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# A Geoportal Design for Drought Risk Monitoring in Tigray Ethiopia

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**Abstract:** Currently information is the base for every activity throughout the Universe. The information technology provides advantage of data storage and retrieval. Geoportal is one part of the information systems which can help in disseminating spatial and non-spatial information. Disasters risk monitoring, and specifically drought risk monitoring, is one of the area that is in need of information in order to reduce their potential negative effects. The drought-prone region of Ethiopia is currently using a manual system to collect, organize as well as disseminate drought risk information to various stakeholders, hence delaying the decision making processes. This study was done with the aim of developing a Geoportal for drought risk monitoring system in Tigray region. During the development of the system the basic requirements were collected and analysed. These requirements have been modelled to a concept that satisfies the needs of identified users. This portal has a web interface that allows interaction between the user and the system and analysed using Map server for window (MS4W) and P. Mapper framework are the software tools used to implement the prototype system. As a result the system can be used for distributing information online with the help of internet connection. In addition the system can produces maps by querying data from the database. The study concludes that with further modifications it can be fully implemented to the institutions involved on drought risk monitoring activities.

**Keywords:** Geoportal, Web-GIS, Disaster Management, Drought Risk Monitoring, Tigray

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## 1. Introduction

Drought is a natural disaster in many places of the World, so let us start by describing a disaster. A disaster is characterized by the scope of an emergency. An emergency becomes a disaster when it exceeds the capability of the local resources to manage it. Disasters often result in great damage, loss, or destruction [2]. A disaster can be manmade or natural. Natural Disasters include those unplanned events that occur as a result of natural processes such as earthquakes, tornadoes, tsunamis, freezes, blizzards, extreme heat or cold, drought, or insect infestation [2]. Natural disasters have an effect on many important economic and social parameters, which are related to a wide spectrum of geosciences. The complexity of natural disasters concerning each of the five phases in their lifecycle - prevention, mitigation, preparedness, emergency management, and recovery - leads to the selection of strong and capable tools, which contribute towards their management. Nowadays the most appropriate tools for this purpose are the Web-based Geographic Information Systems (GIS) [1], by providing an

interactive user friendly interface through the web.

Efficient risk drought monitoring systems commonly involve on-time collection and dissemination of these geo-spatial data to various stakeholders for timely decision making.

A Geoportal, which is a web-interface that allows fast and reliable dissemination of geo-spatial data, can play an important role in this aspect.

A Geoportal is a user friendly web-GIS interface that can give a chance to the users to easily access the information about drought at anytime and anywhere they are, with a simple Internet connection, without the need of expensive GIS software and/or GIS expertise. The aim of this research was to improve data accessibility for different stakeholders interested in the status of drought in Tigray spatially in Early Warning and Vulnerability Bureau of Tigray region and attempts to address this issue and hence propose a solution to improve it.

## 2. Methodology

Different methodologies are applicable for variety of applications depending on the requirements of the current business activity and further future modification concepts of the business.

To come up with this Geoportal design, different activities were covered, from requirement gathering, Analysis, designing and implementation. The prototyping software development approach was adopted. In this chapter, these steps are explained in details, after introducing the study area.

### 2.1. Requirement Gathering

Requirements are the basic elements to develop a system. In case of this research work, requirements were gathered from different sources. That is:

- The basic requirements for the available/used information and their characteristics were extracted from existing documents at the TEWVSB.
- Requirements about the existing system (data collection and dissemination processes) were gathered via the questionnaires and interviewing of the data administrator of the bureau.
- The remaining requirements were assessed via reviewing different published papers, journals, articles as well as web sources.

### 2.2. System Requirement Analysis

Requirements gathered as stated in the requirement gathering phase, were qualitatively analyzed in a way that they can serve as an input during the design and implementation phase. The qualitative analysis by summarizing and comparing information collected in the previous process. This was conducted in order to describe the existing system, to assess the static and dynamic components of the database so as to know the basic elements of the Geoportal to be developed in order to support the data and information dissemination, and finally to specify the required software and hard ware components in order to implement the system.

### 2.3. System Design and Implementation

#### 2.3.1. System Architecture

The system activity flow and its interaction with users and the database were designed following the unified modeling language (UML) concepts. That is, a use case diagram was designed using the Enterprise Architect software. The overall system architect has the Three-tier approach.

In the application tier, functions are grouped into three modules, namely geoprocessing and transformation, modeling and analysis, and feature editing and management. Geoprocessing and transformation module consists of a series of tools for handling, piping and transformation of geographical data in different formats. Feature editing and management is another important module that data

administrators use for data maintenance purposes. Modeling and analysis module is a group of functions for various kinds of analyses i. e. spatial analysis, geostatistical analysis, temporal analysis and other standard database analysis.

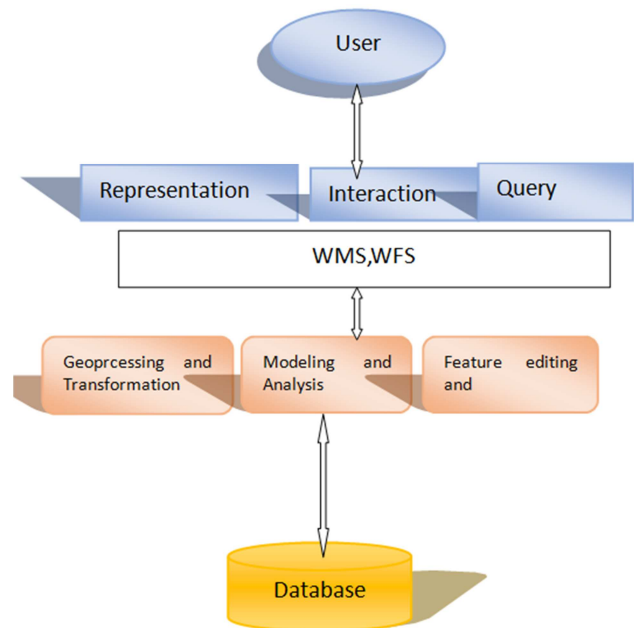


Figure 1. System Architecture.

#### 2.3.2. Web Map Service (WMS)

One fundamental component of the web map (and the simplest to understand) is the map image. The Web Map Service (WMS) is a standard protocol for serving georeferenced map images generated by a map server. In short, WMS is a way for a client to request map tiles from a server. The client sends a request to a map server.

The map server generates an image based on parameters passed to the server in the request, and then returns an image. It is important to note that the source material from which the image is generated need not be an image. The WMS generates the image from whatever source material is requested, be vector or raster based data [3].

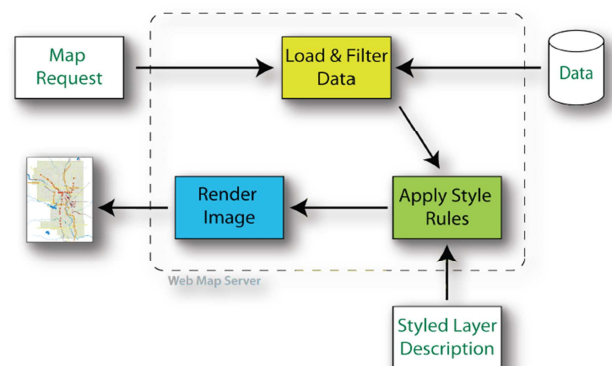


Figure 2. Diagram showing how WMS works.

#### 2.3.3. Web Feature Service (WFS)

A web mapping server can also return the actual geographic

data that comprise the map images. One can think of the geographic data as the “source code” of the map. This allows users to create their own maps and applications from the data, to convert data between certain formats, and be able to do raw geographic analysis of served data. The protocol used to return geographic feature data is called Web Feature Service (WFS).

#### 2.3.4. Sample WFS Request

The following is a sample WFS request, rendered as HTTP GET request (with line breaks added for clarity):

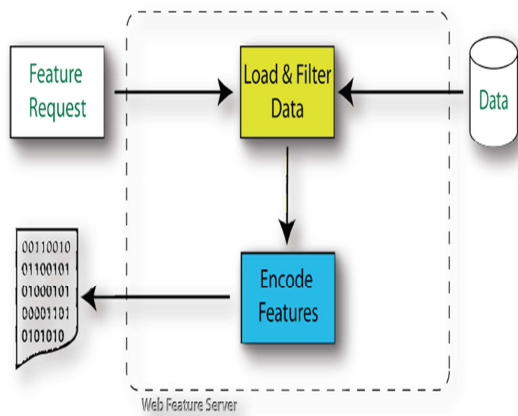


Figure 3. Diagram showing how WFS turns data into a map image.

#### Software Requirements

Depending on the activities to be covered within the scope of this work different tools and software were specified. For example the:

#### 2.3.5. P. Mapper

Is a framework based on MapServer and PHP/MapScript. It provides a good set of tools ready to use and it has a plug-in API to add functionalities. Developed by Armin Burger, it is distributed under GPL.

- Hyper Text Mark Up (HTML) language for developing the forms which serve as a webpage in developing the interface,
- MapServer[4] is a popular Open Source project whose purpose is to display dynamic spatial maps over the Internet. Some of its major features include:
- Java for writing server side scripting used to interact the database with the map server for Windows (MS4W) in order to display information output as map.
- PostgreSQL[8] with postGIS as an extension to provide a spatial database with its full functionalities that will help in spatial analysis.
- Notepad++ [9] as an editing environment for all the programming languages such as php, java, SQL as well as the hyper Text mark-up language (HTML)

## 3. Result and Discussion

### 3.1. Describing the Existing System

The existing data dissemination system of the Tigray Early

Warning and Vulnerability Studies Bureau (TEWVSB) is performed in a mixed approach, i. e. semi-manual. Paper-based forms about drought situations [Appendix 7. 2] are filled by woreda administrators to the TEWVSB, which enters the information in Microsoft Excel sheets, and further forwards it to the federal level for further processing.

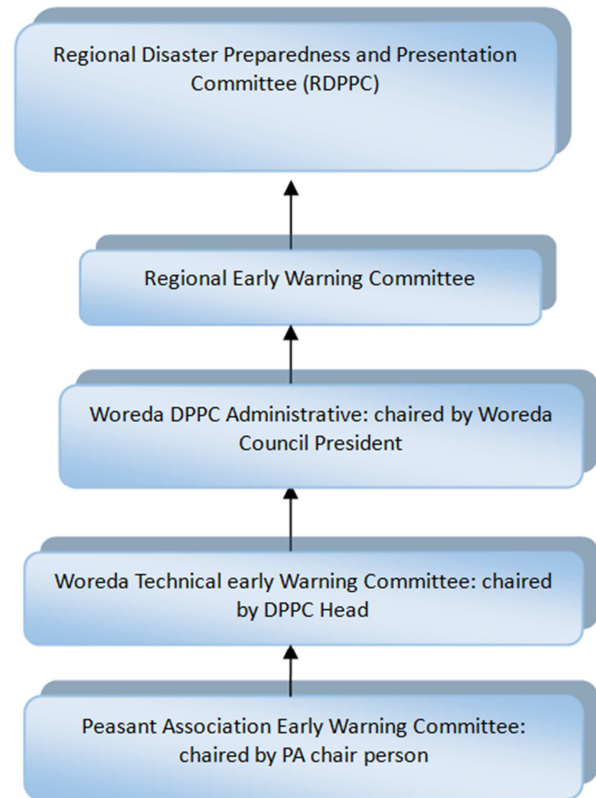


Figure 4. Data flow from Woreda to Regional TEWVSB.

On the question of “which data are used for drought monitoring, what are their characteristics and how are they disseminated?” the following answers can be given:

- Data used: Monthly reports on meteorological data, crop status, land preparation, Animal food supply, water supply, and these data have been organized in a database.
- Dissemination strategy: The only dissemination so far is done towards the federal agency.

The database that will support the Geoportal was designed to store and to handle data about the Woreda based on production activities (crop type, land preparation sowing and harvesting) in relation to the drought and its risk. Based on this, the database consists of six base tables and four derived tables. All these tables were designed based on the assumption that considers the main factors whether a drought will happen or not.

### 3.2. System Functionalities

Although a Geoportal can offers many different services, the Geoportal proposed in this study will only offer services related to accessing information about drought risk

monitoring, as in use at the TEWVSB in general.

The following functionalities/services are offered:

- Browse for metadata: this link will allow the users to access information about where to collect certain data and how. The metadata link is in this study not implemented, as the TEWVSB has not yet developed such a service. The bureau only forwards the information it gathers from Woreda, to the federal agency.
- Contact: the possibility to contact the website administrator
- Publication: the list of publications related to drought risk monitoring in Tigray. This activity of collecting publications by the TEWVSB does not exist for the time being; hence this service will not be implemented with real data.
- Information access about the following types of drought:
  - Agricultural drought
  - Meteorological drought
  - Hydrological drought
  - Socio-economic drought

Information includes: Maps and attributes tables information related to maps. Users can interact with the information by performing some queries by location, i. e., by woreda.

It has to be noted that only one user's actions, of the *data viewer* actor, has been considered for implementation, due to time constraints. The actors capable of interacting with the systems are described in further sections.

## 4. System Design and Implementation

### 4.1. Results of System Design

Figure 5 presents the Use Case diagram of the interactive map service.

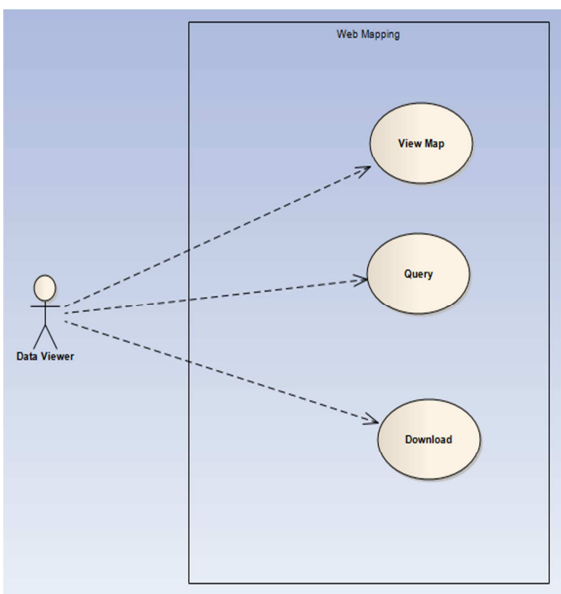


Figure 5. Use Case Diagrams for Web Mapping System.

Figure 5 shows different actors and their interactions with the interactive part of the system: the web-mapping. A *data viewer* can be defined as any entity interested in collecting/gathering/viewing information about drought risks in Tigray region. That entity can be a scientist, a researcher, an officer of the federal bureau in charge of drought risk monitoring, a non-governmental officer, etc.

The *data viewer* can perform the following actions, based on P. Mapper capabilities:

- I. Viewing a map is one of the functionality of the Geoportal for Drought Risk Monitoring System. A user can easily know where the drought is occurred; i. e in which area of the Tigray region is located the drought event.
- II. Querying: if an end user need specific information, the system has a searching mechanism tool for that. For instance, by entering a Woreda name, the user can view all information related to that woreda. Users can also access information by using the *identifier* tool and *click query*.
- III. Downloading selected information in Acrobat reader or in Microsoft Excel based on the user interests.

### 4.2. Results of System Implementation

The first step is to link the attribute data (in excel format) data with the shape file, which will be converted into a map file to be displayed on the web. At completion of the entire process, the following screen can be viewed from a web browser:

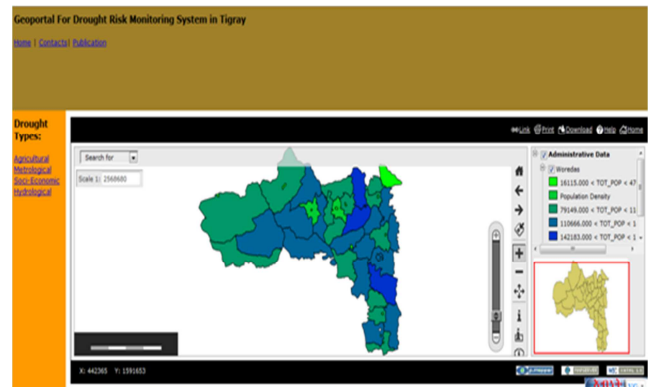


Figure 6. Geoportal Site Home Page.

## 5. Conclusion and Recommendations

### 5.1. Conclusion

This study aimed at developing a prototype Geoportal for drought risk monitoring in Tigray region of Ethiopia. It is well motivated with the fact that despite Tigray being a drought-prone area, it is virtually impossible for various stakeholders to access information on drought risks in appropriate format such as maps, in a relatively short period of time.

The research work started with a data collection on the dissemination process, conducted mainly at the TEWVSB.

The data collection was performed through interviews, questionnaires and observation. It was clear that there is no strategy in place for data dissemination. Respondents confirmed that the data and information they receive from the Woreda in paper format, are entered into an excel database purposely to be forwarded to the federal level. Such a process caused delays in data transfer and did not allow them to share information with other potential stakeholders. As such, a web-based interactive interface that can allow users to access appropriate geo-spatial data on time, and without an expertise in GIS, was welcomed.

The second objective was to identify the functionalities that such a system can offer. The number one priority was the web-mapping service, which offers GIS capabilities on every computer terminal, requiring only an active Internet connection. After conducting a literature review, and after discussion with the relevant staff from the TEWVSB, and especially given the technical constraints, a few web-mapping capabilities were proposed. This involved giving the user the opportunity to view the map, related attributes and query based on location. A web interface with a home page, links such as contact, publication, metadata etc. was also proposed. Although such a system would provide the minimum requirements of a Geo-portal, it is largely enough for the current demand.

The third objective was to develop the system prototype. This was done mainly with open source and free software tools, which prove to be a very good option for developing economies. Such tools are not only free but can be customized to meet systems requirements. PHP and P. Mapper were used to implement the Geoportal.

In conclusion it can be said that this study has successfully proposed a way to develop a Geoportal for drought risk monitoring in Tigray region, Ethiopia.

## 5.2. Recommendations

Most researches come up with many solutions and limitations. Those have to be recommended in further implementation or to be done again. This can be due to many reasons such as financial, time, as well as professionals to

handle the research consistently. This study incorporates web portal for drought risk monitoring system for regional level. Since this study is new to the region it is recommended to continue doing on the research in order to fully implemented. It requires time and integration of different sectors such as the bureau of agriculture, metrological agency, the bureau of early warning and food security.

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