Development of an Opensource Web Based GIS for Geocollaboration in Geothermal Resources Management

Wekesa.F, and Wandia. M
KenGen;
Geothermal Resource Development-Olkaria,
Dedan Kimathi University of Technology(DeKUT)
fwekesa@kengen.co.ke
dmwaura@kengen.co.ke
marywandia@gmail.com

Keywords: *WebGIS, Opensource, MapServer*

ABSTRACT

GIS technology has revolutionalized data analysis and dissemination in a myriad of disciplines. Geothermal resource development has been a major beneficiary of the budding technology especially within the African context. Most of the GIS applications for geothermal resource development have been desktop based, utilizing the technology's inherent powerful tools to prospect for geothermal potential. There is even more potential in utilizing the power of the internet in the development and management of geothermal resources. At KenGen there is great need of harmonizing and sharing centrally stored geothermal data over a large number of departments including Geochemistry, Geophysics, Geology, Drilling, Reservoir, Steamfield and Environment among others. Use of desktop GIS applications can be limiting in efficient dissemination and centralized management of geothermal data. This research entails developing a web-based GIS application that manages the company's geothermal resources for key decision making and planning and also provides the users with an innovative and interactive way to access the spatial content over the internet/intranet. The application developed provides various users with a variety of functionalities such as; querying and displaying geothermal well properties e.g. megawatt capacity, map editing and printing from the web interface, geothermal facilities identification, search and web editing of features. These functionalities are provided for different users with varying access rights levels according designation

1. INTRODUCTION

A considerable proportion of geothermal information is geothermal well-related and location-oriented, thus geographic information systems (GIS) become central to any geothermal information system. Practically speaking, GIS can provide geothermal activities with unprecedented benefits, which may lead to a reform of their work and achievements (Bails 2002). Most organizations lack a perfect comprehensive understanding of what can be realized from web GIS development, especially when considering the widely varying functions carried out by the various inter-related departments.

In reality, the management of the flow of spatial and attribute data within the geothermal development departments and with other bodies is difficult and time consuming, because the departments and other agencies maintain separate digital records. At present, the internet and GIS are becoming useful means for involving all in having a holistic approach to geothermal development.

Currently in KenGen hardcopy maps are central to any well siting activity within the geothermal resource development section. Maps enable various users to conceptualize the areal extent of geothermal development activities and amount of physical investment involved.

The approach to developing a web geothermal GIS solutions aims at instituting intrinsic changes into the geothermal site linking procedures and performance. GIS capabilities encourage geothermal developers to utilize their potential to enhance decision making and effectiveness in managing exploration and development affairs. Geothermal GIS is concerned with breaking down data barriers to corporate GIS that serves various departments to increase the appropriation of spatial data (Bails 2002). The objectives of a geothermal web GIS include the provision of a reliable, accessible database that supports the needs of explorers and other geothermal development users in a cost-efficient way. Most geothermal GIS approaches are exploration oriented and focus on processes in the institution covering analysis of all GIS components, that is, hardware, software, staffing, data and applications; however this study is concerned with developing a model web based geothermal GIS for data sharing among departments.

1.1 Geographic Information Systems

GIS is such a strong technology that many people have started or starting to use it in their fields. GIS is being used as a standalone or a supporting technology. Tom Bernhardsen (1999) defines GIS as a "system that captures, stores, manage, manipulates, retrieve and analyze geographic or spatial data through computer hardware/software and other cartographic special devices to create map products".

McAdam (1999) also defines GIS in a very simple way as a relational database that is capable of manipulating both kinds of spatial and non-spatial data together. Spatial data is in the form of digitized maps and non-spatial data is the attribute data in the form of alpha numeric records associated with the spatial data.

Due to its flexibility it can support endless applications in various domains. It has become a valuable tool and is been applied in the natural, social, medical, and engineering sciences, as well as in business and service planning (Wahi, 2002).

1.1.1 Web GIS

When GIS data and functionality are made available over the Internet, the system is referred to as a "Web GIS". With Web GIS, users do not need to purchase and install expensive GIS software in order to access and work with maps and databases. Also, users do not need to become experts in sophisticated GIS applications, since the functionality is made available through a regular web browser with a user-friendly GIS interface.

1.2 Problem Statement

Currently in KenGen's geothermal resource development department GIS form a critical component in activities such as geothermal wells siting, spatial planning of infrastructure, estimation of resources per unit area amongst others. These functions are carried out with aid of maps created from desktop GIS applications where users have to physically visit the GIS laboratory or have the products sent to them through email. This usually leads to a number of bottle necks as far as dissemination of the products is concerned. First it takes a considerable amount of time for GIS personnel to create a custom map for the user and may take some time in printing and seeking approval before the final map can be given to the user.

In the map provided to users, they cannot change the scale of the map; select an area of interest, find a suitable route to an area instantaneously. It therefore becomes too rigid when a bit of flexibility is required by the user.

Moreover, KenGen lacks a designed intranet framework to serve spatial data within the various Resource Development departments the click of a button. This not only makes it hard for the various geothermal resource development staff to access and share the vital geothermal information whenever needed but also they handle bulky, sensitive spatial data thus requires large spaces for their storage with dynamic updating structures.

1.3 Research Questions

The problems that are to be addressed in this research are summarized below:

- How can open source GIS tools develop a prototype application that showcases a geothermal site its facilities and potential?
- How can suitable query tools be developed for the prototype system?
- How can a map be used within a web-based information system prototype to provide the user with the information they want to access?

1.4 Objectives

The main objective of this project is the creation of an online GIS application that acts as a road map for geothermal resources management. In specific, other objectives include the implementation of an intranet based geothermal facilities viewing and querying system that would allow the all departments within the Geothermal Resource Development department to obtain spatial and non spatial information within the resources areas with ease. This also involves providing a system that facilitates data request, retrieval and viewing of geothermal related information on digital online maps and enable sharing of information over the web.

In detail it involves designing and developing a prototype interface that provides both spatial and non spatial geothermal resource development extents within geothermal sites using University of Minnesota Map Server, customizing the interface for enhancements with added functionalities of finding a location through queries, hyperlink the features and proximity search.

Finally the research will enable development of a geothermal systems database which holds spatial data for the Olkaria in which all data relating to geothermal resources and facilities can be stored and served

1.5 Study Area

Olkaria is home to Africa's largest geothermal project with an installed capacity of about 260 megawatts. Located in Naivasha, it is about 140km from Nairobi, the capital of Kenya and is an area of recent volcanic activity surrounded by many volcanoes such as Suswa and Longonot. In theory Olkaria has a geothermal potential of about 7000 megawatts and is central to Kenya's geothermal projects expansion with many future expansion development activities targeting the area.

Figure. 1. Map of study area

1.6 Justification

The main benefits that can be achieved from the system includes; increased productivity due to the ease of retrieval of spatial and attributes data whenever needed by different departments in the geothermal exploration and resource development, less space and time will required for data storage, easy classification of activities in progress based on level of development such as geothermal well pads, power stations, pumping station, infrastructure on the site and indicating phase of development e.g. the electricity potential in megawatts being developed within a specified time .

Accordingly, the benefits of geothermal GIS include the enhancement of the quality of decision making, expediting data sharing between various departments, providing Internet-based transactions and information, and contributing to the increased overall efficiency.

The project is in line with KenGen's transformation strategy of moving from a good to a great company specifically through the foundation ingredient of ICT. It will enable the efficient sharing of vital information within the geothermal resource area and thus hasten the objective of achieving more that 3000 Megawatts by the year 2018.

The project in addition employs open source software products which reduces costs especially of acquiring GIS software which is very expensive. The expected output will not be compromised in terms of quality thus making this venture very cost effective. It is a simple user-friendly front-end application on Mapserver to work on any Internet browser.

2.0 DEVELOPMENT METHODOLOGY

According to the New York state Archives GIS development guide, database planning is the single most important activity in any GIS based project. It is one of the most valuable assets for any GIS analysis in a project and therefore forms an integral part in the process (Jones, 1997).

An updated and an accurate database is necessary in order to give the best results to the users. Chawla & Shekhar (2003) mentions the three classes of GIS or spatial database users as the business users, scientific users and the common public user. The application i.e. Geothermal GIS is intended for the departmental users as they are more interested in using spatial data to personalize their experience and interaction on the worldwide web. This project mainly depended on availability of data which was obtained in form of shape files. These shape files were obtained from KenGen's GIS laboratory.

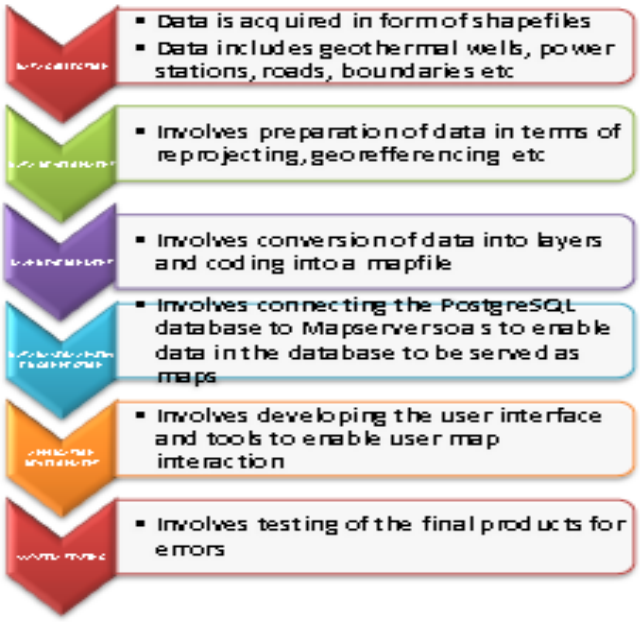

Figure. 2. Flowchart of development methodology

2.1 Data processing

This basically involves preparing data for use within the GIS system. This involved projecting the raster and vector data to their required reference system using tools available within the GIS application software's. Data processing also involved creating fields for each specific feature class so as to include non-spatial attributes of each feature object to be stored in the geodatabase.

Generally, the tasks involved were assignment of map co-ordinates and spatial location, transforming between different reference systems, creating fields and assigning attributes to individual features. All the datasets in the geodatabase were projected to a common coordinate system World Geodetic System 1984 Universal Traverse Mercator Zone 37 South.

Data was added in form of layers to the map created in Quantum GIS as shown in the figure below. The data layers added to the map frame were the production wells, exploration wells, reinjection wells, boundaries, steam pipes, roads among others.

The data was then exported to PostgreSQL relational database in form of Tables which contained Geometry columns through PostGIS. PostGIS is an open source software program that adds support for geographic objects to the PostgreSQL object-relational database. PostGIS follows the Simple Features for SQL specification from the Open Geospatial Consortium. As such, PostGIS includes; Geometry types for points, line strings, polygons, multipoint's, multiline strings, multi polygons and geometry collections, Spatial operators for determining geospatial measurements like area, distance, length and perimeter, spatial operators for determining geospatial set operations, like union, difference, symmetric difference and buffers and index selectivity support, to provide high performance query plans for mixed spatial/non-spatial queries.

Therefore PostGIS adds support for geographic objects to the PostgreSQL object-relational database and in effect spatially enables the PostgreSQL server, allowing it to be used as a backend spatial database for geographic information systems.

Mapserver was then used to deploy an Internet based system that combined GIS tools with attribute data to be served over the geothermal network. On a basic level, the Minnesota Map Server 5.x architecture includes the server and the client. The client requests information from the server which then processes the request and sends the information back to the client.

2.2 Map development

The content of the internet map that would be seen by a user was developed using the University of Minnesota Mapserver application. MapServer is an open source development environment for building spatially-enabled internet applications. It runs as a Mapscript which supports several programming languages. MapServer was originally developed by the University of Minnesota with support from NASA, which needed a way to make its satellite imagery available to the public.

2.2.1 Mapfile

This is MapServer's most basic requirement. All information concerning the map to be served, its color properties, the layers definition and many other attributes are configured from the Mapfile. The Map file is presented as ASCII file. It configures basic information for UMN Map Server mechanism such as map's units, projection and the path of the data. The Mapfile defines the data to be used in an application and display and query parameters.

The Mapfile also includes information about how to draw the map, the legend, and maps resulting from a query. Mapfiles normally have a .map extension. After Mapfile has been properly configured the application is ready to run on a user's web browser using an interface provided in the next section. The figure below illustrates the whole working process of the application.

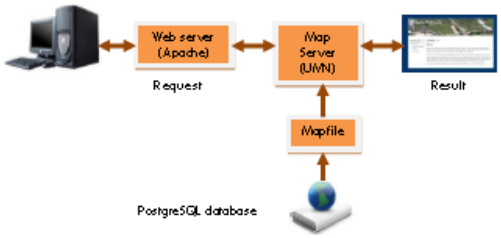

Figure. 3. Map publishing process diagram

2.3 User Interface Design

The interface is designed using PHP and HTML such that the user interface supports a thin client architecture and convenient for users of Web based Internet applications. JavaScript and Ajax add more functionality to the interface. Size of the frame and the corresponding HTML file that fills in each frame can be seen in the layout

The HTML files generate each frame in the Viewer and the JavaScript files handle and support the actions performed on the interface. The basic viewer is divided into sections which are called as frames in HTML and are allotted to each specific activity. It includes title bar, layers information, tool bar, legends, overview and a detailed map with the display area for query results. Drupal content management system was used to host all content of the interface and also to introduce security by providing an authenticated user login system.

3.0 RESULTS

The main goal of this application is to provide a powerful application with a simple and user friendly interface which a user with no GIS experience and knowledge of using the GIS tools should be able to navigate through the system without any confusion.

The basic HTML viewer provides tools for navigating the map and performing various functions over it. Some of these tools are complex to operate for a naive GIS user, and therefore, needed to be simplified by combining or removing them according to the user requirements.

The tools were represented by buttons customized in Adobe Photoshop. The buttons created are medium sized with a picture representing the functionality but no names are described on them. Whenever the mouse pointer comes over the tool, respective function is dynamically displayed in the form of a tool tip. The tools are divided into the following categories as follows;

- **Map Navigation Tools** – Zoom In, Zoom Out, Zoom to Full Map, Zoom to Last Extent & Pan.
- **Attribute Data Retrieval Tools** – Identify, Select, Query Editor and Auto identify.
- **Other Tools** –Measure, Select Feature, Clear Selection, Print, Help, and Layer select and download.

Figure. 4. Intranet page home page

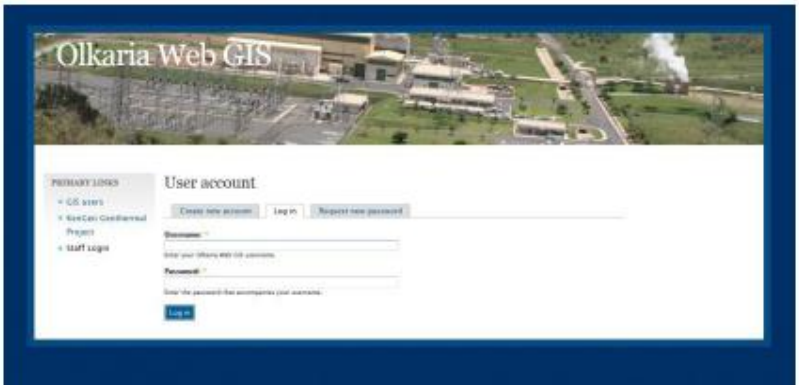

Figure. 5. User login page

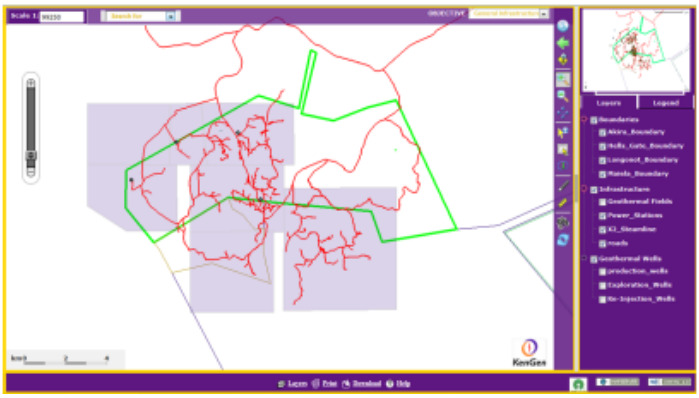

Figure. 6. WebGIS interface

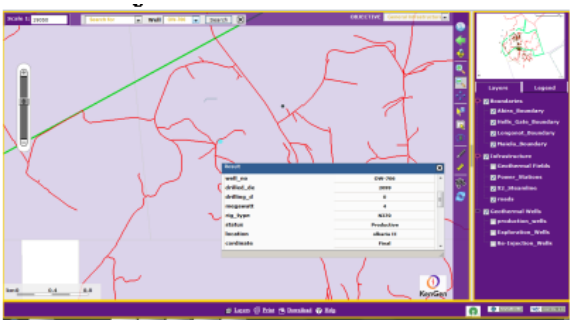

Figure. 7. Basic search function (OW-706)

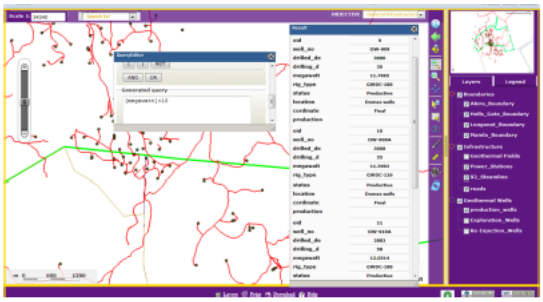

Figure. 8. Query function (wells with above 10 MW)

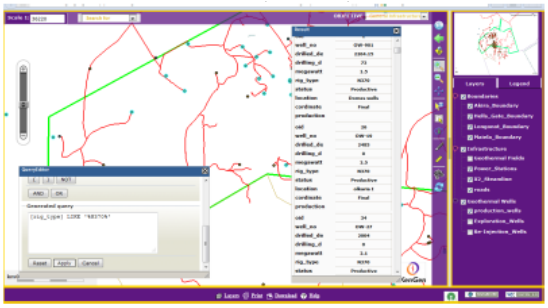

Figure. 9. Query function (wells drilled using rig N370)

3.1 Security

During the course of this project, concerns over security issues associated with the publishing of geothermal data over an intranet were addressed by creating different levels of users, use of encryption, and application of a geothermal database which is separated from final interface.

Only the administrator can update the information in the website while other users have limited privileges. Because this application was developed for intranet use, security issues and concerns are the responsibility of those in charge of creating and maintaining the geothermal network.

4.0 CONCLUSION AND DISCUSSION

This research has developed an accessible web GIS prototype through which the spatial information related to geothermal activities in KenGen can be disseminated to various end users. This integrated online application allows users to interact with various maps customized to their own use. The users can also get important information about geothermal resources and facilities through online GIS queries and searches; this is useful for fast information delivery.

During the research project a geothermal resource database was created. The database in conjuction with the application allows various users to access information quickly and efficiently.. The web mapping application proved that open source servers such as UMN MapServer has the capacity to serve large amounts of spatial data quickly and with good quality.

As had been envisioned, web GIS application design, development and implementation are inevitably related to multiple challenges. From the perspective of the web GIS application, a developed base map is very beneficial because many users will find it easier to get information they need via a web browser rather than a visit to the lab

REFERENCES

Bernhardsen, T. (1999): *Geographic Information Systems, an Introduction* (2nd edition) Wiley, New York, pg.550-572.

Chawla, Sanjay and Shekhar, Shashi (2003). *Spatial Databases: A Tour*. Pearson Education Inc., New Jerseml, pg.678-705.

Jones, Christopher B. (1997). *Geographical Information Systems and Computer Cartography.* Addison Wesley Longman Limited.pg 432-670.

McAdam, David. (1999). *The value and scope of geographical information systems in geothermal management.* Journal of sustainable development. Vol. 7, No. 1, pg 1123-156.

Wahi, Ramesh Col. (2002). *Managing GIS projects*, ESRI India. Proceedings of Map India.