MIDLANDS STATE UNIVERSITY

FACULTY OF SCIENCE AND TECHNOLOGY

DEPARTMENT OF SURVEYING AND GEOMATICS

WEB BASED CITY ENGINEERING SERVICES FAULT REPORTING SYSTEM: A CASE STUDY OF

GWERU CITY COUNCIL ENGINEERING DEPARTMENT

CHAPTER 3: METHODOLOGY

BY

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THIS FINAL YEAR PROJECT IS SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS OF THE BACHELOR OF

SCIENCE HONOR'S DEGREE IN SURVEYING AND GEOMATICS

ABSTRACT

Located in and forming part of their communities, councils are ideally positioned to search out the fine approaches to meeting local needs. Accountable for delivering an estimated eighty per cent (Andrew, et al., 2013) of public sector transactions of their areas, local authorities have a particular responsibility to design their services in probably the most accessible, monetary and 'user-friendly' manner. A critical function is to work intently with other public, private and voluntary sector partners to be certain that local services are citizen centric.

City services fault reporting is directly linked to service delivery as is allows the citizenry to contact the local authority in regards to the services they are receiving. A Web Based City Engineering Services Fault Reporting System is an electronic system that automates the process of reporting service faults, information logging for task assignments and for attended faults. The system has been developed to meet the challenges posed by a manual system currently being used by the Gweru City Council. The system also serves to address the need to improve the citizen quality of life by providing e-solutions for interactions or communication with the city council. Using GI technology, the system provides easy to use data visualization and reporting tools.

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The undersigned certify that they have supervised the student, **R113914V** dissertation entitled: **WEB BASED CITY ENGINEERING SERVICES FAULT REPORTING SYSTEM**, submitted in Partial fulfilment of the requirements of the **Bachelor of Science Honors' Degree in Surveying and Geomatics** at Midlands State University.

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DISSERTATION TITLE:	**WEB BASED CITY ENGINEERING SERVICES FAULT REPORTING SYSTEM**
DEGREE TITLE:	Bachelor of Science Honors in Surveying and Geomatics

YEAR THIS DEGREE GRANTED: 2016

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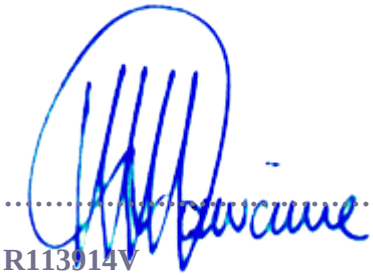

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(Researcher)

DEDICATION

This research is dedicated to my mum Prishia Mawarire and my father Alex Mawarire who gave me their unwavering support

ACKNOWLEDGEMENTS

A lot of thanks to the Midlands State University academic staff under the Department of Surveying and Geomatics for imparting their vast knowledge they have imparted into me and for being patient with me during my studies. I would like to appreciate all their valued support and care. Special mention to my Supervisors Doctor. C Paradzayi and Mr. E Kurwakumire for being readily available to assist when I needed. More so, I would like to express my gratitude to my class mates for their support and motivation. Lastly but not least, special thanks to my family for their prayers, encouragement and unwavering support during good and difficult times. Therefore, I do hereby mention the names of my beloved parents as a sign of high level appreciation for their countless investment in my life: **Mr. Alex & Mrs. Prishia Mawarire**. I give all the honor and glory my Lord and God, Jesus Christ for these five fruitful years of gaining knowledge in the field of **Surveying and Geomatics**. I love you Jesus Christ!!!

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CHAPTER 1

1 INTRODUCTION

1.1 BACKGROUND

More than half of the population of the Earth now live in urban areas (UNITED NATIONS, 2012). Modern cities face many challenges and opportunities because of this (ESCHER GROUP, 2014). The challenges vary from providing a good quality of life for citizens to ensuring appropriate socio-economic development year on year. While the opportunities can be seen in businesses becoming more efficient and innovative, to the reduction of operational costs through the use of ICTs in policing. The concept of making cities "smart" has grown out of the need for cities to meet these challenges and opportunities. A smart city gives viable coordination of physical, computerized and human frameworks in the assembled environment to convey a manageable, prosperous and comprehensive future for its residents. A smart city must empower better decisions by its residents, associations and governments (MENCHACA, Daniel, 2015). A good interaction between public administrations and citizens is imperative in modern smart cities. Semantic web technologies can aid in achieving such a goal. In the last few years, the smart city paradigm (CARAGLIU, A et al., 2011) has begun to spread in academic and industry fields, with the development of various solutions to address issues brought by the fast growing urbanization (ANDREW, Grant et al., 2013). Besides, several local governments worldwide have invested heavily to improve public service delivery (CARAGLIU, A et al., 2011). According to (ESCHER GROUP, 2014), this is mainly because of the availability of ubiquitous ICT infrastructures that stimulates the development of new services and applications by various types of users, and allows for the gathering of a more realistic data that can help in performance measuring and decision making.

Zimbabwe has 92 local authorities, which are the land and planning authorities in rural and urban areas as per Regional Town and Country Planning Act Chapter [29:12] (Zimbabwe, 2012 & Moyo & Mlilo, 2014). City councils or local authorities fall under the ministry of Local Government, Public Works and Urban Development which is governed by three acts in Zimbabwe: The Urban Councils Act, the Rural District Councils Act, the Provincial Councils and Administration Act. The Minister of Local Government, Public Works and Urban Development is responsible for the administration of these three Acts and is answerable to Parliament for all matters relating to local authorities (MOYO, Simbarashe and Mlilo, Mfundo, 2014). The legislation provides for the Minister to intervene in Council matters in the interests of good governance and public administration. However, the advent of a new constitution for the Republic of Zimbabwe in 2013 has resulted in Local Government being granted a

constitutional status which is a departure from the pre-2013 era where Local Government was created through legislation (DEWA, Didmus et al., 2014). Local government has been given a new constitutional mandate to promote devolution and improve the day to day lives of citizens as a basis for building a democratic developmental local state (MOYO, Simbarashe and Mlilo, Mfundo, 2014).

In pursuit of a brand new trajectory of accelerated fiscal growth and wealth creation, the Zimbabwean Government has formulated a new plan known as the Zimbabwe Agenda for Sustainable Socio-Economic Transformation (Zim Asset): October 2013-December 2018. This blueprint states that, Local Authorities have to expand the accessibility and utilization of ICTs to improve service delivery and accelerate economic growth. It also states that, the government is to improve the living standards of the citizenry for an empowered society and a growing economy through the Social Services and Poverty Eradication Cluster (Section 2 of Chapter 7) (GOVERNMENT OF ZIMBABWE, 2013). However, according to (DEWA, Didmus et al., 2014), local authorities are the backbone of any democratic method of government and thus local authorities are the institutions to target in the implementation of this cluster. This suggest that local authorities rethink how public services can be oriented towards the creation of public value and citizen empowerment.

It is the local authority's mandate or responsibility to the provide and maintenance of public services and infrastructure at local levels utilizing funds generated from the local community, in addition to grants and loans from central Government, and other sources. However, local government has been democratized on paper but it is still structured in the old way as they still fail to provide adequate services (KURWAKUMIRE, Edward, 2013). Among the mandates of the city councils, is to provide services like water, electricity; health care, solid waste collection and disposal and many more. They also have to provide means of communication between the local authority as a service provider and the citizenry as the consumer. The quality of services offered by these local authorities in turn determines the citizen's quality of life (MENCHACA, Daniel, 2015).

(CITY OF EDINBURGH COUNCIL, 2013) states that there needs to be a strong move towards ensuring that e-government serves the needs of the citizenry rather than government. In this light, municipalities across world are working hard to become more customer driven, and to change how they deliver day to day services to their communities (CARAGLIU, A et al., 2011). This has seen municipalities improving on their Customer Contact Centers (CITY OF EDINBURGH COUNCIL, 2013). It is common for service providers to set up help lines and call centers where their clients can request for the services they offer or report any faults in the current infrastructure concerned with the services they provide. This creates a bond between the people receiving the service and the providers of the service as this is a demand-driven approach to delivering services. From literature, it can be noted that

several municipalities worldwide have set up call centers where citizens can report faults or request for services. However, some of these call centers run on analogue systems where all reports have to be written put on paper with the relevant information (ANDREW, Grant et al., 2013). In this scenario, call records and the associated information are filed and then sent to the appropriate departments or information is transferred over a call. This provides but a slow system where information can be lost before it reaches the personnel who is to act on the request or the fault. Other municipalities have different numbers for each department which burdens the citizens by forcing them to know all the numbers for the many departments in the city council. All these are good systems as they make that initiative towards offering demand driven service. But somewhat, these analogue systems fail to provide a performance measurement mechanism to support decision making. With the advancement in technology and the rising of the internet, some cities in developed countries have developed online service request centers where citizens can submit request or report faults anonymously or register with the city council so that the municipality is able to provide feedback to the citizen (ANDREW, Grant et al., 2013). This action was in an effort to supplement where the analogue system of reporting failed and also to embrace the several advantages of using ICT in service delivery. The online service portals will be directly linked to the call service centers making it possible to report via the online platform and also the service numbers. In the United States and Canada, these service centers are commonly known as 311 Service Centers. This has greatly increased convenience for citizens as citizens don't need to take down several numbers for the different municipal departments. According to (CITY OF EDINBURGH COUNCIL, 2013), in European municipalities, these web portals are known as Customer Contact Centers and Service Reporting Systems. New York City as an example has developed an online service, NYC 311, which serves as a one-stop service for all municipal issues. To create this department, the city consolidated call centers from 14 agencies and also began online and mobile-reporting services (ANDREW, Grant et al., 2013). According to (ANDREW, Grant et al., 2013), NYC 311 now receives over 60,000 calls daily. Benefits of the centralized group include increased convenience, greater efficiency and better performance measurement and management.

However, for developing countries, Zimbabwe to be more specific, it can be observed that municipalities are rather working on their own pace of improvement regardless of the needs of the communities they serve. This is contrary to the urge by (CITY OF EDINBURGH COUNCIL, 2013) and the Zim-Asset (GOVERNMENT OF ZIMBABWE, 2013) blueprint, that the municipalities have to develop a demand-driven approach to delivering services. The current state of the local government opposes the vision of new constitutional mandate which is to promote devolution and improve the day to day lives of citizens as a basis for building a democratic developmental local state (DEWA, Didmus et al.,

2014). Cities like Bulawayo[1], Harare[2], Kadoma[3], Masvingo[4] and Mutare[5] have developed websites which provides information on different issues and also provides contact number for the different emergencies and services. The websites also offer online services like bill inquiry (Harare City Council & Bulawayo City Council), submission of meter readings and citizens are also able to track the transactions that they have made to the city council (Bulawayo City Council). These online services are initiatives to the implementation of a e-government services. However, according to (CITY OF EDINBURGH COUNCIL, 2013), customer contact centers and service reporting systems are at the hub of a customer-centric service delivery approach as they promote citizen cocreation (i.e. citizens reporting faults in their neighborhoods and this information will be used to make informed decisions and optimize resource deployment). Many municipalities in Zimbabwe are still toying with the idea of developing service reporting systems, and are unsure and hesitant about how to implement such radical changes in their work patterns, business processes and in service philosophy.

In Gweru, for one to report a burst water pipe, or other related service faults, citizens have to travel to the municipal offices where they are directed to different offices just to make a single report. Citizens can also call the city service numbers which can be found online via the Telone Online Directory or My Gweru website[6]. The city doesn't even have a public website where citizens can be updated on the current events and programmes by the local authority. The service numbers are reportedly unreliable and faults can take up to several weeks to months without being attended to (DEWA, Didmus et al., 2014). This shows that local governments still remain unaware, by and large, of the opportunity presented by e-government technologies, and how it can be utilized to deliver better and more cost-efficient public services.

1.2 Problem Definition

Many Zimbabwean municipalities are slow in responding service faults reported by the citizenry (DEWA, Didmus et al., 2014). Decisions by the municipality related to fault repairs are uninformed and there is a lot of bias in resource deployment and thus the citizenry is always complaining (MOYO, Simbarashe and Mlilo, Mfundo, 2014) . This reduces the transparency and accountability of local government and thus all members of society aren't enjoying the inherent social and economic value (ESCHER GROUP, 2014). Municipalities are failing to foster innovation, efficiency and effectiveness in the services they offer.

[1] www.citybyo.co.zw/
[2] www.hararecity.co.zw
[3] www.kadomacity.org.zw/
[4] www.masvingocity.gov.zw/
[5] www.mutare.intersol.co.zw/
[6] www.mygweru.com/information/gweru-city-council---emergency-numbers/

1.3 Research Objective

The main objective of this research is to develop a GIS enabled web based fault reporting system that will allow the citizenry to report faults in their neighborhood to the city council. This will also allow the city to use geospatial analysis to improve service delivery.

1.3.1 Specific Objectives

i. Conduct a User Needs Assessment

ii. To design and develop an integrated database for the web based engineering service fault reporting application.

iii. To develop a prototype web based engineering service fault reporting system.

1.4 Expected Results

i. An Integrated database to be used for service reports

ii. A functional web based engineering service fault reporting system.

1.5 Study Area

Gweru which once was called Gwelo until 1982 is a city situated so close to the focal point/ centre of Zimbabwe. It is the capital of Midlands Province, and was established in 1894 by Dr. Leander Starr Jameson. It turned into a region in 1914 and accomplished city status in 1971 (MATENDERE, Munyati Brenna, 2014). The name change was effected in 1982 from Gwelo to Gweru. The target organisation is Gweru City Council (GCC) which is the Gweru local authority. The research will focus on particular services provisioned by the GCC Engineering Department.

1.6 Justification of Study

The research covers the basic elements of modern management efficiency measures (MOYO, Simbarashe and Mlilo, Mfundo, 2014). A fault reporting system is at the hub of a customer centric service delivery approach. This increases convenience to the citizens, greater efficiency in management of service request and repots and geospatial analysis provides for better resource deployment. The system will also provide for performance measurement which is a critical tool to monitor service delivery, and that resources are being used efficiently. It also establishes performance indicators that can be produced in consultation with citizens to increase transparency and accountability (ANDREW, Grant et al., 2013). Whatever the priorities maybe, by involving communities in development and reporting back to communities on performance, accountability is increased and public trust in the local government system enhanced (MOYO, Simbarashe and Mlilo, Mfundo, 2014). This strengthens the social contract.

1.7 Research Synopsis

Chapter One introduces the research and discusses the background of the research. It then gives the research problem and the objectives of the research as well as the justification stating why the research is an important one. In Chapter Two, the research will include broad exploration of different diary articles, passed proposition and reports, books, news articles and web references that detail data about e-government solutions developed in other countries that leverages the use of GIS to improve the existing business processes. This will also include a review of different web architectures, database management systems and related technologies that will aid in the development of the fault reporting system. Chapter Three includes the methodologies that will be employed in coming up with answers to the existing system's flaws. It details how Investigation & Analysis will be carried out as a methodology for information gathering. Chapter four is the system design and development. It gives the results of the user needs assessment, functional and non-functional system requirements. A complete transcript of the interviews done and critical evaluation of the information gathered is also presented in this chapter. Analysis of the current solution, its merits and demerits to provide a schematic representation of the current solution. This will facilitate the designing of a proposition of the new solution and justification of its selection. Quality related functionality are identified in the literature study and analysis. User requirements will be extracted from case studies and are mapped to quality characteristics and relations among them are figured out to solve the research questions. The design will involve the schematic representation of processes in the proposed system. Flow charts, DFD, Data structure design along with any schematic to explain relationship among data i.e. physical design model, logical model and the conceptual data models. Design queries that will allow CRUD operations on the database. Interface and input (Forms) designs and hand drawn mock-ups or prototyping in the development tool being. Menu/module design for the web application for this will allow the interaction between the user and the database. The last chapter gives the overall evaluations or discussions of the project, limitations and challenges or problems faced in carrying out the project. It also gives recommendations for future researches and also a concluding note.

CHAPTER 2

2 LITERATURE REVIEW

2.1 HISTORY OF CITY SERVICES FAULT REPORTING

Located in and forming part of their communities, councils are ideally positioned to search out the fine approaches to meeting local needs. Accountable for delivering an estimated eighty per cent (Andrew, et al., 2013) of public sector transactions of their areas, they actually have a particular responsibility to design their services in probably the most accessible, monetary and 'user-friendly' manner, and a critical function to work intently with other public, private and voluntary sector partners to be certain that local services are developed around the citizen as a substitute than the desires of service deliverers. City services fault reporting is directly linked to service delivery as is allows the citizenry to contact the local authority in regards to the services they are receiving. In Zimbabwe, the initial system to be adopted for services fault reporting was via telephone call and this is still practiced in the present day. For those who did not have access to telephones, the only option was to visit the council premises. However due to advancements in technology, more that 50 percent of the citizenry have access to mobile phones and this has been of great convenience. This change has however only affected the citizenry, but did not see the local Zimbabwean city councils adopting technology to improve on service delivery. Many of the services and the infrastructure currently being utilized is what former colonial masters left behind. This has created a big gap in the quality of the services offered by local authorities. It would be expected that these local authorities establish a strong service reporting systems since much of the infrastructure is aging and failing to sustain the increasing population in urban areas. However, this is not so as public services are facing predominant challenges.

At a time when public services face predominant challenges, technology and digital instruments and procedures are principal to attaining all of this. For councils and their partners, these tools can allow:

- more effective management of demand – for example, enabling user self-service and supporting peer-to-peer advice-giving and assistance via social media (JAMES, Jacky, 2003)
- more reliable, speedy, and precise handling of routine, repetitive tasks – allowing costly and scarce professional expertise to be targeted at cases which need judgement or at new and unexpected situations (ANDREW, Grant et al., 2013).
- faster access to, and sharing of, data between councils, customers, and partner organizations, avoiding the need to collect the same information many times over and saving time on research and information collation new ways of working that potentially reconcile the goals of providing a better quality of customer experience while cutting costs (ANDREW, Grant et al., 2013).

2.2 CURRENT ZIMBABWEAN SITUATION

Local governments are poised to foster development as they are at the centre of people participation (Makwara & Tavuyanago, 2012). In Zimbabwe, the local governance sector is placed to stimulate good

governance and development, courtesy of the decentralization policy adopted by President Mugabe at independence in 1980 (Dewa, et al., 2014). Considering then, decentralized local government strived to service all areas under their jurisdiction competently (RUHODE, Ephias et al., 2008). However, the new millennium saw deterioration in service provision by local authorities largely due to the socio-monetary and political dynamics and dimensions enveloping Zimbabwe (Makwara & Tavuyanago, 2012). Such issues manifest themselves via downward trend in water delivery; refuse collection; greening, and deterioration of instructional and recreational centres. Gweru metropolis is certainly one of such cities in Zimbabwe hit by local governance challenges even after the creation of the multicurrency regime in 2008 (Annatoria & Toma, 2013). In Mkoba North and South, dumping sites have emerged as a common site. Within the affluent residential areas like South Downs, Kopje, Windsor Park and Harben Park, dumping sites are not so common but the roads are in a sorry state and many are without functioning road lighting (Dewa, et al., 2014). Potholes have remained a permanent feature in most of the city roads and roads in the density residential suburbs. Specified pick up points within the towns are being unnoticed by commuter omnibus and taxi operators ensuing in congestion and chaos, mainly along 6th street in Gweru. Additionally, challenges like water shortages succeed (Mahlahla, 2007). Burst sewers and waterworks have, however, become a nationwide trouble as municipalities war to maintain historical infrastructure amid low budgets and long-running disputes with ratepayers (Njini, 2011). Some of these challenges are confronted because of dilapidated infrastructure that is characterised by consistent service failure in several residential regions (Moyo & Mlilo, 2014). The council has an analogue and unreliable system for coping with service faults as they are stated by way of the citizens (Dewa, et al., 2014). Because of this, citizens find it better to visit the council offices to report those faults as a depend of trying to carry out emphasis on the want they have got. Because of delays on interest given to faults, at times a lot of the water is lost in leaks and sewer burst and there is not anything to account for that loss (Banes, et al., 2015). In step with council officials, the metropolis is losing as much as 50% of its purified water due to leaks and burst pipes (Njini, 2011). The council then pushes the weight onto the citizenry forcing them to pay high charges than anticipated (Makwara & Tavuyanago, 2012). Citizens lamented corruption by way of council workers on the dearth of transparency on how things should be done by different departments of the City Council (Alemseged, 2010). This loss of transparency has led to workers asking for bribes for services rendered to unsuspecting residents (DEWA, Didmus et al., 2014).

2.3 E-Governance Information Systems

As Information and Communication Technologies (ICTs) are dramatically changing the lives of people around the world, governments recognise that they must find solutions that will increase public value

to their citizens (RUHODE, Ephias et al., 2008). According to the World Bank's definition [7] ,e-Government" refers to the use by government agencies of information technologies (such as Wide Area Networks, the Internet, and mobile computing) that have the ability to transform relations with citizens, businesses, and other arms of government. These technologies can serve a variety of different ends such as better delivery of government services to citizens, improved interactions with business and industry, citizen empowerment through access to information, or more efficient government management (RUHODE, Ephias et al., 2008). E-Government is a key enabler for accelerating work processes, delivering services to citizens and businesses, increasing transparency and accountability, while also lowering costs of operation (KILDUFF, Alan and Walsh, Ivan, 2015).

Analogous to e-commerce, which permits corporations to transact with each other more efficiently (B2B) and brings buyers in the direction of businesses (B2C), e-government targets to make the interaction between governments and citizens (G2C), government and business enterprises (G2B), inter-agency relationships (G2G) and Internal Efficiency and Effectiveness (IEE) more friendly, convenient, transparent, and inexpensive (CHEN, Y.N. et al., 2006) At the same time ICTs have emerge as the dealers for a metamorphosis agenda inside governments globally, there's absence of meaningfully coordinated efforts at government level in Zimbabwe to transform government service delivery through e-government (KURWAKUMIRE, Edward, 2013). (KURWAKUMIRE, Edward, 2013) states that, today's public has evolved into information society powered people and have dynamic service needs. Information is central in service delivery but timely access is a drawback within the Zimbabwean context. E-government initiatives are a part of the measures that some governments all over the world have implemented to give a boost to service delivery (RUHODE, Ephias et al., 2008). Timely information is principal for planning and decision making for offering effective services to the citizens (ANDREW, Grant et al., 2013).

2.4 Information Systems in Local Authorities

E-Technology has grown to be a catalyst for enabling more effective government by means of higher access to services and the democratic process (ASGARKHANI, Mehdi, 2005). As public interest within the web and e-technology solutions continues to develop, there is an increasing expectation that they'll be utilised in national and local governments (ANDREW, Grant et al., 2013). (BERMÚDEZ, José Ramón Rodríguez et al., 2007) also mentions the fact that, these technologies are not only for more efficient governance but also improving public access to information and services through enabling residents at all stages to interact with government easily and access services through electronic means. According to (ASGARKHANI, Mehdi, 2005), e-government enables electronic transactions

[7] http://web.worldbank.org

between government departments and the private sector to be executed easily and cheaply. Regardless of these benefits, (CHEN, Y.N. et al., 2006) says that its implementation in economically and technologically developing countries stays troublesome. That is generally because of the hole between the prevailing e-government implementation models and the local context for these countries (BANES, Chris et al., 2015).

According to (KURWAKUMIRE, Edward, 2013), local governments have a responsibility to serve the general public through supplying primary public goods that incorporate common information and offerings akin to water and roads infrastructure. He also mentions that; this is in the wake of the world progressing closer to an undeniably associated information society. The information society has as a result grown to be a part of the drivers for local governments to put into effect information technology initiatives as a way to keep abreast with the information needs from the public and the stakeholder network at large (KURWAKUMIRE, Edward, 2013). Part of this has been realised up to date by way of e-government implementations and digital service delivery initiatives (RUHODE, Ephias et al., 2008). In developed nations, governments came up with initiatives to lift their state of governance by way of policies and tasks that facilitated government corporations to abreast state-of-the-art technologies (ANNATORIA, Chinyama and Toma, Tendai, 2013). Because local authorities are the backbone of any democratic method of government, they were not spared but became part of these e-government initiatives (GONÇALVES, Gil and Pannetier, Christophe, 2014). Despite efforts by some countries in Africa to keep abreast with technology, according to (Hongbo, 2014), in a survey by the United Nations, Africa remains with the lowest E-government development Index (EGDI).

Local governments take different forms in different countries and fluctuate in their levels of accountability to the citizenry or immediate higher-tier of governments. In administrative sense, four fundamental themes may act as key to run a local government authority; such as management, communication and coordination, instant risk management, and trust, confidence, and transparency (ANTTIROIKO, A, 2004) & (CALISTA, D. J and Melitski, J, 2008). While applying thought of ICTs, one can think of the local e-government system be comprised from an online resource designed to guide digital entry to government supply intermediaries; provide homogeneous linkage to technology, policy, and organizational administration; promote inter-organizational integration at the local level to information system development, management, and institutional partnership; accommodate subsidies, offers, and other services to empower the citizenry with larger autonomies; deliver efficient, citizen-centric, and price-effective contents to speed up participation and partnership-established e-services; integrate communities, societies, and localities to local, national, regional, and global e-government initiatives; produce strategic plan to aid effective supply of government offerings; establish degree of organizational readiness on the nearby context to arrange for the effectiveness

and effective service supply; and lead toward the ultimate purpose of transformation to present better citizen services on the grass roots (Austin City, 2008; CTG, 2002, 2003; Hoogwout, 2003; Kolsaker, 2005; Perotti & von Thadden,2006;Rahman,2008).

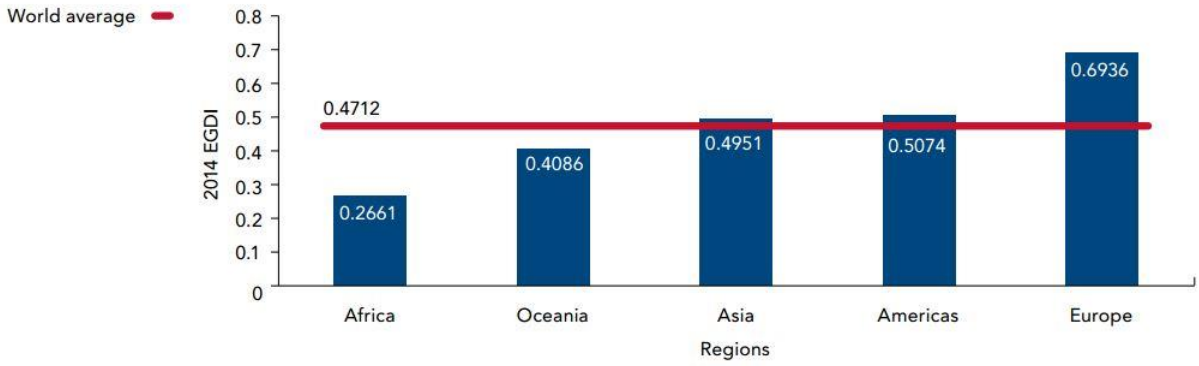


FIGURE 2-1: 2014 REGIONAL AVERAGES OF E-GOVERNMENT DEVELOPMENT. ADOPTED FROM (HONGBO, WU, 2014)

Countries often consider merging of local governments as a means to lower service-delivery costs, improve service quality, increase accountability, improve equity, or enhance participation in government system (Fox & Gurley, 2006). But according to (Government of Pakistan, 2005; Kim, 2002; Rainford, 2006), the concept of e-government is to make them more independent, provide more autonomy, offer them more power to act within, and formalize their institutional framework by upholding all the benefits of local government through elected representatives.

2.5 INFORMATION SYSTEMS IN THE CITY ENGINEERING DEPARTMENT

The role of the Engineering Department is to provide the services to plan, design and manage the construction and reconstruction of public infrastructure. The Engineering Department is responsible for overseeing the design of public improvements of city streets, water and wastewater system improvements and new installations, subdivision design review and provides the final authority for infrastructure inspections. The Engineering Department prepares and oversees all public bidding processes for infrastructure contracts, prepares and updates the City Standard Specification and Improvement Drawings, provides information to the City Council as requested. Much of the work that the City's myriad departments perform depends upon timely and accurate geographic information about the City. Therefore, it is important for City employees to have access to information that is pertinent to the responsibilities of their position and thus e-government solutions become handy.

Geographic information (GI) types a key component to the operations of local governments as their services are to the public whose location in a geographical area can be outlined by means of locational information (Kurwakumire, 2013). GI is key in aiding to the decision and policy making process and in that capability local authorities have been executing localized geographic information systems (GIS) which will maintain geographically referenced data. Given that the engineering department

specializes in setting up and sustaining infrastructure, Geographic information systems (GIS) technology presents the instruments for developing, managing, examining, and visualizing the information related to setting up and managing infrastructure. GIS makes it possible for the division personnel to manage and share knowledge and easily turn the data to understandable reports and visualizations that can be analyzed and communicated to others. It also helps firms and governments work collectively to develop procedures for sustainable development. For this reason, GIS is playing an increasingly fundamental position within the engineering department, assisting all phases of the infrastructure lifestyles cycle (Danis, 2003). GIS supplies tools for modeling understanding to help extra smart, faster decisions; become aware of and represent geographic patterns; optimize network and resource allocation; and automate workflows through a visual modeling atmosphere (ESRI, 2013).

2.5.1 Emerging Trends in Engineering Services Fault Reporting

Due to aging infrastructure, water leaks and sewer burst have become a common thing to the residents in Gweru (BANES, Chris et al., 2015). Because of the financial status of our local government, it would be a vain push to propose that the city rehabilitates its infrastructure (UNICEF, 2014). A quick solution that will remain effective in the long run is to improve on the reporting of engineering services faults by the citizens to the municipality (MAKWARA, Enock and Tavuyanago, Baxter, 2012).

Using geospatial analysis[8], the municipality can seek funding for rehabilitating infrastructure in areas where it is greatly required i.e. using trends in the reported faults. It is often time-consuming, expensive, and tedious to compile the extensive data sets needed for geospatial analysis (ANDREW, Grant et al., 2013). But governments may be able to reduce some of the complications by promoting citizen involvement in various ways (ANDREW, Grant et al., 2013).

[8] Geospatial Analytics is an approach to applying statistical analysis and other analytic techniques to data which has a geographical or spatial aspect. Such analysis would typically employ software capable of rendering maps processing spatial data, and applying analytical methods to terrestrial or geographic datasets, including the use of geographic information systems and geomatics

For instance, as in Boston Connect, the government could call on citizens to report problems in their neighbourhoods, such as damaged public property (CHIRAG, Rabari and Michael, Storper, 2013).

(ANDREW, Grant et al., 2013) also states that, although governments cannot mandate participation, they may find that public interest is high and that people want to be part of the solution, especially for problems that concern their own neighbourhoods.

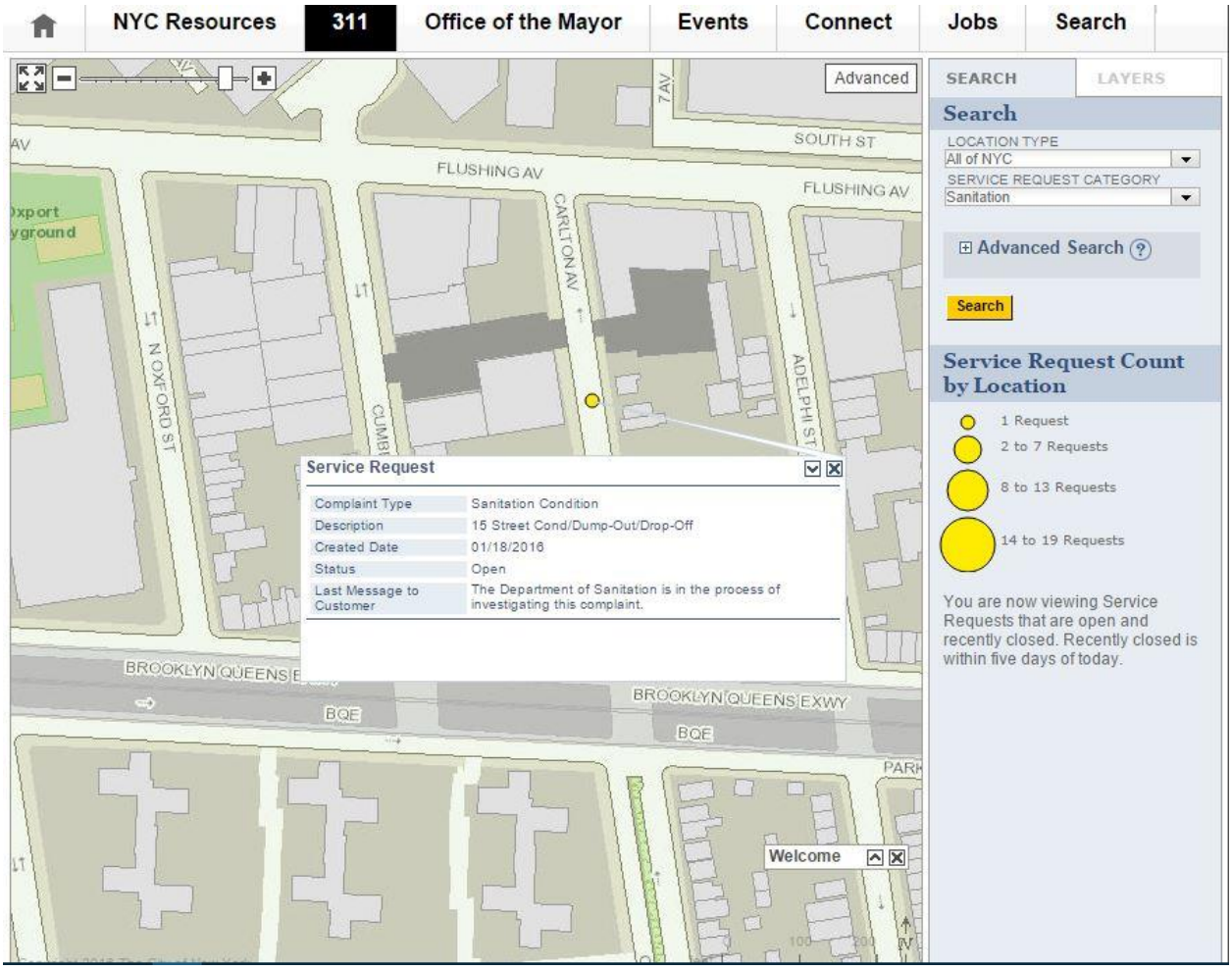


FIGURE 2-2: NYC 311 SERVICE

Governments could also encourage citizen participation by offering themed competitions or "hack-a-thons" in which computer programmers, professional or amateur, develop geospatial applications based (RICHEY, Chantal, 2014). For instance, the US Department of Health and Human Services holds meetings in which it shows stores of data to leading health-care and technology experts, the agency then challenges them to develop apps based on the information and present them at "Health Datapaloozas" (ANDREW, Grant et al., 2013). (ANTTIROIKO, A, 2004) states that, if governments decide to collect information from the public, it might be helpful to create a central database of all reports and requests, which will provide officials with an integrated view of the issues that matter to constituents. A central database can also promote efficiency by reducing response times and making it easier to analyse data (such as the number and type of requests by location) (CHIRAG, Rabari and

Michael, Storper, 2013). New York City, for example, has a GIS-enabled service, NYC 311, which serves as a one-stop service for municipal issues (Figure 2) (CHIRAG, Rabari and Michael, Storper, 2013).

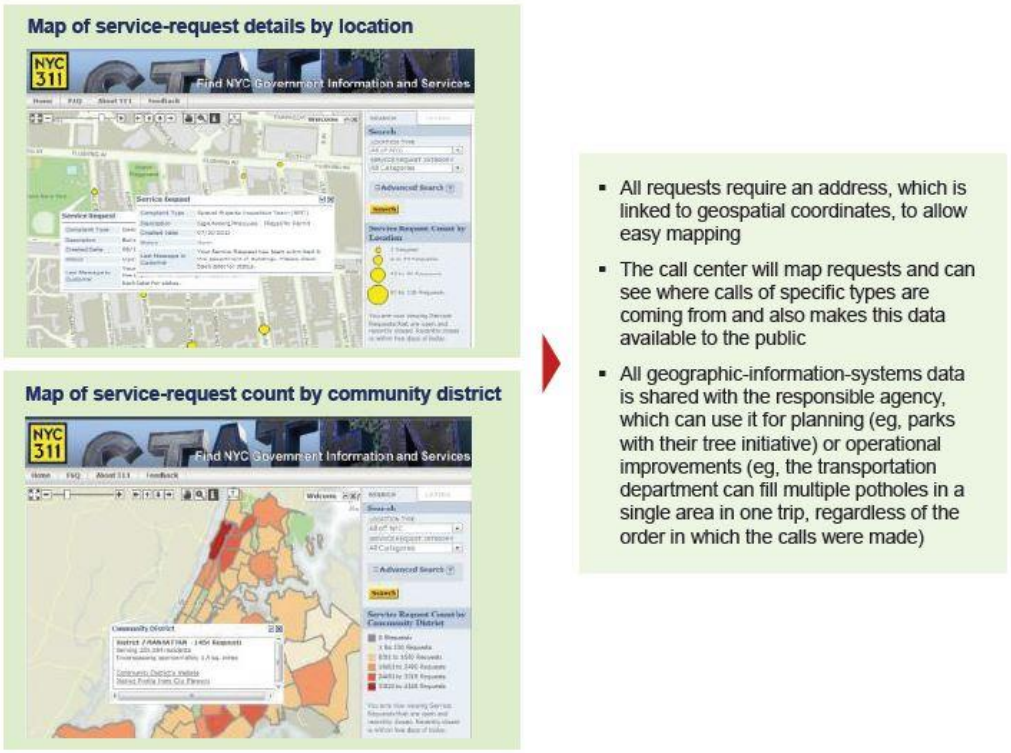


FIGURE 2-3: ADVANTAGES OF A FAULT REPORTING SYSTEM

To create this department, the city consolidated call centres from 14 agencies and also began online and mobile-reporting services. According to (ANDREW, Grant et al., 2013), NYC 311 now receives over 60,000 calls daily.

Benefits of the centralized group include the following:

- ✓ Increased convenience. Citizens only need to know one phone number or Web site to receive help from all city agencies.
- ✓ Greater efficiency. NYC 311 has set rules for routing calls, which helps ensure that they go to the right agency. One-stop reporting also eliminates the time consuming step of having one agency to contact another if it receives a request outside of its purview (RICHEY, Chantal, 2014).
- ✓ Better performance management. All service requests are tracked centrally and top managers receive frequent progress reports. If there are problems—for instance, specific requests that take a long time to resolve—managers can review work processes to identify areas for improvement

If governments do encourage citizen cocreation, they should ensure that safeguards are in place to filter “noise” from the system, such as prank calls or frivolous complaints (ANDREW, Grant et al.,

2013). For instance, callers who make nuisance calls could be fined or even charged with crime acts. Some cities have also had success by requiring users to create a login or password to monitor their activity (CHIRAG, Rabari and Michael, Storper, 2013). If many citizens begin contributing information, governments may be overwhelmed with data or requests for service. To ensure the most important problems receive the most rapid attention, officials can create procedures for prioritizing reports, similar to how emergency phone calls are ranked (CHIRAG, Rabari and Michael, Storper, 2013).

2.6 Review of Existing Engineering Service Fault Reporting Systems.

Local governments strive to respond effectively when citizens need assistance but many times they struggle because citizens don't know which department is responsible for fixing the problem and what contact number, or web site, to use when inquiring (ESRI, 2013). Many times, the citizen becomes confused and frustrated by this experience. In response to these challenges, local governments across the United States and Canada have implemented 311 call centres or centralized service request numbers to organize non-emergency requests for service (ANDREW, Grant et al., 2013). The number 3-1-1 is intended in part to divert routine inquiries and non-urgent community concerns from the 9-1-1 number which is reserved for emergency service (ANDREW, Grant et al., 2013). Typically, these centralized call centres are complimented by web applications that allow citizens to submit their requests online as well (CHIRAG, Rabari and Michael, Storper, 2013). Unfortunately, many of these systems fail to use a map in the request process and instead require the citizen to describe the location by address or some other form (ESRI, 2013). (ESRI, 2013) also claims that, this shortcoming delays the response and makes it difficult to determine which agency is responsible for responding to the request. Similar systems have also been developed for European local governments like those in Sweden and the United Kingdom. In South Africa, Joburg and Cape Town have implemented web applications that supplement their fault reporting call centres which work in a similar manner to the ones in the United States of America (CHIRAG, Rabari and Michael, Storper, 2013). (CHIRAG, Rabari and Michael, Storper, 2013) also states that that the only difference is on specifying the location, you have an option to a map and the application will automatically pick the address using geocoding (Figure 3).

However, there are some exceptional municipalities like East Sussex County Council in Great Britain that have implemented a map based reporting system similar to the one developed by ESRI. According to (ESRI, 2013), ESRI's Citizen Service Request System helps governments overcome these shortcomings and leverage the power of location to improve their response to non-emergency service requests. It includes a simple ArcGIS Server JavaScript application (Figure 4), called Service Request, that allows the general public or other interested parties to communicate requests for service to their Local Government (ANDREW, Grant et al., 2013).

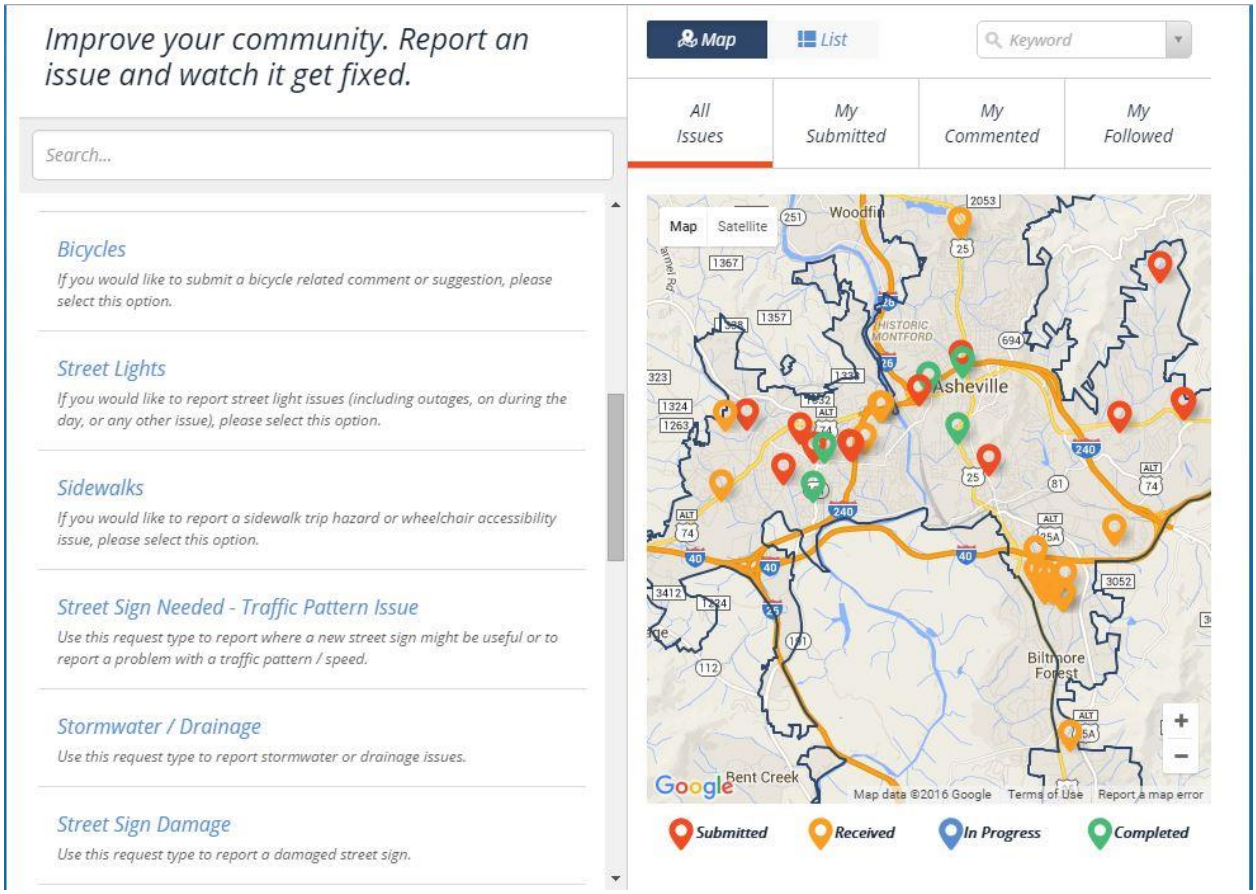


FIGURE 2-4: ASHEVILLE CITY CITIZEN SERVICE REQUEST

It can be configured and deployed by water utilities, public works agencies, public safety, planning and zoning, or other local government organizations looking to deliver a web-based service request application (ESRI, 2013). The system allows fault reporting by simply clicking on a map. A drop down menu allows citizens to select from a list of problems, such as abandoned vehicles, beach pollution and fly-tipping, and then the map can be searched using a postcode or street name. The system then automatically forwards issues to the appropriate authority (ESRI, 2013).

2.7 WEBGIS SYSTEMS OVERVIEW

According to (KURWAKUMIRE, Edward, 2013), there has been a motion in patterns whereby the frameworks have become to be interconnected (disseminated) and with access accessible remotely via web interfaces. (KURWAKUMIRE, Edward, 2013) further states that, reasons for implementation differ from organization to organization though the most common include: improving efficiency and effectiveness in planning, improving the map making process, developing workflow management

systems, an offer to digital data sets and electronic GI services. This in turn improves information dissemination and access.

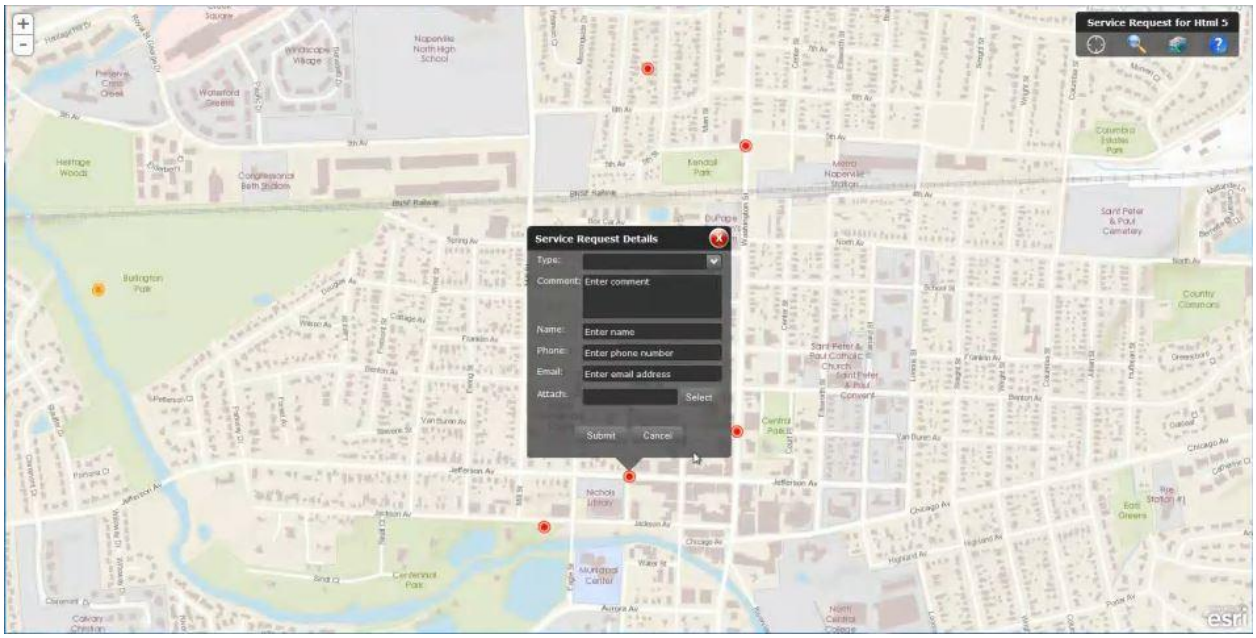


FIGURE 2-5: ESRI'S SERVICE REQUEST APPLICATION

Web-GIS systems are used to represent spatial information over the internet or intranet (Dickmann F: 2002). Web-based system will allow citizens to be served online without the need to physically visit the offices. Web based systems offers worldwide and real time accessibility and speeds up the fault reporting process (ANDREW, Grant et al., 2013). There is no need of costly GIS software, the WebGIS systems does it all through a viewer coordinated to a browser that access information from the database and displays the data using an easy to use interface (DANIS, James, 2003).

A GIS basically tries to improve coordination between different datasets maintaining flexibility, extensibility, reusability, scalability, reliability, and security (Luaces, et al., 2003). So as to provide this, the database management system for a GIS has to be highly organized. There are several architectures that have been developed to try and provide these conveniences. There is the two tier and three tier architectures. The two tier is also known as the Client -Server Architecture. The client request communicates directly to server and client will get response directly from server. On the other hand, there is the three tier application architecture, here in between client and server middle ware will be there, if client hits a request it will go to the middle ware and middle ware will send to server and vice versa. There are several advantages though, this architecture is easy to maintain as it separates concerns. It separates the database, logic layer and the presentation layer. The presentation layer is what the user interact with. The logic serves the requests by the client and is the middle man between the database and the presentation layer and what is returned is a well formatted data on an HTML web page. Listed below are some of the advantages of a three tier architecture according to (NODEEN, Raju, 2013): High performance, lightweight persistent objects; Scalability – Each tier can scale horizontally; Performance – Because the Presentation tier can cache requests, network utilization is minimized, and the load is reduced on the Application and Data tiers; High degree of flexibility in deployment platform and configuration; Better Re-use of tiers; Improved Data Integrity; Improved

Security – Client is not direct access to database; Easy to maintain and modification is bit easy, won't affect other modules. (DANIS, James, 2003) also states that, three tier architecture has better performance compared to the two tier architecture.

According to (SWEDBERG, Karl, 2014), this is mainly attributed to the use of asynchronous communication between the server and the business layer using technologies like Ajax (Asynchronous JavaScript and XML). (MCFARLAND, Dave, 2014) also states that, AJAX is an important front-end web technology that lets JavaScript communicate with a web server. He further elaborates that ajax lets you load new content without leaving the current page, creating a better, faster experience on the client side. (WENZ, Christian, 2007) also states that ajax provides interactive web sites that minimize client to server request. With Ajax, web applications communicate with the server asynchronously (i.e. in the background) without interfering with the display and behavior of the existing page (i.e. reloading the page) (SWEDBERG, Karl, 2014). Data calls can be in the form of XMLHttpRequest objects. Despite the name, the use of XML is no longer required, JSON (JavaScript Object Notation) is often used (Milosavljević, et al., 2006).

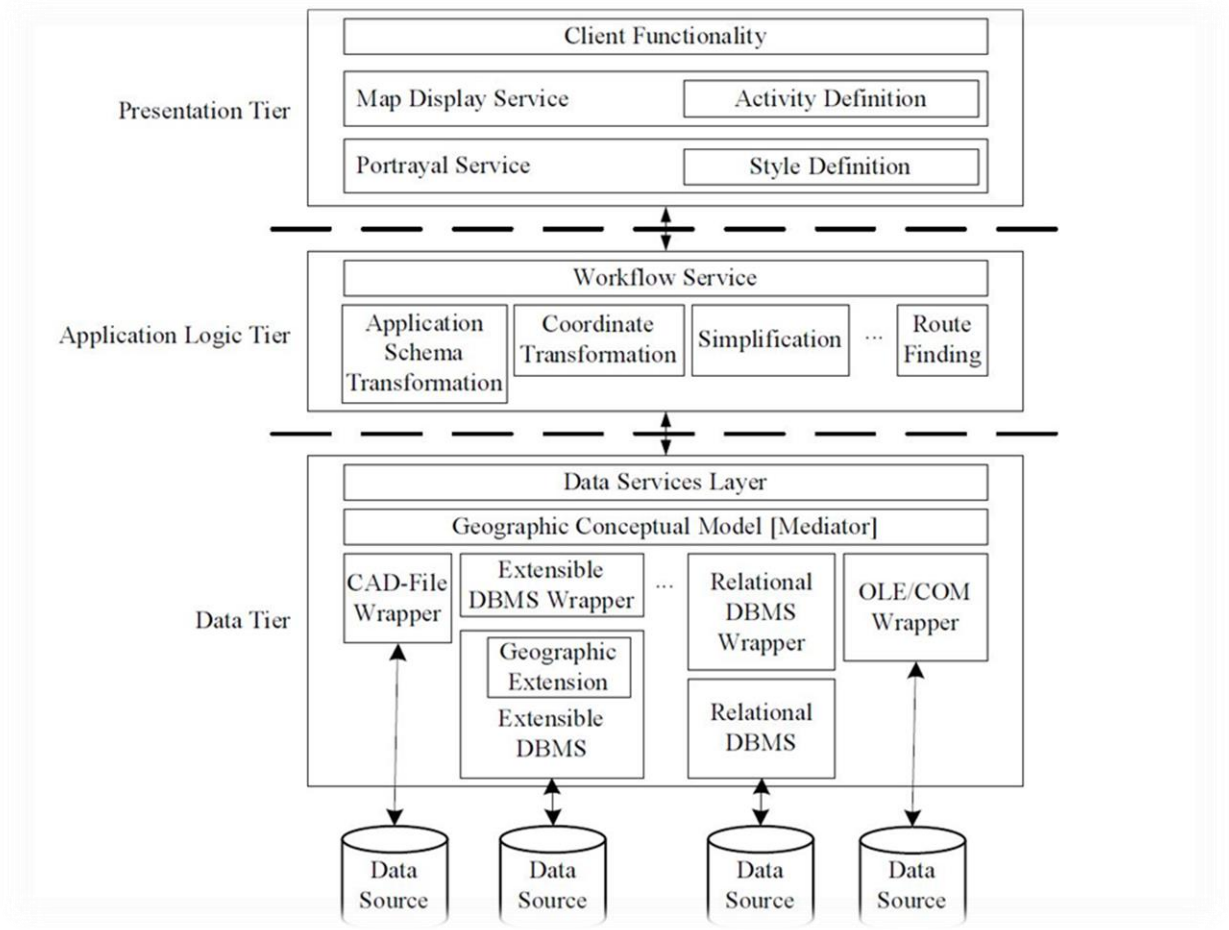


FIGURE 2-6: WEB APPLICATION ARCHITECTURE (DANIS, James, 2003)

Figure 5 shows the basic structure of a three tier application. As elaborated earlier on, the data tier gives database management functionality (including operations on the data i.e. CRUD operations and other related operations like spatial queries), be it spatial data or non-spatial data independently from

the application or software technology. The database (or data source according to the diagram) is an important part of web applications. In GIS web-based applications, it becomes more important because of the storage requirements of geographically referenced data (Luaces, et al., 2003). The presentation tier which is the third tier is responsible for serving the clients with the requested data or functionality, displaying the tables, charts, grids, etc. and it also gives some functionality over them to allow the user perform desired operations and use the application with minimal technical skills (NASSER, Hussein, 2014). This is also responsible for presenting maps to operate the spatial functionality of the web application (DANIS, James, 2003). Finally, the application logic tier, usually known as the middle tier implements all the problem solving functionality of the system (NASSER, Hussein, 2014). (NASSER, Hussein, 2014) further states that this tier acts as the controller for all the functionality available to the client and often can consist of several independent services that do several different operations on the data tier. Keeping in mind the end goal to empower reusability and adaptability of the framework structural planning, the usefulness of these levels must be actualized autonomously (Adnan, et al., 2010).

2.7.1 DATABASES

A database is a collection of information that is organized so that it can easily be accessed, managed, and updated (LONGLEY, Paul A et al., 2005). According to (SHARMA, Neeraj et al., 2010) databases can be classified according to types of content: bibliographic, full-text, numeric, images and more recently, spatial databases. (SHARMA, Neeraj et al., 2010) also states that a database management system (DBMS) is system software for creating and managing databases. The DBMS provides users and programmers with a systematic way to create, retrieve, update and manage data (AITCHISON, Alastair, 2013). GI Systems are data driven systems and thus they rely on databases. Different DBMS vendors have now added features that support storage and retrieval of spatial data i.e. allowing the development of spatial databases (AITCHISON, Alastair, 2013). Spatial Databases is the first unified, in-depth treatment of special techniques for dealing with spatial data, particularly in the field of geographic information systems (GIS) (CHIRAG, Rabari and Michael, Storper, 2013). (AITCHISON, Alastair, 2013) also states that spatial database, or geodatabase is a database that is optimized to store and query data that represents objects defined in a geometric space. Most spatial databases allow representing simple geometric objects such as points, lines and polygons. Some spatial databases handle more complex structures such as 3D objects, topological coverages, linear networks, and TINs. While typical databases are designed to manage various numeric and character types of data, additional functionality needs to be added for databases to process spatial data types efficiently (AITCHISON, Alastair, 2013). These are typically called geometry, geography or feature (LONGLEY, Paul A et al., 2005). The Open Geospatial Consortium created the Simple Features specification and sets standards for adding spatial functionality to database systems (AITCHISON, Alastair, 2013). Several DBMS vendors on the market now support spatial data, some proprietary and some of them open source. The different vendors all provide an SQL API to allow custom applications to interact with the databases (SHARMA, Neeraj et al., 2010). SQL Server is a relational database management system (RDBMS) from Microsoft that's designed for the enterprise environment. SQL Server runs on T-SQL (Transact -SQL), a set of programming extensions from Sybase and Microsoft that add several features to standard SQL, including transaction control, exception and error handling, row processing, and declared variables (JOHNSON, Sebastian, 2014). The RDBMS started support spatial data in its Express

version of 2008. Ever since, it has been upgraded to handle complex spatial data operations (AITCHISON, Alastair, 2013). Using various tools, spatial data can be imported from different file formats into SQL Server databases. No special functionality or extensions have to be enabled, SQL Server databases are spatial data ready upon creating the database (LEMINGTON, Consulting, 2015). SQL Server supports two spatial data types: the geometry data type and the geography data type. The geometry type represents data in a Euclidean (flat) coordinate system. The geography type represents data in a round-earth coordinate system. Both data types are implemented as .NET common language runtime (CLR) data types in SQL Server. Considering major issues such as security, stability and affordability, SQL Server exhibits one of the best value propositions on the market with a low cost and a highly favorable price/performance ratio (CREASY, Cassandra, 2015). (CREASY, Cassandra, 2015) also states that since 2002, Microsoft's SQL Server has compiled an enviable record. It is the most secure of any of the major database platforms. (AITCHISON, Alastair, 2013) also mentions that SQL Server has recorded the fewest number of reported vulnerabilities — just 49 from 2002 through June 2014 — of any database as compiled independently by the National Institute of Standards and Technology (NIST), the government agency that monitors security vulnerabilities by technology, vendor, and product.

2.7.2 WHY THE .NET PLATFORM

2.7.2.1 Advantages of SQL Server over other database management systems i.e. MySQL & Postgres

- ✓ Transactions. MySQL & Postgres doesn't fully support transactions (any operation on MyISAM tables, as well as any DDL statements, will silently commit a pending transaction, which makes the transaction support practically useless)
- ✓ SQL Server, Visual Studio, and the entire .NET ecosystem, are built to work together. While you can use MySQL & Postgres with .NET, they just don't integrate as nicely.
- ✓ More powerful stored procedures. T-SQL has a complete set of imperative programming features, and while the syntax is still far behind a proper programming language, a developer can do amazing things with it.
- ✓ A developer can import .NET DDLs into SQL Server and run .NET CLI functions from within T-SQL queries: this means any function you feel is missing from your SQL dialect can be provided through this mechanism i.e. a developer can write their own function and classes to handle data in different ways as they desire.
- ✓ SQL Server has better replication support. If ever the developer need to scale their database beyond a single-server or simple master-slave configuration, MySQL and Postgres will be trouble.
- ✓ Finer-grained locking. MySQL often locks entire tables; the result can be that if you run an expensive query joining two or three of your most important tables, these tables may be completely inaccessible for several seconds. SQL Server has more sophisticated per-row locking, which means even though you're querying some rows in a table, other rows can still be inserted or modified concurrently.
- ✓ Native support for GUIDs as primary keys - if a developer prefers GUIDs for your keys, that is (which is one way to reduce migration pain).

2.7.2.2 Disadvantages of SQL Server

- ✓ Cost. MySQL & Postgres are essentially free; SQL Server licenses come with a hefty price tag (unless one can use the Express version)
- ✓ Script ability. MySQL & Postgres are built with a command-line mind-set, and it is very scriptable; SQL Server, coming from Microsoft, wants the developer to use the full-blown GUI for pretty much everything, including backup scheduling, migration, maintenance, etc.

2.7.3 WEB MAPPING TECHNOLOGIES

Web mapping is the procedure of designing, implementing, producing, and delivering maps on the arena vast net and its products. With the support of the internet and accompanying tools, creating and publishing online maps has end up simpler and rich with options. There are many mapping APIs that exist on the internet today, some which can be open source and some that aren't. All these mapping APIs are rather an identical within the work that they do except the truth that some have brought services to add functionality that isn't available in community developed APIs (MITCHELL, Tyler, 2005). Google's JavaScript Mapping API has many services some excelling to drawing cross sectional elevation profile between two points placed on the map (SVENNERBERG, Gabriel, 2013). According to (MACLEAN, Malcolm, 2014) community developed APIs like Leaflet are always grooving with contributors developing plugins that suite their desires at any factor in time giving the ability to produce highly customizable map interfaces. (MACLEAN, Malcolm, 2014)also states that leaflet is a widely used open source JavaScript library used to build web mapping applications. First released in 2011, it supports most mobile and desktop platforms, supporting HTML5 and CSS3 (SVENNERBERG, Gabriel, 2013). Along with OpenLayers, and the Google Maps API, it is one of the most popular JavaScript mapping libraries and is used by major web sites such as FourSquare, Pinterest and Flickr (MACLEAN, Malcolm, 2014). Leaflet is designed with simplicity, efficiency and usability in intellect (Trygve, et al., 2013). It really works efficaciously throughout all major desktop and mobile platforms, can be improved with tons of plugins, has a beautiful, effortless to use and well-documented API and easy, readable supply code that may be a joy to contribute to (DINCER, Alper and Uraz, Balkan, 2013). This makes leaflet a mapping API of choice for many developers even though it is still in its early versions.

Different platforms have also been used to serve spatial data on web applications. Geoserver is one open source framework that is used to serve spatial data from various DBMSs like SQL Server and PostgreSQL PostGIS. It is a powerful map and feature server for sharing, analyzing and editing geospatial data using open standards. However, recently developers have been adopting vector features which are now being offered by existing RDBMSs. The ability of RDBMSs like PostgreSQL PostGIS and SQL Server to serve spatial data as JSON has seen many developers migrating from the use of traditional Web Mapping Service some which required extra licenses JSON (JavaScript Object Notation) is a light-weight information-interchange structure. It's handy for humans to read and write. It's effortless for machines to parse and generate. It is established on a subset of the JavaScript Programming Language, normal ECMA-262 third version - December 1999 (ISO/IEC JTC 1, Information technology, 2015). JSON is a text structure that's completely language unbiased however makes use of conventions which can be acquainted to programmers of the C-family of languages, together with C, C++, C#, Java, JavaScript, Perl, Python, and lots of others. These residences make JSON an ultimate data-interchange language. Round mid-2008, a geospatial data interchange format based on

JavaScript Object Notation (JSON) was developed. GeoJSON is a format for encoding a variety of geographic data structures. A GeoJSON object may represent a geometry, a feature, or a collection of features. GeoJSON supports the following geometry types: Point, LineString, Polygon, MultiPoint, MultilineString, MultiPolygon, and GeometryCollection. Features in GeoJSON contain a geometry object and additional properties, and a feature collection represents a list of features. A complete GeoJSON data structure is always an object (in JSON terms). In GeoJSON, an object consists of a collection of name/value pairs -- also called members. For each member, the name is always a string. Member values are either a string, number, object, array or one of the literals: true, false, and null making it highly readable and easy to create. Many of the existing JavaScript mapping APIs now include GeoJSON support.

JavaScript is a high-level, dynamic, untyped, and interpreted programming language (SHARMA, Neeraj et al., 2010). It has been standardized in the ECMAScript language specification. Alongside HTML and CSS, it is one of the three essential technologies of World Wide Web content production; the majority of websites employ it and it is supported by all modern Web browsers without plug-ins. JavaScript is prototype-based with first-class functions, making it a multi-paradigm language, supporting object-oriented, imperative, and functional programming styles (SHARMA, Neeraj et al., 2010). It has an API for working with text, arrays, dates and regular expressions, but does not include any I/O, such as networking, storage, or graphics facilities, relying for these upon the host environment in which it is embedded.

2.8 System Development Life Cycle

One of the most common System Development Lifecycle (SDLC) is the Waterfall. The main reason being it is simple and easy to understand and use due to its flow structure. Each stage has specific deliverables. Each phase of the model has specific and clear deliverables which makes it easy to follow up and make sure you deliver as expected. The main disadvantage though is that, there is no tangible deliverable in the early stages of the life cycle. This is a draw back when you are racing with time. The life cycle has five (5) main stages and these are: Requirements gathering, System Design, Implementations, Integration and testing and System Development. However due to some critical disadvantages of this SDLC, Agile approaches are being adopted. An Agile approach to software development covers an array of SDLC styles, but the overarching theme is the same, this category is more adaptable and gives developers time to work while requirements are changing. There is a flexibility to check for errors under any part of the development stage which usually makes this approach less susceptible to bugs. The Agile approach is illustrated in Figure 1; where after each phase, developers have the opportunity to cycle back and check their work.

This increased flexibility gives more insight as to why it's called it "agile"; developers can make improvements on an ad hoc basis which ultimately reduces the risk of encountering problems.

However, teams that take the Agile route for software development may run into the problem of the "never-ending project"; where developers are constantly circling back to test and make changes, that

nothing is ever 100% completed. This reason is why there needs to be strong project management in place to know when something is taking up too much time. Listed below are the pros and cons of the agile SDLC.

Pros

I. Flexibility to make changes to requirements
II. Testing is integrated from start to finish
III. Increased speed to market
IV. Improved Risk Management

Cons:

I. Projects can run longer than anticipated
II. Requires high level commitment of time and energy from developers

An Agile approach to the SDLC fits the preferences of this study. Due to this format of breaking tasks into short sprints, end-users and relevant stockholders have the capability to see results after each stage rather than waiting till the end of the project; this method typically presents fewer problems within the final release.

- Requirement Gathering and analysis: All possible requirements of the system to be developed are captured in this phase and documented in a requirement specification document.
- System Design: The requirement specifications from first phase are studied in this phase and system design is prepared. System Design helps in specifying hardware and system requirements and also helps in defining overall system architecture.
- Implementation: With inputs from system design, the system is first developed in small programs called units, which are integrated in the next phase. Each unit is developed and tested for its functionality which is referred to as Unit Testing.
- Integration and Testing: All the units developed in the implementation phase are integrated into a system after testing of each unit. Post integration the entire system is tested for any faults and failures.
- Deployment of system: Once the functional and non-functional testing is done, the product is deployed in the customer environment or released into the market.
- Maintenance: There are some issues which come up in the client environment. To fix those issues patches are released. Also to enhance the product some better versions are released. Maintenance is done to deliver these changes in the customer environment.

CHAPTER 3

3 RESEARCH METHODOLOGY

3.1 INTRODUCTION

Gweru City Council engineering department runs a paper based system for handling fault reports. This system presents several challenges both to the municipality and to the citizens it serves. An engineering service fault reporting system is a tool that the municipal department can use to manage fault reports, deduce geospatial trends and measure on performance of the department. The citizenry will also use the same system to engineering service faults in their neighborhoods via a web interface that will allow them to pin point the location of the fault on a map. They will also be able to give a brief description of the fault and any other information that will assist the municipality in planning for attending the reported fault. This makes the citizenry the main source of information.

3.2 STRUCTURE OF THE CITY ENGINEERING DEPARTMENT

Engineering Services Department guides and promotes a sustainable Urban Environment that fosters economic and social development, provides a total quality service and efficient infrastructure to the community through sound Municipal Engineering, Urban Planning and Administrative excellence. The department of Engineering Services comprises of four branches namely Water, Roads, Town Planning and Administration. They are described briefly below: -

The department is through it different branches responsible for:

- Water Branch Functions
- Roads Branch Functions
- Town Planning Branch Functions
- Administration Branch

Water Branch

Sections Include:

- Water Supplies
- Water Distribution
- Electro-mechanical Section

Functions:

- Supplies Section – management if dams, water treatment works and sewerage treatment works, pumping mains.

- Distribution Section – water reticulation, sewerage reticulation, chokes, burst pipes / leaks.
- Electro-mechanical Section – electrical repairs, mechanical repairs, fitting.

Roads Branch

Sections Include:

- Road Planning and Design
- Road Maintenance
- Road Operations
- Traffic Management

Functions:

- Projects and Planning Section – project management, projects budgeting and prioritization, detailed designs and project specification, management contract, management planning reporting and evaluation.
- Public Lighting and Traffic Section – street lighting maintenance and design traffic lights maintenance and design, traffic safety, communication radios maintenance.
- Operations Construction and Maintenance – implementation of projects, implementation of maintenance plans, resource planning and monitoring quality control.

Town Planning Branch

Sections Include:

- Estate Section
- Forward Planning
- Development Control
- Survey Section

Functions:

- Development Control Section – guiding development, processing applications, subdivision and consolidation.
- Estates Section – layout plans
- Forward Planning Section – master plan, local plans, subject plans, traffic/ transportation
- Land survey Section – title surveys, engineering surveys, boundary disputes, survey information.
- Administration Branch

Is responsible for the following in the department:

- Budget formulation (Capital and revenue
- Coordinating all department activities
- Stores services
- General and staff record management (electronic and manual)
- Recruitment and selection process, termination and redeployment
- Disciplinary process provision and grievance handling
- Induction/Training
- Typing and reception services
- Processing payments
- Costing services
- Tender processing management
- Printing and Plotting services
- Messenger services
- Transport management services

For the purposes of this research, the researcher is only going to focus on water and sewerage reticulation chokes, burst pipes and or leaks.

3.3 System Conceptual Framework

We're familiar with using maps to figure out where to go, or how to get from point A to point B. But now we can also use maps to figure out where and when burglaries are most likely to occur in a particular city, the parts of a country most in need of prenatal health-care clinics, and where a parking spot just became available in a congested neighborhood. The rapid retrieval and presentation of such highly specific, extremely valuable information is possible because of one innovative technology: geographic-information systems (GIS).

GIS technology allows users to integrate and analyze large, disparate data sets that involve geospatial information—in other words, location data—and non-geospatial information like population density or customer preferences. Through GIS, users can quickly detect patterns and trends that might otherwise be overlooked—a perspective that helps them develop innovative solutions to long-standing problems.

An engineering service reporting system is one of such solutions that utilize GIS to address a long standing problem. The system implements a concept that allows citizens to report problems in their neighborhoods, such as damaged public property, service faults and more related issues. The concept promotes citizen involvement in gathering data that is often time-consuming, expensive, and tedious to compile. These extensive data sets can then be used for geospatial analysis which can then be used in decision making. This will also aid the city council to provide information to the citizenry concerning

the services that they would have reported on. GIS technology, with its mapping capability, can help the public visualize information about their communities in a more rapid, interactive way. The system will also allow the city council to inform the citizenry on the progress of the faults that they would reported. The citizenry can also track the progress of the faults they would have reported using the associated issue number / fault number which is given them after they have successfully logged their fault using the system.

On the other hand, the city council will be able to view all the submitted service faults by their categories. The city personnel will also be able to change the status of a fault, i.e. Unassigned, Assigned & Closed. The status tells current state of the fault:

a) Unassigned: a fault that has not been attended to yet: all faults are logged as unassigned by default

b) Assigned: a fault that is currently being attended to;

c) Closed: a fault that has been attended to no further attention is required.

For performance measurement, the system will generate reports on how many faults have been attended to over a given period of time as well as how many have been reported and how many are in progress over a given span of time. The city council can also assess on which areas have a highest count of a given fault. This data can be accessed by responsible agencies and parties that can assist the city council in planning and resource mobilization. The city council call center can also map faults and these are distinctly tagged with a reported via Phone attribute. This will be useful to evaluate how many faults were reported via the web application or via the call center. Associated workflow documents can be found in the Appendix

3.4 System Development Life Cycle

3.4.1 Requirement Gathering and analysis

3.4.1.1 Introduction

Requirements details the solution developers are working on, the expectation of the client and other affected stakeholders. The city council has its way of handling their business process and this had to be clearly understood before developing anything. The main purpose of this phase is to understand the way fault reports are reported and attended to by the Gweru City Council. To understand the way in which other departments involved in the process affect the work flow and the importance of their input. Existing work flows can aid in the design and implementation of the engineering service fault reporting system.

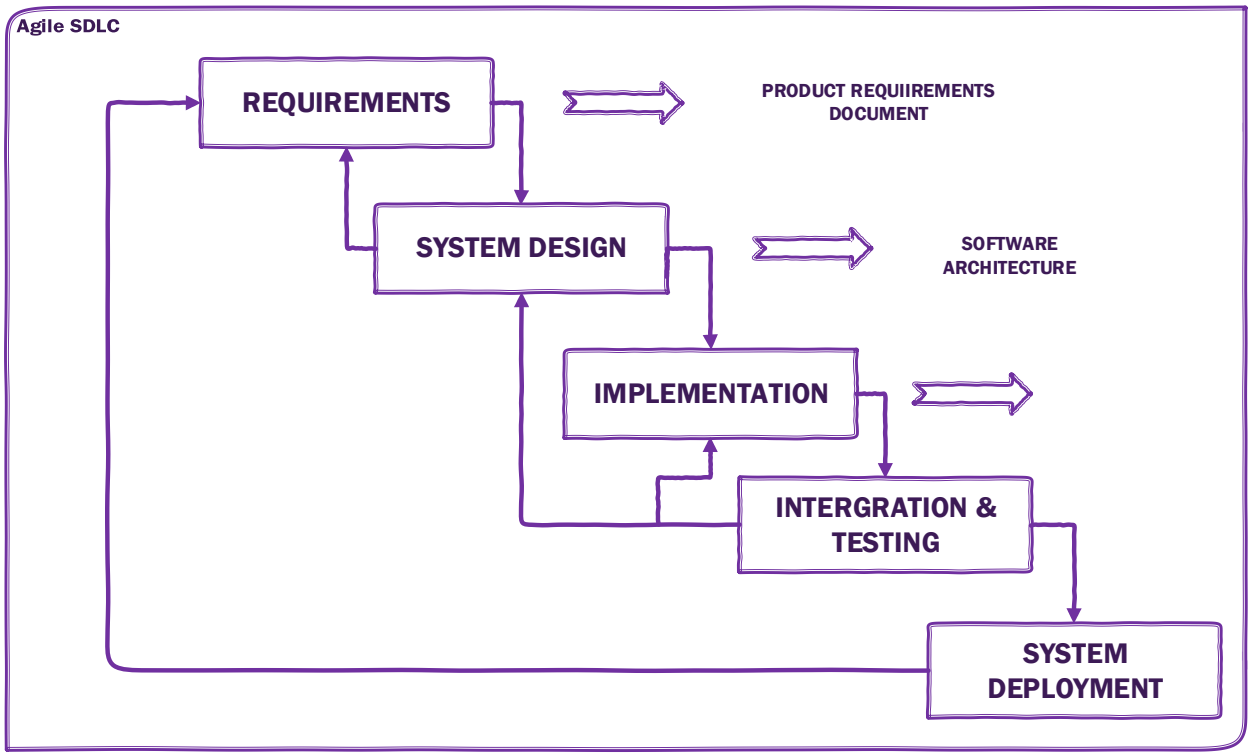


FIGURE 3-1: AGILE SYSTEM DEVELOPMENT LIFECYCLE

3.4.1.2 Approach

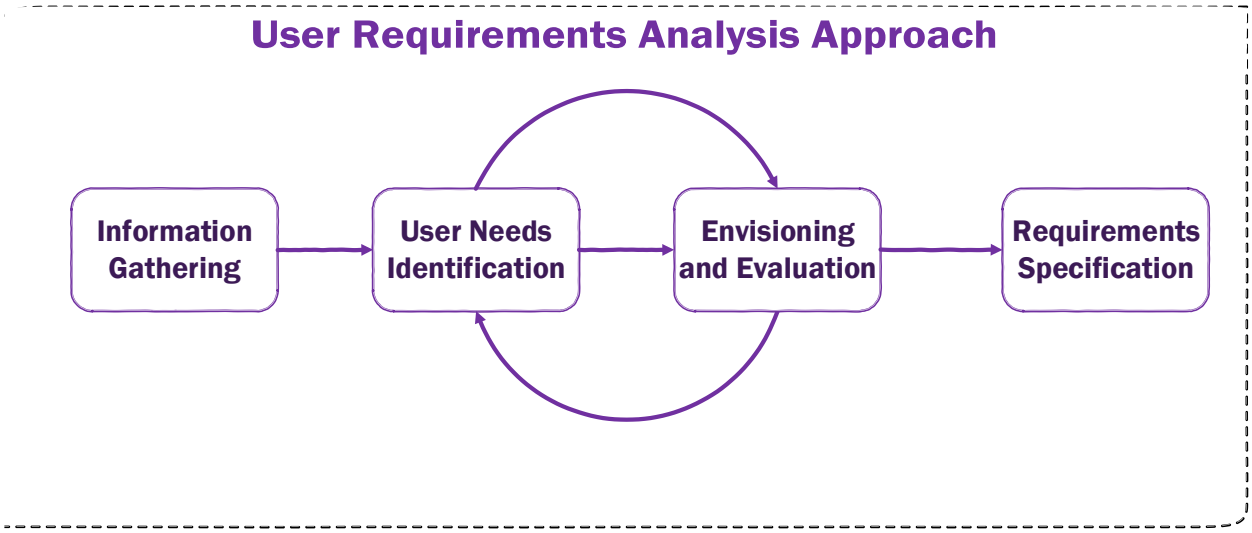


FIGURE 3-2: USER REQUIREMENTS ANALYSIS APPROACH

User needs evaluation refers back to the systematic or formal procedure used in the identification of gaps between the modern and desired effects, placing the needs in precedence order based totally on the value to satisfy each want as opposed to the cost of ignoring it (Kaufman, 1998). Distinctive facts collecting techniques such as personal interviews and questionnaire surveys had been used to

conduct the user needs assessment. Envisioning and Evaluation is the phase where the identified needs are evaluated and quantified. This is the best way to come up with quality related functionality requirements.

3.4.1.3 Tools used for User Needs Assessment

This section describes the tools to be used to gather the required information.

3.4.1.3.1 Questionnaire Surveys

Surveys are very much organized inquiries where respondents just reply by ticking or utilizing short answers, for example, yes, presumably, surely and different terms. Polls has the accompanying favorable circumstances and detriments. The upsides of survey are that they allow to the respondent to have room schedule-wise to think before reacting to any inquiry and there are no one-sided reactions. However, surveys require a lot of paper work which is costly, will be excessive in dispersing and gathering poll structures, can have restricted space for respondents to clarify their answers and they are hard to plan and tedious.

3.4.1.3.2 Interviews

Meetings are led vis-à-vis with the respondent. For focused populaces, meetings are the main practical information accumulation technique. Individual meetings have the most astounding reaction rates yet are generally the costliest system for information accumulation as a result of transportation and cabin costs for questioners. These outcomes in littler example sizes than would have been chosen for self-specification or phone interviews. Another issue with individual meetings is that it can be hard to discover individuals at home or at work, so the questioner may be required to visit the habitation or work environment a few times before effectively reaching the respondent. Once in a while, the respondent is available, yet the time is badly arranged, requiring the questioner to reschedule the meeting. There is immediate association and correspondence with the general population that are right now included in the work along these lines complete and precise data can be acquired. Input is given in a split second, in this way defers are decreased.

3.4.1.4 Spatial Data Gathering

Mainly Open Street Map data will be used for mapping the city roads and facilities aided by base maps from providers like google and ESRI.

3.4.2 System Design

3.4.2.1 System Architecture Design

System architecture includes distinct components of the system and describes its shape and structure. The design includes approaches of figuring out sub-systems that makes up the Engineering Service Fault Reporting system and the framework for sub-control and communication. The researcher chose to adopt a three tier architecture because of its principle of separation of concerns. A three tier architecture is also easy to test and implement.

3.4.2.2 Integrated Database Design

Using data gathered from the requirements analysis, several questions are brought to attention. Database design depends on what type of data the database will contain; how this data will be inputted and retrieved from the database; how this data will be displayed to the end user and in what format; who should access this data and the privileges they have in manipulating this data (CHEN, Jacky, 2015). Several constraints have to be observed as this will also influence the way the business logic layer will be programmed. The conceptual design basically details the entities present and their existing relationships. All designs diagram in this phase are drawn using Microsoft Visio and will be implemented in SQL Server 2014 Express.

Conceptual, logical and physical model are three unique ways of modeling data in a domain (DYKSTRA, Tom, 2014). While they all contain entities and relationships, they differ in the purposes they are created for and audiences they are meant to target (LONGLEY, Paul A et al., 2005). A general understanding to the three models is that, business analyst uses conceptual and logical model for modeling the data required and produced by system from a business angle, while database designer refines the early design to produce the physical model for presenting physical database structure ready for database development (NEERAJ SHARMA, Liviu Perniu, Raul F. Chong, Abhishek Iyer, Chaitali Nandan,Adi-Cristina Mitea, Mallarswami Nonvinkere, Mirela Danubianu, 2010).

Conceptual ERD models information gathered from business requirements. Entities and relationships modeled in such ERD are defined around the municipality's need. The need of satisfying the database design is not considered yet. Conceptual ERD is the simplest model among all (NEERAJ SHARMA, Liviu Perniu, Raul F. Chong, Abhishek Iyer, Chaitali Nandan,Adi-Cristina Mitea, Mallarswami Nonvinkere, Mirela Danubianu, 2010).

Logical ERD also models information gathered from business requirements. It is more complex than conceptual model in that column types are set (CHEN, Jacky, 2015).

Physical ERD represents the actual design blueprint of a relational database. It represents how data should be structured and related in a specific DBMS so it is important to consider the convention and restriction of the DBMS on designing a physical ERD. This means that an accurate use of data type is

needed for entity columns and the use of reserved words has to be avoided in naming entities and columns. Besides, primary keys, foreign keys and constraints can now be added to the design.

3.4.2.3 Data Acquisition

The core functionality of the engineering service fault reporting system will depend on fault data that inputted by the citizenry. Base data from Google Maps and Open Street Maps will be utilized. Depending on the needs of the city council, it may be necessary to other secondary data. This will be attended based on the municipal needs.

3.4.3 Web Application Design

A Web application is an application that can be accessed by the users through a Web browser or a specialized user agent. The browser creates HTTP requests for specific URLs that map to resources on a Web server. The server renders and returns HTML pages to the client, which the browser can display. The core of a Web application is its server-side logic. The application will contain several distinct layers. The typical example is a three-layered architecture adopted in this research that comprised of presentation, business, and data layers.

3.4.3.1 Design Considerations

Partitioning the application logically: Use of the layering concept to partition the application logically into presentation, business, and data access layers. This helps in writing maintainable code and makes it possible to monitor and optimize the efficiency of each layer separately. A transparent logical separation additionally presents extra selections for scaling the application. (MSDN, 2015).

Using abstraction to implement loose coupling between layers: This will also be comprehensive by defining interface components, comparable to a map with well-known inputs and outputs that translates requests into a layout understood by components inside the layer (SHAIK, Khader, 2014). Furthermore, Interface types or abstract base classes can be used to define a shared abstraction that interface components must implement.

Understanding how components (or the different application layers) will communicate with each other (MSDN, 2015). This requires an understanding of the deployment eventualities the application have got to aid. Of importance also is determining communication across physical boundaries or process boundaries will have to be supported, or if all components will run within the same process (SHAIK, Khader, 2014). This can be aided also by keeping the data format consistent within a layer or component. Mixing the data formats can make the system more difficult to implement, extend, maintain, or even troubleshoot if something goes wrong.

Consider caching to minimize server round trips (MSDN, 2015). When designing a Web application, it is important to consider using techniques such as caching and output buffering to reduce round trips between the browser and the Web server, and between the Web server and downstream servers. A well designed caching strategy is the single most important performance related design consideration. ASP.NET caching features include output caching, partial page caching, and the Cache API (JOSE ROLANDO, Guay Paz, 2012). The web application design will take advantage of these features.

Another design consideration is authenticating users across trust boundaries. The application will be designed to authenticate users whenever they cross a trust boundary; for example, when accessing a remote business layer from the presentation layer.

Privacy and Security: Sensitive data is passed in plaintext across the network. Whenever sensitive data is passed such as a password or authentication cookie across the network, according to (SHAIK, Khader, 2014), one has to consider encrypting and signing the data or using Secure Sockets Layer (SSL) encryption.

Lastly but not least, the Web application will be designed to run using a least-privileged account. If an attacker manages to take control of a process, the process identity should have restricted access to the file system and other system resources in order to limit the possible damage to the municipal's data residing on the same server with the application.

3.4.4 System Development Method

Taking into consideration the design principle mentioned above, the web application is initially created in little projects called units, which are coordinated in the following stage. Every unit is produced and tested for its usefulness which is alluded to as Unit Testing. SQL Server Management Studio is going to be used to develop the database tables and the required constraints. ASP.NET, an improvement from the old Microsoft ASP (Asynchronous Server Pages) is an open-source server-programming framework that works well with any of the languages supported by the .Net Framework (MSDN, 2015). It was developed for creating dynamic web applications. Again, it was developed by Microsoft and any changes required or improvements are effected by the ASP.NET team (JOSE ROLANDO, Guay Paz, 2012). (JOSE ROLANDO, Guay Paz, 2012) also states that, ASP.NET is a development framework for building web pages and web sites with HTML, CSS, JavaScript and server scripting. ASP.NET supports three different development models: Web Pages, MVC (Model View Controller), and Web Forms. This is the framework which will be used to develop the web application as per the researcher's choice. It also has several advantages, the main one being Microsoft Visual Studio. Visual Studio is an Integrated Development Environment which makes it easy to develop applications using .Net supported languages, mainly C# and Visual Basic (JOSE ROLANDO, Guay Paz, 2012) though it now also supports

extensions to develop using PHP, Ruby, Python and several other languages. This IDE provides advanced features that makes application development most favorable. Since SQL server is built on the .NET framework, this will make it easy to implement some default functionality provided by ASP.NET boiler plates. One other technology which will be utilized by the researcher is Entity Framework. According to (DYKSTRA, Tom, 2014) "Entity Framework (EF) is an object-relational mapper that allows .NET developers to work with relational data using domain-specific objects" (DYKSTRA, Tom, 2014). This mapper eliminated the need to write raw SQL code and other functions to connect your application with the database. To make the application easy to develop and integrate, the researcher has chosen to use ASP.NET MVC programming models which is one of three ASP.NET programming models. MVC is a framework for building web applications using a MVC (Model View Controller) design:

•The Model represents the application core (for instance a list of database records).

•The View displays the data (the database records).

•The Controller handles the input (to the database records).

The MVC model also provides full control over HTML, CSS, and JavaScript. This is a web application development model that uses the principle of separation of concerns. The Model is the part of the application that handles the logic for the application data. Often model objects retrieve data (and store data) from a database. The View is the parts of the application that handles the display of the data. Most often the views are created from the model data. The Controller is the part of the application that handles user interaction. Typically, controllers read data from a view, control user input, and send input data to the model. The MVC separation helps manage complex applications, because one can focus on one aspect a time. For example, you can focus on the view without depending on the business logic. It also makes it easier to test an application. The MVC separation also simplifies group development. Different developers can work on the view, the controller logic, and the business logic in parallel. Modern interactivity can have added by enabling asynchronous controls that reduce the page loading when the user request something from the server. Security and User management will be implemented using ASP Identity API (OWIN OAuth 2.0 Authorization) which comes inbuilt with ASP.NET. This will provide an efficient way of user management and a secure way for accessing the system using technologies like two factor authentication and cookie based login. ASP.NET also provides other functionalities out of the box that enhance integrity and security of data as it is transferred from the client to the server.

3.4.5 Integration and Testing

All the units developed in the implementation phase are integrated into a system after testing of each unit. Post integration the entire system is tested for any faults and failures. This will be facilitated by easy to use Visual Studio Unit Test Tools. Visual Studio also makes it easy to integrate and publish different units into a single project.

CHAPTER 4

4 RESULTS AND ANALYSIS

4.1 INTRODUCTION

This chapter gives results from the user needs assessment and results from the physical design, architecture design, interface design, system design and a general overview of how the City Engineering Service Reporting System works. It is based on the exercises that were carried out by the researcher according to the methodologies described in the previous chapter.

4.2 USER NEEDS REQUIREMENTS

City Engineering Services Reporting System benefits the City of Gweru Engineering Department in serving their citizens better. This system is intended to improve the way the citizens report faults to the engineering department. The system also has to improve the way the city responds to the citizens by establishing a two-way communication between the city and the citizenry. The system is also to be used to provide feedback to the citizenry concerning what the city has been doing in regards to what the people have reported. Last but not least, the system is to assist the city in managing the reported faults, by categorizing them based on the importance or significance of the issue reported.

The results of the user need assessment were categorized into inputs, processing, storage, and output. The user needs assessment assist the developer to be able to meet the expectation of the stakeholders and thus a crucial step in the research. Also, since this research will only focus on sewer and water reticulation services, main emphasis will be places on how these service issues are addressed. Currently the city council relies on a manual system for services reporting. The citizens either visits the town house or makes a call to the city council engineering department for them to report their issues. The city council requires the information of the reporter and the precise location of the fault. After this information is has been collected, the city council may attend to the scene so as to understand the nature of the fault so as to determine what is it that is require to fix the problem.

Inputs

Information that is required for reporting a fault includes, the precise location of the fault and this can be a description based on the predominant feature notable or close to the fault, a house number or street description. Also required is the contact details of the person who reported the fault and the description of the nature of the fault.

The system thus has to have a means of capturing all this information and provide an accurate means of giving precise location of the fault. Since the main source of information in this system is the citizen, it is important that the system be designed in such a way that it takes into consideration the literacy of the people that are going to be using the system. It is equally important to provide the city call center with an interface where they are also able to log in faults reported via the phone. It was also

requested if the citizenry could have access to the system on a friendlier platform, i.e. a system that is mobile friendly.

Storage

Information provided by the user is stored on record cards that are then delivered to the personnel responsible for assigning duties to the teams that will go do the work on the ground. A work record is also logged by the city personnel after they attend to each issue. This information is stored as hard copies. Currently, there are no computers in use neither is there any databases in use for storing and retrieving this information when needed.

This means that the system has to provide an efficient storage mechanism that is able to capture geographic information that will be used to locate the faults and relate it to the users that have logged the faults.

Processing

When the information has been submitted to the city council, the main action they take is to go to the ground and starting the repair process. The system will provide a mechanism to categorize service issues by their current state i.e. whether they have been attended to or not. This will allow the city to track their progress and also provide the citizenry with progress information concerning issues they have reported. Based on this criteria, the system has to be able to generate reports on the current progress of the faults that have been reported over a certain time period.

Outputs

The engineering service reporting system will be accessible to the citizens and city personnel anytime anywhere as long they have an internet connection. Currently, there is no means of communicating back to the citizenry concerning the reported issues. The system should be able to generate unique Ids for the citizen that they can use to track the progress of the fault that they have reported. The system should also generate automated emails to update the user on each stage of fault repair to reduce or eliminate their need to contact the city again in regarding the same issues.

4.3 USE CASE DIAGRAMS

To model a system, the most important aspect is to capture the dynamic behavior. To clarify a bit in details, dynamic behavior means the behavior of the system when it is running /operating. A use case diagram at its simplest is a representation of a user's interaction with the system that shows the relationship between the user and the different use cases in which the user is involved. Use case diagrams are used to gather the requirements of a system including internal and external influences. These requirements are mostly design requirements. So when a system is analyzed to gather its functionalities use cases are prepared and actors are identified. Use case diagrams are considered for high level requirement analysis of a system. So when the requirements of a system are analyzed the functionalities are captured in use cases. So basically, use cases are nothing but the system functionalities written in an organized manner.

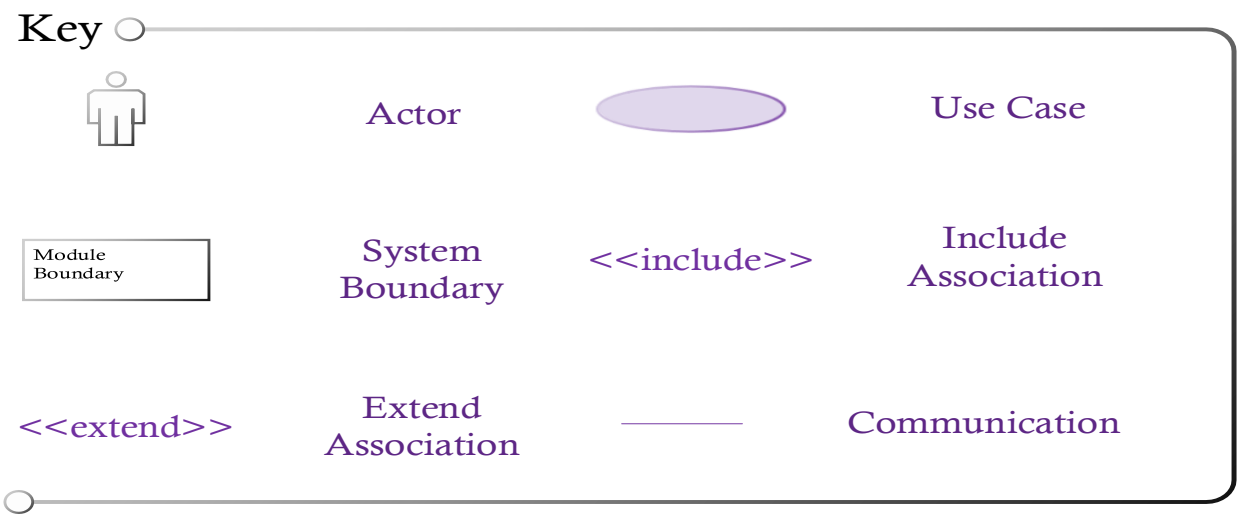


FIGURE 4-1: USE CASE KEY

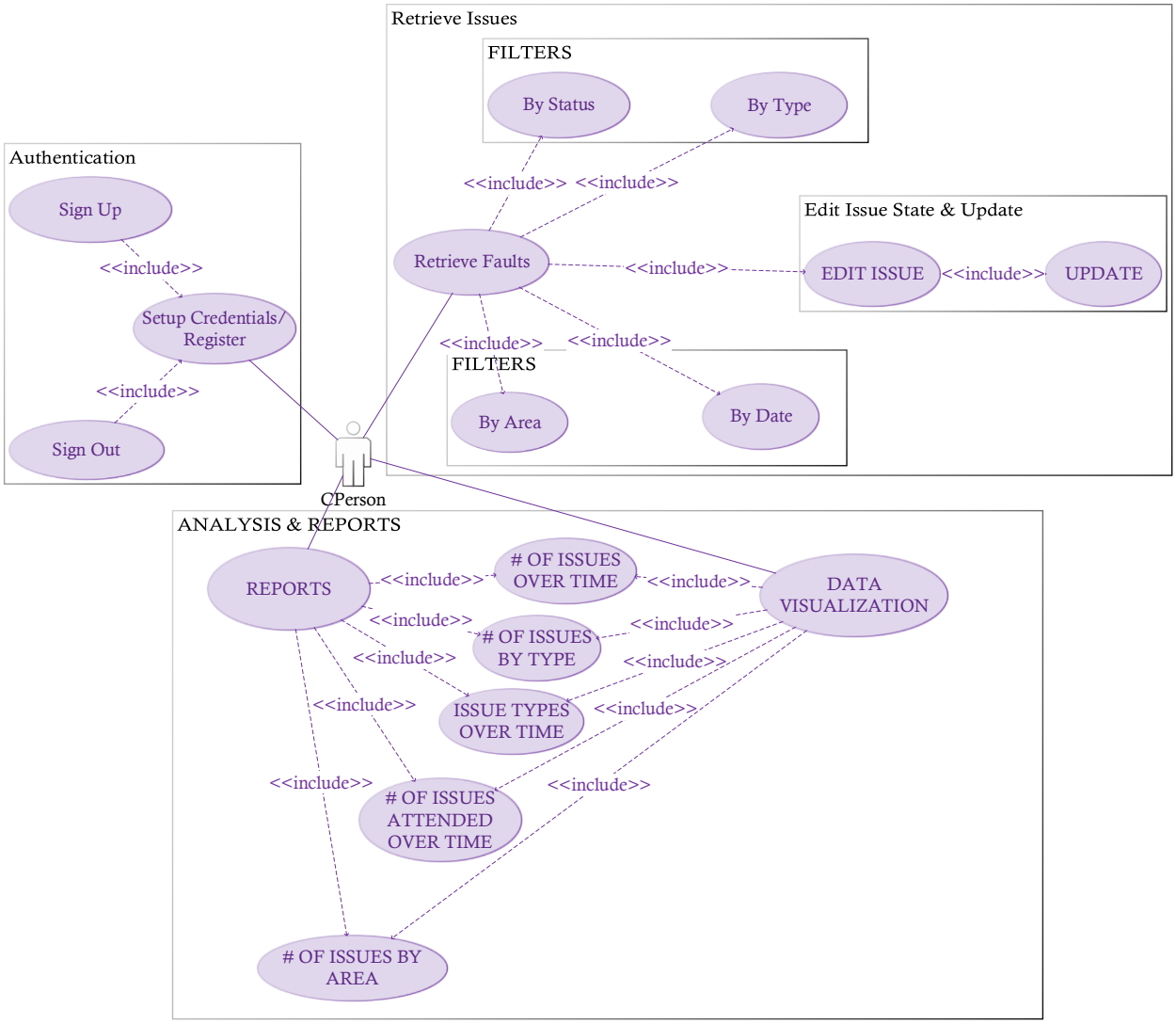


FIGURE 4-2: CITY PERSON USE CASE(CPERSON)

Use Cases describe a sequence of actions & provide the measurable value to an actor.

Actors are a person, group of people, organization, or external system the plays a role in one or more interactions with the system.

Associations or Communications indicate the interaction described by a use case

System boundary is the rectangle around the use cases. Anything within this boundary is the functionality in scope of the system.

Figure 1 shows the different subsystems or functionalities that are going to be available to the city personnel. These functionalities are only meaningful if the citizens have logged some service issues through the system. So as is demonstrated by the diagrams, the council personnel have access to all kinds of tools that allow them to view and analyze all the information submitted by the citizens. This will provide for a quick and efficient way for resource deployment.

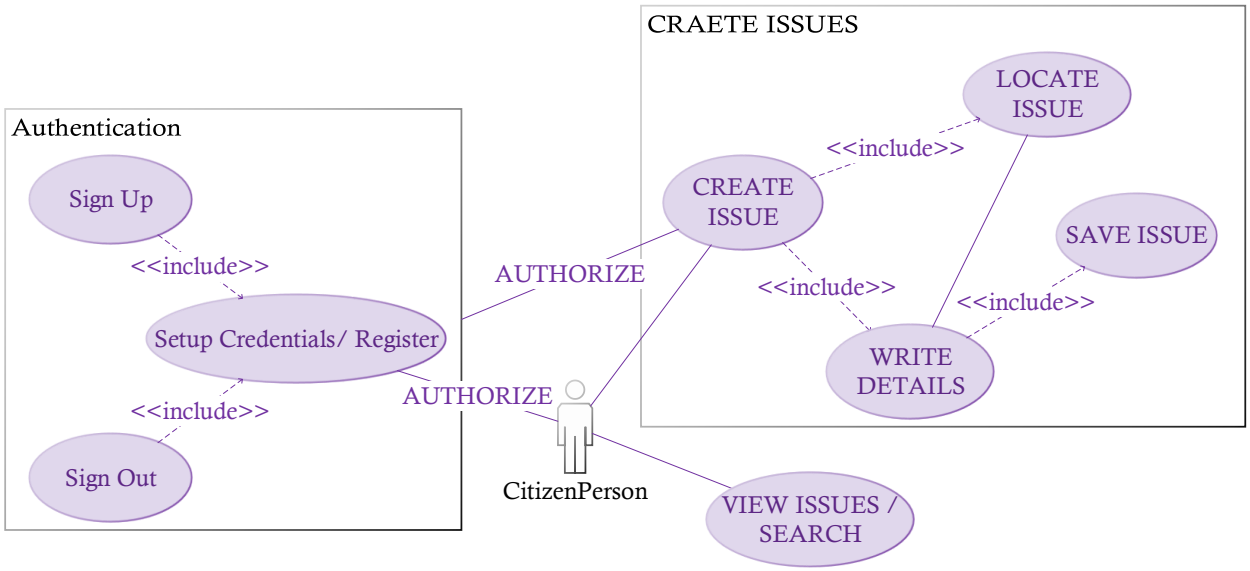


FIGURE 4-3: CITIZEN USE CASE

The citizen use case demonstrates how the citizen has to be able to view currently reported issues and their states. The citizen also has to be able to search for the issues they have reported to see on the current progress of the issue. For the sack of security and authenticity, the citizens will also have to create accounts with the system so as to be able to log any faults noticed in their area.

4.4 SYSTEM DEFINITION

System definition gives a detailed description of how the engineering service fault reporting system operates. As mentioned afore, the current system is manual and no electronic means are incorporated in processing or storing the information. The citizens currently report faults to the engineering department in two ways:

a) Via phone call,
b) By visiting the engineering department.

Either ways, the information that is provided by the citizen is logged onto a book or record cards. The hard copies stored in file cabinets require much storage space and results in difficulties when retrieving files from the cabinets. It also makes it difficult for the council to analyze any of these reports

so as to get insights on the information since there is no means of doing so with hard copy books. The fault report information is then passed to the relevant personnel that is going to the ground to check on the nature and validity of the information provided. This will allow them to know best they can fix the fault provided the required resources are available. After attending to any fault, the personnel record the what they name “Work Log”. This is a log that details work that has been done on the field visit for the purposes of performance measurement.

The engineering service fault reporting system will be used by two main actors (the citizens and the city council engineering department) as demonstrated by figures 1 and 2. Since the system is web based, it will be accessible over the internet with any browser of choice that supports JavaScript and CSS3 (all recent versions from different vendors do). The system will be available to through the city’s website and it will also reside on council’s servers. This means the city personnel can also access the system via a Local Area Network. The diagram below shows the high level conceptual view of the system.

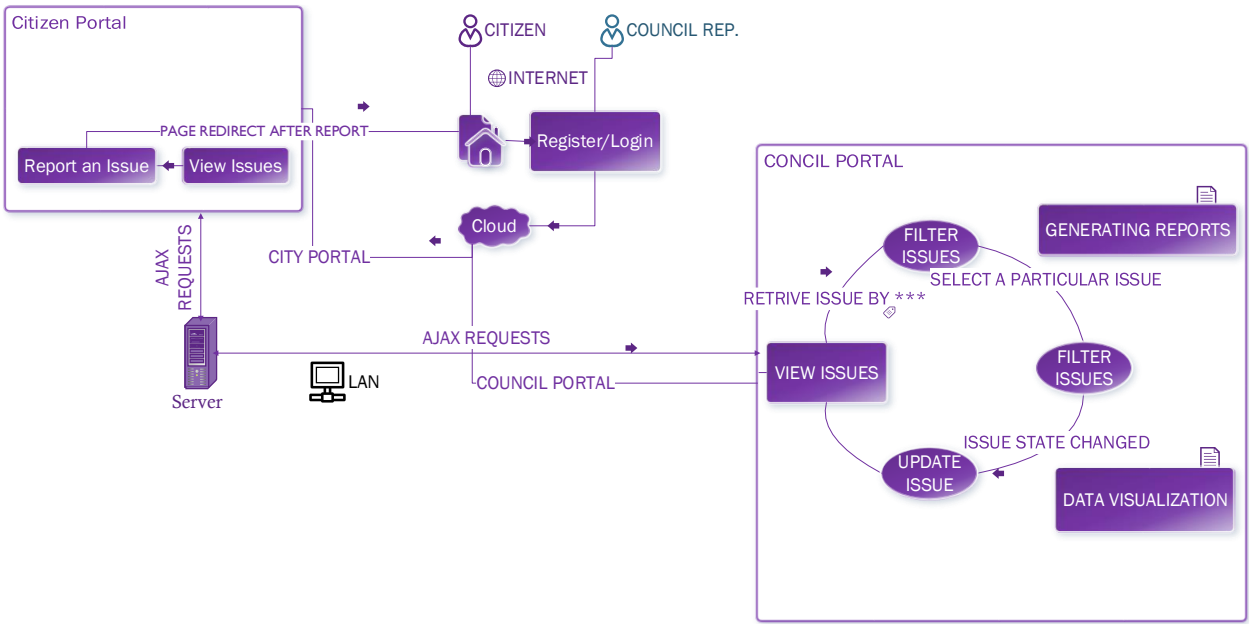


FIGURE 4-4: SYSTEM CONCEPTUAL VIEW

At each stage of progress, the system automatically mails the reporter. The system also will provide an option to send custom mails to the reporter in case the fault reported requires special attention. This is mainly to improve the communication between the city council and the citizenry.

4.4.1 CITIZEN PORTAL

The citizen portal is the interface that is used by the citizens. This interface allows the citizens to search for faults that were already logged to see the current progress or to view if the area they want to report on has already been reported. This portal’s design is such as one that can be used by any citizen that once used a computer for day to day basics. To improve on usability, the system also has a manual accessible after logging into the system. Also available is a simple GIF animation picture that demonstrates the few steps used to report on a fault. Basically, the first step is to log in or sign up into

the system because it will not allow for any faults to be logged without registering with the system. After login, the user is presented with a map with flags on faults that are currently logged into the system. Different markers are used to distinguish between the status or current progress of the fault. Having seen that there is no record logged for a fault in specific area, the user clicks on the map. This automatically inserts a marker that tells the user to drag it to the exact location of the fault. The map is also equipped with simple navigation tools that allows the citizen to easily pinpoint the location of the fault. On clicking the marker (after dragging it to the exact fault location), a window pops up prompting the citizen to enter information related to the fault and the location of the fault. After filling in the required information, the citizen has to click the button send so as to send through the information to the server/ database. The page will automatically redirect them to the system's homepage. The citizen is also then given an issue number that they will use for reference and also so as to notice the mails the system will send as it will be in the email subject. The citizen will not be able to edit any of the information that has been sent to the server, they are only allowed to view.

4.4.2 Council Portal

The council portal is what will be used by the city personnel to attend to the reported issues. The portal contains more tools that allow fault status updating. The council portal will not allow editing of any fault information other than the status. Faults reported have three states:

Unassigned: - these are faults that have been reported and the city hasn't taken any action to attend to the fault.

Assigned: - the city takes an initiative to start fixing the fault and thus a team is assigned to attend to the fault.

Closed: - this status indicates that the city has already attended to the fault and thus no further actions required.

The status update will also not allow an issue that has been assigned to be unassigned or an issue that has been closed to be assigned or unassigned. Such changes are only available to the database administrator. Upon editing the status, the system automatically creates a work log that tells who changed the specific fault status and on what date. This information is used for further analysis in performance measurement. The council portal is also equipped with tools that allow the users to execute intelligent queries without any knowledge of SQL. Interfaces are also designed to be simple as not all council personnel are that computer literate. The system is also able to quick reports easy to understand that can be exported to excel or pdf for further analysis for those who are well versed with excel.

4.5 System Database

4.5.1 Conceptual Model

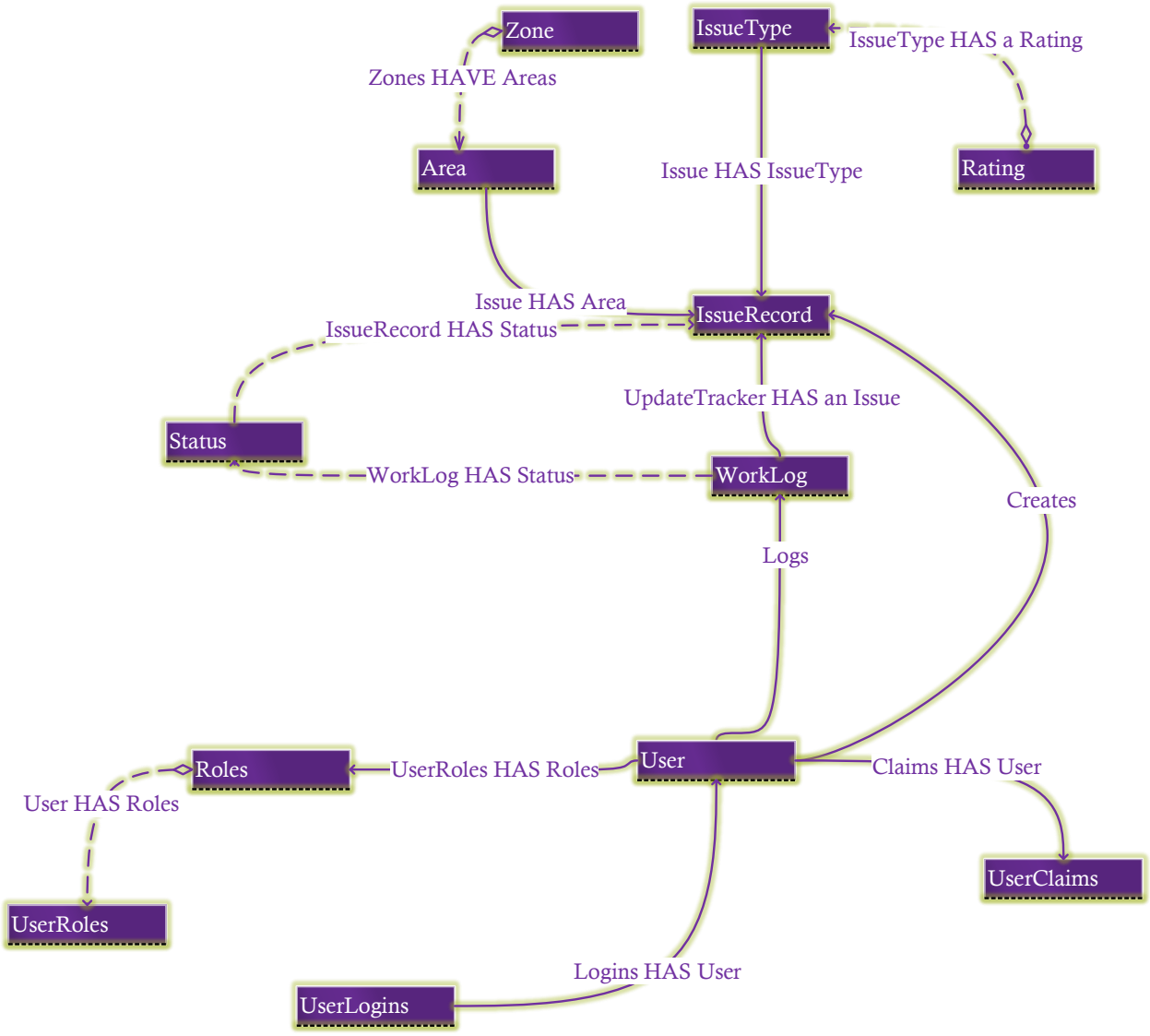


FIGURE 4-5: ER DIAGRAM (UML)

4.5.2 LOGICAL MODEL

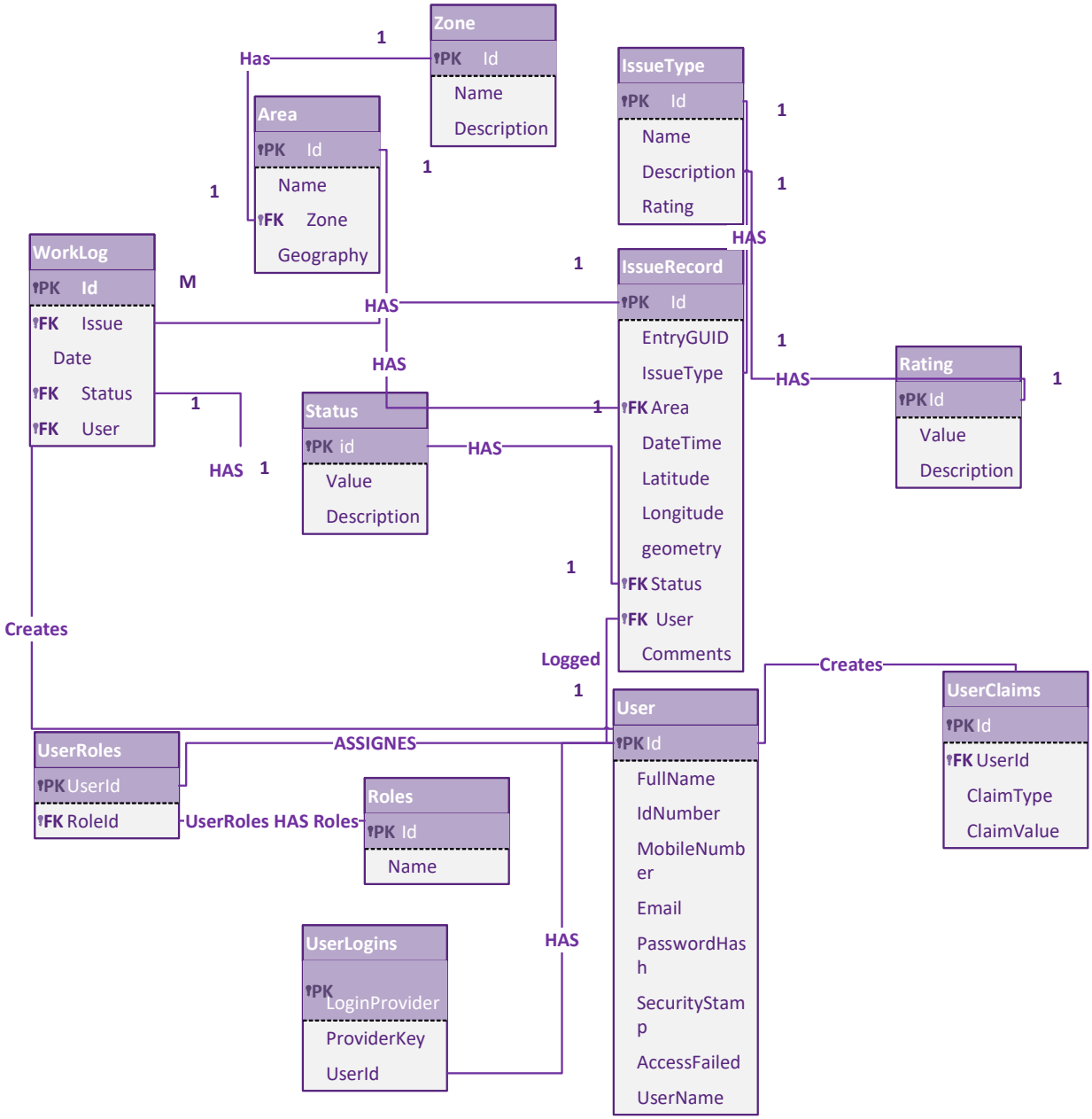


FIGURE 4-6: LOGICAL MODEL

4.5.3 DATABASE TABLES

IssueRecords

Column Name	Data Type	Allow Nulls
IssueRecordId	int	☐
EntryGuid	uniqueidentifier	☐
IssueType_IssueTypeId	int	☑
AreaId	int	☐
DateTimeCaptured	datetime	☐
Latitude	real	☐
Longitude	real	☐
StatusId	int	☐
[User]	nvarchar(MAX)	☑
Comments	nvarchar(MAX)	☑

Entity: Issue Records

Description: The table that contains fault record information.

IssueTypes

Column Name	Data Type	Allow Nulls
IssueTypeId	int	☐
Name	nvarchar(MAX)	☑
Description	nvarchar(MAX)	☑
RatingId	int	☐

Entity: Issue Type

Description: The table that contains fault categories.

Ratings

	Column Name	Data Type	Allow Nulls
🔑	RatingId	int	☐
	Value	int	☐
	Description	nvarchar(MAX)	☑
			☐

Entity: Issue Rating

Description: The table that contains fault rating information.

Areas

	Column Name	Data Type	Allow Nulls
🔑	AreaId	int	☐
	Name	nvarchar(MAX)	☑
	ZoneId	int	☐
			☐

Entity: Areas

Description: The table that contains records on areas considered in the case study i.e. Windsor Park.

Status

	Column Name	Data Type	Allow Nulls
🔑	StatusId	int	☐
	Value	nvarchar(MAX)	☑
			☐

Entity: Issue Status

Description: The table that contains fault status i.e. Assigned/ Unassigned.

UpdateTrackers

	Column Name	Data Type	Allow Nulls
🔑	UpdateTrackerId	int	☐
	IssueId	int	☐
	DateOfUpdate	datetime	☐
	StatusId	int	☐
	[User]	nvarchar(MAX)	☑
	IssueRecord_IssueRecordId	int	☑

Entity: Work Log

Description: The table that contains work log information.

AspNetUsers *

	Column Name	Data Type	Allow Nulls
🔑	Id	nvarchar(128)	☐
	FullName	nvarchar(MAX)	☐
	IdNumber	nvarchar(MAX)	☑
	Email	nvarchar(256)	☑
	EmailConfirmed	bit	☐
	PasswordHash	nvarchar(MAX)	☐
	SecurityStamp	nvarchar(MAX)	☑
	PhoneNumber	nvarchar(MAX)	☑
	PhoneNumberConfirmed	bit	☐
	TwoFactorEnabled	bit	☐
	LockoutEndDateUtc	datetime	☑
	LockoutEnabled	bit	☐
	AccessFailedCount	int	☐
	UserName	nvarchar(256)	☐

Entity: Users

Description: The table that contains user information.

AspNetUserRoles

	Column Name	Data Type	Allow Nulls
🔑	UserId	nvarchar(128)	☐
🔑	RoleId	nvarchar(128)	☐

Entity: User Roles

Description: The table that contains assigned user role information.

AspNetRoles

	Column Name	Data Type	Allow Nulls
🔑	Id	nvarchar(128)	☐
	Name	nvarchar(256)	☐

Entity: Roles

Description: The table that contains user role information.

AspNetUserClaims

	Column Name	Data Type	Allow Nulls
🔑	Id	int	☐
	UserId	nvarchar(128)	☐
	ClaimType	nvarchar(MAX)	☑
	ClaimValue	nvarchar(MAX)	☑
			☐

Entity: User Claims (For claims based login)

Description: The table that contains user claims information.

AspNetUserLogins

	Column Name	Data Type	Allow Nulls
🔑	LoginProvider	nvarchar(128)	☐
🔑	ProviderKey	nvarchar(128)	☐
🔑	UserId	nvarchar(128)	☐
			☐

Entity: User Logins

Description: The table that contains information on who has logged into the system at what time.

4.6 Web Based System

Below is the interface that is used to access all the functionalities in the system. Based on the user roles, some links will not work for reasons of security. The citizen can access the citizen portal from the menu strip or from the getting started section.

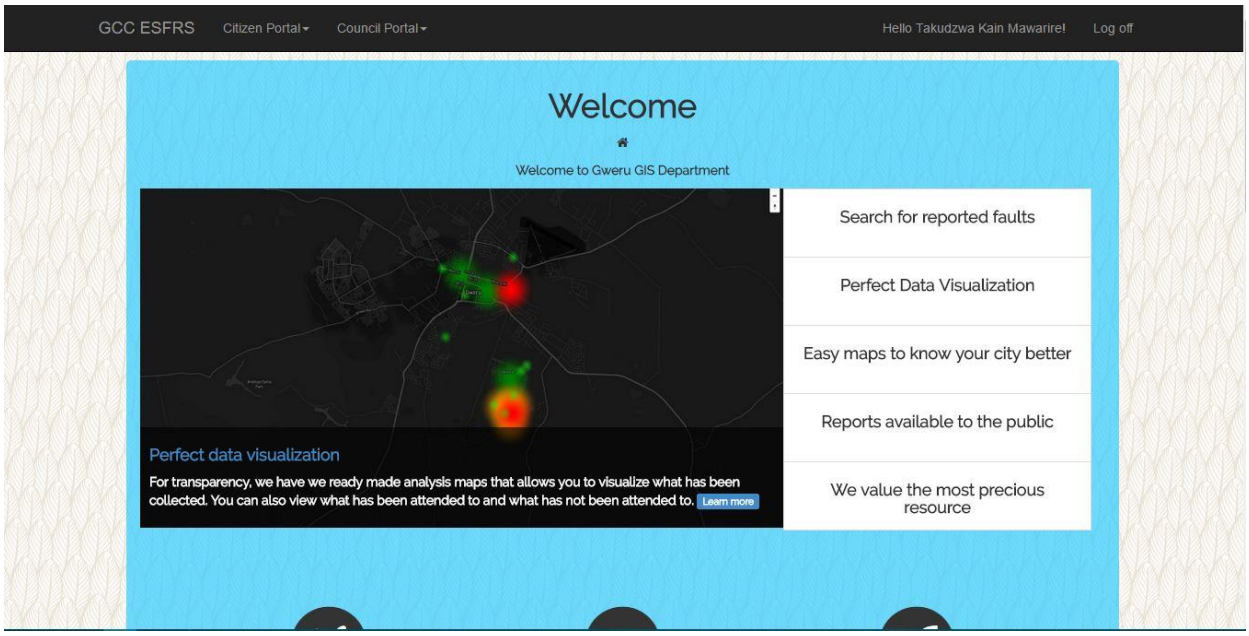


Figure 4-7: Home Screen

4.6.1 CITIZEN PORTAL

After trying to access the citizen portal, the user is requested to login.

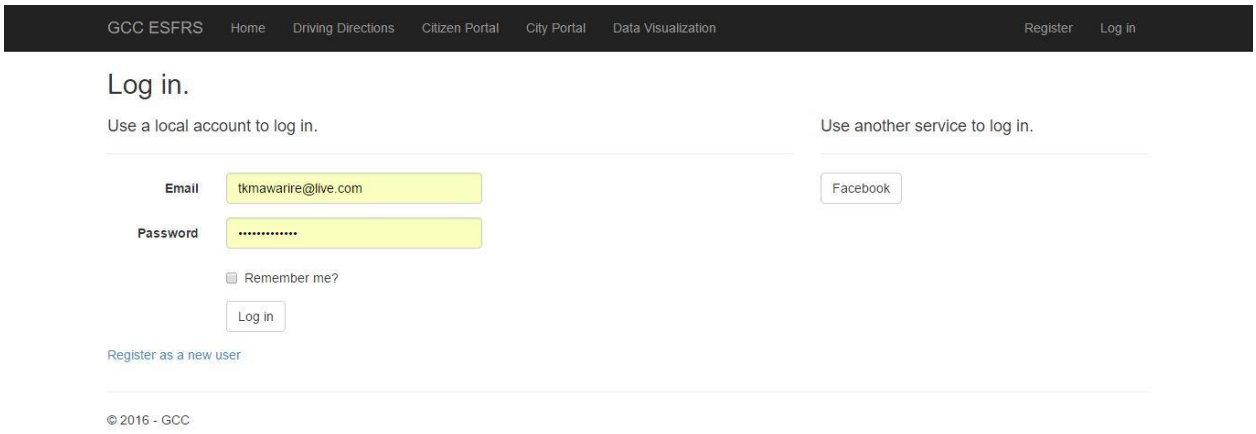


FIGURE 4-8:LOGIN PAGE

If the user hasn't registered with the system already, they are required to register.

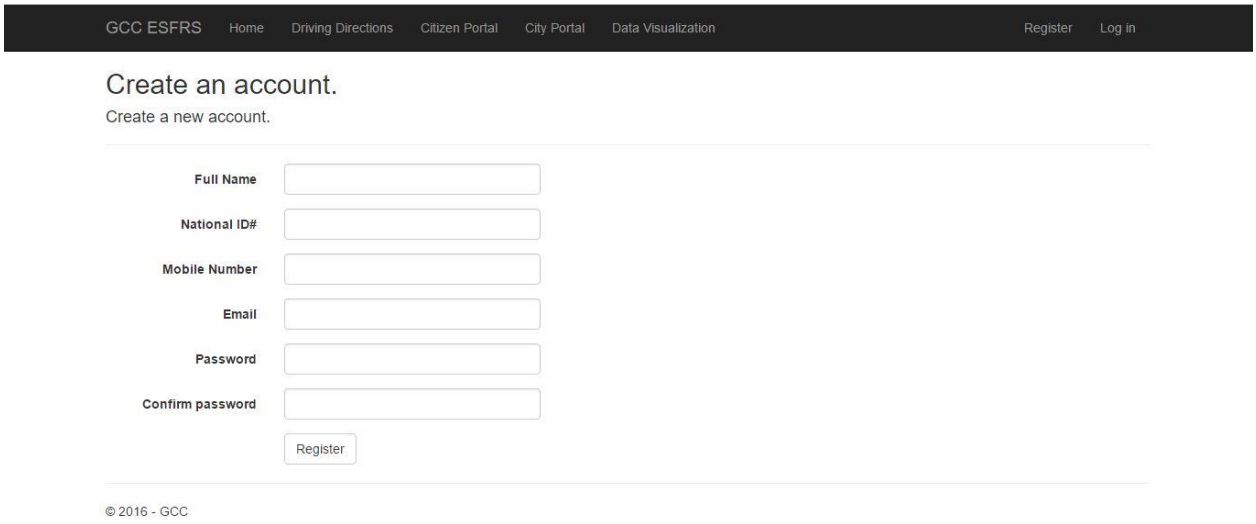


FIGURE 4-9: REGISTER PAGE

The registration requires information that will be used to contact the citizen in regards to the issues they will be reporting. After registering or logging in, the citizen is welcomed by a map where they are required to locate the exact location of the fault.

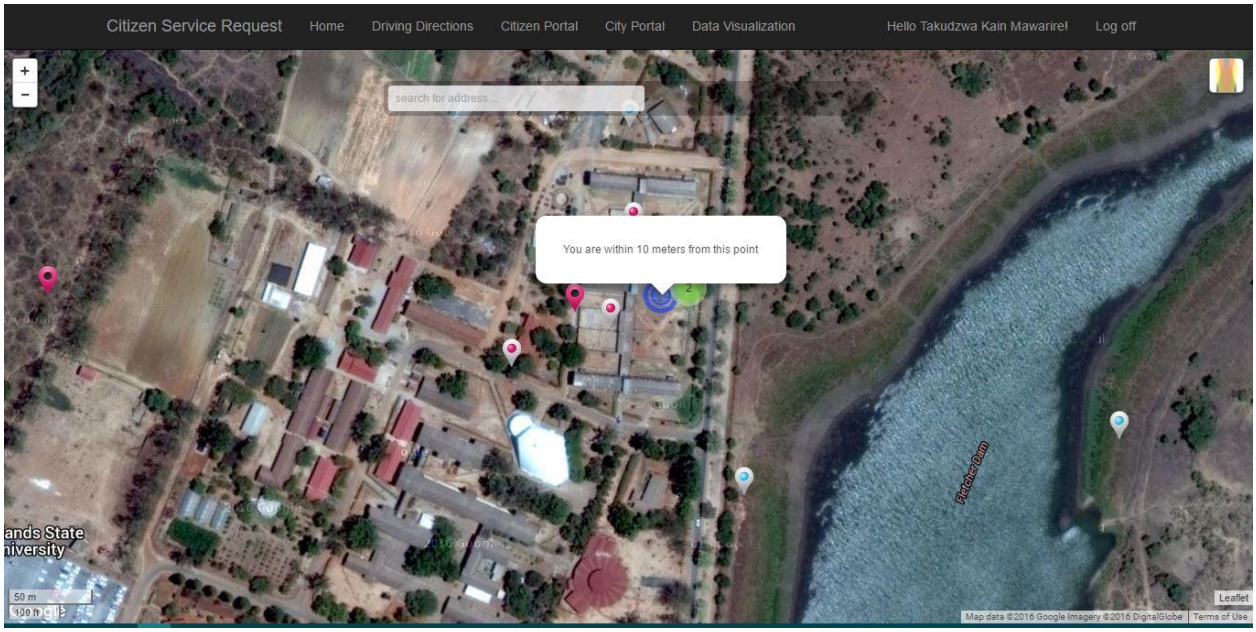


FIGURE 4-10: WELCOME MAP ZOOMED TO USER LOCATION

The map automatically zooms in to the user's current location. The user can click on any of the markers shown to get information on other reported faults or they can go straight to locate the location the report on. Zooming out, the map will automatically cluster the reported faults by category.

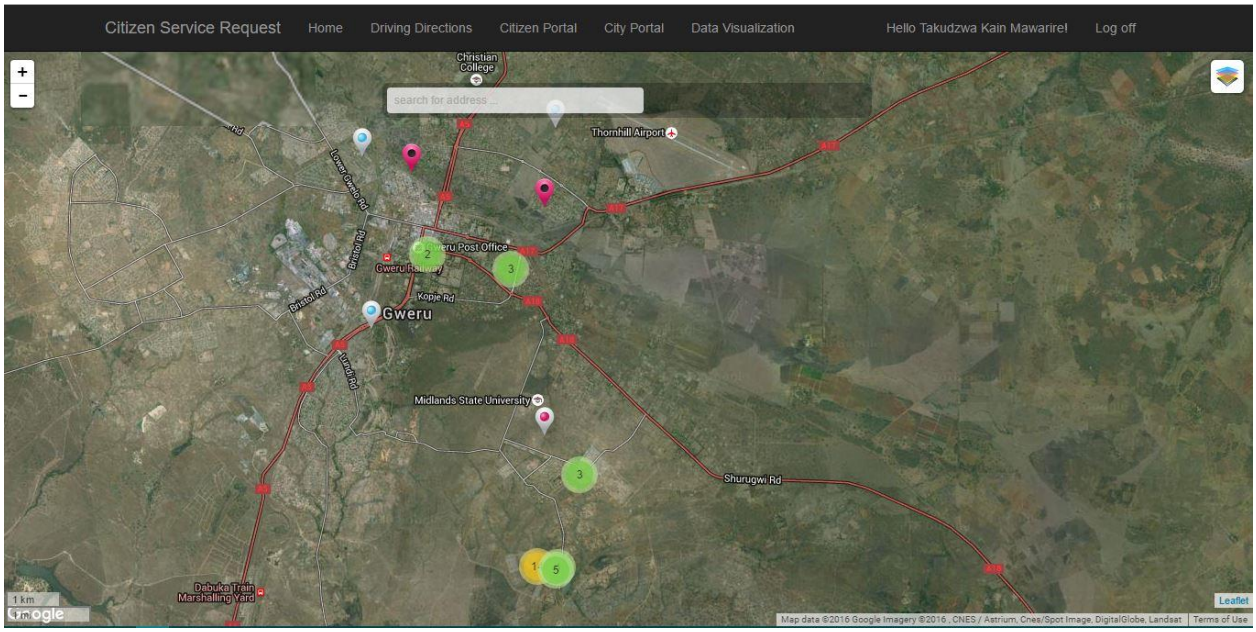


FIGURE 4-11: MAP CLUSTER CATEGORIZING FAULTS

When the user clicks on a marker cluster, the map automatically zooms in decluttering the fault markers.

4.6.2 REPORTING PROCESS

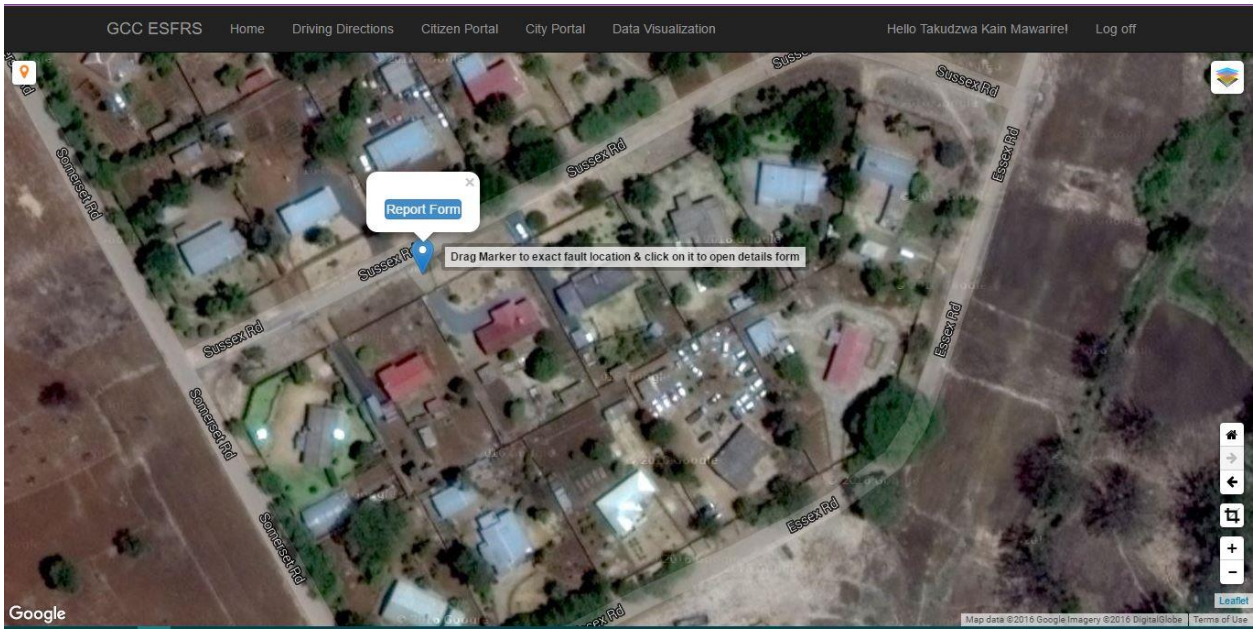


FIGURE 4-12: MARKER POPUP

The user navigates the map to the desired location. He or she then clicks on the map and a marker with an instruction is automatically inserted on the map. The instruction tells the user to drag the marker to the exact location (figure 20). On drag end, the popup window containing the report button becomes available to the user.

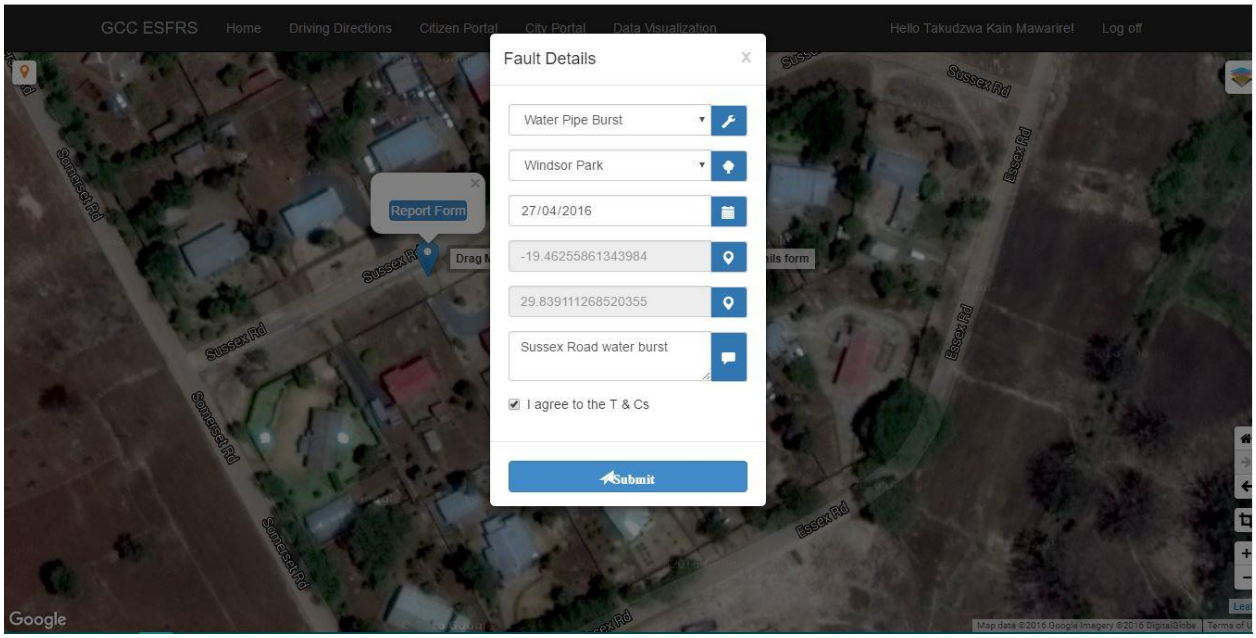


FIGURE 4-13: FAULT DETAILS FORM

The user is then required to fill in all fields of the form as the form will not save the fault if any field value is missing (figure 21). To send the information, the user clicks the send button and the information is automatically sent to the server. The user is then informed that the record was successfully saved and they are redirected to the issue details page where they are given the Issue number. This is all that's required for a citizen to report a fault. At this point, the system sends an

email to the citizen with all the information concerning the fault he/ she has reported. Users can also at any time inquire about the faults they have reported via an interactive map.

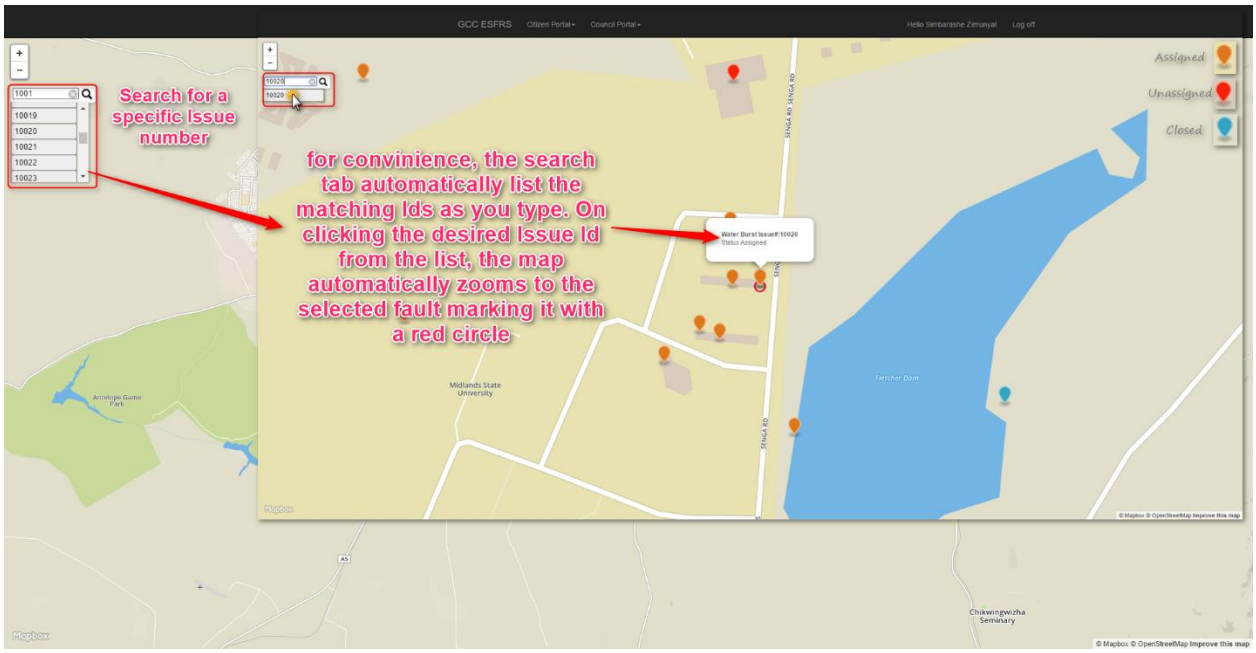


FIGURE 4-14: CITIZEN FAULT SEARCH

4.6.3 COUNCIL PORTAL

The council portal has two sections, one for the field team supervisor who is responsible for assigning work to field teams, and the other portal for the field team leaders responsible for logging what each team has accomplished. Both sections of the council portal are also accessible via the home page navigation bar.

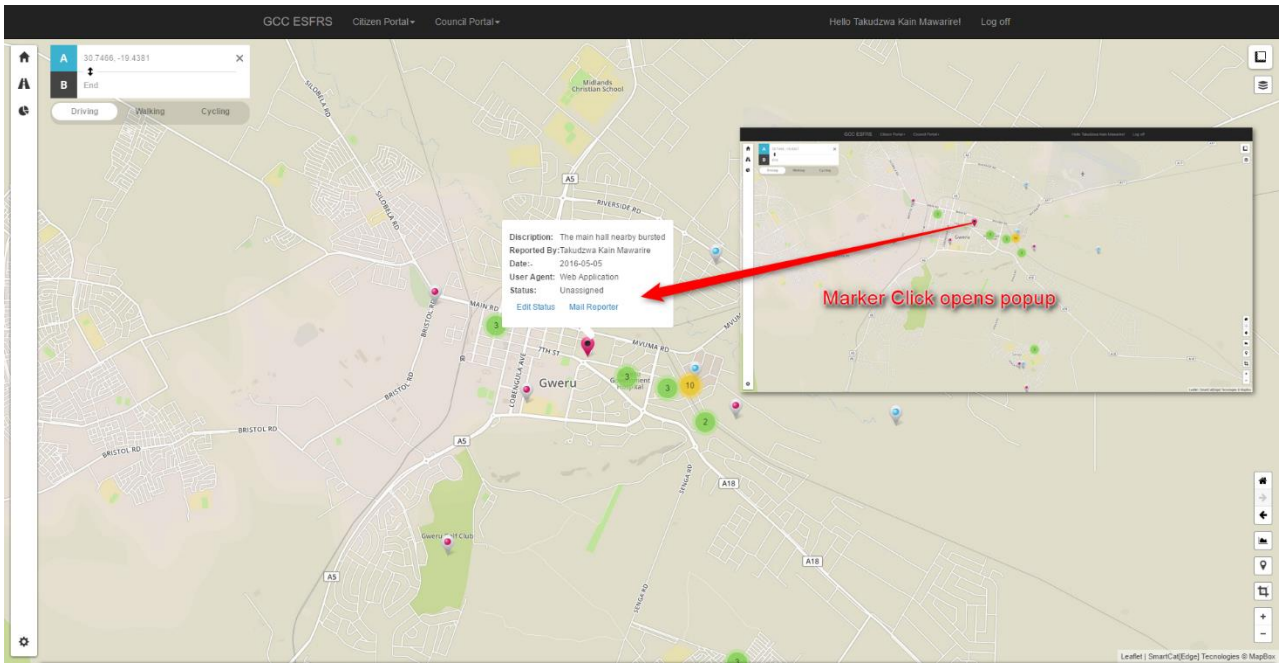


FIGURE 4-15: COUNCIL DASHBOARD (INITIAL LOOK AND POPUPS)

The user is welcomed with a map that has adequate tools for data visualization, analysis and reporting. Figure 23 shows initial look of the council portal map.

Supervisor Portal

The purpose of the supervisor is to assign work or tasks to his field teams. So the portal is equipped with tools to assign work to available teams. The supervisor is also provided with quick statistics and analysis tool. Markers are displayed with different colors symbolizing the different status assigned to each marker. Here if the supervisor can quickly locate the desired records, using the edit button, the can assign the reported faults to a desired team. The supervisor portal only allows assignment of tasks to individual teams. This changes the status of the fault from an “Unassigned” status to an “Assigned” status. Figure 23 shows the map side panel used in assigning tasks.

Tools available

- Task Assignment pane
- Query and Analytics grid: This grid is equipped with tools that allow the supervisor to execute intelligent queries on the data for better insights. Any queries execute can be shown on the map if the user wills. The data on this grid allows the supervisor to generate reports that can be exported to excel or portable document format (pdf).
- Quick navigation pane: For zooming to a specific area
- Team Monitering and Evaluation tools: For monitoring the progress of each team in regards to the work assigned to them

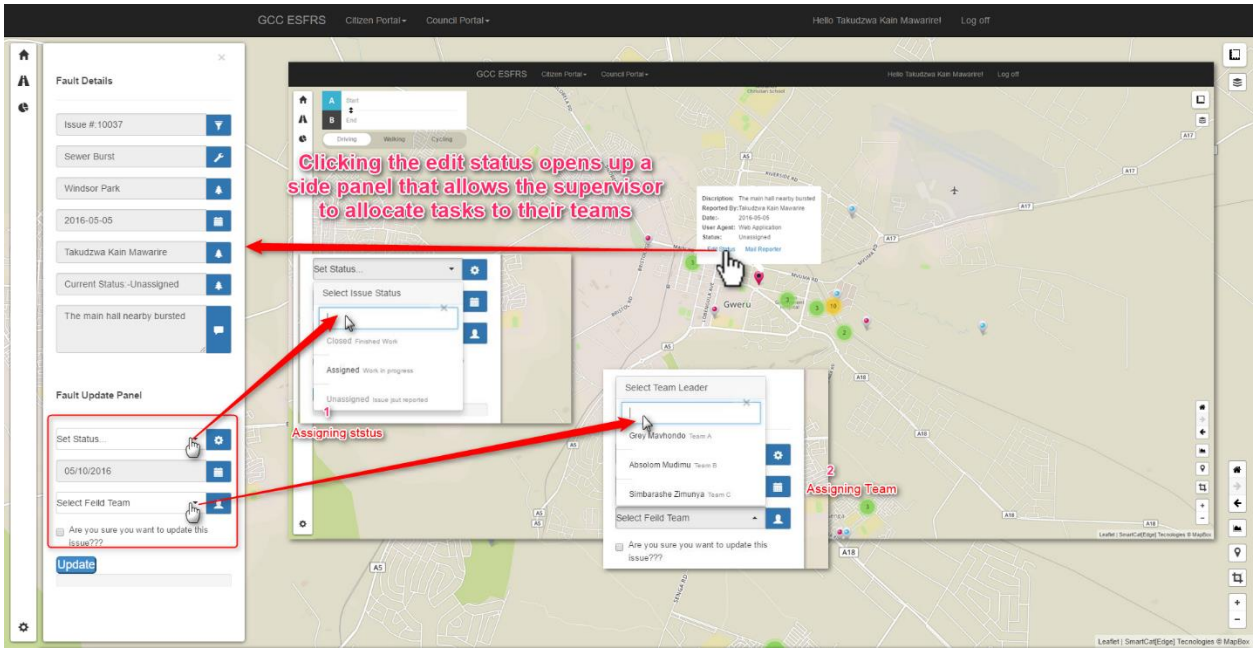


FIGURE 4-16: SUPERVISOR ASSIGNING TASKS

Query and Analytics Grid Functionalities

Outstanding Performance - a major advantage of map grid is its outstanding performance – it can handle hundreds of thousands of records at a time, without hurting the user experience. Featuring a revolutionary LINQ-based data engine. Data is processed with LINQ queries that offer unrivaled performance characteristics and extensibility. Moreover, it delivers row and column virtualization utilizing a container reuse and recycling for further improving the grid performance as well as the memory footprint.

Grouping - the users can interactively organize their data in a way that suits best their needs with a single drag and drop action. Data can be grouped according to several criteria effectively creating a tree of groups with the leaf nodes holding the actual data records. Users can group data by dragging a column header and dropping it in the group area. Users can also rearrange the grouping headers in the group area (again by dragging and dropping).

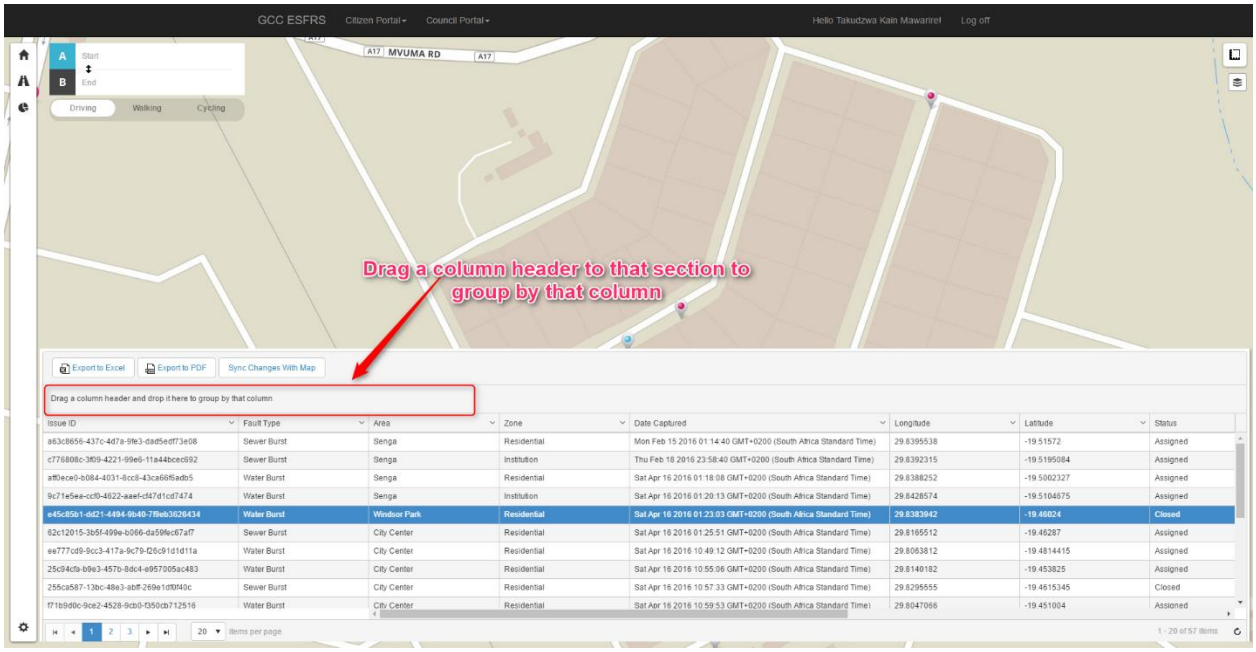


FIGURE 4-17: GROUP BY SECTION

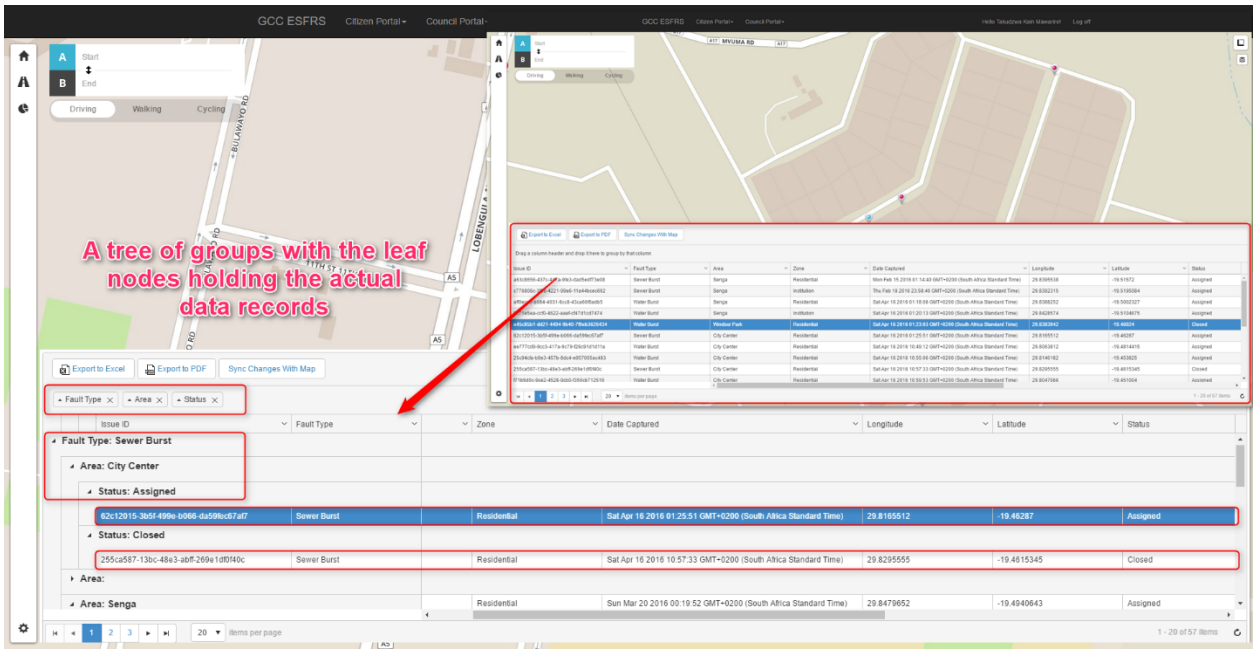


FIGURE 4-18: A TREE OF GROUPS

Sorting –The map grid supports records sorting. Just click on the header of the column you wish to have your data sorted by and you are ready.

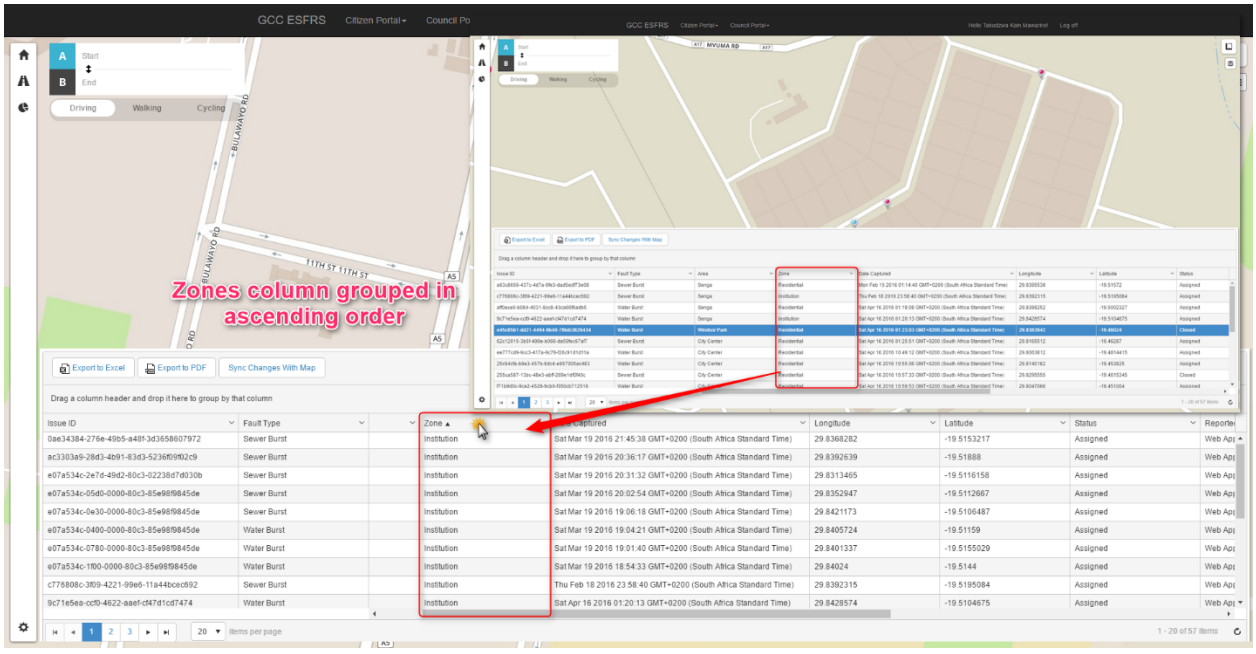


FIGURE 4-19: SORTING DEMONSTRATED

Filtering -The map grid also has support for records filtering. Clicking the filtering icon in the column headers opens a menu with the distinct values for the current column and the user can select which of those values to be displayed. Also the user can choose to filter by certain criteria utilizing conditions like Contains, StartWith, IsEqualTo, etc.

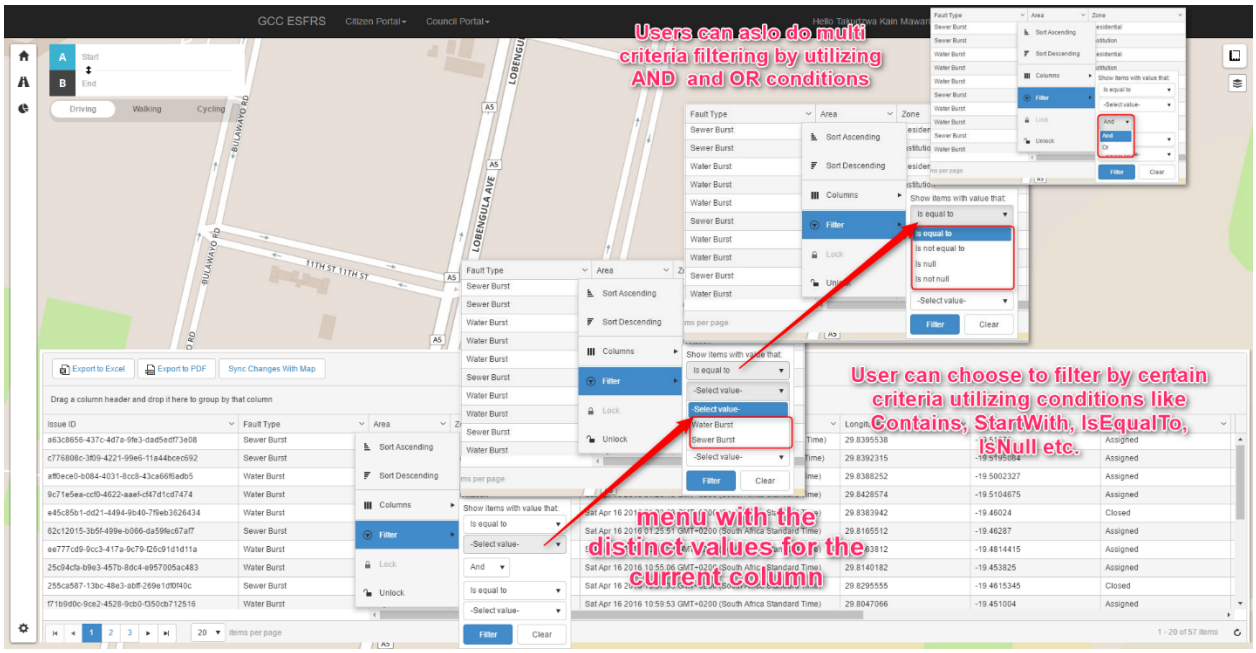


FIGURE 4-20: FILTERING CRITERIA

Frozen columns – last but not least, the map grid allows you to keep part of your data always visible putting the rest of it in context. To freeze columns, you simply lock the desired columns via the column menu.

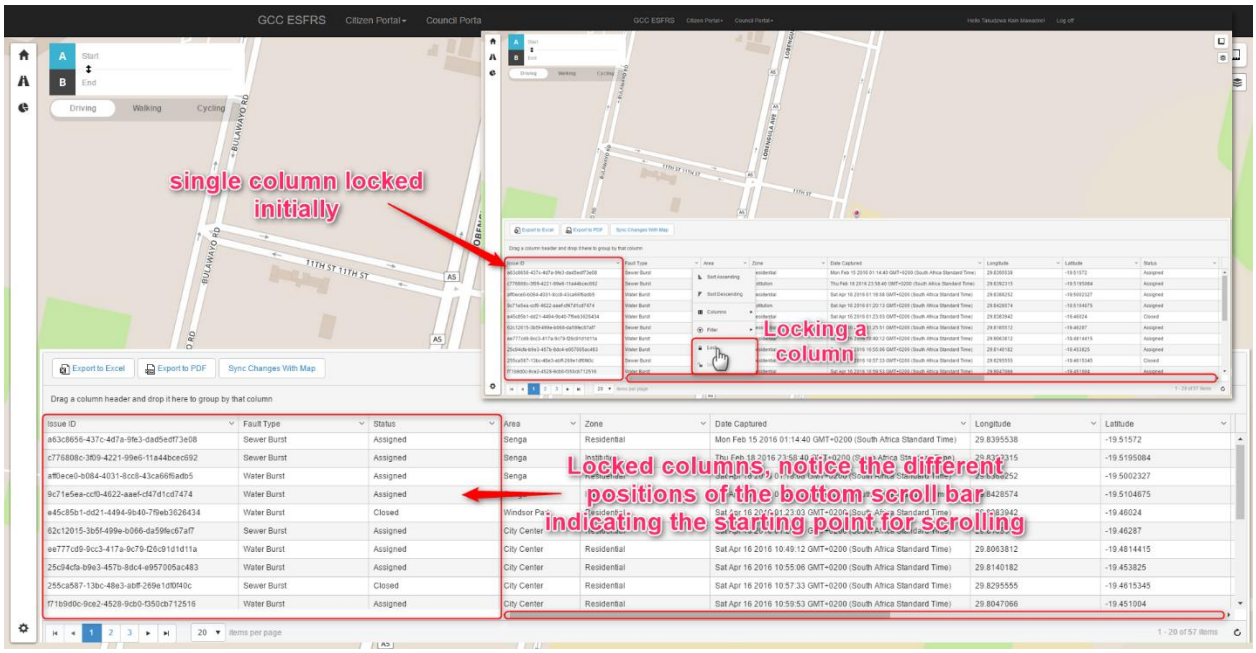


FIGURE 4-21: LOCKING GRID COLUMNS

Accessing the map grid.

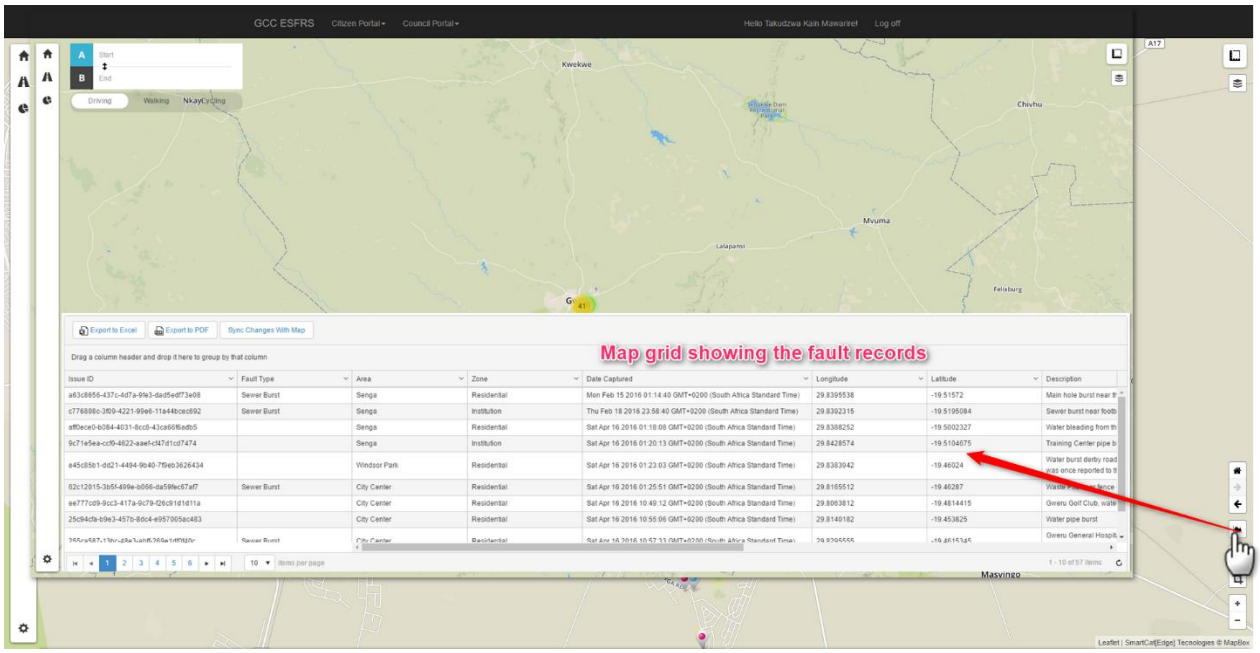


FIGURE 4-22: ACCESSING THE MAP GRID

Figure 29 shows how to access the map grid and the initial view of the map grid. As mentioned before, the records on the map grid can be exported to excel or pdf document formats using buttons on the map grid tool strip. Records exported maintain formatting and any grouping, filtering or sorting that the user had done on the map grid.

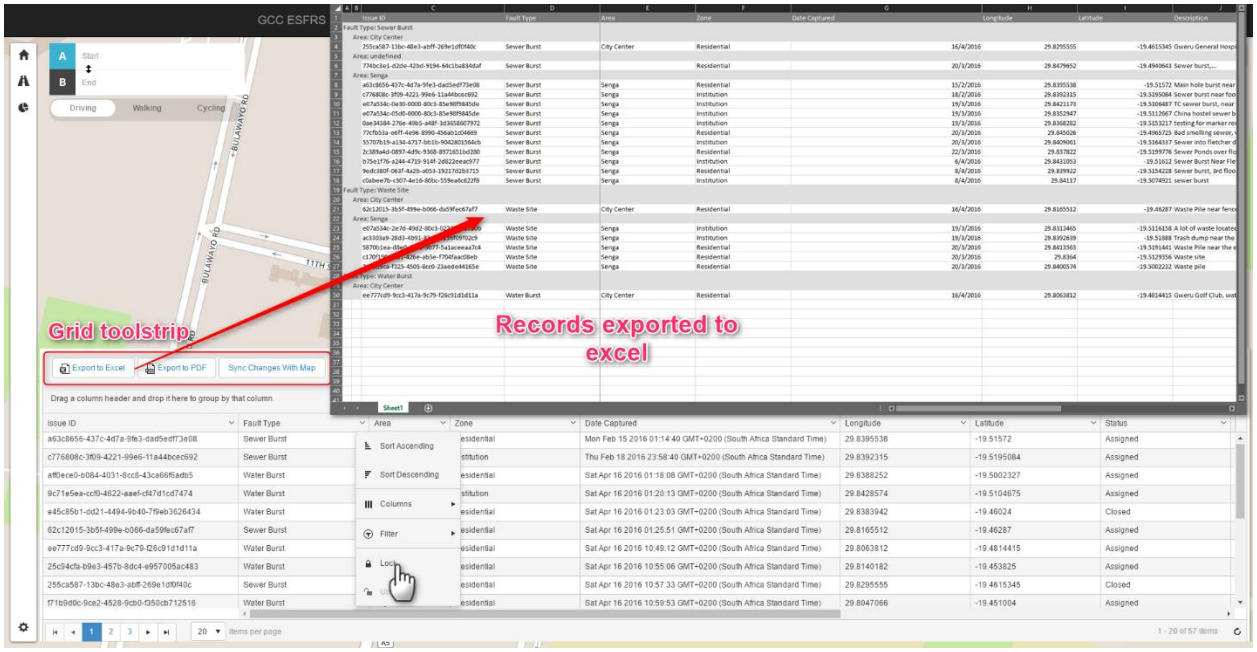
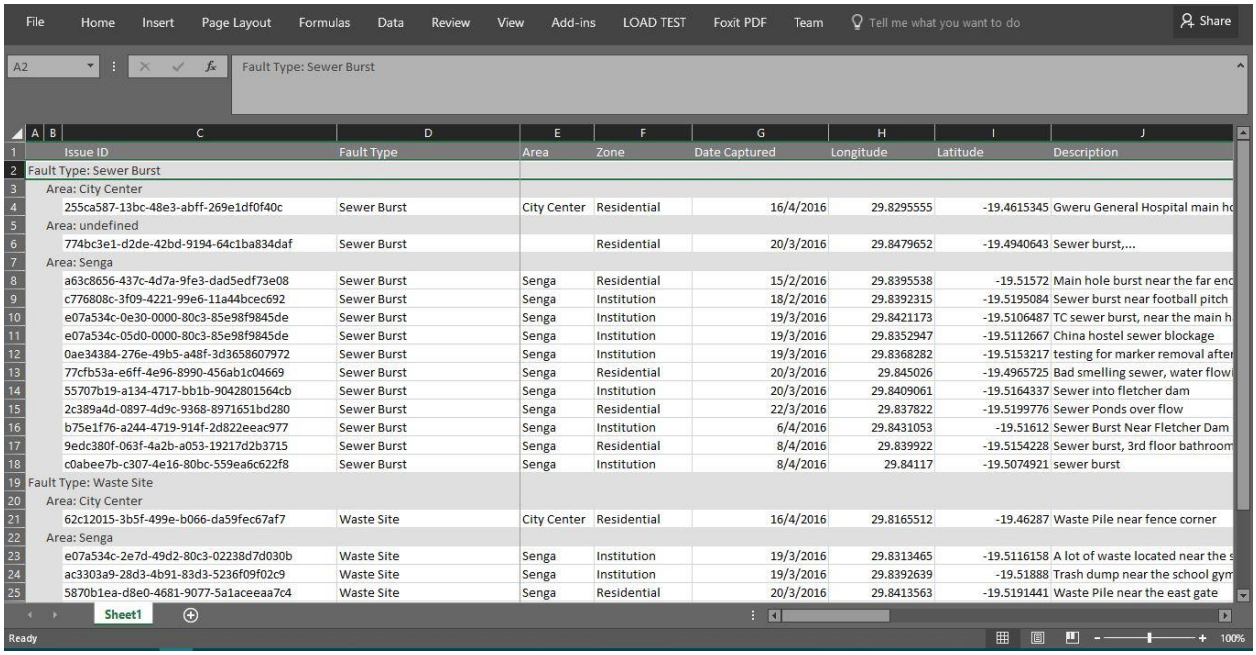


FIGURE 4-23: EXPORTING GRID RECORDS



	Issue ID	Fault Type	Area	Zone	Date Captured	Longitude	Latitude	Description
2	Fault Type: Sewer Burst							
3	Area: City Center							
4	255ca587-13bc-48e3-abff-269e1df0f40c	Sewer Burst	City Center	Residential	16/4/2016	29.8295555	-19.4615345	Gweru General Hospital main ho
5	Area: undefined							
6	774bc3e1-d2de-42bd-9194-64c1ba834daf	Sewer Burst		Residential	20/3/2016	29.8479652	-19.4940643	Sewer burst,...
7	Area: Senga							
8	a63c8656-437c-4d7a-9fe3-dad5edf73e08	Sewer Burst	Senga	Residential	15/2/2016	29.8395538	-19.51572	Main hole burst near the far end
9	c776808c-3f09-4221-99e6-11a44bcec692	Sewer Burst	Senga	Institution	18/2/2016	29.8392315	-19.5195084	Sewer burst near football pitch
10	e07a534c-0e30-0000-80c3-85e98f9845de	Sewer Burst	Senga	Institution	19/3/2016	29.8421173	-19.5106487	TC sewer burst, near the main h
11	e07a534c-05d0-0000-80c3-85e98f9845de	Sewer Burst	Senga	Institution	19/3/2016	29.8352947	-19.5112667	China hostel sewer blockage
12	0ae34384-276e-49b5-a48f-3d3658607972	Sewer Burst	Senga	Institution	19/3/2016	29.8368282	-19.5153217	testing for marker removal after
13	77cfb53a-e6ff-4e96-8990-456ab1c04669	Sewer Burst	Senga	Residential	20/3/2016	29.845026	-19.4965725	Bad smelling sewer, water flow
14	55707b19-a134-4717-bb1b-9042801564cb	Sewer Burst	Senga	Institution	20/3/2016	29.8409061	-19.5164337	Sewer into fletcher dam
15	2c389a4d-0897-4d9c-9368-8971651bd280	Sewer Burst	Senga	Residential	22/3/2016	29.837822	-19.5199776	Sewer Ponds over flow
16	b75e1f76-a244-4719-914f-2d822eeac977	Sewer Burst	Senga	Institution	6/4/2016	29.8431053	-19.51612	Sewer Burst Near Fletcher Dam
17	9edc380f-063f-4a2b-a053-19217d2b3715	Sewer Burst	Senga	Residential	8/4/2016	29.839922	-19.5154228	Sewer burst, 3rd floor bathroom
18	c0abee7b-c307-4e16-80bc-559ea6c622f8	Sewer Burst	Senga	Institution	8/4/2016	29.84117	-19.5074921	sewer burst
19	Fault Type: Waste Site							
20	Area: City Center							
21	62c12015-3b5f-499e-b066-da59fec67af7	Waste Site	City Center	Residential	16/4/2016	29.8165512	-19.46287	Waste Pile near fence corner
22	Area: Senga							
23	e07a534c-2e7d-49d2-80c3-02238d7d030b	Waste Site	Senga	Institution	19/3/2016	29.8313465	-19.5116158	A lot of waste located near the s
24	ac3303a9-28d3-4b91-83d3-5236f09f02c9	Waste Site	Senga	Institution	19/3/2016	29.8392639	-19.51888	Trash dump near the school gym
25	5870b1ea-d8e0-4681-9077-5a1aceeaa7c4	Waste Site	Senga	Residential	20/3/2016	29.8413563	-19.5191441	Waste Pile near the east gate

FIGURE 4-24: EXCEL GROUPED FAULT RECORDS

The map also contains a quick navigation tool; this also provides a quick insight into how many records are recorded in each area irrespective of their status.

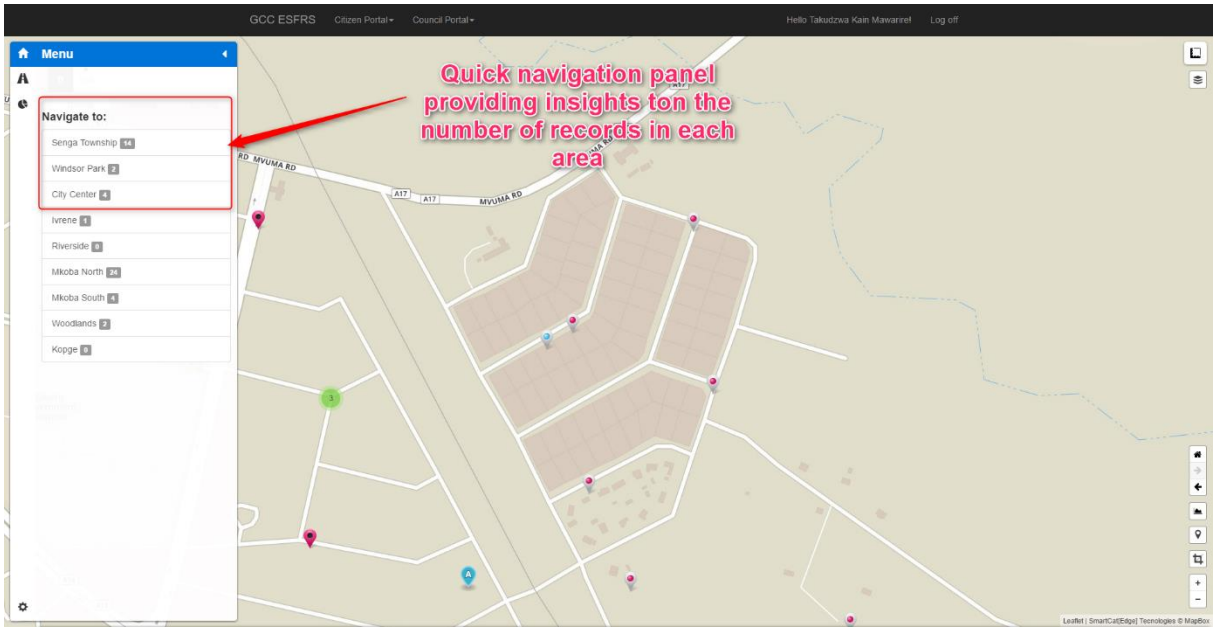


FIGURE 4-25: QUICK NAVIGATION PANE

Team Monitering and Evaluation Tools

The supervisor's portal also provides visualization tools for team monitoring and evaluation. These tools can also be utilized for performance measurement.

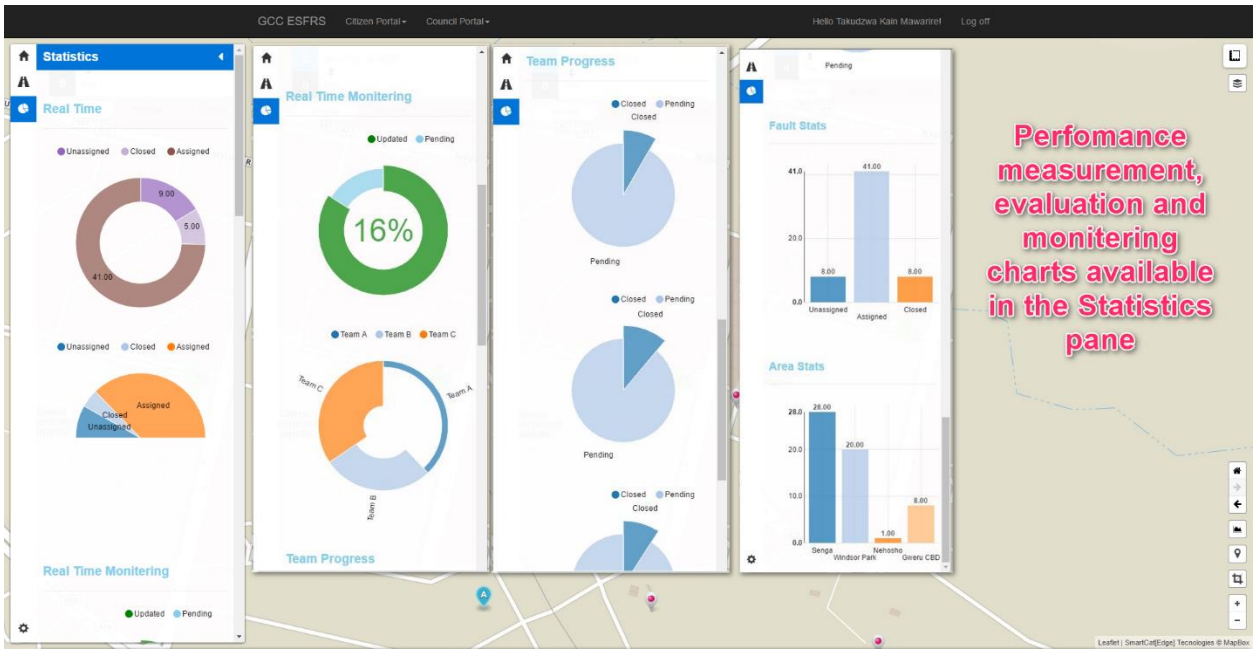


FIGURE 4-26: MONITERING AND EVALUATION INSIGHTS

Field Team Portal

The field team portal is so much similar to the supervisor portal except that, instead of assigning tasks, they attend to the assigned tasks and register if they have successfully accomplished each task. An accomplished task is registered as closed. The field team portal also provides insights into the current progress of each team i.e. against assigned tasks.

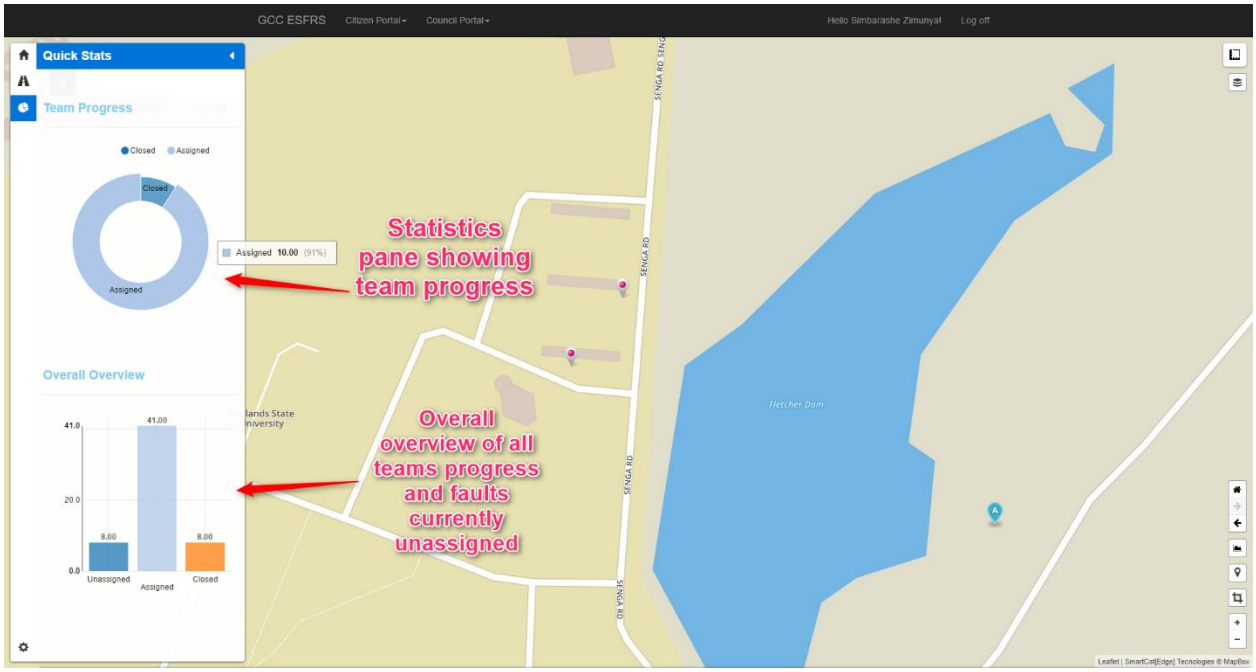


FIGURE 4-27: FIELD TEAM DASHBOARD

The field team portal also contains a simple routing function that allows the teams to plan for their field work.

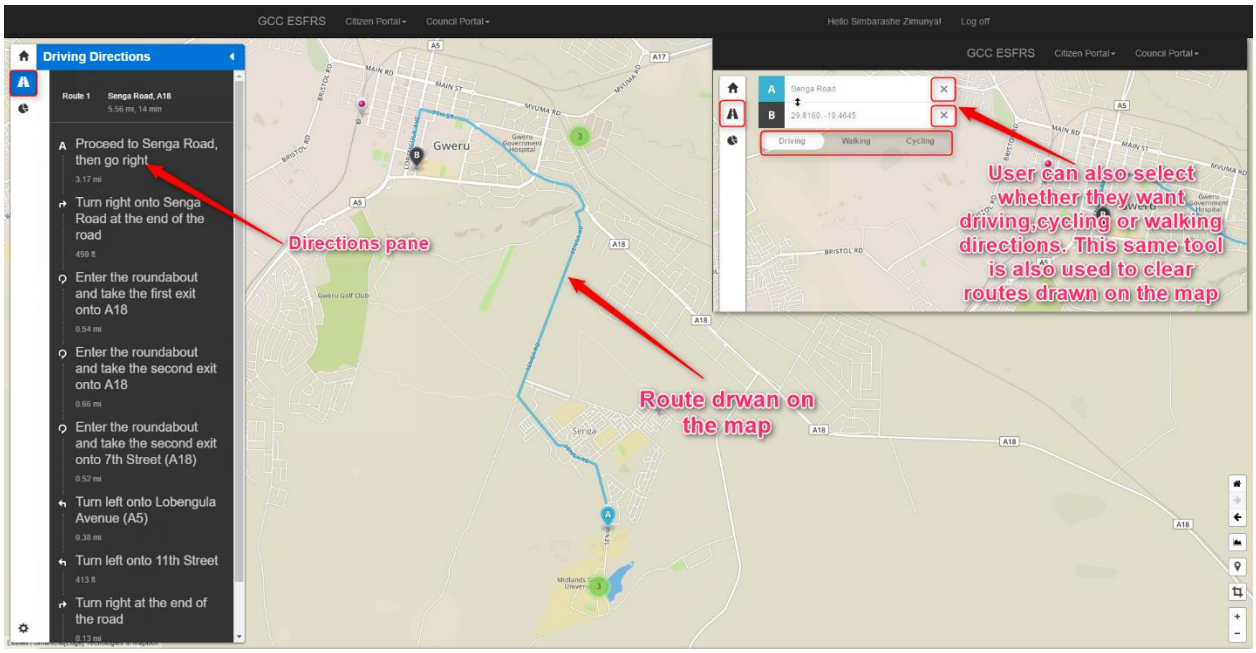


FIGURE 4-28: DRIVING DIRECTIONS

Reporting

Besides exporting records to excel or pdf after custom analysis, the system also allows the user to generate generic / predefined reports that are automatically downloaded as pdfs or SAP crystal reports.

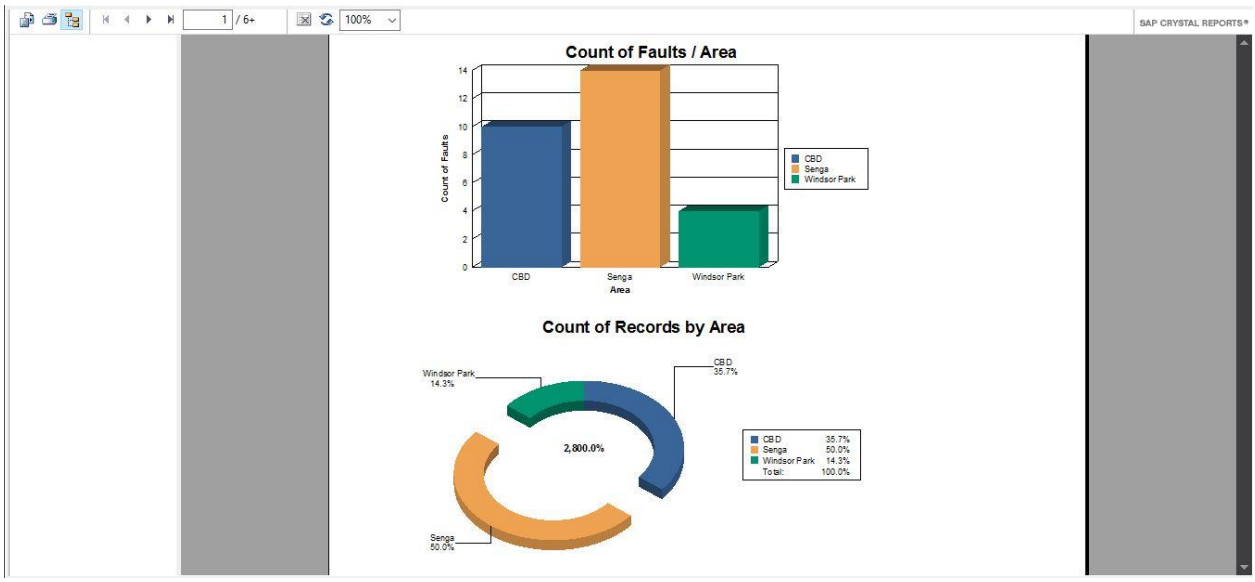


FIGURE 4-29: SAMPLE REPORT PAGE 1 (CRYSTAL REPORT VIEWER)

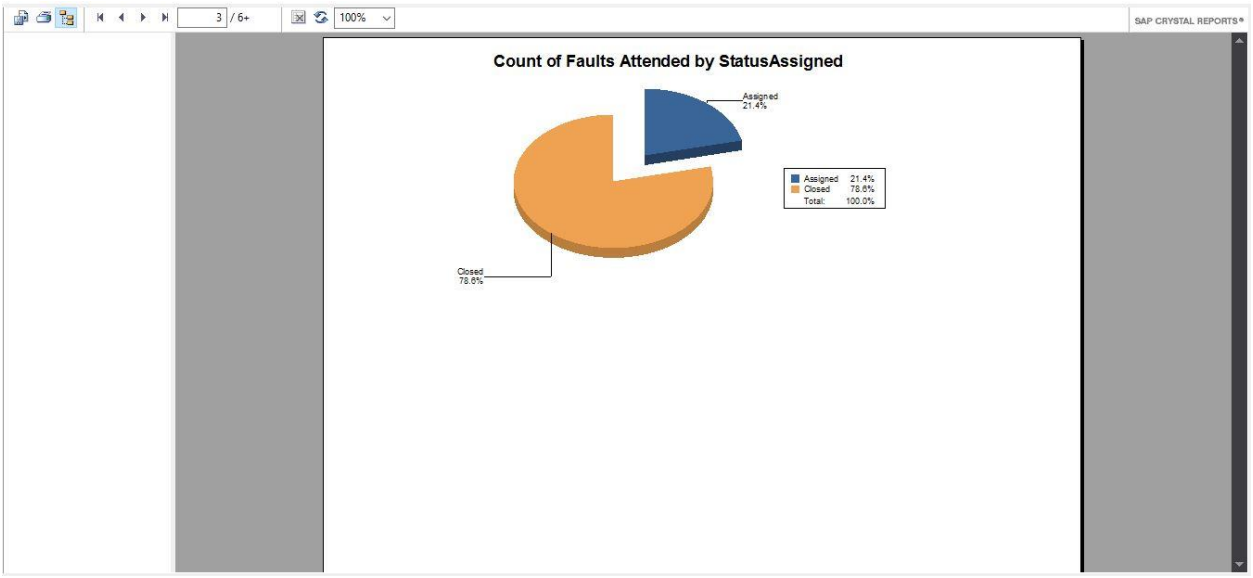


FIGURE 4-30: SAMPLE REPORT PAGE 2(CRYSTAL REPORT VIEWER)

The system also contains other data visualization platforms like heat maps showing areas with the most number of reported faults. Figure 39 shows a screenshot of a heat map generated by the system.

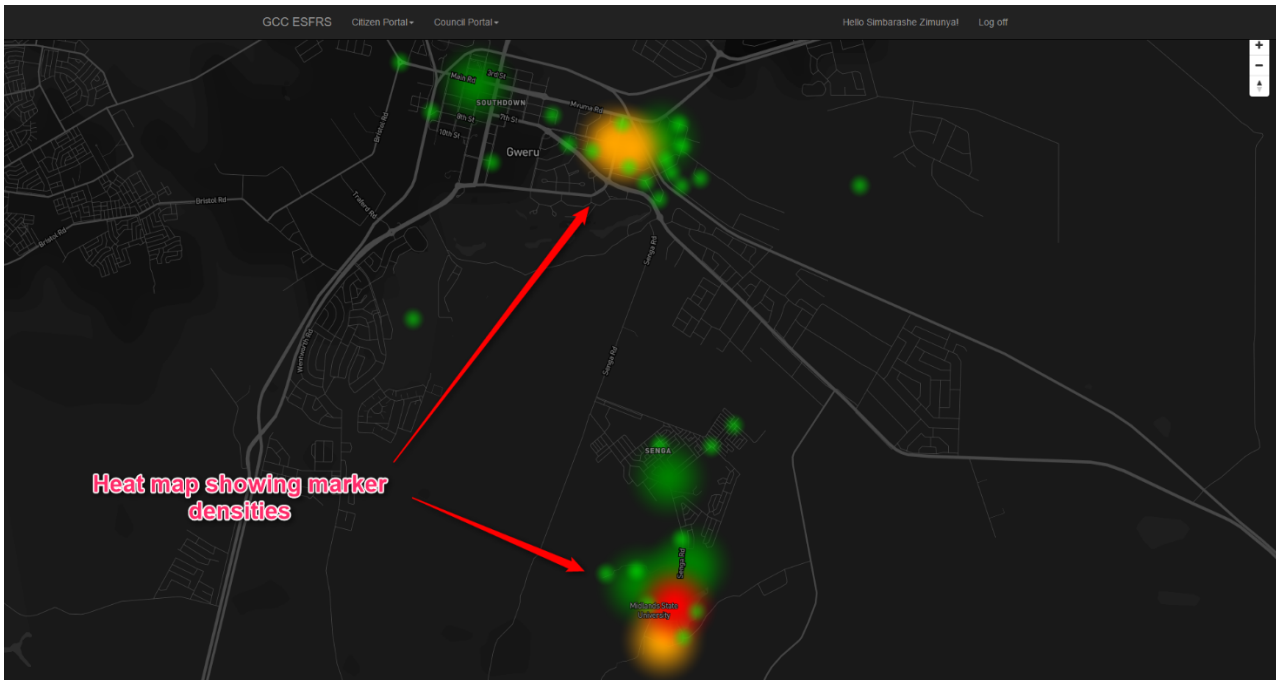


FIGURE 4-31: HEAT MAP SHOWING FREQUENCY OF FAULTS

The information systems community is going smart by developing responsive solutions. This means these solutions can be accessed via smartphone web browsers without distorting or disturbing content presentation. The web based service fault reporting system is not an exception, it is also responsive and thus can be accessed with almost any smart device with a screen large enough to

accommodate all the tools. Below is a screenshot of the system accessed via different sized emulated smart phones.

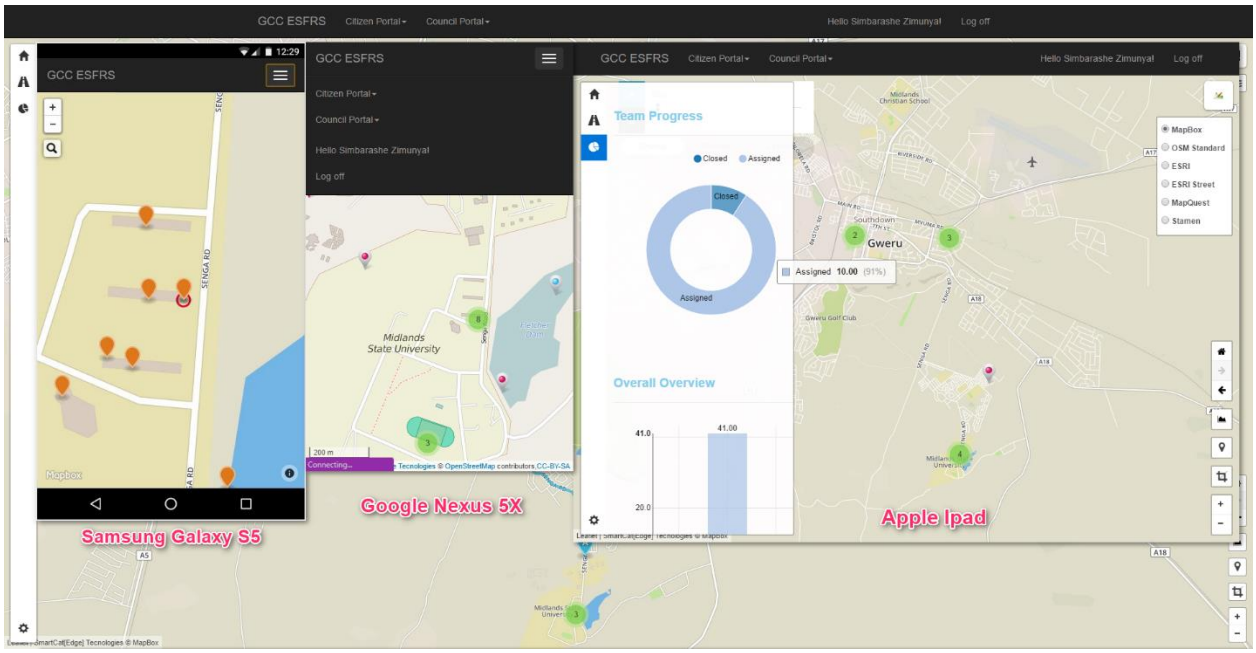


FIGURE 4-32: THE SYSTEM BEING USED ON SMART PHONES

4.7 SYSTEM ARCHITECTURE

The researcher adopted a system architecture that allowed for easy server client side interaction. To improve on user experience, client -server communication is asynchronously using Ajax. The web services (written in C#) use Entity Framework for fast and reliable communication with the database. Database responses are then formatted and serialized as JSON which is returned to the client side. the data access layer in the schema is mapped and managed using entity framework. The Entity Framework enables the system to query, insert, update, and delete data, using common language runtime (CLR) objects (known as entities). The Entity Framework maps the entities and relationships that are defined in the DbModels layer to a database. The Entity Framework provides facilities to do the following: materialize data returned from the database as entity objects; track changes that were made to the objects; handle concurrency; propagate object changes back to the database; and bind objects to controls (MSDN, 2013).

The primary class that is responsible for interacting with data as objects is the ApplicationDbContext (often referred to as context) (MSDN, 2013). The context class manages the entity objects during run time, which includes populating objects with data from a database, change tracking, and persisting data to the database (SWEDBERG, Karl, 2014). Figure 41 shows the system architecture diagram.

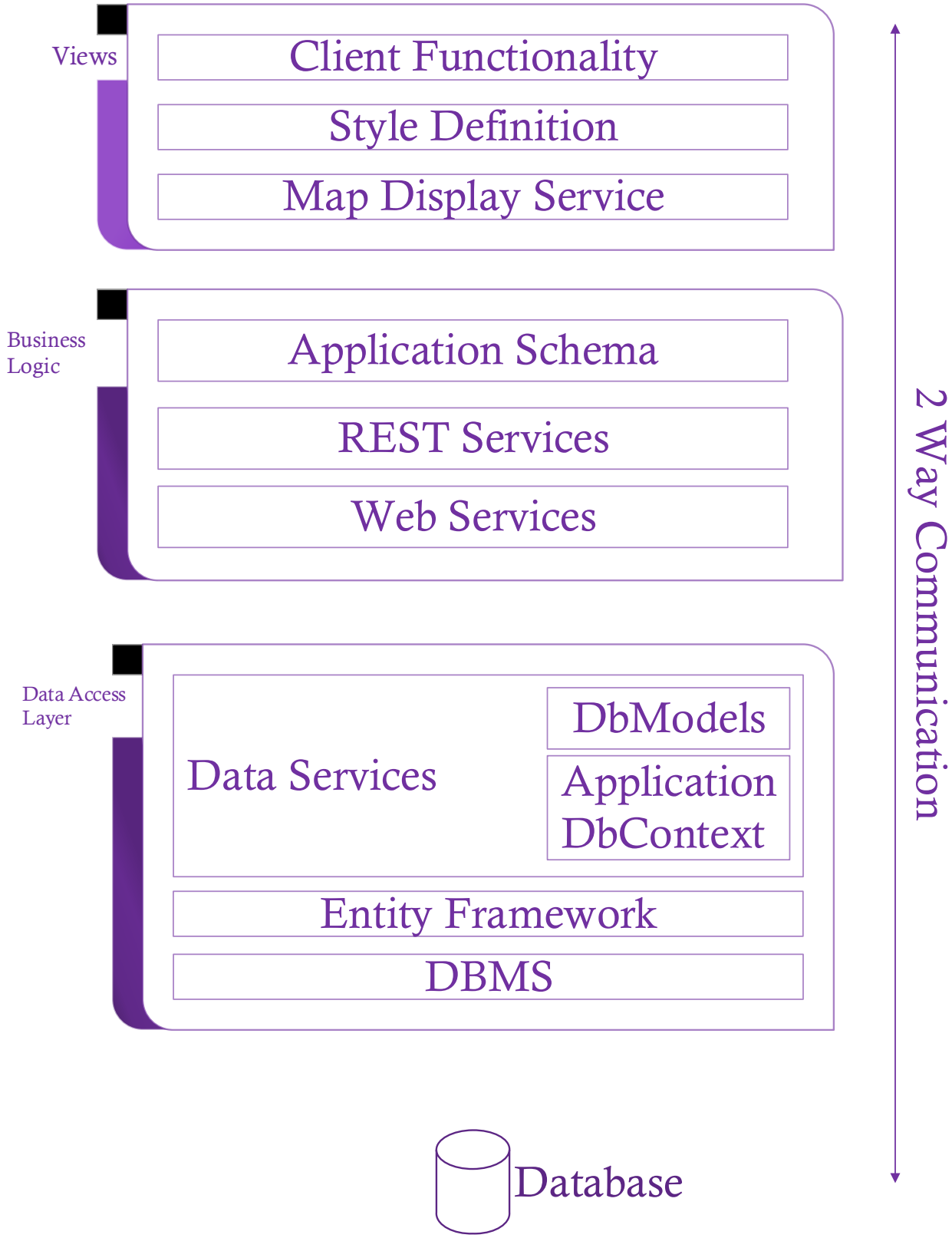


FIGURE 4-33: SYSTEM ARCHITECTURE

CHAPTER FIVE

5 EVALUATIONS AND DISCUSSIONS

5.1 INTRODUCTION

This chapter gives the overall evaluations or discussions of the research, limitations and challenges or problems faced in carrying out the research.

5.2 DISCUSSIONS

The main objective of this research was to develop a GIS enabled web based engineering service fault reporting system that will allow the citizenry to report engineering services faults in their neighborhood. Gweru City Council Engineering Department has been using a manual system where by the citizenry had to visit or call the city council every time they had an issue to report. This information is being stored in hard copy format which limits the analysis and visualization of the information. The manual system not only limits visualization and analysis but, it also doesn't give value to the information reported because no insights can be derived from the data in hard copy format. Hard copy storage limits the potential of the city engineering department in attending to the reported faults. With the system that has been developed the citizenry can now report faults in a very efficient way. The system provides a precise way of pin pointing the exact location of a fault. The system also provides a tool that can assist in trip planning by providing driving routes from one point to the other allowing for effective resource usage. The system allows the city council to attend to faults that have been reported in near real-time as the system is accessible over mobile platforms. This means the team attending to faults in the field has no need to come back to the office to check in for other reported faults or faults that have been assigned as they can access the system on the go. The system provides an efficient way of attending to faults where by a supervisor assigns work to the teams responsible for attending faults on the ground. This also improves on resource deployment as a specific team can be assigned faults in a specific area or a specific type of faults in an area. For convenience and transparency, the system also allows the citizenry to check on the current status of the faults they have reported on.

Several existing fault reporting systems were reviewed aiding in the development of the GIS enabled web based engineering service fault reporting system. Existing systems mainly targeted cities that had fully developed land information datasets and thus citizenry could easily locate faults by mentioning the street names. However, thus not the case with Gweru and thus by providing a map based reporting solution, the system is of great convenience. Also it has been observed that other systems were only focused on reporting of the faults and not providing insights from the collected data. The developed prototype of the GIS enabled web based engineering service fault reporting system allows both the city and the citizenry to get insights of the data available in a simple and easy to understand manner. Existing systems required also require one with knowledge of the place they have seen a fault i.e. the street name. Also the procedures adopted in reporting require someone with some good background in working with computers. Since the research study area was Gweru, developing a similar system will cause the citizenry to resort back to calling or visit the council offices because of the system

complexity. Because of this truth, the prototype was developed with simplicity as it incorporates a simple flow in reporting the faults. The City council personnel as well do not have that much expertise in GIS and so the system presents little or no challenge in all its operations. As mentioned afore, the system also provides easy to understand insights for performance measurement through a simple field team management module.

5.3 Research Limitations

It must be noted that although the project was a success, there were some limitations that were encountered throughout the research process. The major limitation was the restricted access to some of the information which the researcher needed to include in the research consideration as there was lack of cooperation from the city council engineering department. This slowed down the system development process. Another limitation was financial funding, this restricted the researcher to free mailing APIs which can cause performance issues in low bandwidth areas. SMS APIs had to be acquired at a price which the researcher wasn't in a position to pay.

5.4 Conclusions

Considering the technological advancement that have been noted in the Information management systems and Geographical Information systems and that the City Council intends to introduce a GIS in the city engineering department, the author saw it an opportunity to introduce a GIS enables web based fault reporting system as information provided can easily be integrated with infrastructure management systems. This will provide insights that can aid in infrastructure rehabilitation programs. Making use of the analysis tools in the system, the council can make informed decisions. The city council also can now seek funding by presenting figures on the current state of service faults statistics. The system was developed to be compatible with modern smart phones and thus the citizenry can access it anytime anywhere. Technologies used in the system development also makes the system mobile ready as it can still perform all required operations on low bandwidth networks. This makes it ideal for the Zimbabwean situation. The researcher managed to meet all the set of objectives and thus the research was a success.

5.5 Recommendations

The system is still extensible to allow SMS notifications instead of electronic mails its currently using. The system can also be integrated to include infrastructure management. On the citizenry side, the system can be developed to include a dedicated mobile application accessible via google play or windows store or apple store that feeds into the same database for greater convenience. It is also recommended that the city council personnel be trained on using computers in solving problems relate to their work so that they may be able to utilize technologies being developed.

References

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6 APPENDIX

6.1 APPENDIX A: CITIZEN QUESTIONNAIRE

Greetings, my name is Takudzwa Mawarire, I am a student at the Midlands State University currently studying Surveying and geomatics and doing my final semester. This questionnaire is to is to collect information that will assist on my final year project and it will only be used for academic purposes. Please feel free to answer this questionnaire appropriately as it will also assist in achieving desired results.

The title of my project is **A GIS enabled Web Based Engineering Service Fault Reporting System**. This is a system that will allow citizens to report service faults using the web or a mobile app without visiting the council offices. This will also allow the city council to collect data concerning citizen needs which can later be used for decision making. Your help is greatly appreciated.

YOUR INFORMATION

Name: _____

Position: _____

Number: _____

e-Mail: _____

PART I

How long have you been a resident of Gweru?

< 5yrs	< 10yrs	< 15yrs	< 20yrs	< 30yrs	> 30yrs

Have you ever come across a service fault? i.e. Water Leak, Sewer Burst etc.

Yes	No

If yes, have you ever reported any fault to the city council?

Yes	No

If no, you can stop here. Thank you;

If yes, how did you report the fault? (visiting the city council premises/ via a phone call)

Phone Call	Council premises visit

If no, Why?

_____
_____
_____
_____

How long did it take before the city council attended to the fault you reported?

1 day	< 3 days	< week	< 2 weeks	< a month	> a month

How satisfied were you with the service offered?

Not bad	Moderate	Good	Above Average	Excellent

Part II

How conversant are you with computers?

Not bad	Moderate	Good	Above Average	Excellent

How often do you use the internet?

Everyday	Once in a week	Can spend a while without	I don't use the internet

Have you ever used an android phone?

Yes	No

Have you ever used Google maps or Bing maps or any of online mapping websites?

Yes	No

Would you like the city council to implement a mobile / web system that citizens would use to report faults? i.e. Using a map

Yes	No

What would you prefer, mobile or a web based system?

Mobile	Web Based

What would you recommend if the city council is to implement such a system for its residents?

_____
_____
_____
_____
_____

6.2 Appendix B: City Council Questionnaire

Greetings my name is Takudzwa Mawarire, I am a student at the Midlands State University currently studying Surveying and geomatics and doing my final semester. This questionnaire is to is to collect information that will assist on my final year project and it will only be used for academic purposes. Please feel free to answer this questionnaire appropriately as it will also assist in achieving desired results.

The title of my project is **A GIS enabled Web Based Engineering Service Fault Reporting System**. This is a system that will allow citizens to report service faults using a web app without visiting the council offices. This will also allow the city council to collect data concerning citizen needs which can later be used for decision making. Your help is greatly appreciated.

Your Information

Name: _____

Position: _____

Number: _____

e-Mail: _____

a) Part I

The responded will be asked to describe their job functions, the department structure and its size.

1. How long have you been working in the city council engineering department?
2. How long have you been in your current position?
3. What specifically is your function within the Engineering Department?

b) Part II

The responded will be required to give information on current workflows, information flow across sectors.

4. Are you aware of the process by which citizens report service faults to the department? i.e. Reporting of water leaks and sewer burst
5. Can you give a brief description of this process, how its carried out by the citizen and how the city council responds to this?
6. Can you give a brief description on how long it generally takes for council officials to attend to these reported faults?
7. What criteria is used to attend to these reported faults.

8. Can you detail the criteria which is used in resource deployment? i.e. In relation to the reported faults.
9. Roughly, how many faults are reported in a day, a week or a month.
10. Do you have a team that watches after the state of the infrastructure in the city, or you rely on citizen reports?

c) Part III

The responded is required to give details on the use of maps in the existing workflows.

11. What type of maps are used in the engineering department? (If any)
12. How current are the existing maps?
13. Who is responsible for updating the maps?
14. What are the formal or informal procedures in updating the maps?
15. Are there any maps used in attending faults?
16. Currently, do you share data with any other sectors? If so, briefly describe the maps and databases involved and the reason for sharing. [If no, then what data do you foresee as shareable with other sectors?]

d) Part IV

Computer Use and Staff acquaintance with ITC

17. Are there any computers in your department, if yes, what are they used for?
18. Do you have an internet connection on your premises?
19. Are there any software packages that are used in the department?
20. Has there been any plans to buy computers for your department?
21. Does the department have an intranet site / portal?
22. Does the department have a server of its own?
23. Have you ever used any web systems in the department?
24. Have you ever encountered / used a GI System?
25. What would you recommend for a web application that the city council will use for handling reported faults?

e) Part V

Requirements in terms of sector upgrade to use of ICT (CURRENT AND PLANNED DATABASE ACTIVITIES)

f) Are there any databases currently being developed within your department? If so, what are they?
g) What (additional) are database the capability would you like to see in your department? (in relation to fault reporting)
h) What frustrations do you have with your current way of storing information? (e.g. lack of data, inaccessible data, limited flexibility in report formats)

i) Do you experience (or can you foresee) any problems when sharing maps and databases with other departments within the city council e.g. conflicts over reference points or geographic mismatches?
j) Are there any particular concerns about data security and control over access and updating that might complicate data sharing?
k) Which models are being used currently for analysis in your sector and how can they be incorporated into the proposed information system?
l) Do you have any other comments or concerns that you would like to share with me at this time?

6.3 APPENDIX C: USER MANUAL

Below is the interface that is used to access all the functionalities in the system. Based on the user roles, some links will not work for reasons of security. The citizen can access the citizen portal from the menu strip or from the getting started section.

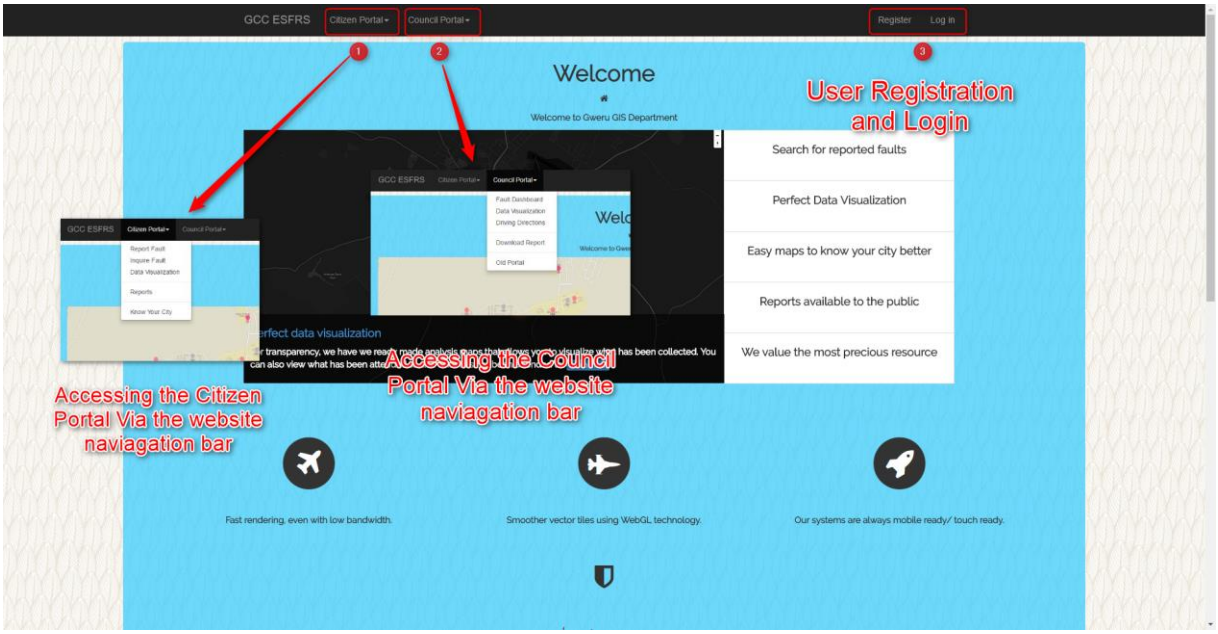

FIGURE 6-1: HOME PAGE

1. Accessing the citizen portal
   a. The citizen portal allows the citizenry to login or register with the council system.
   b. After registering, the user will now be allowed to report a fault.
   c. For the purposes of integrity, the system does not allow anonymous fault reporting.
2. Accessing the council portal
   a. The council portal allows the engineering services supervisor to assign tasks to his field teams.
   b. The portal also provides data visualization tools that will allow the supervisor to monitor progress of each team.
3. Registering with the system
   By default, if you try accessing any of the tools in the council or citizen portal, that system will redirect you to the login page. If the user is not currently registered with the system, they are allowed to create a new account.

▪ CITIZEN PORTAL

After trying to access the citizen portal, the user is requested to login.

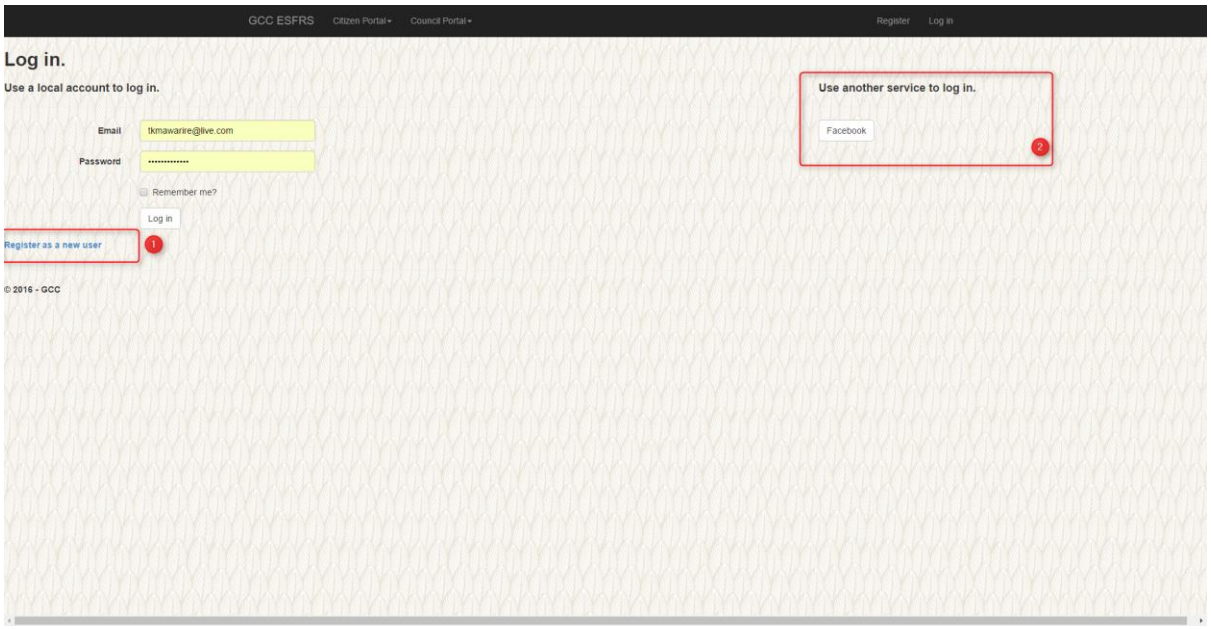

FIGURE 6-2:LOGIN PAGE

If the user hasn't registered with the system already, they can use option 1 highlighted in figure 43 to register with the system. Figure 44 shows the registering window. Option 2 highlighted in figure 43 allows the user to login with their Facebook account. Here the system will not store any password as it will use an authentication token generated from the Facebook account.

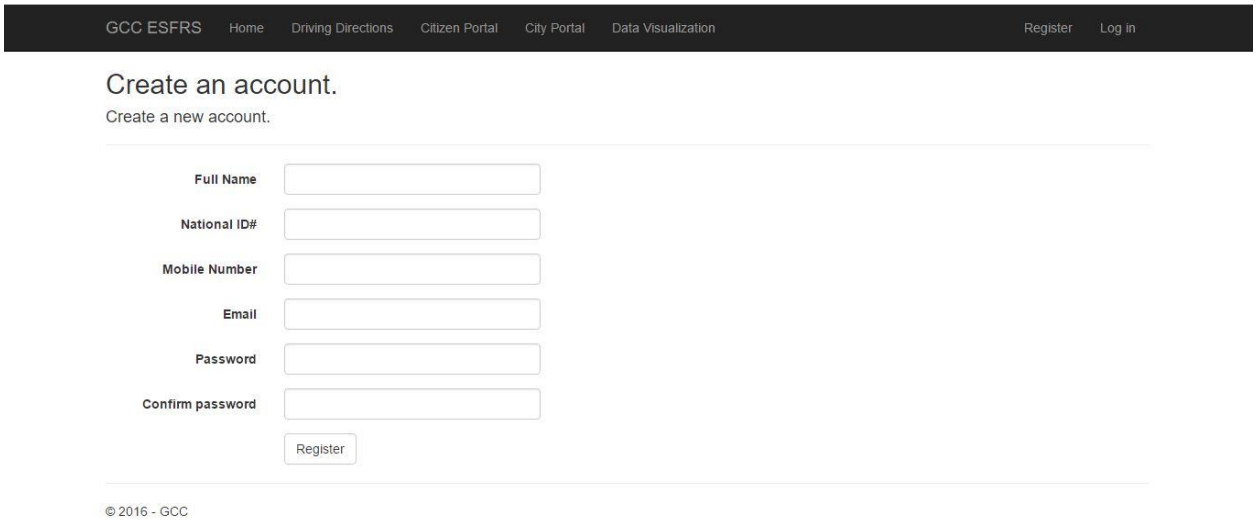

FIGURE 6-3: REGISTER PAGE

The registration requires information that will be used to contact the citizen in regards to the issues they will be reporting. After registering or logging in, the citizen is welcomed by a map where they are required to locate the exact location of the fault.

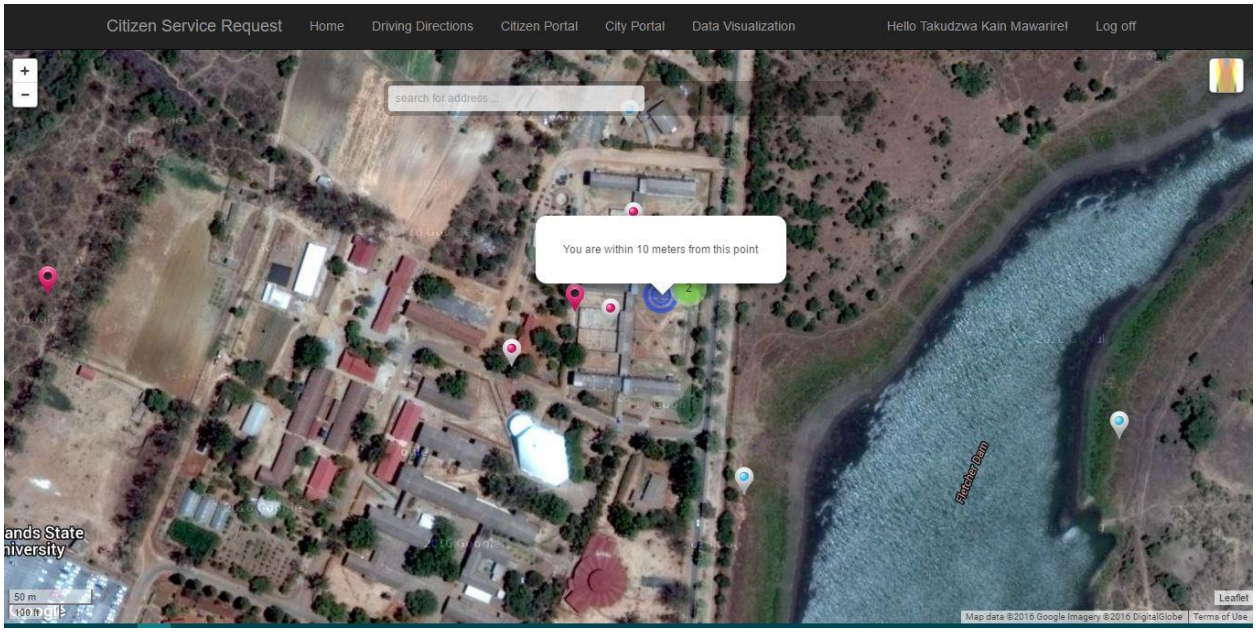

FIGURE 6-4: WELCOME MAP ZOOMED TO USER LOCATION

The map automatically zooms in to the user's current location. The user can click on any of the markers shown to get information on other reported faults or they can go straight to locate the location the report on. Zooming out, the map will automatically cluster the reported faults by category.

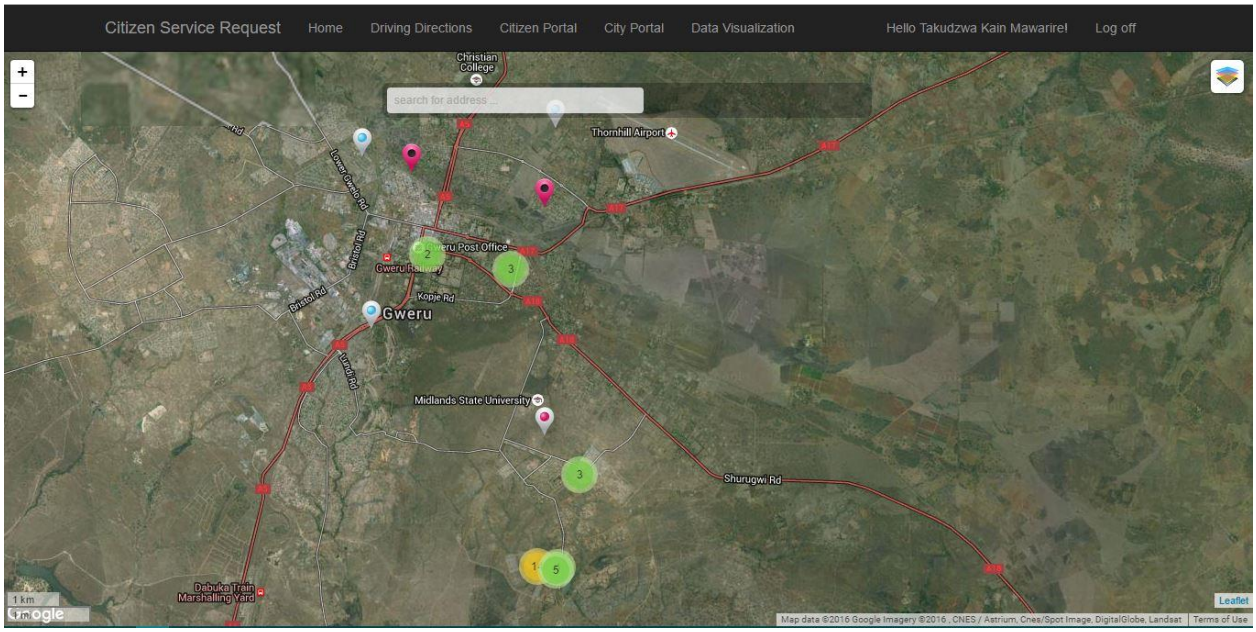

FIGURE 6-5: MAP CLUSTER CATEGORIZING FAULTS

When the user clicks on a marker cluster, the map automatically zooms in decluttering the fault markers.

- REPORTING PROCESS

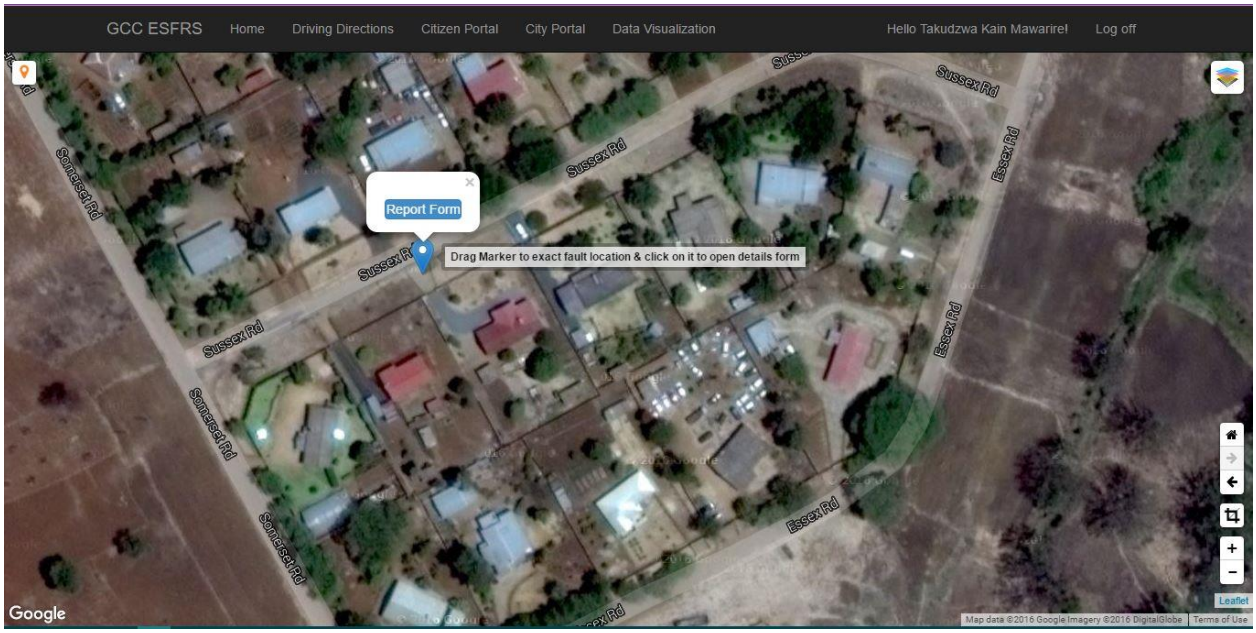

FIGURE 6-6: MARKER POPUP

The user navigates the map to the desired location. He or she then clicks on the map and a marker with an instruction is automatically inserted on the map. The instruction tells the user to drag the marker to the exact location (figure 47). On drag end, the popup window containing the report button becomes available to the user.

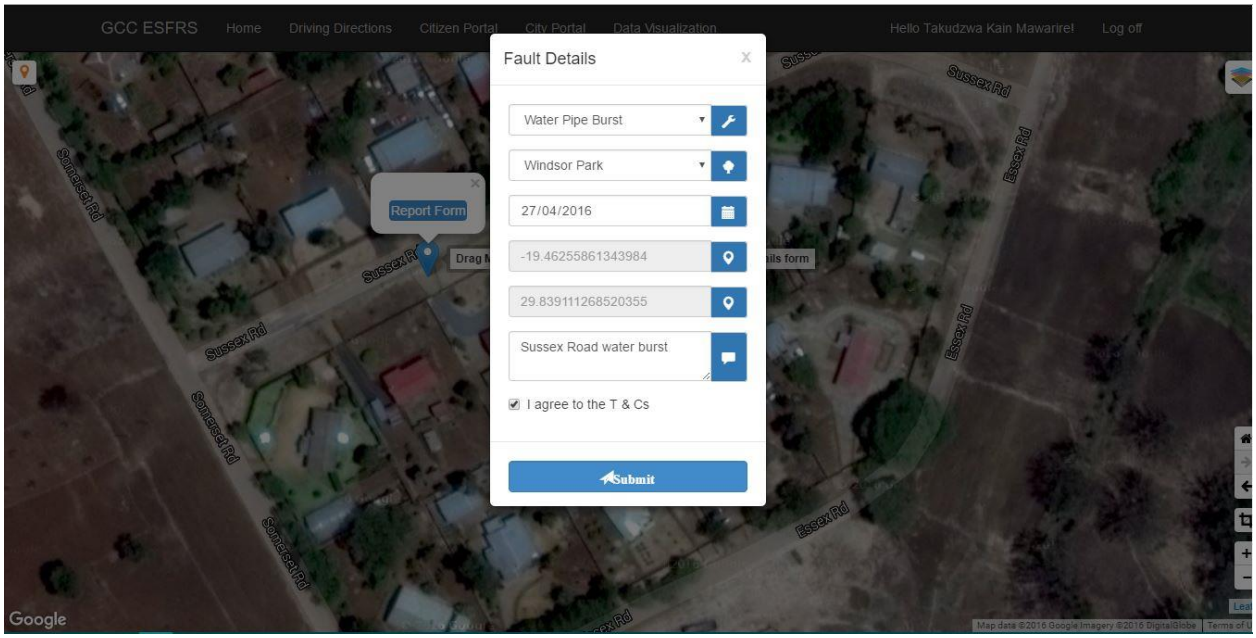

FIGURE 6-7: FAULT DETAILS FORM

The user is then required to fill in all fields of the form as the form will not save the fault if any field value is missing (figure 48). To send the information, the user clicks the send button and the information is automatically sent to the server. The user is then informed that the record was successfully saved and they are redirected to the issue details page where they are given the Issue number. This is all that's required for a citizen to report a fault. At this point, the system sends an

email to the citizen with all the information concerning the fault he/ she has reported. Figure 49 shows an example of the mail sent to the citizen.

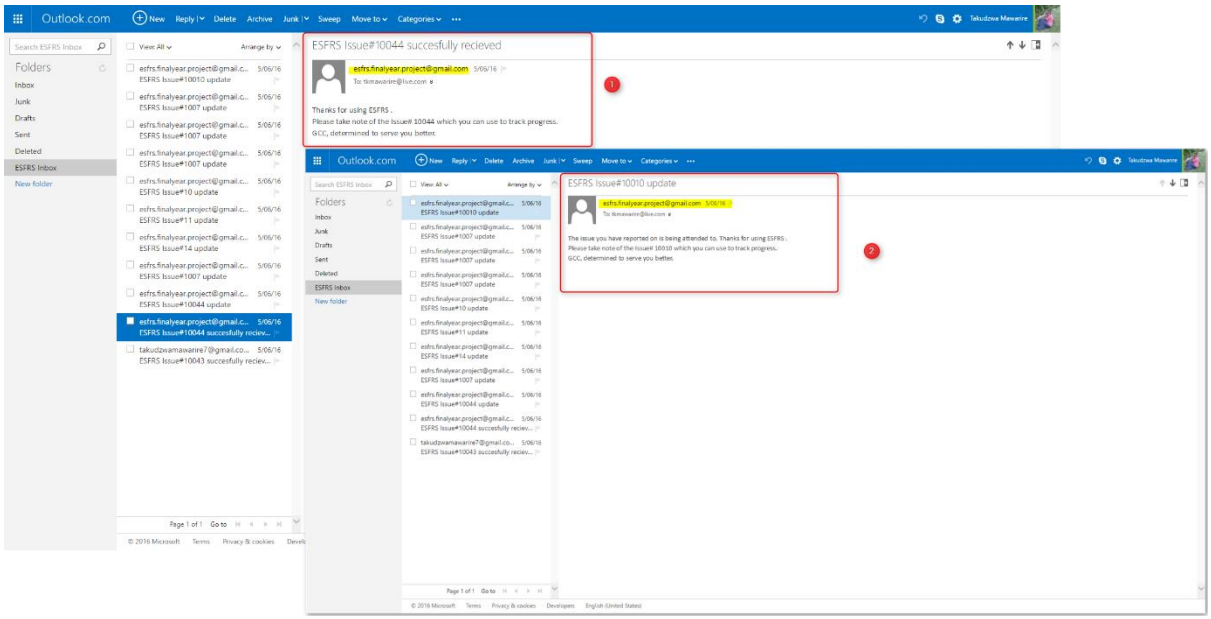

FIGURE 6-8: EMAIL SENT TO USER

The above figure also shows a sample mail that is sent to the citizen when the issue they have reported has been attended to or assigned.

Users can also at any time inquire about the faults they have reported via an interactive map. Here they are required to use the issue number that is sent to their mail.

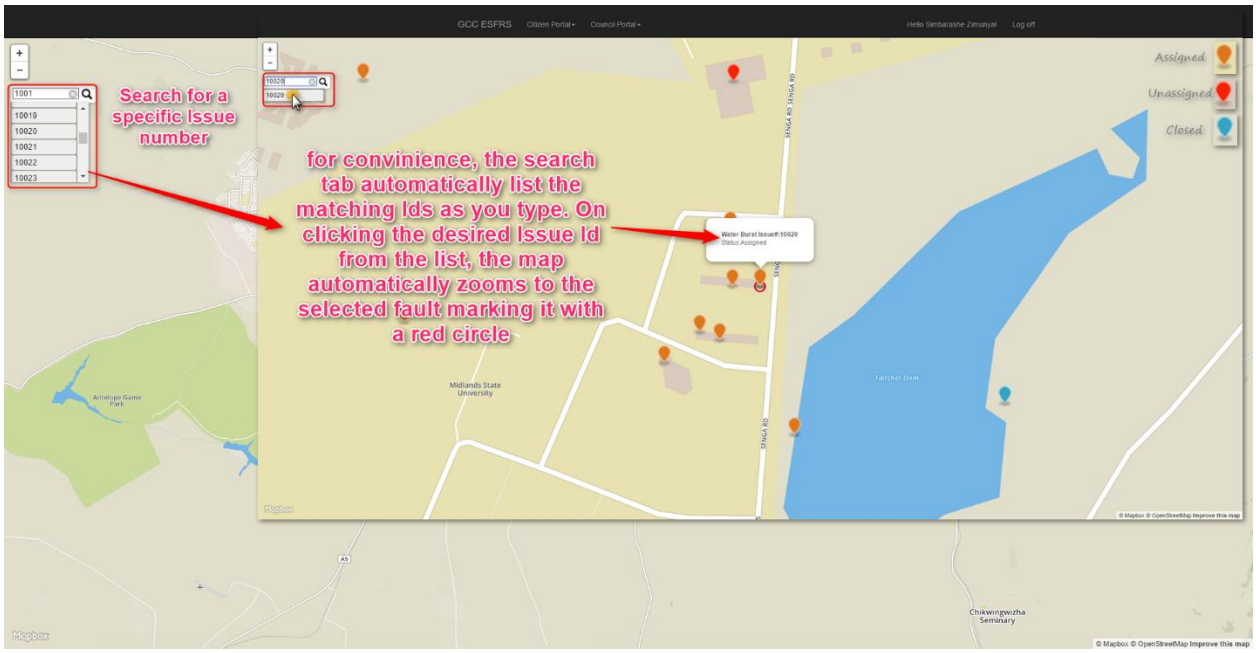

FIGURE 6-9: CITIZEN FAULT SEARCH

- COUNCIL PORTAL

The council portal has two sections, one for the field team supervisor who is responsible for assigning work to field teams, and the other portal for the field team leaders responsible for logging what each team has accomplished. Both sections of the council portal are also accessible via the home page navigation bar (please refer to section one of this manual).

Portal Tools.

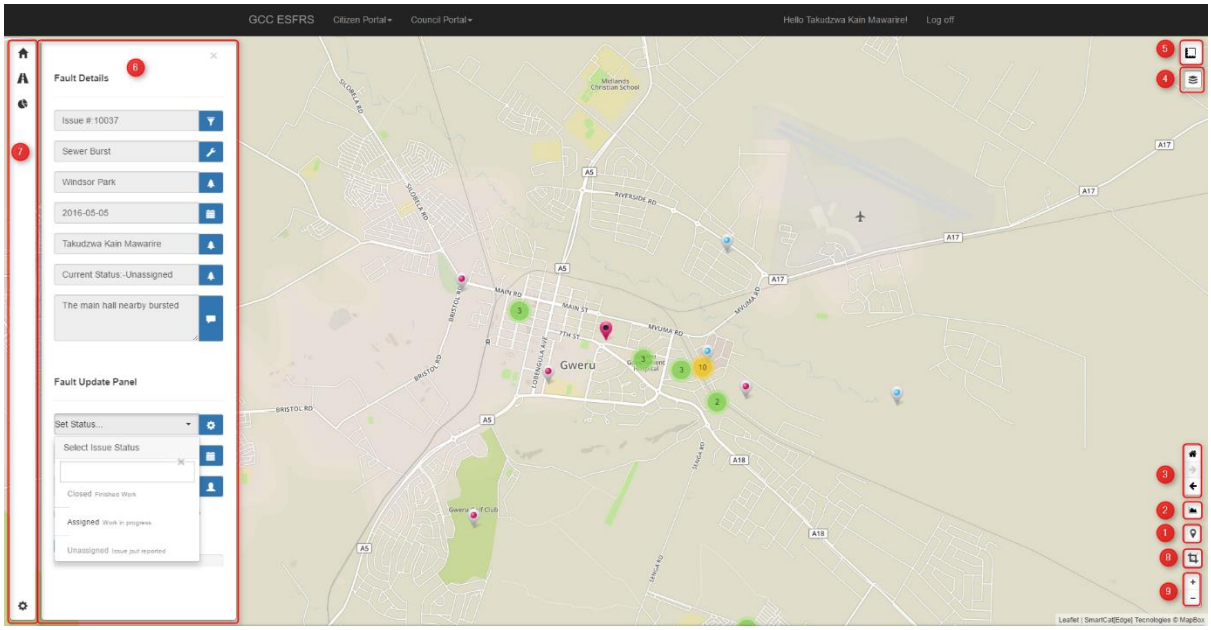

FIGURE 6-10: COUNCIL DASHBOARD TOOLS

1. User Location control. Used to locate the current user location.
2. Map grid control. Used to toggle visibility of the map grid. This grid is equipped with tools that allow the supervisor to execute intelligent queries on the data for better insights. Any queries execute can be shown on the map if the user wills. The data on this grid allows the supervisor to generate reports that can be exported to excel or portable document format (pdf).
3. Navigation Control. This will allow map users to navigate forward and back in the map's view history as well as navigate to a home view.
4. Layers control. This allows the user to toggle layers' visibility.
5. Measure control tool. This allows the user to perform simple measurements on the map.
6. Task Pane. By default, this pane is hidden and can only be map visible on marker click. This is used to edit fault information i.e. Assigning tasks and closing tasks.
7. Map side bar. The sidebar has three sections or panes.
    a. Navigation pane: allows the user to navigate from one area to another.
    b. Driving directions pane: when the user requests for driving directions, this is the pane that houses the directions description.
8. Zoom IN Control. Allows the user to zoom to a selected area.
9. Zoom Control. Allows the user to zoom in and out of the map.

Using the council dashboard.

When the user logs in, the map loads all the faults that have been reported on regardless of their status. The different marker colors represent the different fault statuses. Each fault will show related information on mouse click. Figure 52 shows an example of the popup. The popup has two buttons, one to mail the reporter in case of a special situation, and another one to edit the fault status.

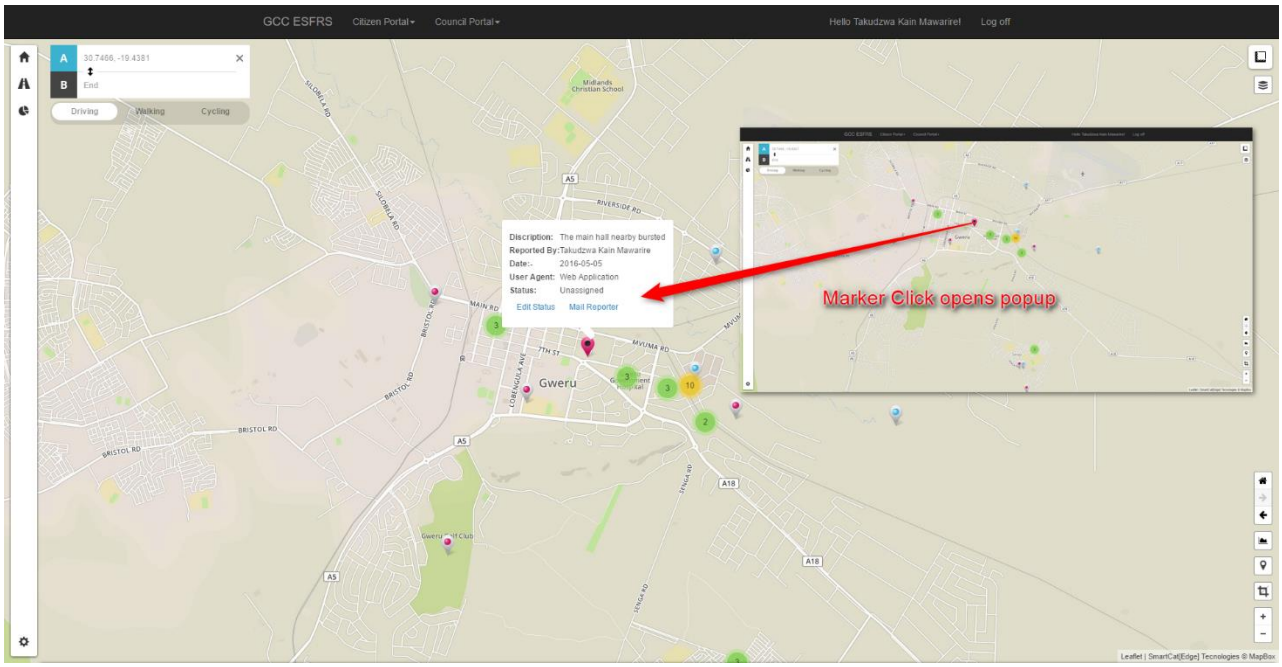

FIGURE 6-11: COUNCIL DASHBOARD (INITIAL LOOK AND POPUPS)

Supervisor Portal

The purpose of the supervisor is to assign work or tasks to his field teams. So the portal is equipped with tools to assign work to available teams. The supervisor is also provided with quick statistics and analysis tool. Markers are displayed with different colors symbolizing the different status assigned to each marker. Here if the supervisor can quickly locate the desired records, using the edit button, the can assign the reported faults to a desired team. The supervisor portal only allows assignment of tasks to individual teams. This changes the status of the fault from an “Unassigned” status to an “Assigned” status. Figure 23 shows the map side panel used in assigning tasks.

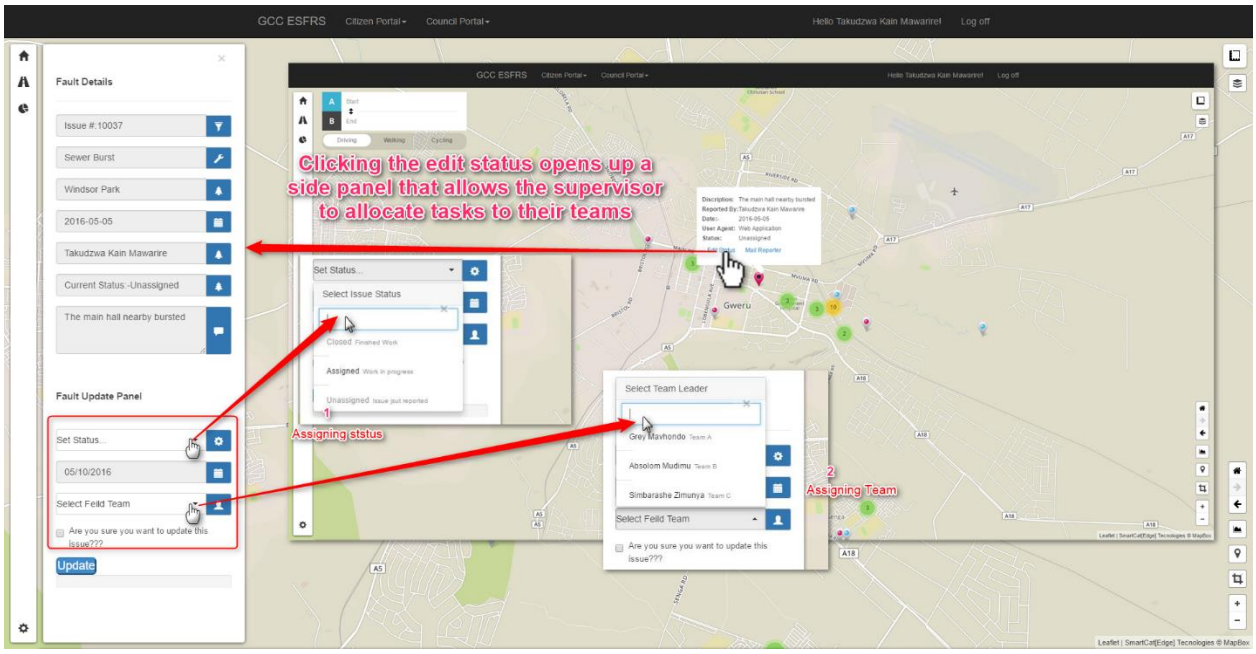

FIGURE 6-12: SUPERVISOR ASSIGNING TASKS

Query and Analytics Grid Functionalities

Outstanding Performance - a major advantage of map grid is its outstanding performance – it can handle hundreds of thousands of records at a time, without hurting the user experience. Featuring a revolutionary LINQ-based data engine. Data is processed with LINQ queries that offer unrivaled performance characteristics and extensibility. Moreover, it delivers row and column virtualization utilizing a container reuse and recycling for further improving the grid performance as well as the memory footprint.

Grouping - the users can interactively organize their data in a way that suits best their needs with a single drag and drop action. Data can be grouped according to several criteria effectively creating a tree of groups with the leaf nodes holding the actual data records. Users can group data by dragging a column header and dropping it in the group area. Users can also rearrange the grouping headers in the group area (again by dragging and dropping).

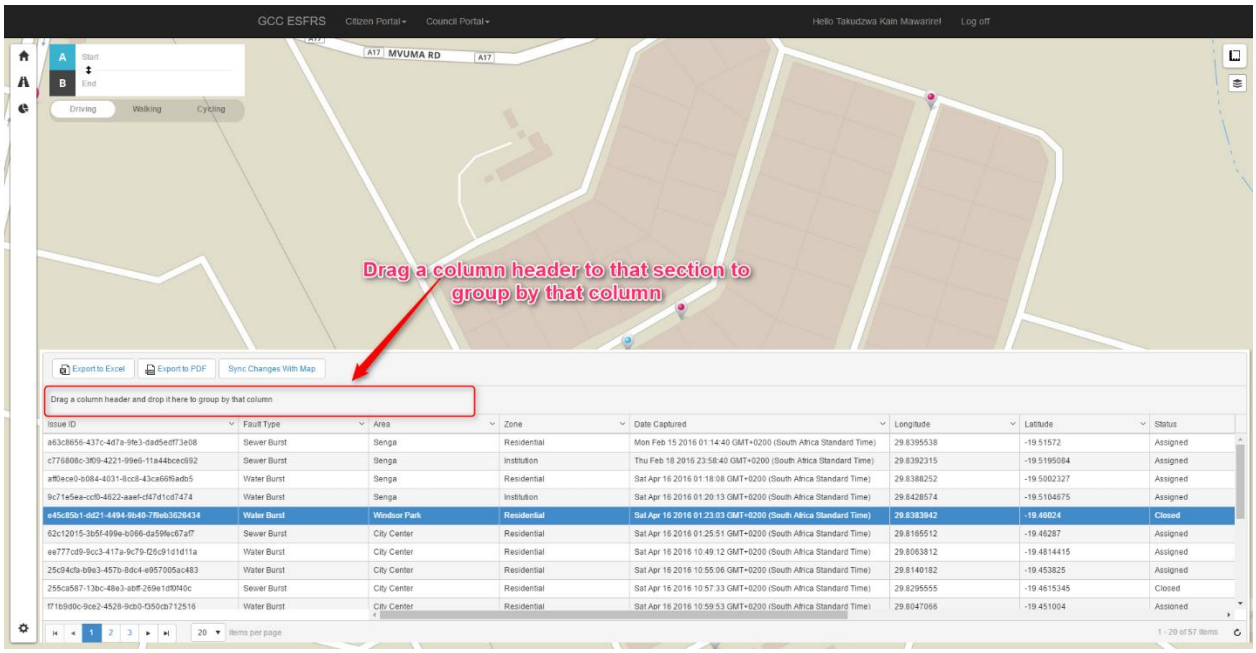

FIGURE 6-13: GROUP BY SECTION

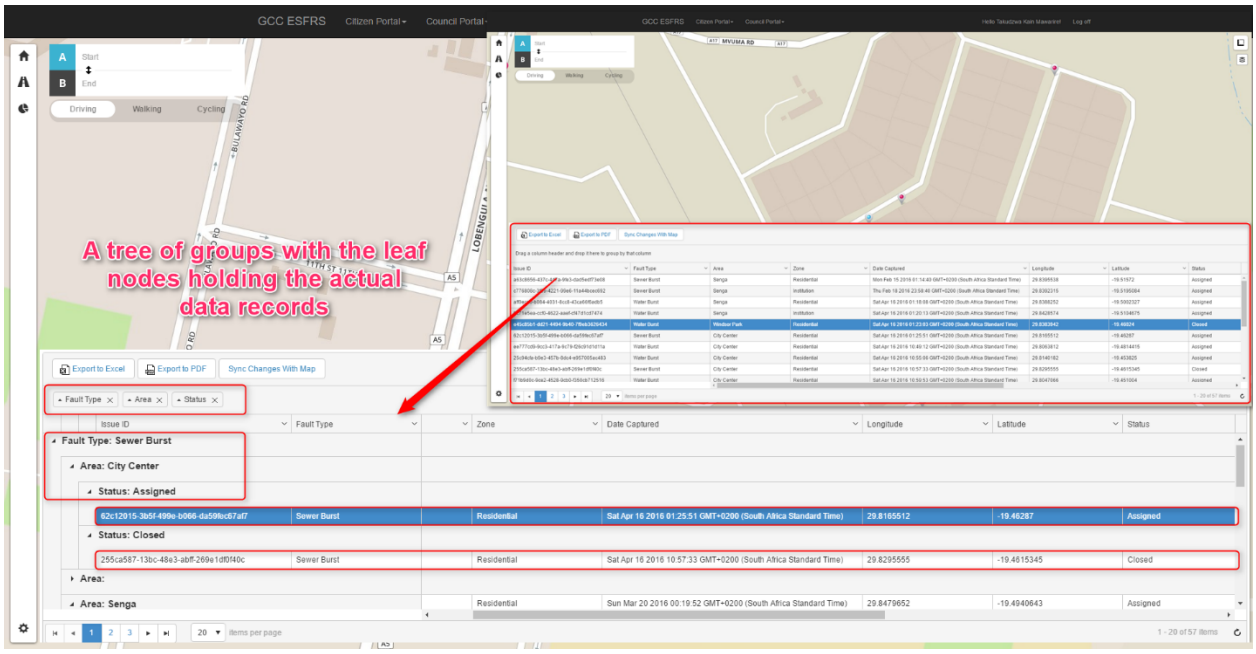

FIGURE 6-14: A TREE OF GROUPS

Sorting –The map grid supports records sorting. Just click on the header of the column you wish to have your data sorted by and you are ready.

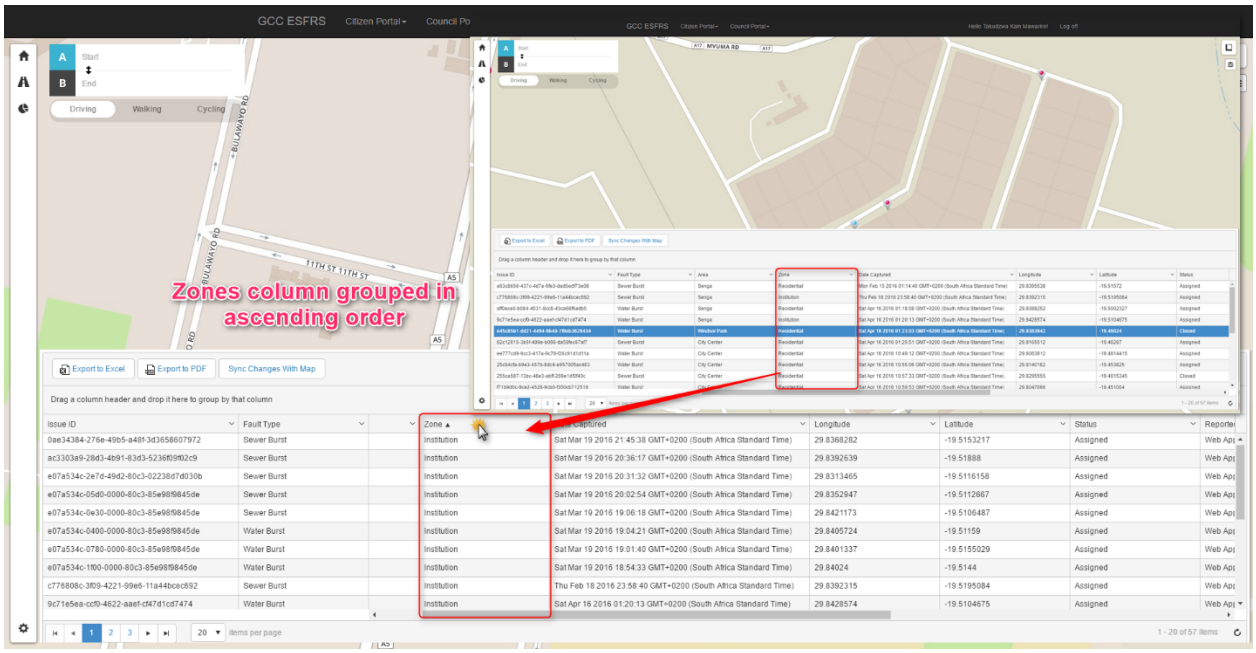

FIGURE 6-15: SORTING DEMONSTRATED

Filtering -The map grid also has support for records filtering. Clicking the filtering icon in the column headers opens a menu with the distinct values for the current column and the user can select which of those values to be displayed. Also the user can choose to filter by certain criteria utilizing conditions like Contains, StartWith, IsEqualTo, etc.

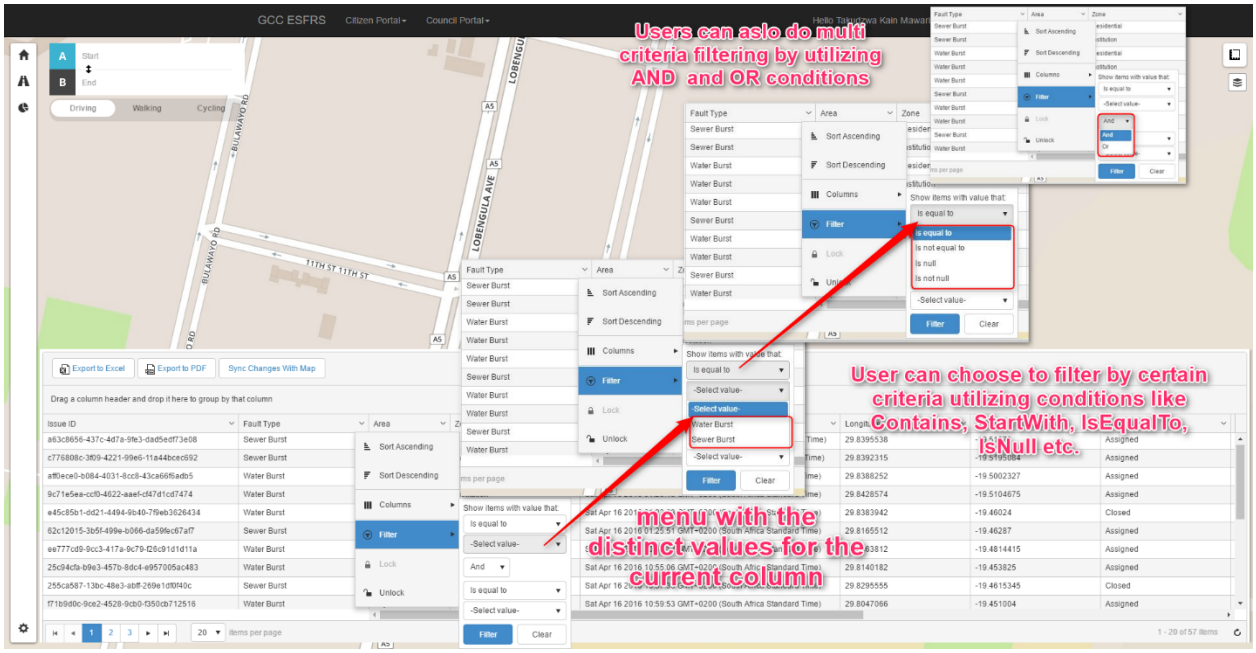

FIGURE 6-16: FILTERING CRITERIA

Frozen columns – last but not least, the map grid allows you to keep part of your data always visible putting the rest of it in context. To freeze columns, you simply lock the desired columns via the column menu.

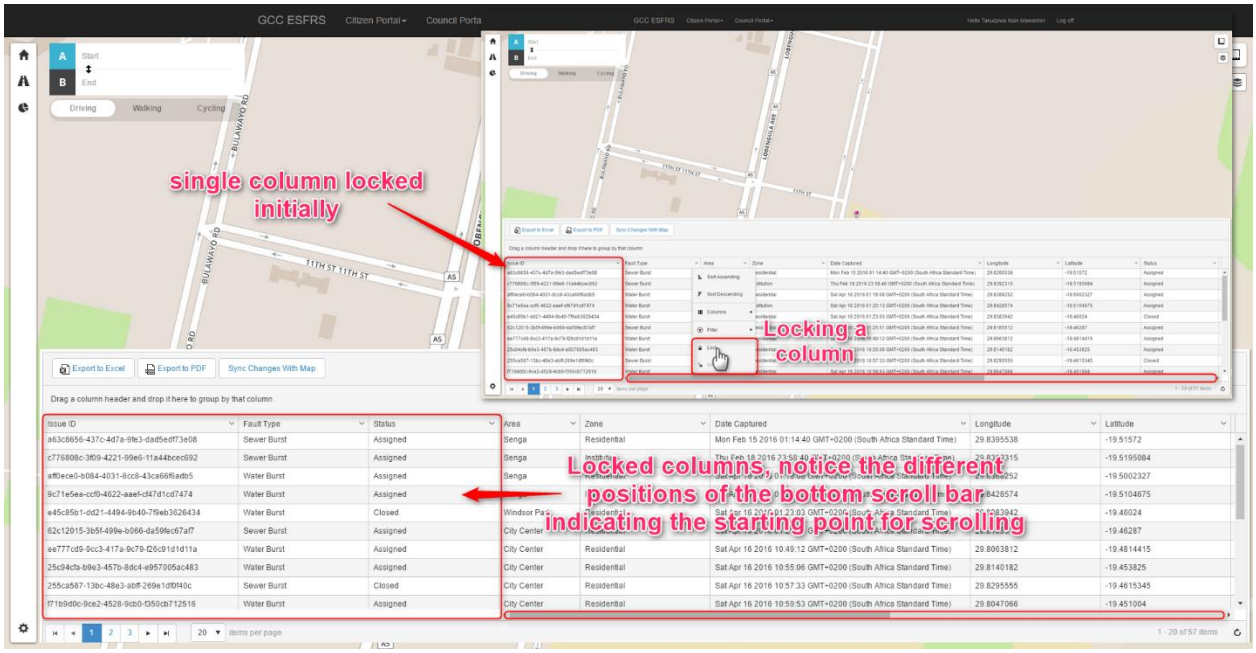

FIGURE 6-17: LOCKING GRID COLUMNS

Accessing the map grid.

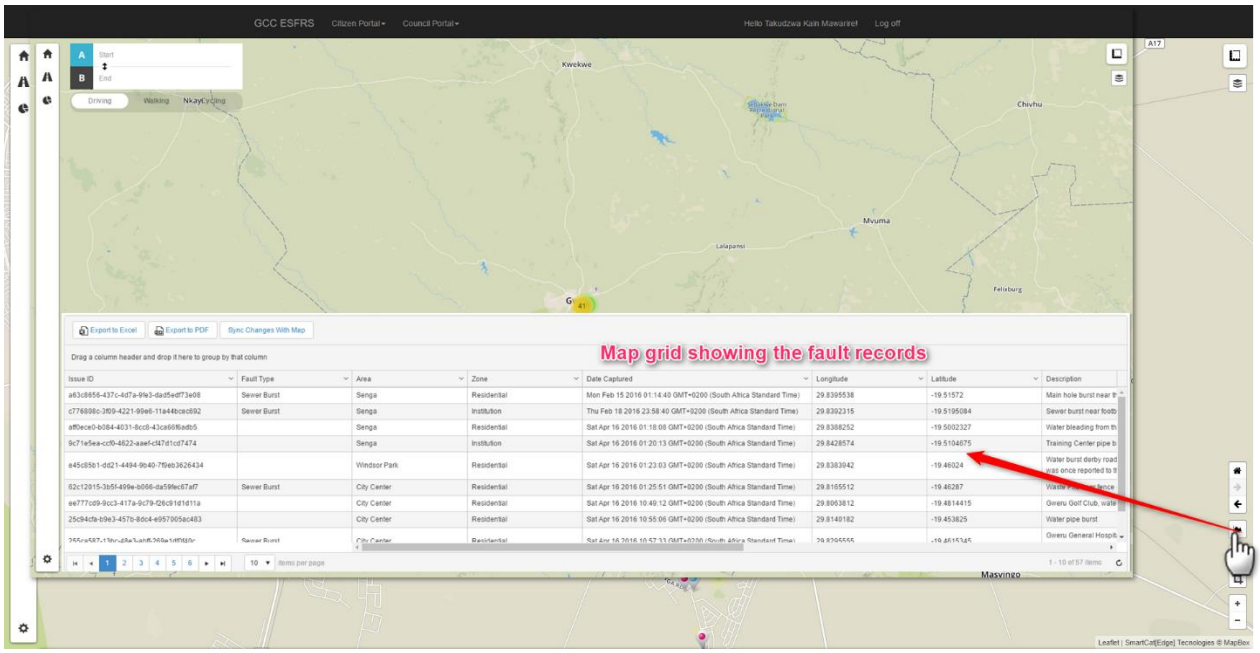

FIGURE 6-18: ACCESSING THE MAP GRID

Figure 29 shows how to access the map grid and the initial view of the map grid. As mentioned before, the records on the map grid can be exported to excel or pdf document formats using buttons on the map grid tool strip. Records exported maintain formatting and any grouping, filtering or sorting that the user had done on the map grid.

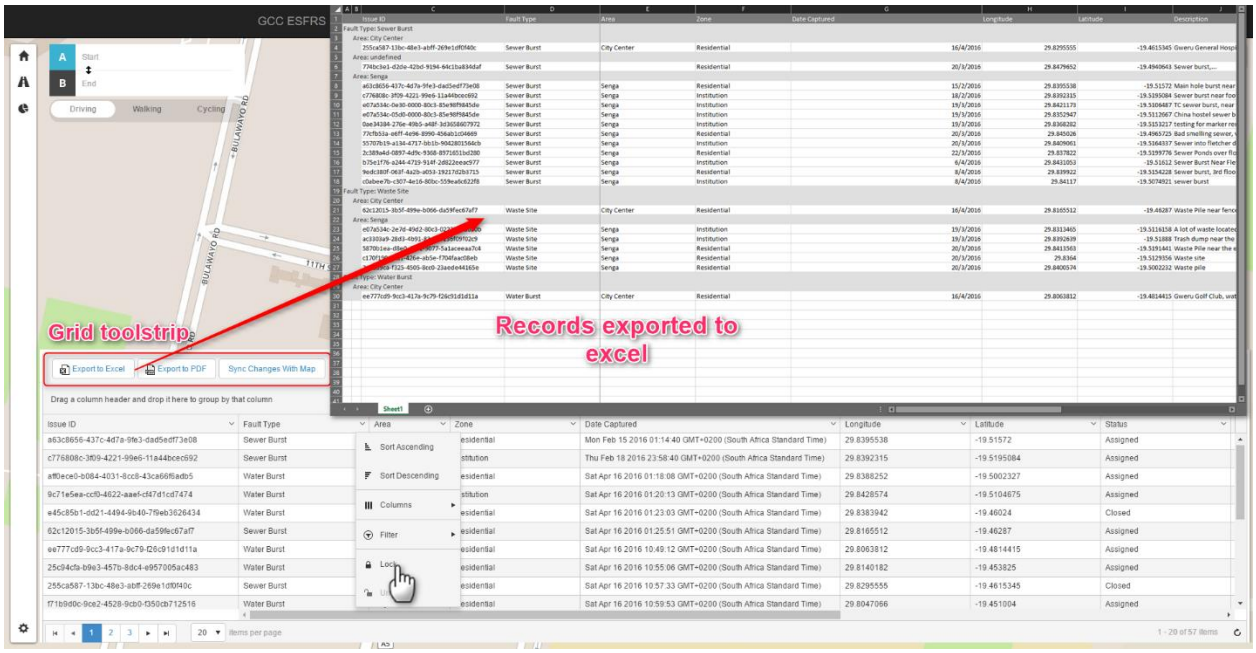

FIGURE 6-19: EXPORTING GRID RECORDS

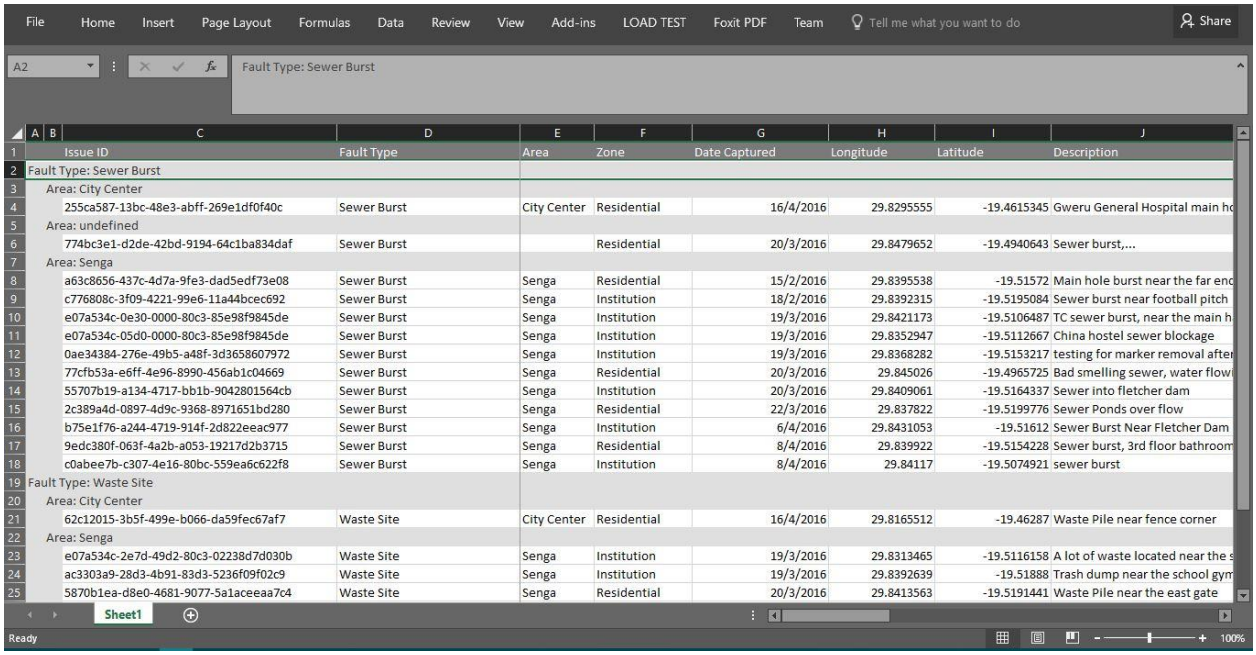

FIGURE 6-20: EXCEL GROUPED FAULT RECORDS

The map also contains a quick navigation tool; this also provides a quick insight into how many records are recorded in each area irrespective of their status.

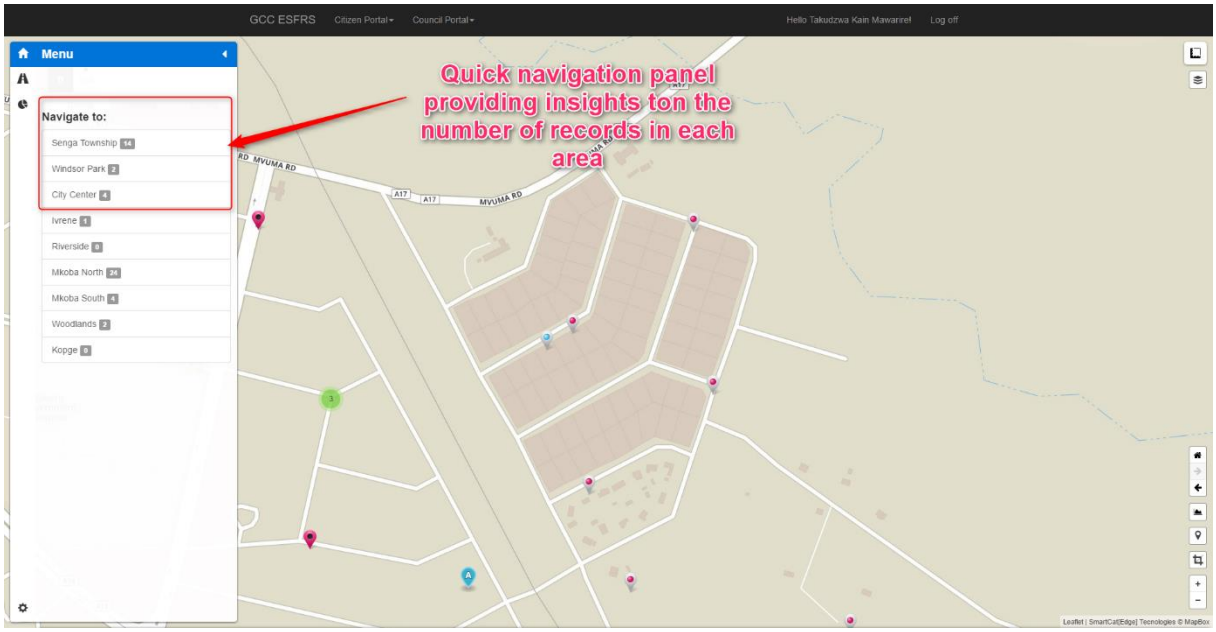

FIGURE 6-21: QUICK NAVIGATION PANE

Team Monitering and Evaluation Tools

The supervisor's portal also provides visualization tools for team monitoring and evaluation. These tools can also be utilized for performance measurement.

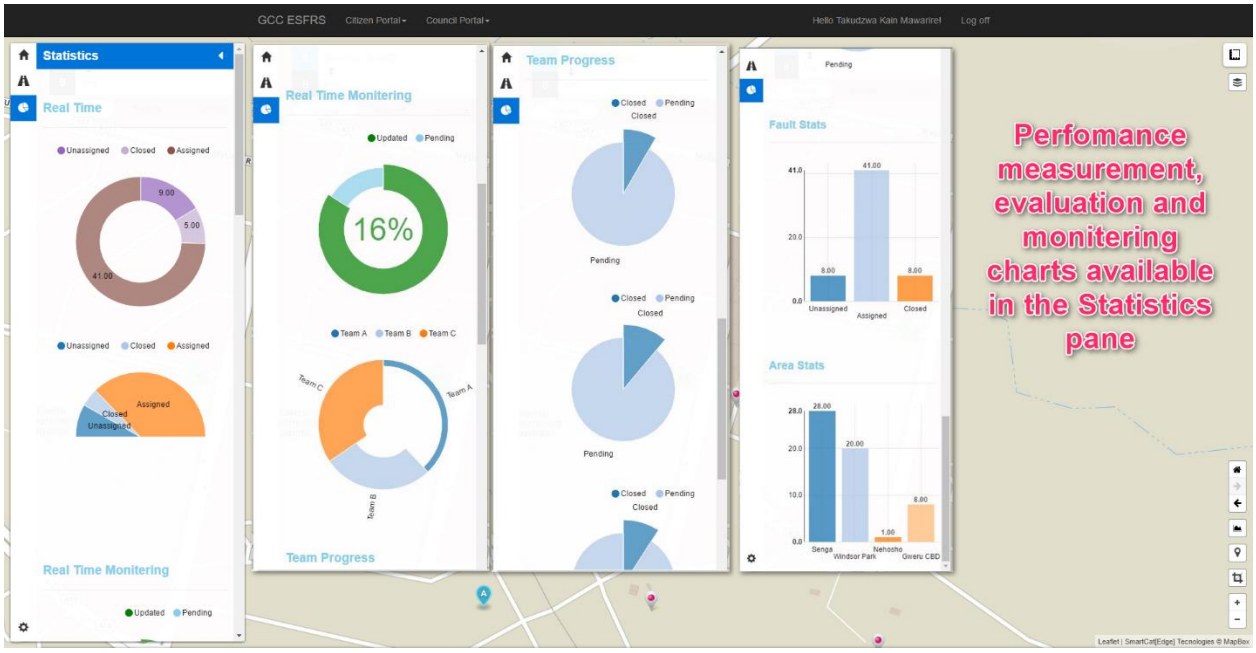

FIGURE 6-22: MONITERING AND EVALUATION INSIGHTS

Field Team Portal

The field team portal is so much similar to the supervisor portal except that, instead of assigning tasks, they attend to the assigned tasks and register if they have successfully accomplished each task. An

accomplished task is registered as closed. The field team portal also provides insights into the current progress of each team i.e. against assigned tasks.

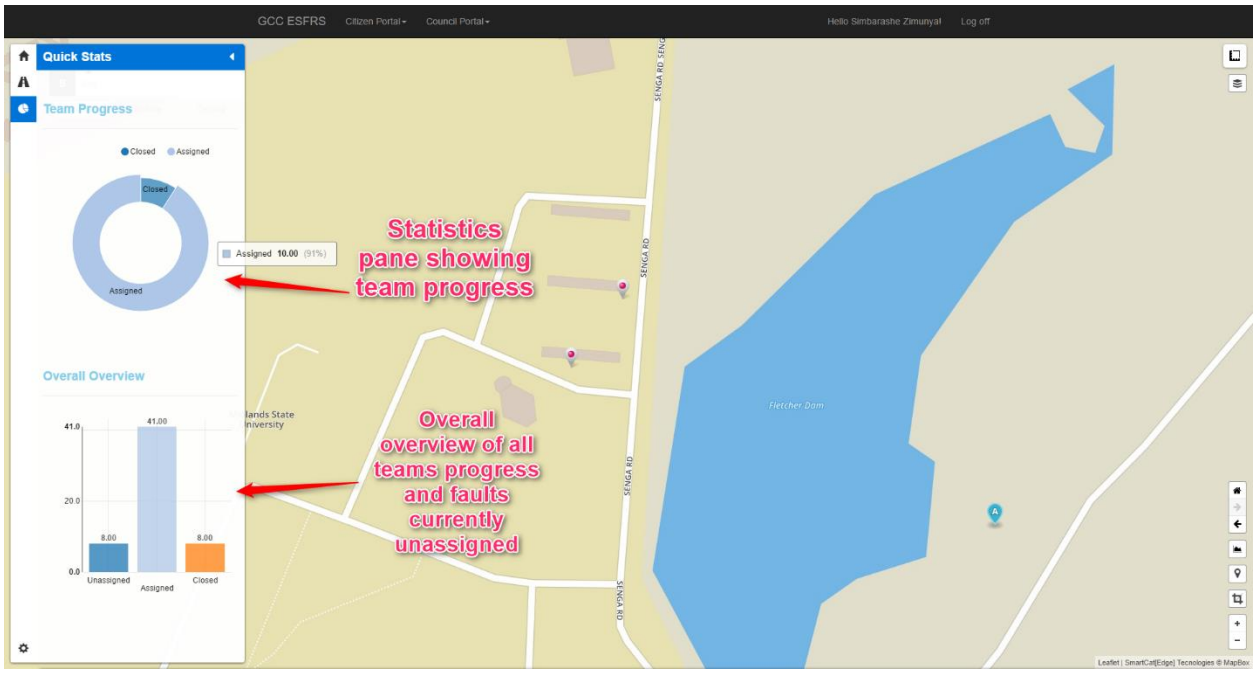

FIGURE 6-23: FIELD TEAM DASHBOARD

The field team portal also contains a simple routing function that allows the teams to plan for their field work.

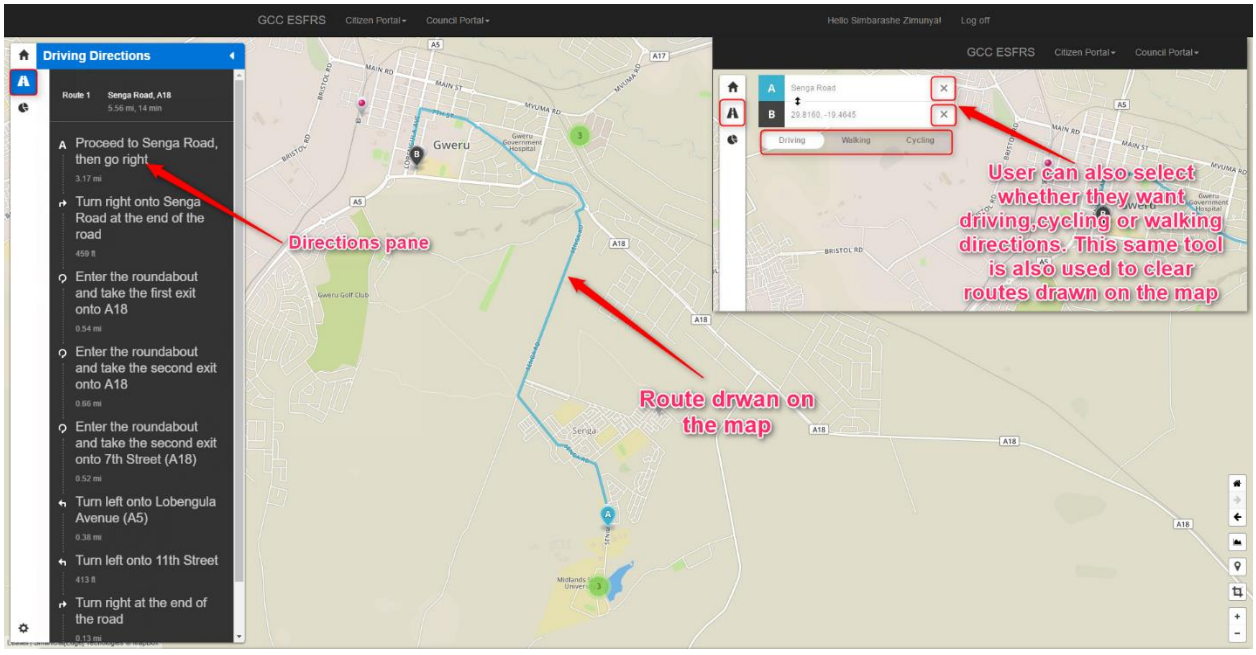

FIGURE 6-24: DRIVING DIRECTIONS

Reporting

Besides exporting records to excel or pdf after custom analysis, the system also allows the user to generate generic / predefined reports that are automatically downloaded as pdfs or SAP crystal reports.

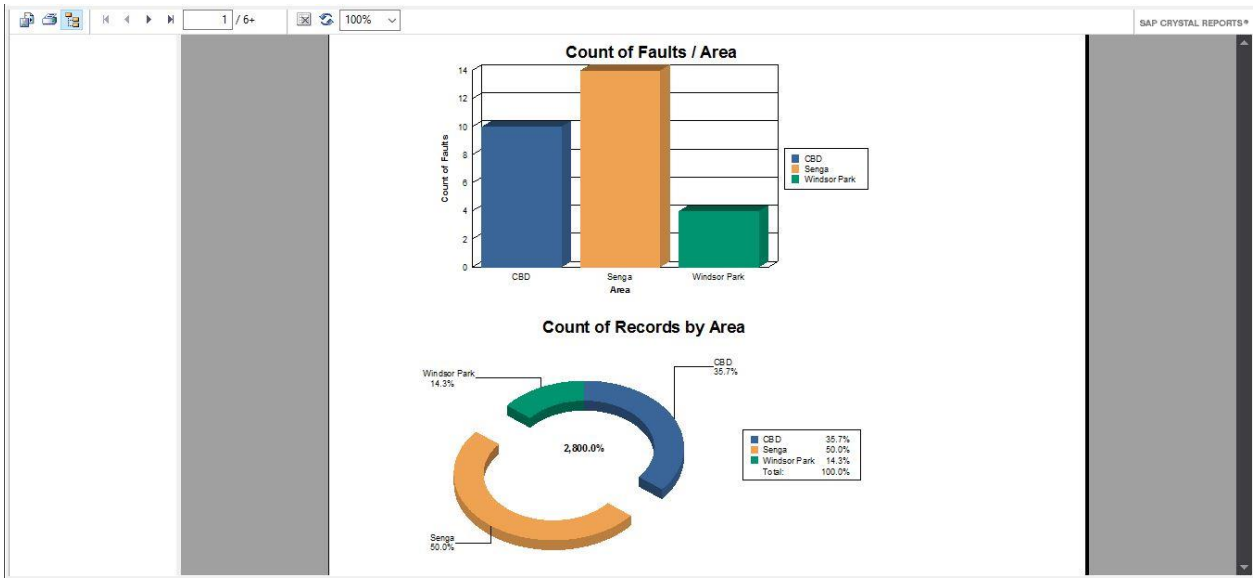

FIGURE 6-25: SAMPLE REPORT PAGE 1 (CRYSTAL REPORT VIEWER)

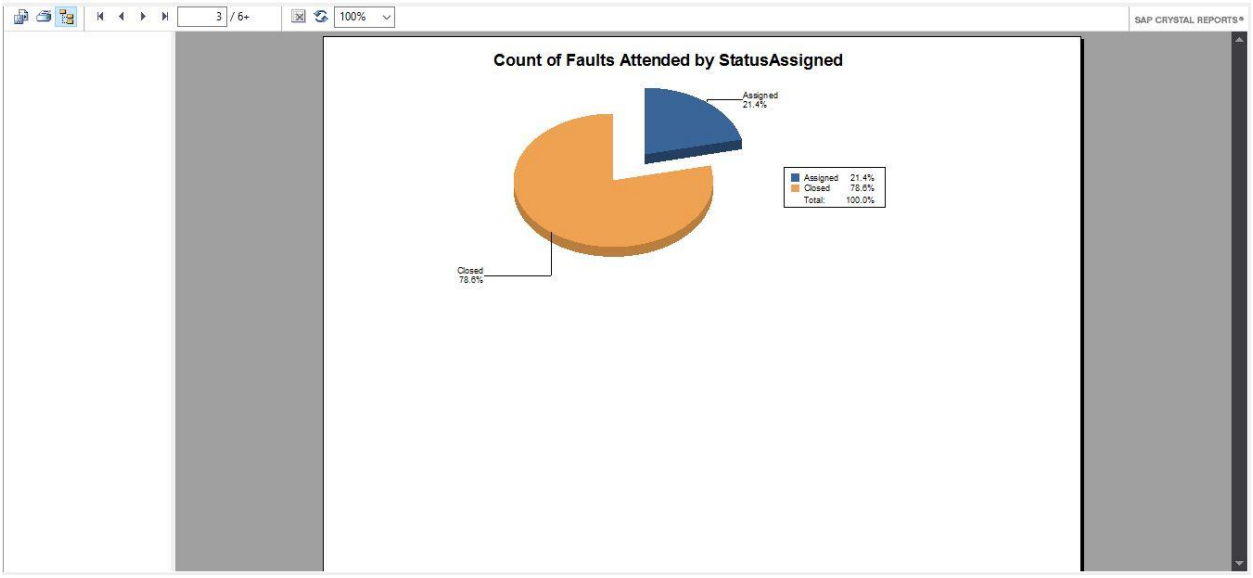

FIGURE 6-26: SAMPLE REPORT PAGE 2(CRYSTAL REPORT VIEWER)

The system also contains other data visualization platforms like heat maps showing areas with the most number of reported faults. Figure 39 shows a screenshot of a heat map generated by the system.

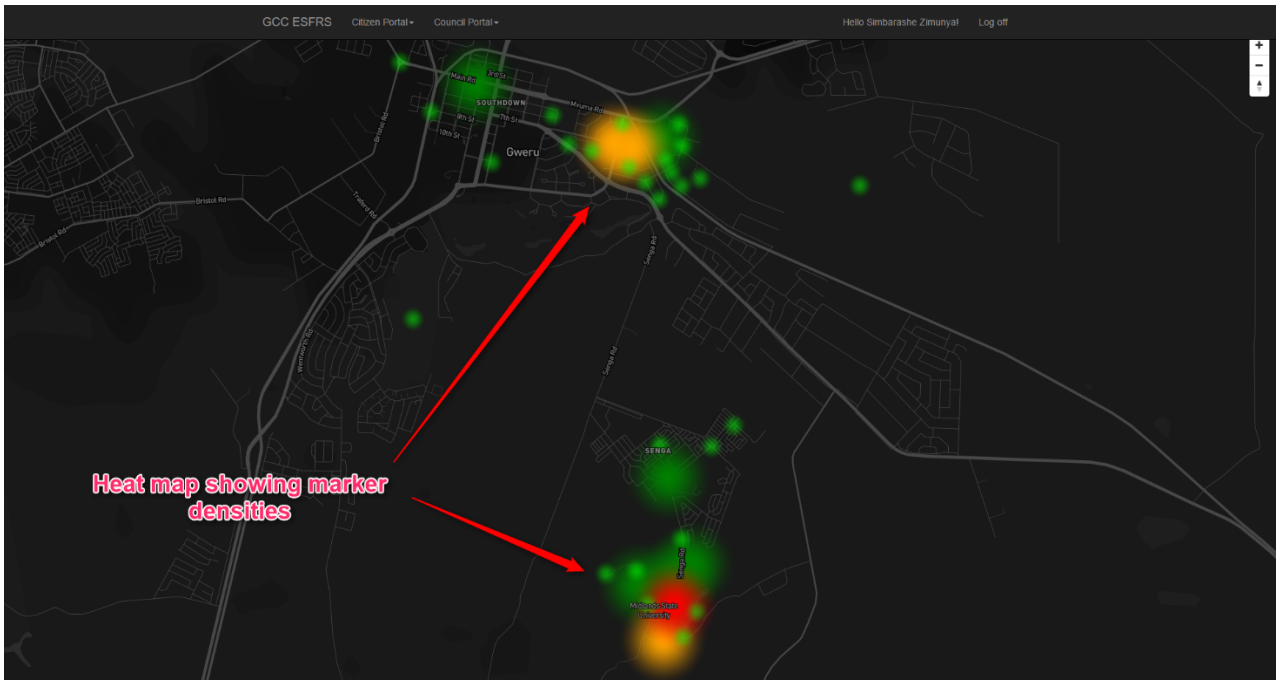

FIGURE 6-27: HEAT MAP SHOWING FREQUENCY OF FAULTS

The information systems community is going smart by developing responsive solutions. This means these solutions can be accessed via smartphone web browsers without distorting or disturbing content presentation. The web based service fault reporting system is not an exception, it is also responsive and thus can be accessed with almost any smart device with a screen large enough to accommodate all the tools. Below is a screenshot of the system accessed via different sized emulated smart phones.

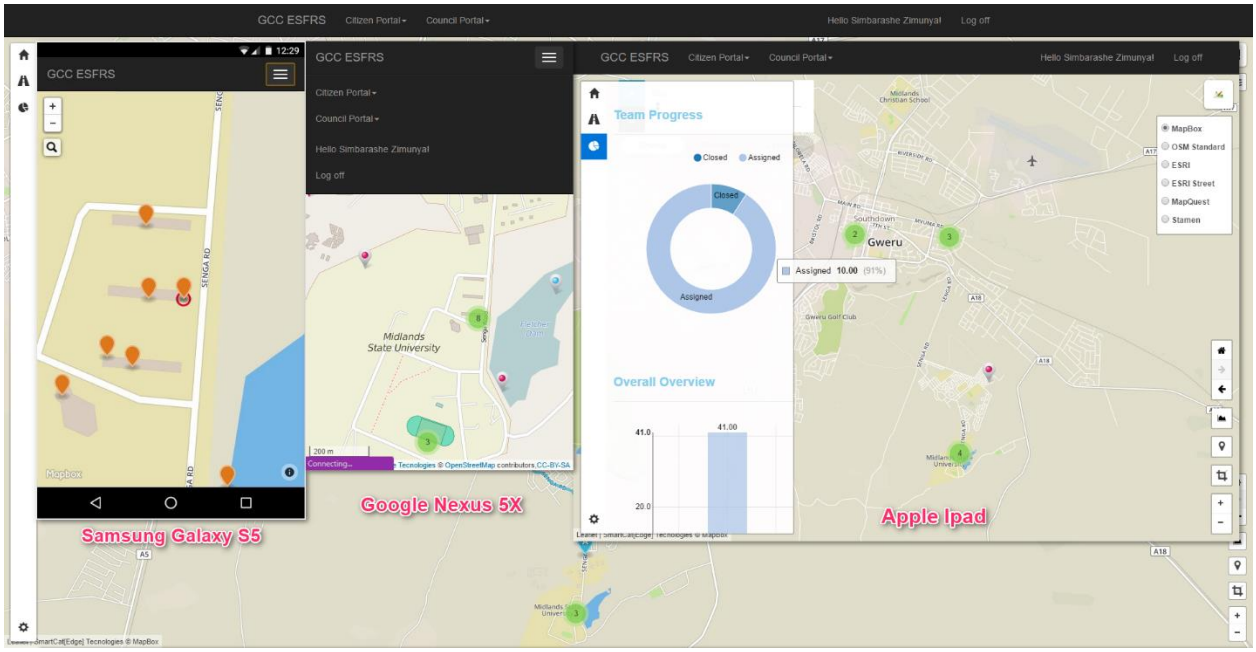

FIGURE 6-28: THE SYSTEM BEING USED ON SMART PHONES