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ICT and Food Security: Case of GIS in Food Emergency Response

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ABSTRACT

This paper presents a framework for food emergency response and demonstrates the use of Geographical Information Systems as a solution to planning for and managing food emergencies. This is particularly critical in countries such Kenya where there is no unified communication framework to facilitate the management of food emergencies. The research contextualized the WHO/FAO Multiagency Coordination Group Framework to the Kenyan situation, established information essential to the resolution of food emergencies, and developed a GIS system that can be used for early warning, monitoring, surveillance and logistics in times of emergency. The prototype was tested with data obtained from relevant government agencies. This research aimed to address the effects of famine so that it is least felt as a result of well-coordinated food emergency response. The solution can be adapted not only in other countries but also in other emergencies. The framework can be a key element of a national policy on food emergency response particularly in those countries where there is none.

General Terms

Food Security, GIS

Keywords

Food Emergency, Food Emergency Response, GIS in Food Security, GIS in Food Emergency

1. INTRODUCTION

Food availability, access and utilization are major problems in many African countries and as a result, food crises will always be present. Since food crises affect lives directly, the manner in which food crises are managed is very important. One of the biggest problems in these crises is coordination and inadequate information. Food emergency is a situation, whether accidental or intentional, that is identified by a competent authority as constituting a serious and as yet uncontrolled food borne risk to public health that requires urgent action. Food emergency response comprise of actions taken to contain food emergencies, including food aid distribution.

Sharing of correct and timely information during food emergency periods is critical in efficient management of the emergencies. In Kenya, there is no unified communication framework to facilitate management of food emergencies. In its national policy for disaster management, the government of Kenya confirms inadequate information and data as one of the impediments in disaster management (GOK, 2009).

The objective of this research was to develop a framework for food emergency response and design a prototype system that would be used in planning for and managing food emergencies using Geographical Information System (GIS).

The research contextualized the FAO/WHO Multiagency Coordination Group (MACG) framework (FAO/WHO, 2010), established information of essence to food security that can be mapped onto a GIS and used in the resolution of food emergencies, and developed a prototype system that can be used for early warning, monitoring, surveillance and logistics in times of emergency. The prototype was tested with data obtained from Kenya National Bureau of Statistics (KNBS, 2012) and related government agencies.

This research aimed to address the effects of famine so that it is least felt as a result of well-coordinated food emergency response. The tool developed can be used by the various players in making decisions based on accurate information by agencies directly making regular returns onto the system instead of waiting for end of month. This way, more regular assessment of the situation can be done.

2. RELATED WORK

2.1 ICT and Food Security

There are several ways in which ICTs can address the problem of food security at the local and global level (Boon, 2010; Riely et al 1999). ICTs are used by many international organizations for mapping and monitoring world food supplies, early warning systems, and to respond when disasters strike. In developing countries, the use of ICTs by farmers and the rural population to overcome hunger and food security remains in its early stages. The full potential of ICTs to address food security has yet to be realized (Romero, 2009).

ICTs can be used as an enabler, both locally and globally, to ensure food security (UNDP, 2005; UNECA, 2005). There are many initiatives that have been made towards achieving adequate food availability using ICT as a catalyst. A summary of key ICT driven projects, either covering the whole country or regional are documented below (Gakuru et al, 2009).

Table 1: ICT Based Projects aimed at Improving Food Availability in Kenya: Source Gakuru et al

Project	Project Description	Project Owner
Banana Information Line www.irinnews.org/	A text to speech telephone service with information in English/Kiswahili on banana growing	Local Language Speech Technology Initiative (LLSTI)
National Farmers' Information Service (NAFIS) www.nafis.go.ke	A nationwide government initiative to avail timely news on weather and other agricultural information through mobile phones.	Government of Kenya
The Organic Farmer www.organicfarmermagazine.org	Published information on relevant reliable and ecologically sound information to farmers	The Organic Farmer
Kenya Agricultural Commodities Exchange (KACE) www.kacekenya.com	This project collects, updates and disseminates market information to farmers and other market intermediaries.	KACE
Livestock Information Network and Knowledge System (LINKS) www.lmiske.net	Provides information on livestock production and marketing.	Global Livestock Collaborative Research Support Program (GLCRSP)
DrumNet www.drumnet.org	A regional project providing value chain management platform to link smallholder farmers to markets, financing and information	Pride Africa
Infonet-Biovision Farmer Information Platform www.infonet-biovision.org	Provides information to farmers and rural communities in Africa with contributions from local experts and international scientists on topics such as sustainable agriculture, livestock and human health.	BiVision Foundation
Linking Local Learners (LLL) www.linkinglearners.net	This provides a platform for food chain stakeholders to share information	Technical Centre for Agricultural Cooperation (CTA)
Millennium Information Centres and Community Parliaments www.kendat.org	Project aimed at establishing millennium information centres and call for side actors to provide information on crop and livestock enterprises, technologies, value addition and other information to farmers and intermediates	Kenya Network for Dissemination of Agricultural Technologies (KENDAT)

Food mapping includes mapping agricultural production and food shortages, and establishing comprehensive databases. 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 lowest level of mapping out environmentally degraded lands at village levels (Jayaraman & Srisastava, 2003). This resulted in the maintenance of scale of mapping, GIS database layers, digital domains and a classification system. 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, 2011).

ICTs can be used in strengthening the role of supply chains in food security (Romero, 2009). Essentially, ICTs can be used as an enabler, both locally and globally/nationally, to ensure food security. GIS can help to establish cross-sectoral communication by providing powerful tools for storage and analysis of statistical data, and integrating databases of different sources and map projection.

2.2 Food Emergency

Food emergency is a situation, whether accidental or intentional, that is identified by a competent authority as constituting a serious and as yet uncontrolled food borne 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. The last two stages, emergency and crisis, need central coordination (FAO/WHO, 2010).

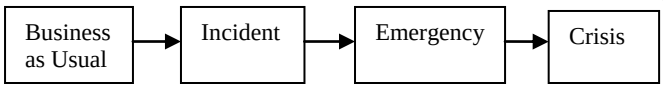

Fig 1: Evolution of Food Emergency

2.3 GIS Based Food Emergency Response

India, having had a number of calamities, and backed up with good IT infrastructure, 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 has a framework for the use of GIS in food emergency response (USDA, 2005). Its initiatives include rapid alert and notification system, school food safety programs based on hazard analysis and critical control point principles, and food defense training and tools for nutrition assistance programs. FAO/WHO have also proposed a framework for adoption by countries that do not have an emergency strategy. This framework however does not use GIS.

2.4 The FAO/WHO Multiagency Coordination Group (MACG) Framework

The Multiagency Coordination Group (MACG) framework (Figure 2) was designed to assist countries that do not have food safety emergency response plans to develop such plans, and was designed by FAO in reference to countries such as USA, UK, Ireland, Australia, Canada and France that already have elaborate strategies and plans (FAO/WHO, 2010). 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.

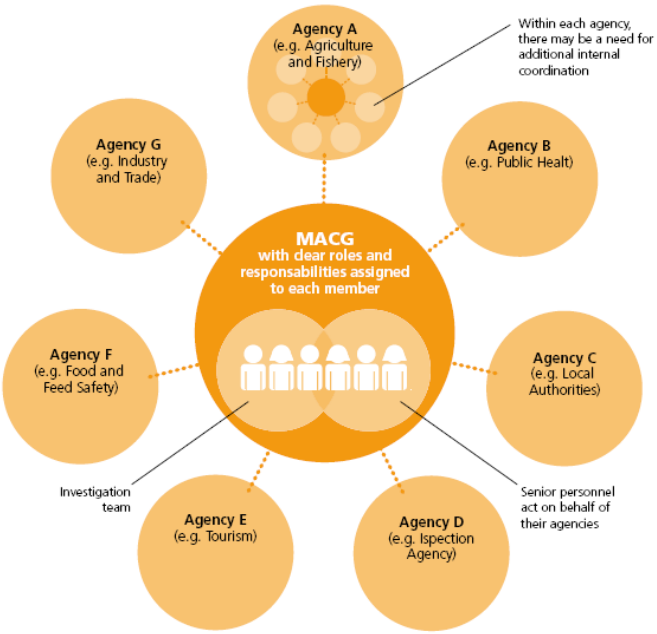

Fig 2: Multiagency Coordination Group (MACG): Source: FAO/WHO, 2010

The framework has five key elements that make up the response plan: Essential background information; Incident Identification; Incident Management; Post Incident Review and Evaluation; and Communication.

Essential Background Information: Emphasizes the use of a coordinated approach involving relevant government agencies. *Incident Identification*: This element emphasizes the use of a coordinated approach involving relevant government agencies. *Incident Management*: The investigating agency should work closely with the MACG to enable the effective coordination and review of information in order to determine the appropriate risk management action. Adequate and timely information is needed at this stage to ensure minimal casualties. *Post Incident Review and Evaluation*: Lessons learnt from the incident should be evaluated in order to strengthen the communication protocols, regulatory procedures, capacity and reporting, etc. *Communication*: The communication with partners, stakeholders, and international organizations should be well documented to avoid confusion during emergencies.

2.5 Case of Food Emergency in Kenya

The Ministry of Special Programmes is the main government department responsible for emergencies in Kenya. The ministry maintains the National Disaster Risk Coordination System that is used to maintain data on identified food emergency cases. The government uses two key sources for information fed to this system: WFP and the local administration officials. 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 (WFP, 2009). For the non-ASAL districts, the ministry relies on local administration officials who collect information on food situation in the districts and make monthly returns to the ministry.

The ministry 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 to the ministry and these returns are then fed onto the commodity tracking system. 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 government food security and nutrition strategy (FSNS) puts the blame on diminishing growth of agricultural production among other reasons (GOK, 2008). In the FSNS, the National Food Security and Nutritional Executive Committee (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 National Food and Nutrition Secretariat (NFNS) to NFSNSC, which in turn report to NFSNSC. NFNS coordinates the various agencies domiciled in various ministries through the ICCFN. The agency in charge of emergencies is in the Office of the President.

2.6 Contextualized Framework for Food Emergency in Kenya

The contextualized FAO/WHO framework was built around the five elements of the MACG and in the Kenyan context; the agencies were mapped as shown in Figure 3 below.

Fig 3: Multiagency Coordination Group (MACG) Proposed for the Kenya Context

In the Government of Kenya strategy paper (GOK, 2005), the strategic interventions in emergency situation are:

a) Provide budgetary allocations for prompt response to droughts and other natural catastrophes.

b) Decentralize and devolve decision making on acquisition, targeting and distribution of resources for mitigating catastrophes.

c) Promote emergency intervention programs that provide nutritious foods according to different physiological and regional needs.

d) 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.

e) Develop guidelines for transfer entitlements with a view to harmonizing coordination and synergy building among actors.

f) Harmonize guidelines for management of targeted feeding programs for populations in severe distress or with specific nutrition needs.

g) Strengthen financial and technical capacity of grassroots institutions such as District Steering Groups to respond to crisis.

h) Develop an effective monitoring system for the assessment of food distribution.

The government strategic interventions were mapped onto the FAO/WHO five elements as indicated in Table 2.

Table 2: A Mapping of the Information Produced/Used to the Various Agencies in the MACG

Element	Agency from MACG	Strategic Intervention	Information Produced/Used/Deduced
Background Information	▪ Office of the President ▪ Ministry of Agriculture ▪ Ministry of Health ▪ Ministry of Environment and Natural Resources ▪ Ministry of Livestock ▪ Ministry of Roads	▪ Provide budgetary allocations for prompt response to droughts and other natural catastrophe ▪ Formation of the MACG	▪ District Budgets Allocation ▪ National food reserve levels; Environmental Monitoring (rainfall, water bodies, vegetation cover, livestock count, and road network) ▪ Population spread
Incident Notification	▪ Ministry of Special Programmes	▪ 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	▪ Office of the President ▪ Ministry of Health ▪ 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	▪ Office of the President ▪ Ministry of Planning ▪ Kenya Plant Health Inspectorate	▪ 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

3. METHODOLOGY

Based on the contextualized multi-agency model framework, a GIS system was designed. Information relating to food emergencies was obtained from various government sources mainly from the open data portal (www.opendata.go.ke) and Kenya National Bureau of Statistics. The GIS system was then tested to confirm the suitability of both the framework and the system using the data obtained. Furthermore, data from the ministry responsible for emergencies (Ministry of Special Programmes) was used to validate the framework and the system.

3.1 Design of the System

The conceptual design of the system is shown in Figure 4 below.

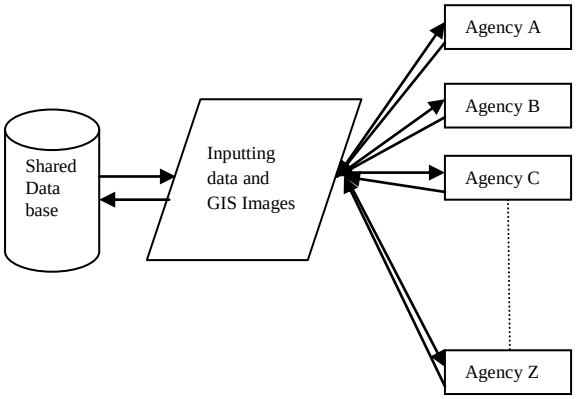

Fig 4: System Conceptual Design

The design comprised of these basic components: *Database* to store the spatial data, food emergency data, and user login details; *Data Editing* tool to allow for editing in spatial mode; Map presentation interface; and *Application Web Interface*. The architecture of the interface is modular with the map rendering, map editing, map layers creation and the main access interface being distinct from each other. The goal was to have all the various interfaces point to the same database as illustrated in Figure 5 below.

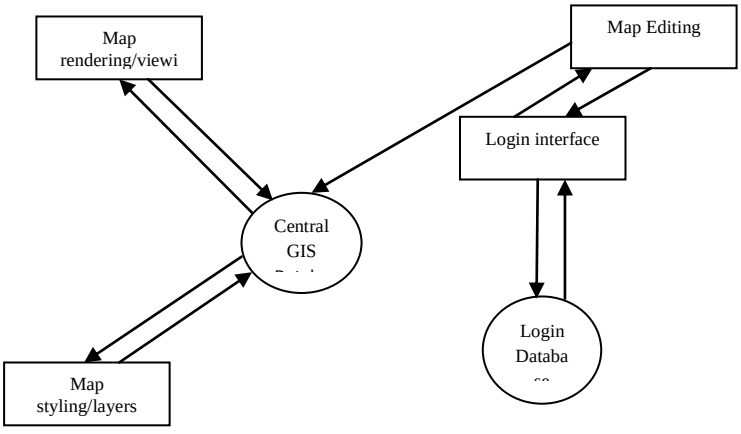

Fig 5 Application Context Diagram

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 input data to a central database by multiple agencies. Deploying the system over a web based platform is easy 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.

The system focuses on making it possible to update information in the database by different government departments, ministries, and non-government agencies involved in responding to emergencies. The aim is to have each agency to update information of relevance to it and the aggregate information pooled for sharing.

The GIS Map Editor allows the various players in the multi-agency coordinating group to input the data relevant to them. For example the Ministry of Livestock can update details about the livestock count in a district. For contingency purposes, the system was designed to allow for a client based map editor called Quantum GIS.

Since the reason of maintaining the data in a single database was to be able to present the various layers to the 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 are presented as links on the application. 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, population spread and livestock population to help determine the nature and extent of intervention required.

3.2 Data Collection

Data was obtained from the following sources and stored the data in a Postgres database:

1. 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.
2. Food crop production statistics (2005 – 2009) and arable land from the Ministry of Agriculture.
3. Livestock spread by type and district across the country from the Ministry of Livestock.
4. Rainfall patterns from the Meteorological Department.
5. Distribution of food stores across the country from National Cereal and Produce Board, the institution responsible for strategic grain reserves.
6. Water bodies and water catchment areas from the Ministry of Agriculture.
7. National and regional boundaries.
8. Food emergencies.

The database was implemented using *Postgres* with the *Spatial PostGIS* extension to support geospatial data manipulation. The data was loaded and 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 and to query the database.

3.3 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 Programmes to confirm if the framework and GIS proposed contribute to the achievement of the objectives. The interview confirmed that the GIS system would solve the existing problem of food emergency response.

4. RESULTS AND DISCUSSION

4.1 The Prototype

Based on the framework a prototype system, focused on making it possible to update the various information in the database by different government departments and non-government agencies in a distributed manner, was developed. Among the key features of this system is importing shapefiles into the database, creating map layers, setting the threshold on for an area to be declared in need of food emergency response, and determining what the other users see in terms of areas requiring emergency response.

4.2 Availing Essential Background Information

This research demonstrates that information required to address food emergences can be very effectively availed and presented in geospatial format. For example, a layer of demographics, combined with roads layout, water bodies spread etc. has been achieved. 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.

4.3 Identifying Food Safety Incidents

Although there are competent mechanisms of identifying food emergency situations in the country, the challenge in the current practice is that each agency involved does its returns in its own format. It takes time to convert to a format ready for input into the National Risk Coordination System. In the national policy for disaster management the government, confirms inadequate information and data as one of the impediments in disaster management. This model provides a better solution of capturing the data directly and hence reduces the time taken to identify emergencies. In the proposed system, the information takes spatial representation, making it easy to interpret.

4.4 Managing Incidents

Compared to current commodity tracking system maintained by the Ministry of Special Programmes in order to track and monitor food aid distribution, the proposed GIS system provides a mechanism for the agencies involved to directly make the returns more regularly instead of waiting for the end of month. This way, more regular assessment of the situation can be done. When incidents occur, the emergency maps designed will 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

4.5 Managing Post Incident Review

The maps created are can 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 to avoid recurrence.

4.6 Coordinating Communication

Since all the information is available in a single portal, coordination of communication is seamless. All that is required is Internet connection. This is a big advantage of using the proposed solution since proper coordination is critical to speedy resolution of emergencies.

5. CONCLUSIONS

This paper proposes a framework based on the five elements of the Multiagency Coordination Group that use GIS to respond efficiently to food emergencies. Timely information is of great essence in food emergency response. The GIS developed is meant to achieve the goal of availing the required information in a timely and accurate manner. GIS have been used in Kenya on a number of fronts but not in food emergency resolution. The development of a prototype system would assist in early warning, monitoring, surveillance and logistics in times of emergency. This was tested using data from the various agencies. The web technology used adds value by facilitating the sharing of information over the Internet to various agencies involved in food emergency response.

Although the study specifically looked at food emergency situation in Kenya, the framework can be adapted and used not only in other countries but also in other emergencies. The framework can be a key element of a national policy on food emergency response particularly in those countries where there is none. There will be a challenge lack of uniformity of the data available from different times and hence difficult to correlate. Further research should be done on how GIS can be used more effectively in responding to various types of emergencies.

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