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ELECTRONIC WATER RESOURCES MANAGEMENT SYSTEM (EWRMS)

A case study of the Department of Water Resources Development Copper Belt Province Zambia

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Ackim
Phiri
(Author)
School of
Engineerin
g
Information and Communications
University Zambia Lusaka, Zambia
Email: ackimhill@yahoo.co.uk

Abstract

The prime objective of this research paper is to design and develop an Electronic Water Resources management System (E-WRMS), a web based database application meant for facilitating the capture and collection of Water Resources Development data for the Copper Belt province ten (10) Districts. The development methodology adopted for this research is the Agile approach. The exercise largely involved collecting of primary data through interviews, field surveys and application of satellite and computer technologies namely; Google earth, Global mapper and Arc GIS. Secondary data was also captured by utilising Water Acts and written reports such as Geodin Database manual. The aim of this study is to create an accessible and user friendly online system that will be accepted by the users. This will bridge the gap in the information divide that has been there for many years. This research will help the policy makers in the water sector to include Information and Communication Technology tools in the future water reform policies for ICTs are enablers to electronic government successes.

Keywords—Agile; database; technologies; water sector; information and communication technologies; divide.

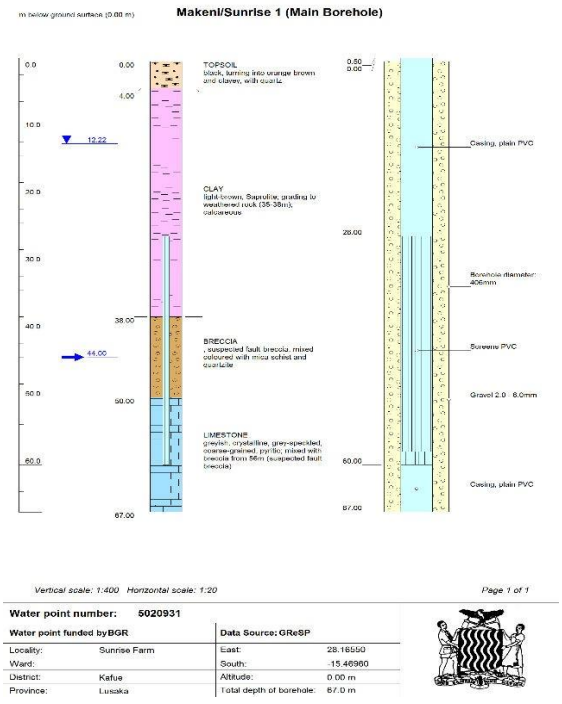
I. INTRODUCTION AND BACKGROUND

The Department of Water Resources Development (DWRD) on the Copper belt province of Zambia which is under the Ministry of Water Development, Sanitation and Environmental Protection (MWDSEP) was formed as a result of the Water Act No. 21 of 2011 which repealed and replaced the Water Act 1948, despite these reforms there has been no online database web application system for Boreholes, Dams, Water levels, quality water analysis and other related information in place to manage these water resources (Water Act, 2011).

The department's obligation and functions are to promote sustainable development of water resources in ensuring availability of quality, affordable safe water to enhance national social and economic development. The department has two sections namely Infrastructure Development and Hydrogeological (groundwater) (Kalonge, 2017).

There is a significant study by Chisenga (2004) which has shown that government websites are beneficial in informing the public of new developments through government documents and provide electronic service delivery like online applications hence forth enhancing interaction between the government and the members of the public through feedback facilities. Therefore, the electronic water resources management system will provide online content of the province water resources development sites such as Boreholes, Dams, Rivers, Streams, and Wells etc.

Previous studies have also been done by the Groundwater Resources Management Support Programme (GRESP) for the Ministry of Mines, Energy and Water Development. According to GRESP GeoDin Manual (2010, p. 1), this commercial software package is defined as 'GeODin Software is a tool used for Groundwater Management System which manages the groundwater levels, chemical water analysis and climate data combined with geological layer data, and depth correlated data sequences and well design. Data is stored in a structured database. GeODin also connects with several Geographical Information systems (GIS) to display the data. This enables the user to visualise the data using a map' (Tewodros, 2012). The geology and casing data that is entered produces what is called the borehole log. The borehole completion form is generated; and many others. See an example below: (Tewodros, 2012).



Source: (Geodin Manual 2012)

This is a very special tool for managing ground water resources, I hope future studies will include other water resources information such as Dams so as to serve the communities better.The justification to conduct this study is to see to it that water resources data and information dissemination is made available to the main stakeholders and members of the public in all the ten (10) districts of the Copper belt province. This is in accordance with the government of the Republic of Zambia National Information and Communications Technology (ICT) Policy and Information Technology plan of 2007 (Ministry of Communication and Transport, 2007). This ICT policy is focused on thirteen (13) pillars of which the researcher concentrated on Environment and Natural Resources pillar. Water resources provide a pivotal role in promoting food security and economic prosperity through crop irrigation, management of forest plantations, fisheries, animal husbandry and to provide recreational amenities. Dams play a role of minimizing impacts of climate by either holding or delaying the release of runoff water during prolonged dry spells and extreme rainy periods respectively. Finally carrying out this study will help the province as a stepping stone to future studies. Furthermore, the study would create a platform of practicing and localizing some of the internationally developed methodologies in systems and software production.

II. METHODOLOGY AND METHODS

II.I Methodology

The objective of methodology is to describe the research methodology for answering the research questions. Methodology overviews the research design, identifies the study population and addresses measures of new system design, development, usability and

functionality. It also unfolds with sections on research design overview, electronic government framework, population, and data collection techniques and data analysis.

II.II Research design

Research methodology revolves around two major approaches; quantitative and qualitative. Quantitative approach involves collecting numerical data whilst qualitative approach involves methods that collect verbal or textual data. The research used a mixed survey research strategy in this study. This research was administered by qualitative, with some quantitative elements, as it focused on obtaining in- depth information about the key issues of the department's mandate of Zambia's Copper belt province and its ten (10) districts.

II.III Framework of the study

The Department of Water Resources Development Ndola was evaluated in order to define the framework. This framework included criteria to address aspects of services targeted towards the Province and its district, communities, stakeholders, businesses as well as other government and utility agencies. Stowers (2002) identify and labels six parameters comprising e-Government websites usability: (a) online services,
(b) user-help, (c) navigation, (d) legitimacy, (e) Information architecture (f) accessibility accommodations. The departments Electronic Water Resources Management System was developed by following three usability variables

1. Web Content
2. Web Interactivity
3. Web Accessibility and Usability

II.IV ation of the research

The Population of this research consisted of all the ten (10) districts of the Copper belt province of Zambia. However, the targeted population of this study comprised the department head (the Provincial Water Development Officer), Senior Water Engineer, Senior Hydro geologist, ten (10) District Water Development Officers, ten (10) Engineering Assistants, Senior Drillers and the Executive Officer. This study targeted the Provincial Water Development Officer, Senior Water Engineer and Hydro Geologist. According to Leedy (1997) there is little point in sampling a population that is less than 100 therefore, no sampling was involved in this study.

II.V Data collection methods

Primary Data collection involved using self- administered questionnaires, semi-structured interviews and computer technologies such as Global Positioning Satellite (GPS), Global Mapper and Arc Geographic Information Systems (GIS) for site data capturing. Secondary data was collected via Government documents. Ngulube (2007) observed that although no single method is perfect, if different methods lead to the same answer, then greater confidence can be placed in the validity of the conclusion.

II.VI Questionnaires

The quantitative aspect of the research was facilitated by semi-structured questionnaires. The questionnaires were administered to the District Water Development Officers and Engineering Assistants who were conveniently selected to participate in the study. Questionnaires are used to collect information on facts, attributes and opinions as observed by Chifwepa (2006).

II.VII Interviews

The qualitative aspect of the research was facilitated by semi-structured interviews with the Provincial Water Development Officer, Senior Water Engineer and Hydro geologist at the provincial office Ndola in a face-to-face setting. The quality of data from interviews as observed by Burto (2000) is usually superior to that obtained by other methods; this is also attested by Chifwepa (2006).

II.VIII ata analysis

Data that was collected for this study was largely qualitative with few quantitative elements. Data analysis was therefore carried out differently for both qualitative and quantitative data. Therefore, the analysis of quantitative data from questionnaires was done through the aid of SPPS software.

II.IX Administering the questionnaires and interviews

The Provincial Water Development Officer, Senior Water Engineer and Hydro geologist were expediently contacted individually through office visits to introduce the research and its purpose. The methodology was evaluated by using agile methodology.

II.X cal consideration

The study was conducted in English, the language used by both the researcher and the participants. This was in order to ensure accuracy of meaning optimised. The participants were informed from the inception about the nature and purpose of the study. Confidentiality and the rights of the participants were also considered.

II.XI Limitations of the Research

The study focused on the department of Water Resources Development of the Copper Belt Province of Zambia and its ten Districts only. Other provinces were not part of the scope. The research purposefully addressed water resources development management system design and development providing online services, user-help features and information architecture. The exclusion of other provinces is the major limitation.

III.I. Materials

The Electronic Water Resources Management System application was developed using the Agile software development model and other open source software and these are Hyper Text Mark-up Language (HTML), Cascaded Style Sheets (CSS), JavaScript, Hyper Text Pre-processor (PHP) and My Structured Query Language (MySQL). The use of open source software

for this application development makes it cost effective and flexible. MySQL is used as a database server for it is a multi-user, multi-threaded and robust SQL (Structured Query Language) database server. The MySQL database server embodies a resourceful software architecture that maximises speed and customisability.

Apache is used as a web server. It is a fast, stable and feature-full open source web server. It is designed to run under multitasking operating systems and is capable of managing synchronised requests. PHP is used as a scripting language. PHP is a widely used open source scripting language. PHP is particularly appropriate for web database applications because it supports a wide range of databases and has tools that integrate the Web and database environments (Hugh, 2002).

III.II. Methods

The implementation of EWRMS web database can be described as three-tiered architecture model. The base of the application is the database tier, which integrates the database management system, MySQL. Built on the top of the database tier is the middle tier that contains most of the application logic, which is accomplished by using HTML or PHP: Hypertext Pre-processor (PHP). Apache web server is used to facilitate communication between tiers. On top is the client tier, i.e., typical web browser software that interacts with the application (Apache, 2017)

III.II.1. First tier

The client in EWRMS three-tier architecture model is implemented as thin client. Web browsers are very thin clients and thus the first tier in our three-tier architecture model is just a web browser. Using a web browser as a thin client offers the advantage of easy deployment, the user who has a web browser can use our application without installing anything new. Also using web browser as a thin client makes our application platform independent. Thus, a diverse range of geographically dispersed users can access useful information online using the website (MySQL, 2017).

III.II.II. Second tier

The second tier handles most of the application logic. It mainly serves as an interface to connect the other two tiers. It consists of an Apache web server, PHP engine and PHP scripts. The second tier is responsible for collecting the data from the user (a request is made to the web server, which is then passed to the scripting engine through the engine's web server interface. Based on the information provided by the user data query is prepared and sent to the database (An appropriate PHP script is retrieved from the disk which is then compiled and run by the Scripting engine. Finally, the results are formatted and sent back to the user for display using the Internet (The web server interface returns the output to the web server which passes it back to the user.)

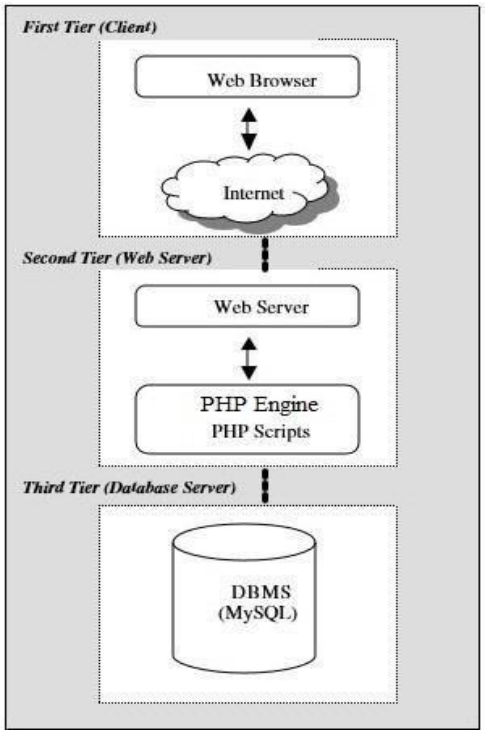


Figure1. The three-tier architecture model of web database

III.II.III. Third tier

The third tier in the website three-tier database application is the Relational Database Management System (RDBMS). We have used MySQL RDBMS to provide the required functionality. The responsibilities of RDBMS include

- To effect efficient storage of data
- To provide data integrity constraints
- To provide concurrent multi -user access
- To guarantee authorized and secure access to the data
- To recover the database in case of a crash

Figure 2 demonstrates how the marked sites appear on the EWRMS website.

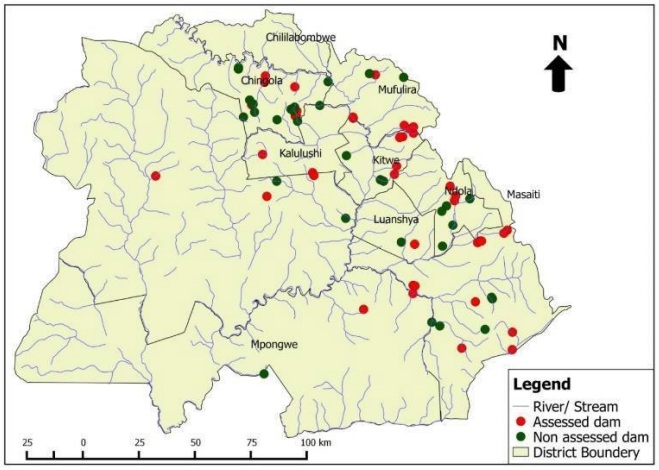


Figure 2 showing the Copper belt Province marked Dams, Streams / Rivers and Administration Boundaries

III. RESULTS

The results of the study were collected via questionnaires, interviews and computer technology such as Global positioning satellite (GPS). The intent of the research was to develop an Electronic Water Resources Management System (EWRMS) for the Department of Water Resources Development Copper belt Province and its ten (ten) Districts. The aim of this system is to contribute towards improving quality and effectiveness of online information of Water Resources development.

III.I Questionnaires and Interviews

Response rate for the two categories of key information of face-to-face interviews was conducted with one (1) head of the department at the provincial office, Senior Water Engineer and Hydro geologist in Ndola. In addition, a total of twenty (20) questionnaires were distributed to District Water Development Officers and the Engineering Assistants in the ten (10) districts respectively. All the questionnaires were correctly filled and returned representing response rate of 100%.

III.II Profile of the Respondents

The targeted key respondents were the Provincial Water Development Officer, ten District Water Development Officers. The main attributes of concern under profile include gender and professional qualifications.

Table 1 Profile of Respondents

Responses	Frequency	Percentage
Male	6	60
Female	5	40
Total	11	100

III.III Districts

A total number of 35 respondents from the ten (10) districts participated in the study. Table 2 below summarises the data on respondents from the department.

Table 2 Respondents from the Districts

District	Frequency	Percentage
Ndola	2.0	10.0
Luanshya	2.0	10.0
Kitwe	2.0	10.0
Mufulira	2.0	10.0
Masaiti	2.0	10.0
Mpongwe	2.0	10.0
Kalulushi	2.0	10.0
Chingola	2.0	10.0
Chililabombwe	2.0	10.0
Lufwanyama	2.0	10.0
Total	10.0	100.0

III.IV Boreholes and Dams

The aim of this question was to collect data on Boreholes and Dams from the Province districts. According to the findings, most of the respondents were aware of Dams and Borehole sites. The tables

of both existing Boreholes and Dams are shown in figures and tables section.

III.V ary purpose of developing EWRMS

The study gave the researcher choices of one variable for developing an Electronic Water Resources Management System (EWRMS) which is web based database driven application of Boreholes, Dams and other water resources sites information. The findings indicated that there is no website in existence to manage water resources data. Henceforth, there is no electronic and online dissemination of information on important water resources development to the major stakeholders in the water sector.

The interviews revealed that the department surely needed to develop a website in order to provide critical information about Water Resources to communities in the province and districts.

III.VI Purpose of EWRMS

The purpose of Electronic Water Resources Management System is to disseminate information, market the department and to act as a communication tool. The table 3 below shows how the respondents responded to the purpose of the system.

Table 3 Purpose of EWRMS

Target Audience for EWRMS

The study showed the following results: 61.2% of the respondents said the EWRMS must

be designed for the general public; 18.4% were for civil servants, 10.2% were for the department staff, 6% were for businesses and 4% stated other groups.

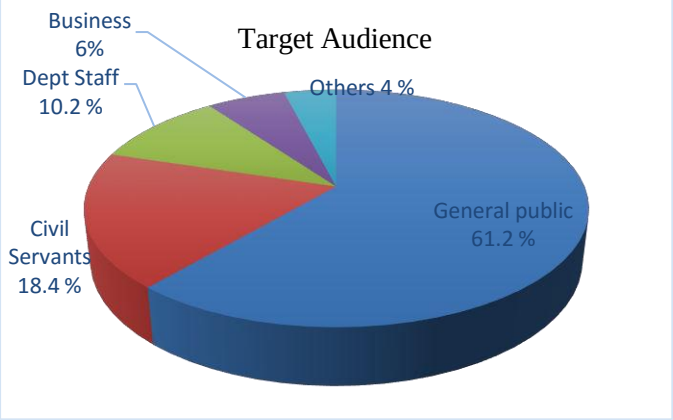


Figure 1: Target audience

III.VII Information to be disseminated by EWRMS. The aim of this question was to find out the nature of information to be posted on electronic water resources development system. Among all respondents Boreholes 76%, Dams 12%, Rivers 8% and Streams 4%. The figure about EWRMS is shown in figures and tables section.

Reponses	Frequency	Percentage
Information dissemination	36	73.5
Market Department	6	16.3
Communication tool	3	6.1
Not sure	2	4.1
Total	49	100.0

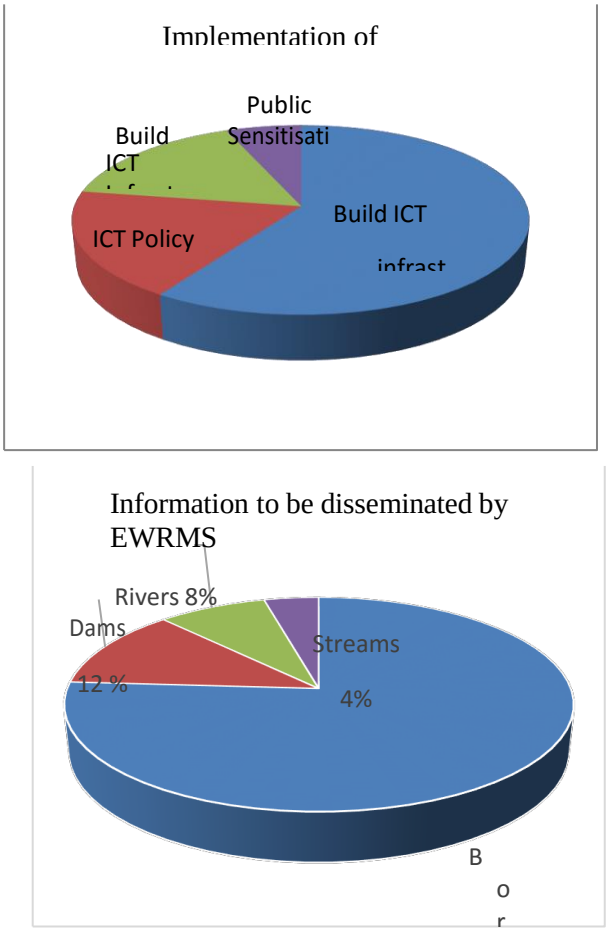


*Figure 2: Target audience*Frequency of updating EWRMS

The aim of this question was to establish whether the department would pay attention to content updates on the system. The study found that 70% regular updates, 16% seldom, 8% not

sure and 6% neve.

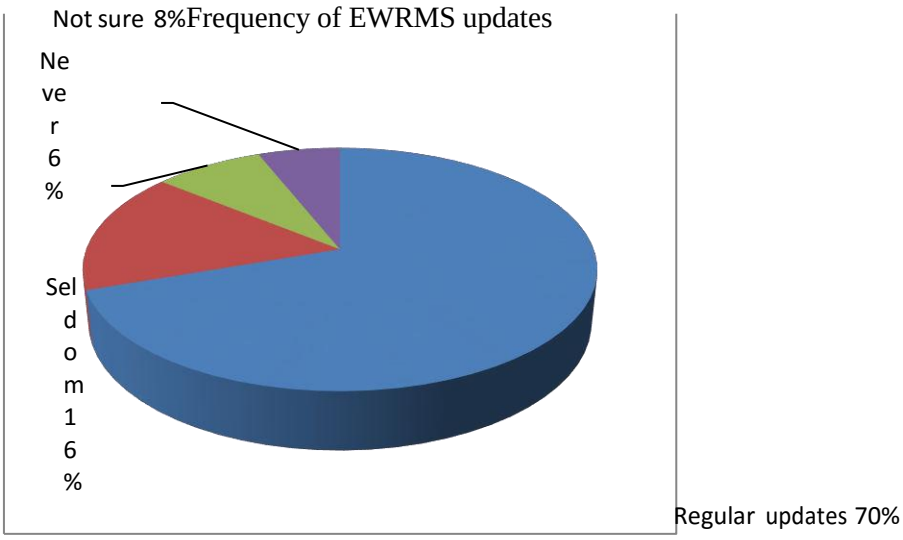


Figure3: showing frequency of EWRMS updates

III.VIII Implementation of EWRMS

The action to be taken in order to encourage implementation of Electronic Water resources Development System is Strong ICT Policy 18.4%, Build ICT infrastructure 59.2%, Redesign Manual System 16.3% and Public Sensitisation 6.1% as given in the figure below.

Figure4: showing implementation of EWRMS

These materials, methods and design, enabled the researcher to design and develop a database driven website by using HTML, CSS, PHP, JavaScript and MySQL database. Due to the nature of the of the Water Resources data, sufficient Security must be maintained on all access to the database. To this effect, user-level access is controlled through a login system; when an individual or an organization is granted access to the database, they are assigned a unique "Username" and "Password" which is required to access the system. Figure 3 shows the initial screen challenging the user for authentication.

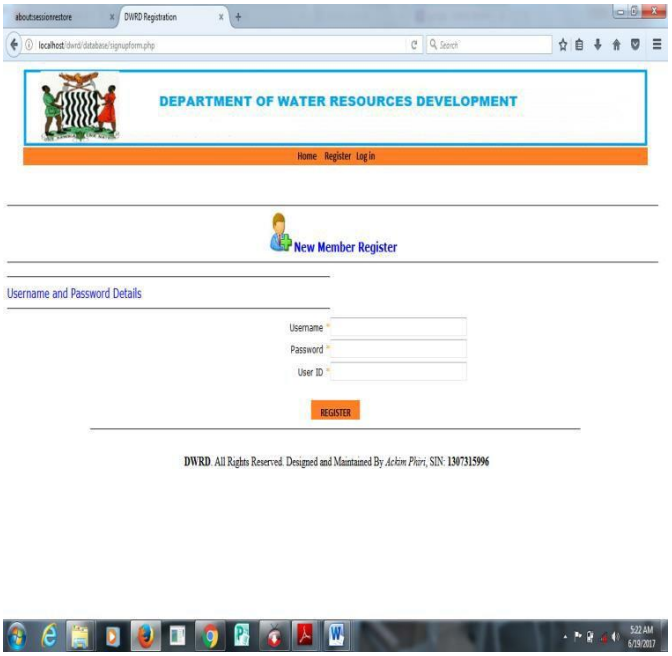


Figure4. System Signup, user-level security

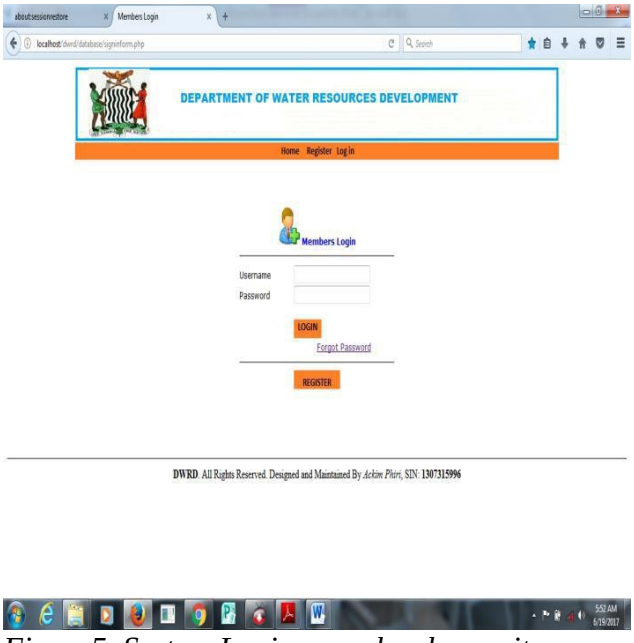


Figure5. System Login, user-level security

Using the signup and login scheme, different privilege levels can be granted to various users depending on their nature of work. For instance, the Provincial Water Development Officer and District Development Water Officers may have privileges to add or modify Boreholes and Dams records while the systems administrator may have privileges to add, modify or delete user accounts. General users may have read-only privilege on the data. Furthermore, general user accounts may be restricted to the PWDO and Systems Administrator, or may have access to both.

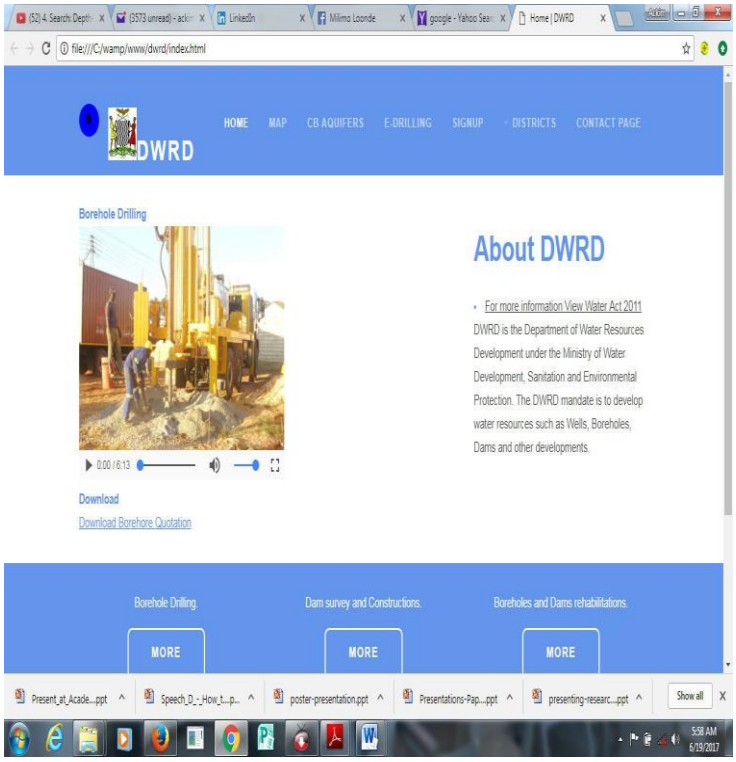


Figure6: System Home page

In order to enhance security, all accesses whether to user accounts by administrators, or to the database itself by the end-users, are logged; if the user has any suspicions about whether unauthorized accesses have taken place using their username and password, they can communication to the administrative staff who will have access to the entire login history for that particular user. The complete system functions seamlessly from the end -user's perspective, providing them with an easy –to use secure interface to a wealth of data. Enabling the system to deliver content in an elegant format allows the End -user to spend less time retrieving the required data and more time on its applications in their respective research. Effectively, the system discussed above is more "knowledge -delivery" than "data-delivery."

IV. FINDINGS

The findings obtained from this research revealed that the Department of Water Resources Development (DWRD) has no Web presences and an online electronic database to manage the water resources data and electronic participation of stakeholders, despite having undergone various reforms from time in memorial.

After summarising the obtained data through a thorough analysis, the researcher was motivated to undertake this study in order to improve on record keeping of Dams and Boreholes and improve the customer service satisfaction by also designing and developing electronic Borehole Drilling (E-BD).

V. DISCUSSION

The discussion highlights the significant aspects based on the following specific research questions:

1. How effective is the existing system?
2. What technologies are used in the existing system?
3. Is monitoring and evaluation of water resources sites being undertaken? If not, what are the hindrances to the processes of monitoring and evaluation of water points?

In order to answer the specific research questions outlined above the work by the Zambia Research and Development Centre (ZRDC) assisted the researcher in designing and developing the Electronic Water Resources Management System. According to *Electronic Public Service Management (e-PSM) (2010, p. 16-17),* 'The e-PSM portal is a web-based/SMS-based tool that will integrate access to currently stand-alone systems in the PSMD into a one central contact point for public service processes. The central module of the e-PSM will provide functionality and interface to facilitate the usage of public service marketplaces such as e-registration, e-recruitment, e-learning and skill management, and to offer more self-service to the civil servant. The development and implementation of e-PSM portal will change things in the PSMD.

It will create an opportunity to delegate the data entry to civil servants. Transactional and Traditional tasks will now be largely carried out through the e-PSM system. As a result, the introduction of e-enabled delivery of public service such as online recruitment and training systems will save more time and resources in particular.

The use of e-PSM portal to support operational processes will increase the amount of information available to civil servants by providing online access to civil service policy and practice handbooks. Strategic processes will be streamlined through online notification of events such as holiday or sickness, online applications for leave, and online selection of options such as training course registration and benefit systems. Web-based / SMS-based operational activities focusing on civil servants will facilitate collaboration between individuals through discussion groups, and communities of practice, as well as giving civil servants the opportunity to carry out their work at remote locations through this e-working facility.

Finally, at the strategic level, e-PSM portal will help civil servants be constantly ready for change, encouraging online training and learning activities, as well as 360° feedback systems and internal vacancy application systems. The e-PSM portal will manage online processes (public service interaction, information searches, work scheduling) and community services (balancing work and home life by allowing civil servants to deal with certain personal tasks at work)' (Silumbe Richard, 2010).

This master piece related work done by the ZRDC case study helped the researcher to methodically probe the existing system at the department and helped to come up with an online database driven website.

After a careful study it was also revealed that the technologies used by the department were good and if they can be integrated into an electronic system the information can be readily available to the stakeholders and members of the public on the Copper belt Province.

Monitoring and evaluation of water resources development sites is done but it is only the Provincial Water Development Officer who undertakes the process. Now during the event of not having allocated funds, the activity cannot proceed henceforth the electronic system can alleviate this dilemma.

This is a clear indication that the Copper belt province is ready for Electronic Water Resources Development System to manage all the water resources development data and information which is pivotal to the sustainability in the health, social and economic needs.

VI. CONCLUSSION AND RECOMMENDATIONS

The following are the recommendations:

i. There is need for water policy makers to include ICTs. There is need for them to seek reference to some regionally developed rational methods for estimating basic hydrological and hydraulic parameters whenever formulating water policies;

ii. There is equally need to create awareness on the importance of seeking for professional assistance in ICTs during the design and development of databases in the study area;

iii. There is need for an in-depth study on the concept for generating hydrological graphs for the systems that are ideal for designing of boreholes and dams databases in the study area.
iv. There is need to build an ICT infrastructure.

Conclusions

Water Resources development affects even the richest of economies. Its poor development can result into a social and health problem. It is therefore imperative for the Department of Water Resources Development, to be prepared and to be able to adequately manage the existing and new water resources sites.

It is the collected data on water resources that is critical in the development of water resources. In the information era, information is generally managed through an information system. It defines the functions of specific offices and the type of data they require. The Electronic Water Resources Development Management system is a tool that will help in the management of water resources. Components of the system such as dams and boreholes electronic database, development of water resources, searching capabilities, online drilling application, and borehole quotation download can be

performed by this system. This is a major significance of this project.

The development of the system has far reaching implications beyond the Ministry and the department but will also help in prudent decision making by the government as it strategizes towards public water sector data in the country. This is also a contributing factor to the agenda of E-Governance that the government has adopted. By having a central repository of water resources data, other miscellaneous aspects related to the management of sanitation and environmental protection of the public, the indexing and locating of records relating to water will be greatly streamlined. This streamlining will greatly improve inter department communication and enhance the effective management of safe water for drinking.

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My fellow exchange students for the academic interactions we had whilst at Information and Communication University, including our lecturers and members of staff;

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God bless all of you.

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A. Tables and Figures

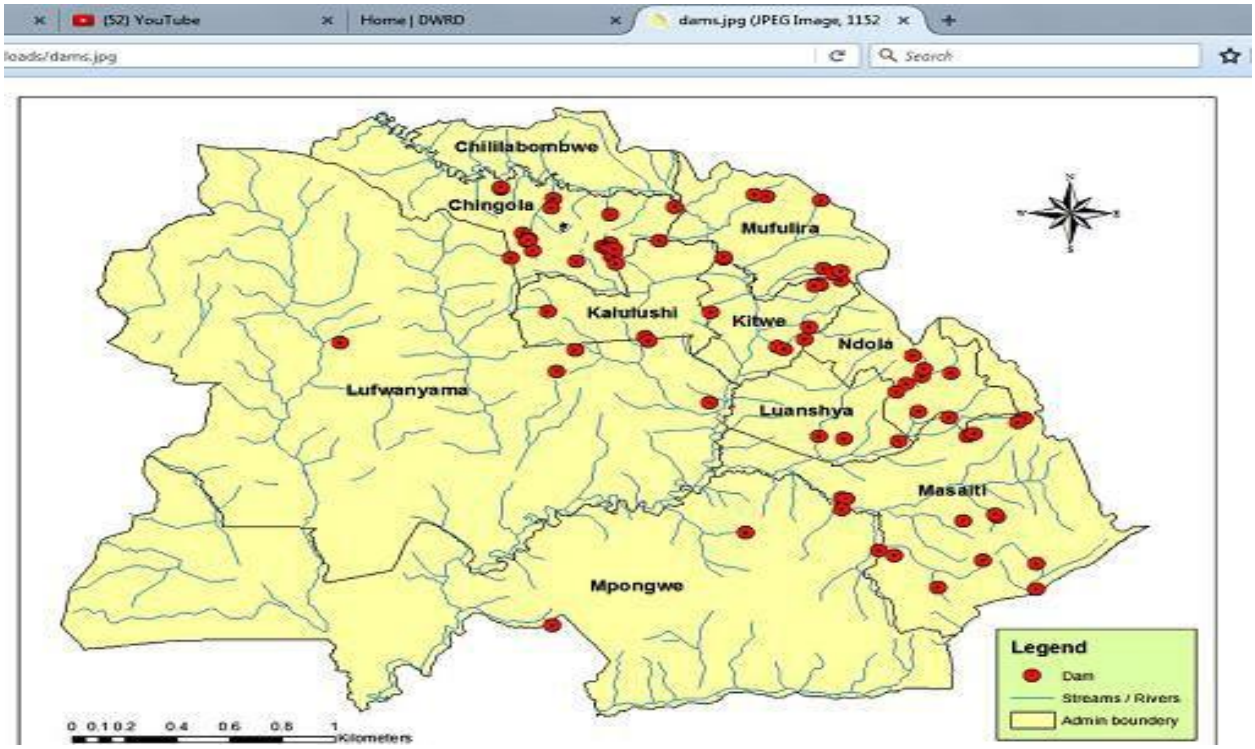


Figure 2 demonstrates how the marked sites appear on the EWRMS website.

Table 1 Profile of Respondents

Responses	Frequency	Percentage
Male	6	60
Female	5	40
Total	11	100

Table 2 Respondents from the Districts

District	Frequency	Percentage
Ndola	2.0	10.0
Luanshya	2.0	10.0
Kitwe	2.0	10.0
Mufulira	2.0	10.0
Masaiti	2.0	10.0
Mpongwe	2.0	10.0
Kalulushi	2.0	10.0
Chingola	2.0	10.0
Chililabombwe	2.0	10.0
Lufwanyama	2.0	10.0
Total	10.0	100.0

Table 3 Purpose of EWRMS

Reponses	Frequency	Percentage
Information dissemination	36	73.5
Market Department	6	16.3
Communication tool	3	6.1
Not sure	2	4.1
Total	49	100.0

Table 4 Dams with Traceable ages

S/N	Name of Dam	Period of	Location
1	Chilimulilo	Pre 1960s	Copperbelt Province
2	Dam 16	Pre 1960s	Copperbelt Province
3	Dam 17	Pre 1960s	Copperbelt Province
4	Makango	Pre 1960s	Copperbelt Province
5	Kambowa 1	Pre 1960s	Copperbelt Province
6	Dam 14	Pre 1960s	Copperbelt Province
7	Mwekera	Pre 1960s	Copperbelt Province
8	Kambowa 2	1960s	Copperbelt Province
9	Kanfinsa	1960s	Copperbelt Province
10	St Mary's	1960s	Copperbelt Province
11	ABM	1960s	Copperbelt Province
12	MMG	1970s	Copperbelt Province
13	Kanjili 2	1970s	Copperbelt Province
14	Kanjili 1	1970s	Copperbelt Province
15	RN	1980s	Copperbelt Province
16	ED	2000s	Copperbelt Province
17	Kalumbwa	2000s	Copperbelt Province
18	GDN	2010	Copperbelt Province
19	BTL2	2010	Copperbelt Province
20	BTL1	2010	Copperbelt Province
21	JF	2010	Copperbelt Province

Table 5 Boreholes with Coordinates and Water Levels

Name	Locality	Southing	Easting	Water Level
Turg Argan School	Turg Argan	-13.09185	28.76827	
Turg Argan School	Turg Argan	-13.09172	28.76813	
Turg Argan Barack	Turg Argan	-13.09243	28.75575	
Turg Argan D-Camp	Turg Argan	-13.09232	28.75972	
Kambowa Community	Kambowa	-13.1061	28.80281	
Kambowa Community	Kambowa	-13.10459	28.80628	
Fipande Citrus Farm	Munkulungwe	-13.11286	28.77183	4.5
Masaiti Holding FRA Depot	Masangono	-13.20851	28.67671	7.37
Masaiti Holding FRA Depot	Masangono			
Bwana Mukubwa SubStation	Bwana Mukubwa	-13.046	28.7084	2.8
Lumano Primary School	Lumano	-13.14406	28.69705	
Lumano Primary School	Lumano	-13.14452	28.69712	
Lumano Primary School	Lumano	-13.1445	28.69647	6.7
Lumano Clinic	Lumano	-13.14337	28.69569	
Chokolo Farm 1	Chondwe	-13.19901	28.76814	8.45
Chokolo Farm 2	Chondwe	-13.1989	28.7696	
Chokolo Farm 3	Chondwe	-13.19797	28.76738	10.29
Late Chief Ideya Chiwala	Chondwe	-13.20418	28.775	
Kalahari Farm	Chondwe	-13.20923	28.77326	7.15
Kalahari Farm	Chondwe	-13.20813	28.77162	
Sumba Farm 1	Chondwe	-13.19514	28.77515	
Sumba Farm 2	Chondwe	-13.19598	28.77817	5.7
Sumba Farm 3	Chondwe	-13.1963	28.77796	5.6
Sumba Farm 4	Chondwe	-13.19774	28.77787	
Fiwala Mission School 1	Fiwala	-13.20809	28.71514	11.7
Fiwala Mission School 2	Fiwala	-13.20834	28.71528	
Fiwala Mission Community Rural Health center 1	Fiwala	-13.2081	28.71715	
Fiwala Mission Community Rural Health center 2	Fiwala	-13.20812	28.7177	13.2
Fiwala Mission community Rural Health center 3	Fiwala	-13.20832	28.71927	
Kapompa Community	Kapompa	-13.21568	28.68397	
Nyenyezi Community	Nyenyezi	-13.49677	28.65929	7.7

Nyenyezi Market	Nyenyezi	-13.49732	28.66043	
Lyembe Village	Lyembe	-13.4875	28.6629	10.2
Mundawanga Market	Mundawanga	-13.46972	28.67317	15.46
Mundawanga Market	Mundawanga	-13.46993	28.67155	
Teka Farm 1	Teka	-13.49882	28.76435	17.3
Teka Farm 2	Teka	-13.49862	28.76546	
Teka Farm 3	Teka	-13.49921	28.76311	
Teka Farm 4	Teka	-13.49923	28.76007	
Teka Farm 5	Teka	-13.4983	28.7515	
Fyando Village	Walamba Tayabunga	-13.48304	28.75057	9.1
Teka Village	Teka	-13.48228	28.77485	
Walamba Teka Village	Walamba Teka	-13.4814	28.7461	16.4
Kemuzi High School	Kemuzi	-13.47472	28.76461	
Masaiti District Hospital 1	Masaiti District Hospital	-13.33407	28.6883	
Masaiti District Hospital 2	Masaiti District Hospital	-13.3547	28.68837	
Masaiti District Hospital 3	Masaiti District Hospital	-13.33522	28.68757	8.73
Masaiti District Hospital 4	Maisati District Hospital	-13.33537	28.68787	
Kabwata Primary School 1	Kabwata	-13.2827	28.68206	8.1
Kabwata Primary School 2	Kabwata	-13.28228	28.68185	8.4
Pupulwa	Mpongwe Turnoff	-13.50903	28.18087	
Mpongwe-Mikata Turnoff	Mpongwe Turnoff	-13.51227	28.18236	
Kabya Primary School	Kabya	-13.51793	28.19624	
Mikata Market	Mitaka	-13.55398	28.34535	
Mikata Primary School	Mitaka	-13.55889	28.3458	
Mikata Clinic	Mitaka	-13.55927	28.34641	
Malembeka Primary School	Malembeka	-13.59081	28.41251	
Malembeka Clinic	Malembeka	-13.59179	28.4097	
Chieftainess Malembeka Old Palace 1	Malembeka	-13.58633	28.39793	
Chieftainess Malembeka Old Palace 2	Malembeka	-13.58706	28.39664	
Kantolo Market	Kantolo	-13.58706	28.39664	
Kamanga Community	Kantolo	-13.39743	28.45676	
Mikata-Chinsandu Village	Chinsandu	-13.53844	28.31759	
Chintifu Primary School 1	Mikata	-13.52158	28.27862	
Chintifu Primary School 2	Mikata	-13.52205	28.27963	

Chintifu Chilufya Farm	Mikata	-13.5033	28.2859	8.65
Chibangu Community School	Chibangu	-13.76335	28.27543	15.31
Fisher Farm House 1	Chibangu	-13.75619	28.2748	
Fisher Farm House 1	Chibangu	-13.75639	28.27461	
Lukanga Turnoff	Lukanga	-13.67111	28.23237	
Shukulumbundu	Lukanga Norht Block A	-13.7653	28.19724	26.8
Mono Village	Lukanga North Block A	-13.76317	28.17498	19.16
Mapalo Village	Lukanga North Block B	-13.77627	28.17401	24.1
Bana Banda Bethel	Lukanga North North C	-13.79009	28.08336	19.17
Lukanga North Block C Center	Lukanga Norht Block C	-13.80543	28.10532	23.1
Lukanga North Block C	Lukanga North Block C	-13.83985	28.10222	19.27
Nvula Farm	Lukanga North Block C	-13.85266	28.10176	12.07
Muchindushi Primary School	Lukanga North Block B	-13.78876	28.14212	6.26
Lukanga North Community School	Lukanga North Block B	-13.80095	28.15383	12.33
Machiya Clinic 1	Machiya	-13.64661	27.61496	4.78
Machiya Clinic 2	Machiya	-13.6464	27.61509	4.88
Kapili Primary School 1	Machiya	-13.58009	27.33817	
Kapili primary School 2	Machiya	-13.58032	27.33777	
Kapili Village	Machiya			
Luswishi Primary School 1	Luswishi	-13.81131	27.38781	4.11
Luswishi Primary School 2	Luswishi	-13.81157	27.38815	
Luswishi Clinic	Luswishi	-13.81063	27.38699	
Luswishi Market	Luswishi	-13.80049	27.38338	5.14
Ntambo Village	Luswishi	-13.72287	27.45297	10.19
Luswishi-Kapili TurnOff	Luswishi	-13.6496	27.4975	7.1
Machiya Cold storage	Machiya	-13.64731	27.6144	
Machiya Primary School 1	Machiya	-13.6452	27.61216	
Machiya Primary School 2	Machiya	-13.64543	27.61216	6.8
Machiya Community	Machiya	-13.64454	27.61029	5.83
Chief Machiya	Machiya	-13.64406	27.61346	
Machiya Gadging Station	Machiya	-13.64326	27.61295	5.38

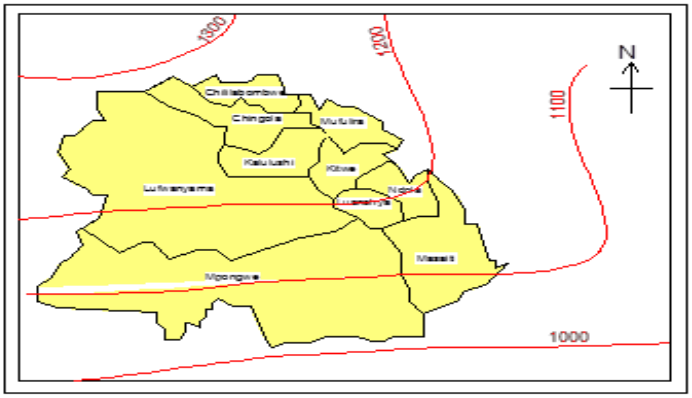
Sese Communiy	Ndubeni	-13.6405	27.62138	3.07
Nkanda Community	Kashiwa	-13.43285	27.92959	2.8
Kalesha Village	Kashiwa St Antony	-13.44018	27.93539	
Shamawona Village	St. Antony	-13.44757	27.93585	5.9
St. Antony Primary School	St. Antony	-13.45586	27.93382	7.36
Milambo Community	St. Antony	-13.46031	27.93141	6.61
Agriculture Camp	St. Antony	-13.45736	27.93374	
Kapopo Community	St. Antony	-13.45189	27.92738	
Bilima Community	St. Antony	-13.47786	27.98234	8.57
Kafusha Community	Nfulafunga	-13.49417	28.02362	5.25
Nfulabunga Primary School	Nfulafunga	-13.49672	28.0312	
Chitaba Village Baptist Church	Kanyenda	-13.45578	28.21599	5.01
Kanyenda Center 1	Kanyenda	-13.44082	28.23723	6.57
Kanyenda Center 2	Kanyenda	-13.44115	28.23749	
Nguvulu Village	Nguvulu	-13.33789	28.31282	
Nguvulu Village	Nguvulu	-13.33823	28.31162	6.32
Mazuba Farm Chief Nkalunkumya 1	Shabala	-13.36071	28.28814	
Mazuba Farm Chief Nkalunkumya 2	Shabala	-13.35988	28.28853	4.63
Mazuba Farm	Shabala	-13.36009	28.28819	5.3
Kwilimuna skills Center 1	Ibenga	-13.3612	28.40675	
Kwilimuna skills Center 2	Ibenga	-13.36092	28.40628	7.6
Mutembo's residence 1	Ibenga	-13.34792	28.41856	
Mutembo's residence 2	Ibenga	-13.3466	28.4181	2.7
Mutembo's residence 3	Ibenga	-13.34768	28.41822	
Chief Mulembeka Palace New 1	Ibenga	-13.3598	28.40867	
Chief Malembeka Palace New 2	Ibenga	-13.35909	28.40826	11.71
Kasamba Baptist Church	Kasamba	-13.27737	28.25698	11.9
Kangeshi Gaging Station	Kasamba	-13.25655	28.22203	
Kasamba Primary School	Kasanda	-13.2613	28.26366	
Kasamba Primary School	Kasanda	-13.26133	28.6333	
Kasamba Clinic 1	Kasanda	-13.26229	28.262	
Kasamba Clinic 2	Kasanda	-13.26215	28.26113	5
Kapitolo Community	Kasanda	-13.26344	28.2605	7.13
Mulilo Village	Chiwala	-13.00828	28.71255	
Chiwala Primary School 1	Chiwala	-12.99821	28.74075	

Chiwala Primary School 2	Chiwala	-12.999	28.73953	16.8
Chiwala Community	Chiwala	-12.99514	28.74371	
Chiwala Primary School 1	Chiwala	-12.99949	28.74206	
Chiwala Primary School 2	Chiwala	-12.9995	28.74176	15.02
Lubendo Primary School 1	Chiwala	-12.95115	28.71147	
Lubendo Primary School 2	Chiwala	-12.95107	28.71154	
Lubendo Primary School 3	Chiwala	-12.95182	28.7115	4.3
Priscah Farm	Chiwala	-12.94002	28.73312	
Priscah Farm	Chiwala	-12.941	28.73094	22.13
Konkolola Mutolilo	Chiwala	-12.95612	28.7172	
Makuku Village 1	Chiwala	-12.91533	28.71119	
Makuku Village 2	Chiwala	-12.90864	28.71647	
Makuku Village 3	Chiwala	-12.90925	28.7166	
Makuku Village 4	Chiwala	-12.90925	28.7166	24.38
Smart Village	Minsundu	-12.88236	28.68634	
Happy Village 1	Minsundu	-12.97828	28.73058	2.37
Happy Village 2	Minsundu	-12.97828	28.73058	2.2
Kabanga	Minsundu	-12.86341	28.67406	
Chimpeta Community	Minsundu	-12.86296	28.65677	
Chela Farm 1	Minsundu	-12.84448	28.63511	
Chela Farm 2	Minsundu	-12.84756	28.63735	11.5
Chenda Farm	Minsundu	-12.84479	28.63893	14.9
Saladi Farm	Minsundu	-12.86732	28.65787	7.3
Chilungu Village	Minsundu	-12.84248	28.66478	22.35
Zulu'S Farm Plot	Minsundu	-12.85489	28.62816	
Chichele Station	Chichele	-12.99975	28.5558	
Chichele Station	Chichele	-13.00122	28.55683	
Hope Community	Kasongo	-13.02893	28.53537	
Insenge Community	Insenge	-13.07844	28.56228	2.2
Kafubu Block 1	Kafubu Block	-13.12842	28.52566	
Kafubu Block 1	Kafubu Block	-13.13048	28.5279	
Kafubu Block 10 Primary School 1	Kafubu Block	-13.15291	28.5309	
Kafubu Block 10 Primary School 1	Kafubu Block	-13.15287	28.53093	

Location - Bordered by North-western and Central Provinces and DR Congo, area of 31,328 km^2, population of 1.9milliom and has 10 districts

Climate - Annual average rainfall of 1200mm, Mean annual temperatures of minimum of 5.7 °C and maximum of 26.1°C.

Districts on the Copper belt and isohyets for annual rainfall in mm



(Copperbelt Study Area. The rainfall data is based on the 30-year period of October 1964 to September 1993)

Figure 1: Target audience

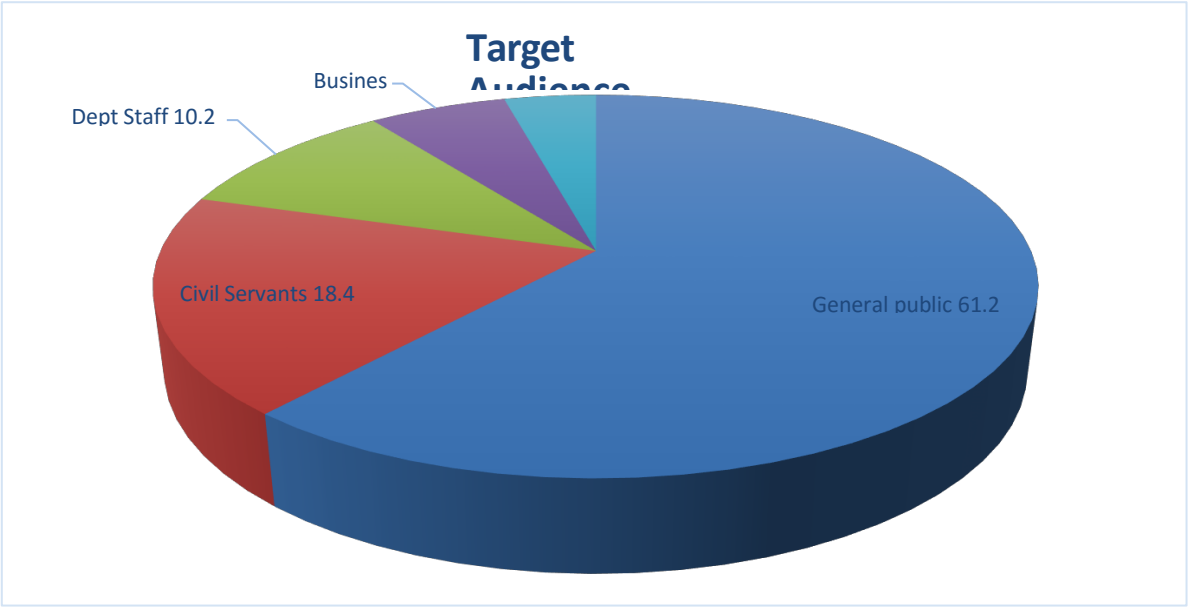
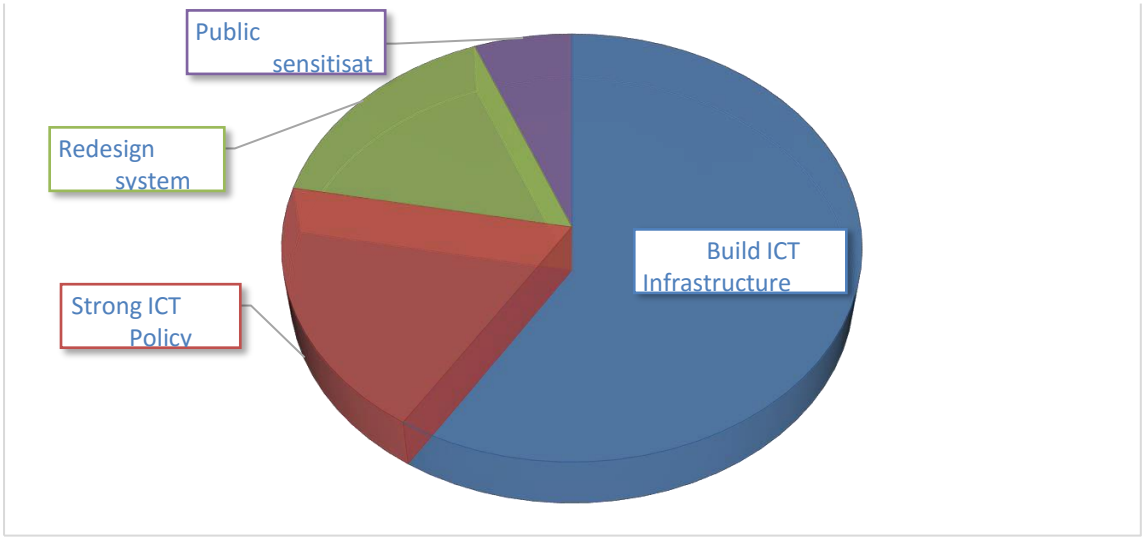
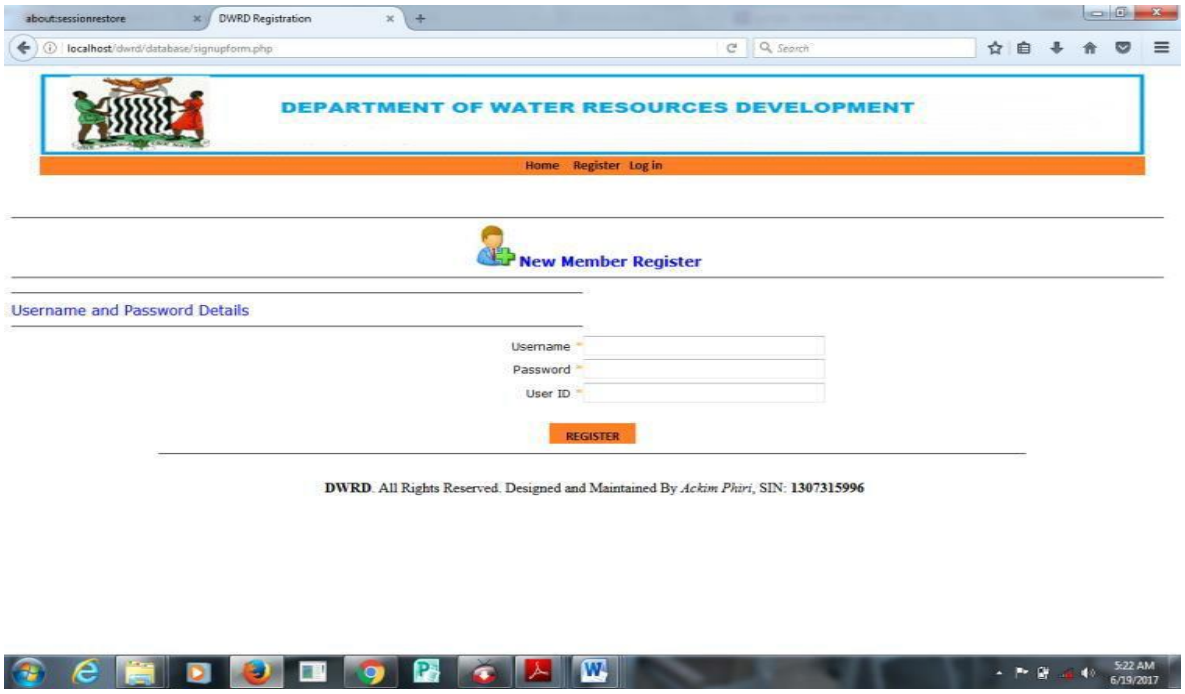


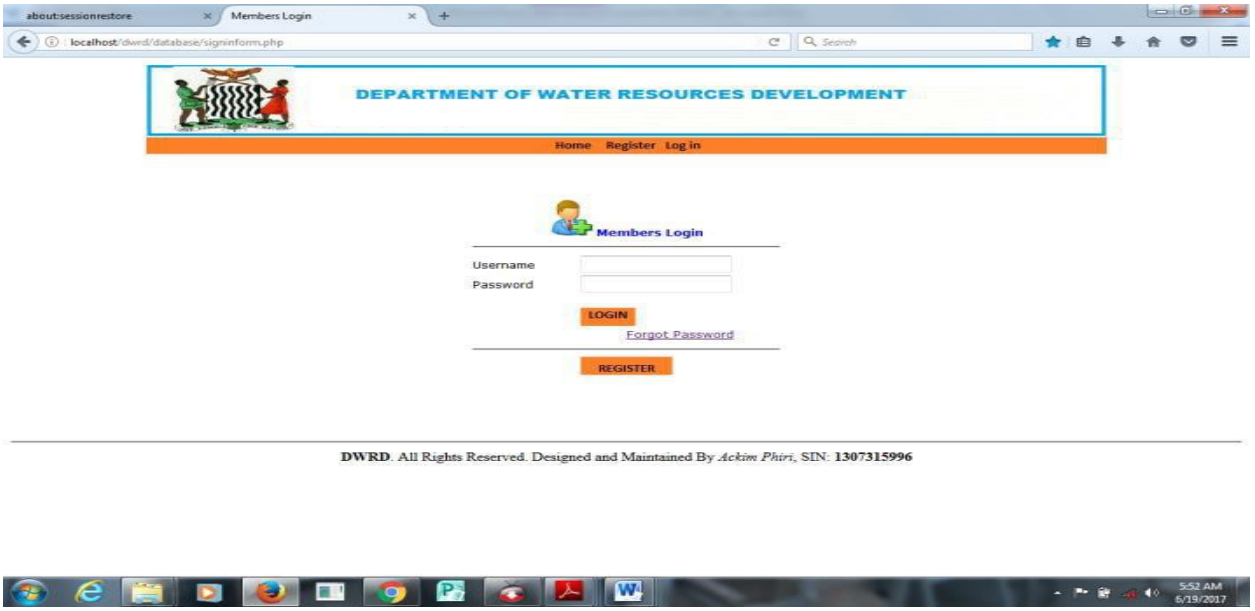
Figure3: showing implementation of EWRMS



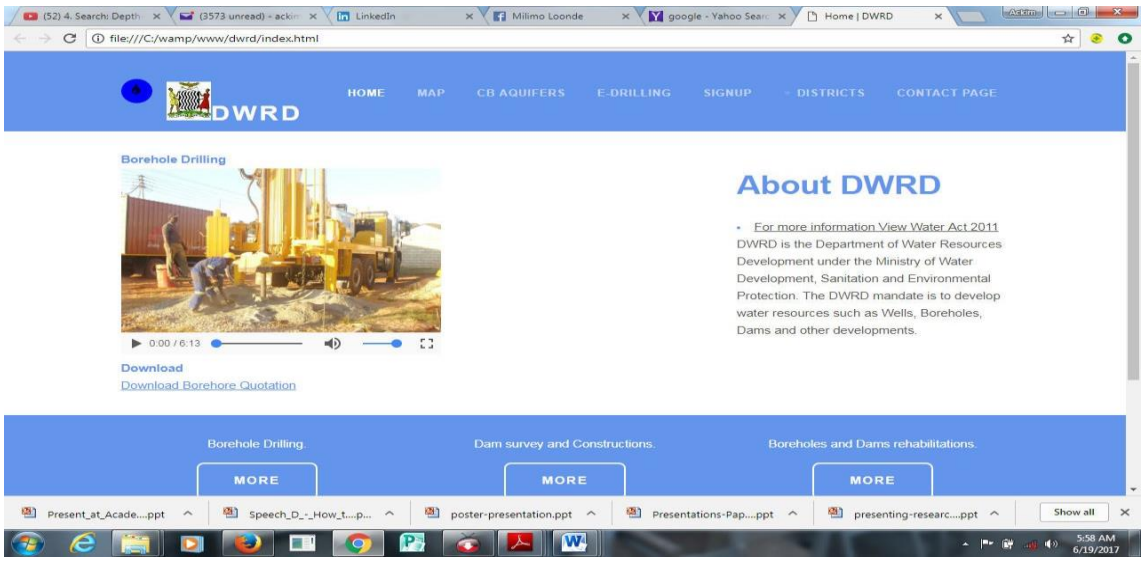
Electronic Water Resources Management System Sign In form

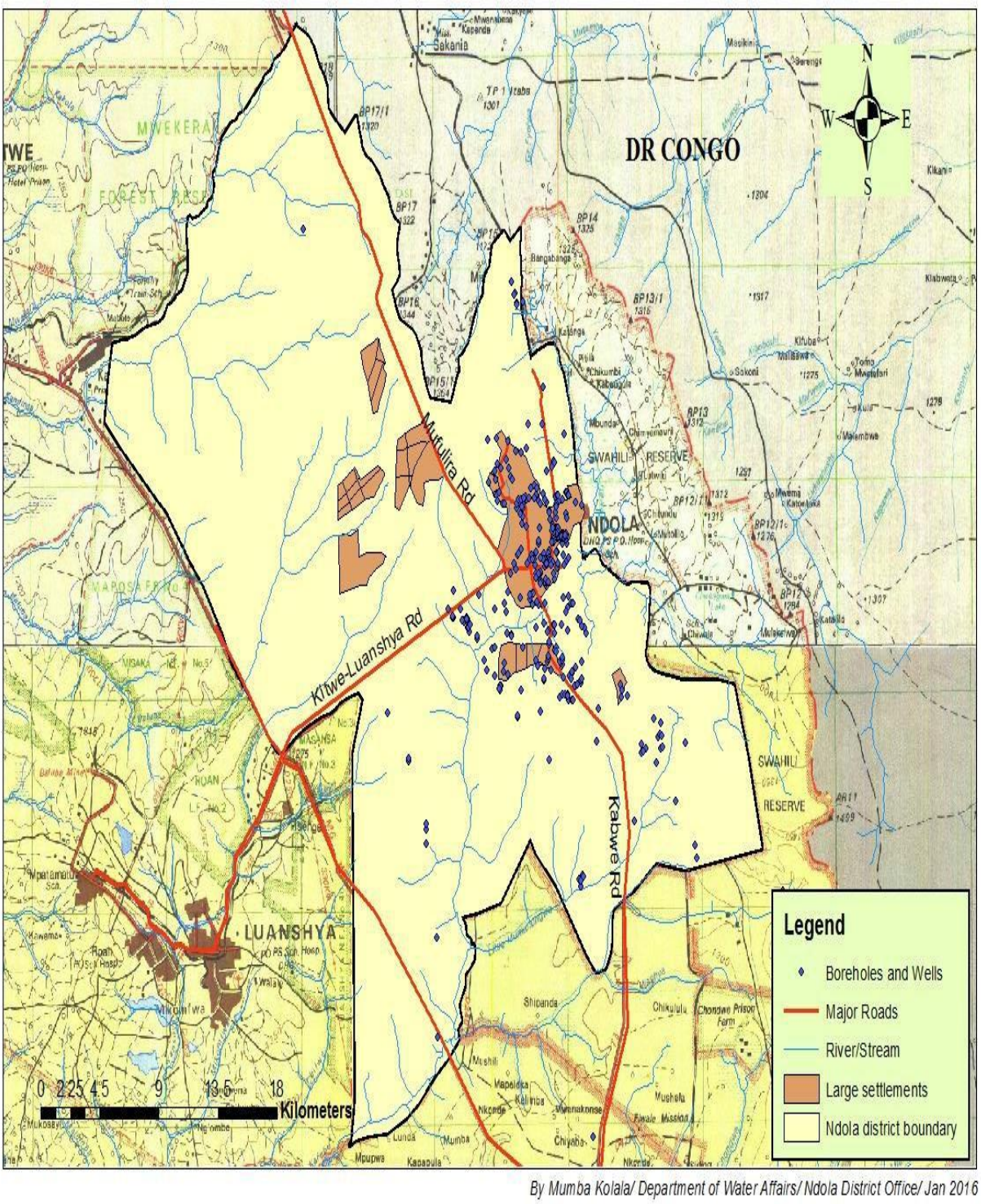


Electronic Water Resources Management System Login In form

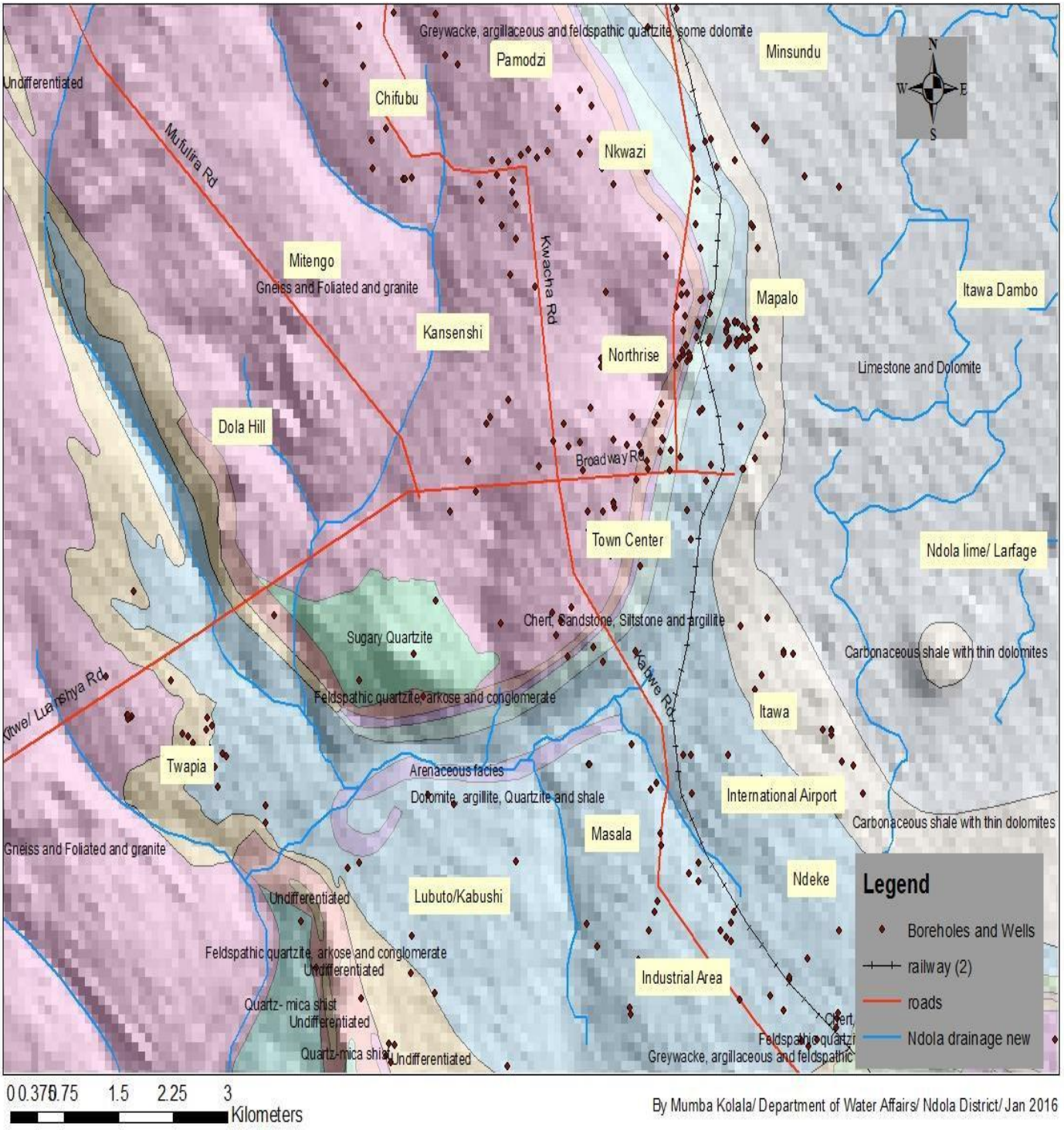


Electronic Water Resources Management System Home Page





Source: Mumba Kolala (2016)



Source: Mumba Kolala (2016)