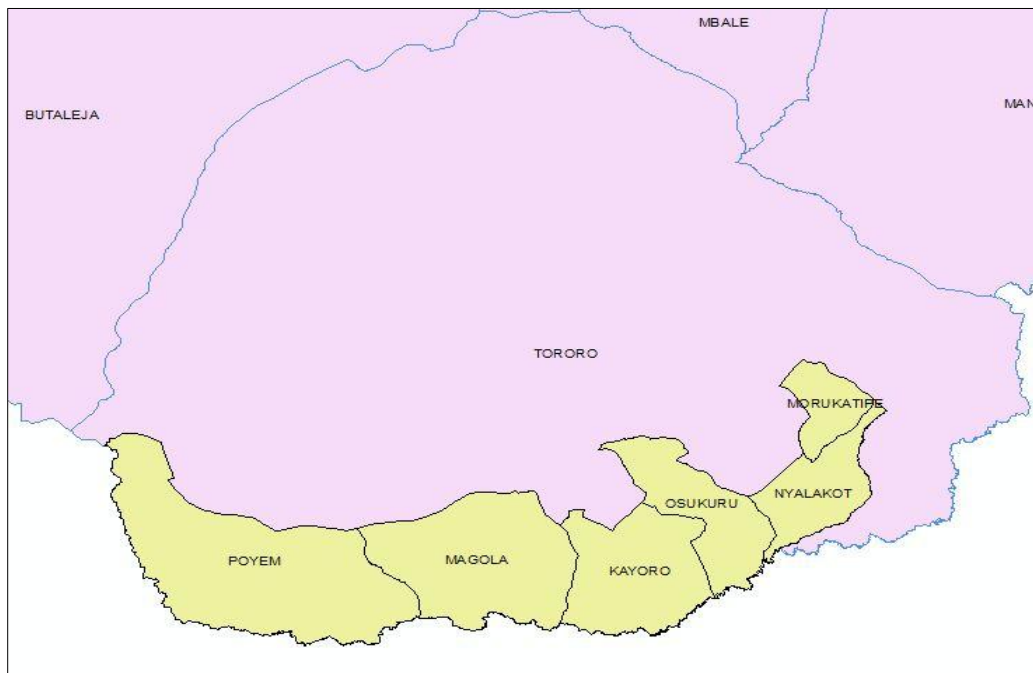


Figure 7: ArcMap Translation with the Poyemi Scenario

A union of the geometry of each flood event is added to the flood events table in the geometry column created earlier. A view is created from this table to create a points feature (centroid) of the flood events. Figure 8 is a representation of the structure of flood events inside Postgres database.

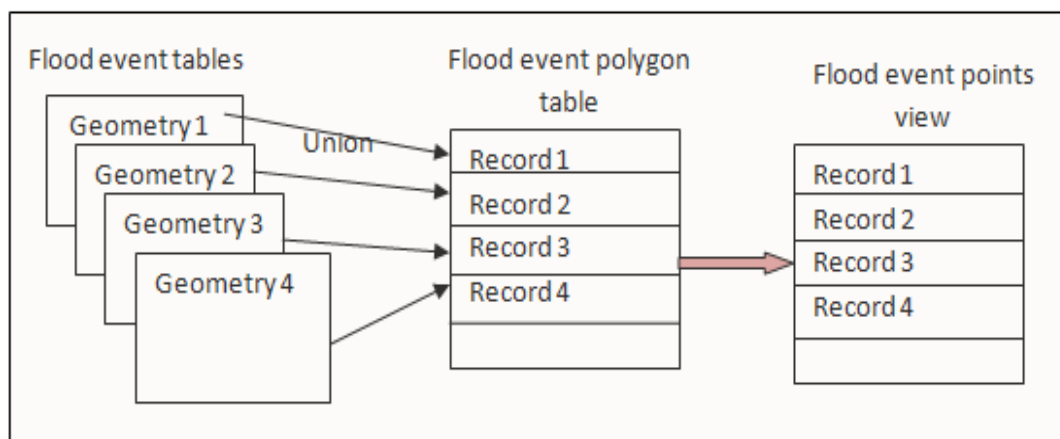


Figure 8: Flood Events inside Postgres Database

In the above figure, the different tables with different flood events geometry are translated into single records in the polygon flood table which is after used to create a flood events point view.



5 IMPLEMENTATION

This chapter illustrates the steps involved in developing the Qiva platform, a platform designed to assist disaster managers assess the vulnerability of communities to risk.

5.1 Development environment

Developing the application is done in Eclipse a multi-language open source free software development environment comprising an integrated development environment (IDE) and an extensible plug-in system (Holzner, 2004). It is written mostly in Java and can be used to develop applications in Java and, by means of various plug-ins, other programming languages including PHP, Python, and R.

For the Qiva platform, Java is the base language but in the form of JSP and specifically a library called JSTL. These technologies were introduced earlier in chapter 2 of this thesis.

The JavaServer Pages Standard Tag Library (JSTL) is a component of the Java EE Web application development platform. It extends the JSP specification by adding a tag library of JSP tags for common tasks providing an effective way to embed logic within a JSP page without using embedded Java code directly.

GlassFish (Goncalves, 2010) the Java EE Reference implementation supporting all Java EE API specifications is the choice application server for the application. It is an open-source project by Sun Microsystems for the Java EE platform and now sponsored by Oracle Corporation. An install of the GlassFish Server and Eclipse is done in one bundle called the **GlassFish Tools Bundle for Eclipse**.



5.2 Technology choices

To fulfill the modular design chosen in chapter 3, these technologies (table 3) are chosen depending on availability of support in terms of documentation, vicinity to persons with previous knowledge and learning curve of the chosen technology.

Web application	Map service	Data management
ArcGIS JavaScript API + HTML + JSP	ArcGIS Online or ArcGIS Server	PostgreSQL
OpenLayers JavaScript API + HTML + JSP	GeoServer	

Table 3: Technology Choices

The technologies can all stand alone but putting them together results in two design routes (figure 9); the first one aims to take advantage of ArcGIS Product services. These products include ArcGIS JavaScript API for the Web application design and ArcGIS Online for map services. The second route involves using free extendable open source GIS products. This route comprises of OpenLayers JavaScript API for the web application and GeoServer as the map service provider. The data management functions in both routes are serviced by Postgres (Obe & Hsu, 2011), a powerful relational database system.

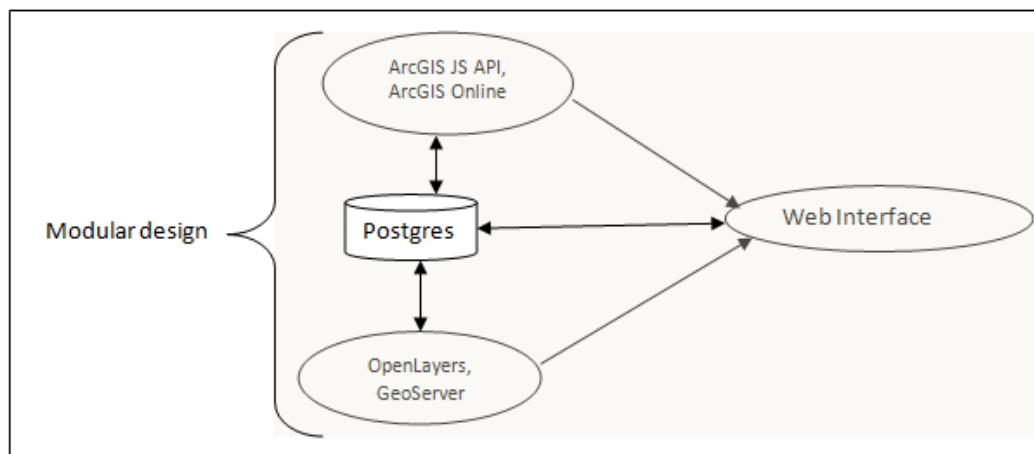


Figure 9: Technology Routes

5.2.1 Using ArcGIS product

The first step is to upload shape files to a created account on ArcGIS online. These shape files need to have less than 1000 features, in the event of a file having more than 1000 features as is for the sub county layer and the parish layer, these need to be split into smaller files and then uploaded.

The second step is to create a Web Map (figure 10) using the uploaded ArcGIS. A choice to use the shared data on ArcGIS online is available and a topographic map of the world is chosen for use as the base layer. There are options to set layer visibility, choose symbols, and add pop ups. The map is finalized by adding basic map elements.

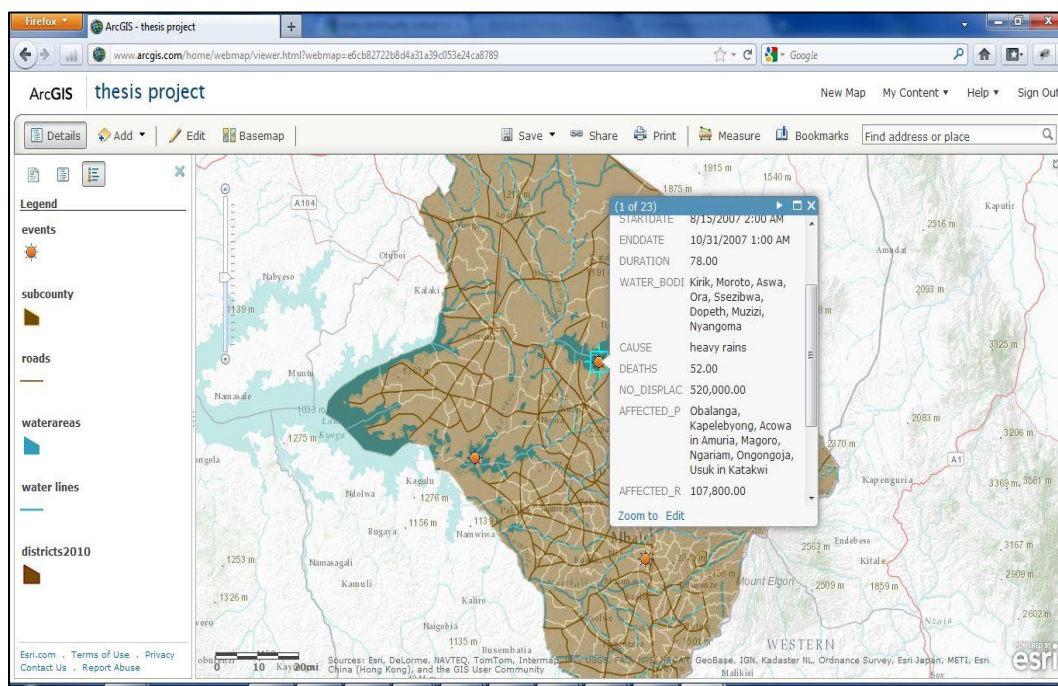


Figure 10: ArcGIS Online Web map

The third step is to create the Qiva platform in Eclipse using the ArcGIS JavaScript API using method calls specific to ArcGIS online web maps. These functions and their use can be accessed at ArcGIS²⁰. Figure 11 is a sample of the platform developed with the ArcGIS JavaScript API.

²⁰ <http://help.arcgis.com/en/webapi/javascript/arcgis/index.html>

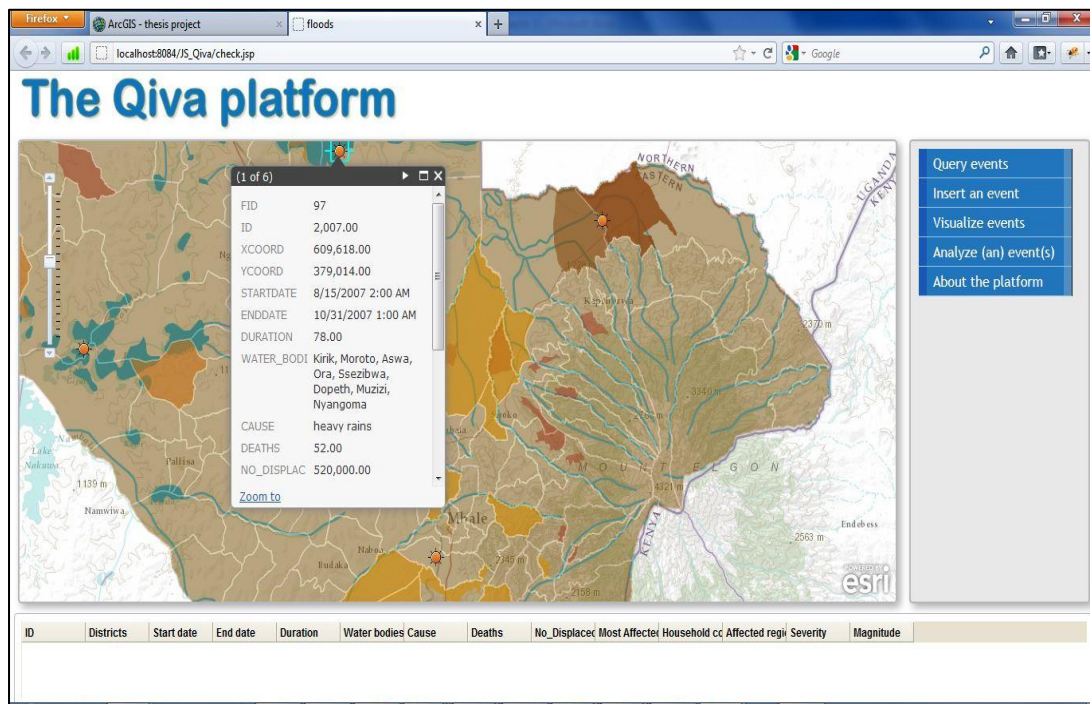


Figure 11: ArcGIS products Qiva platform implementation

Having no access to a layer id is a big development challenge while using this route. On ArcGIS online, it is possible to create a map using own data to share with the public. It is also possible to visualize the web maps created on ArcGIS online but it is not possible to manipulate the web map using calls from the ArcGIS JavaScript API. This technology works best with data layers published using ArcGIS server.

The next step is to find an ArcGIS server and create dynamic layers from the shape files.

A functioning ArcGIS server is not available; this means that developing the prototype with ArcGIS products cannot proceed.



5.2.2 Using Open Source Products

The first step is to set up GeoServer and then publish layers to it so that they can be accessed by the web application. A GeoServer WAR file is downloaded and installed on GlassFish the application server. Installation instructions for software can be found at GeoServer²¹.

GeoServer consumes data from many sources. Shape file repositories and PostGIS database tables are the data sources of interest to this project. Both the background data from the shape file repository and flood events data from the database are published to GeoServer. To publish data to GeoServer, a data store is created.

There are two types of data stores, a vector data source and a raster data source. All this application data falls in the vector (Tang, Adams, & User, 1996) category. In the vector category, GeoServer can consume data from a shape files directory, PostGIS Database, PostGIS Database (JNDI), a Web Feature Server and more.

Publishing data to GeoServer only requires completing forms with information about the layer; this information helps to add more value to the data layer. This information can take the form of Meta data, style rules, and layer description.

Once the layers are published, they can be previewed in the OpenLayers, GML or KML format. Table 4 has previews of a point feature layer and a polygon layer published on GeoServer.

²¹ <http://docs.geoserver.org/stable/en/user/installation/index.html>



GeoServer previews	
<p>Scale = 1 : 1M <i>Click on the map to get feature info</i></p> <p>33.16435, 1.87253</p>	Point feature layer
<p>Scale = 1 : 940K <i>Click on the map to get feature info</i></p> <p>33.01618, 1.83704</p>	Polygon feature layer

Table 4: GeoServer Layer Previews



The second step is to develop the web application using the OpenLayers JavaScript API. Using OpenLayers methods and pure JavaScript, the application user interface (figure 12) is developed consisting of the map, map elements and controls, a right panel that allows users access to the application functions.

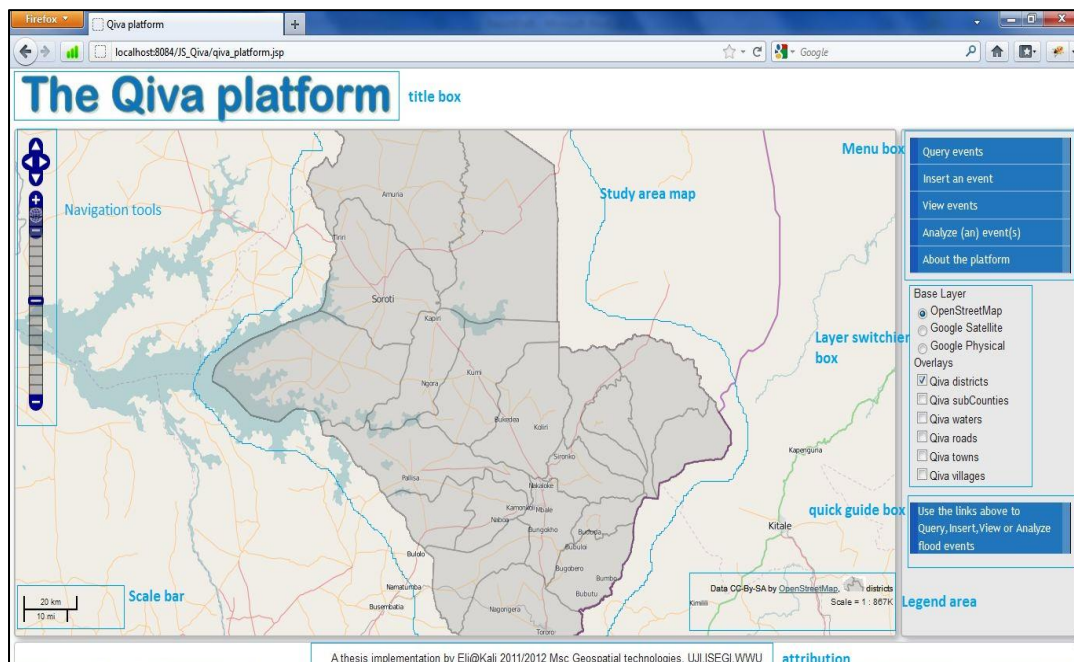


Figure 12: Default page of the web application

The map area houses map control features; the navigation tools consisting of the zoom bar and the pan tool on the far left, the scale bar and the legend at the bottom.

The study area takes up the rest of the map area and consists of layers served by GeoServer in either Web Feature or Web Map Services.

The left panel consists of the application menu which is divided into query, insert, view and analyze map functions, the map layer switcher panel which allows users to turn map layers on and off and the quick guide information at the bottom which changes text at every function call to give a user quick steps to performing tasks in that particular function.

The web application (qiva platform) functions are grouped into;

5.2.2.1 Query events

The query functions of the platforms allow a user to select an event and view details about the event, two layers of the map make this possible, 'Qiva events' is a points layer showing the centroids of the flood event extent represented by the ark icon. The 'ePolygon' layer is a polygon layer showing the extent of the flood events whose visibility is triggered by event clicks on the 'Qiva events' point feature. Visual queries can be performed on an event by selecting layers from the layer switcher.



Figure 13: Visual Query

Figure 13 shows an example of a visual query result achieved by selecting the village layer on top of a sample flood event. In this event for example, more than 20 villages were affected. This visual query also tells that this specific area has suffered 3 flood events!

5.2.2.2 Insert an event

The insert function of the application allows a user to select a flood extent using the parish layer and add event details, there after send all the data to the database. This functionality is achieved by combining OpenLayers and JSTL sql capabilities. In chapter 6, figure 14 shows the process followed to perform an insert function.

On the event detail input form, an option to erase the details is available as a Reset button, to change the geometry of the event or if the user is not ready to add a new event, an option to close the form is also available.



5.2.2.3 View events

The 'view events' functions of the application are accessed when the layers 'Qiva events' and 'Qiva floods' are visible. The difference between the Query functions and the View functions is that in the latter, a user has access to all the events while the 'query' functions focus on one event. Figure 15 is a screen shot of the view function interface of the application. The shades from red to yellow represent how recent the event happened.

The color scheme of the view events are explained (table 5)

Color	Year of event occurrence
Red/ #FF1100 ■	2012
Scarlet/ #FF3300 ■	2011
International orange/ #FF5500 ■	2010
Flush orange/ #FF7700 ■	2008
Orange peel/ #FF9900 ■	2007
Selective yellow/ #FFBB00 ■	2006
School bus yellow/ #FFDD00 ■	default

Table 5: View Event Color Scheme



6 SCENARIOS, TESTING AND EVALUATION

6.1 Scenarios

Two scenarios fulfilling the objectives pointed out in Chapter 1 are required to determine if the overall aim of this study which is to examine the possibility of providing disaster managers the means to assess vulnerability of communities to risk is accomplished. Both Objectives 1.3.1 and 1.3.2 are considered beginning with the former in 6.1.1 and the latter in 6.1.2.

6.1.1 Scenario 1: Add a recent flood event to the system.

User Group: local Citizen

Heavy rains started a week ago causing flooding in Paya sub-county affecting two parishes Paya and Nawire. The flood has wiped away a bridge along the Busiu- Nagongera highway and cases of people's houses being wiped away have been coming in, the rains ended yesterday and officer working at the local council wants to alert this event and its impacts to disaster managers in the nearby area with whom the council has collaborations.

He goes to the Qiva platform to add a flood event. On the default page he zooms in to his district Tororo and selects the 'Qiva roads', subCounties, towns and water layers to determine the affected area (figure 14, box 1). He unselects the layers and clicks 'Insert an event'. Keeping the Sub counties layer visible, he zooms in to Paya Sub County and selects the two parishes (figure 14, box 2). He finds the Save button and clicks it. On the form (figure 14, box 3) that appears, he fills in details about the flood and its impacts. He clicks save and is directed to the default page. The Officer wants to see the recent created event, he selects 'query events' and clicks on the event he just created (figure 14, box 4).



The Qiva platform

Box 2

The Qiva platform

Box 3

The Qiva platform

Box 4

Figure 14: Insert Event Steps

6.1.2 Scenario 2: determine communities most affected by floods

User Group: Disaster manager

A small NGO has acquired a grant to construct long lasting latrines in the flood affected areas of Uganda. The director of this NGO sends his disaster manager to give him a list of 3 communities most vulnerable to floods in the region to further investigate their needs and decide which community the organization will choose to invest this grant.

The disaster manager goes to the Qiva platform and selects the view events link. He is presented with a map with all events that have occurred in the region since 2006 assuming that all the events on the platform right now are real events (figure 15).

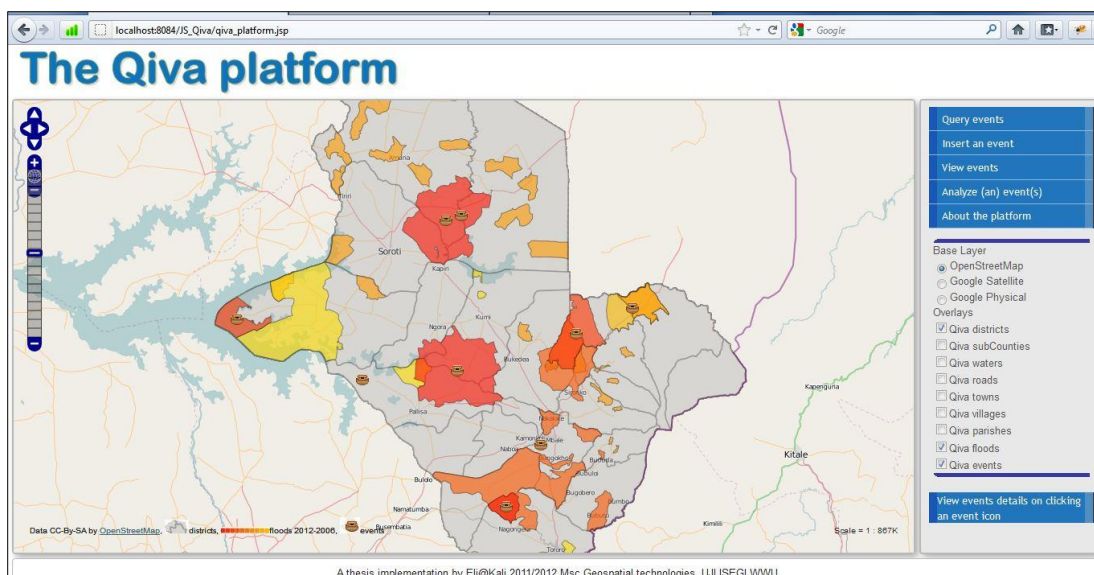


Figure 15: View Events

His task is to find 3 community choices where floods have occurred most, factors like proximity to a highway or water body may influence the decision. He selects the subCounties layer and turns off the 'events' since this layer represents flood 'centroids' and not where the flood occurred. A closer look reveals that some SubCounties have experience more than 1 flood.

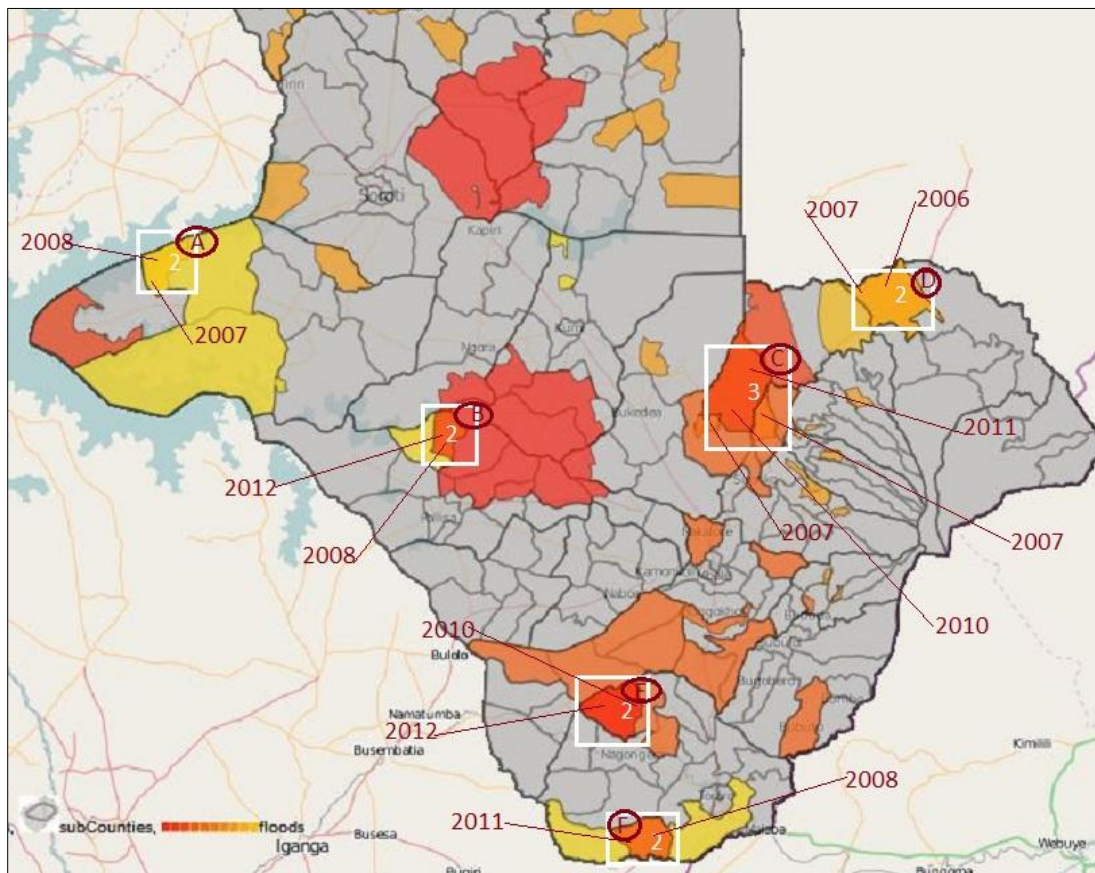


Figure 16: SubCounties with More Than 1 Flood Event

The manager looks at the years in which these events have occurred and determines that D and A are not so recent, choice of vulnerable communities will come from the other zones B, C, F and E.

The manager decides to change the base layer to Google physical and selects the village layer. He discovers that zone B, area 1 figure 17 almost has no villages in the affected area, does this mean there are no people living there? This is a question to answer with more data.

The manager is now left to present to the director areas 2, 3, and 4 (fig 17). He will need to couple these findings with other data gathered elsewhere like the population of each zone and the development ratios of the identified zones to choose the 3 communities.

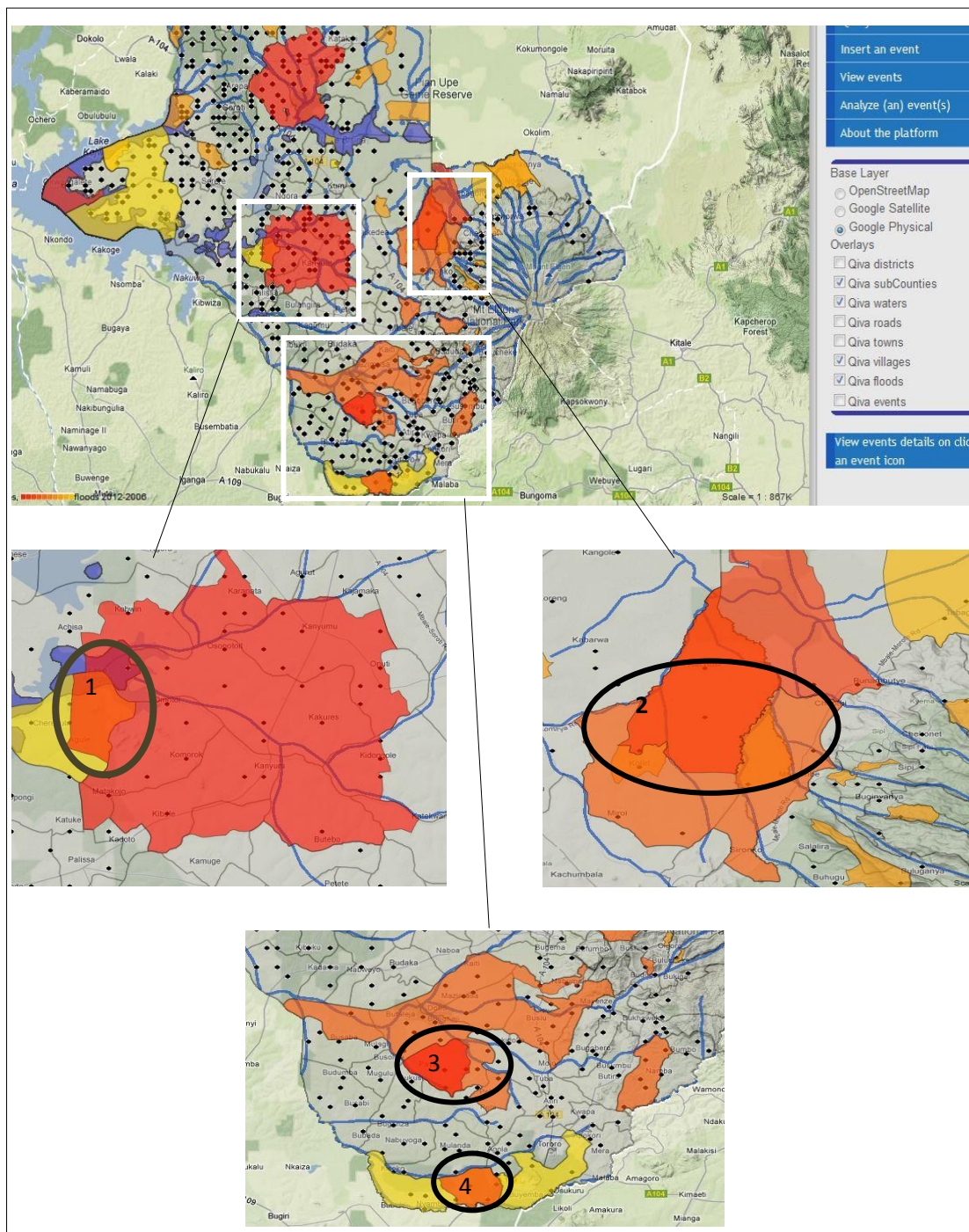


Figure 17: Identified Communities



6.2 Testing and Evaluation

A feedback form (Appendix 8) was developed for testing the web application (Qiva platform) on functionality and ease of use. Factors including the functionality of the application in terms of GIS and as a visualization were included in the test.

To fulfill the objective of determining community vulnerabilities, disaster managers need to perform some tasks on the developed platform. These tasks include determining flood extents, creating new events, performing simple GIS functions and since the application is a visualization tool, disaster managers need to perform some visualization tasks.

Three personnel in the field of disaster management were chosen for the evaluation; an expert geospatial technologist, one with no GIS knowledge and one involved in the development of the application.

Table 6 is a summary of the evaluation results (Appendix 9) grouped into the listed functions and their scores.

Function Group	Maximum points	Acquired average points
Determining floods and their extents	25	20.3
Add and maintain flood events	30	16.5
GIS functions	25	18.3
Visualization functions	30	22.0
Usability	10	8.2
	120	85.3 ~71.1%

Table 6: Evaluation Summary



Section 3.3 stated that to determine if this application can be useful to disaster managers for response preparedness, the platform needed to achieve at least 70% success in the evaluation. With a 71.1% score in the evaluation, the application is eligible for use. However it is important to explore the reasons for this result.

In determining floods and their extents, the application acquired a 20.3 average mark. The points scored for each tester were 24, 19 and 18. 24 points were given by the tester involved in the application development. An explanation for this could be that increasing the time users spend using the application may bring these scores up.

Adding and managing flood events low mark (16.5/30) can be explained by the fact that the tool does not provide the possibility to edit or delete flood events and data about these events and for this reason the application lost 10 points.

Visual queries are good but being able to perform advanced GIS operations like making buffers and calculations like distances is much better, the fact that these functions are missing explains the mark acquired in the GIS functionality of the application. These functionalities were to be implemented in the Analysis part of the platform. The application visualization tasks can be improved by increasing the hands on time of users but also, improving the functionality of the application.

Overall the application is good enough to help disaster managers carry out vulnerability assessment of communities during disaster response preparedness. Users mentioned the application has a clean and simple design and could be improved by improving its usability.



7 CONCLUSIONS

7.1 Limitations

The major limitation in developing the Qiva platform is the lack of data for the study area. Most of the focus in Uganda is put on rehabilitating the north and the Karamoja regions and as such, most of the resources are focused there. The studied area is not considered a 'red' zone until such events as the Bududha landslides (Atuyambe et al., 2011) happen. For this application to be a success there is need to have access to current data. This data includes roads, villages, parishes, towns and population counts. Having access to infrastructure data like schools and hospitals is urgent for aid workers and as such should be included in this application but this is not possible due to the unavailability of this data. Another essential data set to consider is population statics of the highest administrative level. It is difficult to have a realistic scenario without having accurate population counts for logistics.

7.2 Future works

The Qiva platform can be improved in many ways, due to time constraints the Analysis section of the platform is lacking in functionality. The analysis functions that suit this tool are:

-time serie visualization: this analysis allows for visualization of flood events dictated by time. In time serie (Wolfgang et al., 2011), it is possible to visualize flood events that occurred at specific time in history hence allowing for temporal visualization of flood events.

-shortest route analysis: this is an analysis that can be carried out on a road network affected by a flood. This can be especially crucial for future events in determining the least cost route to flood victims.



-statistics: it can be an added feature for the platform to provide statistical analysis in the form of graphs and charts. flood impact costs and other flood specific information can be shared in a simple form.

As a future work, a search function can be implemented on the platform to facilitate search and find. In this function searching by a place name should result in highlighting of features with this place name.

7.3 Technology

In developing this application, two technology routes were chosen to implement a modular design consisting of a web application, service layer and a data layer. The ArcGIS Products route and an Open source products route. The biggest hinderance in using the technologies was lack of reference materials. Many situations arose where the provided documentation did not help in resolving the current problem and there were no technology experts in the vicinity. This resulted in a lot of time being spent looking for work arrounds to the problem.

ArcGIS products were the first choice technology, developing with ArcGIS is interesting and challenging at the same time but the major limitation faced in this route was the lack of an ArcGIS Server to continue the implementation. The final design of the qiva platform architecture was implemented with PostgreSQL database to store flood events, GeoServer, a powerful geospatial server to publish flood events as point and polygon layers. Background data in form of Shapefiles was published and displayed through GeoServer as well.

The User interface of the application was finalized by using OpenLayers, a web API that can be used to imbed maps in web pages with data coming from various sources. The Qiva platform is developed as a web tool which comes with a key advantage that web tools provide the posibility to work from anywhere as long as there is internet. The Web Interface is easy to manage with simple click and select functions.



The tool's development comes with a need for continuous updating of background data on which analysis can be performed if objectives of the study are to be met. To fully harness the power of Geospatial technologies despite answering the question in this project, further spatial analysis needs to be included in the Qiva platform. This analysis has been documented as future works.

7.4 Conclusion

This thesis was motivated by the need for data affecting disaster managers in Uganda. This need for disaster data explains why Geospatial technologies are not being used for disaster management in Uganda. With the overall aim to answer the research question "Can geospatial technologies be used to prepare for disasters in Uganda and if so, how?", an application to help aid disaster managers perform vulnerability assessment has been researched and developed.

It is possible now to collect flood events and create spatial data for these floods in a two dimensional scale. The sources of this information can be the media, reports and statements of NGOs. This data can then be used for analysis in a real GIS scope. The application can be used to determine areas in need of urgent aid alongside other information sources.

Additional contributions of this thesis are that the application can be used by experts to report floods and also by citizens to validate or also insert data as seen in chapter 7.

This thesis presented a simple but useful application design based on interoperable and modular components a design which facilitates re-use of components since each component can operate independently to serve a unique purpose.



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9 APPENDIX

1. Table of Districts in the Study area with their population counts 2002

Region	Districts	Population 2002
Elgon	Bududa	123,103
	Bukwa	48,952
	Bulambiri	97,273
	Butaleja	157,489
	kapchorwa	74,268
	kween	67,171
	Manafwa	262,566
	Mbale	332,571
	Sironko	97,27
	Tororo	379,399
Teso	Amuria	180,022
	Budaka	136,489
	Bukedea	122,433
	katakwi	118,928
	Kibuku	128,219
	Kumi	165,365
	Ngora	101,867
	pallisa	255,870
	Serere	176,479
	Soroti	193,310

2. Proposed Work Plan extracted from the project proposal

Tasks	Mth 1	Mth 2	Mth 3	Mth 4	Mth 5	Mth 6
Phase 1						
Literature Study	■					
Data collection	■	■				
System design		■				
Phase 2						
Prototype Development			■	■		
Testing and Evaluation				■	■	
Phase 3						
Prototype review					■	■
Report writing		■	■	■	■	■
Thesis submission						■



3. Steps to perform projection transformation in ArcMap 10

To transform the projection of a shape file in ArcMap 10, add a new data frame and define its coordinate references by choosing data frame properties->coordinate systems->predefined-> geographic coordinate systems-> world->WGS 1984->Apply and then ok. Add data for re-projecting to the data frame by clicking Add data icon-> browse to folder with the shape file and add it to the data frame. Export the shape file by right clicking the shape file in the data frame, choosing Export all features: choose to Use the same coordinate system as: the data frame, change the directory and name the export output. Clicking ok will result in a prompt to add the new file to the data frame as a layer. The new file's reference system can then be seen in the shape file's properties.

4. Clipping layers

Choose a reference layer and add it to the data frame, change its symbology to hollow to make it easier to see the other layers. Right click the layer ->open attribute table. In the table properties (columns) choose the fields of the features needed. Right click->selection->create layer from selected features and a new layer with only the features needed is added to the data frame. The new layer acts as the clipping layer for the other layers. To do this using the clipping tool in Arc Toolbox, select the Analysis Tools-> Extract->Clip. In the clip tool box, select the desired layer as the input feature from the list of features listed. Select the reference layer created earlier as the clip feature, rename or change the directory of the new layer and OK. A new layer is now added to the data frame with only features that conform to the study area.

5. Flood events data source sample: extract from Dartmouth

177	USA	Chitwan - Narayangard and Bharatpur. other districts: Nwalparasi, Mugu, Mustang, Tanahu, Darchula, Bajura, Makwanpur, Tanahun, Tehrathum							
		Alaska - Susitna Valley: Houston, Willow, Matanuska-Susitna Borough, Copper River Basin, Anchorage and Valdez areas, Prince William Sound area, Cordova, Eastern Alaska Range- Girdwood	Little Susitna, Kahiltna, Sheridan, Eyak, Lake Creek, Campbell Creek, Troublesome Creek.	19-Aug-06	24-Aug-06	6	0	150	
176	FL-2006-000124-UGA	Uganda	Sironko District - Bumufuni, Bunambute: Busangai, Bukhayaki, Bumbocha, Bumuyonga, Kapchorwa District -	Ngenge, Atari	12-Aug-06	21-Aug-06	10	3	1,680
		Nan Province - Tha Wang Pha, Maung, Vieng Sa, Bo Klue, Thung Chang, Song Khwer, Chiang Klang, Pua, Muang Nan, Phu Phiang, Wiang Sa, Na Noi, Na Mun. Chiang Rai Province - Doi Luang, Phan, Mae Rim, Mae Chan, Muang. Phayao Province - Pong, Chiang Muan, Dok Kham Tai. Phitsanulok - Nakhon Thai, Noen							



6. Flood events data source sample: extract from Red Cross Statements

Heavy rain continues in the flood-affected areas of north and eastern Uganda including Karamoja. Approximately 352,000 people are reported affected with 68.4% being in Teso and Bugisu sub region, 24.4% in Lango and 7.2% in Karamoja. Access to some of affected populations has not been very easy, due to severely damaged infrastructure. As a result some of the people have not been reached with food aid and other basics for survival since the flood started. It is anticipated that most of the households cut off by flood which have not been reached with some food aid by now have exhausted their reserve and we do not know what they are surviving on. The lives of especially children & elderly are at high risk of mortality due to severe hunger and infectious diseases precipitated by poor living conditions. Much as there is no disease outbreak reported since the onset of floods, there has been increase in cases of malaria and diarrhoea diseases reported in some flood affected districts. Water sources are contaminated. Access to some of the health units has been cut off making it difficult to operate out reach programmes as some potential sites are in accessible due to floods.

7. Flood events table in Postgres

	code integer	districts_inv character vai	startdate date	enddate date	dur inte	water_bod character \	cause character \	death numi	no_dis numeri	affected_plac character vai	househol numeric(affected_regi numeric(12,2	sever nume	magniti numeri	al cf	info_source character vai	info date
1	471																
2	472																
3	473																
4	473																
5	2006	Sironko, Ka	2006-08-12	2006-08-21	10	Atari, Ng	heavy rai	3	1680	4 villages	686	4050.00	1.0	1.5		http://www.	
6	2007	Amuria, Kata	2007-08-15	2007-10-31	78	Kirik, Mo	heavy rai	52	520000	Obalanga, K	13621	107800.00	1.5	7.1			
7	2008	Kapchowa, To			0	kyoga, lak	heavy rai	0	0	Bumanda Pri	0	0.00	0.0	0.0			
8	2010	Mbale, Butal	2010-09-26	2010-09-30	5	river man	heavy rai	0	600	Bubyango pa	16340	3303.97	1.5	4.4			
9	5467																
10	222	thfe	2011-04-06	2011-05-06	3	rgrg	water	6	56	thtr	45	56.00	1.0	1.0	yt	thf	2011
11	1	dekerhjero	2012-03-04	2012-04-05	5	euth3iuhu	vk1jo:ljo	6	5	rtuh4uie	56	454.00	1.0	4.0	ej	5/4/2011	2011
12	1	dekerhjero	2012-03-04	2012-04-05	5	euth3iuhu	vk1jo:ljo	6	5	rtuh4uie	56	454.00	1.0	4.0	ej	5/4/2011	2011



8. Feedback form

Qiva platform Evaluation and Testing:

The Qiva platform has been developed to aid disaster managers in determining vulnerabilities of communities to risk in a flood case scenario. For this objective to be fulfilled, disaster managers need to be able to perform the following tasks;

1. Determine flood extents

To support the above task, functional requirements of the platform include a user being able to select, view and identify affected places and their surroundings.

On a scale of 1-5 (poor to very well), how easy is it for a user to?

1. identify affected places
2. select flood locations
3. view flood locations at different scales
4. display interactive maps of different admin levels
5. identify necessary geographic features (eg rivers, mtns)

2. Record and store data about flood events

To support the above task, the application needs to allow a user to save details about flood events and also have the possibility to view the saved flood events and their details

On a scale of 1-5 (poor to very well), how easy is it for a user to?

1. Create a new flood event
2. Add details about an event
3. Make changes to a flood event
4. View saved events
5. Delete a flood event
6. compare flood events records

3. Qiva platform as a GIS tool

GIS tools are important not only for visualization but to aid users in making decisions. On a scale of 1-5 (poor to well done), how easy is it to?



1. Determine high flood risk zones
2. Determine safe zones
3. Identify most vulnerable district, county or parish
4. determine the most affected places
5. determine the most impacting flood event

4. The platform as a visualization tool

The Qiva platform as a visualization tool needs to provide a user the ability to perform visual queries. How successful is the tool in achieving this basic functionality on a scale of 1-5 (poor to very well), can a user easily tell?

1. How many villages were affected in the flood
2. The nearest urban populated place to a flooded place
3. How many geographic features influenced the event
4. how to get to a populated place
5. the most vulnerable district, county or parish
6. compare flood events and their impacts

5. General user design centered questions (1-5)

1. How easy is it to use the platform?
2. Can this tool be beneficial to a disaster manager?

6. Comments

1. How can the platform be improved to better support the above functions?

2. Any suggestions about the platform in functionality and design?

3. How can the tool be more appealing to a user?



9. Testing and Evaluation results

Questions	Max	involved	non gis	expert	Average
Determine flood events					
identify affected places	5	5	4	3	
select flood locations	5	5	4	4	
view flood locations at different scales	5	5	4	4	
display interactive maps of different admin levels	5	4.5	3	3	
identify necessary geographic features	5	4.5	4	4	
Total	25	24	19	18	20.3
Record and store data					
Create a new flood event	5	5	3	5	
Add details about an event	5	4	4	4	
Make changes to a flood event	5	0	0	0	
View saved events	5	4.5	4	4.5	
Delete a flood event	5	0	0	0	
compare flood events records	5	4.5	3	4	
Total	30	18	14	17.5	16.5
platform as a GIS tool					
Determine high flood risk zones	5	4	2	3.5	
Determine safe zones	5	4	4	4.5	
Identify most vulnerable district, county or parish	5	4	3.5	4.5	
determine the most affected places	5	4.5	3	4	
determine the most impacting flood event	5	4	2	3.5	
Total	25	20.5	14.5	20	18.3
platform as a visualization tool					
How many villages were affected in the flood	5	4	3.5	3.5	
The nearest urban populated place to a flooded place	5	5	3	4	
How many geographic features influenced the event	5	4	3	3	
how to get to a populated place	5	3.5	3	3	
the most vulnerable district, county or parish	5	5	3	4.4	
compare flood events and their impacts	5	4	3	4	
Total	30	25.5	18.5	21.9	22.0
User design					
How easy is it to use the platform	5	5	3	4	
Can this tool be beneficial to a disaster manager	5	5	3.5	4	
Total	10	10	6.5	8	8.2
	120				85.3



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