UNIVERSITY OF NAIROBI
SCHOOL OF COMPUTING AND INFORMATICS

USE OF GIS FOR FOOD EMERGENCY RESPONSE

By

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July 2012

A project report submitted in partial fulfillment for the requirements of Master
of Science in Information Systems of the University of Nairobi

Declaration

I, declare that this is my original work achieved through my personal study and research. To the best of my knowledge, it has never been submitted to any other college or university by anybody else for any purpose. All information from other sources has been duly acknowledged. Am solely responsible for any errors of commission or omission that may be in this dissertation. Am also solely responsible for the conclusions reached in this dissertation.

Signed _____   Date __14/11/2012__

(Benjamin Otieno) Reg. No P56/7362/2006

This project has been submitted for examination as partial fulfillment to the requirements of the Masters of Science in Information Systems course of the University of Nairobi with my approval as the University supervisor.

Signed _____   Date __14 Nov 2012__

(Christopher Moturi)

Acknowledgements

I sincerely acknowledge the contribution of my supervisor, Mr Christopher Moturi to the realization of this work. I also with gratitude acknowledge the contribution of all the project examination panelists, Lawrence Muchemi, Peter Wagacha, Dan Orwa and Joseph Ogutu, whose positive criticism made it possible for me to complete this project and attain the expected standards. Lastly I acknowledge my fellow students whose contributions through the collaborations was of great value.

Dedication

With thanks to Lydia, Hiram and Hope, your patience, sacrifice and inspiration made this happen. You all have made life worth living

Abstract

This research presents a framework for food emergency response and uses a Geographical Information System (GIS) prototype to demonstrate how the framework can be applied in planning for and managing food emergencies.

The framework is based on the WHO/FAO Multiagency Coordination Group Framework, which was contextualized to fit the Kenyan setup. A GIS system that can be used for early warning, emergency planning and emergency management was designed based on the framework. The GIS was tested against data obtained from the relevant government agencies charged with management of food emergencies.

The framework developed can be used not only in food emergencies but also in other emergencies such as fires, floods, famine, road accidents, collapsing buildings etc. The framework can be a key element of a national policy on food emergency response in Kenya which currently does not exist.

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Definition of terms

Food security: when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life

Food emergency response: actions taken to contain food emergencies, including food aid distribution

Food emergency: A situation, whether accidental or intentional, that is identified by a competent authority as constituting a serious and as yet uncontrolled foodborne risk to public health that requires urgent action.

Food availability is achieved when sufficient quantities of food are consistently available to all individuals within a country.

Food access is ensured when households and all individuals within them have adequate resources to obtain appropriate food for a nutritional diet.

Food utilization is the proper biological use of food, requiring a diet providing sufficient energy and essential nutrients, portable water, and adequate sanitation.

Abbreviations

APEC	Asia Pacific Economic Cooperation
CBO	Community Based Organization
DMC	Drought Monitoring Centres
ETC	Emergency Telecommunication Cluster
FAO	Food and Agricultural Organization
FSNS	National Food and Nutrition Secretariat
GIS	Geographic Information System
ICCFN	Inter-ministerial Coordinating Committee on Food and Nutrition
ICT	Information and Communication Technology
IGAD	The Inter-governmental Authority on Development
ITU	International Technology Union
KNBS	Kenya National Bureau of Statistics
KRC	Kenya Red Cross
MACG	Multi-Agency Coordinating Group
MDG	Millennium Development Goals
MENR	Ministry of Environment and Natural Resource
MOA	Ministry of Agriculture
MOE	Ministry of Education
MOF	Ministry of Finance
MOH	Ministry of Health
MOLFD	Ministry of Livestock and Fisheries Development
MORPW	Ministry of Roads and Public Works
MOTI	Ministry of Trade and Industry
MoWI	Ministry of Water and Irrigation
NCPB	National Cereals and Produce Board
NFNS	Food Security and Nutrition Strategy
NFSNSC	Food Security and Nutritional Steering Committee
NFSNEC	National Food Security and Nutritional Executive Committee
NGO	Non-Government Organization

NSIS	National Security Intelligent Service
OP	Office of the President
PDS	Public Distribution System
PRSP	Poverty Reduction Strategy papers
SADC	Southern Africa Development Corporation
UN	United Nations
UNDP	United Nations Development Programme
USAID	United States Development Agency
WFP	World Food Program
WHO	World Health Organization

CHAPTER 1: INTRODUCTION

1.0 Background

Many African nations have had several challenges such as political unrests, tribal clashes, economic catastrophes, etc. The challenges are nearly uniform across nations but not one solution to any of these challenges can fit all circumstances. Kenya has also had its fair share of challenges. Apart from political challenges which almost saw Kenya precipitate into a lawless jungle, there is one perennial plague in Kenya called famine.

Food security, according to FAO (Rivera W., Qamar K., 2003), is defined in terms of food availability, access and utilization.

Food security, which refers to food availability, food access and food utilization, according to the World Food Summit organized in Rome in 1996, is deemed to exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life (**Boon E.K.**, 2010).

The government and non-government agencies have made several steps in moving away from food emergencies. However, it is still a reality that food emergencies are common-place in Kenya, and as such, we have always resorted to food distributions in emergencies.

In the past, both government agencies such as the army, and non-government agencies such as Kenya Red Cross (KRC) and United States Development Agency (USAID) have come in strongly to carry out the emergency food distributions. At these times of emergencies, there are always natural deterrents to smooth flow of this aid food. Such deterrents include floods, bad roads, bandits, poor communication, among others.

To limit the number of people who die as a result of the food aid not reaching the famine stricken areas, proper coordination of food emergency response should be done. A mapping of the areas that require the food aid and the areas where the food can be found, the terrain, the populations, etc should be clearly done if this food aid distribution is to be done efficiently. ICT can make this mapping quite effective by ensuring availability of reliable data for the agencies planning the food emergency response.

1.1 Problem Statement

Food availability, access and utilization are still problems that plague Kenya. As long as they have not been completely resolved, food crises shall always be present in Kenya. The manner in which these food crises are managed is very important since they affect lives directly.

The handling of these food crises is done through food aid. The timely distribution of this food aid is very important. One of the biggest problems in these crises is coordination and inadequate information. There are many instances where food has been available in other parts of the country whereas other parts of the country face starvation. Yet there are some times when the agencies tasked with monitoring the food situation in the country identify food crises very late.

1.2 Objectives

Main Objective

The main objective of this research was to identify a framework for food emergency response and design a system that would be used in planning for and managing food emergencies in Kenya, using Geographic Information System (GIS).

Specific objectives

To achieve the broad objective stated above, the following were the specific aims of the research:

1. To identify and contextualize a framework to assist in an efficient food emergency response in Kenya.

2. To establish essential information needed to respond to food emergencies.

3. To develop a prototype system that can be used for early warning, monitoring, surveillance and logistics in times of emergency.

4. To test the prototype system

1.3 Justification

As put correctly by Boon, "more food production does not necessarily mean more food for those who need it." (**Boon E.K.**, 2010). As the government makes efforts to address the three components of food security – availability, access and utilization, and as long as famines are experienced in Kenya, food emergencies will always be present. And for Kenyans not to die in times of such food crises, proper coordination before and during food emergencies must be properly done.

This research aimed at making sure that the effect of famine is least felt as a result of well-coordinated food emergency response. The research sought to avail a tool to be used by the various players in making decisions based on accurate information.

1.4 Research Questions

The questions being answered by the research were:

- What is the appropriate framework that can serve the purpose of planning for, managing and evaluating food emergencies in Kenya?
- What data can be mapped on a GIS for the purpose of planning for, managing and evaluating cases of food emergency in Kenya?

1.5 Significance of the research to the audience

This research targeted the government, and-non government agencies that manage food emergency response. With a GIS tool, they would be able to plan for food emergencies, and carry out food aid distribution to the required spots in timely manner avoiding wastages and delays.

The research also aimed at providing a framework and a tool to the government agencies that do planning to budget for food aid for the areas that from time to time are registered as hot spots by the mapping tool. This way, planning for food emergency response can be planned ahead of the catastrophe happening.

CHAPTER 2: LITERATURE REVIEW

2.0 Food and poverty

Poverty reduction is the first pillar on the Millennium Development Goals (MDG) adopted by many countries. Kenya has poverty reduction prominently featuring on its MDG (GOK, 2005). The prominence of poverty reduction in development goals is a show that poverty is a major impediment to development. Or looked at the other way, development cannot co-exist with poverty. It is common knowledge that poverty and food insecurity go hand in hand and solving the poverty problem is as good as solving the food insecurity problem.

2.1 Food Mapping

This includes mapping agricultural production and food shortages, and establishing comprehensive databases (Romero A.F., 2009).

The statistics on famine and agricultural production need to be mapped for the country and a monitoring mechanism put in place. This should be done at household level with data such as vegetation, productivity, yield forecasts, among others, being monitored.

This has been effectively implemented in India where the government participates at policy level even at the basest level of mapping out environmentally degraded lands at village levels. This is done by the ministry of Rural Development and Poverty Alleviation resulting in the maintenance of

- Scale of mapping
- GIS database layers
- Digital domains
- Classification system comprising of:
  i.   Gullied and/or ravinous land
  ii. Land with or without scrub

iii.   Waterlogged and marshy land
   iv.   Land affected by salinity/alkalinity coastal/inland
   v.   Shifting Cultivation area
   vi.   Under-utilized/degraded notified forest land
   vii.   Degraded pastures/grazing land.
  viii.   Degraded land under plantation crops
   ix.   Sands - Desertic /coastal
   x.   Mining/industrial wastelands
   xi.   Barren Rocky/Stony waste/sheet rock area
   xii.   Steep sloping area
  xiii.   Snow covered and/or glacial area

   (Jayaraman V. & Srisastava S.K., 2003)

A lot can be learnt from India, where the government has played an active role in ensuring food access to its citizens. The South Asia Public Distribution System (PDS) ensured equitable food access in India, even during the fiercest drought in 1987 (Kumar M., 2011).

To support governments to do mapping for the purpose of food supplies in case of emergencies, United Nations through ITU has set up a number of early warning systems. Drought Monitoring Centres (DMC) – SADC/IGAD is one such, serving East Africa (Romero A.F., 2009).

Even though the UN has set up the Emergency Telecommunication Cluster (ETC) to ensure the availability of predictable, robust and reliable ICT infrastructure and services (Romero A.F., 2009), the big question is whether the Kenya government really believes that ICT can be used to alleviate food insecurity.

This same question, whether governments believe that ICT can help alleviate poverty, and transitively, food insecurity, is exposed by the United Nations in a paper (UNDP, 2005). The paper views ICT in two aspects – as an enabler and as a sector.
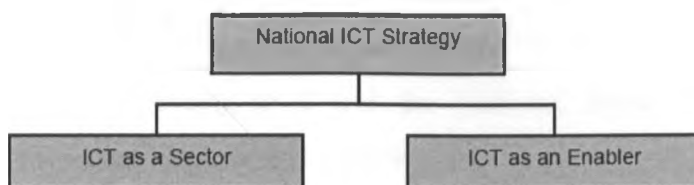
Figure 1: ICT as a sector and an enabler (Source: UNDP, 2005)

Most governments, Kenya included, view ICTs as being effective in alleviating poverty, both as a sector and as an enabler. For this reason, ICT features prominently in many countries' Poverty Reduction Strategy papers (PRSP). The manner in which ICT is used in PRSP is what varies (**UNDP**, 2005). It is unfortunate that in Kenya, ICT is not seen as an enabler in solving the problem of food insecurity.

ICTs can also be used in strengthening the role of supply chains in food security (Romero A.F., 2009). Essentially, ICTs can be used as an enabler, both locally and globally/nationally, in addressing food emergencies in Kenya.

There are many initiatives that have been made towards achieving adequate food availability using ICT as a catalyst. Whether the ICTs being used are appropriate or whether the content is appropriate is to be ascertained (not in this research).

2.2 The government role in emergencies
Food insecurity in Kenya is such a grave issue, with about a third of the country's population being food insecure (GOK, 2008). The government food security and nutrition strategy (FSNS) puts the blame on diminishing growth of agricultural production among other reasons.

In the government FSNS, there is an institution called National Food Security and Nutritional Executive Committee (NFSNEC). The NFSNEC coordinates the various aspects of food security using multi-agency model coordinated by an

Inter-ministerial Coordinating Committee on Food and Nutrition (ICCFN). The NFSNEC has the National Food Security and Nutritional Steering Committee (NFSNSC) reporting to it and the National Food and Nutrition Secretariat (NFNS) in turn reports to NFSNSC.

NFNS coordinates the various agencies domiciled in various ministries through the ICCFN. The agency in charge of emergencies is domiciled in the office of the president (OP).

2.3 Food emergency

The official definition of food emergency according to the Codex Alimentarius is:

> A situation, whether accidental or intentional, that is identified by a competent authority as constituting a serious and as yet uncontrolled foodborne risk to public health that requires urgent action. (FAO/WHO, 2010)

This definition means different things to different countries and in Kenya it is usually defined when the government declares famine a national disaster.

Food emergencies come about as an evolution from business as usual state to a crisis state.

Figure 2: Evolution of food emergency

The last two stages – emergency and crisis – need central coordination (FAO/WHO, 2010).

In Kenya, we have seen situation evolve from business as usual to crisis level culminating in need for food emergency response. This research focuses on

exploring the use of GIS in managing the emergencies before they turn into crises.

2.4 Food aid

Food aid, according to USAID, is meant to achieve one of the several goals. The development goal being achieved determines the type of food aid program to be adopted. (Riely et al, 1999).

Kenya has in the past been aided by several channels to address food crises. In 2004, the army was used to distribute food to Eastern Province (IRIN, 2011). In 2006, Oxfam assisted in addressing food crisis in Kenya. The issue of lack of 'Single Pipeline', which would have ensured efficient aid delivery, was missing. This led to a lot of wastage as the government had set up parallel processes to supply extra food. (Oxfam, 2011)

The various intervention methods/programs used are:

2.4.0 Humanitarian Feeding (HUM)

In these programs food (or cash in isolated cases) is distributed directly to disadvantaged groups, or those severely affected by emergency conditions.

2.4.1 Food-for-Work (FFW)

Food-for-Work programs use food aid as payment for laborers in public works programs designed to build and maintain local infrastructure (e.g., roads, dams, wells, latrines, schools). Cash from monetization proceeds may also be used to purchase inputs or as cash wages in cash-for-work (CFW) programs.

2.4.2 Maternal and Child Health (MCH)

In MCH programs, food aid provides supplementary rations in programs seeking to improve the health and nutritional status of, typically, pregnant and lactating mothers and children under the age of five. Most MCH programs combine food aid with other elements such as nutrition and health education,

growth monitoring and counseling, and immunization, which may, in part, be funded through monetization proceeds.

2.4.3 Child Survival (CS)

In CS programs, food aid is used for supplementary rations and, from monetization funds, other inputs in efforts targeted primarily to improving the health and nutrition of children, including child immunizations, control of diarrheal diseases and acute respiratory infections, and the promotion of breastfeeding.

2.4.4 School Feeding (SF)

School feeding programs provide students with snacks, lunches, and/or breakfasts at schools as incentives to increase enrollment, maintain attendance, and improve the performance of students.

2.4.5 Other Child Feeding (OCF)

OCF programs provide meals to particularly vulnerable groups of children outside the school setting.

2.4.6 Monetization (MON)

The sale of food aid through monetization programs provides financial resources for use in a variety of activities, including education and training, health and nutrition, agriculture, rural credit, microenterprise, cash-for-work, and other development programs.

(Riely et al, 1999).

The most common intervention method used in Kenya during food emergencies is Humanitarian Feeding (HUM). In this case, either food aid donated by foreign donors or food from the national cereal stores is moved to the stricken areas and distributed to the affected populations. In this case, logistics becomes of essence.

2.5 FAO/WHO Framework

FAO/WHO presents a framework to be used by governments in coming up with national food safety emergency response plans. The framework advocates for countries to take into account the general considerations that would require the incidents to be managed in a tiered manner, first at local level, then to the national level when the incident become unmanageable. It also prods countries to take into account country specific considerations as food crises mean different things to different countries.

2.5.0 Elements of Emergency Response

In the FAO/WHO framework, there are five key elements that make up the response plan. These are:

- Essential background information
- Incident identification
- Incident management
- Post incident review and evaluation
- Communication

The framework was designed to assist countries that don't have food safety emergency response plans come up with such plans, and was designed by FAO in reference to countries that already have elaborate strategies and plans such as USA, UK, Ireland, Australia, Canada and France.

This research made use of the key elements elaborated in the FAO/WHO framework in coming up with Kenya GIS maps for emergency food response.

2.5.1 Essential background information

The first element emphasizes the use of a coordinated approach. The approach put forth in the FAO/WHO framework, and that was adopted and contextualized to the Kenyan setup in this research. This also encompassed the

use of multiagency coordinating group (MACG) involving relevant government agencies. (FAO/WHO, 2010).

The other four elements in turn are meant to be effected by designated agencies in the MACG in a coordinated way. This MACG structure is also recognized by the Kenya government in the food security and nutrition (FSN) strategy. In this strategy, the government confirms that in the past, it had failed by letting each ministry or agency act in isolation. The FSN strategy goes for a multi-sectorial approach in its implementation, similar to the MACG in the FAO/WHO framework (GOK, 2008).

The sectors identified as players in the FSN strategy are:
- Office of the President.
- MOA, MOLFD, MOH, MoWI, MOE MOF, MORPW, MOTI, MENR, private sector, NGOs/CBOs, development partners, communities.

2.5.2 Incident Identification

Monitoring systems have to be in place ahead of identification of a crisis. FAO/WHO cites food industry, trading partners, laboratory reports, public health surveillance, hospital admission reports, consumer complaints, environmental monitoring, national food safety monitoring and surveillance programmes, international notification and media monitoring as some of the sources from which an emergency can be identified. (FAO/WHO, 2010)

In Kenya, monitoring is coordinated by the Office of the President, though it touches on various government ministries. (GOK, 2008)

When an incident has been identified, it needs to be validated before deciding on the next course of action. This validation, according to FAO/WHO, can be best done by the MACG using a risk based framework. The Kenya FSN

strategy has documented the risk analysis and evaluation matrix that can be used in such a case (GOK, 2008).

2.5.3 Incident Management

Once identified as an incident, the management of the incident has to be put in place. During this phase, the overall control of the incident should be done in a controlled manner by the MACG. The investigating agency, which is the MOH and NSIS (OP) should work closely with the MACG to enable the MACG to effectively coordinate and review the information in order to determine the appropriate risk management action.

Adequate and timely information is needed at this stage to ensure minimal casualties. With the accurate and timely information, the MACG will be able to manage the risk by means of food distribution and at the same time manage any emerging health risks emanating from the food aid.

2.5.4 Post-incident Review and Evaluation

Lessons learnt from the incident should be evaluated to be used in averting future crises. FAO/WHO suggests evaluation of the response activities in order to strengthen the communication protocols, regulatory procedures, capacity and reporting, etc.

2.5.4 Communication

Communication strategies should be well documented. The communication with partners, stakeholders, and international organizations should be well documented to avoid confusion during emergencies.

2.6 Use of GIS

GIS has been used extensively in the past with great success in poverty mapping. A good example where this has worked with great success is in India (Jayaraman V. & Srisastava S.K., 2003).

Use of poverty maps can effectively help in planning. In South Africa for example, the use of GIS maps in 1999 revealed that there was a correlation between cholera and poverty, thus providing an easy way of managing cholera outbreaks (UNECA, 2005).

In this research, use of multi-layered maps will be employed in mapping the various aspects of food emergency that will feed the MACG for the purpose of decision making.
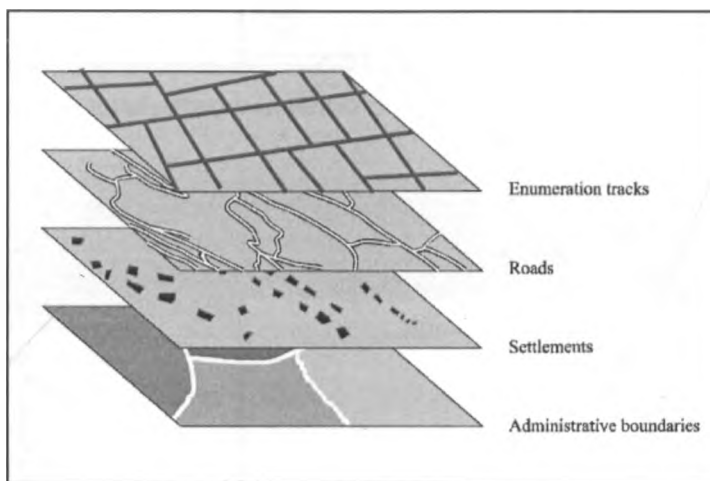
Figure 3: Map layer concept in GIS (Source: UNECA, 2005)

A combination of layers was used to give insight on how to handle the food crises, providing the decision makers with good decision making tools. For example, a layer of demographics, combined with roads layout, water bodies spread, etc to provide an insightful decision making basis.
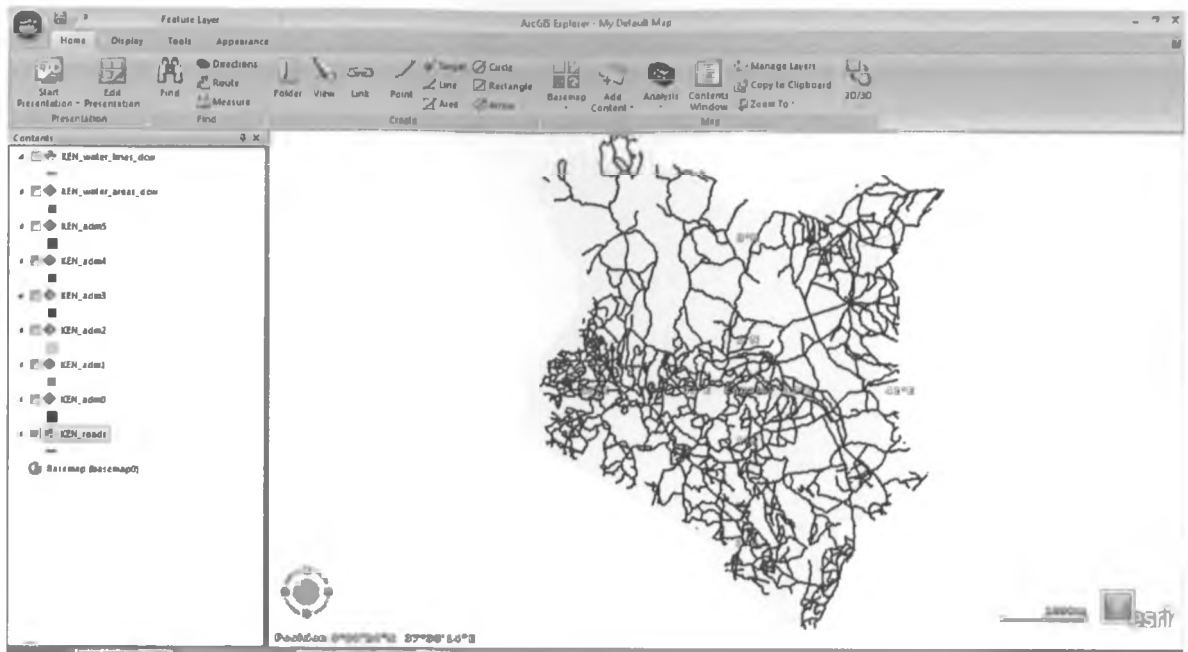
Figure 4: Road network in Kenya

Figure 5: Water bodies distribution in Kenya
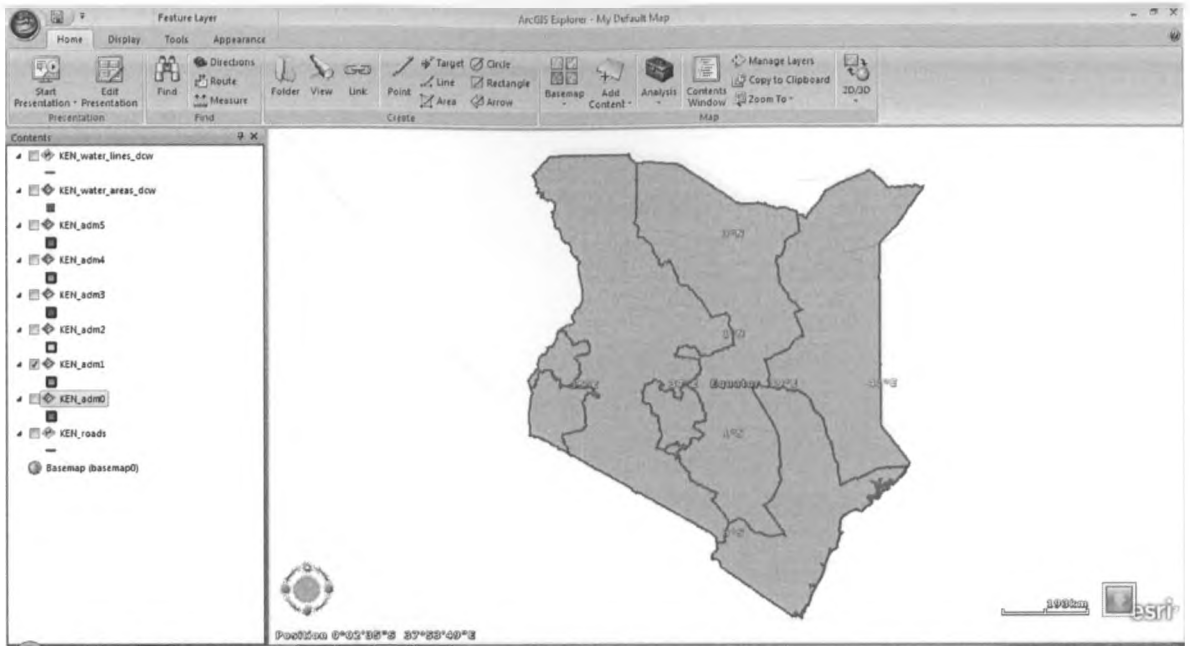
Figure 6: Provincial Administrative boundaries in Kenya
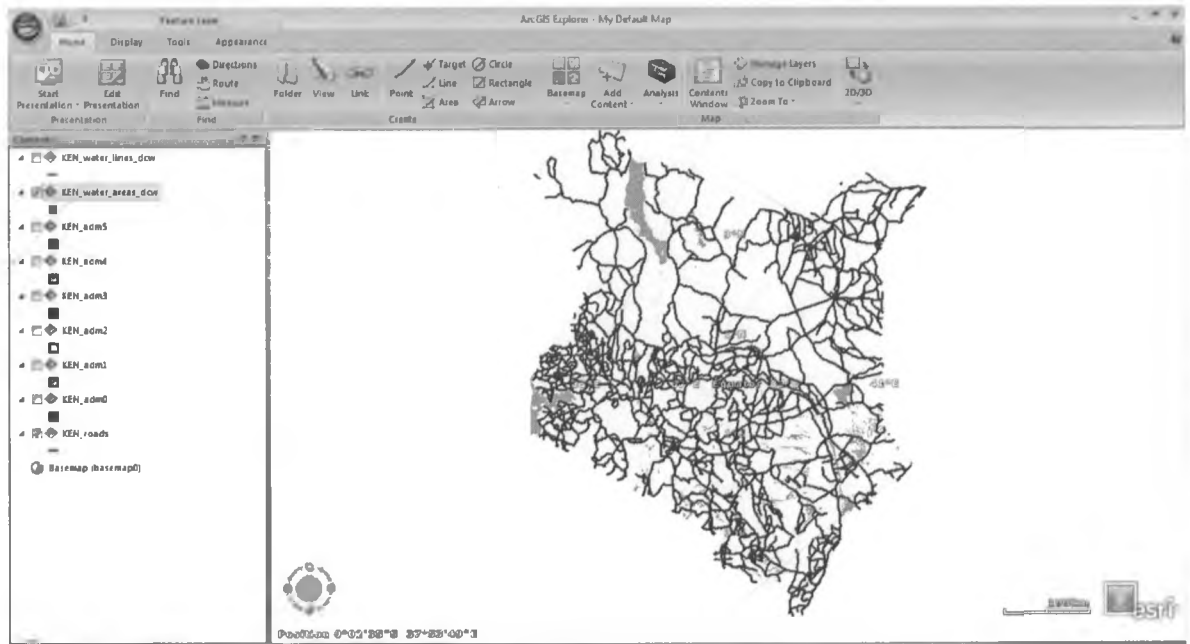
Figure 7: Combination of water bodies and roads network in Kenya
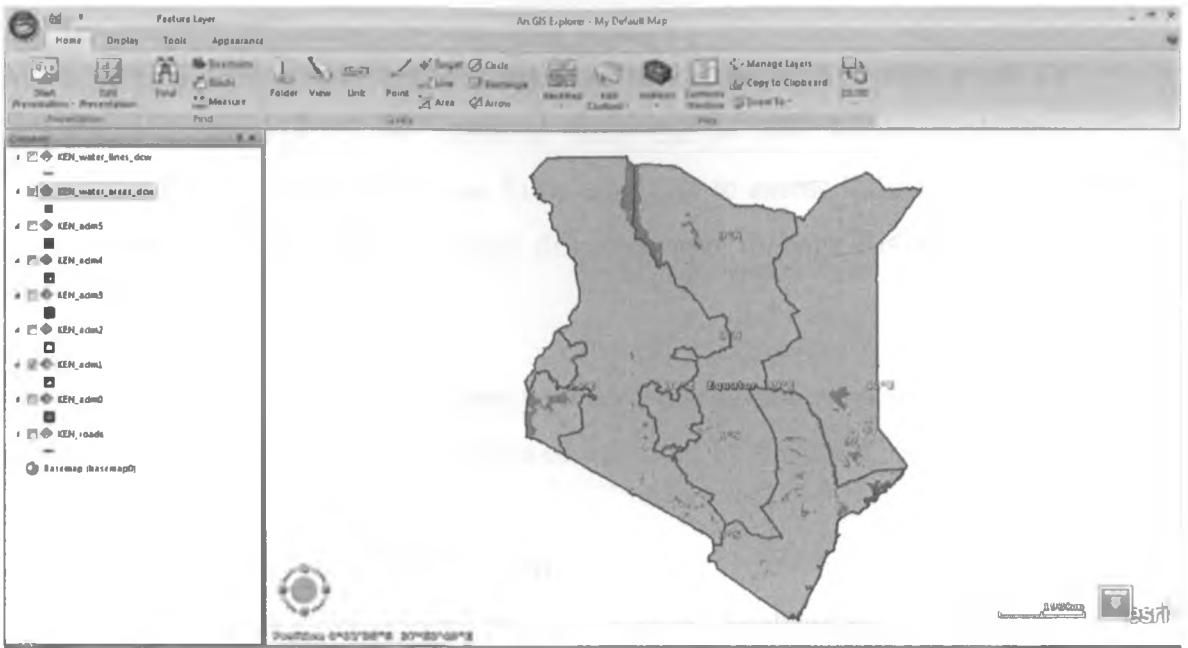
Figure 8: Combination of water bodies and provincial administrative boundaries in Kenya

Figure 9: Combination of roads network, water bodies and county administrative boundaries in Kenya

Combined with data relating to food demand and uptake, these maps were used to provide more meaning to the MACG in managing food safety emergency response.

2.7 GIS Based Food Emergency Response Studies

India, having had a number of calamities and backed up with good IT infrastructure, has reaped the fruits of using GIS to plan for its exploding population in times of emergencies. India uses GIS to assess industry sectors, foresee possible losses under natural disasters, and manage disasters when they happen. (Navya, 2012)

The United States Development Agency (USDA) has a framework for the use of GIS in food emergency response. This is coordinated by the Food Security Unit (FSU). Its initiatives include:

- Rapid alert and notification system
- School food safety programs based on Hazard Analysis and Critical Control Point principles
- Food defense (or Bioterrorism) training and tools for FNS nutrition assistance programs

The dataflow in their GIS response strategy is as illustrated in the figure below:
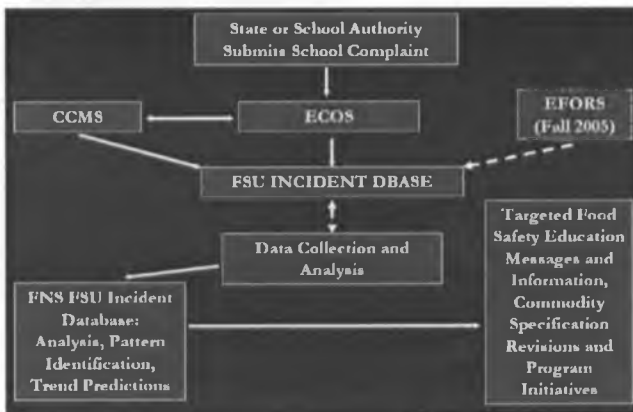
Figure 10: ICT as a sector and an enabler (Source: FNS USDA, 2005)

In Kenya, baby steps have been taken towards harnessing GIS in emergency response. Kenya Red Cross in collaboration with Masinde Muliro University in 2009 did field based simulation of emergency cases including:

- Camp Management and Coordination – Campsite Selection; Security and Communication; Good Enough/Sphere Standards in Emergencies
- Protection and Tracing/Re-unification in Emergencies
- Psychosocial Support in Emergencies

- Disaster Risk Reduction Strategies
- Contingency Planning and Early Warning/Action Systems
- Emergency Needs Assessment and Response tools
- Public Health (WASH) in Emergencies; Leadership
- Communication and Media handling in emergencies
- Inventory Management in Emergencies; First Aid Skills in Emergencies; Team Building in Emergencies
- Community Disaster Preparedness Planning and Response
- Psycho-social care in Emergencies
- Search, Rescue and Recovery in Emergencies
- GIS Mapping and map reading
- Evacuation in Emergencies

In these simulations, use of GIS was limited to mapping and map reading only. (DIMPHIS Kenya, 2012)

2.8 Research Framework

To address a food emergency situation, FAO recommends a multiagency response strategy. In this strategy, the various sectors/agencies each play a role in:

- Availing essential background information
- Identifying the food safety incident
- Managing the incident
- Managing the post incident review and evaluation
- Coordinating the communication between the various players
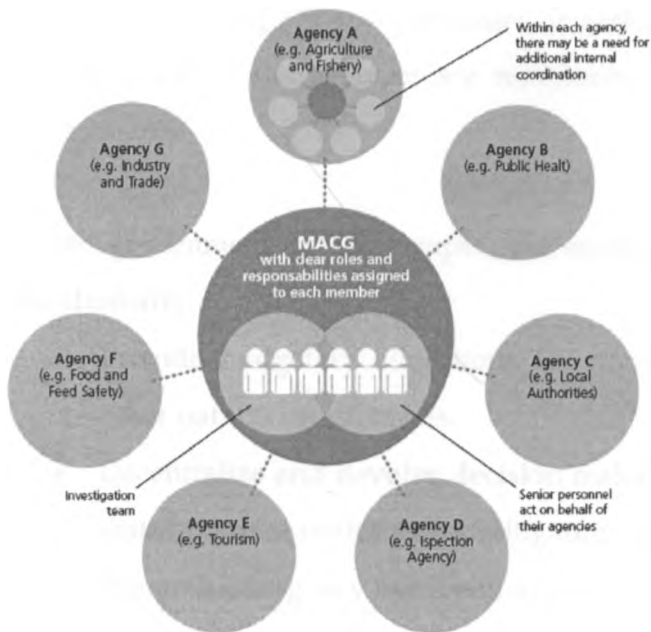
Figure 11: Multiagency coordination group (MACG) (Source: FAO/WHO, 2010)

In the Kenyan context, the agencies were mapped as below:
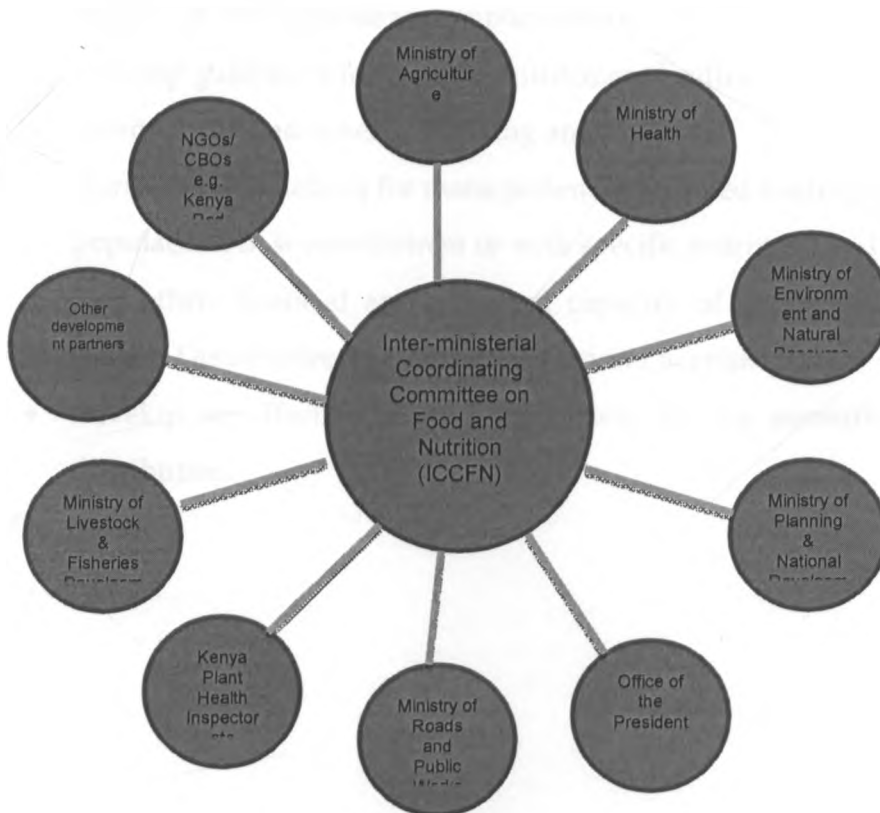
Figure 12: Multiagency coordination group (MACG) proposed for the Kenya context

Each agency being either a consumer or generator of information in the GIS system. Some of the agencies are represented by committees, parastatals or departments.

In the government strategy paper, the strategic interventions in emergency situation are:

- Provide budgetary allocations for prompt response to droughts and other natural catastrophes.
- Decentralize and devolve decision making on acquisition, targeting and distribution of resources for mitigating catastrophes.
- Promote emergency intervention programs that provide nutritious foods according to different physiological and regional needs.
- Promote timely de-stocking, emergency off-take, and disease control activities for sustenance of livelihood support systems through the support of both private and public sectors.
- Develop guidelines for transfer entitlements with a view to harmonizing coordination and synergy building among actors.
- Harmonize guidelines for management of targeted feeding programs for populations in severe distress or with specific nutrition needs.
- Strengthen financial and technical capacity of grassroots institutions such as District Steering Groups to respond to crisis.
- Develop an effective monitoring system for the assessment of food distribution.

(GOK, 2005)

2.9 The Adopted and Contextualized Framework

The mapping of the MACG to the elements for the Kenyan setup is as below:

Element	Agency from MACG	Strategic Intervention	Information produced/used/deduced
Background Information	OP/MOA/MOH/MOENR/MOLFD/MORPW	• Provide budgetary allocations for prompt response to droughts and other natural catastrophe • Formation of the MACG	District Budgets Allocation Collect data on: • National food reserve Stock levels • Environmental Monitoring o Rainfall o Water bodies o Vegetation cover o Livestock count o Road network • Population spread
Incident Notification	Op (Ministry of Special Programs)	• Develop guidelines for transfer entitlements with a view to harmonizing coordination and synergy building among actors.	• Identify emergency situation and post it on the GIS
Incident Management	OP/MOH/NGOs/Other Donors	• Promote emergency intervention programs that provide nutritious foods according to different physiological and regional needs. • Strengthen financial and technical capacity of grassroots institutions such as District Steering Groups to respond to crisis. • Harmonize guidelines for management of targeted feeding programs for populations in severe distress or with specific nutrition needs. • Promote timely de-stocking, emergency off-take, and disease control activities for sustenance of livelihood support systems through the support of both private and public sectors.	• Use of the GIS maps for logistics • Record the emergency response carried out in the GIS and carry out re-evaluation
Post Incident Review	OP/MOPNP/KEPHIS	• Develop an effective monitoring system for the assessment of food distribution.	Post incident review and evaluation – a review of the GIS maps used during the incident management to form input for future planning
Communication	All Agencies	• Decentralize and devolve decision making on acquisition, targeting and distribution of resources for mitigating catastrophes.	Constant reference to the same data by all agencies in the MACG to help in good flow of information

Table 1: A mapping of the information produced/used to the various agencies in the MACG

CHAPTER 3: RESEARCH METHODOLOGY

3.0 Research Design

To answer the research questions, we did literature review to come up with an appropriate framework and basing on the framework, came up with a system based on GIS to assist in solving the problem. Upon completion of the prototype system, we tested the system using data obtained from KNBS and the opendata government data portal.

3.1 Conceptual Design

Based on the contextualized framework, a conceptual design of the system designed was derived and is as below:
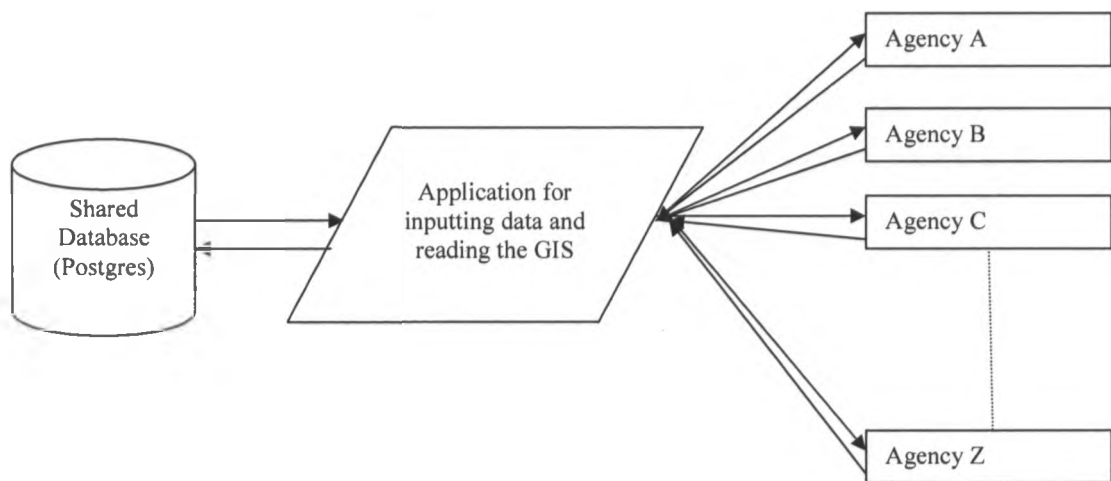
Figure 13: System conceptual design

3.2 Physical Design

We then designed the database using postgres with the spatial postgis plug-in. On it we loaded the data, later used in creating the shapefiles. The database stored the coordinates which were used to reference the various locations in Kenya. The database also stored the various measures of interest.

We used opengeo, open source java platform and php to design data entry forms for capturing data into the database. We also used opengeo for querying data from the database.

3.3 Data Collection Methods

The subject under research has been researched in other countries and successful implementations done. FAO/WHO are experts in food security and as such, study of literature from such bodies formed part of data collection method, especially for the buildup of the framework. Use of literature review as a means of data collection was important as there was a lot to gathered from these past works.

We got demographic data from the ministry of Planning. This assisted in knowing the population spread across the country for the purpose of planning the food distribution. We also got data on food production, arable land and rain patterns across the country from the ministry of Agriculture.

The data that was stored in the database was from various government agencies including KNBS, Ministry of Agriculture, Opendata.go.ke, NCPB and Meteorological department.

The data was arranged by region for the purpose of mapping exemplified by the data in the tables below.

Crop	Indicator	Rift Valley	Nyanza	Eastern	Western	Coast	Central	North Eastern	Nairobi	Total
Maize	Crop Area	644,895	262,455	462,401	225,302	129,979	157,063	2,525	1,055	1,885,071
	Bags 90 Kgs	13,225,039	5,711,215	5,905,141	4,165,878	1,079,583	1,047,879	5,520	6,420	27,142,475
	Yields Bag/Ha	20.5	14.1	8.1	18.5	8.3	6.7	2.2	6.1	14.4
Wheat	Crop Area	103,455	0	14,160	270	0	13,709	0	0	131,594
	Bags 90 Kgs	1,509,961	0	552,495	7,050	0	567,172	0	0	2,456,678
	Yields Bag/Ha	15	0	39	26	0	27	0	0	19
Barley	Crop Area	0	0	3,500	0	0	194	0	0	3,694
	Bags 90 Kgs	0	0	175,000	0	0	3,500	0	0	178,500
	Yields Bag/Ha	0	0	50	0	0	18	0	0	48
Beans	Crop Area	200,263	146,954	286,861	216,343	1,984	107,749	24	527	960,705
	Bags 90 Kgs	1,019,109	1,081,360	1,914,515	689,597	15,844	450,664	141	1,666	5,170,696
	Yields Bag/Ha	5	7	7	3	7	4	6	3	5
Rice	Crop Area	0	6,411	0	1,152	1,571	12,635	80	0	21,829
	Bags 50 Kgs	0	384,660	0	16,326	15,389	424,106	3,556	0	844,056
	Yields Bag/Ha	0	60	0	14	10	34	44	0	39
Sorghum	Crop Area	7,475	62,557	81,594	10,959	7997	659.3	2,757	0	173,172
	Bags 90 Kgs	57.465	498.961	376.118	83.864	32.859	3.895	1.890	0	1,055.051

Table 2: Food Crops Production Statistics, 2005 – 2009 (MOA 2010)

District	BARINGO	BARINGO NORTH	BOMET	BONDO	BORABU	BUNGOMA EAST	BUNGOMA NORTH	BUNGOMA SOUTH
Cattle	68595	38143	210855	66419	22827	59883	77907	83978
Sheep	72260	30446	53060	19004	4416	12384	29975	13374
Goats	168852	128364	82395	52674	8776	9186	8612	28068
Camels	13	28	5	4	-	-	4	8
Donkeys	3047	299	18363	2406	653	346	688	920
Pigs	243	58	604	955	417	1113	1810	7167
Indigenous Chicken	119715	73037	364644	194203	70047	180014	273318	392459
Chicken Commercial	11032	3537	13981	11873	11250	12446	14230	24900
Bee Hives	42416	31570	14807	827	1178	1750	4371	3335
County	Baringo	Baringo	Bomet	Siaya	Nyamira	Bungoma	Bungoma	Bungoma
Location 1	(0.448155493, 35.97415916)	(0.745856425, 35.80555092)	(-0.840969003, 35.31899335)	(-0.09212788, 34.19064437)	(-0.735368659, 35.02803793)	(0.63973936, 34.73645726)	(0.783636675, 34.86452529)	(0.56139561, 34.52131934)
Province	RIFE VALLEY	RIFE VALLEY	RIFE VALLEY	NYANZA	NYANZA	WESTERN	WESTERN	WESTERN

Table 3: Livestock by type and district (www.opendata.go.ke, 2012)

District	Male	Female	Total	Households	Area in Sq. Km.	Household Density	Population Density	Gender Index	County	Province
NYANDARUA NORTH	106111	109785	215896	52503	1394.69	37.64	109861.0821	1.03462412	CENTRAL	36.42343108
NYANDARUA SOUTH	131872	137982	269854	61936	1472.58	42.06	138071.5517	1.046332808	CENTRAL	36.55651343
NYERI NORTH	141423	143971	285394	81307	2253.47	36.08	144033.7579	1.018016871	CENTRAL	36.9811441
NYERI SOUTH	114557	123990	238547	66028	874.13	75.54	124121.0526	1.082343288	CENTRAL	36.89927916
KIRINYAGA	220494	224156	444650	126665	1402.71	90.3	224313.1914	1.016608162	CENTRAL	37.32018369
MURANGA NORTH	151033	163375	314408	87030	913.79	95.24	163540.282	1.081717241	CENTRAL	36.98118146
MURANGA SOUTH	156115	165195	321310	84114	762.77	110.27	165399.6685	1.058162252	CENTRAL	37.05522802
KIAMBU EAST(KIAMBAA)	22768	22306	45074	12468	100.4	124.18	22532.77291	0.979708363	CENTRAL	36.80546766
KIKUYU	424	398	822	251	4.78	52.51	486.7029289	0.938679245	CENTRAL	36.63360077
KIAMBU WEST	25493	25508	51001	13465	197.39	68.22	25637.15041	1.000588397	CENTRAL	36.62625892
THIKA EAST	36828	36775	73603	19226	398.18	48.28	36867.49083	0.998560878	CENTRAL	37.23100647
THIKA WEST	12299	12188	24487	7283	207.31	35.13	12247.32661	0.990974876	CENTRAL	37.04502993

Table 4: Population Distribution by district (www.opendata.go.ke, 2012)

Data that formed part of the input to the postgres database include:

- NCPB stores countrywide
- National and regional boundaries
- Water bodies and water catchment areas
- Population spread
- Livestock spread
- Food emergencies .

Since the government statistics were collected using scientific methods, the use of topical method in data collection adopted had the advantage of completeness.

One pitfall experienced in this research by using this method was scenarios where there were two different sources with differing data regarding the same matter.

Another pitfall was variance in the periods over which the data was recorded since a correlation, for the data to make more sense was to be done to come up with conclusions.

However, since there was need to demonstrate the framework using a prototype, the data was used anyhow for the purpose of demonstration. In the actual usage of the system, data sanitization will be mandatory.

3.4 Data Analysis and System Validation

The analysis of the spatial data was done using OpenGeo GIS and the maps rendered in the web interface. A visual view of the shapefiles in the web interface was done while making various changes on the database values.

To validate the framework, the research carried out an interview with the ministry of special prgrammes to confirm if the framework and GIS proposed contribute to the achievement of the objectives.

3.5 The Developed GIS Model

The model developed comprised of these basic components:

- Database to store the spatial data
- Database to store user login details
- Data editing tool – to allow for editing in spatial mode
- Map presentation interface
- Application web interface

3.5.1 Data flow diagram

The diagram below presents the data flow of the developed system.
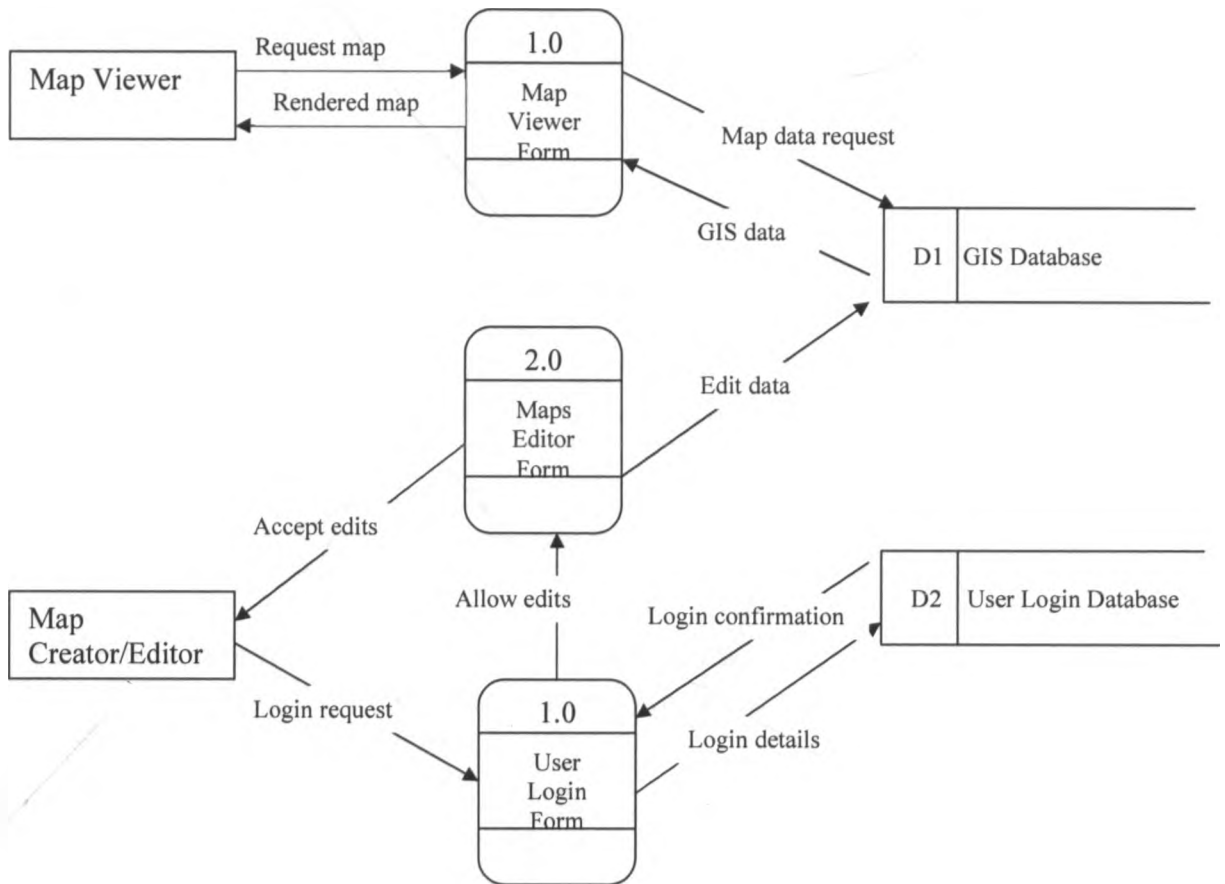
Figure 14: Data flow diagram of the developed system

3.5.2 Entity Relationship Diagram

The login database was designed as a simple database with a single table having three fields – username, password and agency. In the GIS database, all the tables were designed to have a relationship with one pivot table called geometry_columns. This table contained the spatial reference making it possible to render the data in the various tables as maps.

The relationship between the geometry_columns table and the rest of the tables is as represented by the sample of one table below.

Figure 15: Part of the entity relationship diagram for the database

Each table representing a map layer maintained a geometric field called the_geom. This field refers to either a point, a line or a polygon.

```
CONSTRAINT enforce_geotype_the_geom CHECK (geometrytype(the_geom) = 'POINT'::text OR the_geom IS NULL)
CONSTRAINT enforce_geotype_the_geom CHECK (geometrytype(the_geom) = 'POLYGON'::text OR the_geom IS NULL),
CONSTRAINT enforce_geotype_the_geom CHECK (geometrytype(the_geom) = 'LINESTRING'::text OR the_geom IS NULL),
```
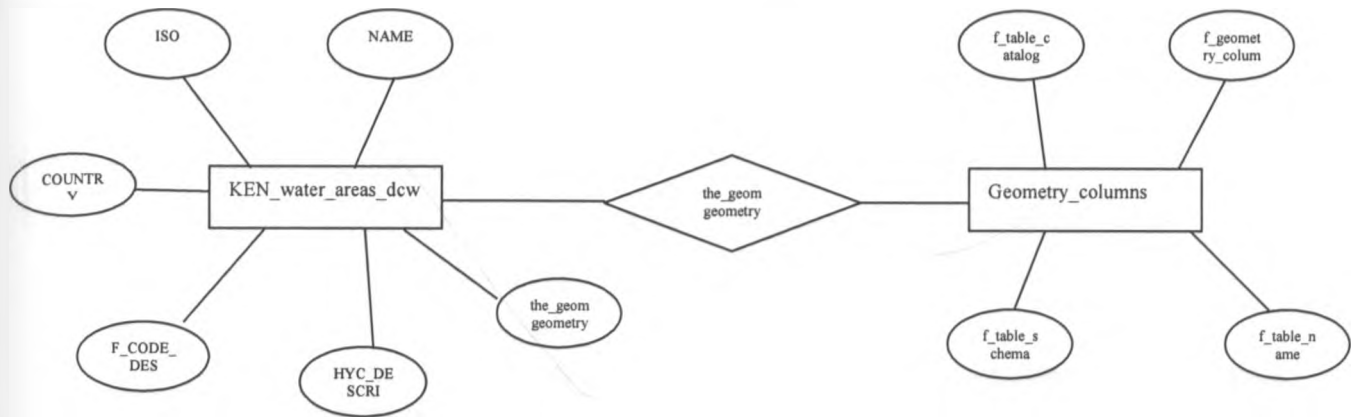
3.5.3 Entity description of the Food Emergency table

The key table used to notify the various agencies of emergencies and their resolution is as described below.
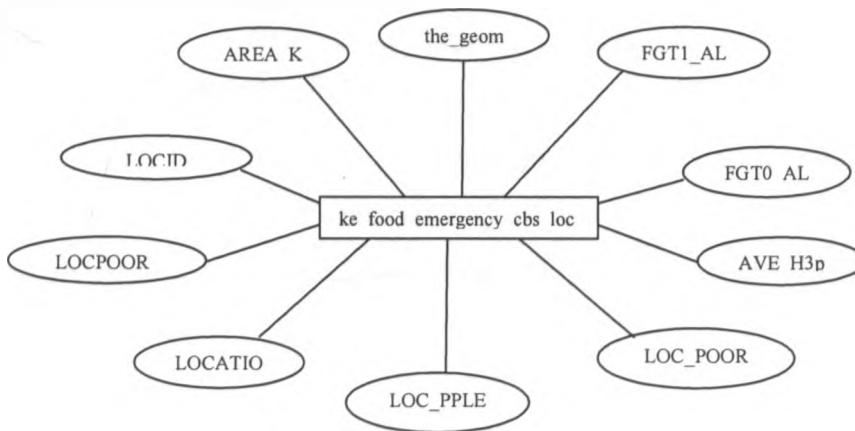
Figure 16: Entity description of the food emergency table

"LOCID" integer,
  "AREA_KM2" double precision,
  "RURAL" integer,
  "FGT1_ALL2" double precision,
  "FGT0_ALL2" double precision,
  "LOC_PPLE_A" double precision,
  "LOCPOOR_AL" double precision,
  "LOCATION" character varying(20),

"LOC_POOR_D" double precision,
"AVE_H3per" double precision,
"the_geom" geometry,

3.5.4 Database design

The database management system used was postgres with postGIS extension to support geospatial data manipulation. The key aspects of the database being the tables, functions and sequences.
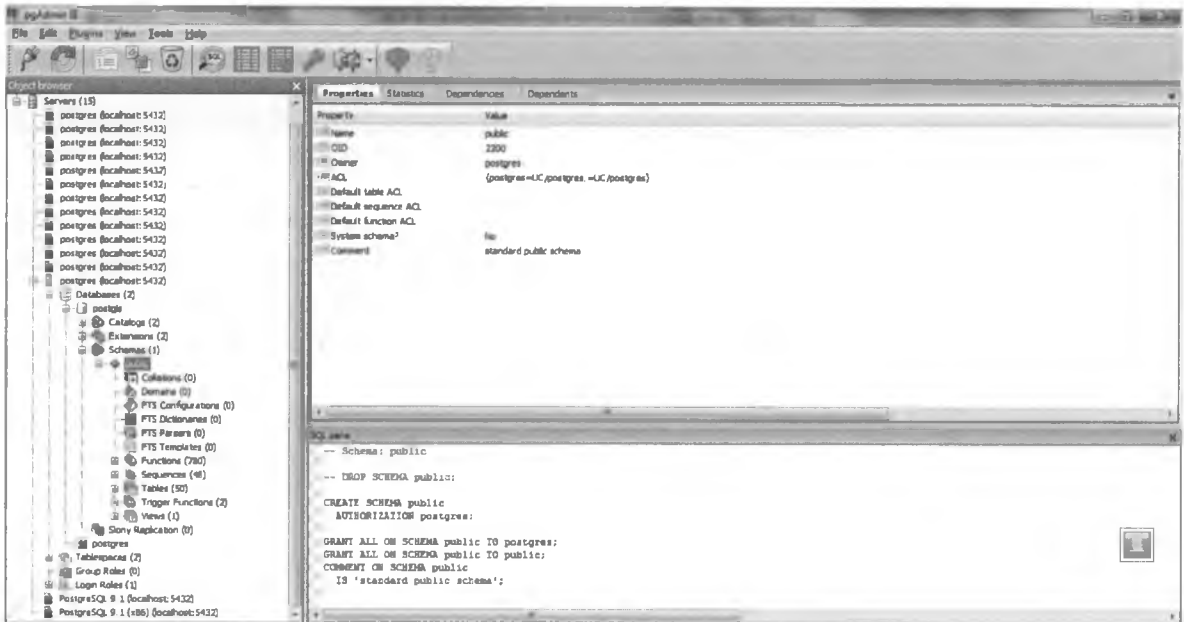
Figure 17: Postgres database schema

There was one table that was used to define the geographic reference system for all the maps rendered - spatial_ref_sys. For the purpose of uniformity, all the maps rendered in this research were standardized to EPSG WGS 84 spatial reference system.

Figure 18: PostGIS spatial reference

3.5.5 Interface design

The interface was designed based on a web platform. The architecture of the interface was modular; the map rendering, map editing, map layers creation and the main access interface being distinct from each other.

However, the goal was to have all the various interfaces point to the same database. The architecture used was as in the diagram below.
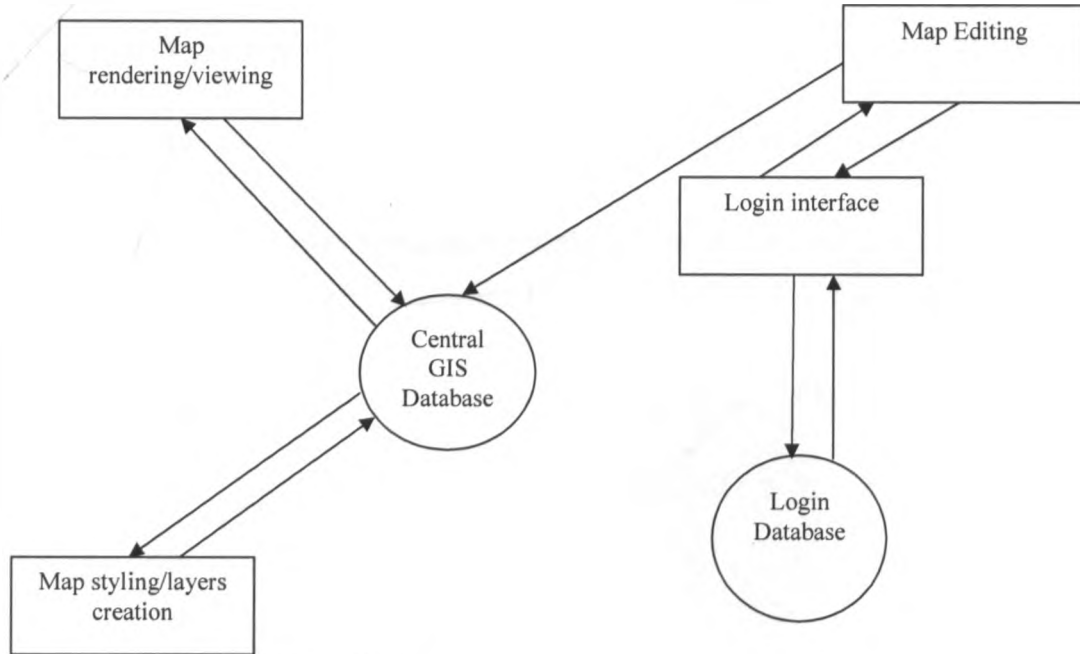
Figure 19: Application context diagram

3.6 Why web based technology

The choice of web based interface was informed by the need to share information between multiple agencies and the need to be able to edit and

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input data to a central database by multiple agencies. Deploying the system over a web based platform is quite easy as there is no installation needed for the various users. This is particularly important for such an emergency system where the players in the emergency resolution come from a broad range of backgrounds – government agencies, non-government agencies, etc.

3.7 System Implementation

Having come up with the framework hinged on five key elements, and meant to be deployed in a multi-agency model, a system was developed. The system focused on making it possible to update the various information in the database by different government departments, ministries, and non-government agencies in a distributed manner. The key was to have each agency update information of relevance to it and the aggregate information pooled for sharing.

3.7.1 GIS Map Editor

The editor in the system allows the various players in the multi-agency coordinating group to each input the data relevant to them. For example, if there is any new road the ministry of roads and public works have added in the country, they can add it to the existing grid.

The research used OpenGeo, an open source java based application for the map editor.
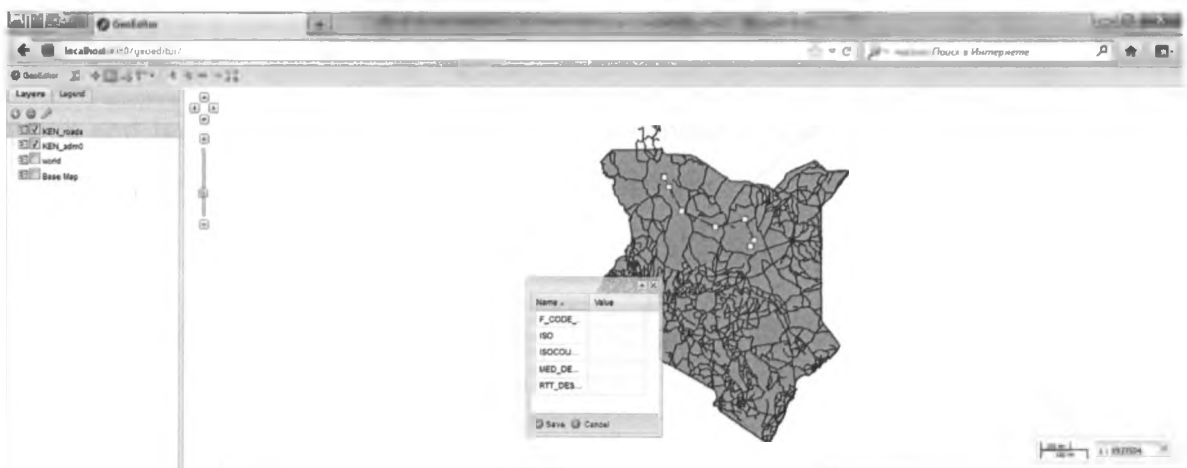
Figure 20: Editing roads map

The ministry of livestock and fisheries can also update details about the livestock count in a district.
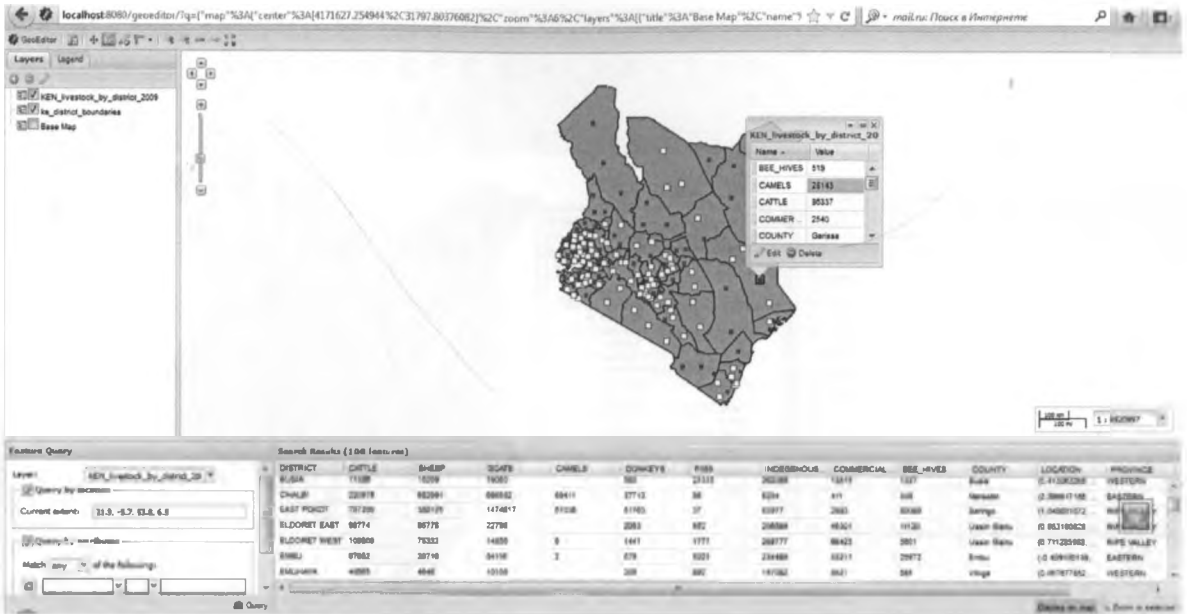
Figure 21: Editing the livestock map

The various data sets from the different agencies in the multi-agency group were designed to be posted onto a single database, all this geared towards making informed decisions.

The fact that the various layers were designed to be edited separately over the web, with each edit posting to the same database was meant to make possible the multi-agency model to work for the emergency response strategy.

For contingency purposes, the proposed system was designed to allow for a client based map editor called Quantum GIS. This also allowed users to edit maps and have the edits posted on the same central database, though from a client installed application.
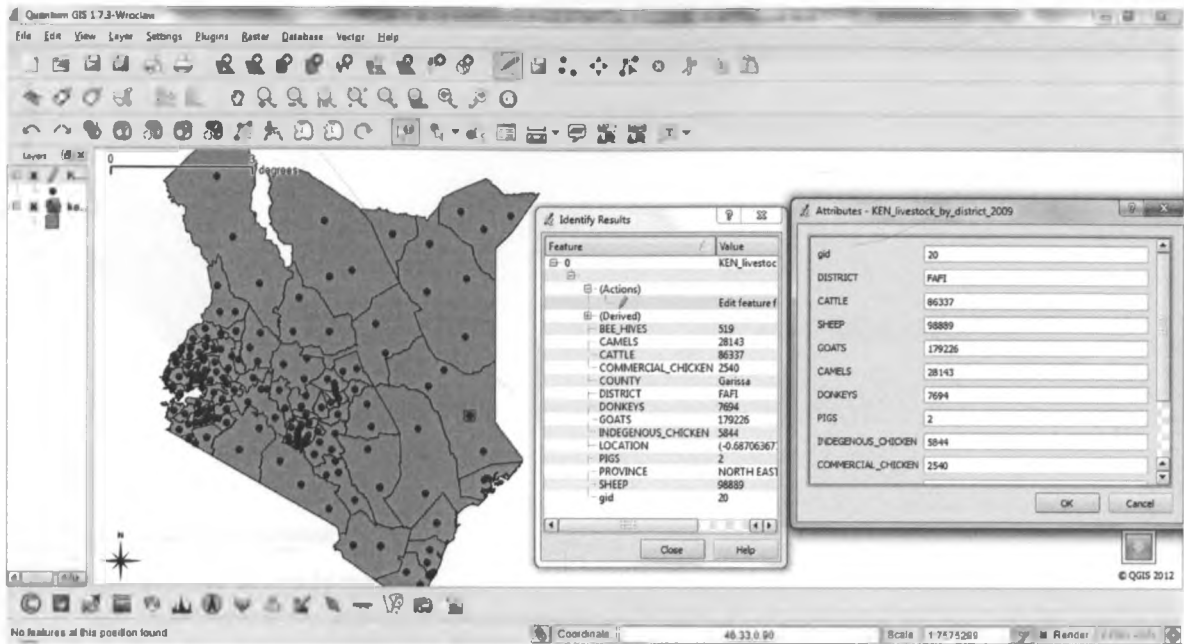
Figure 22: Editing the livestock map using Quantum GIS

The key thing was to allow all the stakeholders to post changes to the parameters that were used in such emergency resolution as relates to their function.

3.7.2 GIS Map Presentation

Since the reason of maintaining the data in a single database was to be able to present the various layers to the parties/agencies requiring the information, our prototype used web based presentations of pre-arranged layers. Each set of layers focused on availing information of relevance to the various players in food emergency resolution chain.

The various map layers that were considered to be of relevance to the food emergency resolution were presented as links on the application. However, the users were allowed room to create their own layers combination as and when required.
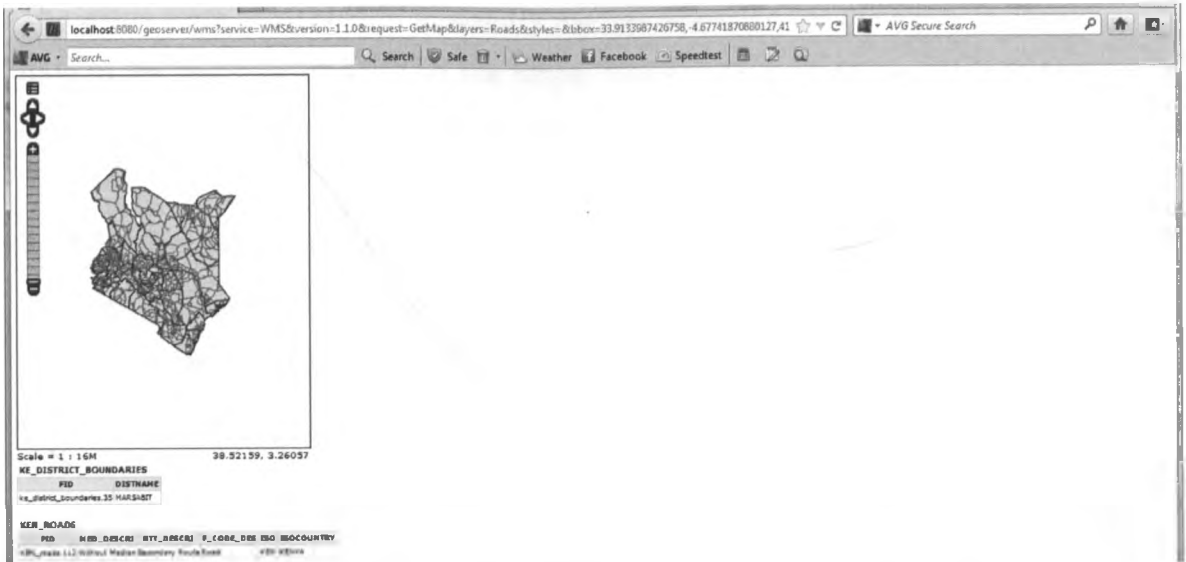
Figure 23: Viewing the roads map

Some of the layers presented include road networks and airfields to facilitate transportation of food aid and personnel, water bodies and vegetation cover to help in telling the possibilities of catastrophes emanating from environmental degradation. Other layers such as population spread and livestock population were also designed to help determine the nature and extent of intervention required.

Figure 24: Viewing the vegetation map

The maps were presented in a friendly manner allowing for the users to query data in the maps by clicking on the maps. The system was designed such that clicking on the map resulted in the underlying data being displayed.

3.7.3 Application web interface

For both the map editing and map viewing, the web interface was designed to present an easy to use interface that does not require a lot of technical expertise to use. The aim was to have the various agencies use the system with ease.

Figure 25: Web application home page

The system was designed such that all edits required login before doing the edit. This was so as to limit the unauthorized modification of the maps as they were meant to be used to solve emergencies and if open to modification without control, this could be abused.

Figure 26: Login section to the map editing interface

On logging in, the system was designed to present the user with the option of editing the various maps.

you have loged in successfully

Hi Mr.otieno

Resource id #4

You have succesfully logged in and you are now able to edit the various maps.

Click here to edit district population statistics

Click here to edit roads map

Click here to edit livestock counts

Click here to edit vegetation cover

Click here to edit the airfields in Kenya

Click here to edit the NCPB stocks

Logout

Figure 27: Links to the map editing pages

For example, clicking on the 'Click here to edit roads map' link opens the page to edit the roads.
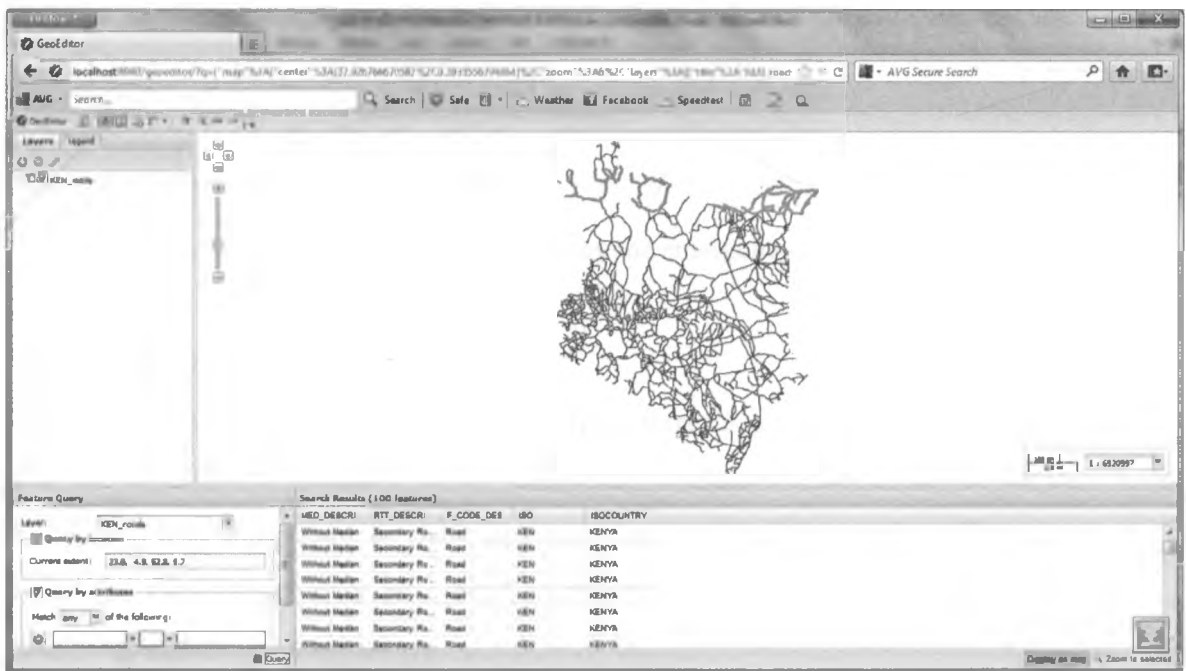
Figure 28: Editing roads

This led to the user being able to edit existing features and add new features.

Any new feature added, or edited would then be viewable by the other users accessing the maps on real time.

The map layer on emergency incidents was meant to be used to show the agencies addressing the food emergencies where the emergency hot spots were. Once addressed, the status of the hot spot should be changed via the 'response' link so that the region is not shown on the map.
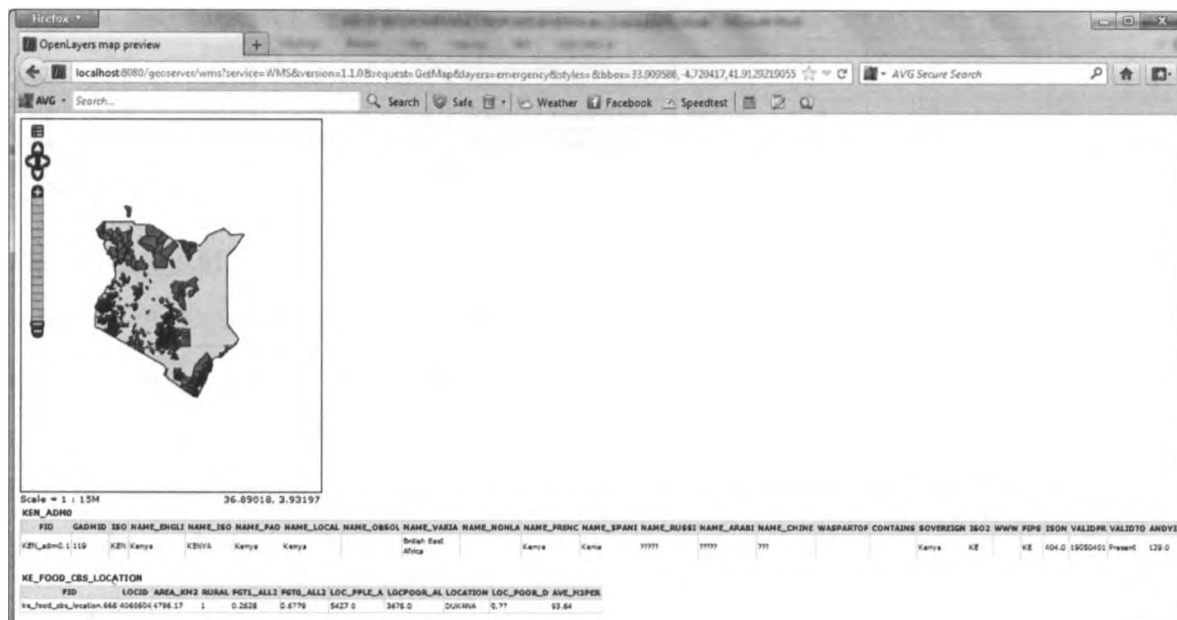
Figure 29: Viewing the food emergency map

The red spots on the map indicate the areas hit by the emergency.

3.7.4 Testing and Evaluation

In order to test the prototype, use of data from various agencies was employed. For the emergency situation to be identified, various methods can be used. However, it is important to have as much information as possible. The data from the various agencies was used to come up with the maps which were used to generate the map layers.

An interview with a director at the ministry of special programmes was done to validate whether the framework and the GIS designed contribute to the objectives of the research. The interview, an open interview, also was to confirm if the contribution of the research adds value to the practice.

The columns of the table with the food emergency records are as below, though not all rows are captured as is in the database.

gid	LOCID	AREA_KM2	RURAL	FGT1_ALL2	FGT0_ALL2	LOC_PPLE_A	LOCPOOR_AL	LOCATION	LOC_POOR_D	AVE_H3per	the_geom	intervention_required	intervention_required	intervention_availed_qty
1	1010101	2.6183	0	0.0622	0.2149	8223	1766	STAREHE	674.48	0.37				
2	1010102	2.4261	0	0.0848	0.2777	32473	9017	KARIOKOR	3716.67	0.49				
3	1010103	1.5873	0	0.1795	0.5317	65230	34684	MATHARE	21850.9	1.04				
4	1010104	1.3822	0	0.1838	0.5384	76324	41091	HURUMA	29728.7	0.36				
5	1010105	2.7081	0	0.0499	0.1735	22975	3986	NGARA	1471.88	1.2				
6	1010201	1.3108	0	0.3378	0.7678	19361	14865	MAKONGENI	11340.4	0.7				
7	1010202	3.5163	0	0.1258	0.353	49586	17504	MAKADARA	4977.96	0.14				
8	1010203	1.5498	0	0.2872	0.6951	27742	19283	MARINGO	12442.2	0.04				

Table 5: Food emergency incidents table

The AREA_KM2 and LOCPOOR_AL fields are helpful in determining the extent of response needed. The LOCPOOR_AL field shows the population that is threatened by the emergency whereas LOC_PPLE_A field shows the total population of the location described by the LOCATION field. The FGT0_ALL2 field shows the proportion of the population under threat in a given location to the total population of the area.

For the purpose of demonstration, a threshold of 0.6 for FGT0_ALL2 was considered to be an emergency case. This was put on the map so that the map was left to show as hot spots only areas filtered by this criterion. This threshold should be set by the agency in charge of determining and declaring emergencies.

3.7.5 System Requirements
The designed system uses a number of technologies.

- The web interface is built using php and html languages.
- The web interface runs on apache web server
- The maps presentation and editing tool runs on OpenGeo web server
- The map presentation and editing tools are built using java.
- The login database is built using mysql database.
- The geospatial database is built using postres with postgis plugin.
- The web application can be run on any web browser such as firefox or internet explorer without having to install anything.

- The server can run best on a computer running 4GB RAM with 20GB Hard Disk space.

CHAPTER 4: RESULTS AND DISCUSSIONS

4.0 Availing essential background information

For the resolution of food emergency to be effective, as much information as can be availed is required. As was demonstrated in this research, these pieces of information can be very effectively availed and presented in geospatial format. The prototype was designed to present an interface where the various agencies each can key in the data relating to what it does for the consumption of the other agencies. The success in this model was in the fact that each agency can capture data independent of the other, and all the data reside in one database to be used jointly with data from other agencies.

4.1 Identifying the food safety incident

From the interview with the ministry of special programmes, the research confirmed that the government has a way in which it identifies food emergency situations in the country.

As discussed in section 2.3, this declaration of food emergency should be done by a competent authority having considered a number of factors, both statistical and non-statistical.

Currently, the Ministry of Special Programmes maintains a system called National Disaster Risk Coordination System. This system is used to maintain data on identified food emergency cases. The government uses two key sources for information fed to this system. The first source is WFP and the second is the District Officers. WFP collects information on food emergencies in Arid and Semi-Arid Lands (ASAL) Districts and presents food structural assessment reports to the ministry after every six months. For the non-ASAL districts, the ministry relies on District Officers, who, through the district food steering committees, collect information on food situation in the districts and make monthly returns to the ministry.

The information from these two sources is fed onto the national disaster risk coordination system. The system is used to determine emergency situations – where there is a disaster.

In both cases (WFP and the government through the District Officers), there is involvement of other stakeholders including churches, the government and other NGOs. The challenge in the current practice, as it emerged from the interview, is that each agency does its returns in its own format. It takes time to convert to a format ready for input into the national risk coordination system. The whole process of making the returns also takes time. If the system was availed to the various stakeholders so that they can input the data directly, then the time taken to identify an emergency would be reduced.

The system maintained by the ministry of special programmes – National Disaster Risk Coordination System maintains tabular presentations of data relating to food emergencies.

In the proposed system, the information takes spatial representation, making it easy to interpret.

Figure 30: Spatial representation of the food emergency

The government, in the national policy for disaster management confirms inadequate information and data as one of the impediments in disaster

management. However, the ministry of state for special programs has formed a national disaster management agency (NADIMA) to coordinate emergencies. This agency has six directorates responsible for different things. (GOK, 2009)

One of the directorates is the directorate for early warning and disaster risk profiling. The research uses the data on a GIS to demonstrate how the role of updating the data can be distributed to the stakeholders, only for NADIMA to do the coordination. Use of GIS also makes interpretation of the data quite easy for the various stakeholders.

Area (sq KM)	Urban/Rural	Proportion under threat	total location population	population under threat in location	location
714.22	1.00	0.91	3,538.00	3,226.00	LOKIRIAMA
32.40	-	0.90	9,216.00	8,305.00	EAST KISUMU
88.56	1.00	0.90	6,592.00	5,905.00	BANDARINI
207.55	1.00	0.90	12,992.00	11,633.00	MWAHERA
117.47	1.00	0.85	8,054.00	6,876.00	GANZE
219.34	1.00	0.85	14,646.00	12,471.00	BAMBA
154.14	1.00	0.85	7,901.00	6,725.00	PALAKUMI
424.87	1.00	0.82	3,560.00	2,929.00	NACHOLA
8.00	1.00	0.82	3,804.00	3,128.00	SIABAI
48.06	1.00	0.82	2,746.00	2,253.00	NTULELE
114.21	1.00	0.82	11,865.00	9,734.00	MWATATE
7.90	-	0.4762	22,254.00	10,597.00	UTHIRU/RUTHIMITU
4.03	-	0.5349	84,386.00	45,139.00	KAWANGWARE
7.31	-	0.4512	63,367.00	28,591.00	RIRUTA
9.40	-	0.1168	26,080.00	3,044.00	KENYATTA/GOLF COURSE
1.60	-	0.56	80,719.00	45,204.00	KIBERA
125.71	-	0.1805	32,438.00	5,855.00	MUGUMOINI
23.05	-	0.079	38,782.00	3,063.00	NAIROBI WEST
0.71	-	0.4973	50,491.00	25,109.00	LAINI SABA
1.02	-	0.5351	46,111.00	24,673.00	SERA NGOMBE
8.16	1.00	0.225	15,045.00	3,385.00	NDUMBERI
7.64	1.00	0.1749	13,062.00	2,285.00	RUAKA
32.02	1.00	0.2408	9,861.00	2,374.00	KIAMBAA S/AREA
9.10	1.00	0.1664	12,206.00	2,031.00	TING'ANG'A

Table 6: Food emergencies represented in tabular form.

4.2 Managing the incident

The ministry of special programmes maintains a commodity tracking system to monitor where food goes. The government distributes food aid directly and through agencies such as WFP, World Vision and Red Cross. These agencies make monthly returns on the food that has been distributed to the ministry of special programmes. These returns are then fed onto the commodity tracking system.

The proposed GIS system provides for the agencies to directly make the returns onto the system more regularly instead of waiting for end of month. This way, more regular assessment of the situation can be done.

When the incident occurs, the emergency maps designed are meant to guide the agencies resolving the emergency. There should be a coordinated mechanism through which the updates of these maps are done so that the various players act on updated maps. This way, all the agencies work on updated information.

The fact that the maps can be availed over the web makes incident management seamless as the information is availed to the various players on real time basis.

4.3 Managing the post incident review and evaluation

The maps created were meant to be stored for later analysis after the emergency has been resolved. This is to ensure that the trends leading to the solved emergency are identified and mitigated so that they don't recur.

4.4 Coordinating the communication between the various players

Since all the information is available in a single portal, coordination of communication is seamless. All that is required is internet connection to facilitate connection to the same web portal. This is a big advantage of using

the proposed solution since proper coordination is key to speedy resolution of such emergencies.

4.5 The solved problem

The government of Kenya has a national food security strategy. However, it lacks food emergency resolution policy/strategy. This research came up with a framework to be used to formulate such a policy. The framework was based on five elements implemented in a multi-agency model. The essence was to enhance information sharing and timeliness in information delivery.

The research also came up with a set of information that would be required in resolution of food emergencies. These were then mapped onto the framework advanced.

Finally, the research came up with a prototype to be used in the multi-agency five-element framework proposed. This was tested using data from the various agencies.

CHAPTER 5: CONCLUSION AND RECOMMENDATIONS

5.0 Achievements of the Study

At the inception of the study, we had four objectives and the discussion below shows how the objectives were met.

5.0.1 Framework Identification
The first objective was to identify and contextualize a framework to assist in an efficient food emergency response in Kenya.

We carried out literature review and identified two possible frameworks that could be used. One was the USDA framework and the other was the FAO/WHO framework. The USDA framework was more focused on school feeding and as such, the adoption of the FAO/WHO framework was appropriate.

The framework adopted mapped very well onto the inter-ministerial group tasked in the Kenya National Food Security Strategy to ensure food security. This informed the adoption and contextualization of the FAO/WHO framework.

5.0.2 Information required
1. The second objective was to establish essential information needed to respond to food emergencies.

To achieve this, we studied varied literature sources and zeroed in on the poverty mapping done by Jayaraman and Srisastava and the Kenya Food Security and Nutrition Strategy.

From these literatures we obtained information which is required in the identification and management of food emergency. This information was then mapped onto the identified framework.

5.0.3 GIS System

The third objective was to develop a prototype system to be used for early warning, monitoring, surveillance and logistics in times of emergency.

Use of GIS was adopted and a system was developed using relational databases. The use of Postgres was employed with a GIS plugin called postgis.

The presentation of the data for viewing and update was done using php and java.

The system developed was web based to achieve the objects of the framework adopted – multi-agency coordinating group.

5.0.4 Testing the prototype

The last objective was to test the prototype system

To achieve this, we got data from opendata.go.ke, KNBS, NCPB and populated the database. For the data which did not have spatial dimension, we added the coordinates so that they could be rendered as maps. We then were able to render the maps, simulate the emergency identification and modify the data in the GIS.

5.1 Limitations and challenges of the research

- One limitation was lack of uniformity of the data available. Most of the data were from different times, hence difficult to correlate.

- At the time of the research, many data sets did not have the same geographic delimitation. The county boundaries had not been clearly set hence some shapefiles available were only with Districts boundaries. We however got a way of merging the various geographical delimitations.

5.2 Contributions of the research

FAO/WHO have a framework that is meant to be used in food emergency response. The framework, however, for it to be usable in Kenya needed to be domesticated. This domestication entailed getting the information of relevance to food emergency response and local to Kenya. The information was obtained by this research and mapped onto the framework. This resulted in a framework that can be effectively used in the Kenyan setup.

The proposal of a GIS system and subsequent demonstration of its use is an achievement of this research. Ministry of Special Programmes currently have two systems – one to monitor emergency situations and another to monitor emergency response. Both systems have real challenges in timeliness of the data and information sharing. GIS have been used in Kenya on a number of fronts but, as shown in the literature reviewed, GIS has not been used in food emergency resolution. The proposed GIS solution will go a long way in solving the problems in the current systems at the ministry of special programmes.

5.2.1 To the policy formulators

In as much as Kenya does not have a food emergency response strategy, the existing national food security and nutrition strategy makes mention of emergencies. The development of a framework that can fit in the government NFNS is a great achievement in this study.

This framework can be used by the government hinging on the existing inter-ministerial coordinating committee on food nutrition in the NFNS to come up with a national food emergency response policy in Kenya.

Using the tool developed, the government can also analyze the maps over time and make this a basis of budgetary allocations.

5.2.2 To the stakeholders

Timely information, as has been discussed in this research is of great essence in food emergency response. The GIS developed is meant to achieve the goal of availing the various information in a timely accurate manner.

The web technology used is also of value in the sense that the information can be shared on real time basis over the internet by various stakeholders.

5.2.3 To the body of knowledge

Various research and implementations have been done on use of GIS for emergency resolution. This research has come up with a framework that can employ the use of GIS to resolve food emergency in particular.

The challenges in food emergencies are different from say fire, war, etc in that, the manner in which they are to be resolved takes into consideration factors such as cultural issues, factors that may not apply in other emergencies.

This development of this framework for the Kenyan setup is a new contribution to the body of knowledge.

5.3 Recommendations

The government of Kenya should consider coming up with a national food emergency response policy. The policy could do very well by using the framework proposed in this research. The government of Kenya could also do very well by making use of GIS as proposed in this research in managing food emergencies.

Further research should also be done on the area of GIS and how more effective it can be used in food emergency response, and emergency response in general.

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Appendix

Appendix 1: System User Manual

Application Setup

The system comprises of two databases – MySQL for access control and Postgres for holding the actual data. The home page and the login pages are designed using php. The rendering of the maps is done using a tool called Geoserver. Geoserver uses java to render the spatial data in the postgres database as maps.

First install the MySQL and Postgres databases and then create the schemas for the two from the scripts on the appendix 2.
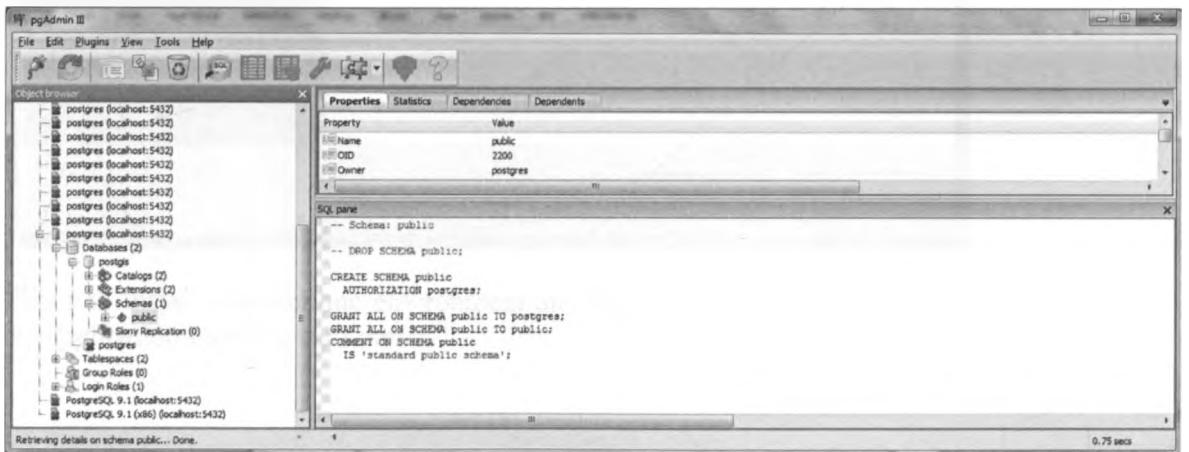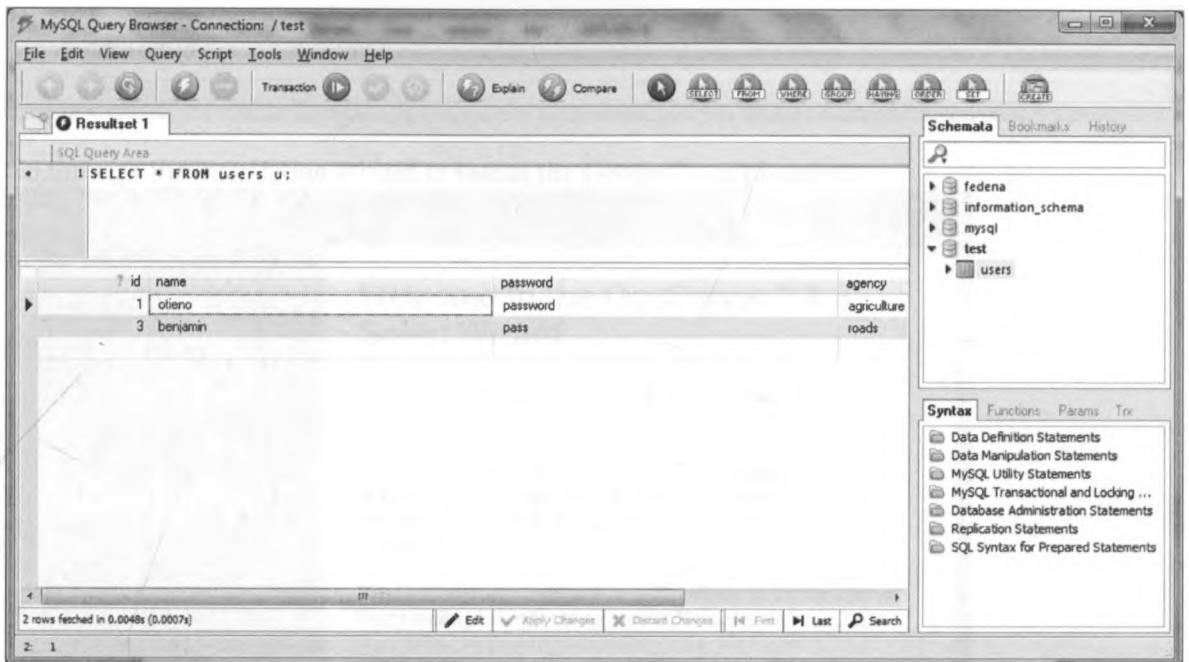
Install a web server (apache, IIS, etc) to be used to launch the various pages and create the index page from the code for the web based interface on appendix 2. This can be placed anywhere on the www or htdocs folder depending on the webserver you decide to use.

Install the Geoserver application by double clicking on the exe file.
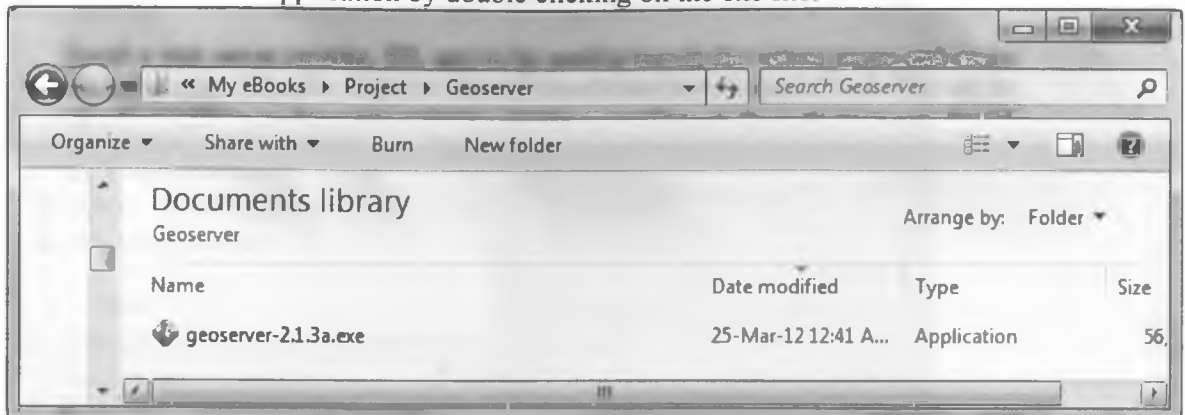
Go through the installation wizard to install the Geoserver application.

This will install java runtime environment and the application. Once installed, launch the application from the start menu.
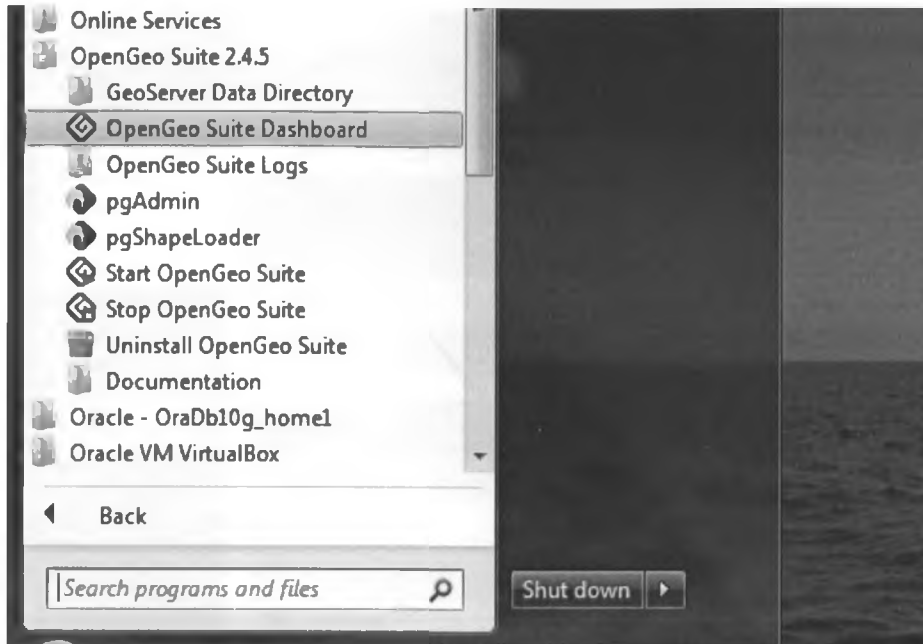
To start the server, click on 'Start'.

Once started, the various links become active.
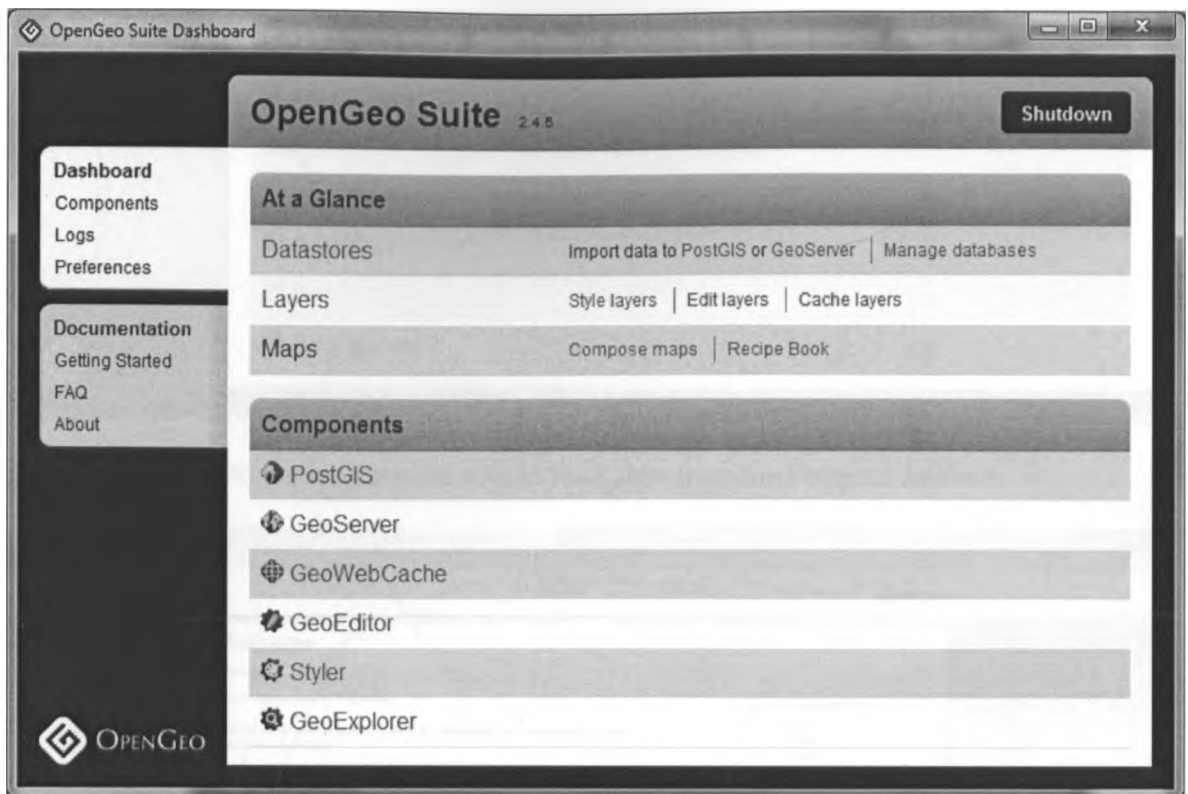
Using this application, you may import shapefiles into the postgres database. This can be done using the PostGIS link.
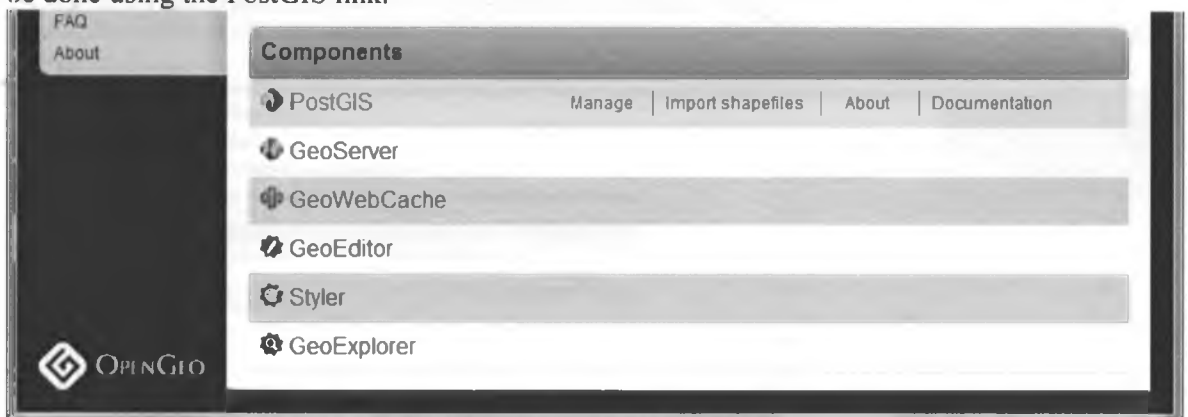
Using the GeoServer link, you will be able to come up with the various map layers.
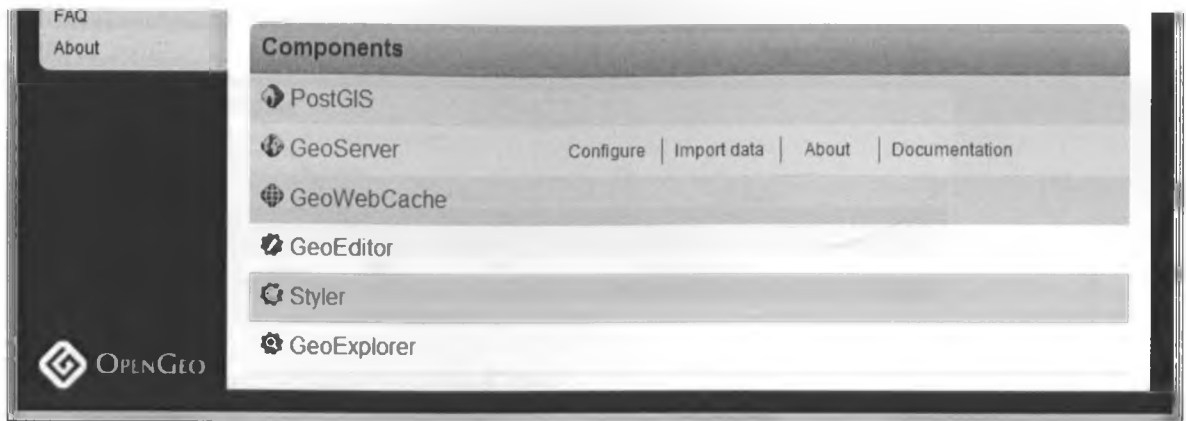
But you will have to log in first to be able to fetch data from the Postgres database.
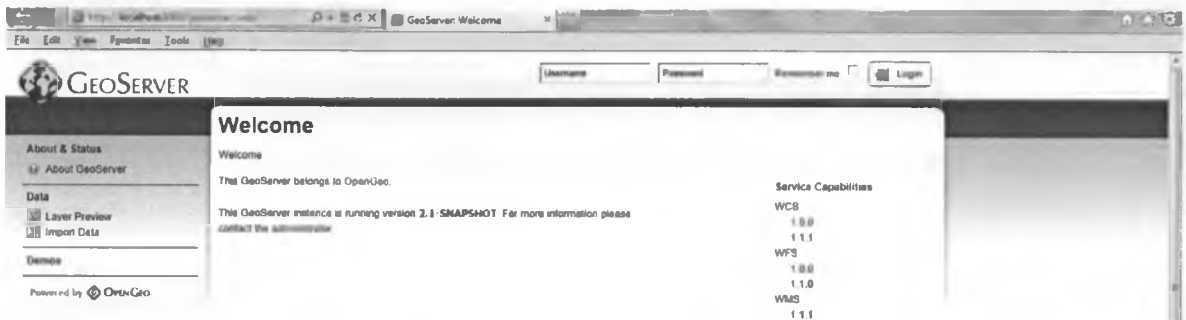
Once logged in, you will be able to define your layers, layer groups, workspaces, stores, etc. (consult the OpenGeo manual for complete documentation).
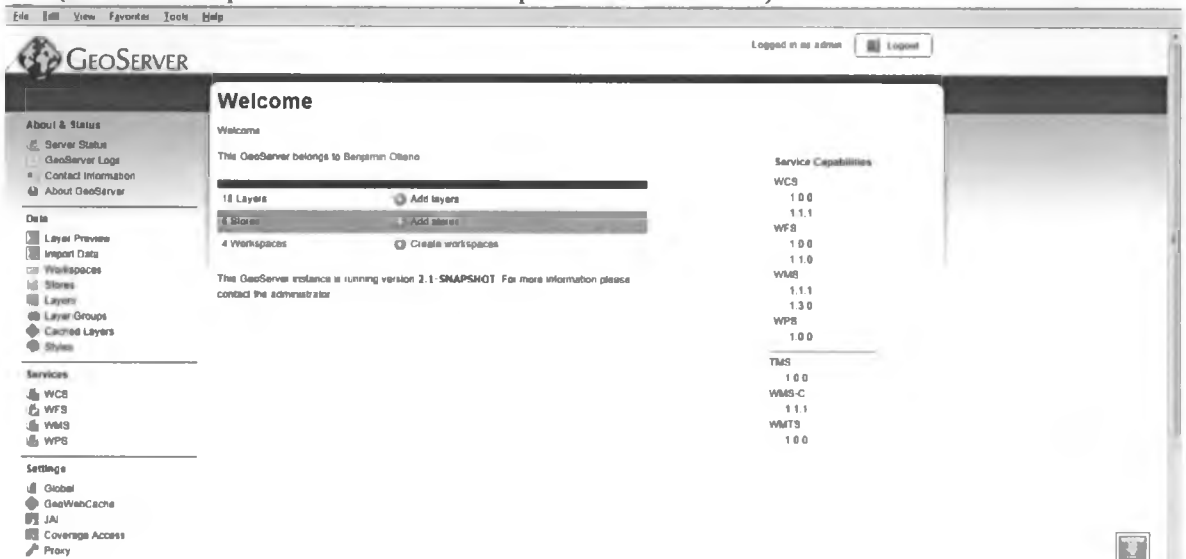
For this research, we defined one store called Kenya of type PostGIS.
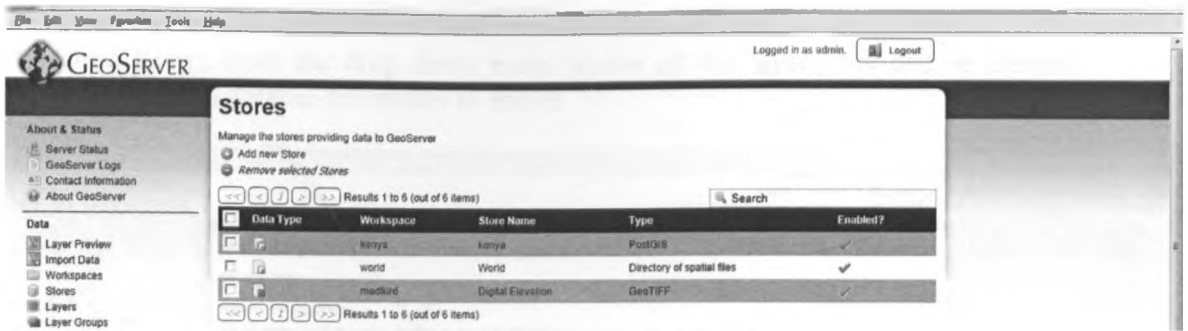
We also created one workspace called Kenya
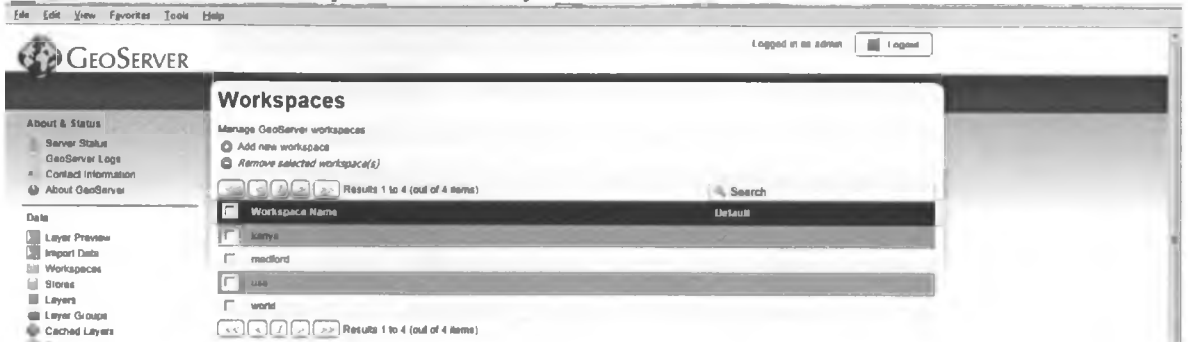
You then need to create a connection to the Postgres database.
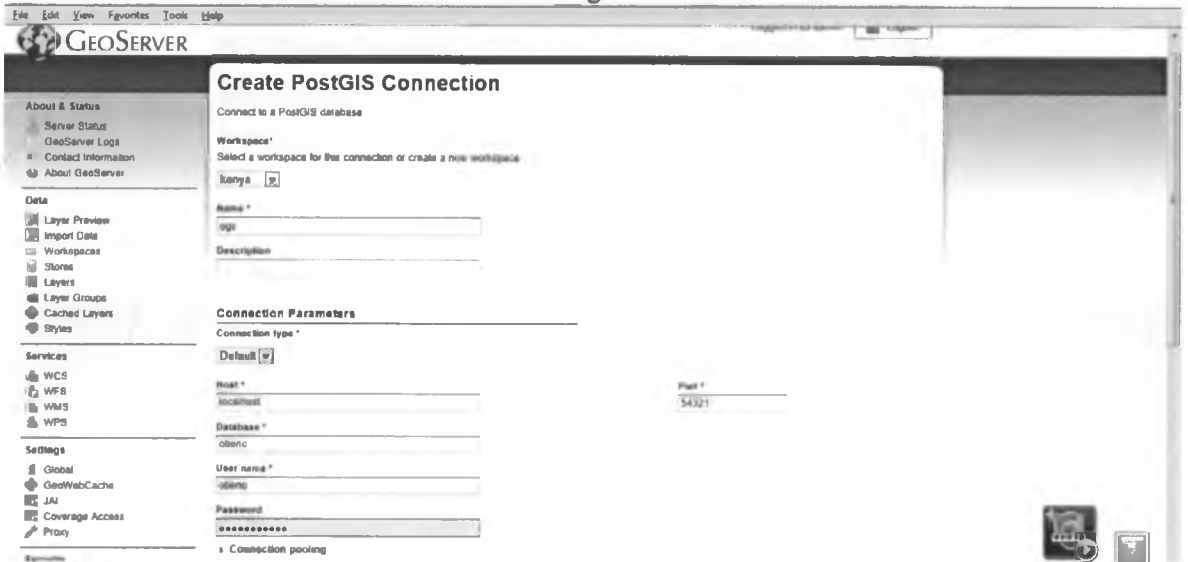
Once you have created the connection, you can create the map layers from the database with ease.

Selecting Kenya from the drop down menu shows all the layers that can be created from the Postgres databse connected to above.
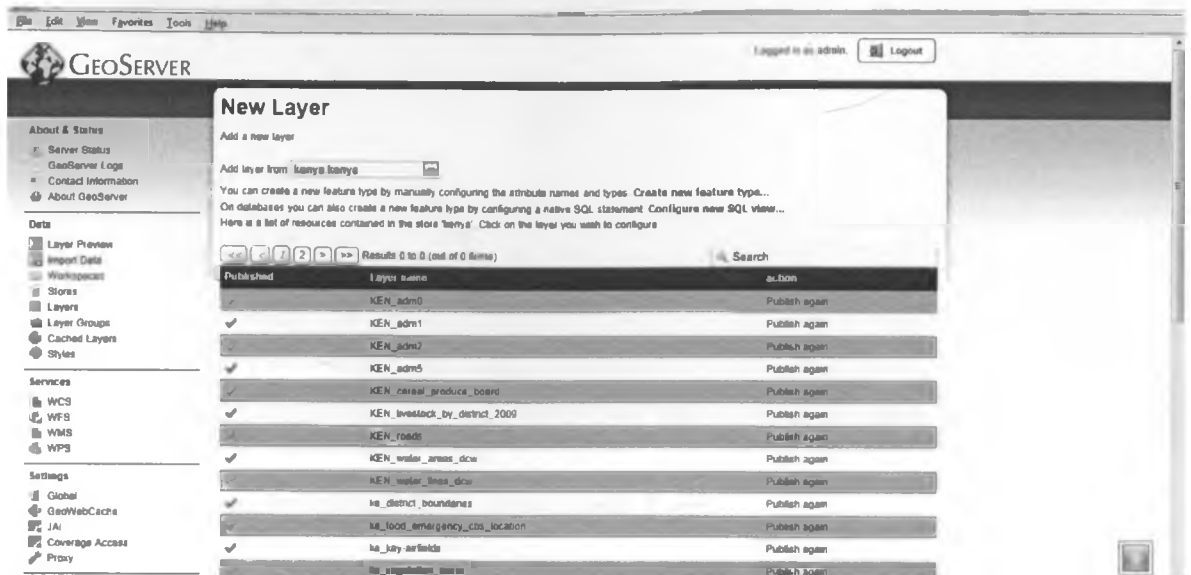
Clicking on Publish gives a screen to define the various parameters of the layer.
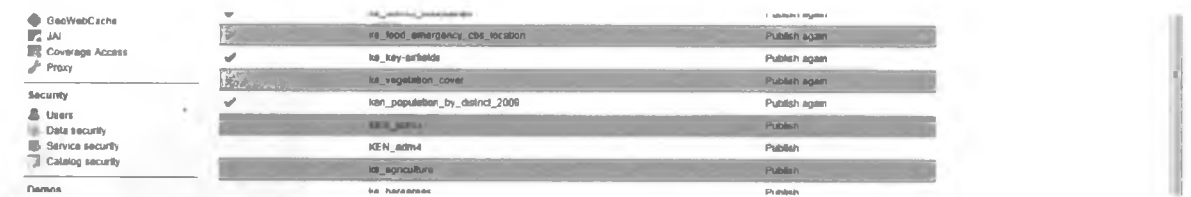
For complete details of the various parameters to be set, consult the Geoserver manual.
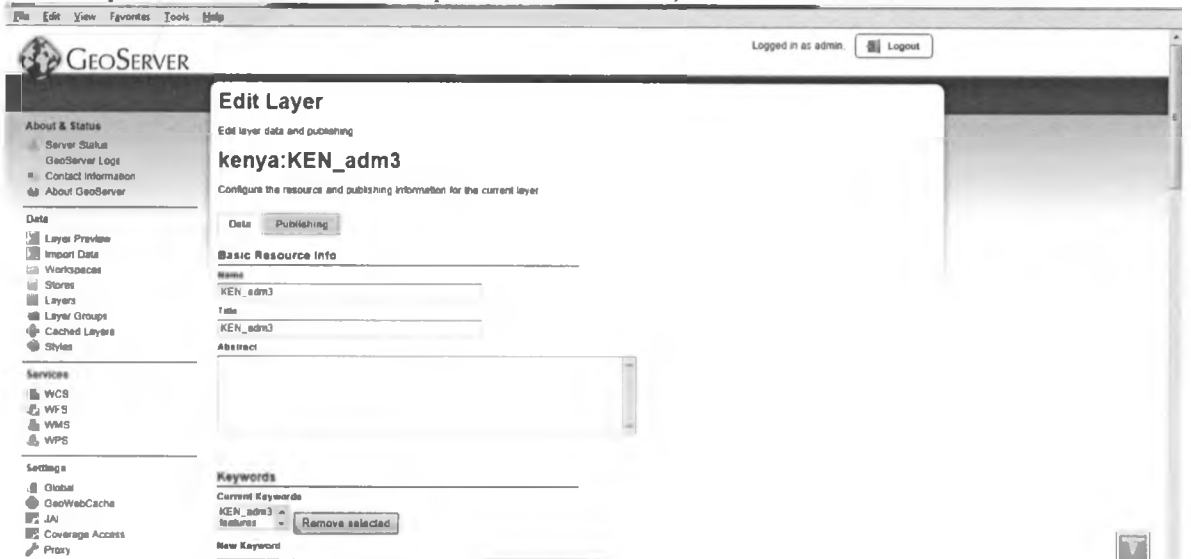
The home page makes reference to the various modules in the Geoserver.

The various links on the left lead to the various map layers.

Scale = 1 : 16M   45.77268, -8.87034

KE_DISTRICT_BOUNDARIES

FID	DISTNAME
ke_district_boundaries.68	WAJIR

KE_VEGETATION_COVER

FID	PRID	FOREST
ke_vegetation_cover.788	FR-7	Open shrubs (45-40% crown cover)
ke_vegetation_cover.796	FR-8	Open low shrubs (65-40% crown cover)
ke_vegetation_cover.827	FR-7	Open shrubs (45-40% crown cover)
ke_vegetation_cover.868	FR-8	Closed shrubs
ke_vegetation_cover.886	FR-5	Closed to open woody vegetation (thicket)

To set the threshold at which an area is declared to be in need of food emergency response, click on the 'Response' link. Key in the login details then click on 'Submit Query'.

Please log in to change the emergency status
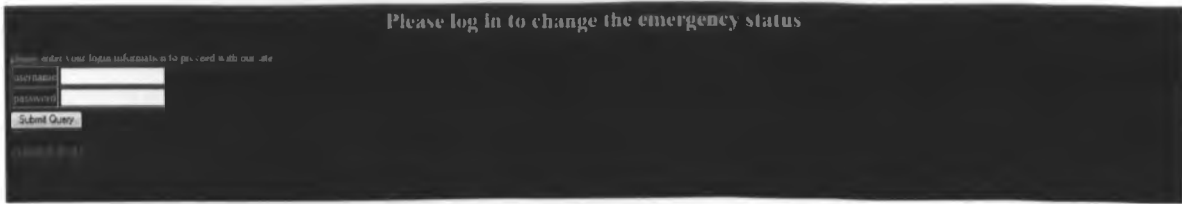
Once logged in successfully, click on 'Click here to set emergency threshold' to set the threshold.

Please log in to change the emergency status

Hi Mr.otieno

you have loged in successfully
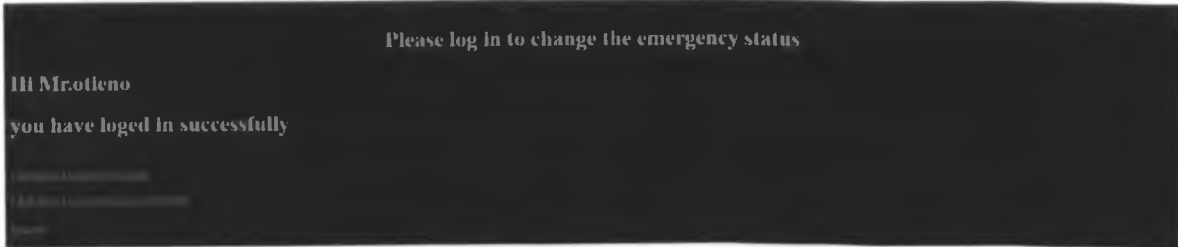
A second login is required to log onto the geoserver.
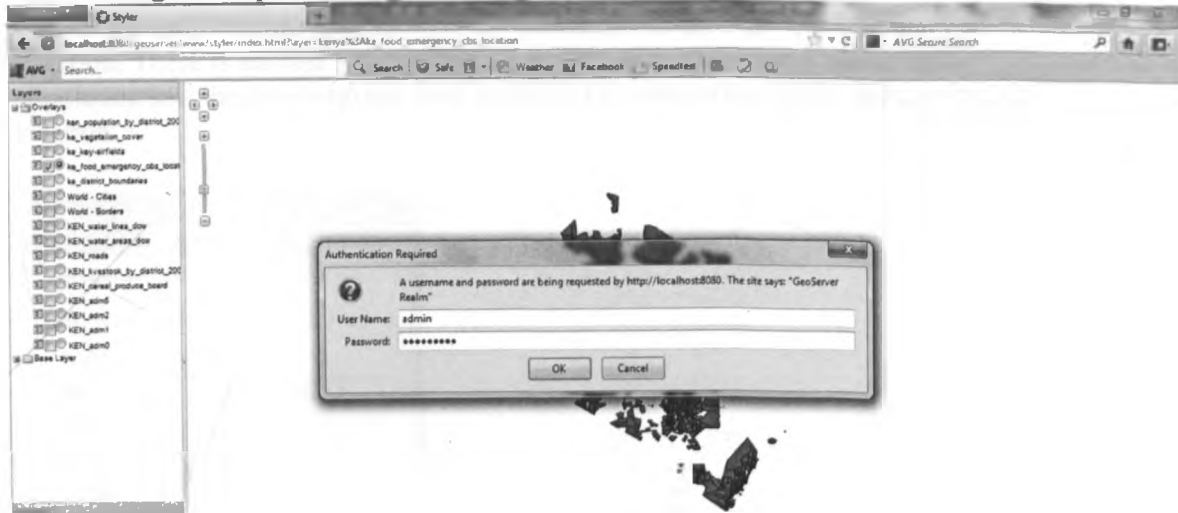
On the bottom left, click on the legend labeled 'Emergency'.

Click on 'Advanced' on the pop up window that comes up to be able to set the threshold.
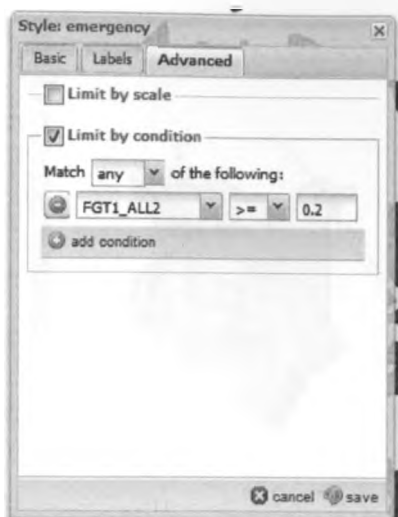
The field FGT1_ALL2 used contains the propotion of the population in a location that are in food distress in comparison to the national population.

Use of this ratio is more appropriate as it takes into account the whole country's situation. There is another optional field – FGT0_ALL2 which has a ratio of the population in a location who are food distressed in comparison to the population in the location.
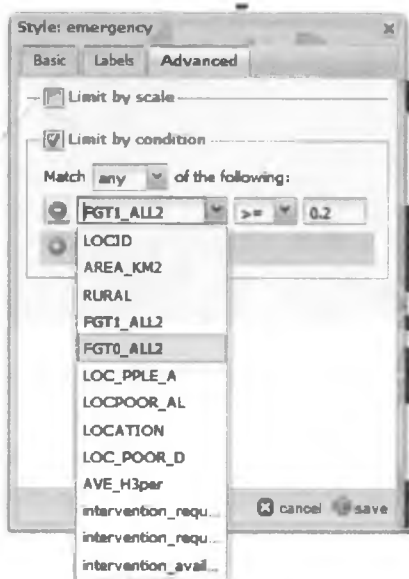
Whatever you set here will determine what all the other users will see in terms of areas requiring emergency response. This can be seen by clicking on the link 'Emergency Incidents' on the home page.

Scale = 1 : 15M location

Click on the map to get feature info

The shaded areas are the areas identified as having food emergency given the threshold set.

To edit the underlying data for the various maps, on the home page, click on 'Response' and log in.
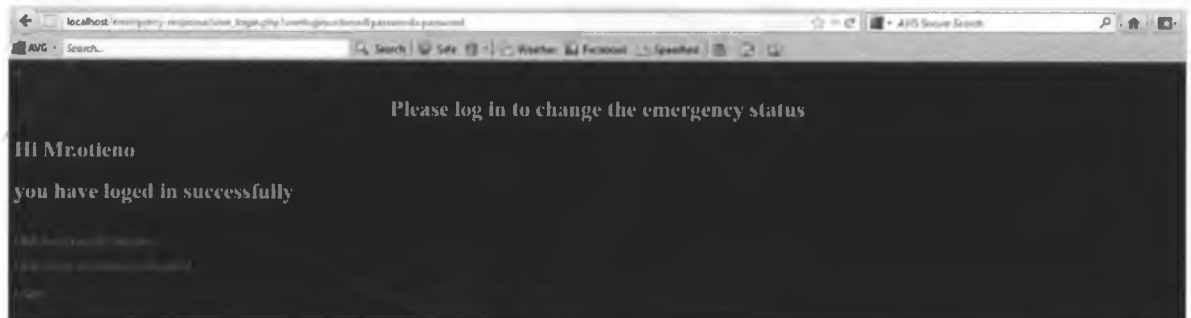
Click on 'Click here to modify the map' and select the map you want to edit.

Use the tools on the tool bar to either edit or add new features.

Appendix 2: Sample Codes

Code for the web based interface (php and html)

```
<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Transitional//EN"
"http://www.w3.org/TR/xhtml1/DTD/xhtml1-transitional.dtd">
<html xmlns="http://www.w3.org/1999/xhtml">
<!-- DW6 -->
<head>
<!-- Copyright 2005 Macromedia, Inc. All rights reserved. -->
<title>Home Page</title>
<meta http-equiv="Content-Type" content="text/html; charset=iso-8859-1" />
<link rel="stylesheet" href="mm_travel2.css" type="text/css" />
<script language="JavaScript" type="text/javascript">
//--------------- LOCALIZEABLE GLOBALS ----------------
var d=new Date();
var monthname=new
Array("January","February","March","April","May","June","July","August","Septembe
r","October","November","December");
//Ensure correct for language. English is "January 1, 2004"
var TODAY = monthname[d.getMonth()] + " " + d.getDate() + ", " + d.getFullYear();
//---------------   END LOCALIZEABLE   ----------------
</script></head>
<body bgcolor="#C0DFFD">
<table width="100%" border="0" cellspacing="0" cellpadding="0">
 <tr bgcolor="#3366CC">
  <td width="382" colspan="3" rowspan="2"><img src="mm_travel_photo.jpg"
alt="Header image" width="382" height="127" border="0" /></td>
  <td width="378" height="63" colspan="3" id="logo" valign="bottom"
align="center" nowrap="nowrap">Food Emergency Response System </td>
  <td width="100%" rowspan="2"><div align="right"><strong><img
src="index_clip_image002.gif" alt="UON_Logo" width="92" height="102"
/></strong></div></td>
 </tr>
 <tr bgcolor="#3366CC">
  <td height="64" colspan="3" id="tagline" valign="top"
align="center">ADDRESSING KENYA'S FOOD EMERGENCY </td>
 </tr>
 <tr>
  <td colspan="7" bgcolor="#003366"><img src="mm_spacer.gif" alt="" width="1"
height="1" border="0" /></td>
 </tr>
 <tr bgcolor="#CCFF99">
      <td colspan="7" id="dateformat" height="25">  <script
language="JavaScript" type="text/javascript">
    document.write(TODAY);        </script>        </td>
 </tr>
 <tr>
  <td colspan="7" bgcolor="#003366"><img src="mm_spacer.gif" alt="" width="1"
height="1" border="0" /></td>
```

```
    </tr>
<tr>
   <td width="165" valign="top" bgcolor="#E6F3FF">
        <table border="0" cellspacing="0" cellpadding="0" width="200"
id="navigation">
     <tr>
      <td width="200"> <br />
                 <br /></td>
     </tr>
     <tr>
      <td width="200"><a href="http://localhost:8080/geoexplorer/composer/"
class="navText">create your own map</a></td>
     </tr>
     <tr>
      <td width="200"><a
href="http://localhost:8080/geoserver/wms?service=WMS&amp;version=1.1.0&amp;r
equest=GetMap&amp;layers=emergency&amp;styles=&amp;bbox=33.909586,-
4.720417,41.9129219055176,5.15700578689575&amp;width=414&amp;height=512&
amp;srs=EPSG:4326&amp;format=application/openlayers"
class="navText">emergency incidents </a></td>
     </tr>
     <tr>
      <td width="200"><a
href="http://localhost:8080/geoserver/wms?service=WMS&amp;version=1.1.0&amp;r
equest=GetMap&amp;layers=Roads&amp;styles=&amp;bbox=33.9133987426758,-
4.67741870880127,41.9129219055176,5.47052097320557&amp;width=403&amp;hei
ght=512&amp;srs=EPSG:4326&amp;format=application/openlayers"
class="navText">road network </a></td>
     </tr>
     <tr>
      <td width="200"><a
href="http://localhost:8080/geoserver/wms?service=WMS&amp;version=1.1.0&amp;r
equest=GetMap&amp;layers=Livestock&amp;styles=&amp;bbox=33.909586,-
4.72042,41.88752,4.63381900000013&amp;width=436&amp;height=512&amp;srs=E
PSG:4326&amp;format=application/openlayers" class="navText">livestock</a></td>
     </tr>
     <tr>
      <td height="40"><a
href="http://localhost:8080/geoserver/wms?service=WMS&amp;version=1.1.0&amp;r
equest=GetMap&amp;layers=Key Airfields&amp;styles=&amp;bbox=33.909586,-
4.72042,41.88752,4.63381900000013&amp;width=436&amp;height=512&amp;srs=E
PSG:4326&amp;format=application/openlayers">key airfields </a></td>
     </tr>
     <tr>
      <td width="200"><a
href="http://localhost:8080/geoserver/wms?service=WMS&amp;version=1.1.0&amp;r
equest=GetMap&amp;layers=vegetation
cover&amp;styles=&amp;bbox=33.9095153808594,-
4.67808818817139,41.9129219055176,5.47052097320557&amp;width=403&amp;hei
```

ght=512&srs=EPSG:4326&format=application/openlayers"
class="navText">vegetation cover </td>
   </tr>
   <tr>
    <td><a
href="http://localhost:8080/geoserver/wms?service=WMS&version=1.1.0&r
equest=GetMap&layers=water
bodies&styles=&bbox=33.9083444196899,-
4.6502805036029,41.8539086046416,4.62499562754137&width=438&heig
ht=512&srs=EPSG:4326&format=application/openlayers"
class="navText">water bodies </td>
   </tr>
   <tr>
    <td><a
href="http://localhost:8080/geoserver/wms?service=WMS&version=1.1.0&r
equest=GetMap&layers=Population&styles=&bbox=33.9133987426758
;-
4.67741870880127,41.9129219055176,5.47052097320557&width=403&hei
ght=512&srs=EPSG:4326&format=application/openlayers"
class="navText">population spread </td>
   </tr>
   <tr>
    <td><a
href="http://localhost:8080/geoserver/wms?service=WMS&version=1.1.0&r
equest=GetMap&layers=NCPB
Stores&styles=&bbox=33.9133987426758,-
4.67741870880127,41.9129219055176,5.47052097320557&width=403&hei
ght=512&srs=EPSG:4326&format=application/openlayers"
class="navText">NCPB Stores </td>
   </tr>
   <tr>
    <td> </td>
   </tr>
   <tr>
    <td>reponse</td>
   </tr>
   <tr>
    <td>contact</td>
   </tr>
  </table>

    </form>

  </td>
  <td width="50"><img src="mm_spacer.gif" alt="" width="50" height="1"
border="0" /></td>
  <td width="305" colspan="2" valign="top"><img src="mm_spacer.gif" alt=""
width="305" height="1" border="0" />

```
 <br />
 <br />
<table border="0" cellspacing="0" cellpadding="0" width="305">
  <tr>
    <td class="pageName">One stop portal for food emergency response </td>
      </tr>
        <tr>
    <td class="bodyText"><p>This portal will assist various stakeholders in
addressing food security problem in Kenya. </p>
        <p>The portal has made use of interactive maps that allow for visual monitoring
of food emergency incidents. Resolution of such emergencies depends on timely
availability of information, and that is what this portal aims at achieving. </p>
        <p>If you have any feedback on how this portal can be improved, you are
welcome to provide us with the feedback. </p>
        <p>Hope the website provides you with the information you need!</p></td>
      </tr>
    </table>
<p> </p>
</p>
<fieldset >
<legend>Login</legend>
<form action="<?php echo $_SERVER['PHP_SELF']; ?>" method=get>
<?php
      loginform();
?>
</fieldset>
</form>
    <p>
<p> </p></td>
   <td width="50"><img src="mm_spacer.gif" alt="" width="50" height="1"
border="0" /></td>
     <td width="190" valign="top"><br />
               <br />
              <table border="0" cellspacing="0" cellpadding="0" width="190">
                  <tr>
                  <td colspan="3" class="subHeader"
align="center">UPCOMING EVENTS </td>
                    </tr>
                    <tr>
                    <td width="40"><img src="mm_spacer.gif" alt="" width="40"
height="1" border="0" /></td>
                    <td width="110" id="sidebar" class="smallText"><br />
                    <p><img src="mm_travel_photo1.jpg" alt="Image 1"
width="110" height="110" vspace="6" border="0" /><br />
                    Inter-government agencies consultation on food security.<br />
                    <a href="javascript:;">Read more &gt;</a></p>

                    <p><img src="mm_travel_photo2.jpg" alt="Image 2"
width="110" height="110" vspace="6" border="0" /><br />
                    Training on use of ICT in addressing food security <br />
```

```html
                        <a href="javascript:;">Read more &gt;</a></p>
                         <br />
                         <br />
                         <br />                         </td>
                        <td width="40"> </td>
                        </tr>
                </table>          </td>
        <td width="100%"> </td>
  </tr>
  <tr>
   <td width="165"> </td>
   <td width="50"> </td>
   <td width="167"> </td>
   <td width="138"> </td>
   <td width="50"> </td>
   <td width="190"> </td>
        <td width="100%"> </td>
  </tr>
</table>
```

```php
                    <?php
                        session_start();
                            if($_SESSION["logged"])
                                    {
                                            print_secure_content();
                                    }
                                else
                                    {
                                            if(!$_SESSION["logging"])
                                            {
                                                    $_SESSION["logging"]=true;
                                            }
                                            else if($_SESSION["logging"])
                                            {
                                                    $number_of_rows=checkpass();
                                                    if($number_of_rows==1)
                                                        {

        $_SESSION[user]=$_GET[userlogin];

        $_SESSION[agency]=$_GET[agency];

        $_SESSION[logged]=true;

                                                        print"<h1>you have
loged in successfully</h1>";
        print_secure_content();
                                                        }
                                                    else
                                                        {
```

```
                                                        print "wrong pawssword or
username, please try again";
                                                        }
                                        }
                        }
function loginform()
{
//      print "please enter your login information to proceed with our site";
        print ("<table border='2'><tr><td>username</td><td><input type='text'
name='userlogin' size'20'></td></tr><tr><td>password</td><td><input
type='password' name='password' size'20'></td></tr></table>");
        print "<input type='submit' >";
        print "<h3><a href='registration.php'>register now!</a></h3>";
}
function checkpass()
{
        $servername="localhost:3307";
        $username="root";
        $password="password";
        $conn= mysql_connect($servername,$username, $password)or
die(mysql_error());
        mysql_select_db("test",$conn);
        $sql="select * from users where name='$_GET[userlogin]' and
password='$_GET[password]'";
        $result=mysql_query($sql,$conn) or die(mysql_error());
        return  mysql_num_rows($result);
}
function print_secure_content()
{
        print("<b><h1>Hi Mr.$_SESSION[user]</h1>");
        print(checkagency());
        print ("<br><h2>You have succesfully logged in and you are now able to edit
the various maps.</h2>
        <br>
        <a
href='http://localhost:8080/geoeditor/?q=%7B%22map%22%3A%7B%22center%22%
3A%5B4220473.7010547%2C44317.894484665%5D%2C%22zoom%22%3A5%2C%
22layers%22%3A%5B%7B%22title%22%3A%22ken_population_by_district_2009%2
2%2C%22name%22%3A%22kenya%3Aken_population_by_district_2009%22%2C%
22visibility%22%3Atrue%2C%22format%22%3A%22image%2Fpng%22%2C%22tra
nsparent%22%3Atrue%7D%5D%7D%7D'>Click here to edit district population
statistics</a>
        <br>
        <br>
        <a
href='http://localhost:8080/geoeditor/?q=%7B%22map%22%3A%7B%22center%22%
3A%5B37.926766670587%2C0.3933556794864%5D%2C%22zoom%22%3A6%2C%
22layers%22%3A%5B%7B%22title%22%3A%22KEN_roads%22%2C%22name%22
%3A%22kenya%3AKEN_roads%22%2C%22visibility%22%3Atrue%2C%22format%
```

22%3A%22image%2Fpng%22%2C%22transparent%22%3Atrue%7D%5D%7D%7D'>
Click here to edit roads map

        <a
href='http://localhost:8080/geoeditor/?q=%7B%22map%22%3A%7B%22center%22%
3A%5B4191925.5605973%2C-
4656.05419081%5D%2C%22zoom%22%3A5%2C%22layers%22%3A%5B%7B%22ti
tle%22%3A%22KEN_livestock_by_district_2009%22%2C%22name%22%3A%22ken
ya%3AKEN_livestock_by_district_2009%22%2C%22visibility%22%3Atrue%2C%22
format%22%3A%22image%2Fpng%22%2C%22transparent%22%3Atrue%7D%5D%7
D%7D'>Click here to edit livestock counts
</br>

        <a
href='http://localhost:8080/geoeditor/?q=%7B%22map%22%3A%7B%22center%22%
3A%5B4215445.8431948%2C42110.89778934%5D%2C%22zoom%22%3A5%2C%2
2layers%22%3A%5B%7B%22title%22%3A%22ke_vegetation_cover%22%2C%22na
me%22%3A%22kenya%3Ake_vegetation_cover%22%2C%22visibility%22%3Atrue%
2C%22format%22%3A%22image%2Fpng%22%2C%22transparent%22%3Atrue%7D
%5D%7D%7D'>Click here to edit vegetation cover

        <a
href='http://localhost:8080/geoeditor/?q=%7B%22map%22%3A%7B%22center%22%
3A%5B4237914.8783187%2C12383.848045265%5D%2C%22zoom%22%3A5%2C%
22layers%22%3A%5B%7B%22title%22%3A%22ke_key-
airfields%22%2C%22name%22%3A%22kenya%3Ake_key-
airfields%22%2C%22visibility%22%3Atrue%2C%22format%22%3A%22image%2Fp
ng%22%2C%22transparent%22%3Atrue%7D%5D%7D%7D'>Click here to edit the
airfields in Kenya

        <a
href='http://localhost:8080/geoeditor/?q=%7B%22map%22%3A%7B%22center%22%
3A%5B4177811.516424%2C-
25986.47184806%5D%2C%22zoom%22%3A5%2C%22layers%22%3A%5B%7B%22
title%22%3A%22KEN_cereal_produce_board%22%2C%22name%22%3A%22kenya
%3AKEN_cereal_produce_board%22%2C%22visibility%22%3Atrue%2C%22format
%22%3A%22image%2Fpng%22%2C%22transparent%22%3Atrue%7D%5D%7D%7
D'>Click here to edit the NCPB stocks

        Logout

        ");
}

function checkagency()
{

```php
        $servername="localhost:3307";
        $username="root";
        $password="password";
        $conn= mysql_connect($servername,$username, $password)or
die(mysql_error());
        mysql_select_db("test",$conn);
        $sql="select agency from users where name='$_GET[userlogin]' and
password='$_GET[password]'";
        $result=mysql_query($sql,$conn) or die(mysql_error());
        return ($result);
}
```

MySQL Database schema sample code

```sql
-- MySQL Administrator dump 1.4
--
-- ------------------------------------------------------
-- Server version       5.0.90-community-nt


/*!40101 SET
@OLD_CHARACTER_SET_CLIENT=@@CHARACTER_SET_CLIENT */;
/*!40101 SET
@OLD_CHARACTER_SET_RESULTS=@@CHARACTER_SET_RESULTS */;
/*!40101 SET
@OLD_COLLATION_CONNECTION=@@COLLATION_CONNECTION */;
/*!40101 SET NAMES utf8 */;

/*!40014 SET @OLD_UNIQUE_CHECKS=@@UNIQUE_CHECKS,
UNIQUE_CHECKS=0 */;
/*!40014 SET @OLD_FOREIGN_KEY_CHECKS=@@FOREIGN_KEY_CHECKS,
FOREIGN_KEY_CHECKS=0 */;
/*!40101 SET @OLD_SQL_MODE=@@SQL_MODE,
SQL_MODE='NO_AUTO_VALUE_ON_ZERO' */;


--
-- Create schema test
--

CREATE DATABASE IF NOT EXISTS test;
USE test;


--
-- Definition of table `users`
--

DROP TABLE IF EXISTS `users`;
CREATE TABLE `users` (
  `id` int(11) NOT NULL auto_increment,
  `name` varchar(20) NOT NULL,
```

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```
  `password` varchar(20) NOT NULL,
  `agency` varchar(20) NOT NULL,
  PRIMARY KEY  (`id`)
) ENGINE=InnoDB AUTO_INCREMENT=4 DEFAULT CHARSET=latin1;

--
-- Dumping data for table `users`
--

/*!40000 ALTER TABLE `users` DISABLE KEYS */;
INSERT INTO `users` (`id`,`name`,`password`,`agency`) VALUES
 (1,'otieno','password','agriculture'),
 (3,'benjamin','pass','roads');
/*!40000 ALTER TABLE `users` ENABLE KEYS */;




/*!40101 SET SQL_MODE=@OLD_SQL_MODE */;
/*!40014 SET FOREIGN_KEY_CHECKS=@OLD_FOREIGN_KEY_CHECKS */;
/*!40014 SET UNIQUE_CHECKS=@OLD_UNIQUE_CHECKS */;
/*!40101 SET CHARACTER_SET_CLIENT=@OLD_CHARACTER_SET_CLIENT
*/;
/*!40101 SET
CHARACTER_SET_RESULTS=@OLD_CHARACTER_SET_RESULTS */;
/*!40101 SET
COLLATION_CONNECTION=@OLD_COLLATION_CONNECTION */;
/*!40101 SET CHARACTER_SET_CLIENT=@OLD_CHARACTER_SET_CLIENT
*/;
```

Postgres Database schema

```
-- Schema: public

CREATE SCHEMA public
  AUTHORIZATION postgres;

GRANT ALL ON SCHEMA public TO postgres;
GRANT ALL ON SCHEMA public TO public;
COMMENT ON SCHEMA public
  IS 'standard public schema';

-- Table: "KEN_adm3"

-- DROP TABLE "KEN_adm3";

CREATE TABLE "KEN_adm3"
(
  gid serial NOT NULL,
  "ID_0" integer,
```

```
  "ISO" character varying(3),
  "NAME_0" character varying(75),
  "ID_1" integer,
  "NAME_1" character varying(75),
  "ID_2" integer,
  "NAME_2" character varying(75),
  "ID_3" integer,
  "NAME_3" character varying(75),
  "VARNAME_3" character varying(100),
  "NL_NAME_3" character varying(75),
  "HASC_3" character varying(25),
  "TYPE_3" character varying(50),
  "ENGTYPE_3" character varying(50),
  "VALIDFR_3" character varying(25),
  "VALIDTO_3" character varying(25),
  "REMARKS_3" character varying(50),
  "Shape_Leng" double precision,
  "Shape_Area" double precision,
  the_geom geometry,
  CONSTRAINT "KEN_adm3_pkey" PRIMARY KEY (gid ),
  CONSTRAINT enforce_dims_the_geom CHECK (st_ndims(the_geom) = 2),
  CONSTRAINT enforce_srid_the_geom CHECK (st_srid(the_geom) = (-1))
)
WITH (
 OIDS=FALSE
);
ALTER TABLE "KEN_adm3"
 OWNER TO postgres;

-- Table: "KEN_cereal_produce_board"

-- DROP TABLE "KEN_cereal_produce_board";

CREATE TABLE "KEN_cereal_produce_board"
(
 gid serial NOT NULL,
 "STORE" character varying(75),
 "MAIZE" integer,
 "BEANS" integer,
 "RICE" integer,
 "COUNTY" character varying(75),
 "PROVINCE" character varying(75),
 the_geom geometry,
 CONSTRAINT "KEN_cereal_produce_board_pkey" PRIMARY KEY (gid ),
 CONSTRAINT enforce_dims_the_geom CHECK (st_ndims(the_geom) = 2),
 CONSTRAINT enforce_geotype_the_geom CHECK (geometrytype(the_geom) =
'POINT'::text OR the_geom IS NULL),
 CONSTRAINT enforce_srid_the_geom CHECK (st_srid(the_geom) = (-1))
)
WITH (
```

```sql
  OIDS=FALSE
);
ALTER TABLE "KEN_cereal_produce_board"
  OWNER TO postgres;
-- Table: "KEN_livestock_by_district_2009"

-- DROP TABLE "KEN_livestock_by_district_2009";

CREATE TABLE "KEN_livestock_by_district_2009"
(
  gid serial NOT NULL,
  "DISTRICT" character varying(75),
  "CATTLE" integer,
  "SHEEP" integer,
  "GOATS" integer,
  "CAMELS" integer,
  "DONKEYS" integer,
  "PIGS" integer,
  "INDEGENOUS_CHICKEN" integer,
  "COMMERCIAL_CHICKEN" integer,
  "BEE_HIVES" integer,
  "COUNTY" character varying(75),
  "LOCATION" character varying(75),
  "PROVINCE" character varying(75),
  the_geom geometry,
  CONSTRAINT "KEN_lovestock_by_district_2009_pkey" PRIMARY KEY (gid ),
  CONSTRAINT enforce_dims_the_geom CHECK (st_ndims(the_geom) = 2),
  CONSTRAINT enforce_geotype_the_geom CHECK (geometrytype(the_geom) =
'POINT'::text OR the_geom IS NULL),
  CONSTRAINT enforce_srid_the_geom CHECK (st_srid(the_geom) = (-1))
)
WITH (
  OIDS=FALSE
);
ALTER TABLE "KEN_livestock_by_district_2009"
  OWNER TO postgres;
-- Table: "KEN_roads"

-- DROP TABLE "KEN_roads";

CREATE TABLE "KEN_roads"
(
  gid serial NOT NULL,
  "MED_DESCRI" character varying(254),
  "RTT_DESCRI" character varying(254),
  "F_CODE_DES" character varying(10),
  "ISO" character varying(7),
  "ISOCOUNTRY" character varying(54),
  the_geom geometry,
  CONSTRAINT "KEN_roads_pkey" PRIMARY KEY (gid ),
```

```sql
  CONSTRAINT enforce_dims_the_geom CHECK (st_ndims(the_geom) = 2),
  CONSTRAINT enforce_srid_the_geom CHECK (st_srid(the_geom) = (-1))
)
WITH (
  OIDS=FALSE
);
ALTER TABLE "KEN_roads"
  OWNER TO postgres;
-- Table: "KEN_water_areas_dcw"

-- DROP TABLE "KEN_water_areas_dcw";

CREATE TABLE "KEN_water_areas_dcw"
(
  gid serial NOT NULL,
  "ISO" character varying(7),
  "COUNTRY" character varying(54),
  "F_CODE_DES" character varying(254),
  "HYC_DESCRI" character varying(254),
  "NAME" character varying(254),
  the_geom geometry,
  CONSTRAINT "KEN_water_areas_dcw_pkey" PRIMARY KEY (gid ),
  CONSTRAINT enforce_dims_the_geom CHECK (st_ndims(the_geom) = 2),
  CONSTRAINT enforce_srid_the_geom CHECK (st_srid(the_geom) = (-1))
)
WITH (
  OIDS=FALSE
);
ALTER TABLE "KEN_water_areas_dcw"
  OWNER TO postgres;

-- Table: spatial_ref_sys

-- DROP TABLE spatial_ref_sys;

CREATE TABLE spatial_ref_sys
(
  srid integer NOT NULL,
  auth_name character varying(256),
  auth_srid integer,
  srtext character varying(2048),
  proj4text character varying(2048),
  CONSTRAINT spatial_ref_sys_pkey PRIMARY KEY (srid )
)
WITH (
  OIDS=FALSE
);
ALTER TABLE spatial_ref_sys
  OWNER TO postgres;
GRANT ALL ON TABLE spatial_ref_sys TO postgres;
```

GRANT ALL ON TABLE spatial_ref_sys TO public;

-- Function: _st_asgeojson(integer, geography, integer, integer)

-- DROP FUNCTION _st_asgeojson(integer, geography, integer, integer);

CREATE OR REPLACE FUNCTION _st_asgeojson(integer, geography, integer, integer)
  RETURNS text AS
'$libdir/postgis-1.5', 'geography_as_geojson'
  LANGUAGE c IMMUTABLE STRICT
  COST 1;
ALTER FUNCTION _st_asgeojson(integer, geography, integer, integer)
  OWNER TO postgres;
-- Function: _st_asgeojson(integer, geometry, integer, integer)

-- DROP FUNCTION _st_asgeojson(integer, geometry, integer, integer);

CREATE OR REPLACE FUNCTION _st_asgeojson(integer, geometry, integer, integer)
  RETURNS text AS
'$libdir/postgis-1.5', 'LWGEOM_asGeoJson'
  LANGUAGE c IMMUTABLE STRICT
  COST 1;
ALTER FUNCTION _st_asgeojson(integer, geometry, integer, integer)
  OWNER TO postgres;
-- Function: _st_asgml(integer, geometry, integer, integer)

-- DROP FUNCTION _st_asgml(integer, geometry, integer, integer);

CREATE OR REPLACE FUNCTION _st_asgml(integer, geometry, integer, integer)
  RETURNS text AS
'$libdir/postgis-1.5', 'LWGEOM_asGML'
  LANGUAGE c IMMUTABLE STRICT
  COST 1;
ALTER FUNCTION _st_asgml(integer, geometry, integer, integer)
  OWNER TO postgres;
-- Function: _st_asgml(integer, geography, integer, integer)

-- DROP FUNCTION _st_asgml(integer, geography, integer, integer);

CREATE OR REPLACE FUNCTION _st_asgml(integer, geography, integer, integer)
  RETURNS text AS
'$libdir/postgis-1.5', 'geography_as_gml'
  LANGUAGE c IMMUTABLE STRICT
  COST 1;
ALTER FUNCTION _st_asgml(integer, geography, integer, integer)
  OWNER TO postgres;

```
-- View: geography_columns

-- DROP VIEW geography_columns;

CREATE OR REPLACE VIEW geography_columns AS
 SELECT current_database() AS f_table_catalog, n.nspname AS f_table_schema,
c.relname AS f_table_name, a.attname AS f_geography_column,
geography_typmod_dims(a.atttypmod) AS coord_dimension,
geography_typmod_srid(a.atttypmod) AS srid, geography_typmod_type(a.atttypmod)
AS type
  FROM pg_class c, pg_attribute a, pg_type t, pg_namespace n
  WHERE t.typname = 'geography'::name AND a.attisdropped = false AND a.atttypid =
t.oid AND a.attrelid = c.oid AND c.relnamespace = n.oid AND NOT
pg_is_other_temp_schema(c.relnamespace);

ALTER TABLE geography_columns
  OWNER TO postgres;
-- Function: checkauthtrigger()

-- DROP FUNCTION checkauthtrigger();

CREATE OR REPLACE FUNCTION checkauthtrigger()
  RETURNS trigger AS
'$libdir/postgis-1.5', 'check_authorization'
  LANGUAGE c VOLATILE
  COST 1;
ALTER FUNCTION checkauthtrigger()
  OWNER TO postgres;
-- Function: postgis_cache_bbox()

-- DROP FUNCTION postgis_cache_bbox();

CREATE OR REPLACE FUNCTION postgis_cache_bbox()
  RETURNS trigger AS
'$libdir/postgis-1.5', 'cache_bbox'
  LANGUAGE c VOLATILE
  COST 1;
ALTER FUNCTION postgis_cache_bbox()
  OWNER TO postgres;
```