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Abstract

Fresh water is a scarce and crucial resource that requires protection from abstraction to consumption through efficient leverage techniques of abstraction and distribution, so as to secure the future of humanity.

In Kenya, Water providers are parastatals mandated by the government and county governments to ensure that there are efficient, effective and sustainable methods or means of providing this important resource to the people.

The project developed a real time web-based map application for water discharge monitoring along the water networks to achieve its objective, through developing and combining modules that; send sensor measured data to a central database, relays the data from the database to the map application on the website.

The project combined the water flow meter sensor, a microcontroller and a 2G/GSM module with GPRS capability. The sensor was installed to a tap with running water and fitted with the other components. The water discharge was regulated using the tap the sensor measured data was viewed on the map application using graphs.

The result was a map application on the web providing information about water discharge on the real time basis. The water discharge results are for the specific location of the sensor and the comparison graphs for two locations along the network.

The complete set up enabled the visualization of water discharge for a single sensor location, its comparison with another sensor location using graphs and giving a geographic view about the location of the sensor measuring the discharge from the field. The project recommends incorporation of other sensors such as vibration sensors along the water network to enable detection of any disturbance, before damage occurs.

Abbreviations

NWSS	National water service strategy
GSM	Global System for Mobile Communication
GPRS	Global Positioning Radio System
PHP	HyperText PreProcessor
HTML	HyperText Markup Language
GIS	Geospatial Information Systems
HTTP	HyperText Transfer Protocol
PNG	Portable Network Graphics
UNMD	United Nations Millennium Declaration
WHO	World Health Organization
WWF	World Wide Fund organisation
MWI	Ministry of Water and Irrigation
MDG	Millennium Development Goals
IPRSP	Interim Poverty Reduction Strategy Paper
MIDI	Musical Instrument Digital Interface

Chapter one: Introduction

The traditional and advanced human societies continue to be dependent on the continuous available supply of water. In areas where the home source of portable water is not available, pipe network systems have been developed and installed to convey this resource to the consumers.

Water distribution is the process of conveying water from a source to the consumers. It takes different forms from tank trunks that supply water to community’s access points to piped water that delivers water directly into homes.

In all public services in offer, water distribution is one of the most crucial services. As the population continues to grow all over, it becomes clearer that anything that interrupts the supply of water tends to disturb the very survival of population.

Worldwide, freshwater supplies are scarce and in most areas water scarcity is a significant issue. Low water supplies are especially pressing in desert areas and also in regions with issues of environmental pollution e.g. Undeveloped countries

Water distribution systems convey water drawn from a distant water source or treatment facility, to the point where it is delivered to the users. Water distribution thus involves getting water supplies to consumers, ensuring efficient use of allocated water and providing access to safe water for as many people as possible.

The water distributions process starts with identifying a source of water and then determining the kind of treatment necessary to make it usable. Then water flows through treatment facilities and finally into supply systems such as pipe networks, canals, and aqueducts. This whole system is controlled by officials who make decisions about the time to release water for distribution and the amount to release at any given time.

Currently, water supply systems are experiencing challenges which has direct impact to the end users. Public water services in many countries have been assigned to a single water authority and the abilities of governments to distribute water adequately have been negatively affected by factors such as inadequate water management and poor water resource utilization.

Thus, urban water systems are characterized by heavy losses both financially and of water itself mainly due to weak and unsustainable management systems, and poor customer confidence resulting to low revenue collection.

Despite these problems water providers continues with their primary responsibility to provide affordable water services through efficient, effective, and sustainable utilization of the available resources in an environmentally friendly manner, and meet and exceed the expectations of its consumers and other stakeholders. The priority areas are: to enhance customer satisfaction, to efficiently manage resources, to improve access of water to informal settlements, and to improve technical efficiency.

1.1 Background of the study

In the global perspective, human societies still depend on supplied water and the mode of conveyance remains the pipes from the source to the consumers' destinations but not without challenges.

A continuing challenge for the management of water resources and aquatic ecosystems is to balance environmental and developmental needs. This is particularly true where efforts are designed to share the benefits of water related ecosystem services rather than merely sharing the water resource alone (Russell Arthurton et al, 2007)

One of the international goals set for the year 2015 in the UNMD and in the plan of implementation of the world summit on sustainable development is reducing the proportion of people without adequate access to water and basic sanitation by one-half.

In Africa, due to urbanization more than 30% of Africans residing in urban areas currently lack access to adequate water services and facilities. In the year 2000, WHO estimated that Africa contains 28% of the world's population without water access to improved water services Only 62% of the people in African countries have access to improved water supplies, and only 60% have access to improved sanitation. (WHO report p6, 2000).

WWF in The Hague in 2000 shared an Africa Water Vision, water supply and sanitation targets which stated that it aspires an Africa where there is an equitable and sustainable use and management of water resources for poverty alleviation, socioeconomic development, regional cooperation by 2025.

Kenya is limited by an annual renewable fresh water supply of only 647 cubic meters per capita and is classified as a water scarce country (Momanyi et al, 2005).

Sustainable access to safe water is around 60% in the urban setting and drops to as low as 20% in the settlements of the urban poor where half of the urban population lives
In rural areas, there are large disparities between geographic areas where in North Eastern and Eastern Provinces less than 30% of the poor have access to safe water compared to some 60% in Western Province (IPRSP, 2000–2003).

All water resources in Kenya remain vested in the state. The MWI is tasked with the responsibility of creating institutions to manage water resources and provide water services to ensure rational and equitable allocation of water resources, water quality monitoring, testing and surveillance to ensure compliance with drinking water standards and other standards for various water uses and effluent discharges into public sewers and the environment and mapping and publishing of key water catchment areas, groundwater resources and flood prone areas.

The MDG 7C outlines the target for halving the proportion of population without sustainable access to safe drinking water and sanitation by 2015 (MDG)

Kenya is classified among the most water scarce countries in the world. Water shortages are experienced by users across the country Kenya is plagued with chronic cycles of flooding and drought that are increasing in frequency and severity, in part aggravate by climate change, and coupled with population growth, significant upland watershed destruction, and no equitable distributed of water resources. (Website 1)

Effective management and access to water resources is vital to sustainable development and good governance

1.2 Statement of the problem

Water distribution systems failure is a universal problem where significant portion of treated water is lost in the conveyance between the source and the consumer. This is due to a variety of factors e.g. breakage due to; failures at the joint threads, pipe connection, mechanical damage, poorly maintained valves and fittings, inadequate corrosion protection, material defects and faulty seals.

In the developing countries, governments face problems of provision of social facilities, especially the supply of sufficient water in good quality at a reasonable price to their citizens. Water services studies done within the water sector reveal that, the management of water resources and water supply has continued to be a major problem.

Another huge problem with clean water supply in Kenya has been high entry of individuals moving into cities such as Nairobi, which results in large slum areas with some of worst living conditions and most polluted water.

In urban areas like Nairobi there are frequent tendencies of water running out of supply without an on time warning on the client-side and also lack of knowledge on the providers-side about the occurrence of the shortage/problem, until customer send reports and complains about the situation.

The purpose of this project is to development a GIS-based water monitoring systems that aims to provide information to water providers on a real-time basis about the amount of discharge (ml/s) along the water network.

1.3 Objectives of the project

2.2.1 General objective

To develop a real-time web-based map application for water discharge monitoring, for timely notification of the state of the water network.

2.2.2 Specific objectives

i To develop a module to send the data availed to the GPRS module by the sensor (after conversion to from binary or digital pulse voltage to float number) to a database.

ii To develop modules for parsing discharge values to and from the database.

iii To develop modules for water discharge visualization at point locations on a map platform.

iv To develop a module to display multiple water discharge charts for comparison between two sensor locations.

1.4 Significance of the study

The project aims at developing a prototype of a real-time web-based water discharge monitoring map application that will be used by water providers to monitor the already installed water network and future network installation. As a secondary solution the state of the distributing system e.g. the interpretation of the result will drive the water experts to alert the field officers to conduct investigations on along water network to ascertain the root cause of the displayed results.

In connection to the above relevance, the interpretation of the acquired discharge data will help water engineers to make informed decisions in issues such as water allocation, design of storage structures, water demand analysis, rationing e.t.c

The interpretation of the displayed discharge will have varied interpretation based on the location of the sensor on ground to avoid misleading interpretations.

1.5 Scope of the study

The data used to produce the figure 1 was acquired from NCWSC which represents the area used to develop the web application part of the project for the purpose of network mapping demonstration. The water network is for the company's eastern region as per their division of the Nairobi County.

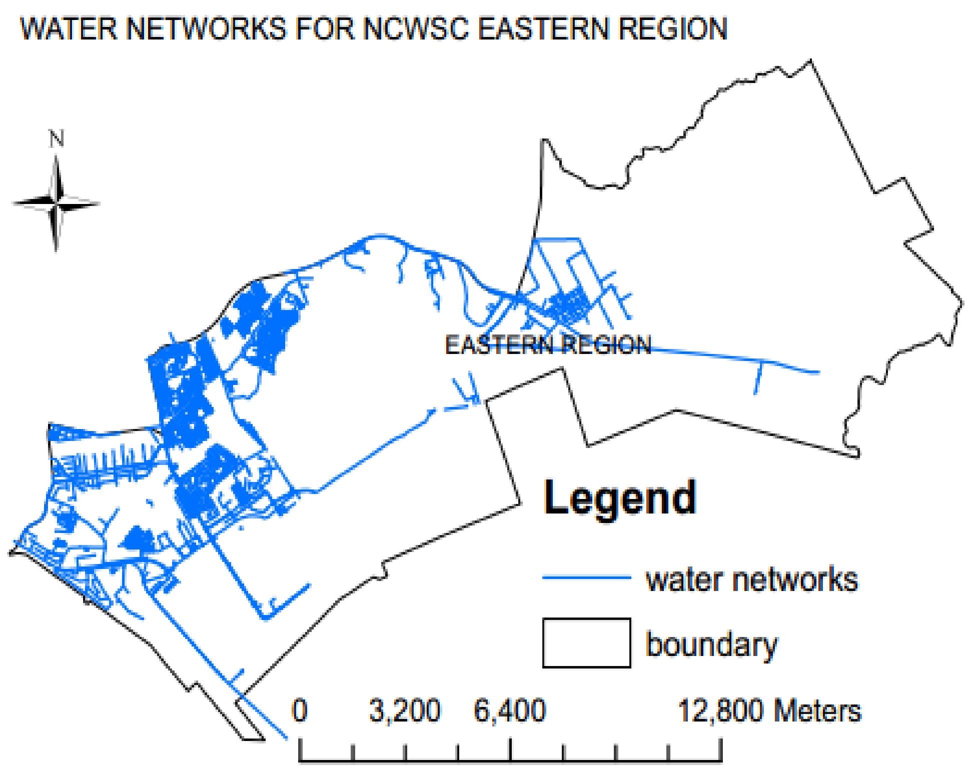

Figure 1 Region used web mapping interface customization

Chapter two: Literature review

2.1 Introduction

Ministry of Water Irrigation, (2005-2007) conducted a study on the NWSS which was published and was prepared in accordance with section 49 and 50 of the water act 2002. The study found out that there were no enough strategies and funds to expand water to all underserved areas in the republic. There was no proper national monitoring and evaluation mechanisms on water service deliveries. The study recommended that, for the success of the reforms in the country, there should be arrangements to come up with well-structured and working water institutions to ensure that at all times there, is in every area of Kenya, a person and institution providing water supply to the citizens at fair tariffs. The other recommendation of the study was the need to design programs to bring about the progressive extensive of water supply infrastructure to all the Kenyan people.

Barreiro, (2003) conducted a study on implementing integrated water resources management in Philippines. He found out that in Philippines, there is need for sound basic principles and structural framework relating to appropriation, control, conservation and protection of water resources to achieve their optimum development and efficient use to meet present and future needs. He found out that there is need for adequate administrative machinery to implement the water resources management in Philippines.

Sanjay Rode, (2009) in a research that he conducted on equitable distribution of drinking water supply in municipal corporations in thane district Mumbai, brings out the point that higher urbanization increases water demand in small and big municipalities. He found out that the demand of drinking water was continuously increasing but supply not matching with increasing demand. Municipal Corporations have not made the provision of drinking water to the growing population on 24/7 basis. They proposed that alternative policies of rainwater harvesting, reducing leakages and wastage, more provision of funds for water supply projects, revision of tariff structure and private sector participation in distribution of drinking water supply will yield the better results in terms of growing demand of water Supply.

Prashant, (2012) conducted a research on issues surrounding India's water scarcity, and also comparison of clean water standards between developing and developed nations. The findings showed that India's water crisis is predominantly a manmade problem. India's climate is not particularly dry, nor is it lacking in rivers and groundwater. Extremely poor management, unclear laws, government corruption, and industrial and human waste have caused this water supply crunch and rendered what water is available practically useless due to the huge quantity of pollution. He noted that for the problem to be solved, they needed to take actions as stipulated in the MDG and reduce reliance on the government. He recommended that large scale investments in new recycling and conservation technologies such as the deep pond system should be considered.

Luis Castalier et.al, (1997) described design and fabrication of a low cost water flow meter which can measure up to 9 litre/minute avoiding direct contact of flow with silicon sensors.

Shiqian Cai et al, (1993) proposed a technique of measuring flow rate in
Air-Water Horizontal Pipeline with the help of Neural Networks.

Young-Woo Lee et al, (2008) had developed a wireless Digital Water Meter with Low Power Consumption for Automatic Meter Reading in which they used magnetic hole sensors to calculate the amount of water consumption and they had used ZigBee wireless protocol to transfer amount of water consumption to the gateway.

Javad Rezanejad Gatabi et al (2010) developed an auxiliary fluid flow meter in which the flow of an auxiliary fluid is measured, instead of direct measurement of the main fluid flow. The auxiliary fluids injected into the main fluid and with measuring its travel time between two different positions, its velocity could be calculated.

Zhang Wenzhao et al (2010) had developed a liquid differential pressure flow sensor for straight pipe. In this system a pressure difference between the upstream branch pipe and the downstream pipe is detected and converted into a voltage signal by the DP sensor. This voltage signal is transmitted to a microprocessor to determine liquid flow rate.

2.2 A hall effect water flow sensor

Ria Sood et al, (2013) stated that water flow sensor consists of a plastic valve body, a water rotor, and a hall-effect sensor. When water flows through the rotor, rotor rolls. Its speed changes with different rate of flow. The hall-effect sensor then outputs the corresponding pulse signal/digital output as a result of left-hand rule interaction of magnetic field and electric current. The number of pulses generated per litre is counted by the C module. Thus, pulses produce an output frequency which is directly proportional to the total flow rate through the sensor. Measuring flow rate through rotating rotor provides high accuracy, excellent repeatability, simple structure and low pressure loss, which are necessary properties for the project.

2.2.1 Theory of the sensor

Sensors/transducers are electronic devices that measure a physical quality such as pressure or temperature and convert it to a voltage pulses. This process of changing one form of energy into another is called transduction.

Figure 2 Water flow sensor.

(Source: website 11)

In order to measure the quantity of water flow in particular time through the hall effect sensor. A program in the microcontroller counts the number of high pulses recorded per second as result rotations made by the rotor and the counts are converted to flow rate.

2.2.2 **Sensor Scaling Factor**

The water flow-rate sensors output a series of pulses at a rate that varies proportional to the water flow being measured. The output pulse count is converted to flow rate using the sensor design scaling factor as follows.

$$Sensor\ frequency\left(\frac{pulses}{sec}\right) = 7.5 \times Q\left(\frac{liters}{min}\right) \dots\dots\dots\dots\dots\dots\dots..(1)$$

$$Liters\ = Q \times time\ elapsed(sec) \div 60\left(\frac{sec}{min}\right) \dots\dots\dots\dots\dots\dots\dots\dots\dots(2)$$

Replacing (2) into (1):

$$Liters = \left(frequency\left(\frac{pulses}{sec}\right) \div 7.5\right) \times time\ elapsed(sec) \div 60$$

$$Liters(sec) = pulses \div (7.5 \times 60)$$

$$Milliters(sec) = liters \div 1000.0$$

The program for this project, therefore, acts as a simple frequency counter to determine how many pulses are being generated per second, and then applies that scaling factor to convert the measured frequency into a flow-rate value in liters per minute.

2.2.3 **Teensyduino**

Teensyduino is a software add-on for arduino softwares, and compiles and executes its programs on the teensy compiler. Most of arduino programs often work on teensy since they share the standard functionalities and also most of the libraries.

Teensy offers a variety in terms of serial device type where a type of device can be selected.

Teensy is very easy to use for applications that need the serial port (MIDI, GPS modules), because uploading takes place on the USB port, which is not shared with serial.

2.2.4 **Arduino**

- An arduino is an open source open hardware programmable controller with several inputs and outputs as shown in figure 3 below. It is easy to use, connects to computer via USB and communicates using standard serial protocol, offers a variety of digital and analog inputs, SPI and serial interface and digital and PWM outputs. It comes with free authoring software

Figure 3 Arduino board.

(Source: website 12)

	Comparison between arduino and teensyduino	
Parameter	**Arduino**	**Teensyduino**
Community	Large community support	Small and growing community support
Availability	Readily available in the market since it has already many users	Not easily available, relatively new in the market
Independent	Fully independent	It's an arduino software add-on
Flexibility	Offers variety of digital and analog inputs	Offers variety of digital and analog inputs

2.3 **GSM-GPRS shield**

GSM stands for Global System for Mobile Communication and is an open, digital cellular technology used for transmitting mobile voice and data services.

It digitizes and compresses data, then sends it down through a channel with two other streams of user data, each in its own time slot. It operates at either the 900 MHz or 1,800 MHz frequency band.

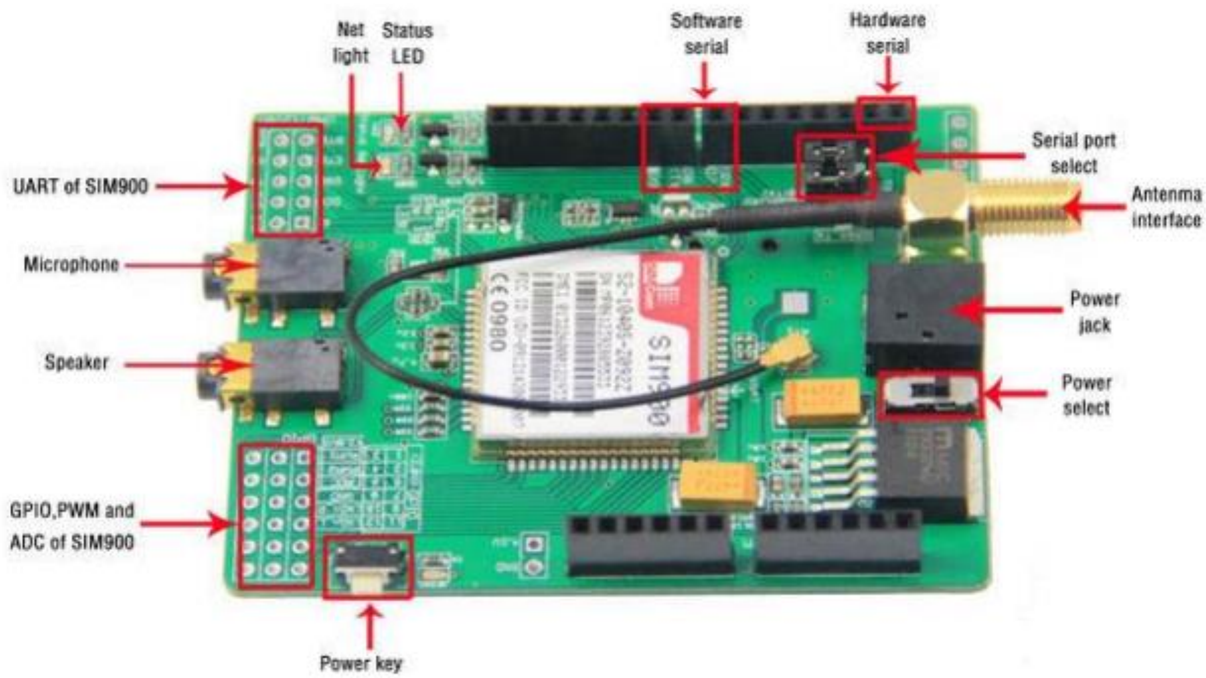

Figure 4 A SIM900 GSM shield.

(Source: website 13)

The GPRS Shield is based on SIM900 module and is compatible with Arduino. The GPRS Shield provides you a way to communicate via SMS, MMS, and GPRS using the GSM cell phone network.

Chapter three: Methodology

3.1 Introduction

This research involves creation a web mapping services that displays the real time status in terms of charts and colour signals of the water volume levels in the water conduits. The data is sent via GSM data transfer protocol mode to a database using the GPRS aided by arduino.

Using another PHP program to get the data from the database and display it on the map at points of sensor installation.

3.2 Hardware and software

Hardware:

- *Computer Server (map and data)*
- *Arduino uno*
- *GSM shield*
- *Waterflow sensor*

Software:

- *Programmer notepad + +*
- *MySQL and APACHE*
- *PHP/JavaScript*
- *HTML5*
- *Highcharts library*
- *Geojson.js file*

3.3 Flow diagram of the system

The figures 5 and 6 below represent the system implementation whereby the water flow sensor was fixed to a tap with running water. The sensor was then fixed to the arduino board and the GPRS module after the arduino module had been uploaded onto the board.

The arduino module contained the equation stated above to convert the pulses in meaningful information.

The values were then sent using the GPRS from the sensor location to a central database table. The sent values represented the discharge measured by the sensor and the table recorded each value with a primary key and the time when the value was inserted.

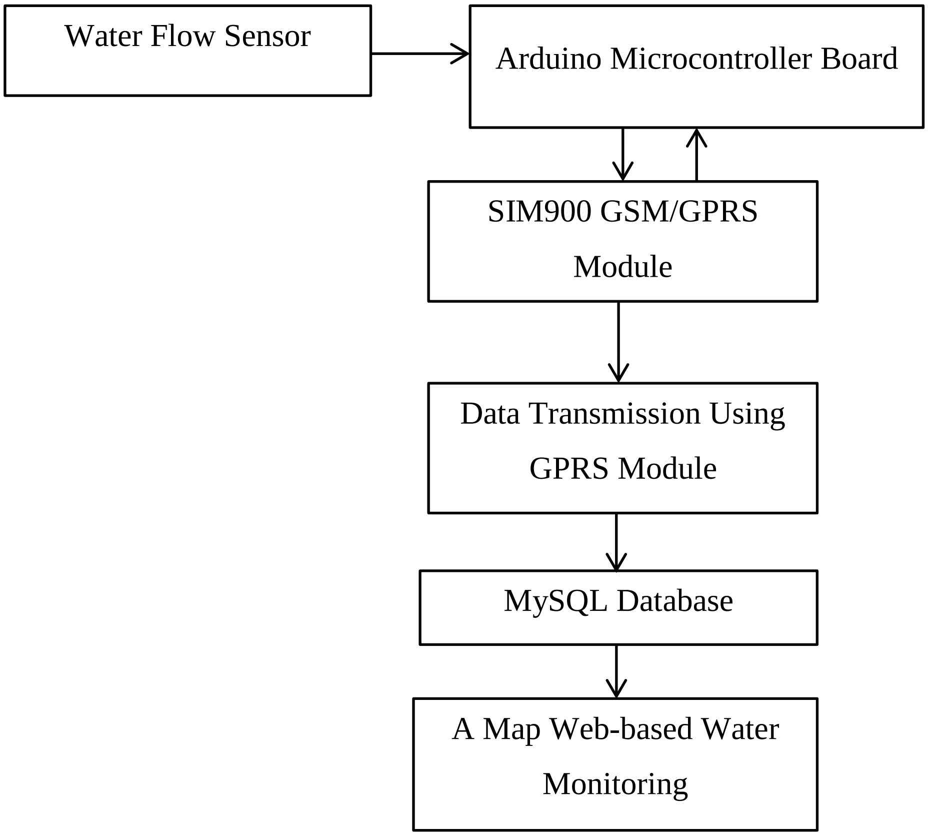

Figure 5 Flow diagram of implementation

As soon as the values streams in the table they are fetched and displayed on the map application using graphs as a visualization tool. And thus, discharge information for a single sensor was now visible on the map application.

The basemap and the map layers served to give the viewer a notation of the geographical location of the water networks and the location of the sensor providing the information.

The application also simulated a two sensor situation whereby the viewer was able to query the comparison of the discharge between the sensors along single water pipe connection.

The figure 6 below gives a condensed explanation of the flow of data from the sensor upto the map platform using 3 distinct stages: measurement, transmission and visualization.

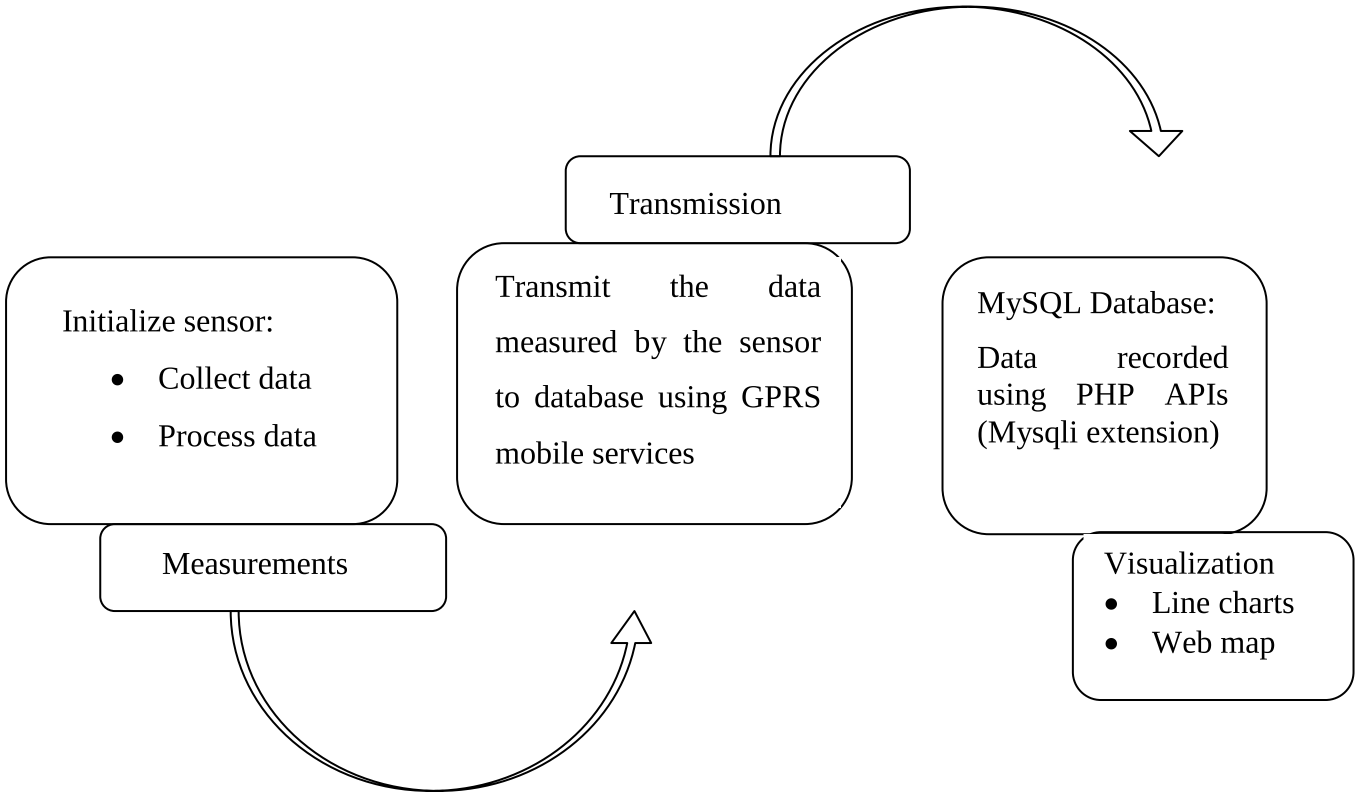

Figure 6 Simplified implementation flow diagram

3.4 Data collection and preparation

The data that was used for this application to develop them web map was obtained in a shapefile format. This data was then converted to geojson file format which allowed for easy data overlay on the basemap which in this case was google maps.

Then a few locations were digitized along the water network and a shapefile of point data was obtained. Figure 7 below shows the shapefile for the points which was also converted and added as a layer on the basemap. This layer represented the web map locations along the water networks of the sensors used in programming of the application. On the web map application the points were symbolized with green markers and more features added to them.

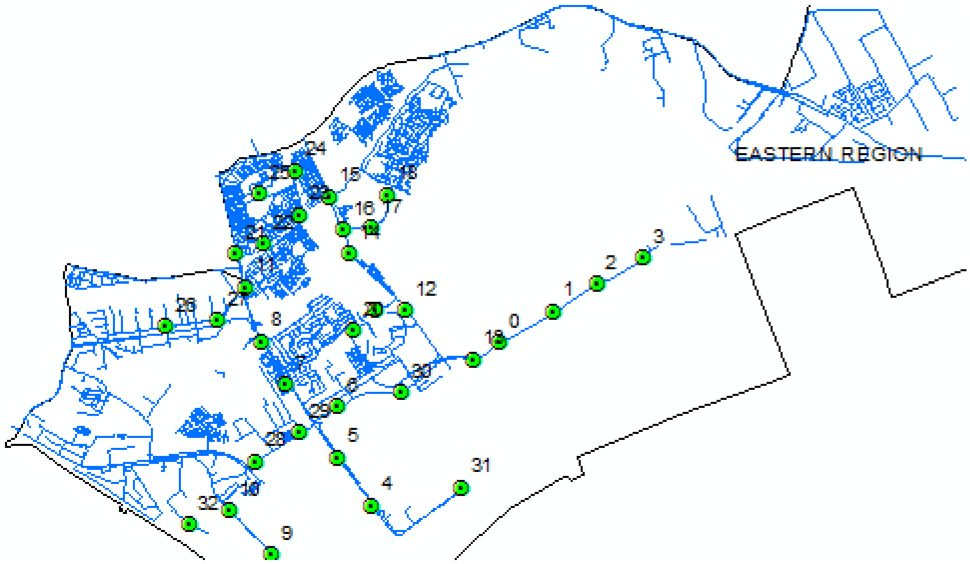

Figure 7 Sensor location adopted in programming the web application

3.5 Prototype system design: 3-tier architecture

A 3-tier architectural system represents a server-side, database and a client-side system as show in figure 8 below.

The server-side involves the microcontroller board on which the GPRS shield is mounted with a cable connection to the waterflow sensor. This side collects and interprets the impulses using a program and then sends this data to the database tables.

The database adopted in the development of this application was MySQL database that is hosted by the apache server. All the data is stored in the tables that were created in the database.

The last section of the 3-tier is the client side which contains the basemap, layers and the water flow information which is available to clients viewing the website for information.

The test of the application was done in Jkuat university ground where the sensor was fixed to a tap with running water. Then the client viewer stationed at the laboratory of the geomatic engineering department used the web map interface to interact with the application and view the data recorded by the sensor on the real time basis. As the water discharge changed the visualization chart displayed the same changes, thus enabling water discharge monitoring using additional technologies to web mapping application.

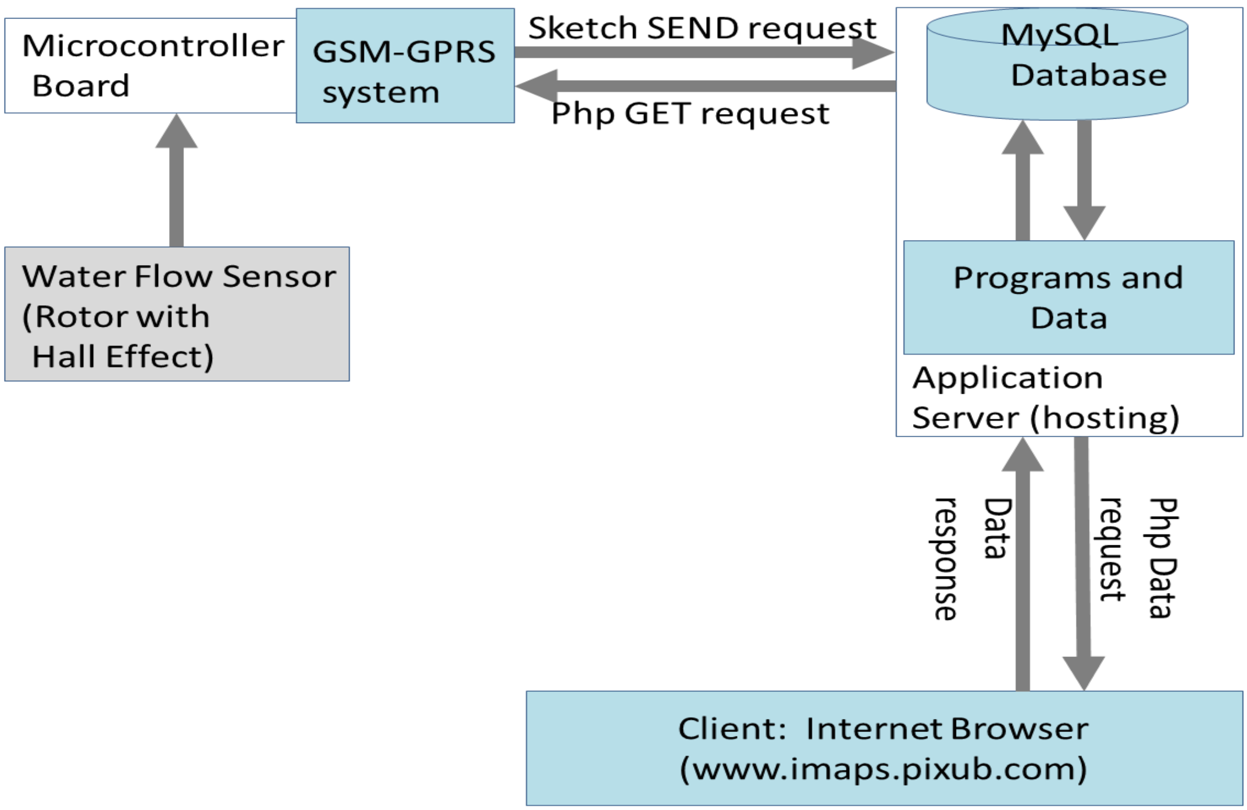

Figure 8 System design

3.6 Ground implementation

The figure 9 below is ground implementation setup recommendation for the project. The electronic gadget has lamppost height elevation to protect it from both human and natural causes such as water runoff.

The elevation also serves to enhance network connectivity of the G.P.R.S module and lastly, if a lamp is installed then it will serve as a disguise to protect the gadget from vandalism.

The sensor is supplied with the connecting cables to whereby red and black provides the electric energy required for the system to operate and the yellow cable which maintains the communication of the impulses from the sensor to the electronic gadgets for transmission to the central database system.

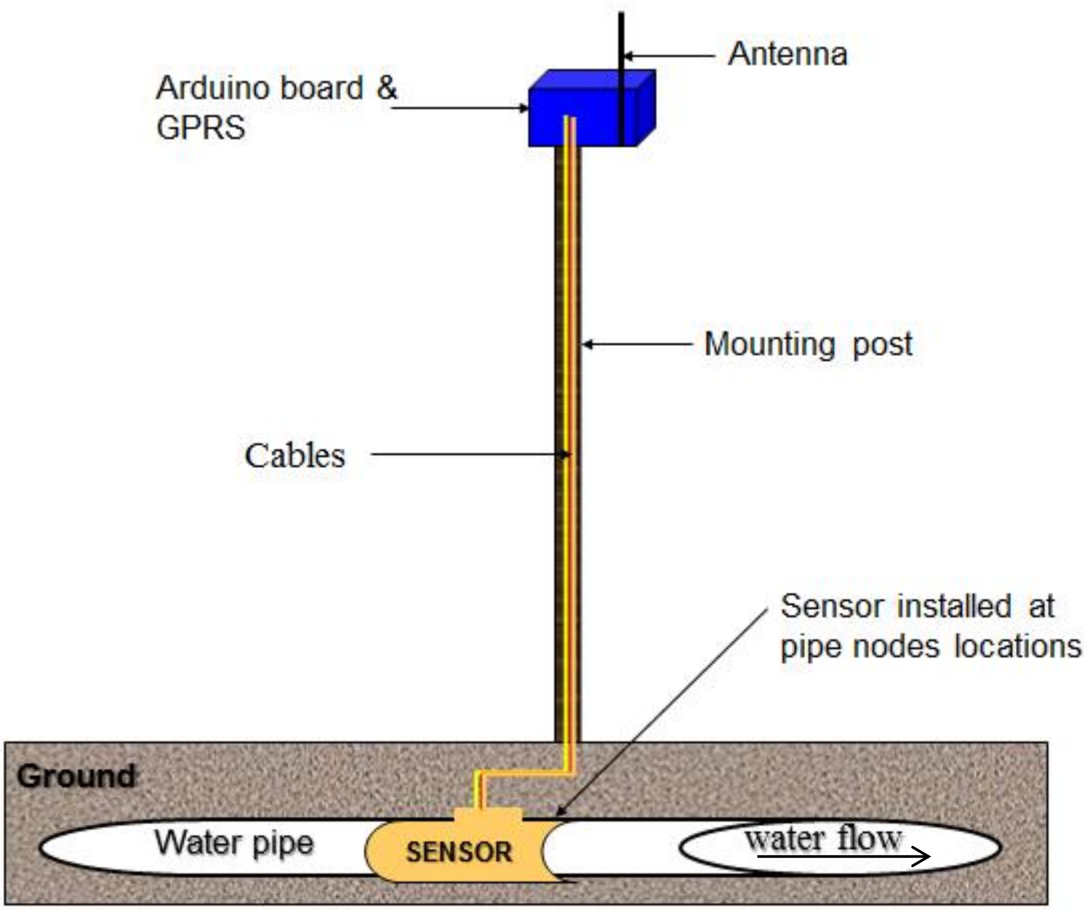

Figure 9 Ground implementation design

Chapter four: Interface customization and results

4. 1 Database results

Database provides a reliable storage space where the acquired data is stored in relational tables. The information that was stored in the datalog table included primary key id, rate of flow, discharge and time of discharge.

The table 4.1 below shows data arrangement in descending order to using the primary key, to enable retrieval of the latest values of time and volume from the table.

Sample results from the database			
Id	Rate (ml/s)	Volume(ml)	Time(yymmdd h:m:s)
59	0.2894	4.8228	2014-09-21 17:16:43
58	1.4762	24.6028	2014-09-21 17:14:53
57	0.0169	0.2809	2014-09-21 17:14:46
56	0.1770	2.9500	2014-09-21 17:07:27
55	0.3989	6.6840	2014-09-21 17:06:10
54	0.1744	2.8560	2014-09-21 17:04:59
53	0.2248	3.7465	2014-09-21 17:02:37
52	0	0	2014-09-21 17:00:53

Table 4.1 Recorded parameters

4. 2 Interface customization

Visualization of information allows for easy and convenient interpretation of the information being relayed by the sensor. Customization of the web map interface calls for the use of the cartographic expertise and presentation of accurate and reliable information. The interface was customized as shown on figure 10 which included the following features:

- Headings with onclick function call for network display, sensor location display and areal boundary display.
- Search box capabilities

- Google maps sensor locations icons
- Infobox with interactive real time charts visualization at sensor locations.
- Pop up interactions of all the map elements for displaying their properties to the user
- Pop up modal box with multiple Y-axis values for water discharge comparisons between two known locations of the sensor.
- Chart visualization with tooltip capabilities

The figure 10 above also displays some of the map application functionalities such as onclick functions of the navigation menu to display the water distribution networks, the boundary of the region which forms the study area and the adopted positions of the sensor along the water network. All the above functionalities have an enabled on click function which displays attribute information about the feature that was selected as demonstrated.

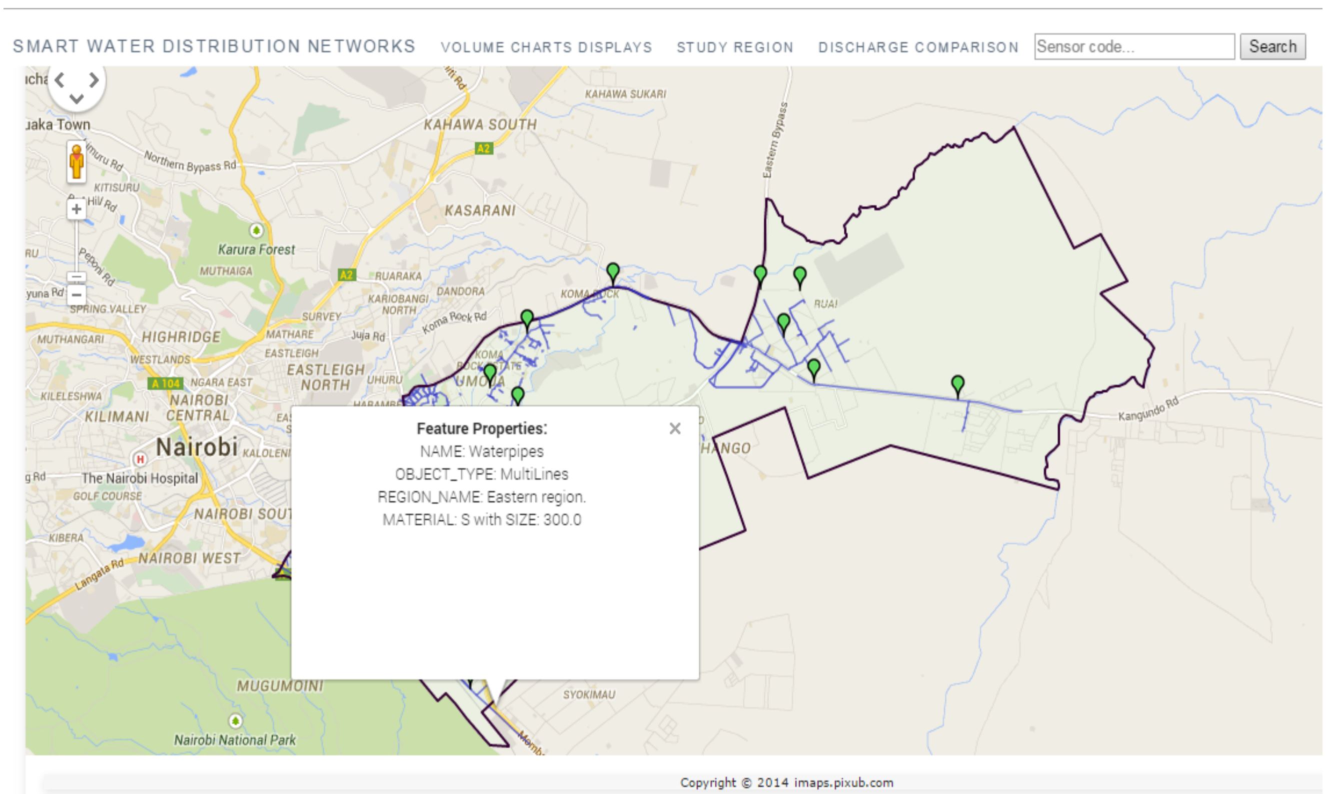

Figure 10 Website interface display

The figure 11 below shows a snapshot of an interactive real time chart visualization showing the amount of water discharge that was recorded by the sensor at the recorded time. The chart is placed within the information box alias infobox which is prompted by an onclick function propety of the sensor point markers.

The line chart visualization has water discharge as the y-axis and the time as the x-axis with a push and shift functionalities to allow the real time display effect. When the discharge value remains constant for few minutes the line chart displays a straight line graph as is the case above.

The interactivity of the chart visualization is a function of the onclick activity of the water discharge points display on the line chart which provides the user with complete description of time and the discharge value recorded at the point of query.

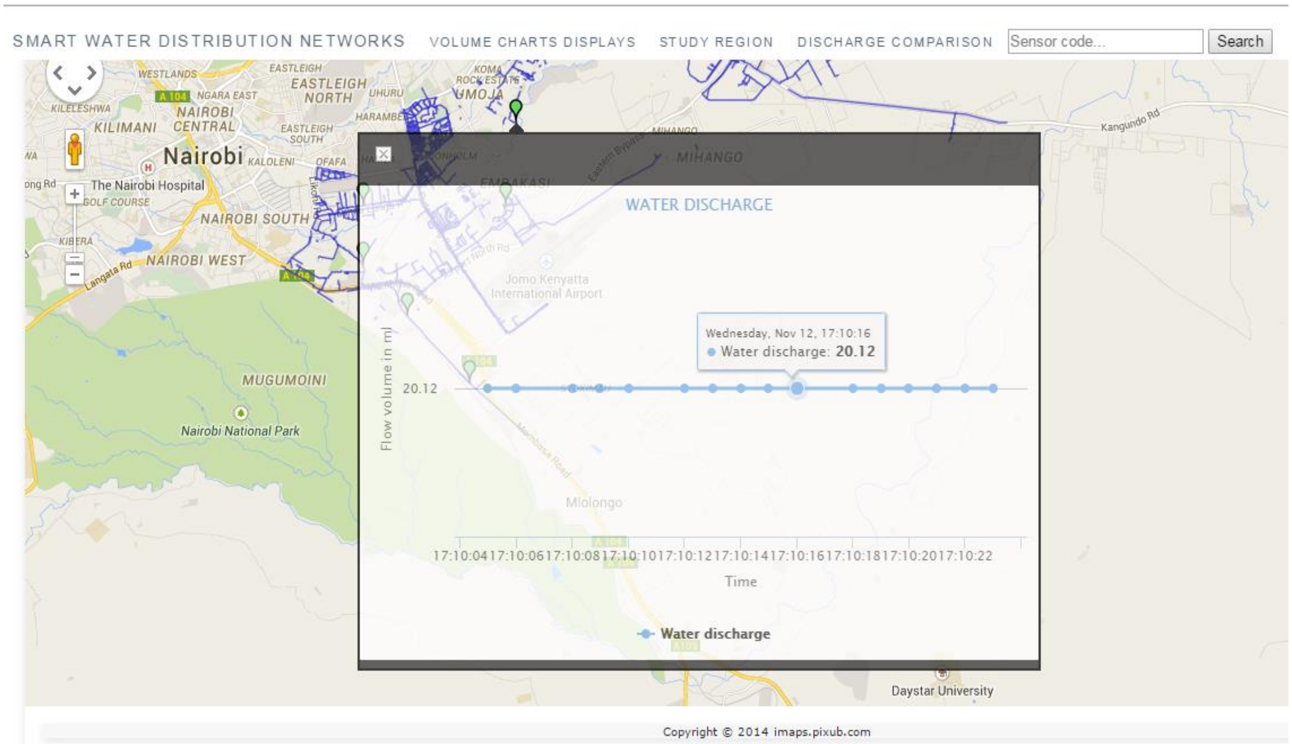

Figure 11 Sensor water discharge graph visualization

The figure 12 below displays the jQuery model dialog box which has the logic like centering events and model overlay. Model box provides an impressive way for the user to quickly view more information within the website. This model box gives the information within an element using four edges namely; the margin, border, padding, and content edge.

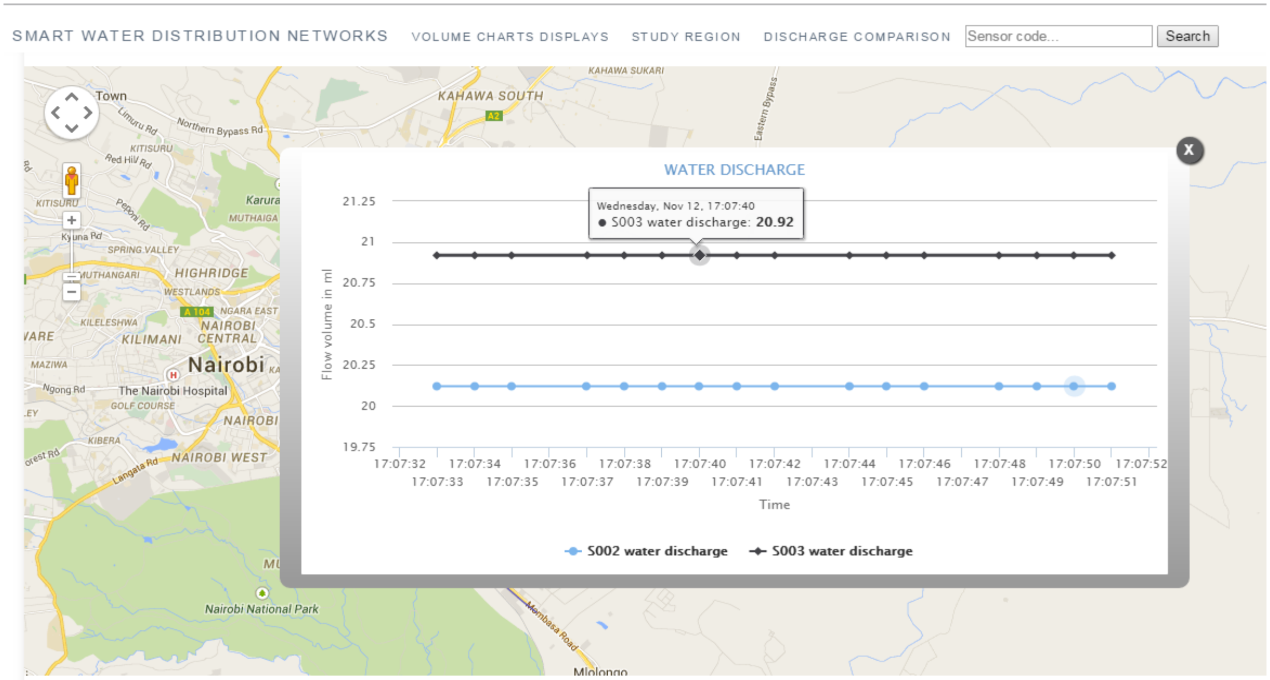

Figure 12 Sensors water discharge graph comparison.

The content area is positioned inside the content edge and contains the real content of the element. The padding area is between the content and the borders surrounding it.

The margin area is the area inside the margin edge, extends the border area and separates the element from its neighbours.

The border area is an area within the border edge with the padding area extension.

Using the modal overlay logic, the modal box provided the best option to present the multiple y-axes line graph visualization for comparison of the water discharge values between the any 2 given sensor locations. The graph also contains the tooltip capabilities to provide the user with more information about the water discharge points.

4. 3 **Results**

The real-time web-based map application for water discharge is as show in figure 13 below with interactive line chart visualizations of the amount of discharge measured by the sensor at point locations displayed on the map with point markers.

Figure 13 Website all functions visualization.

Thus, figure 13 above shows the final product of this project, point chart visualizations and sensor water discharge comparison graph visualizations with the other map elements.

Chapter five: Conclusion and recommendations

5.1 Conclusions

The development of a real time web-based map application for water discharge monitoring was successful as the main objective was met through achievement of the specific objectives. The complete set up enabled the viewer to not only view the water discharge level for a single sensor location and its comparison with another sensor locations through graphs but also to get the geographic view about the location of the sensor measuring the discharge from the field.

The combination of the water flow sensor, arduino, GPRS and web mapping tools enabled the success of this application - a spatial decision support tool for water network failures mitigation by water providers to have intelligent and targeted field searches for water network failures, thus improving the efficiency of recovery operations.

Web mapping application as a tool will go a long way in providing real time solutions in the future to the most of geospatial problems facing the world of today.

5.2 Recommendations

The recommendations for future work are as follows:

1. Further modification the SIM900 G.P.R.S signal reception to enhance the network connectivity all over the world or rather adoption of another model of the G.P.R.S shield with an aim of improving network connectivity.
2. The future research to concentrate more on the security of the website information to protect the integrity of the information displayed on the screen.
3. Develop a more intelligent real-time web-based water discharge map application to the with self-monitoring capabilities such onscreen video recording for the charts and mobile phone alert messages to the monitoring personnel when the level are below set thresholds.

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(Ria Sood, 2013)

Appendix

Websites

Website 1: Water in Kenya: Water Resources, scarcity, pollution and sanitation in Kenya. From *http://www.softkenya.com/water/* Last accessed February 6, 2015.

Website 2: *http://123doc.vn/document/1644118-practical-arduino-cool-projects-for-open-source-hardware-p20-doc.htm*. Last accessed July 14, 2014

Website 3: https://developer.mozilla.org/en-US/docs/Web/CSS/box_model. Last accessed October 23, 2014.

Website 4: http://www.wisegeek.com/what-is-water-distribution.htm. Last accessed September 9, 2014.

Website 5: *http://tirta-amertha.com/pages-3-water-distribution.html*. Last accessed December 7, 2014.

Website6:*http://charitywater.in/index.php?option=com_content&view=article&id=86&Itemid=8.* Last accessed December 7, 2014.

Website 7: http://www.imf.org/external/NP/prsp/2000/ken/01/INDEX.HTM. Last accessed July 7, 2014.

Website 8: http://www.slideshare.net/ijcsea/design-and-development-of-automatic-water-flow-meter. Last accessed August 7, 2014.

Website 9: http://vbn.aau.dk/da/publications/auxillary-fluid-flowmeter(e75d489b-2de5-4d8a-b495-c3d21139633e)/export.html. Last accessed August 1, 2014.

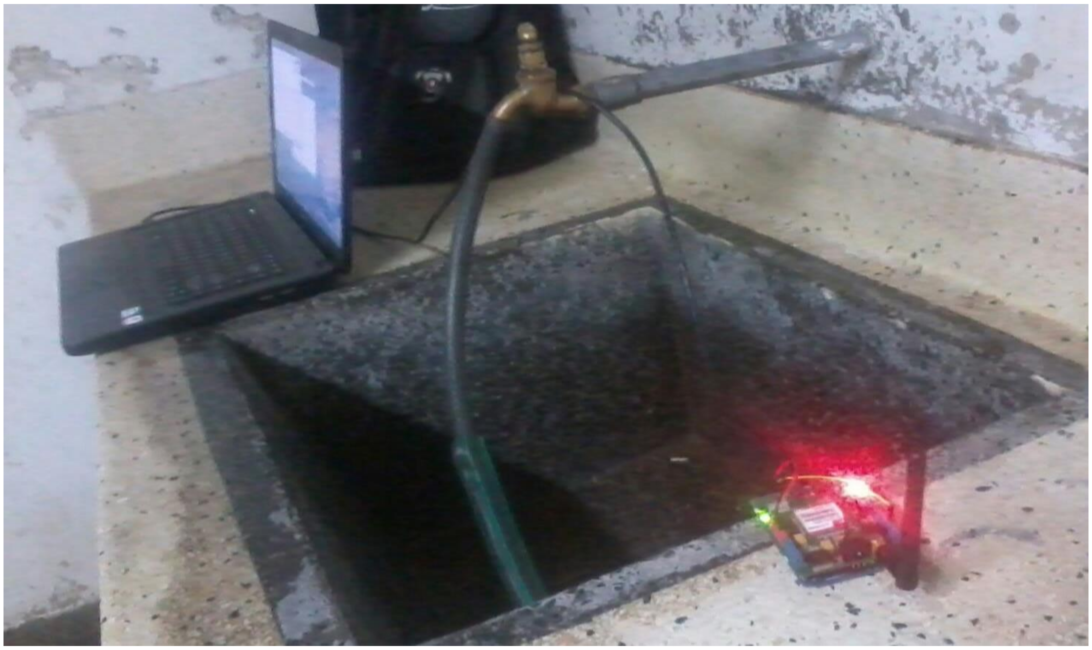
Website 10: http://en.wikipedia.org/wiki/Kenya_water_crisis. Last accessed July 28, 2014.

Website 11:http://ecx.imagesamazon.com/images/I/412Y52TABDL._SX425_.jpg Last accessed February 6, 2015

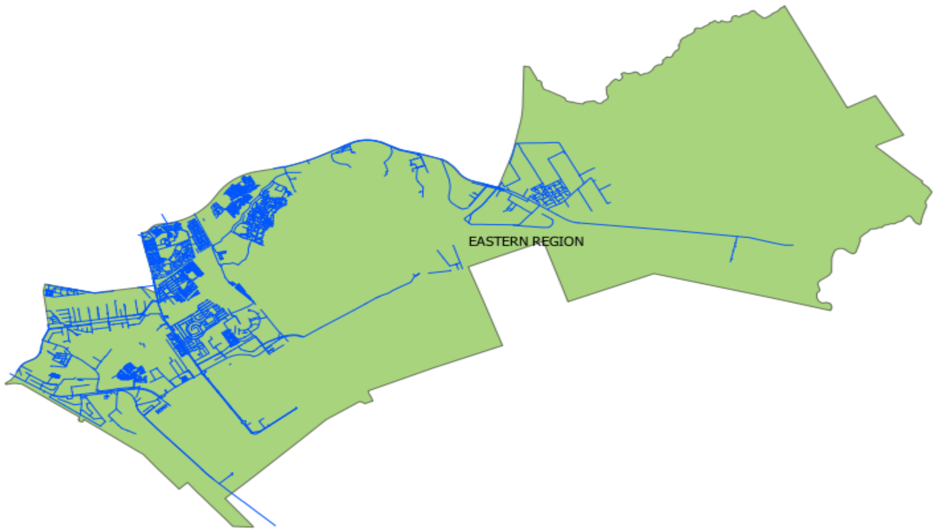
Website 12: http://arduino.cc/en/Main/arduinoBoardUno. Last accessed February 6, 2015

Website 13: http://www.geeetech.com/wiki/index.php/Arduino_GPRS_Shield. Last accessed February 6, 2015

- Module for sensor-arduino-G.P.R.S control



Water pipes network in shapefile format (.shp).



Geojson data for water network (.json)


```
"type": "MultiLineString",
"coordinates": [
[ [ 36.890539493886052 ,   -1.312483618    ]   ,   [ 36.89053402146002    ,   -1.312475024    ]]  ,
[ [ 36.891122739845898 ,   -1.313150352    ]   ,   [ 36.891144939219537   ,   -1.313136718    ]]  ,
[ [ 36.893081495649533 ,   -1.312487127    ]   ,   [ 36.893057992186094   ,   -1.312448863    ]   ,   [ 36.893009006208096   ,   -1.312375679    ]   ,
[ [36.890754233560372  ,   -1.311246162    ]   ,   [ 36.890776793349382   ,   -1.311231172    ]]  ,
[ [ 36.891122739845898 ,   -1.313150352    ]   ,   [ 36.891070521975635   ,   -1.313182313    ]   ,   [ 36.891018254375787   ,   -1.313166356    ]   ,
[ [ 36.890776793349382 ,   -1.311231172    ]   ,   [ 36.890840607773555   ,   -1.311188914    ]   ,   [ 36.890972200237421   ,   -1.311198609    ]   ,
[ [36.89053402146002   ,   -1.312475024    ]   ,   [ 36.89020890600203    ,   -1.311963926    ]   ,   [ 36.890128162075264   ,   -1.311840989    ]   ,
[ [ 36.892703229809108 ,   -1.312692673    ]   ,   [ 36.892933417009026   ,   -1.312533744    ]   ,   [ 36.893032375571572   ,   -1.312466924    ]   ,
[ [ 36.865582284723999 ,   -1.325901828    ]   ,   [ 36.865584065448452   ,   -1.325920364    ]   ,   [ 36.865584050371481   ,   -1.325937993    ]   ,
[ [36.865586818159272  ,   -1.326167817    ]   ,   [ 36.865315713764971   ,   -1.326169119    ]   ,   [ 36.865301970126637   ,   -1.326168926    ]]  ,
[ [ 36.865586818159272 ,   -1.326167817    ]   ,   [ 36.865864655040632   ,   -1.326172036    ]   ,   [ 36.865978827380211   ,   -1.326172135    ]]  ,
```


Geojson boundary data:

```
"type": "Polygon",
"coordinates": [
[
    [ 37.063555494073285, -1.205421099504041 ], [ 37.081194629920823, -1.238319261616621 ], [ 37.089135246793703, -1.23439651434177 ], [ 37.097064000884849, -1.247136833834654
]
```


Sketch programming

Configuring GPRS profile using the *AT+SAPBR* command that returns OK.

Checking the state of GPRS attachment using *AT+CGATT:* command that returns 0 when detached and 1 when attached.

Initializing HTTP service with *AT+HTTPINIT* command that returns OK or ERROR response to the execution command.

Configuring HTTP parameters with *AT+HTTPPARA* command that takes the URL and sensor string values and returns OK or ERROR response to the execution command.

Setting HTTP Method Action, GET in this case with *AT+HTTPACTION=0* command that is supposed to return OK or ERROR response to the execution command.

Reading HTTP response/data using *AT+HTTPREAD* command which is supposed to return "*1 record added*".

Closing the opened HTTP session using *AT+HTTPTERM* command that returns OK or ERROR response to the execution command.

Creating a send function that contains some of the above commands, performs the conversion of the float to string using the *dtostrf ()* that takes 4 arguments i.e. *character array*, *float precision, decimal precision and string output* and then uploading the string values to the database by printing the URL string.

PHP get request program

Data base using Mysqli in Apache database server

- Create database

Mysql=>*created database u117430912_imaps*

- Create table

Mysql=>*created datalog table with 3 columns (ID with auto-increment option, volume with float datatype and time for TIMESTAMP)*

- Get data from the URL with connection and get function as arguments using variables with escape for security after the posting.

Mysqli=> *$rate = mysqli_real_escape_string ($con, $_GET ['r']);*

Mysqli=> *$volume = mysqli_real_escape_string ($con, $_GET ['v']);*

- Populate columns with data as assigned to the variables

Mysqli=>*$sql="INSERT INTO datalog (rate, volume) VALUES ($rate, $volume)";*

- Send alert of the added data using the echo mysqli command

Mysqli=>*echo "1 record added";*

PHP fetch data program

- Query statement to fetch the latest 5 rows

Mysqli=>*$qry = $mysqli->query ('SELECT volume, time FROM datalog ORDER BY id DESC LIMIT 6');*

- Exploding by space and conversion of the time into seconds

Mysqli=>*$dt = $row ['time'];*

Mysqli=>*$date_array= explode (" ", $dt);*

Mysqli=>*$time= $date_array [1];*

Mysqli=>*$parsed = date_parse ($time);*

Mysqli=>*$seconds = $parsed ['hour'] * 3600 + $parsed ['minute'] * 60 + $parsed ['second'];*

- Fetching the results using a variable assignment and concatenation

Mysqli=>*$return = array($seconds, $dvf);*

Javascript (jquery) and html program

- Assignment of the $return values to javascript variable and declaration of the line graph properties

```
//JQuery
        $(document).ready(function() {
                chart = new Highcharts.Chart({
                        chart: {
                                renderTo: 'container',
                                defaultSeriesType: 'line',
                                events: {
                                        load: parseData
                                }
                        },
                        title: {
                                text: 'water discharge'
```