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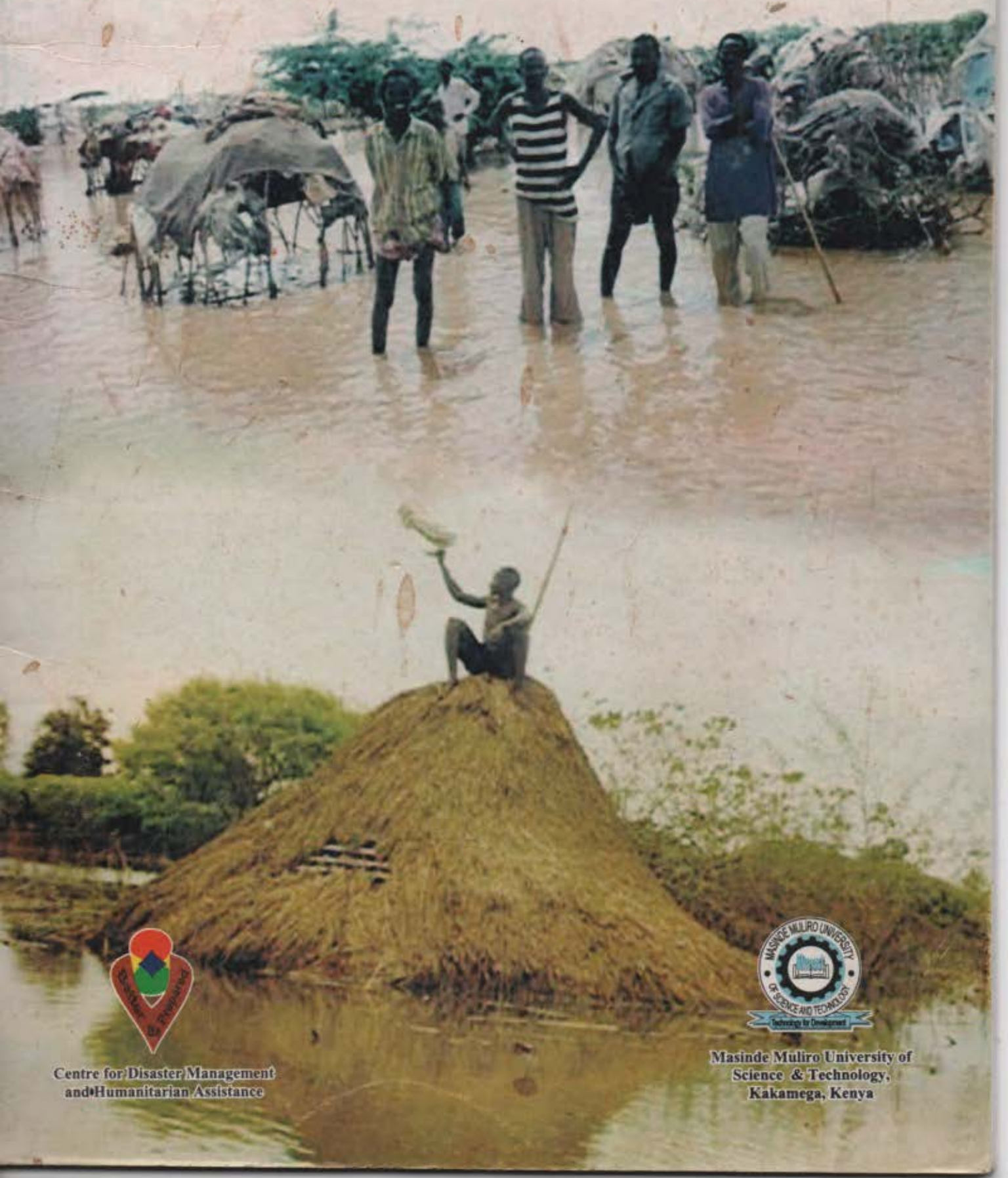

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Disaster Forecast and Management: Lessons from Hurricane Katrina

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Abstract

In August 2005, a Category 5 hurricane hit the gulf coasts of Mississippi and Louisiana. The hurricane's destructive winds bombarded coastlines, leading to the displacement of populations, a considerable death count, flooding, and environmental damage. It is estimated that property damage cost reached billions of dollars. For experts and disaster managers around the world, some questions relating to disaster mitigation remain unanswered. This paper examines the causes, implications, and human factors related to damage, and presents a critical pedagogy of the impacts of Hurricane Katrina. Scientific facts are examined, while the social factors and environmental damage are assessed to outline critical lessons learned from Katrina. They provide helpful insights to disaster relief managers and planners elsewhere who may be confronted by a disaster of such magnitude. This paper suggests that lessons derived from comparisons and contrasts learnt from Katrina devastation can foster mutual collaboration between disaster managers in East Africa and North America.

Keywords: Hurricanes, Flood Forecast, Disasters, Flood Risk Modeling

Introduction

This paper presents a critical pedagogy that investigates the cause and impacts of Hurricane Katrina. The tragedy of New Orleans, an important city because of its economic importance was the epitome of the Hurricane Katrina disaster. According to Womble *et al.* (2006) coastal Louisiana is subjected to frequent and sometimes severe impacts from hurricane including flooding of river channels and coastal marshes, as well as salt water inundation. On August 28, 2005, residents of New Orleans and neighbouring cities received a news dispatch spelling massive damage from both TV and radio (*http://www.srh.noaa.gov/lix/Katrina_overview.html*). Hurricane Katrina made a landfall the Gulf Coast area (CDC 2005) with winds of 125 mph (NOAA 2005) as a Category 3 hurricane (NOAA 2005, NOAA 2006). Defying a government advisory some people remained behind for a variety of reasons outlined by (Van Herden and Bryan, 2007), including but not limited to poverty, lack of logistics and mobility, physical challenges, outright defiance, and emotional bonds to family, friends, pets and the city. Immediately after the landfall on the coast there was slow rise of water (Womble *et al*, 2006). Some of people who remained behind gathered at the New Orleans Super Dome as directed by government advisories. High winds brought down trees, damaged the Superdome's outer covering, shattered weakened wooden and brick homes and torrential rains flooded streets. Rising waters tossed cars and boats onto highways and homes. Storm surges caused widespread damage along the coast, with waves sometimes reaching heights of eight metres.

Van-Herden and Bryan (2007) discuss events after Katrina landfall. People and animals retreated to and camped on elevated highway ramps and nearby rooftops waiting to be rescued. Boats and helicopters became the primary means of rescue. New Orleans Police were out-manned, and ill-equipped to deal with the situation. Hurricane Katrina destruction caused power blackouts, disabling radio and television communications, cell-phone towers, and telephone lines. A breakdown in communication stressed an already skeleton command and control structure. Before Hurricane Katrina the majority of National Guardsmen had been deployed to various overseas conflicts; those present were too few to effectively tackle the devastation. Members of the New Orleans Police Department resorted to looting food, water, generators for survival, as others engaged in misdeeds against the same public they swore to protect.

Van-Herden and Bryan explain further that in the New Orleans Superdome, after a few days with inadequate law and order, overcrowding and fear led to rapes, theft, murder, and beatings. National Guardsmen from other states and U.S. federal government troops had to be deployed to restore law and order, after which evacuation to neighboring states proceeded more efficiently. The

public watching TV wondered whether this was the same country that aided other nations at times of distress. Although there was talk of limited government resources, the under-utilization of resources was an ironic observation.

Hurricane Katrina's Impact on Louisiana's Transportation Infrastructure

The overview of damage painted a disturbing picture (Rix *et al*, 2006). Over 45 bridges sustained damage in the Gulf of Mexico states, mostly related to loose barges and boats crashing consistently into the bridges pilings. There was also extensive damage to roads in storm surge areas. Along the southern coast roads were impassable. Debris on roads and bridges caused major disruption as displaced cars, uprooted trees, boats, and leaking sewerage, blocked any chances of escape after the storm subsided. Mississippi, Alabama (FEMA 2006), and Louisiana were affected by coastal flooding from storm surge (NOAA 2005). Damages from Hurricane Katrina damaged electricity and public-service facilities of drinking water supply and treatment and sewage treatment plants (Copeland 2005).

Hurricane Katrina Relief Effort and Challenges: Overview

With about a million people displaced, a massive relief effort was undertaken, requiring thousands of volunteers. Help included providing logistical support at available facilities, churches, and other local institutions. It was necessary to provide assistance long after Hurricane Katrina (Van Herden and Bryan, 2007). This required long-term strategies including temporary housing, welfare, clothing and food vouchers, medicine, and equipment. With a massive charity challenge, major charity non-governmental and faith based organizations had to play a role in stabilizing a displaced population. Most evacuees sought refuge with close relatives, friends, co-workers, classmates, religious institutions, and shelters. The first author of this paper not only had to house nine evacuees at his house, but also had to assist the Kenyan embassy in Washington DC to account for New Orleans residents of Kenyan origin (Jamhuri Magazine, 2005), as well as mobilize help for the evacuees who did not qualify for any kind of federal assistance.

Internationally the major question was "*What was the role of the U. S. government?*" The US government has tiers of government equipped to deal with such an eventuality, but because of specialization different agencies have different departments and bureaus, hence the question "*Why did Federal Emergency Management Agency (FEMA) fail?*" FEMA's failures were a manifestation of everything that went wrong in New Orleans. It was a compounded situation of many factors. Some of the factors highlighted by Van-Herdeen and Bryan (2007) are: a) communication breakdown; b) poor decision making; c) poor coordination; d) under estimation of the problem; and e) untimely action. The FEMA Director was recalled to Washington DC and finally forced to resign (Washington Post Company, 2005). The situation necessitated the US government to seek international assistance. Several countries offered cash, material aid, and troops. The Kenya government responded by donating 7.5 million US dollars. Did trends indicate a profiling or discrimination? The polemic about the impact of the largest migration of people in U.S. since the Civil War and Post Reconstruction is not yet resolved but the issues revolve around: a) Race, b) Class, c) Age, d) Education, and e) Income.

Environmental Issues and the Role of Technology

The devastation by Hurricane Katrina was mainly water related leading to a wide range of damages (Copeland 2005). The impacts were biological (Sheikh 2005), environmental (U.S. Army Corps of Engineers 2006), and health related (Stoppler 2005). Hurricane Katrina altered coastal wetland areas, affected wildlife habitats (U.S. Army Corps of Engineers 2006), and caused flooding (Esworthy *et al*, 2005, Sheikh 2005, Copeland 2005).

The main role of technology was forecasting, visualization and forensic engineering after Hurricane Katrina. Hurricane-induced storm surges, waves, and rain all contributed to widespread coastal flooding, particularly in low relief areas in the Gulf of Mexico Coast. Data was required to evaluate the extent of inundation to enable the planning of emergency relief, infra-structure repair, and generate flood risk maps. With the help of computer models and visual evidence, scientists and engineers at Louisiana State University's Hurricane Center concluded that Katrina's storm surges did not overtop most of the levees (Womble *et al*, 2006). Technology was helpful in explaining the cause of the floods, supporting scientific analysis and helping to model mitigation efforts and strategies as well as highlight economic issues.

Impact of Hurricane Katrina on Gulf Coast

The impact of Hurricane Katrina on gulf coast was significant (EPA 2005a, EPA 2005b). Several thousands of people were rescued but a few thousands are still missing and unaccounted for. Hurricane Katrina exposed the startling fact that the country was unprepared for a complex major disaster caused by the extreme environmental forces (Van-Heerden and Bryan, 2007). It was

flooding and not high winds that inflicted the most devastation to New Orleans (Demas, 2006, EPA 2005a). Eighty-percent of New Orleans was flooded by four major breaches and a dozen smaller ones along the levee system (Womble, 2006). In the end, nearly 100,000 homes were inundated. The impact was disastrous on water quality, (LDEQ, 2006) with chemical and microbiological contamination resulting in water full of pathogens and toxicants (Manheim, 2005, NRDC, 2005, Pardue *et al*, 2005, Presley, 2005 and Roper, 2005). The causes of levee failure have now been positively identified. Katrina's storm surge overtopped some levee sections. Most of the floodwater damage occurred in New Orleans, LA (Esworthy *et al*. 2005). The flooded parts of New Orleans were below sea level, lacking natural drainage (Esworthy *et al*. 2005). The earthen levee system failure along Lake Pontchartrain resulted in up to 80 percent of New Orleans to be flooded (NOAA 2005). Comparisons and contrasts made with East African disasters provide interesting observations.

Disaster Management Prediction and Early Earning in East Africa

Kisoyan (2005) outlines the major disasters in East Africa as: a) Famine, b) Floods, c) Disease epidemics, and d) Traffic accidents, others are a) Fires, b) Landslides, c) Invasive species d) Terrorism, e) Food poisoning, and f) Tsunamis. Contributing factors are climatic variability, population increase, land degradation, and global warming. The compounding factors are political instability / insecurity, poverty and poor communication network (LaTrobe, and Davis, 2005). Trends and patterns demonstrate a significant increase in frequency of disasters. Disaster management capacity is hampered by the lack of policy (Kratt, *et al*. 2005), weaknesses in the institutional framework for coordination, undeveloped emergency response infrastructure, low budgetary support, and breakdown of traditional institutions and knowledge (LaTrobe and Davis, 2005; Clay, 2005). There is a lack of comprehensive preparedness, response, mitigation, and prevention. Observation of past events indicated reactionary emergency responses as well as an over-dependence on external aid (Benson and Twigg, 2004).

Capacity Building Required for Data Management in East Africa

Like in North America, global oceans play a major role in determining rainfall variability within East Africa, but due to limited observational networks, available information is not adequate for disaster forecasting in the East African region. Capacity building is required in areas of data management/processing, climate change modelling and building of regional climate change scenarios should be undertaken. Early warning products would enable users to put mechanisms in place for coping with extreme climate and weather related risks for sustainable development in the region. There is a need for specific users of climate information to share information. The untapped opportunities for solutions are many. They range from a) existing institutions/universities, b) a pool of trained manpower, c) the availability of free data sources, d) public awareness, e) improved communication networks, f) regional, g) relative political stability in the region and h) networking and linkages. Some of the sectors required to cooperate and coordinate include among others: agriculture and livestock sectors, natural resource management, energy, health, transport networks, infrastructure management.

Modelling capabilities are still weak in the region and there is need for a core of scientists in the area of disaster modelling. Indigenous knowledge (IK) is very critical. Climate data and observational network needed to monitor, understand, detect, predict and attribute the complex and closely related climate change processes is still a major problem in the region. Risk identification involves hydro-meteorological, physical, socio economic data, and expertise. The comparison of how one gathers risk identification data, versus how and when decision makers act on the results is a good basis for comparing the western Kenya situation with that of the southern United States. An excellent model recommended to address the perennial Nzoia floods is the Geospatial Stream Flow Model (GeoSFM), from USGS FEWS NET, based at EROS Data Center, USA (Dvorsky *et al*., 1999 and EROS Data Center International Program 2006). FEWS-NET is a USAID-funded activity whose purpose is to provide objective information about food security conditions (EROS Data Center International Program 2006). The FEWS NET weather hazards assessment process and products include participation by FEWS NET field and home offices, NOAA-CPC, USGS, NASA, and a number of other national and regional organizations in the countries concerned. GSM exemplifies the role of GIS in flood monitoring, and has been successfully applied to the Mid-West Floods of 1993 and has been successfully applied in Southern and East African rivers. Model validations applied to the Nzoia and Limpopo River basins were satisfactory.

A good example of a successful disaster forecast modelling is that of River Tana, the source of 75% of Kenya's power (Gadain *et al*, 2006). La Nina 1999-2000 droughts in Eastern Kenya led to water shortages, severe cutbacks in power generation, power rationing, and blackouts, with estimated

losses at $2 million per day. Flooding in June 2003 displaced an estimated 10,000 people. From the model it was evident that risk identification offers potential for improving early warning systems and consequently better contingency planning.

Comparison of East African Flooding vs. Hurricane Flooding

The table below compares the resources, challenges and issues between the River Nzoia floods and the hurricane related flooding in the Gulf of Mexico.

Table 1: Comparison between R. Nzoia floods and hurricane related floods in the Mexican Gulf.

Resources, challenge or issue	River Nzoia Disaster	Hurricane Katrina Disaster
Monetary Resource	Scarce	Adequate
Experts/Decision maker coordination	Needs Improvement	Needs Improvement
Modelling/Simulation	Requires refinement	Well established
Quick Response	Fair	Needs Improvement
Pre-Emergency Drills	Lacking	Lacking
Data Monitoring	Needs Improvement	Adequate

Lessons Learnt

Hurricane Katrina demonstrated that resources and expertise alone are not adequate to mitigate a large scale human disaster. In developing countries there is the mistaken notion that adequate resources and expertise is able to tackle major disasters. In disaster management planning there needs to be well coordinated communication, manpower and equipment coordination, and networks linking data transfer constantly between experts and decision makers (SADC, 1994, SADC, 2000). In tackling Hurricane Katrina the experts did an excellent job with hurricane forecasting, data acquisition, as well as model simulation of hurricane impact. Evidently, either the first line responders did not prepare adequately, or the decision makers either underestimated the impact of the hurricane or were otherwise inadequately prepared.

The Way Forward

Scientists in North America and the Gulf of Mexico region have a wealth of information, data, and lessons learnt from Hurricane Katrina. East African disaster managers can use these lessons to incorporate worst case scenarios in disaster management planning. Least-developed economies are widely perceived as most economically vulnerable, experiencing the greatest direct losses relative to a country's wealth. However, where a high proportion of impacts are on the assets and livelihoods of poor, self-provisioning households these losses were likely to be inadequately recorded. These effects are now more visible because of media coverage and the publicity surrounding humanitarian response. At higher levels of development, the financial costs of capital losses are massive (as illustrated by Kobe volcanic eruption and Hurricane Katrina), but the economic impacts of disasters are proportionately less.

The power to mandate government action and accountability belongs to the voters. Scientists from the African Diaspora can be very helpful in creating exchange programs with their colleagues at universities in East Africa. The most critical issue to be addressed is that of capacity building. Scientists from the developed countries can assist in the development of GIS and Remote Sensing applications. Cultural and technological exchanges between scholars and other governmental agencies could provide developing countries skills in GIS modelling. One project that lends itself to potential collaboration is the long term flood mitigation of the River Nzoia basin. The author suggests some tangible projects that can be initiated by scientists working together from the two regions.

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Early Warning and Contingency Planning for Disaster Preparedness in Kenya

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Abstract

This paper focuses on the main considerations taken to provide sustainable solutions to disasters by discussing the significance of early warning and contingency planning that are key in preparing for imminent disasters. Early warning strategies are discussed by focusing on the role they play in ensuring that the community and member of public is adequately informed about the dangers of looming disasters. Additionally emphasis is put on the nexus between effective disaster reduction and early warning systems. This paper further underscores the major constraints to early warning systems and priorities that need to be dealt with to attain a functional early warning system. A discussion is also made on the significance of contingency planning approaches to disaster management, in which the advantages of having and writing incident action plans are also addressed. There is a need for a planning process with specific emphasis on the demobilization

Key words: *Disaster, Early warning systems, Contingency planning, Mitigation, Preparedness, vulnerability*

Introduction and background

Disasters in Kenya whether man-made or naturally occurring are not phenomena of the past. Man-made disasters though catastrophic, are usually hard to plan for because they are sporadic and random events. On the other hand natural disasters in Kenya are usually seasonal events which are relatively predictable and easy to plan for, such as drought and floods. Even though natural disasters can be planned for, such plans seem not to be available or existing ones (if any) are not properly implemented. Thus disasters are still rampant every year with devastating impacts. As such Kenya needs to have a very comprehensive and an actionable disaster plan which should have an elaborate early warning and contingency planning dimensions.

Early warning is defined as "the collection, analysis and use of information in order to better understand the current situation as well as the likely future events" (Quarantelli, 1996). It also refers to the information on degree of danger (risk) to a hazard that could result into a disaster. Early warnings refers to information that comes to a community prior to disaster

Every year, disasters affect tens of hundreds of people in Kenya. The underprivileged tend to be affected more by disasters than the privileged rich in terms of death rates, shattered livelihoods, malnourishment and diseases. The economic implications of disasters especially on the developing world like Kenya cannot be overemphasized. The losses on few hours or one day could be enormous, for instance, Nairobi Bomb Blast, many human lives and buildings were destroyed. Once a disaster strikes, friends and relatives carry out the overwhelming majority of search and rescue activities. It is impossible to predict how people will respond, but knowing of risks and preparing communities to face them can improve response. Although some activities such as rescuing people from derailed wagons, passengers plane or a huge trailer may require heavy equipment, those in charge should ensure that working equipment and trained crews are available. For instance, during early 2006 Marsabit air tragedy in North-Eastern Province, the army personnel were called from Nairobi as the community could not handle the disaster. The Nairobi Bomb Blast in August 7, 1989 and Nairobi Ronald Ngala St. building tragedy was not manageable by the community and the Government; experts were called from Israel for recovery. Disasters result in loss of life, homes, livelihoods, and economic activity. The industrial areas, business districts, crops and livestock are frequently ravaged during disasters.

Businesses and economic entities often face not only the loss of a place of business, inventory (the blast at the Israel owned Kikambala Hotel in Mombasa in 2000 and Nairobi Norfolk Hotel Blast,1980), and income during the days of the disasters; there are numerous impacts. Suppliers may be delayed in delivering products, people may have lost the means to patronize a business, and employees and customers may be suffering from a lingering trauma that hampers a business' return to normality. Small businesses are typically hardest hit since protective measures may be prohibitively expensive. Corporations tend to have more

measures in place and multinationals are often best equipped to pay for and carry out mitigation strategies. Surprisingly, prior preparedness planning seems to have little effect on recovering from a disaster, although this might be due to poor preparedness planning that did not take into account the special needs of businesses from the start.

Warning the Public about Disasters

Communities should be warned about disasters because early warning signs of a potential critical event should trigger a contingency planning process (Metrological Department in Kenya has severally warned of heavy rains in advance). In all major disasters, new behaviours and groupings will emerge, as people and organizations cope with the multiple contingencies created that cannot be handled by routine service delivery. In fact, the greater the disaster, the more improvisations will emerge, accompanied by pluralistic decision making in tasks ranging from evacuation and the provision of emergency medical services to inter-organizational coordination and community priority-setting. Warning has an advantage of giving psychological preparation for a disaster. Apart from giving the would be victim a chance to understand what is likely to happen to them, there is the chance to sort out a few things depending on how early the warning comes. For instance, a fire warning may save all the lives and some property. It may also enable the threatened to call the fire brigade in good time or at least take precautionary measures that may avert the disaster. In essence, early warnings that are effectively acted upon can substantially reduce the damage of any disaster.

The best example of early warning planning is the biblical story of Noah (The African Bible, 1999), who planned the construction of boat prior to the flood (Genesis: 6:15). The boat was stocked with a food supply sufficient for five months (Genesis: 6:21), and seven days prior to the heavy rain starting Noah evacuated into the boat (verse 7:1-10). Noah was warned by God that a flood was going to take place and he responded by making a preparedness plan and assembling the necessary resources to protect his family, domestic livestock and wild animals.

The early warning planning requires the combined effort of all those involved as well as the authorities (Genesis: 6:22 - Noah and his family did carry out all the commands that God gave him). This requires an appreciation of all the sources of risk and vulnerability, and the integration of early warning systems into public policy and community action.

Early caution has been recognized by the International community as an essential element of disaster reduction strategies and action plans at all levels. It is also recognized, in many global frameworks, as an important element of sustainable development. Such global frameworks on early caution include Agenda 21 or Global Plan of Action - Rio de Janeiro –Brazil, Yokohana World Conference on National Disaster Reduction and United Nations Framework Convention on Climate Change amongst others. All these conferences identified early warning mainly as a key element of the International strategy for disaster reduction and a core component of disaster prevention.

Major obstacles of early warning

In as much as early warning systems are crucial, there exists several institutional and local capacity hindrances to their success in Kenya. First, there is lack of suitable information gathering systems and sufficient technology to ensure that there is sufficient evidence of an eminent disaster. The government needs to make more investment in upgrading the current early warning systems infrastructure. Secondly, there lacks community commitment to accepting early warning messages. This is evident in flood prone areas, where residents are usually informed early but wait until the disaster occurs for them to evacuate. This is usually affected by trustworthiness of the messages at community level. Thirdly, there is a gap between early warning messages delivered and the understanding of the appropriate responses to take. Even with clear messages, no proper follow-up is done to ensure that there is a proper response to the disaster. There also lacks accountability and authority by the government in ensuring that early warning messages are adhered to. Finally, there is insufficient access to warnings by the most vulnerable communities who are normally marginalized informationwise, yet most affected. The government should ensure that all affected communities are equally treated as far as the dissemination of early warning messages is concerned.

Main concern of early warning

The development of early warning systems by the Kenya government and communities require coordinated support and action. One way to achieve this is through a proper legislation and political goodwill evidenced by total commitment in utilizing early warning information to mitigate disasters. Additionally, there need for sufficient training of leaders at all levels as well as community groups to ensure the community embraces proper utilisation of early warning information. Further to this, nkages between the government and non-governmental agencies need to be strengthened and properly coordinated. All

institutional stakeholders reacting to early warning messages in a bid to design and implement disaster reduction intervention need to have joint planning to avoid duplication of efforts in one area and neglecting another. With such coordinated planning intervention efforts will reach the wider community. It is also vital to develop and implement benchmarks and targets for early warning system performance. This is done for posterity, such that current lessons can be duplicated in future. Additionally there is need to intensify the role of early warning national development frameworks, national platforms for disaster risks reduction, and in regional coordinating mechanisms. Promotion of early warning in important national and international fora improving data collection is also key. Improving data collection will help to ensure utility in early warning systems. This can then help in; protecting basic hazard monitoring and data infrastructure, improving the quality of warnings (accuracy, timeliness, relevance), building the capacities of relevant, including social and scientific expertise national economic expertise. In addition to that, data collection will help in developing and disseminating systematic risk assessments and mapping, standardizing early warning concepts, terminologies, databases, and information management, and developing networks for freely exchanging information and experience among stakeholders and disciplines and enhancing trans-boundary cooperation and data exchange.

Contingency planning and considerations

Contingency Planning is linked to preparedness. It is defined as, "a forward planning process, in a state of uncertainty in which scenarios and objectives are agreed, managerial and technical actions defined, and potential response systems put in place in order to prevent, or better respond to, an emergency" (UNHCR, 2000). Contingency planning is a pre-requisite for rapid and effective emergency response and there is no rule as to when to start such planning except that when in doubt develop a contingency plan. It is better to plan in absence of emergencies than during emergencies.

Good information management tools can help contingency managers create and organize their plans as well as in executing them. While contingency plans may often end up in shelves or file cabinets, a good information management system can make them and other supportive materials easily available to managers.

Where two or more jurisdictions are involved, it would be unrealistic to plan for incidents singly as an organization. In case of a drought in Turkana, the Department of Agriculture has to mobilize the food resources which will be transported by another Department dealing with transport, but security has to be provided (by another Department) to ensure the food gets to its indented destination). The same applies to medical services. While the Ministry of Health provides drugs to counter disaster, these have to be transported to the disaster zone, a job for the Transport Ministry.

There has to be follow up to ensure recovery of victims due to the physical as well as the Post Traumatic Stress Disorders (PTSD) which are common among the victims. Effective disaster management has to take care of both the response and recovery phases. It is also not surprising that disasters of the same or different kinds may occur concurrently, causing an overlap in the operational periods.

Disasters demand the concerted effort of all or at least most of the agencies dealing with disasters. For instance, in one single disaster will trigger various organizations to assist.

Disaster Planning

There is considerable variation in planning for disasters. A survey of mitigation and other preparations for disasters in developing countries in Asia and the Pacific found that while there was some minimal planning for natural disasters, but almost none for technological disasters (Asia Development Bank, 1991). A survey of national disaster plans of developing countries suggests that governments give less attention to technological disasters than natural disasters. Mexico City, for instance, paid little attention to planning for technological disasters until after the 1985 earthquake.

Disasters cause damage to both humans and property, so we need to plan for disasters for various reasons. Such would include the reduction the disaster shocking effect by planning ahead so that response is fast once the disaster happens. Secondly, there could never be any effective relief and response without appropriate and sufficient planning. Thirdly, disasters cause disorientation and decreased confidence in those in administrative positions such as government authorities. Planning helps guarantee some budgets for handling disasters, and finally, in mobilization of the relevant personnel and other resources in the shortest time possible during disasters.

Disaster planning includes developing a set of activities and systems to prepare for and predict disasters. In particular, this involves, forecasting and warning systems, community education, emergency operations centres, and medical and

food stockpiles are part of the preparation. This process can be difficult in areas that are struggling to develop and where basic infrastructure is lacking. Funding infrastructure and activities in these areas for events that may never occur may seem like a waste of precious financial resources. Communities should put disaster preparedness planning on their community agendas and link it to overall developmental planning - an investment that need to be protected. This is especially important in developing countries where disaster management agencies and awareness at the local level are rare, (Quarantelli, 1991).

In planning for disasters, it is vital to have written plans circulated to all agencies dealing with the disaster. Written plans are required for the emergency operation plans. An emergency operations plan is necessary for effective planning and effective management. This way, resources can be mobilized in good time or alternatives sought in advance. The only way people commit themselves to plans is by having them in writing. (In any case, disputes are bound to arise with unwritten plans, and also provide perfect grounds for negligence). Therefore, contingency plans provide among others, a lucid statement of objectives and actions, a foundation for measuring work/cost efficiency, a foundation for measuring work development and providing accountability, and a foundation for guarantee success in disaster recovery success.

Disaster planning is a carefully skilled work and not hastily conceived. For instance, how long does the drought in Turkana and Kitui areas take? This means that disaster planners have to understand the disaster cycle, understand the specific situation, and establish incident goals and strategic goals. Incident goals must be measurable and make good sense, be within suitable safety limits and cost-effective.

Discussion and conclusion

Disaster should be used as a an opportunity to take steps to reduce vulnerability as people are often more open to change at that time (when a disaster strikes, the planning should be made firm in the sense of application, e.g. the tragedy in Nairobi buildings or fire in slums in Nairobi). Disaster plans can have far reaching benefits beyond the community it is designed to assist (e.g., security of the particular country in regards to terrorist threat).

The community should prepare for possible disaster including planning prior and after the disaster (drought in North-Eastern Kenya, floods in Budalangi, fire in slums).

The public/community should respond to the needs of all members, prior and after disaster. (The children, the aged and disabled, how will the community respond to their needs during disaster and after disaster). The public/community should keep constant review the changing disaster situation and adjust their response accordingly. Disaster planning, mitigation, preparedness and community involvement are crucial factor that may reduce the impact of the disaster and its effects on a given community. There are various significant strategies that different communities can undertake in response to the many disasters that disrupt their lifestyles and social wellbeing.

Disasters on the community part are becoming more complex, with increasingly long term consequences as they strike communities with economic problems and/or weaken their fragile public services such as water, and health. Recurring crises such as droughts year after year, as is the case with the communities around Kitui and the Turkana areas in Eastern and Rift Valley provinces respectively give people and their crops no time to recover. The impact of disasters is high; leaving people traumatized by the death of family and friends, their lives devastated by the loss of homes (they need to move in search of food), possessions and animals. Contingency Planning and early warning are fundamental if disaster effects are to be put up as a bare minimum.

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The Aftermath of Prosopis juliflora in Marigat Division of Baringo District, Kenya

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Abstract

Kenya has been a victim of uncontrolled introduction of foreign fauna and flora since her independence. This paper reviews the local experiences since the introduction of such species and pinpoint the weakness that has led to misery, suffering and loss of biodiversity. Examples abound including the Nile Perch, the water hyacinth plant and the blue gum trees at reverines among others. The latest misery from the *Prosopis juliflora* that is now widespread in the arid and semi-arid areas is just but one of the many hazards with us now. We analyze the case of *Prosopis juliflora* in Marigat Division of Baringo District and use it as a case study to highlight the weaknesses in our laws and ethics governing the introduction of foreign matter into our country. We propose the way forward based on the recent legal developments.

Key Words: *Prosopis Juliflora, ecological hazards, drought, Baringo District, goats, arid and semi-arid.*

Background Information

Marigat Division is in Baringo District in the expansive Rift Valley Province of Kenya at an altitude of about 1000m above sea level (Figure 1). The traditional lifestyle was pastoralism but which has changed significantly with time. Population pressure, modern ways of life and urbanization have worked against the pastoral way of life. In order to raise the standard of living among the local community, the Kenya Government commissioned technical studies in 1997 (Sanyu Consultants, 2002) culminating into a Master Plan for Marigat and Mukutani Divisions of Baringo District. The Master Plan integrated sectoral plans to fit into higher-level plans for the district and national development.

Marigat Division

In the early 1800's, Marigat Division being on the shores of Lake Baringo was referred to as a granary due to its dependable grain reserves. Partly, this was the very reason that encouraged pastoral migration into the area in search of resources. In 1948, the population density of Marigat and Makutani divisions with an area of 1224km2 was only 4.4 people/km2 increasing to over 44 people per/km2 in 1999. The people in two divisions are Tugens (44%), Il Chamus (40%), Turkana (9%), Pokots (5%) and others (2%), according to 1999 census. Although the major crop is maize (accounting for about 70% of entire farm land) the grazing lands that are communal rear large numbers of livestock comprising cattle, goats and sheep.

Drought Hazards

Being an arid area, the main climatic hazard is drought that tends to occur every 10-15 years with minor droughts every 3-4 years. For example during the 1984 drought, large numbers of cattle died. Other droughts struck the area in 1992, 1993, 1994, 1999 and 2000. During the 1999-2000 drought, the villagers in Rugus and upper Mukutani sub-location lost over 70% of their cattle. Due to the perennial droughts, sustainable development was not possible and the poverty level continued to rise. Development constraints may be listed as shortage of water, overgrazing, poor breeding of livestock, land degradation, poor marketing conditions, unhygienic living conditions and disease, low literacy and aid dependency syndrome. One characteristic about pastoralists is to try to increase the size of herds in a similar way that a trader tries to increase savings.

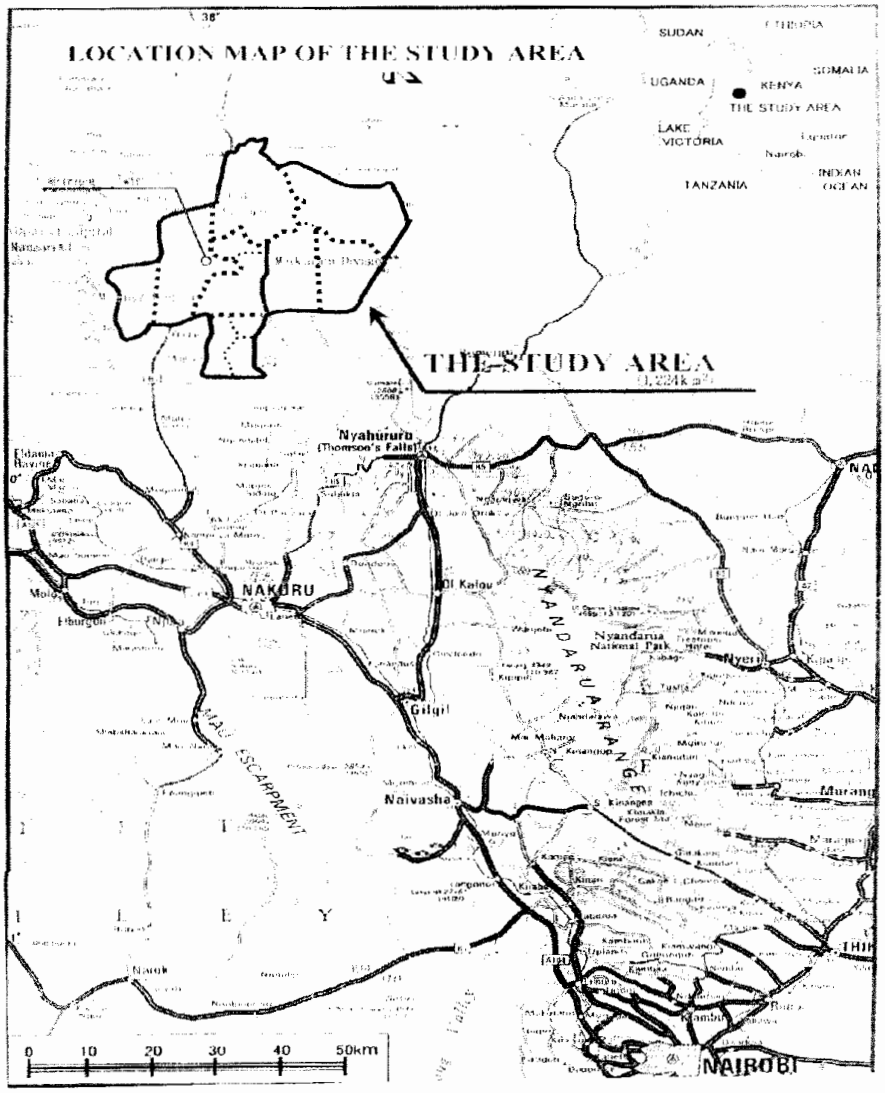

Figure 1: Location of Marigat Division in Baringo District Kenya *(Sanyu Consultants)*

Table 1: Population of Goats by District

District	Area in Km^2	No. of Goats per Km^2
Baringo	10,790	83
West Pokot	5,076	51
Turkana	64,048	33
Kajiado	21,105	31
Narok	18,513	31
Marakwet	2,722	29
Samburu	20,809	26
Laikipia	9,718	25
Uasin Gishu	3,784	19
Kericho	4,890	11
Nakuru	7,200	10
Nandi	2,745	9
Trans Nzoia	2,468	8
Total Rift Valley Province	**173,868**	**32**

Assessment of Forage Resource

Baringo District has the highest density of goats in the arid and semi-arid lands (ASAL) and possibly in the entire country. The population density of goats is in excess of 83 heads/km2, the highest in the Country. Table 1 shows the significance of goats in the Rift Valley Province (GOK, 1998).

The Marigat Division is the nucleus of goats, hosting over 188 heads/km^2, which is 2.3 times the Baringo district average. Figure 2 shows the number of goats in Marigat Division vis-à-vis districts in Rift-Valley province. This shows the significance with which goats are regarded in Marigat Division. Goats feed on grass and leaves, and can live in harsh environments. However, goats also eat grass seedlings and will therefore cause vegetation to deteriorate.

Natural grazing land makes up about 85% of the area. The livestock is overstocked and overgrazing is evident. Goat rearing is the mainstay of people in Marigat Division. The renowned goat auctions at Kimalel in Marigat Division were famous in the 1980's.

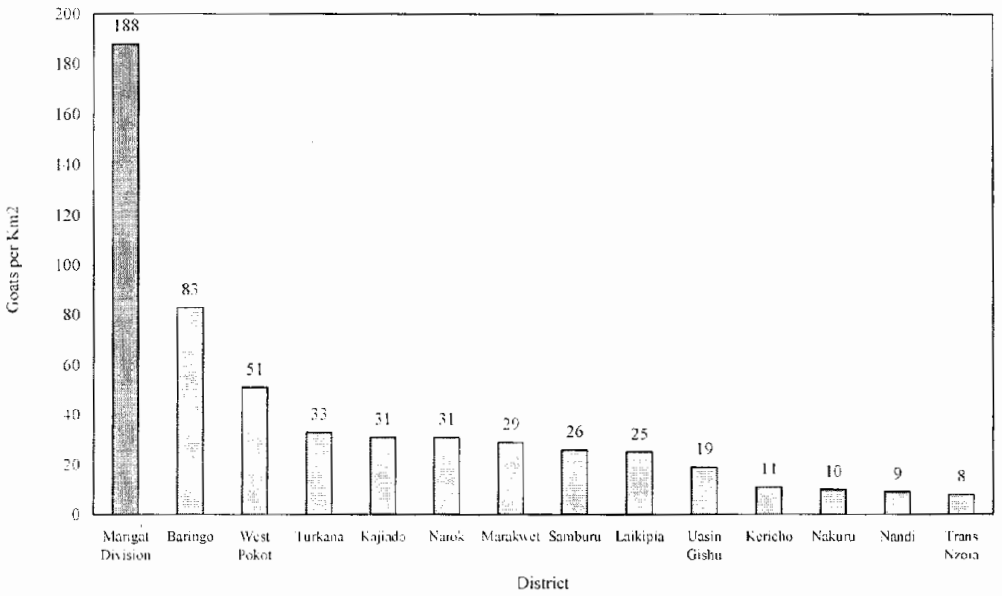

Figure 2: Goats per area in Rift Valley Districts

Social Forestry: The Dilemma of *Prosopis Juliflora*

The planting of *Prosopis juliflora* commenced as a social forestry programme in the 1970's, for Baringo District first in Ngambo location where about 5 ha of community forest was established by villagers who planted the *Prosopis Juliflora* in the barren land of the "Inner lowland." This was under the Kenya Forestry Research Institute (KEFRI), in Marigat who were engaged in activities to identify suitable tree species for the semi arid areas. Among the tree species that were considered included *Prosopis juliflora, Acacia nilotica. Azadirachta sp, Balanites eagyptiaca, Melia volkensi* and *Moringa oleifera.* The *moringa oleifera* is a known natural coagulant in water treatment (Mayabi *et.al.*, 2003)

First Hand Account of *Prosopis juliflora*: The Aftermath

How "weed from hell" has made village life a horror, was the title of special report in one of the local dailies (Obonyo Oscar, 2006). The above title summarizes the perception about the Prosopis *juliflora* by the people of Marigat Division almost 30 years after the plant was introduced. The plant spreads very fast, its sweet sap gives rise to rotting of the goats' teeth which fall out, and its poisonous thorns have maimed many innocent villagers. When one flees from it, the plant colonizes the homesteads, blocking footpaths and cattle paths thus making life a total misery. The shrub grows vigorously especially near water courses and can easily overrun swamps, grazing fields and homesteads. The weed is now known by different names in different places: "*Mathenge* in Baringo, "Msumari wa Norad" in Turkana and "Mrassia" in Tana River. The names are associated with field officers (*Mathenge)*, the donor agency (NORAD) in the area at the time of introduction, and troublesome vegetation (*Mrassia*) in Tana River District.

Introduction of *Prosopis Juliflora* in Kenya

Existing literatures shows that *Prosopis juliflora* is native to South and Central America (Pasiecznik, 2006). It was first introduced in the African continent as an ornamental plant, as shade or fodder in the 1800's: Senegal (1822), South Africa (1801), Egypt (1900), Sudan (1917) and Kenya (1970's). Specifically, the first documented introduction of the *Prosopis Juliflora* tree in Kenya was in 1973 when seeds were imported from Brazil and Hawaii for rehabilitation of abandoned quarries formed due to cement mining and manufacture near Mombasa. The plant then reached Tana River the same year and subsequently reaching other districts like Turkana, Baringo, Taita Taveta, Malindi, Suba, Garissa, Isiolo, Mandera, Marsabit, Wajir, Kajiado and

Migori. At present the following districts are severely affected by the plant. Tana River, Garissa, Turkana, Baringo, Taita Taveta and Mandera. It is just a matter of time that the other districts and even new districts will be affected by the *Prosopis juliflora.*

Is *Prosopis Juliflora* a Menace or Resource?

The proponents of *Prosopis juliflora* argue that the plant is a great resource if used correctly. The plant yields good and heavy hardwood that is excellent for charcoal making and use as firewood. It burns slowly with little smoke. The wood is also good for construction and carving. Its posts and poles are robust durable and strong. Its timber can last over 30 years underground when treated.

The plant has a powerful canopy that can cover the arid area with green colouring. The desert-like environment is converted to green land by the plant. The plant can successfully restore degraded and saline lands. The sweet and sugary seedpods can be used to make coffee substitutes, syrup, and alcohol. They are also a major source of carbohydrates, sugar and proteins for both humans and livestock.

Experience from Outside Africa

Thousands of people in Sahelian and Eastern Africa face malnutrition and starvation on a frequent basis. They are surrounded, however, by an abundant 'free' food in the shape of the long yellow beans of wild Prosopis trees, though the millions of tonnes produced each year across dryland Africa just fall to the ground while people go hungry (Pasiecznik, 2006). At best browsed by livestock and at worst left to rot, they are rich in protein, carbohydrates and essential amino acids and should become a vital source of food especially in dry years but in Africa they are not eaten. *Prosopis Juliflora* and its close relatives were introduced from South and Central America over the last 200 years by the British, French and Portuguese as fast-growing, drought-resistant trees to provide much needed firewood and fodder. No selection was made, and the thorny, shrubby types originally planted are now commonplace throughout the continent, but today achieve more notoriety as invasive weeds rather than useful trees. Also, when whole beans are eaten, animals can become sick, making people believe they are poisonous. But if milled and mixed, the protein-rich seeds can be digested forming a nutritious food, and this also eliminates further spread as weeds. In contrast, in its native Peru for example, Prosopis trees are widely respected. The beans from the best trees are traditionally made into flour to make bread, cakes or a rich porridge, boiled up into molasses-like syrup for sweet drinks, or just chewed as a snack. Home-made products are sold in local markets and some are even commercialised nationally. The gum can be used in cooking, the honey is excellent, flowers are edible and all parts of the tree are used in herbal medicines. However, this indigenous knowledge has not followed Prosopis trees across the Atlantic and so, while the beans abound, people ignore them. Also, as roaming animals are left to eat fallen pods, they spread the seed and, being unmanaged, the trees have invaded nature reserves, agricultural and pasture lands in recent years. Prosopis has now been declared a noxious weed in Kenya, with legal disputes in some areas over compensation for its spread. The matter has been referred for legal redress in the courts of Law (Ogutu, 2006). However no efforts are made to educate and get the most from this free food. Policy makers, like those they serve, also do not know the value of this tree-that people can be nourished, and the timber resources used - all of which can help address the problems of the lowest levels of poverty, with very little investment.

A group in the UK has been working on the utilisation and management of Prosopis for almost 20 years (Pasiecznik, 2006). This work has included bringing experts from Peru, Mexico and Argentina to India, where the trees are equally widespread and poorly used, to share their experience. Training courses were organised to teach farmers, foresters, entrepreneurs and extension workers the uses and benefits, and this work is now showing dividends, with reports of knowledge from the training and books and briefs produced by the project, being taken up and used by businesses in rural development. The same simple technologies suggested for processing Prosopis tree products can also be applied to other trees, increasing the potential impacts.

Suggested Way Forward for Kenya

Pasiecznik (2006) argues that the knowledge on the use of *Prosopis juliflora* is there, and the means to transfer it is tried and tested. It is essential that this type of activity is adapted for dryland Africa, starting in countries, such as Kenya, where malnourishment and Prosopis are most common. Training could then be extended, training trainers, and providing them with support and resources to carry their new knowledge out to each neglected corner of every drought-hit district.

A workshop was held and traditional recipes such as *chapatis*, *mandazi* and *ugali* were made using up to 30% ratio of Prosopis flour to wheat or maize flour. It was emphasised that the seeds needed to be crushed during milling not only to release the protein in the seed, but also to prevent further spread of the trees as an unmanaged weed. The feedback from participants of the workshop was overwhelmingly positive and outreach strategies to spread the knowledge further, such as demonstrations and promotion in the media, were also discussed. Some of the participants subsequently carried out further cooking demonstrations in Nairobi, and there are plans to introduce the idea in other severely drought affected areas of Kenya. However twenty similar programmes are needed to begin carrying the message across the country and the continent.

Application in Disaster Management and Food Security

Work on the utilisation of Prosopis fits naturally into issues including food security and dryland resource management, both of which contribute to the disaster management sector. There is a demonstrated demand for further training and dissemination of information on using Prosopis in human food, and several areas of study, research and practical development that would contribute to this:

a). Research on milling methods in terms of suitability for Prosopis pods, capacity for crushing the seeds, and accessibility and cost to pod collectors.
b). Research on pod collection methods, drying time and methods and storage for
c). Preserving flour quality and pest control.
d). Research on different recipes and preparation methods for flour products in terms of other foods available in severely drought affected areas.
e). Analysis of nutritional composition of the flour, and different ratios of Prosopis to other flours.
f). Research and development of methods for disseminating information on Prosopis.
g). Development of advocacy campaigns in drought affected areas.

Ethical and Legal Issues

All said and done, the community in Marigat Division of Baringo district of Kenya is now up in arms against the introduction of the *Prosopis Juliflora*. We therefore ask the question whether any ethical issues were breached in this whole exercise. The role of specialized institutions in Kenya such as the KEFRI and the Kenya Plant Inspectorate Services (KEPHIS) are charged with the vetting of all foreign flora into the country. Obvious the community was not adequately involved at the stage of introduction and technical issues were left only to the experts. With the introduction of the National Environment Management Authority (NEMA) Act of 1999 it is now possible to have more control over such issues and communities will have a chance to indicate their feelings through public comments on the Environmental Impact assessment reports that are now mandatory for such activities.

Conclusions

Whether *Prosopis juliflora* is a resource or hazard may be a case of conjecture. However one lesson we have learnt is that its introduction into Baringo District and other areas of Kenya was not accompanied by the necessary education and awareness. No effort was made to build local capacity and knowledge in the management and use of the plant as well as its products. Whereas this may still be done, the damage that the negative effects of the plant have attracted will need a lot of effort to turn around the perceptions by the villagers. We can draw lessons from elsewhere where the plant has been used and a lot of research is still required to show the benefits of the plant and to address the negative effects that have been witnessed. In particular the fact that the plant affects the very livelihood of the pastoralists: by destroying their animals (goats) will make this idea unpalatable. The *Prosopis juliflora* cannot replace the herds of goats. The alternative of turning back on the idea of social forestry is even harder to achieve. It took a lot of effort to introduce the plant in Baringo district and elsewhere, and it will take an even harder effort to eradicate it. Probably the most viable solution can only be achieved through involvement of the local community, researchers and the Government which has an obligation to listen to the plight of its citizens as exhibited in the anguish that can be witnessed on livestock and the people.

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Reduction and Management of Geo-Hazards in Mozambique

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Abstract

Over the last decades, Mozambique has experienced worse geo-natural and man-made disasters such as drought, floods and landslides, causing major loss of human lives, livelihoods and destruction of the environment and economic and social infrastructures. The 2000 floods in south and central parts of Mozambique are just the latest example. These disasters have raised poverty rates in the affected regions and destroyed achieved development, putting its progress at risk. Mozambique with 18.9 million inhabitants and a total area of 799,390 sq. km has a high poverty level. Thus, there are various activities aimed at eliminating absolute poverty for the majority of the Mozambican population. Because vulnerability is strongly linked to poverty, governmental institutions and civil society organizations should adopt more pro-active policies and develop programs for preparedness and mitigation instead of focusing on response only. Efforts must take in consideration disaster risk reduction approaches and the inclusion of disaster risk management into relevant sector and country strategies to reduce people's vulnerability and achieve sustainable, positive results. The Mozambican multi-sectoral professional expertise, skills and research communities are also vital resources to disaster risk reduction. The article analyse some impacts of disasters caused by geo-hazards, the main related vulnerabilities in the country, and the possible disaster reduction measures to be able to cope with such geo-hazards in Mozambique.

Keywords: Geo-hazards, risk management and reduction, Mozambique

1. Introduction

Mozambique is situated in Southern Africa and covers an area of 799,380 km^2 and extends from 10° 27' Northern latitude at the mouth of the river Rovuma to 26° 52' Southern latitude at Ponta d'Ouro, with a population of 18.9 million. It remains one of the poorest countries in the world with very low socioeconomic indicators. Nearly 70% of the population lives in absolute poverty, and there are notable urban-rural and regional imbalances, with a greater incidence of poverty in rural areas (Government of Mozambique, 2001). However, in the last decade, Mozambique has experienced a notable economic recovery, with GDP growing from 2000 to 2004 by 9.2% on average (UNDP, 2005). The goal of the current Government is to reduce the level of absolute poverty in the country. Natural hazards such as floods, earthquakes and landslides are potentially damaging to the physical and may cause loss of life or injury, property damage, social and economic disruption besides environmental degradation (ISDR, 2004). Natural hazards may give rise to a disaster when they impact the built and natural environment. Mozambique is prone to natural hazards like floods, tropical cyclones, windstorms, drought, landslides, outbreaks of epidemic diseases (diarrhoea/enteric, cholera, meningitis, malaria and insect plagues etc).

The major vulnerability factors in Mozambique are related to its being situated downstream of the 9 of the 15 major river basins in the southern Africa. The country position originates high coefficients of rainfall variability associated with extremes of this variability. It is also located in a region of extreme instability and in the direct path of tropical cyclones formed in the Indian Ocean, with about 3 to 4 powerful cyclones per year. The country lies on two main seismic regions of high seismicity. Above all, there is a high level of poverty.

This paper looks at geo-meteorological hazards/disasters in Mozambique taking as references the 2000 Floods and Tumbine Landslide disasters as well as the threatening 2006 Earthquake hazard.

2. The 2000 Floods

2.1. The Origin of the 2000 Floods Disaster

The 2000 floods took place between February and March and affected areas covered by the Save, Buzi, Limpopo, Incomati and Umbeluzi river basins. The affected areas comprised urban areas and rural areas. Two main reasons of 2000 flood disaster in Mozambique are:

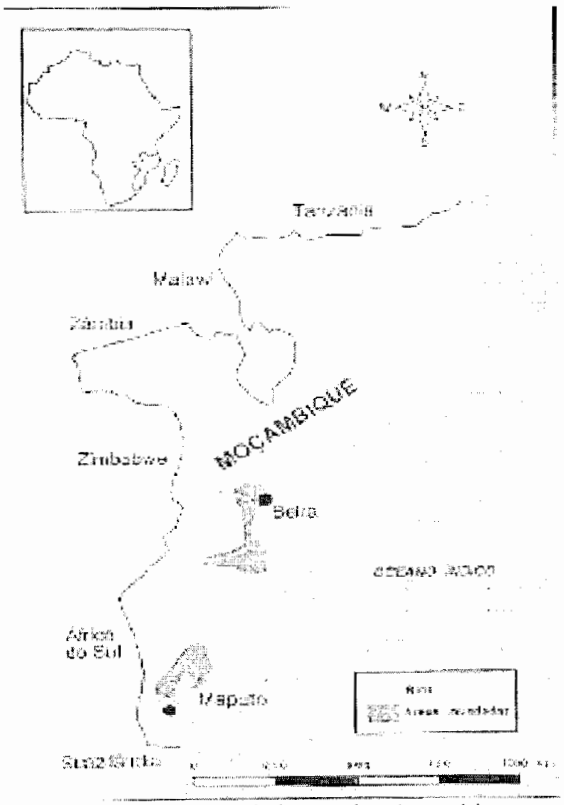

Figure 1: Maps of flooded areas in Mozambique. *Source: Direcção Nacional de Geografia e Cadastro*

1. The 2000 floods arose from intense and unusual heavy rains within a short span of time resulting from a nucleus low pressure, as well as the Eline and Gloria tropical cyclones. A nucleus of low pressure hit the Punguè and Buzi basins in the central part of the country and Limpopo and Umbeluzi basins in the South. This tropical depression extended to South Africa, Botswana and Zimbabwe and affected the weather conditions during the first two weeks of February causing heavy rains. There only one way was for this water to flow down to Mozambique causing extreme rise of water levels in the rivers resulting in the 1st flood. While the rivers were still flooded, the tropical cyclone *Eline* crossed Mozambique and caused heavy rains resulting in the second and more destructive flood wave (Christie, F. & Hanlon, 2001: Manuel, . & Vicente, 2002).
2. Poor river management in Mozambique. Although the Mozambican authorities took some measures to prevent the worse impacts of 2000 floods, they were insufficient. The low preparedness was linked to shortage of financial and human resources. In addition was the lack of infrastructures storage dams, protection dykes, poor flood warnings systems, insufficient communications between Mozambique and the neighbouring countries on the flood waves, poor land use planning and poor public understanding and awareness (Manuel & Vicente, 2002; Vaz, A. C. 2000).

2.2. Effect of Floods

The 2000 floods in Mozambique resulted in complete disruption of the social and economic life of vast areas in the southern and central regions of Mozambique. Examples from Christie and Hanlon (2001), Manuel and Vicente (2002), and Vaz, 2000 are illustrative of the effect which include loss of 800 people; displacement of 550,000 people mostly the vulnerable, composed of children, women and elder. A total of 4.5million people were affected, in which 2 millions lost their belongings. 10 % of arable land of the country was degraded and 90 % of operational irrigation systems damaged. More than 20,000 head of cattle and 4000 goats were lost. Many cities villages and towns were seriously destroyed, e.g. in the City of Chókwè where more than 2m of water flooded the city. Apart from severe damage to water supply, electricity, and communication systems, there was also destruction of schools, hospitals, protection dykes, public buildings, roads and railway lines and bridges. Besides, there arose high incidences of diseases such as malaria, diarrhoea and cholera, skin and eye diseases as conjunctivitis.

2.3. What was done after Floods?

Since the 2000 experience, several measures have been taken to reduce the vulnerability of the people in Mozambique. These include structural measures such as infrastructural rehabilitation and maintenance - storage dams and dykes, buildings, roads, bridges etc. No big storage dam was constructed.

Non-structural activities comprised mapping of flood prone areas. Hazard mapping was done for the whole country, but the most extensive assessments were done in the Limpopo and Buzi river basins. An atlas of flood risk reduction in the Limpopo River was produced (INGC, 2005), including development of early warning systems for floods and cyclones. The flood early warning system consists of regular gauging of water levels and interpretation of data in the major rivers. The cyclone early warning system aims at monitoring the formation and development of cyclones along the Mozambican coast. The National Meteorological Services has enhanced the observation network within Mozambique and improved the communication systems. There is

also a telemetric hydro-meteorological network. the SADC-HYCOS (hydrological Cycle Observation System) network, managed by National water Board (DNA), formed by 50 stations linked by satellite, covering key points of the main river basins of the southern African region. This enables an almost real time monitoring of hydrological situation (UNDP, 2005).

Mozambique is preparing contingency plans; the only country in Southern Africa that has a contingency plan, drawn up annually, under the aegis of the Prime Minister (UNDP, 2005). There has also been training awareness raising and information management training for decisions makers at different levels (INGC, 2005), and public awareness targeting local communities. These programmes are being implemented by INGC and NGO's – i.e., the Munich Re Foundation set up a community-based early warning system in Búzi River. The German Agency for Technical Cooperation (GTZ) has assisted the integration of disaster risk management in disaster-vulnerable districts' development plans in Sofala Province.

3. The 2006 earthquake in Mozambique

3.1. Earthquake Features

The largest and strongest earthquake recorded in the last 100 years in Mozambique occurred on Thursday, 23 February 2006 at 0:19:07 a. m.

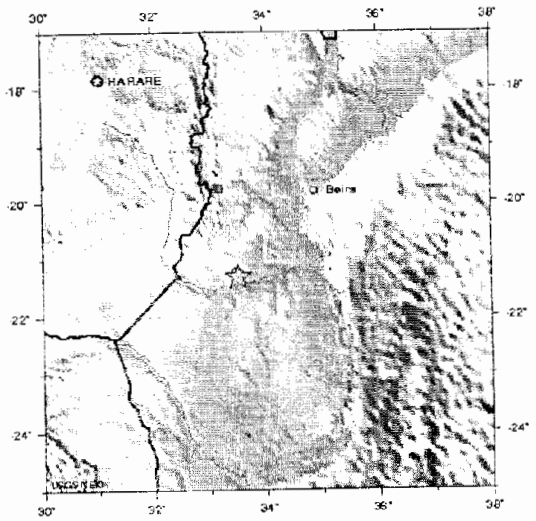

Figure 2: Map. of the earthquake's epicentre and the seismicity in 2006 Source: USGS, (2006)

The earthquake's magnitude was reported as 7.0 on Richter scale by the U.S. Geological Survey (USGS, 2006). It occurred along well defined narrow belt near the southern end of the East African rift system in Central Mozambique (USGS, 2006). The earthquake's epicentre was located in 21.259°S, 33.480° E, in Espungabera, District of Mossurize in Manica Province. (USGS 2006). The epicentre was situated around 215km from Beira, 235km from Chimoio, and 530 km from Maputo the capital of Mozambique. In all these cities the intensity of the earthquake was V according to modified Mercalli scale. This earthquake was also felt in neighbouring countries of Zimbabwe, Zambia, Swaziland and South Africa (USGS, 2006) (Figure 2.).

3.2. Impact of the earthquake in Mozambique

The 2006 earthquake resulted in death of 5 people in Manica and Sofala Provinces, while about 40 people were injured in the same area. Approximately 300 houses were partially damaged mostly in central part of Mozambique. These buildings suffered cracks, especially in partition walls and five primary schools (poorly constructed in the last 20 years) destroyed in Machaze and Manica Provinces.

Most people fled their rural and urban homes after the earthquake and slept in the open. Those living in high-rise buildings were also scared and spent two nights on sidewalks in front of their homes. In comparison to other earthquakes with similar magnitude and intensities, the devastation was considerably lower in the 2006 earthquake. The minimal deaths, destruction and damages were mainly because the epicentre of the earthquake was far from the cities and low populations in rural areas near the epicentre. The Mozambican safety codes for building and construction which include strict seismic codes of standard helped save lives and somehow protected large number of buildings and infrastructures in these cities from collapse. The safety codes were inherited from Portugal. After the 1775 earthquake disaster in Lisbon and surrounding, that caused more then 90 000 deaths, the Portuguese authorities have defined since, tough safety codes for building and construction. The earthquake occurred at the night, when people were sleeping and few people were in the streets, offices, factories or schools.

3.3. Earthquake vulnerability and risk in Mozambique

Subsequent to the 2006 major earthquake, numerous aftershocks were registered near the

epicentre (USGS, 2006) in the direction of southern end of the East African rift system in Central part of Mozambique (Map 2). The 2006 earthquake and related earthquake hazards are precursors of imminent future earthquake hazards in these parts of the country. Presently, Mozambique is confronted with vulnerabilities such as presence of some seismic zones prone to earthquakes and the people are not aware of these risks (Manuel, 2006). The country has few seismic-monitoring stations which are in poor conditions, abandoned and badly maintained. The stations can neither perform any basic geosciences research nor work correctly to produce reliable data. There are also institutional weakness in terms of disaster management and related scientific research and poor coordination between the various institutions. Schools curricula has very little information about all hazards as well as disaster risk reduction and disaster management. Besides the poor communication systems, Mozambique does not have specific building codes for seismic risk. Although an earthquake can not be prevented, its impact can be mitigated by reducing the earthquake risk thus reducing the vulnerabilities of the communities.

4. The Tumbine Landslide

4.1. Background

Mount Tumbine is located in Milange District, Zambezia Province, Central Mozambique close to the Malawi-Mozambique border. It lies between longitude 35° 50' 00'' and 35° 46' 30'' E and latitude 16° 07' 40'' and 16° 02' 30'' S. The Mountain rises to an altitude of 1548 m above the sea level, with a sub-circular shape measuring about 8km diameter. The average annual rainfall in the area varies between 1200 and 2000 mm with peaks in January, February and March. Geologically, Mount Tumbine is made of Mesozoic, probably Late Cretacious to Early-Middle Jurassic alkaline syenite stock that intruded Precambrian high-grade metamorphic granulites and gneisses (Araujo, *et al.* 1977; Afonso, *et al,.* 1977). The soils from syenite intrusion are dark brown, humic top layer, followed by red, plastic clay horizon and underneath, are friable brown yellow soils. The granulites and gneisses produce lateric soils. Both soils are deep and usually overlaid by colluvial material from fine sizes to boulders and blocks. The Mount Tumbine has many water springs and aquifers. Historical records from 1949, 1958, 1968 and 1993 show occurrence of landslides during the high rainfalls (Manuel, *et al,.* 1998). The movements started mainly in areas covered by loose and highly weathered material. These movements were in forms of debris flows, which found their way out through different streams to the plain areas. The debris comprised huge boulders and blocks, some bigger than 10m diameter, which were transported down with mud, sand, gravel and logs of trees. More than 40 scars (starting areas) produced debris flows within the loose soil covering the bedrock of syenites.

4.2. Impact of Tumbine Landslide

The landslide event caused severe loss of lives, disease outbreaks and loss of property (Manuel, *et al.* 1998; Novo, 1998; Daily Notícias, from 20thJanuary to 6th February, 1998). It resulted in 100 deaths and 95 missing. Tens were injured in Chinzongué and Tamanda villages. There was also damage to infrastructures such as water supply systems, bridges and huts destroyed. Many roads were blocked by huge amount of debris and mud and circa 1000 hectares of different crops belonging to peasants were destroyed. 4,000 people were displaced and many other areas flooded.

4.3. Causes of the Disaster

The Landslide disaster in Mount Tumbine occurs due to interplay of several factors namely:

- The intense heavy rainfall of short duration, after a adequate normal precipitation
- High declivity of the Mount Tumbine especially in affected area.
- Geological and soil characteristics.
- Saturation of the existing aquifers and blocking of streams had lead to bursting of the aquifers and debris flows.
- During the civil war, people coming from various parts had chaotically occupied the Mount Tumbine especially the N.Eastern part of the Mountain, growing in the slopes maize, beans, banana trees, manioc and sorghum amongst others, replacing the originally natural forest and vegetation of acacia species. The natural forest has a high root density than these artificial crops, hence a stronger interlocking network for holding loose soil particles.
- High level of exploitations of timber for charcoal purposes on the forests
- Fires, which destroyed the forest, have also the effect of reducing the forest cover and making land more susceptible to landslides and soil erosion.

4.4. Vulnerabilities

During and after the Tumbine Landslide disaster, some of the main vulnerabilities in Milange were

identified as poor and insufficient public awareness about the nature and risks of the event; and very little is taught in schools about landslides, floods and earthquake hazards. Inappropriate agriculture practices are prevalent, with many land-use conflicts on arable land. Others include institutional weakness and poor coordination, non-working meteorological stations in Milange, lack of any early warning system and poor involvement of academics and professionals on the solutions of these problems. There is also a high level of poverty.

5. Discussion

Disasters impact on all aspects of development, and have undermined efforts to achieve the Millennium Development Goals (MDGs) by impacting on macro-economic systems, household livelihoods and human Development (DFID, 2006). Tumbine Landslide and 2000 floods disaster had retrogressed Mozambique's economy and obstructed the poverty reduction attempts. The floods were a hard lesson, after setting back the economic development of Mozambique for many years. Mozambique besides the losses of more than USD 600 millions, it decreased drastically the economic growth from 10% in the previous year to 1.5% (INGC, 2005). The government of Mozambique's aim is to reduce the absolute poverty in its different dimensions (Government of Mozambique, 2001). The poverty reduction was also proclaimed a main objective by international community through the Millennium Development Goals (ISDR, 2004). Natural hazards disrupt poor people's livelihoods, especially the poor who are often more vulnerable to natural hazards (Schmidt *et al.*, 2005). The 2000 floods and Tumbine Landslide disasters impacted mostly on disadvantaged groups in different ways. The subsistence income base of those vulnerable people was severely affected, and they became even poorer. By reducing their poverty, it would be possible to reduce the vulnerability to hazard.

In all three situations of natural hazards/disasters discussed above, institutional weakness and insufficient coordination was identified as main factors leading to vulnerability between the various stakeholders in relation to disaster management. The public lack adequate awareness of natural hazards and disasters. Safety and risk reduction measures at various levels such as in general public, local decision makers groups and from primary to university students is also lacking.

Mozambique has shortage of adequate infrastructural installations that could help prevent or reduce the impact of disasters (e.g. dams). Poor communications systems, deficient seismic stations and meteorological stations, lack of (or embryonic stage of) early warning systems are other weaknesses increase the vulnerability of the country. There is also insufficient cooperation and contacts with neighbouring countries in order to exchange available data, information and outline strategies and/or establish agreements in issues related to disaster management, river flows, meteorology, seismic etc.

Turker (2004) observed that after learning of the forecast for the heavy rain season in 2000, Mozambique appealed to the international donor community for $2.7 million to prepare for the expected floods. Only half this amount was provided, but after the onset of the devastating floods, the international donor community award $100 million for emergency assistance, and later pledged an additional $450 million for rehabilitation and reconstruction. This is a clear demonstration that it is better and cheaper to invest on reduction measures than on response.

6. Recommendations for managing future similar hazards

Mozambique needs to significantly improve its preparedness so as to manage natural hazards. The following recommendations are thus suggested:

1. Mozambique should shift from response to reduction. Governmental institutions, civil society organizations and other stakeholders should adopt policies (e.g., establishing a national strategy for risk management or country-specific building codes for seismic risk) and develop programs for pro-active preparedness and mitigation instead of response only. It should integrate disaster risk assessment in poverty reduction programs.
2. There is a need to improving and raising society's awareness on large scale about hazards/disasters and risk reduction. Understanding of concepts relating to sustainable development shouldbe promoted amongst the general public and professionals. This would discourage inappropriate development and encourage use of appropriate technology and good practices (both in agriculture and building practices) in order to protect the environment and ensure a sustainable development.
3. Integrate hazards/disasters, safety and risk reduction into all learning programs. The

schools should play important roles as resources centres for education and spreading information on hazards/disasters and disaster risk reduction.

4. Create a multi-early warning system and improve the existing early warning systems for floods and cyclones in all disaster prone zones of the country, ensuring that people have confidence in them. The communication systems should also be improved.
5. Institutional strengthening and coordination at all levels (regional, national, provincial and local levels) between the various institutions and actors related to disaster management in the country. The few seismic stations, and meteorological stations and other basic and supporting equipment and infrastructures should be rehabilitated, equipped, maintained and restarted to work correctly and produce reliable data that can contribute to disaster reduction. The multi-sectoral professional expertise and skills are vital resources to Disaster Management, especially to disaster risk assessment, hence they must be cultivated and engaged in order to be sustainable. Thus, training and professional development of technical staff should be taken into consideration.
6. As part of structural measures, Mozambique should invest in some large infrastructural facilities that can minimise such disasters (e.g. dams).
7. Strengthening cooperation between countries in the region and establish win-win situation agreements on issues of disaster management.
8. Transfer lessons from the past disasters to future generations.

Mozambique should reduce poverty and develop the country integrating in all their activities, the disaster reduction measures and enhance disaster risk management in general. We should learn positively how to live with these hazards like floods, droughts, landslides or earthquakes, which hit every year the country.

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Brick Making Activities and their Environmental Impacts in Busia, Siaya, Bondo and Butere-Mumias Districts of the Lake Victoria Basin of Kenya

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Abstract

The rapid increase in construction of permanent and semi-permanent dwellings in Kenya has led to a sustained demand for building materials. Baked clay remains a cheaper source of building blocks, thus encouraging the growth and expansion of small-scale brick-making activities in areas within the L. Victoria basin. This study was carried out in four districts within the lake basin to investigate the nature and extent of environmental degradation associated with brick making. The study was carried out in Butere-Mumias and Busia districts in Western Province, and Bondo and Siaya in Nyanza Province. Data was collected through site visits, observations and interviews with brick makers, local provincial administration and other government officials. Findings reveal that the practice proliferates because: (i) of high levels of poverty, (ii) it requires negligible investment, and thus can be done by single individuals, and (iv) there is increasingly high demand for building materials. There has been increasing encroachment or destruction of wetlands, road reserves, and arable land. Whereas environmental problems posed by brick making are at present still manageable, they are likely to worsen in future due to escalating demand for bricks. There is need to promote environmental awareness among the brick makers, introduce fuel-efficient technologies and improve enforcement of environmental legislation to minimise the negative impacts.

Keywords: *Brick-making, deforestation, food security, Lake Victoria Basin, land degradation, wetlands.*

Introduction

Background

In Kenya brick-making was previously seen as an activity for poorly educated or semi-skilled persons in the community. However, due to rising demand and a readily available market, it has now blossomed into a lucrative commercial venture, with cheaply available human and material inputs. Brick-making is currently providing alternative source of income generation, as climate variability pattern has resulted in a declining agricultural production thereby forcing changes in livelihood strategies. With increasing growth in population, demand for housing both in urban and rural areas has been steadily rising (GOK,2002a; GOK, 2002b). Concrete blocks and *carved* building stone are still expensive for majority of the people. Baked clay bricks remain a cheap source of building materials, as they are usually made from easily available clay soils; using very basic production technology which doesn't require high-level knowledge and training.

Clay bricks are mainly produced by using fuel-wood for firing moulded clay blocks. Most firewood comes from individuals' private woodlots and often from communal trust land and wetland areas. Both indigenous and exotic trees have been used indiscriminately for brick firing activities. Clay soils in the Lake Victoria Basin vary in texture; and range from fine clays, clay-loams, sandy clay loams, sandy clays and silty clay-loams GOK, 2002a; 2002b; 2002c).

The clay is usually dug manually and mixed with water. Mixing is carried out in a shallow pit where the soil is excavated, using hoes and spades. It is then left for ageing for 12 or more hours and thereafter mixed again prior to moulding into brick shape. The moulded bricks are left to sun-dry for 2-3 days depending on the capacity of the kiln and daily output of green bricks. Dried bricks are heaped in a stack specially designed in shape and form, leaving room for insertion of fuel wood. Animal dung or soil is used for covering outside walls of the kiln. Wood in placed centrally into the kiln and ignited. Brick firing requires optimum temperatures of between 900°C and 1000°C for about 1-4 days depending on the size of stack. All these activities degrade the environment as gaping holes are later filled with water while removal of tree cover exposes the soil surface to high radiation

loads, erosive rains and desiccating winds, high atmospheric evaporative demands, high temperatures and others that degrade the agricultural lands.

Study justification

Most of the bricks used for house construction in urban and rural areas within the Lake Victoria Basin come from rural and peri-urban areas. Unregulated excavations commonly take place along road sides and in wetland areas, arable lands, around homesteads and periphery of urban centres. In the process of making bricks water, soil/land and trees are used, often in unsustainable manner, thereby affecting the environment. The impacts of small-scale brick making on the environment has largely been ignored. It is often assumed that that such small-scale ventures, can hardly impact on the environment. However, resultant cumulative ecological damage is significant within the Lake Victoria basin. In the face of rapidly expanding brick production activities, the study on environmental impact becomes necessary to ensure sustainable resource utilisation. The main objective of this study was investigate the impacts of brick-making on the environment in the Lake Victoria Basin by determining, evaluating and assessing their effects on vegetation cover and excavations that lead to environmental damage and degradation.

Materials and methods

Study site

This study was carried out in the four districts of Bondo, Siaya, Busia and Butere-Mumias as shown in Figure 1 in the month May, 2006. The altitude here varies from 1,130m above sea level on the shores of the lake to over 1375m further north. The study area receives a mean annual rainfall of between 760mm and 1820mm, in which the lower values of rainfall occur in the immediate areas to the shore (GOK 2002a; b & c). Most of the soils in the study area are moderately deep, which widely vary in texture and are moderate to well-drained.

Predominant soils are clay-loams, and sandy-loams. The soils in the study areas are mostly clayey due to frequent flooding, for example Budalang'i in Busia district. Budalang'i has two major rivers, namely Nzoia and *Yala*, which drain into Lake Victoria. Swampy areas like Yala Swamp consist of heavy clay types that are difficult to cultivate. Brick-making has increasingly become a common activity in the study area due to an abundant range of suitable soils; and unregulated tree cutting for brick-firing.

The population characteristics show minor pockets of concentration near urban areas, but relatively evenly distributed in rural areas. There are few gazetted forest areas with approximately 579 ha in Busia, whereas Siaya, Bondo and Butere-Mumias have no gazetted forests.

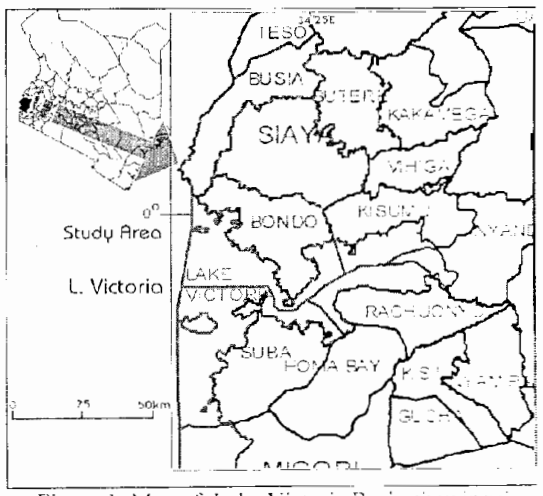

Figure 1: Map of Lake Victoria Basin showing the districts of Bondo, Siaya, Busia and Butere-Mumias where the study was carried out.

Methods

The study used interviews, discussion with key informants and field observation to collect data. Discussions and initial interview sessions were conducted with different key administrative persons and experts including the District Commissioners, District Environment Officers and Forest Officers, Chiefs and village elders. This helped in identification of several brick-making sites, from which a sample was taken and site visits made. Interviews with brick-makers were carried out on the basis of prepared questionnaire and checklists. Information about size of enterprise, number of workers, sources and type of raw materials, production capacity, total quantity of inputs (wood fuel, water, etc) used in brick making, marketing channels, general income, socio-economic information and problems related to these were collected through personal contact with the brick-makers, and the local people.

Results and Discussion

Results

The results of the study showed that brick-making activities are widespread and are carried out in nearly all villages in the four Districts (Busia, Siaya, Butere-Mumias and Bondo). Most of the brickwork is done on private farms; however, where communal or trust land is present such as wetlands, people have tended to encroach and

exploit them as a free and ready source of clay soil. Wetlands degradation was closely linked to development in urban centres. The study established that many construction activities which were being carried out required inputs from wetlands such as bricks and sand; a factor that led to over-exploitation of these resources. Clay is the preferred soil type for brickworks, and is commonly found in wetlands due deposition processes coming from runoff. Padmalal and others (2004) show that clay mining for brick-making causes profound changes in the surface and ground water sources of a given are area. These risks are becoming real in these areas.

Figure 2 shows extensive damage to the environment by brick making in the study area. The observed damages to the soil surface included scraping of topsoil, minimal damage, regeneration by dumping & planting crops in Bar-Kowino and Onyata/Sakwa both in Bondo district and Mundika –(Budalang'i) in Busia. Others included pitting of farms, encroachment of wetlands and leaving water filled ponds, and encroachment of road reserves in Butula and Siginga-Budalang'i in Busia and also in Karapul, Karemo, Jera/Ugenya(Ukwala) and Barding' in Siaya districts.

Damage to private was also from pitting as was observed around Butere town in Butere-Mumias district. The study learnt that wetland encroachment was more rampart in Butula division of Busia district. It was observed here, that wetland encroachment around the Murumba/Masengewa area resulted in destruction of riverine ecosystem. Exploitation of clay soil for brick making included scraping of top soil, digging holes that were later filled with stagnant water, encroachment into road reserves and so on. Loss of topsoil through scraping as happens at Mundika in Budalang'i division result in reduced soil fertility. Damage to private was also from pitting as was observed around Butere town in Butere-Mumias district. The study learnt that wetland encroachment was more rampart in Butula division of Busia district. It was observed here, that wetland encroachment around the Murumba/Masengewa area resulted in destruction of riverine ecosystem. Exploitation of clay soil for brick making included scraping of top soil, digging holes that were later filled with stagnant water, encroachment into road reserves and so on. Loss of topsoil through scraping as happens at Mundika in Budalang'i division result in reduced soil fertility.

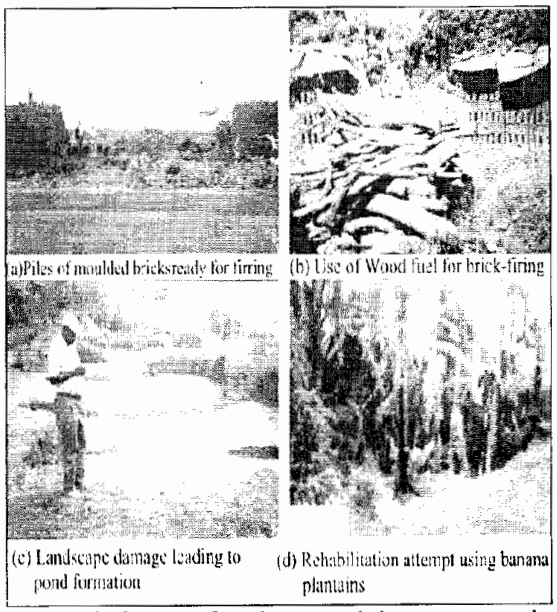

Figure 2. Scenes of environmental damage captured during field survey in different parts of the study area. (a) Brick piled in kilns just before firing, Siaya; (b) Firewood being prepared for brick-firing at Siginga-Budalang'i; (c) Hazardous, water-filled un-rehabilitated excavations in Butula, Busia; and (d) Use of banana plants used for rehabilitation of excavated pits in Butere-Mumias.

The study learnt that in a single season, brick-makers scraped off up to 1 acre of topsoil of the farmland. Such farms could take several years to regain their productive potential, if left to revitalise naturally. Soil erosion in excavated sites rendered land unusable for farming. Coupled with the damaged landscape, the arable land diminished hence resulting food insecurity.

Impacts of brick making on lands included creation of clay pits and burrows, which when improperly managed, became safety hazards (Rau and Wooten 1980). The pits further accumulated rainwater and became breeding grounds for mosquitoes and snails. The pits also posed a danger for physical accidents and injuries especially for grazing animals and young children in parts of Busia. It was observed that very few workers thought of rehabilitating them immediately after excavation.

The collapse of riverbanks and localised landslides occurred where excavations were done close to river systems and sloping lands, as this weakened areas around the riverbanks and the sides of sloping. Results also showed that excavations in highly erodible areas in Siaya district led to massive erosion and landslide risks. Other studies show that brick making is mostly done along riverbanks (Keddie and Cleghom, 1980) and in wetland areas, where the most preferred clay soils are abundant. Currently however, excavation

activities are done haphazardly without regard of suitability of the soil for bricks.

The study learnt that the misuse of biomass/woodfuel was mainly due to the crude and improper construction of kilns, a situation that led to inefficiency energy usage, which resulted in excessive woodfuel consumption: hence more tree cutting of trees that grow along roads and trust lands. Most brick makers prefer to use indigenous trees as they are considered to have a higher calorific value than most exotics. The result is that most indigenous tree species have almost been depleted, and many people are turning to exotic trees, which they grow on their farms. According to the study most trees used in brick-firing came from private woodlot on individual farms. Freelance brick makers hardly own any land to grow trees, but mainly buy from other farm owners. Other activities that compete with brick-making for tree biomass include domestic firewood, poles for construction and other purposes. Tree species commonly used as fuelwood include: *Acacia nilotica, Acacaia tortilis, Eucalyptus spp., Psidium guajava, Gravillea robusta*, etc.

It was observed that a kiln stack of 10,000 bricks on average, required 14 tones of wood (that is, 2 medium size lorries). This translated to about 3 mature trees of 1½ft basal diameter (Howard, 1986). Therefore in a 5-6 year plantation there would be 180 such trees per acre. Given that there are over 2,000 active brick-makers in the region, this translated to 6,000 trees for a single kiln firing (33.3acres). Hence, in a year, brick-firing could be done as many as 10 times, which resulted in an immense loss of tree cover.

Discussions

Rehabilitation and environmental management issues

Results on number of holes with different moisture status, depth and reclamation are presented in Figure 3. These showed that 27% of the holes observed were dry while 7% had water. The deep holes were 20% whereas shallow ones were 13%. Reclamation claimed 9% of the dug holes while 24% were not reclaimed. Currently the Environmental Management and Coordination Act (EMCA) 1999, under Schedule II, requires any enterprise involved in "... *mining, including quarrying and open cast extraction of ... clay*" to undergo an environmental impact assessment. However, enforcement has overlooked artisanal workers, who are seen as insignificant in terms of environmental impacts at individual level. At local administrative level, brick-makers are only be required to seek authority or obtain a permit from the District Forest office, backed by authorisation from their local chiefs from when they want to cut down a tree for use; a condition that is often overlooked due to poor supervision from concerned offices. Many of the brick makers interviewed did not seem to be aware of the above condition and the negative environmental impacts associated with brick making. During this study only a handful of brick makers were aware and were found to engage in rehabilitation activities after excavating the soil. They did this by: (i) directing runoff into the pits to hasten healing; (ii) using them as household dumpsites for various organic wastes; (iii) planting crops, especially banana plantains within excavated pits, or other suitable material including Napier grass, etc. This was often combined with waste dumping. In wet areas, resultant ponds were being converted to fishponds, but on limited scale.

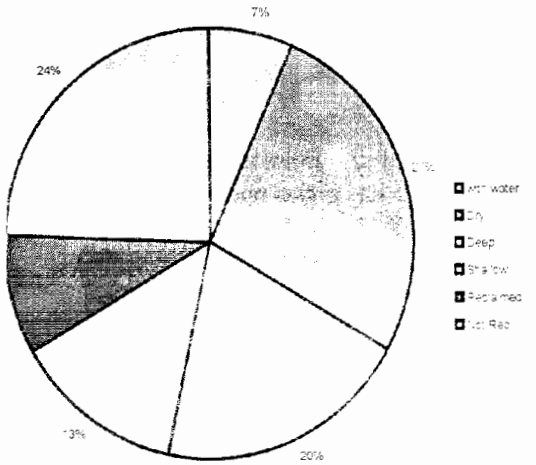

Figure 3. Number of pits with different moisture status, depth and reclamation.

Labour and gender issues

Brick making was found to be male dominated, however a few children were found to play a significant role in assisting brick-makers, when they were not in school. In some areas women assisted by fetching water for use and other minor chores.

Conclusions and recommendations

In conclusion, the study found the nature of environmental effects from brick making differ

from area to area depending on scales of production and technologies used. Introduction of more efficient technology in energy use during brick making processes will lessen overexploitation of fuel-wood and reduce deforestation.

Brick-making activities have more significant detrimental environmental impact locally than nationally or globally. These small-scale activities are poorly regulated. There is need to enforce statutory regulations to control and reduce environmental damage by small scale industries; by environmental awareness campaigns.

There is need to extend this study to other parts of Lake Victoria Basin to obtain a comprehensive environmental impact of brick making. Additional studies to establish emissions of pollutants into water systems as well as the effect on local people's health in the Lake Victoria Basin are here recommended.

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Female Gender Vulnerability and Challenges of HIV/AIDS to Health, Education and Development in Kenya

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Abstract
Of the approximately 40 million people living with HIV/AIDS worldwide, two-thirds are in Sub-Saharan Africa, majority aged between 15 and 49 years. Nearly 50 percent are women of reproductive age. According to the 2003 Kenya Demographic and Health Survey (KDHS), more adult women than men are infected with HIV/AIDS, with a prevalence rate of 9 percent to 5 percent, respectively (Ibid). In this case study, a purposive sample of 12 HIV/AIDS willing patients was surveyed using questionnaires and interviews in one of the provincial health facilities in Kenya. Findings of the study reveal women's vulnerability to the virus that causes AIDS. Concerned by the exponential spread in Kenya, HIV/AIDS' was officially declared a national disaster in 1999. This paper enumerates some factors that greatly contribute to women vulnerability to HIV/AIDS; challenges posed to national health care, education and development; and a proposed way forward in combating the spread of HIV/AIDS in Kenya.

Key words: *HIV/AIDS, Female Vulnerability, VCT, Mother-to-Child-Transmission, National Disaster*

Introduction

The Human Immunodeficiency Virus (HIV) once contracted renders the body deficient in resisting ailments; a condition medically known as Acquired Immunodeficiency Syndrome (AIDS). The disease has indiscriminately killed many across demographic divide with the female gender universally facing the larger brunt of the scourge.

In Kenya, women and the girl-child suffer more from the impact of HIV/AIDS due to cultural and social constructs, which make them vulnerable to it. Popular misinformed beliefs that for instance, HIV/AIDS is a mystical condition caused by bad omen or witchcraft, and the deep-rooted beliefs in some communities, for example, that women are property and belong to their men (husbands, fathers or brothers), pre-expose them to sexual exploitation and abuse which further spreads HIV/AIDS.

Strong patriarchal cultures deny women a decision over their sexuality, such as divorcing or walking out of unfaithful marriages. Worse still, they cannot deny their spouse sex. In some cultures, widows are inherited and in others, polygamy is still practiced. Consequently, HIV/AIDS has grown to become a public health burden where while in 1992 HIV/AIDS patients occupied 15% public hospital beds, in 2004 they occupied 49% (Republic of Kenya, 2005b).

In this paper are outlined women's vulnerability to HIV/AIDS and challenges posed by HIV/AIDS to national health, education and development especially for the girl-child in Kenya. Proposed ways forward are presented.

Synopses of Literature: Women's Vulnerability to HIV/AIDS in Kenya

In the early stages of the pandemic, women and girls were peripheral concerns who have since become the central focus. In 1997, 41% of infected adults were women, in 2001 this figure rose to 49.8% (UNAIDS, 2002) or 8.9 million more women in Sub-Saharan Africa (UNO, 2001). In the 1990's, at its highest in Kenya, HIV/AIDS prevalence rates were between 20% - 30% in some parts of the country (Republic of Kenya, 2001). This continued until 2004. The modes of HIV transmission in Kenya include: sexual intercourse (70-80%), mother-to-child (5-10%), blood transfusion (3-5%), Injecting Drug Use (IDU) (5-10%, and health care (0-1%) (Republic of Kenya, 2005b). Prevalence is higher in urban areas (17%), compared to rural areas (12%), (Republic of Kenya, 2002). It is estimated that 1.4 million women between 15-59 years of age are infected with HIV/AIDS in Kenya, compared to 0.9 million men in the same age bracket (UNAIDS, 2002). Moreover, a study carried out in Kenya showed women in the age group of between 15 -19 years had five times higher HIV/AIDS infection rates than men in the same age group. Those in the 20 – 24 years age group had three times higher infection rates than men in the same age group (NACC, 2005), see Table 1.

Table 1: HIV Prevalence in Kisumu District of Western Kenya by Age and Sex in 1997

Distribution	Age-Groups (years)					Total
	15-19	20-24	25-29	30-39	40-49	
Men	4.2%	13.4%	29.4%	34%	29.9%	21.0%
Women	22.3%	39.0%	38.6%	31.7%	19.4%	30.9%
Ratio	5.3	2.9	1.3	0.9	0.6	1.5

***Source**: Adopted from; HIV/AIDS in Kenya, Situation Analysis for National HIV/AIDS/STD Control Programme, September, 1998.*

The latest Kenya Demographic and Health Survey (KDHS) in 2003 found that there were 9% adult women infected with HIV/AIDS compared to 5% adult men. Infection by gender differentiation is most pronounced among young people in the age bracket of 15 – 24 years. It was also observed that women are infected at much earlier ages than men are, leaving the girl-child more endangered. Women in the age group of 20 – 24 years form 10% of HIV/AIDS prevalence in Kenya compared to 6% for men in the same age group (NACC, 2005).

The Study

Due to the sensitive nature of this study, only a small purposive sample of 12 willing women were surveyed in a case study at one provincial health facility in Kenya. Interview and questionnaire methods were used to collect data that were analyzed both quantitatively and qualitatively.

Findings

One hundred percent respondents noted that they: (a) Were faithful in their marriage. (b) Were healthy when they married. (c) Contracted the virus from their husbands. (d) Were socially obliged to have unprotected sex with their husbands. (e) Could not access comprehensive care centres for treatment due to physical distance. (f) Were physically weak to do heavy physical work. (g) Had never visited VCT before the death of their husbands in fear of suspicion. (h) Were not aware they should not breastfeed. (i) Had no power to make decisions. (j) Feared stigmatization therefore could not talk publicly about their health. (k) Were ignored by church and community.

Eighty-three per cent respondents submitted that they: (a) Lacked money for consistent medical care. (b) Did not realize medical conditions of their husbands until it was too late. (c) Were financially constrained after the death of their husbands; their children were school dropouts. Sixty-seven percent respondents observed that they could only access treatment after the demise of their spouses. Fifty percent respondents observed that they were chased away from their marital homes after the demise of their spouses because there was no one to finance their costs.

Forty-two percent respondents noted that their girl children cared for them. Thirty-three percent respondents said: (a) their sisters cared for them. (b) They were in polygamous marriage. (c) Twenty-five percent said their women in-laws cared for them.

Discussion

Factors promoting HIV/AIDS vulnerability among women in Kenya

The above findings suggest that women are vulnerable to HIA/AIDS compared with the men. The various factors that make women and the girl-child more susceptible to HIV/AIDS infection can be broadly categorized into four:

- Social Cultural Factors (SCF)
- Economic Factors (EF)
- Political-Religious Factors (PRF), and
- Medical Factors (MF)

Factors emanating from each of the above categories are highlighted in the tables below.

Table 2: Some SCF Affecting HIV/AIDS Vulnerability among Women in Kenya. (***Source**: Findings and literature.)*

1. Patriarchal demands that women are seen as property/objects of sexual gratification. 2. Males' freedom to divorce, separate or engage multiple sexual partners.	3. Polygamy, adultery, commercial promiscuity. 4. Early or forced marriages for young women, etc. 5. Prevalent high illiteracy rate among women, leaving them largely ignorant and without economic empowerment, etc.

Table 3: Some EF Affecting HIV/AIDS Vulnerability among Women in Kenya..

1. Preference to treat men first or only at the expense of their female counterparts due to insufficiency of funds.	3. Considerably disproportionate time spent nursing the sick as opposed to working for economic gain.
2. Widows' and orphans denied inheritance/property taken away by dead husband's relatives.	4. Much of the family income spent on treatment of HIV/AIDS leaving family poor, etc.

***Source**: Findings and literature*

Table 4: Some PRF Affecting HIV/AIDS Vulnerability among Women

1. Women discouraged from making own decisions.	4. A lack of willpower to assist gender mainstreaming and encourage inclusion of women in the public space.
2. Leadership regarded as the preserve of men only.	5. Religious uncaring attitude and protest against the use of condoms etc.
3. Stigmatization of HIV/AIDS patients and treatment of sex issues as taboo.	

***Source**: Findings and literature.*

Table 5: Some MF Affecting HIV/AIDS Vulnerability among Women in Kenya

1. Increased incidences of rape, lesbianism, and casual sex.	4. Lack of health awareness and information.
2. Increased incidents of incest.	5. High poverty rates.
3. Expensive costs of medical care.	6. Unsafe deliveries in public hospitals that could lead to HIV/AIDS infection, etc.

***Source**: Findings and literature.*

Acting together, or individually, many of these factors above have impact beyond the individual person. They affect whole communities and the nation at large. As such, HIV/AIDS poses a threat to national health, education, and development in Kenya as highlighted below.

HIV/AIDS Challenge to National Healthcare in Kenya. Presently, over 150,000 people die annually from HIV/AIDS in Kenya, twice the number of deaths in 1998 (NACC, 2005). Life expectancy of a Kenyan has reduced from 60 years in 1993 to about 47 years by 2000 (Republic of Kenya, 2002b). Beds occupied by HIV/AIDS patients in public hospitals rose from 15% in 1998 to 49% in 2000 (Ibid). In this study, 100% respondents said they had unprotected sex with their spouses. 33% were in polygamous marriages while 50% of the respondents had been chased away by their late husbands' relatives because they could not afford to treat them.

On the rise as well, are cases of Mother-to-Child-Transmission (MTCT) of HIV/AIDS in Kenya. This factor is responsible for 36% of all infant deaths in Kenya (Republic of Kenya, 2002). MTCT occurs during pregnancy, labour, and delivery or from breastfeeding and it accounts for 90% of all childhood HIV/AIDS infection. 40% of mothers with HIV/AIDS in Kenya pass it on to their babies (Hubley, 2005). No wonder, 41.6% Of the respondents were breast feeding their babies while 100% were not aware that they should not breast feed their young ones.

Increased incidents of sexual offences have also significantly contributed to the spread of HIV/AIDS in Kenya. Cases of rape, incest and forced sex have emerged as a major way by which HIV/AIDS is contracted. Further to this, misinformed belief that HIV/AIDS can be cured through sex with a virgin woman/girl has served to only increase incidents of incest, and rape of girl-children by infected men. 25% of women and girls aged 12 -24 years in Kenya said in a nationwide study, that they lost their virginity through forced sex (Republic of Kenya, 2001). A recent study in Nairobi, revealed that 40% of adolescents aged between 13 – 19 years contracted HIV/AIDS from rape (PCA and NCWK, 2002).

The situation is made worse by expensive and inaccessible medical care for most women in Kenya. Of the 52% of Kenyans considered poor most are women. It was noted that 83.33% of the respondents lacked consistent medical care due to poverty. Whereas 66.66% respondents could only access treatment after the demise of their husbands, 33.33% were chased away from their marital homes because their relatives could not afford to treat them. Pervasive high illiteracy rate among women across Kenya makes it difficult to demystify HIV/AIDS, isolate it as a controllable disease or even offer information and education

about it. 83.33% women said they were not aware that their spouses were suffering from HIV/AIDS; they did not understand the "mystery." Accordingly, HIV/AIDS continues putting a strain on the already stretched medical system in Kenya (there is 1 doctor for every 33,000 Kenyans in rural areas). The few established Comprehensive Care Centres are too far from most patients; all (100%) respondents decried expenses incurred in a bid to access these centres.

HIV/AIDS Challenge to Educational Development in Kenya. Kenya currently has 1.3 million children below the age of 18 years of age orphaned by HIV/AIDS (Republic of Kenya, 2002). Most of them lack school fees. The girl-child suffers doubly because she would have withdrawn from school already to help care for her sick parent(s). In this study, 83.33% respondents said their children had dropped out of school after their husbands' death. 41.6% submitted that their girl-children were responsible for taking care of them. Kenya has also lost a sizable proportion of experienced teachers to HIV/AIDS. The impact of this loss is felt across all levels of the education sector. As a result, education in Kenya is affected by undermined achievements in literacy, increased number of working children and an increased number of poorly educated graduates.

HIV/AIDS Challenges to National Development in Kenya. Presently the HIV/AIDS pandemic is the most serious impediment to Kenya's economic growth. About 80% - 90% of all people infected by HIV/AIDS in Kenya are in the productive ages of between 15 – 49 years of age (Republic of Kenya, 2002). Most HIV/AIDS deaths occur between the ages of 25 – 35 years of age for men and 20 – 30 years of age for women (Magambo, 2002). HIV/AIDS has since 1989 been the biggest single cause of death among Kenya's most productive ages compelling the government to divert significant economic resource towards combating it at the peril of other sectors of the economy.

Agriculture, which is Kenya's biggest employer and foreign exchange earner, faces the largest loss. The forestry department since 1988 loses an average of 36 professional employees at a replacement cost of US$ 40,000. Additional costs include cost of sick leaves, funeral benefits, recruitment and training, replacement staff and the rising cost of health insurance policies (Republic of Kenya, 2001).

As people in rural areas succumb to HIV/AIDS, Kenya is faced with declining agricultural productivity. In Nyanza province for instance, households affected by HIV/AIDS suffered 20% - 30% crop reduction in 2001/02 only. It is estimated that by 2010 HIV/AIDS will reduce Kenya's Gross Domestic Product by 14.5% if remedial steps are not taken to contain the situation. In the sample for this study, all respondents acknowledged that they could not engage in any meaningful economic activity at all because they were physically weak. The overall HIV/AIDS' undermining of the agricultural systems includes reduced labour supply, low crop production and food insecurity (Achoka *et al*, 2005).

Conclusion

From our study findings and discussion, three major conclusions are made:

- Medical Care
  1. There is lack of consistent medical care due to poverty among the infected women.
  2. Treatment of men with HIV/AIDS is considered more urgent than that of women.
  3. Illiteracy and its inherent ignorance make women more vulnerable than men.

- Educational Development
  1. Many teachers have died from HIV/AIDS infection.
  2. Increase in orphans resulting in school dropouts.
  3. More of the girls than of the boys take up care duties for their ailing parents.

- National Development
  1. About 80% HIV/AIDS patients in productivity brackets are mostly women.
  2. The large number of HIV/AIDS patients adversely affects Kenya's national productivity.

Way Forward in Combating HIV/AIDS in Kenya. Kenya has made a concerted effort to fight the spread of HIV/AIDS. The Government of Kenya's Parliament's Session Paper No. 4 of 1997 on AIDS, stresses the importance of advocacy and policy development as intervention measures. In addition, the National Aids Control Council (NACC) established in 1999, the National HIV/AIDS Strategic Plan of 2002, the Technical Sub-Committee on Gender and HIV/AIDS Task Force, among others have provided broad plans and opened insights from national to constituency levels aimed at curbing the spread of HIV/AIDS.

To finance these initiatives, strategic international partners such as DANIDA and WHO work in collaboration with Non Governmental

Organizations (NGOs) and Community Based Organizations (CBOs) sponsoring a broad spectrum of interventions harnessed by the Kenya AIDS Non Governmental Organization Consortium (KANCO) which acts as a resource centre.

However, more effort should be directed at more indigenous and individual participation in combating HIV/AIDS as opposed to the expert approach practiced currently. Effort should be made to encourage participatory appraisals with affected communities with the aim of developing initiative, ownership, appreciation and participation in combating further spread of HIV/AIDS. In consistency with the findings above, given below are some social-cultural/ economic and medical suggestions of ways to curb the spread of HIV/AIDS in Kenya

Social Cultural/ Economic suggestions

(a) Decode men's thinking. Men should be assisted to understand that women are their partners in life and in development. Outlaw and criminalize polygamy. *(b) Stiff penalties.* Give stiffer punishments for rape, incest and domestic violence as well as encourage self-respect. *(c) Leadership.* Advocate for more women inclusion and say in politico-socio-economic decisions. *(d) HIV/AIDS.* Empower all sexually active women to demand for HIV/AIDS status from their male partners before sexual relationships. Provide for women and girl children's education on HIV/AIDS.

Medical Suggestions

(a) VCT. Encourage regular attendance of VCT for HIV/AIDS. Establish more VCT centers. Couples should be encouraged to attend sessions together. Comparative attendance figures from a VCT center obtained for this paper showed that out of 892 patients, 608 were women compared to 284 men. Later records also showed that out of 1,234 patients, 804 were women compared to 430 men. These findings suggest reluctance or unwillingness on the men's part to accept or take responsibility. 50% of the women said that even though their husbands were sickly, they never disclosed their medical status. *(b) Community/Health Care.* Serious community/health care should be extended through administrative and social institutions like churches or mosques. Participatory community involvement should be encouraged in combating HIV/AIDS. *(c) Mother-to-Child-Transmission (MTCT)* can be handled through alternative breastfeeding and delivery modes. *(d) Comprehensive Care Centres (CCCs).* Should be developed within reach of all the people. *(e) Medical Staff to be better trained* to handle the scourge. Thus, an all inclusive approach should be encouraged where participatory communication and development of indigenous ideas and knowledge to dissuade cultures and practices that promote spread of HIV/AIDS, are sought as a way to involve the community more effectively.

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A Framework for the Development of a Geo-informatics Based National Disaster Management Information Systems for Kenya

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Abstract

Geo-informatics, which combine satellite positioning, digital remote sensing and Geographic Information System (GIS) technologies can assist in the three phases of disaster management, namely prediction, response and mitigation. The paper proposes development of a geo-informatics based national disaster management information system (DMIS) for Kenya. Operational modules for such a system are illustrated using some common disasters. The paper identifies the National Disaster Operations Centre (NDOC) as the most appropriate institution to host the system. Key government organizations necessary to implement the system are identified. Such a system can improve the abilities of all stakeholder in disaster management, namely the victims, the government, volùntary rescuers and well-wishers, by enabling them access and communicate disaster-related information in real time and hence make informed decisions on the risks and how best to handle them.

Key Words: *Geo-informatics, disaster management, information management system*

Introduction

The importance of effective management of information in general, and spatial information in particular, in disaster management is increasingly being recognised worldwide (Rego, 2001). Availability of such information and its timely communication can significantly reduce the impacts of disasters and ensure more lives and properties are saved. Spatial information can facilitate identification of an impending disaster. provide directions to a disaster site or assist in developing logistics for ensuring assistance reaches disaster sites. Utility of such information increases when the data are acquired, stored, analysed and communicated in digital formats. Further, significant cost reductions can be realized when such information is shared over a large area. There is thus a strong case for developing a national disaster management information system, based on Internet-based geo-informatics system. Geo-informatics is a set of technologies comprising of satellite position, remote sensing, geographic information systems and information technology. These relatively new but rapidly growing technologies, have great potential in disaster management.

This paper proposes the development of a geo-informatics-based national disaster management information system (NDMIS) in Kenya by showing how this technology can be used in managing commonly occurring disasters. The objectives of this paper are a) outline the role geo-informatics can play in disaster management, b) identify the major components of a geo-informatics based National Disaster management Information System, and c) propose an institutional framework for the NDMIS. The paper is organised in three main parts. The first part develops some common understanding of geo-informatics and disaster management by providing operational definitions. In the second part common disasters are used to illustrate geo-informatics-based models for different components of the disaster management process. Finally, paper looks at the institutional and organization requirements for the proposed NDMIS. The paper concludes by looking at possible hurdles that might hinder the rapid implementation of the proposed system.

Disasters and Disaster Management

Disasters are caused by known events, i.e. hazards, whose occurrences have potentially damaging effects to both life and property (UNCHS, 1993; Frampton *et al.*, 1999). Hazards can be naturally occurring (floods, droughts etc) or man-made (traffic accidents, urban fires etc.) Disasters can also be categorized in terms of the agents that cause them, for example geological, climatological or biological. Consequently, disasters can be studied using physical or biological models. Disasters occur in space over time, making them ideal for geo-spatial analysis. Finally, disasters, particularly natural disasters, are unavoidable. However, we can reduce their impacts and losses through effective management of disaster information. Disaster management consists five

interrelated components namely; disaster prediction, response, recovery, monitoring and the communication of disaster information.

Prediction is the determination of the likelihood of a disaster, the point and time of occurrence, the spatial extent and its magnitude. Disaster response are all activities executed in attempt to contain a disaster, including controlling the hazard and evacuation of victims.

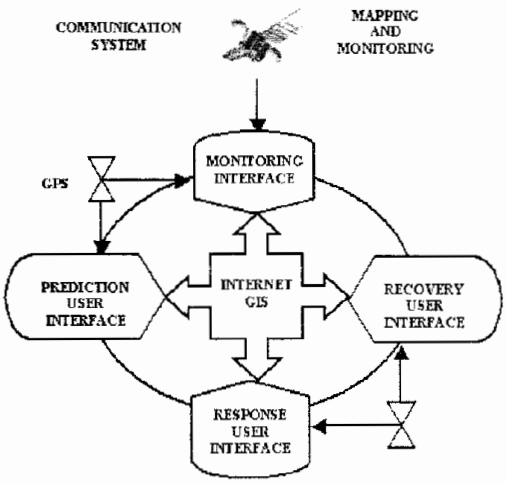

Figure 1 Framework for Geo-informatics Based DMIS

Post disaster recovery operations are measures that aim at reducing the impacts of a disaster such as compensating for losses incurred, resettling victims, provision of relief supplies, forestalling or controlling disease outbreaks, and prevention of recurrences.

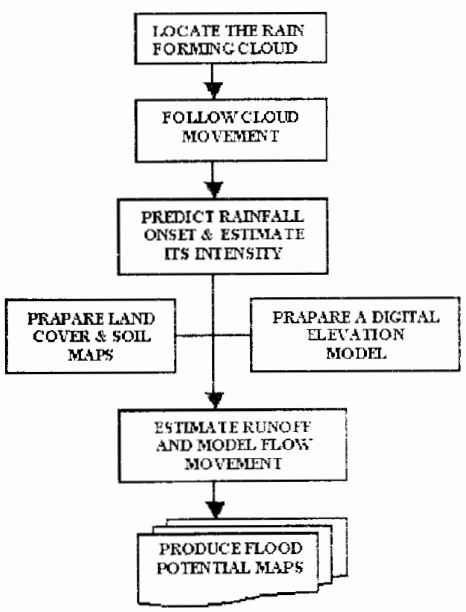

Figure 2 Flood Prediction Model

Disaster monitoring are programmes instituted to monitor the behaviour of the disaster causing agent or the progress of mitigation measures. Disaster management is a continuum of activities, which are hard to separate since in most cases they overlap forming a continuous circle (Figure 1).

Effective disaster management requires a functional integration of all the disaster management components outlined above. This implies a continuous flow of data from acquisition, analysis, communication and utilization of the resultant information as shown in Figure 1 which presents a conceptual model of a disaster management system consisting of data capture, analysis and information communication based on the Internet.

Disaster Prediction

To predict a disaster, it is necessary to understand the environment under which it is likely to occur, including the physical controls which instigate the hazard (climate, geology, etc) and the specific socio-economic attributes that can exacerbate its spread. Prediction information is useful for developing early warning systems. Disaster prediction models for climate-related disasters, such as floods (Islam and Sado, 2000), and droughts (Tappen *et al.*, 1992) are common. Some of these integrate meteorological data, land cover data, soils data and hydrologic models in a GIS environment. A dynamic system, which includes a satellite-based cloud-monitoring component to forecast floods, is shown below.

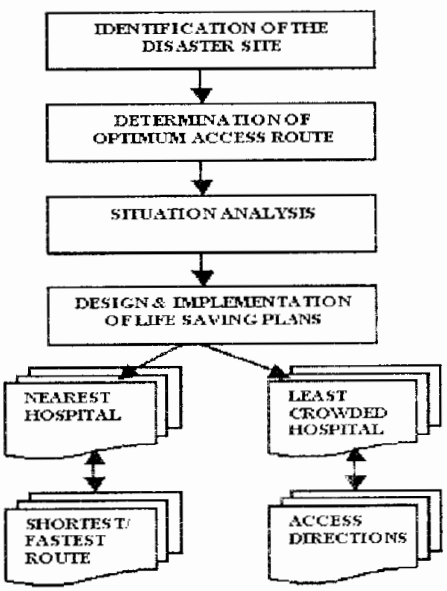

Figure 3 Disaster Response Model

In the prediction model, the cloud location and monitoring are done with meteorological satellites, while land cover and land use maps are made from earth resource satellites. Finally, the ground identification of disaster prone areas is done with the aid of a GPS.

The same process can be applied in predicting landslides, droughts, road accidents, oil spill movements, spread of diseases, etc. The early warning information obtained from such a system can assist both the public and policy makers plan for mitigation measures such as evacuation and re-settlement. For a drought disaster, harvest estimates based on field crop-yield predictions can help governments plan for external sources of food to boost national reserves and hence appropriately mitigate against the impact of drought.

Disaster Response

Disaster response involves the identification of the disaster site, gaining access to it, conducting a situational analysis and implementing appropriate life/property saving operations. Most of these tasks depend on the nature of the disaster, location of occurrence and the resources available. If a disaster occurs in a well-mapped developed area with adequate road networks, it is easy to describe and locate the disaster site. For a disaster in a remote area, with no maps or land marks to facilitate its description and subsequent location, a GPS can be used to describe the site and provide access directions.

Figure 3 illustrates the operations of a geo-informatics based disaster response system using the example of a road accident. From the descriptions of accident location, the GIS network module is used to determine the optimum access route together with the access directions. A situational analysis is performed on site and appropriate decisions taken. These decisions are implemented with the help of the GIS network module to locate the different service categories and identify appropriate routes to access them together with the directions to follow.

This model can be applied in a forest fire incidence, drought, flood or an oil-spill disaster response, where the location of the disaster site can be done using satellite remote sensing. Extent of damage is then assessed using a combination of remotely sensed data and GIS. Operations such as identification of the nearest fire station, hospital and optimum routes are carried out with a GIS or GPS. For an oil spill, spatial interpolation techniques can be used to predict the movement of the spillage and hence assist in identifying the sites for installing the oil moping equipment or where to pour oil-breaking chemicals.

Disaster Recovery

The objective of post-disaster recovery programmes is to reduce the impacts of a disaster. For a road accident, mitigation measures could include re-designing the road to eliminate the accident black spots or incorporation of some speed control mechanisms. These activities require damage assessment and the design of appropriate control measures. Both activities have different dimensions, including spatial, temporal, economic and social. Figure 4 illustrates some of the issues that could arise in a flood disaster situation and how the mitigation measures could be instituted using a geo-informatics based information management system.

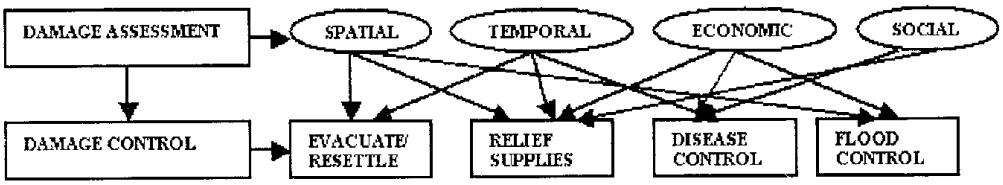

Figure 4 Recovery Model for a Flood Disaster

The spatial dimension refers to the determine of safe grounds for re-settling victims using 3-D spatial interpolation, where to locate flood control mechanisms, etc, while the temporal dimension takes care of how long the condition will remain, how fast it takes to relocate the victims, etc. Finally the socio-economic dimension will cater for issues like the population involved, costs to be incurred, expected disease outbreaks, etc.

Disaster Monitoring

Disaster monitoring operations aim at ensuring that no life or property threatening post-disaster conditions remain unattended to. They also follow the effectiveness of mitigation measures. Repetitive coverage of satellite-based sensors are very useful for this. Monitoring systems also acts as an early warning mechanism in that they can quickly pick unusual trends or raise red flags when certain thresholds are exceeded. To illustrate the monitoring component, HIV/AIDS, which has been declared a national disaster in Kenya, is used.

The figure below presents a GIS-based HIV/AIDS prevalence monitoring system.

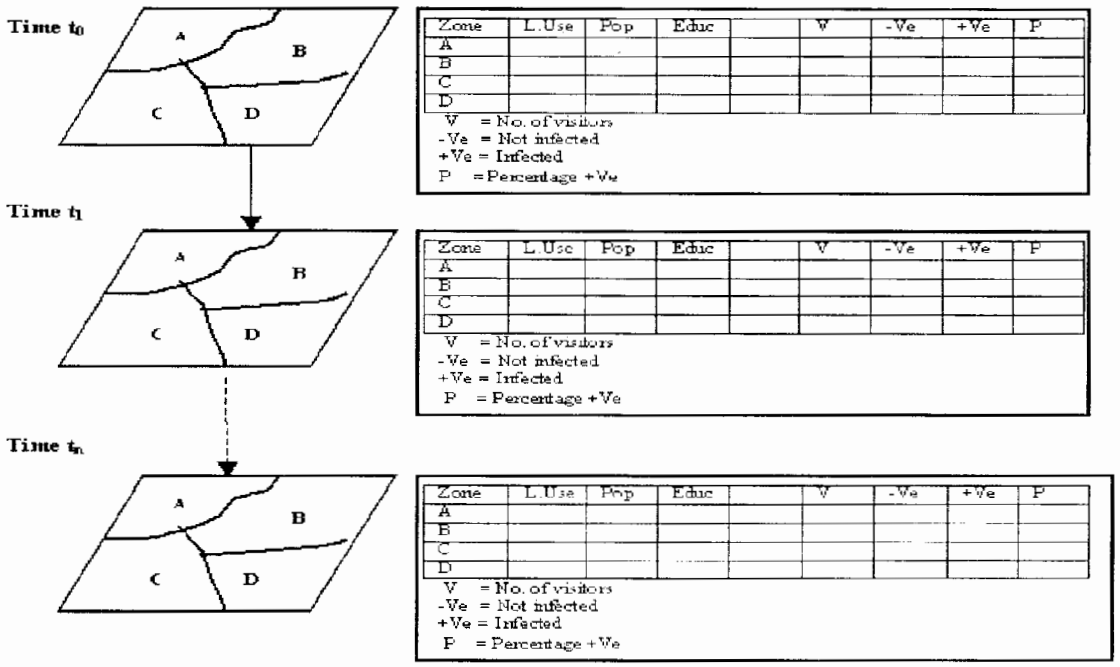

Figure 5 Disease Monitoring

Figure 5 presents a GIS database showing, among other things, HIV/AIDS prevalence, population, land use characteristics and other socio-economic indicators. Using this database, the percentage of positive cases (P) in different areas is monitored. A rapid change in P in a particular area it is easily noticed and related to other characteristics of the area, such as changes in land use or other socio-economic characteristics.

Disaster Communication

Effective communication can save lives and property in a disaster. This requires reliable and continuous two-way communication between the parties involved. Disaster victims should receive information on the kind of assistance being given and what they need to do to facilitate its effective delivery. Rescuers and the general public need to know what the victims need and what the formal disaster response centre is doing so as to decide what else they can do. People living close to a disaster area or in areas with similar characteristics as the disaster area, also need to maintain constant communication with the disaster-monitoring centre.

Institutional and Organizational Framework

The proposed system is multi-disciplinary. It requires a strong institutional framework backed by an equally strong organizational network of technical personnel. The National Disaster Operations Centre (NDOC) in the Office of the President (GOK, 2003), is considered the appropriate institution to host the proposed system in partnership with a number of governmental institutions as indicated in Figure 6.

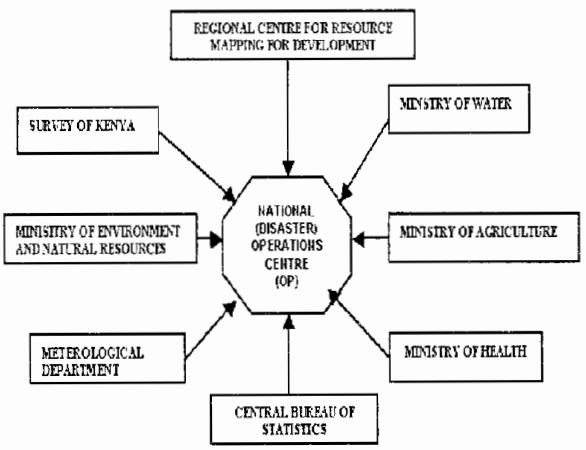

Figure 6 Organizational Framework for the National DMIS

All the institutions suggested are involved in spatial data collection and analysis and are already applying some form of geo-informatics in their operations. Further, most of these organizations deal with data that relates directly to the commonly occurring disaster in Kenya, such as geological,

weather and climate, disease and food situation data.

The NDOC is charged with the coordination of all disaster management activities before, during and after the disaster, including the preparation of media programmes for public information and press briefing. With the help of technical expertise from the organizations shown, the center can build and operate the geo-spatial database which will strengthen the national disaster preparedness capacity.

Conclusions

The paper has presented the technical and the organizational framework for a geo-informatics based national disaster management information system. It is evident from this framework that disaster management is wide in scope, operationally complex and demanding in geo-spatial information. Consequently, development of a geo-informatics based disaster management information system can improve the abilities of all stakeholder in disaster management, namely the victims, the government and voluntary rescuers and well-wishers, by enabling them access and communicate disaster-related information in real time and hence make informed decisions on the risks and how best to handle them.

There are two main challenges in developing an operating such a system. The first one is data availability. Very detailed local level data, which is not readily available, is the cornerstone of such a system. The second main challenge for the proposed system is making it accessible to all stakeholders, who include policy makers, decision implementers, disaster victims and the global public, who are potential voluntary rescuers and well-wishers. However, the current trends in information technology, the Internet and developments in WebGIS, are likely to counter this challenge. A multi-level access system, allowing different classes of stakeholders different levels of access and interactions using passwords can ensure wide access while ensuring database security and integrity.

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Occurrence of Landslides and Challenges to Rehabilitation of Scars for Improved Human Security on Mt Elgon, Uganda

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Abstract

Land degradation by mass movements undermines sustainable development of the mountain ecosystems the world over. This paper examines the occurrence of landslides and the challenges faced in rehabilitating the scars for improved human security in Mt Elgon, Uganda. Data were gathered from field surveys through observations, interviews, discussions and supplemented by review of available literature. Intensive rains, deeply weathered porous soils, steep slopes (>50%) and land use change control the occurrence and distribution of landslides in Bushika sub county. Continued occurrence of landslides threaten the security of the mountain people including those in the immediate lowlands. Problems of ecological insecurity, food insecurity and land conflicts are common. Therefore, rehabilitation of the affected areas is an important strategy for improved human security. The local communities, however, face many challenges in rehabilitation including limited resources, incidences of secondary slides and lack of adequate knowledge on the best management practices.

Key Words: *Human security, landslides, local community, Mt Elgon, rehabilitation*

Introduction

Land degradation by mass movements including landslides raises formidable challenges to sustainable development of the mountain ecosystems all over the world. Large-scale disasters have significant humanitarian, social security, political, and economic implications that undermine the human security. Disasters leave large numbers of people ill, disabled, widowed, orphaned, displaced, or suffering from post-traumatic stress disorder (Basu, 2005). Thus, human security is increasingly being threatened by disasters (Basu, 2005) including landslides especially in the mountain and highland fragile areas. Human security is more than freedom from violence or the threat of violence: it concerns people's health, economic opportunities, political rights, community identity and resilience to shocks such as natural hazards (IUCN/WWF, 2005).

Landslides are a natural phenomena and a normal feature of landscapes experiencing dissections but their magnitude, frequency and geographical distribution have been considerably modified in recent years by human intervention (Jones, 1992). Poor environmental practice exacerbates disasters of nature (e.g. landslides, floods), which in turn increase human insecurity (Tow, *et al.*, 2005). Landslides and mass movements are historical problems in the mountains of Uganda and most particularly on Mt Elgon in Bushika sub county. The narrations by local people indicate that landslides are an old problem in this area and have caused destruction of much property, loss or injury to human life; more than 500 hundred people have lost their lives in the last half a century (Kitutu, 2006).

The most recent wave of landslides in the country particularly in the late 1990s is mainly attributed to multiple factors including deforestation of steep slopes, deeply weathered soils underlain by tertiary and pleistocene volcanic rocks, steep topography, human activities (e.g. cultivation) and triggered by climatic changes (e.g. El Nino rains) (Ngecu, et al., 2004). Intensive rains cause slope failure due to increased pore pressure or soil saturation in excess of shear strength (Selby, 1993).

The destruction by landslides affects people's livelihood security through reduced crop yields, low incomes from farming, food shortage, communication barriers, poverty and death. Environmental degradation that makes communities more vulnerable to disasters is central to the concept of human security yet somehow these are treated in isolation (IUCN/WWF, 2005). The objectives of this paper are (i) to examine the occurrence of landslides in Bushika sub county and

(ii) to discuss related challenges in the rehabilitation of these landslide scars.

Material and methods

Study area

The area is located on in the western slopes of Mt Elgon in Bushika sub county, Bududa district. It is densely dissected by rivers and streams, from the Mt. Elgon, leading to a rugged topography characterised by steep slopes. More than 80% of the land is located on slopes of >15°, which is critical for accelerated mass movement. The main lithology is the fenitized basement rocks, which are the oldest and of Archean age. Landslides are reported to be common in this zone (Kitutu, 2006; Nakileza *et al.*, 2005). The main landuse types are agriculture (farming and small scale grazing) dominating below 2500 m a.s.l. and forest (national park) at >2500 m a.s.l. The dominant perennial crops are banana and coffee, which are intercropped with beans and maize. The area is among the most densely populated in Uganda with a population density of over 400 people/km^2 (UNBOS, 2002).

Methods

An inventory of the landslides and related human security was undertaken through field surveys backed by review of available literature. Data on the occurrence and distribution of the landslides-was derived from interviews, group discussions with the local communities and observations along established transect lines. The data/information from transect walk was integrated in GIS environment for mapping landslides. The identified landslides scars were characterized with respect to depth, length, width, soils and land-use. Information concerning the management of landslide scars was acquired through observations and group discussions with the local community in Bushika. This was supplemented by interviews with the Bududa district officials.

Results and discussions

Occurrence of landslides on Mt Elgon

Landslides on Mt. Elgon occur in different areas under varied landuse, altitude and topographic conditions (Table 1). However, many of the landslides occur within areas receiving 1500 mm-2000 mm rainfall, in altitudinal ranges of 1500 m to 2500 m above sea level and corresponding to steep slopes (averagely >15°) in highly disturbed areas. Therefore, the majority of the landslide prone areas, are found in the south-western part of Mt. Elgon in the districts of Bududa, Manafwa and Sironko (Table 2). A majority of these landslides (~40%) have occurred in the last decade due to the El Nino rains and poor environmental practices on the fragile slopes.

Occurrence and distribution of Landslide in Bushika sub county

Ten landslides were identified in the study area (Table 1). Bottle slides, mud- slides and shallow slides constituted the majority of the landslides (90%) identified in Bushika sub-county. The sheet slides, also referred to as 'superficial slides', were rather shallow (<1.5 m), occurred on midslopes and mainly eroded soils and/or destroyed shallow rooted crops (e.g. maize, beans, bananas).

Table.1. Slide type, dimensions and land use types in Bushika sub county

Date of occurrence	Type of slide	Village	Altitude m	Slope (%)	Length (m)	Width (m)	Area m^2	Depth (m)	Landuse
1998	bsl+ms	Bunakasala	1628	70	175	19	3, 325	12	b+c
2001	bsl+ss	Bunambazu 1	1709	50	50	30	1500	2	b+c
1998	bsl+ms	Bubayela	1757	60				1 - 2	b+c
2001	bsl ms	Bunambazu 2	1737	60	80	40	3200	15	b+c
1970s	bsl+ms	Bunambazu 3	1814	70	150	120	18,000	5	b+c
-	bsl+ms	Bunambazu 4	1910	70	80	8	640	3	b+c
1997	bsl	Bunabutiti	1427		500	80	40,000	5	b+c+m
1997	bsl+ms	Buriri	1655	80	90	40	2600	10	b+c
1997	bsl+ms	Buriri	1664	80	60	50	3000	5	b+c
1997	bsl+ms	Bumushisho	1488	55	110	30	3300	3	b+c

**bsl = bottle landslides; ms = mud landslides; ss = sheet landslides*

b+c = banana and coffee; b+c+m= banana, coffee and maize

The bottle slides were deep scouring (>5-15 m) and mainly occurred on upper slopes. Some of these slides changed to mudflows (bsl +ms) on the lower sections in the valleys or drainage channels due to increased water content in the soil mass.

Most of the landslides (40%) occurred in 1997 due to the effect of the El Nino rains, as also reported by Ngecu, *et al.*, (2004). Observations revealed that the majority of these landslides occurred adjacent the old landslide scars on slopes of > 50% (for 70% of the cases observed in the field) at > 1420 m a.s.l. Interviews and discussions revealed that 50% of the participants have landslide scars in one or more of their fragmented plots in Bushunya parish alone. Most of the people have plots in different locations including steep slopes, which increases their chances of experiencing landslides. Enormous volume of soil mass (e.g.. soils, boulders) was lost; the volume of materials lost from the surveyed scars ranged from 960 to 45000 m^3. The distribution of the landslides reflects a strong control by land use, topography and soils. Nearly all the observed landslides occurred outside the gazetted forests on agricultural land dominated by banana-coffee intercropped system. The degradation of plant cover especially trees on steep slopes undermines the stability of soil particles and contributes to increased infiltration that leads to high subterranean flows hence susceptibility to landslides (slope failures). Note that the dead roots of cut trees provide macropores thus rapid infiltration and change in underground hydrological conditions.

Slope failure is largely attributed to high rainfall intensity that causes sudden high pore water pressure and subterranean flows (Tanya, 2001). The local narrations about landslide occurrence support this geomorphological explanation. People observe that landslide occurrence is a process; it commonly occurs where the cracks have developed overtime and after prolonged rains. The rains cause accumulation of water in the ground that leads to pore water pressure and water blowouts (Temple and Rapps, 1972). Sudden noise is usually heard whenever landslides occur. This may be explained by the abrupt slope failure due to high water pore pressure, water blowouts and the movement of big boulders.

Most of the slides were located in the mid to upper backslope and the summit but none were observed starting from the top of a ridge. The estimated distance from the top of the ridges or hills to the scars varied between 40 to 80 m; this allows water flow and soil accumulation on these slope sections hence build up of pore pressure. The cultivated highly sorptive surface soils and deeply weathered regolith underlain by hard surface (slide plane) on high altitude steep concave slopes are particularly very susceptible compared to low-lying areas. Similar observations have been made for slides on Andosols in Kenya (Ngecu *et al.*, 2004).

Rehabilitation of the landslide scars for improved human security

Rehabilitation of landslide degraded areas is very important is ensuring human security in Mt Elgon. Tow *et al.*, 2005) argues that preventing or overcoming environmental degradation greatly contributes to human security. The majority of landslide scars (60%) in Bushika are either abandoned or cultivated with annual crops (e.g. maize, beans). In general, however, most of the farmers have employed the biological and mechanical management practices on the landslide scars:

(i) The biological approach

This includes planting of trees or grasses and fallowing, and is the most commonly applied.

1) Agroforestry which entail planting trees with crops (e.g. *Eucalyptus* spp. *Grevilia robusta*, *Cordia africana*) on the landslide scars and lower slopes along valleys. Trees are either planted in small woodlots on and outside the scars or intercropped for stabilizing the soils and generating incomes. Thus agroforestry contributes to environmental and economic security. A few of the respondents explain that eucalyptus roots penetrate deep into the soil and are therefore suitable for stabilizing the soil. Based on the indigenous knowledge and scientific research (e.g. Kitutu, 2006) tree planting is an appropriate method than construction of terraces on the slopes that are characterised by highly porous soils. Terraces are avoided here because of the belief that they can easily trigger more landslides.
2) Nappier grass is planted along the contours and in small patches. Nappier grass is useful for fodder, mulching and stabilizing the soil. Exposed soils on old scars are easily eroded and this delays soil formation process. Therefore, the establishment of such conservation measures is very important and should be encouraged for adoption on all the landslide affected/susceptible slopes.
3) Natural regeneration is also employed, where the landslide scars are abandoned to avoid further problems of sliding (secondary slides) and soil erosion. Regeneration usually takes a

long time (>10-20 years) but enables natural plant regeneration processes in the degraded areas. The plants in the neighbourhood (farmland or bushland) enhance re-colonization of scars thus ensuring ecological security. Nevertheless, there is need to accelerate the restoration through planting trees and/or shrubs that can provide multiple benefits (e.g. income, fodder, and fruits) for improved economic and livelihood security. An apple growing pilot project has been initiated in Bushunya parish to diversify and boost the incomes of the farmers.

(ii) Mechanical approach

A few innovative farmers have adopted this approach, which involves heaping or aligning stones to control erosion on the landslide scars; the stones are usually gathered in heaps or aligned along the major rills and gullies. Though this is an important traditional technique in soil conservation not all farmers have systematically and intensively applied the technology. The reasons for limited adoption are not clear but could be attributed to labour constraints.

Challenges in the rehabilitation of landslide scars

The local communities are faced with numerous challenges in rehabilitating degraded landslide areas. Some of these challenges are outlined below.

1) High population pressure presents a formidable challenge. Many farmers on average have up to eight children per family and yet own barely 2 ha of land. Land scarcity is a serious problem leading to encroachment on fragile steep slopes and limited time for regeneration on the scars. Steep slopes are sensitive to disturbance and can easily trigger more slope failures. Therefore, great care is required to ensure minimal disturbance on such slopes.
2) Secondary slides remain a challenge. Many farmers affected fear further destruction by secondary landslides, which are often triggered on the unstable slopes adjacent old landslide scars.
3) The majority of the local community are poor and therefore unable to save adequate funds to invest in technologies that would stabilize the slopes. Lack of funds limit the acquisition of the necessary expertise and materials (e.g. cement, pipes) for stabilizing structures or embankments (gabions). Gabions have been successfully used in other parts of the world including the Democratic Republic of Congo in the area of Bukavu.
4) There is a lack of reliable or established best approaches for adoption by the local communities. This partly arises from limited research on best practices in this area. Most of the previous research has been either too academic or short lived and not addressing management.
5) There has been lack of existing formal community strategy to mitigate or reduce the risks of landslides and rehabilitation of the scars. At the national level, there is a national disaster strategy but this has not yet been implemented or translated into action at local level. Response to landslide disaster issues remains rather irregular or sporadic. This is a big constraint considering that landslide effects are spread over catchments in both low- and high- lands affecting a wide range of people either directly or indirectly and for a long time.

Conclusions

Landslides undermine the different dimensions of human security (i.e. livelihood, social and ecological security) on Mt. Elgon. They have negatively impacted on the productive capacity of the land hence contributing to high poverty levels experienced. There are limited efforts hitherto to address landslide associated degradation problems. Rehabilitation of degraded areas is vital considering the high population pressures and the need to achieve improved environmental sustainability in the area. There are environmental, political and socio-economic challenges faced in rehabilitation of landslide scars that need to be addressed for effective outcome. Further research is needed to investigate the restoration rates of the scars and to identify the best management practices under various conditions in the mountain.

Table 2: Landslide occurrence, distribution, and associated caused plus effects on Mt Elgon.

Year	Sub-Counties affected	Causes of landslide	Losses
1818	Bududa, Bulucheke	Rockslide triggered by rainfall in weathered granite in Bulucheke	Unknown
1900	Bududa	A landslide incised the Konokoyi valley. Triggered by heavy rainfall	Unknown
1918	Bududa (Busayi)	A rotational slump	No death
1922	Bulucheke (Bumwalukana)	Landslides due to undercutting by R. Sakusaku	~ 20 farmers killed celebrating harvest season.
1927	Bulucheke (Busiliwa)	Landslide caused by heavy rains	1 man killed, his home, farm carried downslope
1933	Bulucheke, Bubita	Rock slides at Buwali	Unknown
1942	Bulucheke	Landslides triggered by heavy and intense rainfall	Killed many wild animals. Soil and rock materials blocked the roads
1944	Bulucheke	Landslides triggered by heavy and intense rainfall	None
1960	Bulucheke	Triggered by heavy rains	Destroyed coffee farms
1967	Bududa, Bulucheke	Landslide silted R. Sakusaku which burst and flooded surrounding areas for 3 days forming a lake 2 km long.	Dam overflow destroyed rice fields and killed people in Bunyole, Tororo district ~ 20 km downstream
1970	Bulucheke (Nusu)	Landslide triggered by heavy, intense rain	> 60 circumcision dancers buried alive and houses destroyed
1988	Bumasifwa sub county (Bundagala parish)	Landslide (Translational slide)	Destroyed farmlands
1989	Bulago	Landslide triggered by heavy, intense rains	Destroyed property (farms, houses) & life
1993 (March)	Bumasifwa sub county (Bukyabo parish, butadiga parish)	Landslide (rotational)	Destroyed farmlands
1995 (April)	Buteza (Nabugabwe hill)	Landslide triggered by heavy and intense rainfall	Destroyed property e.g farmlands, livestock, houses and life
1997	Bududa, Bulucheke, Bubita, Bushika,	Landslide triggered by heavy rains	48 killed; houses & bridges destroyed
			In Buwali valley water dammed for 1 day, destroyed houses downstream. 6 killed
			Roads were blocked with debris for about one week.
1997	Sisiyi sub county (Nabekye village)	Land slide triggered by heavy rains- a rock fall from the scar rolled downslope	1 killed, many injured family, house destroyed
1997 (April)	Buyobo sub county (Bumirisa parish)	Debris flow	Destroyed farmlands & vegetation
1999	Bududa, Bulucheke, Bubita, Bushika,	Landslide triggered by rainfall	5 people died &several houses destroyed
2005	Bulegeni	Rockfall due to road undercut and weathering	Blocked road
2006	Bupoto sub county (Bunamunzu village)	Roack slides and Landslide caused by heavy rains in August	Killed 3 people and destroyed farmlands. Aprox. 15, 000 m^3 of soil moved downslope

(Source: Field inventory by author and reviews from Kititu, 2006: Mukholi, 1998)

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