ISSN: 1992-2744

International Journal for Disaster Management & Risk Reduction

Vol. 1 No. 2, 2008

Contents+

Volume 1. No. 2
June 2008

ISSN: 1992-2744

International Journal of Disaster Management and Risk Reduction

Centre for Disaster Management and Humanitarian Assistance

Masinde Muliro University of Science & Technology, Kakamega, Kenya

The Published by the Centre for Disaster Management and Humanitarian Assistance at Masinde Muliro University of Science and Technology, Kakamega Kenya

AIMS AND SCOPE
The ***Journal for Disaster Management & Risk Reduction*** is an international, multidisciplinary journal, which provides a swift publication outlet for research and technical reports on various facets of disasters situations, their scientific aspects and social impacts. It also attends to issues of conflict management, peace research and humanitarianism. Its objectives are to:

- Identify techniques, methods, policies, education & training suitable for disaster risk reductions globally
- Contribute to decision-making by providing information on progress and constraints in disaster management
- Contribute to solving emerging global hazards by stimulating demand-oriented applied science

ISSN: 1992 - 2744

Printed by the University Press, Masinde Muliro University of Science and Technology, Kenya

FOREWORD

Over its brief period of four years since establishment, The Centre for Disaster Management and Humanitarian Assistance (CDMHA) has enthusiastically pursued its activities with the support of other Faculties and the Management of Masinde-Muliro University of Science and Technology. Its activities span from capacity building in disaster management as well as research and outreach programmes. Of particular importance is the determination of the Centre to gather and disseminate disaster reduction information to a wide range of audience, including policy makers and peer scientists. The launching of this Second issue of the *International Journal of Disaster Management and Risk Reduction* is an important step in the accomplishment of these noble objectives.

Disasters are on increase year by year for a variety of reasons including urbanization, growing population, environmental degradation and climate change. In these times where Universities are playing an increasingly more important role in disaster risk reduction and response, this Journal could not have come at a better time, and provides a forum through which researchers can share and exchange their knowledge among themselves and with other workers in the field of disaster management.

I am happy and hopeful that this Journal will stimulate research and provide an avenue for publication of scholarly work in and outside MMUST.

Prof. B.C.C. Wangila
Vice-Chancellor, Masinde-Muliro University of Science & Technology

International Journal of Disaster Management and Risk Reduction

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International Journal for Disaster Management & Risk Reduction Vol. 1 No. 2, **pp** ***X-Y*** July 2008 ISSN: 1992-2744

NEW TRENDS IN REMOTE SENSING FOR WATER RESOURCES MANAGEMENT: HYPERSPECTRAL REMOTE SENSING OF WATER QUALITY

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ABSTRACT

Remote Sensing techniques can be used to assess several water quality parameters (i.e., suspended sediments, chlorophyll, and total phosphorous). The optical and thermal sensors on boats, aircraft, and satellites provide both spatial and temporal information needed to understand changes in water quality parameters necessary for developing better management practices to improve water quality. With recent trends like hyperspectral remote sensing and planned launches of satellites with improved spectral and spatial resolution sensors, greater application of remote sensing techniques to assess and monitor water quality parameters will be possible. In June 2003 hyperspectral sensing in 96 bands in visible, near-infrared and thermal range was performed from a plane over the study area using a Compact Airborne Spectrographic Imager (CASI) sensor. Concurrently, water quality samples were collected directly from sampling points along Woluwe River on the same day as the flyovers. The samples were analysed for biological and chemical water qualities. Using correlations between ground-truth data and combinations of spectral bands from the remotely sensed data, spectral indices were developed which could be used to estimate water quality parameters. Maps of the relative distributions of chlorophyll a, total phosphorous and secchi depth were created from the hyperspectral images of the study area.

Keywords: *hyperspectral remote sensing, water quality, chlorophyll a, total phosphorous, secchi depth, eutrophication*

Introduction

The role of water resource management research is to assess the activity of hydrologic features above and below the Earth's surface. Areas of research focus include groundwater exploration, mapping of snow and ice, description of the dynamic and chemical parameters of water bodies, the measurement of evaporation and transpiration, and erosion and sedimentation studies. (Kish et al. 1997).

Many remote sensing applications have resulted from the various problems created by climate, topography, and the fact that water resources management involves the assessment of water resources underground, on the surface, and in the atmosphere (Kish et al. 1997). More specifically, terrestrial water supply, water demands, watershed runoff characteristics, and water quality are commonly studied with the use of aerial photography and satellite imagery. Remotely sensed data can provide wetland managers with a wealth of information for the inventory, classification, and monitoring of wetlands, and also for many water-resource management decisions.

Batelaan et al. (2003) observed that from ecological point of view wetlands are very valuable since they mostly have an almost permanent shallow water table and a constant lithotrophic water quality and that one of the main objectives of modern land planning is the protection of ecologically valuable areas and land-use that supports integrated water management. Environmental researches have been making efforts to monitor, simulate and control eutrophication for more than two decades. Various mathematical methods have been developed and applied to rivers, lakes and estuaries (Lung 1986, Thomann and Mueller 1987, Kuo and Wu 1991, Kuo et al. 1994). All water quality models simulate increases in eutrophication based on the initial condition of water body and therefore demand comprehensive water quality sampling programs. However, the conventional measurement of water quality requires *in-situ* sampling and expensive and time-consuming laboratory work. Due to these limitations, the sampling effort often does not represent the condition of an entire water body. Therefore, the difficulty of overall and successive water quality sampling becomes a barrier to water quality monitoring and forecasting.

Remote sensing could overcome these constraints by providing an alternative means of water quality monitoring over a greater range of temporal and spatial scales (Shafique et al. 2001). Remote sensing is the science of measuring the properties of objects by measuring the amount of radiation they absorb, emit, or reflect at various wavelengths along the electromagnetic spectrum. Optical water quality research has a broad scope for developing environmental indicators that are useful in assessing, quantifying and monitoring in-stream water quality.

Measurable parameters for optical water quality includes turbidity, concentrations of algal chlorophyll, suspended sediment, and dissolved organic matter. More fundamentally, the absorption and scattering of light by components of a stream's water column provide basic information from which relationships with other water quality indicators (such as water clarity from Secchi disk readings) can be derived (Jupp et al. 1994a, Dekker 1997). Although a fairly new method, the development of spectral indices can be a useful and an easy tool for the diagnosis of eutrophic conditions by water resource managers.

Remote sensing techniques for monitoring coastal and inland waters have been under development since the early 1980's.The tools used to develop these techniques have ranged from an empirically-based method for producing qualitative water quality maps to semi-empirical techniques and analytical methods for producing quantitative water quality maps (Dekker 1997). Several investigators (e.g., Dekker 1993, Gitelson, et al. 1993, Jupp et al. 1994a, Jupp et al. 1994b) have developed empirical regression formulas for the prediction of lake water quality parameters from spectrometer data by employing spectral ratios, typically reflectance ratios, as the independent variables. The predicted water quality parameters have included chlorophyll *a* concentrations, suspended matter concentrations and turbidity.

Remote sensing techniques also show that broad wavelength spectral data available on current satellites like Landsat and SPOT do not permit discrimination of chlorophyll in waters with high-suspended sediments due to dominance of the spectral signal from suspended sediments (Dekker and Peters, 1993). Hyperspectral sensors have been launched to overcome this. Such hyperspectral data have made it possible to differentiate between algal groups because hundreds of narrow, contiguous wavelengths are collected for each pixel allowing a more accurate detection or identification of different materials in a pixel in an image. Laboratory and field studies with hyperspectral data have been used to separate green and blue-green algae (Dekker et al., 1995).

This investigation focuses on the prediction of chlorophyll *a* concentrations, Secchi depth and total phosphorus concentrations by applying spectral indices developed from spectral data collected by a Compact Airborne Spectrographic Imager (CASI) sensor as independent variables. Spectral indices are transformations of reflectance values at specific wavelengths that minimally correspond to a field tested concentration of the parameter of interest and minimize the effects of other optically active constituents. The method used made correlations using simultaneous collected remote data and field collected water quality data to demonstrate the feasibility of remote sensing techniques for water quality monitoring in rivers. The semi-empirical approach was used in this research to estimate concentrations of water constituents. This method is used where spectral characteristics of the compounds sought are more or less accurately known. This knowledge can be included in the statistical analysis, which is focused on well chosen spectral areas and appropriate bands or combinations of bands are used as correlates.

Materials and Methodology

The investigation utilized compact airborne spectrographic imager (CASI) data from Woluwe River in Belgium, a small tributary of 15 km length that drains an area of 9400 ha in the Scheldt river basin. This area has been a subject of detailed ecological studies evaluating restoration scenarios for the wetland ecosystem in river valleys (Triest et al., 2001). Woluwe headwaters are highly fragmented by diverse pond systems. Hyperheic zones locally influence the water quality. The downstream stretch of the river receives sewage waters from household and industry. There are only five tributaries in Woluwe River. Ground-truth and hyperspectral data were collected in June 2003.The hyperspectral sensing in 96 bands in visible, near-infrared and thermal range was performed from a plane over the Woluwe River Basin using the CASI sensor. Concurrently, water quality samples were collected directly from sampling points along the River on the same day as the flyovers. These water quality data for the project were analysed for biological and chemical water qualities.

The remotely sensed and laboratory data were then analyzed in a systematic manner. Single spectral bands, ratios of spectral bands, and combinations of multiple bands were then used to develop linear regression equations. The semi-empirical models were developed in Excel (Microsoft Software, v. 2000) spreadsheets, and the imagery was analyzed using the ENVI (3.5) image processing software. The unsupervised image classification technique, K Mean, was used to cluster imagery into spectrally similar categories. This classification technique was used over another method, supervised classification, because the identifications made by the latter are made on the basis of human sight, which is limited to visible wavelength range (Vincent 1997). Scatter plots were created between spectrally classified image and ground-truthing data, based on their linear trends; simple linear regressions were used to determine the relationships between single and combinations of bands and water quality parameters. Based on the image pixels of the locations from which ground truth data were collected, equations were developed for particular water quality parameters. Then, the entire image was converted into a water quality map using the predictive equations.

Models

All bands were tested for relationships with water quality parameter until it was found which bands and parameters correlated with the highest certainty. Scatter plots showed that linear models using the exponential ratio of wavelengths 705/671 nm and the combination ratio of wavelengths 671, 705 and 740 nm can describe chlorophyll *a* and total phosphorus, respectively. The band readings that represented the difference of 557 nm from 625 nm correlated best to secchi depth. The r-values and R^2 for each of these are above 0.76 and 0.58 respectively,

therefore, indicating the ability to provide good linear models for these water quality parameters (Table1). Based on the linear relationship with water quality parameters, the spectral indices were then transferred to the following mathematical models to calculate the concentrations of the respective water quality parameters.

$$\text{Chlorophyllcells}(\times 10^3/\text{ml}) = 0.17EXP\left[2.75\left(\frac{R_{705nm}}{R_{671nm}}\right)\right] \quad (1)$$

$$\text{SecchiDepth}(m) = -0.12\left[R_{557\text{nm}} - R_{625\text{nm}}\right] + 1.46 \quad (2)$$

$$\text{T.Phos}(\text{mgP/L}) = -18.35\left[\frac{R_{671nm} - R_{740nm}}{R_{705nm} - R_{740nm}}\right] + 42.46 \quad (3)$$

Results and Discussions

The results of this research can be divided into two general sections. The first section describes the development of spectral indices and correlations made between the remotely sensed imagery and water constituents. The second section addresses estimations made for water quality parameters. Through atmospheric and water column correction, the instrument calibrates the remotely-sensed data to the conditions that were present at the water's surface at the time of CASI data acquisition. Semi-empirical models were applied to mathematically convert the hyperspectral imagery into water quality maps.

Development of Spectral Indices from CASI images

Spectral indices are simple arithmetic expressions of a combination of spectral bands that help reduce or eliminate some differences in viewing geometry and atmospheric conditions between measurements. The bands that carry the most information about water quality parameters are selected by qualitatively analysing spectral plots. All bands were tested for relationships with water quality parameters until it was found which bands and parameters correlated with the highest certainty. Correlation values were calculated using CASI image spectral data and water quality data from laboratory analyses, and the spectral indices were developed from exploratory single bands, ratios of bands, differences between bands, and/or combinations of differences and ratios. The spectral index values and laboratory data were used to produce scatter plots for calculation of the R^2 values. Once the bands were selected, three types of indices were developed. These were the difference, ratio, and combination of ratio and difference indices (Table 1).

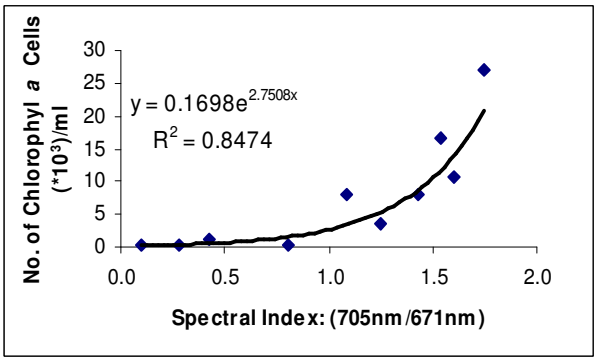
Table 1: Correlation Values between Band Spectral Indices (R^2) and Water Quality Parameters.

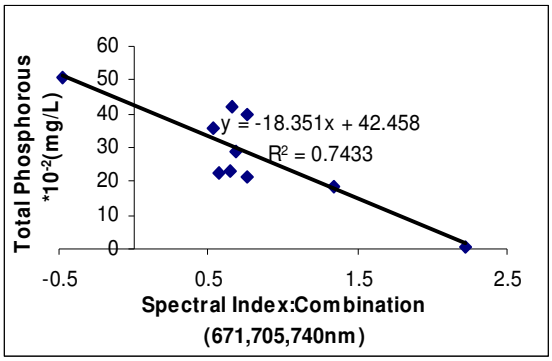
Water Quality Parameter Measured	Difference Index	Ratio Index	Combinations Index
Secchi Depth	R^2 =0.58 [1] (r = 0.76)	0.41 [4]	0.16 [8]
Chlorophyll *a*	0.65 [2]	R^2 =0.85 [4](r = 0.92) 0.84 [5]	0.55 [9]
Total Phosphorous	0.05 [3]	0.0002 [6] 0.01 [7]	R^2 =0.74 [9](r = 0.86) 0.40 [10] 0.17 [11]

Difference Index:[1] *(557-625),* [2] *(705-671),* [3] *(625-439)*

Ratio Index: [4] *(705/671),* [5]*(705/677),* [6]*(Log 557/677),* [7]*(625/439)*

Combination Index: [8]*(439 – 740) / (705 - 740),* [9] *(671 – 740) / (705 -740),* [10]*(557/740) – (625 – 740),* [11]*(625 – 439)705/671*





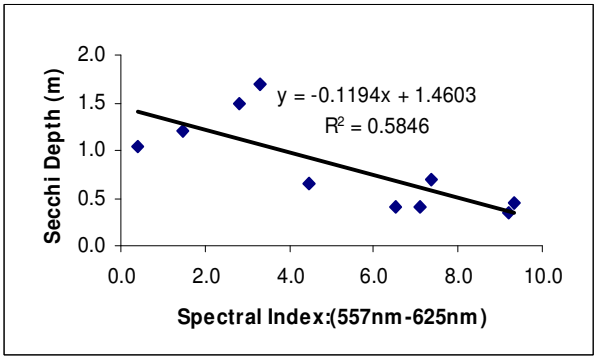
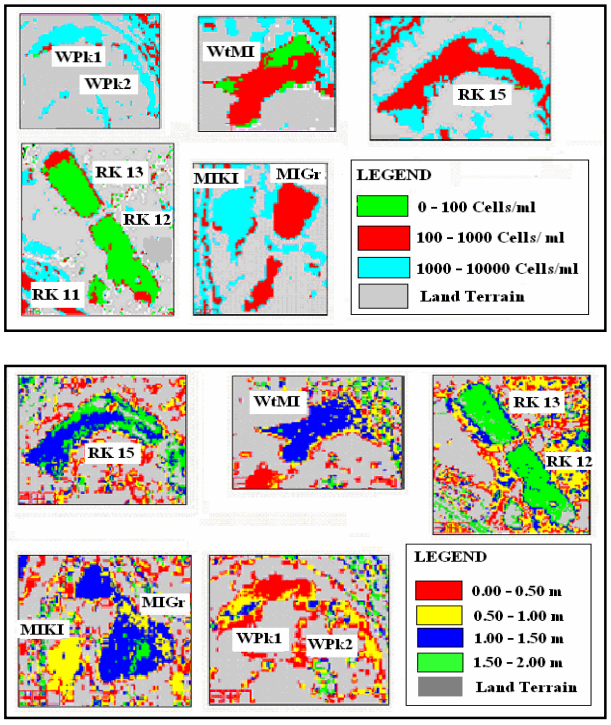
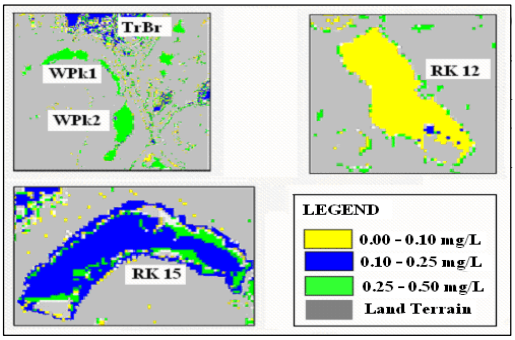


Figure 1. Correlation between Water Quality Parameters and Spectral Indices.

The difference index performed fairly for parameters such as secchi depth, while the ratio index correlated better with chlorophyll *a*. The spectral bands with wavelengths at 557, 671, 705 and 740-nm dominated the spectral indices. Difference index involving 557nm and 625nm provided information about secchi depth while the combination index using 671, 705 and 740-nm wavelengths provided information about total phosphorous. Ratio index of 705nm and 671nm gave information about chlorophyll *a*. (Fig 1)

Chlorophyll *a*, Total phosphorous and Secchi depth estimates from CASI Bands. Based on the different relationships with water quality parameters, the spectral indices transferred to the mathematical models yielded various concentrations and values of the respective water quality parameters. (Fig 2)





Top Left: ***Chlorophyll a (Cells/ml)***
Top Right: ***Total phosphorous (mg/l)***
Bottom: ***Secchi depth (m)***

Figure 2. Water Quality Parameters Map of Ponds within Woluwe River that were Sampled.

Several observations made from the water quality maps generated:

- The sampling points WPk1 and WPk2 were shallower (0-0.5 m) because they both had high concentration of chlorophyll *a* cells (1000-10000 cells/ml) and total phosphorous concentration (0.25-0.5 mg/L).
- Sampling points RK13 and RK12 had the highest values of secchi depth (1.5-2.0 m) because they contained the least concentration of chlorophyll *a* (0-100 cells/ml). The low concentration of total phosphorous (0-0.10 mg/L) also contributed to RK12 high depth.
- RK15, WtMI and MIGr had average water quality parameters as compared to other sampling points; TP concentration (0.10-0.25 mg/L), secchi depth (1.0-1.50 m) and chlorophyll *a* concentration (100-1000 cells/ml).
- Generally the downstream part of the river with sampling points WPk1, WPk2, RK11 and TrBr had high TP values and chlorophyll *a* concentrations ranging

Conclusions

This study demonstrates that hyperspectral remote sensing technique can be a useful tool for monitoring the distribution of chlorophyll *a* concentrations in lakes and rivers. In this study, the wavelengths of 671nm and 705nm from the CASI data were found to be the most suitable wavelengths for predicting chlorophyll *a* concentrations. The results show that it is also feasible to estimate the relative chlorophyll *a* levels in lakes when ground-truth data is not routinely available. This is essential for operational applications in lakes where the total number of *in situ* water quality observations only cover a small fraction of the lake for a limited time. Moreover, the results show that chlorophyll *a* has a unique spectral signature and it is possible to estimate chlorophyll *a* concentrations for any inland water body with the chlorophyll *a* spectral index.

Since in-situ detection and monitoring becomes more expensive (due to rising labour costs) and being less representative spatially, a remote sensing approach makes more economical sense. It will be necessary to have available local airborne imaging spectrometry systems or the availability of

data from space sensors. In the future, these methods may prove to be the preferable techniques for the detection of eutrophic water quality indicators over large rivers and lakes.

Acknowledgments
The authors appreciate the efforts of Mr. L.Q. Hung, who helped in spectral analysis and Mr. B. Verbeiren, for availing some of the water quality data used.

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AFLATOXIN RISKS IN MAIZE PRODUCTION AND ITS IMPACT ON FOOD SECURITY IN RIFT VALLEY, KENYA

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Abstract

Despite a history of fatal poisoning associated with aflatoxin-contaminated maize in Kenya, there is hardly any established standards for gauging the quality of maize and other similar farm produce in the country, immediately after harvest. Harvested maize can be sold freely in the market, without undergoing any quality or consumer safety test. Erratic weather pattern in the past few years has been characterised by unpredictable heavy rains during harvest seasons, resulting in frequent maize storage problems. Moulding of grains, and cases of aflatoxicosis have in the past been reported almost on yearly basis in some parts of the country. This hazard is compounded by the deliberate sell of contaminated maize, where farmers or traders eager to avoid heavy losses, often unscrupulously sell or supply moulded maize to unsuspecting hungry masses in times of food shortages. This study was conducted in the North Rift region of Kenya to assess the extent of the aflatoxin risk, its causes, and the diverse threats to farmers, including the associated impacts on post-harvest losses and household food security. The paper also highlights the traditional as well as innovative aflatoxin management practices by the farmers. It emerged that most losses associated to fungal growth during the pre-harvest and post-harvest stages of maize range from 10% to 30% in rainy seasons, and are attributed to poor storage practices currently in use. These losses seem to portray a low but increasing impact on food security in the region. Health effects associated with aflatoxicosis are few; but contaminated maize is commonly fed to animals increasing the likelihood of indirect exposure through animal products. There is an urgent need thus, to educate farmers and traders on risks posed by direct and indirect exposure to aflatoxins.

Key words: *Aflatoxin hazards, maize, food security and health, North Rift Kenya*

INTRODUCTION

Aflatoxin poisoning and its causes

Aflatoxin belongs to a group of fungal toxins known as mycotoxins, which are poisonous metabolites from a certain type of moulds which can cause pathological changes in the human body. Mycotoxins are produced by certain fungi in agricultural products that are susceptible to mould infestation under favourable conditions of temperature and humidity. These metabolites can exhibit acute and chronic toxicological manifestations in humans and susceptible animals (EHS, 2006). Direct contamination with mycotoxins from moulds growing on food is of great importance in cereals. Many cereals are now a common staple food in many tropical countries. Thus a threat to these cereals threatens the lives of many people in these regions.

Aflatoxin poisoning in cereals (e.g. maize) and oilseeds (such as groundnuts) occurs when the agricultural products are not dried amply fast to a low moisture level (Smith *et al.,* 1994). The poison is produced by two moulds *Aspergillus flavus* and *Aspergillus parasiticus*. Aspergillus is a large genus of mould which grows at an optimal range of temperature of 28-33^{o}C and are principally found in soils and decaying vegetation. They grow in warmer parts of the world such as tropical region where temperature and moisture are high. While the presence of *A. flavus* does not always indicate harmful levels of aflatoxin, it does mean that the potential for aflatoxin

production is present. Indirect contamination can take place when contaminated feed is ingested by cattle. Milk and meat are examples of indirect contamination of food caused by spoiled feed containing Aflatoxins. Aflatoxins are odourless, tasteless and colourless. Chemically, they are stable in foods and resistant to degradation under normal cooking procedures. It is difficult to eliminate aflatoxin once it is produced. The greenish or greyish colour on food is usually indicative of the Aspergillus mould presence (Peraica *et al.,* 1999). Smith *et al (*1994) affirms that occurrence of the mycotoxins in foods and feeds is natural and unavoidable, influenced by certain environmental factors; hence the extent of mycotoxins contamination is unpredictable and may vary with geographic location, agricultural and agronomic practices and the susceptibility of commodities to fungal invasion during pre-harvest, post harvest, storage periods.

Mould occurs in soil, decaying vegetation, hay, and grains undergoing microbiological deterioration and invades all types of organic substrates whenever and wherever the conditions are favourable for its growth, such as high moisture content and high temperature. Different weather conditions, such as excessive rains at the time of flowering; or droughts during harvest and post harvest stages encourage mould growth. Before harvest, the risk for aflatoxin development is greatest during major droughts. When soil moisture is below normal and temperatures are high, the number of Aspergillus spores in the air increases. These spores infect crops through areas of damage caused by insects, and inclement weather. Once infected, plant stress occurs; the production of aflatoxin is favoured (Smith *et al,* 1994).

The greatest human health concern related to mycotoxins is the cancer risk based on long-term, low-level exposure to carcinogenic toxins such as the aflatoxins, ochratoxin A, and fumonisins. At least 13 different types of aflatoxin are produced in nature, with important carcinogens such as aflatoxins *B* *(B_1,, B_2,), G1*and *G2* (O'Keeffe, 2003*)*. Aflatoxin *B1* is considered the most toxic and strongest carcinogenic compound which causes liver cancer.

Aflatoxin risks in Maize harvesting and storage in Kenya

About 25% of agricultural crops worldwide are contaminated by Aflatoxins and other mycotoxins, leading to increased morbidity and mortality throughout Africa, Asia, and Latin America (Smith et al. 1994; Rice and Ross, 1994). Over the past three decades, Kenya has experienced dramatic outbreaks of Aflatoxins poisoning, resulting in loss of life in some cases (Ngindu *et al* 1982; Muture and Ogana, 2005; Lewis *et al,* 2005). There has been concerns that contaminated grains condemned as unfit for human consumption unscrupulously gain entry into the animal feed industry, or worse, sneaked back onto the market and sold to needy persons after 'diluting' with uncontaminated produce. A study in Nairobi found that animal feed samples were contaminated with Aflatoxins, some up to the maximum allowable limit (10 ppb) set by the Kenya Bureau of Standards (CDC, 2004). About 44% of the milk obtained from urban dairy and non-dairy farming households had Aflatoxins M_1 and M_2 to levels above the 500ppt allowed by the United States Food and Drug Administration. The permissible EU maximum levels for total aflatoxin and aflatoxin B_1 are 5 and 3 ppb respectively for cereals; 10 ppb for USA and 30 ppb for India (Ibid).

Peers and Linseli, (1973) sampled evening meals in a clusters of individuals distributed in 132 sub-locations in Kenya over a period of 21 months. In the high altitude area, 39 of 808 samples (5%) contained aflatoxins, mean concentration of which was 0.121 ppb. In the middle area, 7% (54 of 909) of the samples were contaminated with mean concentration of 0.205 ppb; the low altitude area had a highest frequency, 78 of 816 (10%) of the samples, with 0.351 µg/kg, of aflatoxin contamination. In Uganda, Alpert *et al* (1971) showed that food samples from village markets and home granaries contained aflatoxin, with 29% containing more than 1 ppb aflatoxin and 4% containing more than 1 ppm. Aflatoxins occurred most frequently in bean (72%), whereas maize (45%) peanut (18%) and cassava (12%) were contaminated less

frequently. The aflatoxin concentration sometimes exceeded 1000 ppb.

In Kenya, large portions of Eastern Province are semi-arid, and many locals face food shortages on annual basis. Aflatoxin poisoning has been common in these areas as most people are desperate for food and would consumer supplied maize without regard to its condition. In 2004, the area experienced one of the largest, most severe aflatoxicosis outbreaks, which was followed by another in 2005 (CDC, 2004). Earlier in 1981, an outbreak of acute aflatoxicosis was reported in Makueni district, Kenya, which affected 20 people (Ngindu *et al* (1982). Affected patients were found in family groups that shared meals maize contaminated by aflatoxin, which concentrations ranging from 1,600–12,000 ppb. The 2004 outbreak resulted in death of about 125 persons, and total of 317 cases were 34 reported by July 20, 2004. The outbreak resulted from aflatoxin contamination of locally grown maize which had been poorly stored or dried. Maize samples from the victims' homesteads had elevated levels of aflatoxin, up to 8,000 ppb. Aflatoxicosis was again reported in Kenya in 2006, also in association with maize that was improperly stored. However, only few persons were affected this time round. In the 2004 case, 80% of locally available maize stocks in Eastern province was affected. Most victims had symptoms of liver failure - yellow eyes, swollen legs, vomiting and bleeding from nose (Lewis *et al,* 2005). The outbreak extended over seven districts encompassing an area approximately 40,149 km^2. In the aftermath, over 10,000 bags of maize were distributed to the drought-prone Makueni, Kitui, Mbeere and Thika Districts. In May 2005, about 15 people died and scores hospitalised in the same province due to toxic maize grain.

Aflatoxins are ingested and rapidly absorbed in the small intestine where they circulate to the liver to be metabolized. The effectiveness of biotransformation into metabolites determines the severity of disease observed in victims (Bingham, 2006). In humans, aflatoxins interfere at various points to decrease protein synthesis and with the impaired ability to produce functional proteins, cell death results, leading to tissue damage, inflammation and leakage. Once a diagnosis of aflatoxicosis is made, no specific treatment or antidote exists. Most treatment attempts are aimed at supportive care and prevention of further hepatic damage (Chao *et al.,* 1991). First and foremost, remove the suspect feed and aim treatment methods towards protecting the liver and maximizing glutathione synthesis. Glutathione is thought to be protective since it conjugates aflatoxins and reduces free radical formation.

In the past, researchers have successfully isolated the fungi after grinding the corn, and grew them in culture. Surprisingly, they found the *"S"* strain of *A. flavus,* a potent aflatoxin producer not previously known in Africa, to be the most prevalent source of toxins in the maize (Probst *et al*., 2007). *S*-strain isolates from the Kenyan maize were found to consistently produce high amounts of aflatoxins in both liquid medium and living maize. The *S*-strain incidence was strongly correlated with maize aflatoxin content.

The burden of disease attributable to chronic aflatoxin exposure remains undefined. Outbreaks of acute aflatoxin poisoning are a recurrent public health problem. Given that diseases in developing countries often go unreported (Fung and Clark, 2004), the outbreaks that occurred in Kenya are likely to be an underestimation of the problem. A retrospective case–control studying Kenya by Azziz-Baumgartner *et al,* (2005), suggests that traditional methods of drying and storing maize in elevated granaries were protective against aflatoxicosis. Traditional granaries are raised structures that are well ventilated, and they promote the drying of grain. The study also found that storing maize mixed with ash was associated with lower concentrations of aflatoxin than storing maize without ash. Ash acts as a physical barrier against insects and helps keep maize dry. Among the interesting findings are the risk factors in which males were more likely to die from aflatoxicosis, in spite of eating similar quantities of maize as females *(Ibid).*

It has been shown that mould contamination diminishes the on nutritional value of stored maize. O'Keeffe (2003) demonstrates that was

a net loss of 4.6% energy in Kcal, 6.7% crude protein, and 62.5% fat in maize under storage. Maize is currently the primary staple food in Kenya, and is extensively grown in the North Rift region alongside wheat. It is used to make a local meal, *ugali* and porridge. Often, it is also used in manufacture of traditional brews.

METHODOLOGY

Interviews were conducted with maize farmers and middlemen in the North Rift region on methods of post-harvest storage, awareness levels on aflatoxin risk, and preventive practices. A survey was conducted on various farms to determine the extent of mould growth on maize under storage. Maize being delivered to the National Cereals Produce Board (NCPB) was also sampled and physically examined for the presence of moulding, whereas moisture content for sampled farmers were obtained from the NCPB laboratory. Other samples were also collected from maize retailers and wholesalers for a period of 3 months (January – March 2007).

A total of 31 respondents were interviewed, of which 51.6% were farmers growing and marketing their produce, while 48.4% were middlemen. The middlemen usually purchase maize from the farmers in the rural interior and sell them at a higher price to buyers in urban areas such as milling companies and the NCPB.

RESULTS AND DISCUSSION

Maize moisture levels as determinants of aflatoxin risk

There were high variations in moisture content in maize delivered to the NCPB. Maize can significantly increase the likelihood of mould growth on the maize. The NCPB regularly sets a range of acceptable moisture levels of 13-14%, above which the maize is rejected. Results for moisture tests were obtained from a sample of maize delivered to the NCPB in Eldoret, Kenya, as shown in Table1

Table 1: Moisture levels in maize grains at selling points

	N	**Mean (%)**	**Std. Deviation**	**Minimum (%)**	**Maximum (%)**
Middleman	6	15.15	±1.08	13.8	17.0
Farmer	8	15.41	±1.75	13.2	19.0
All	14	15.30	±1.45	13.2	19.0

Only 9.6% of delivered maize fell within the range of acceptable moisture levels of 13-14%. Maize from farmers showed the highest variability in moisture (*SD =1.75*), compared to maize from middlemen (*SD =1.08)*. This indicates that most of the middlemen are more conversant with moisture content requirements, and mostly insist on buying sufficiently dried maize to avoid additional drying costs.

Fungal presence on maize grains and aflatoxin risk awareness

Maize produce from a total of 24 (77.4%) persons sampled did not have any visible fungal growth, while 22.6% had varying degrees of fungal growth (Table 2), but at very insignificant levels(p=0.324), affecting mainly farmers (16.1%) than middlemen (6.5%). Most of the moulding was observed on portions of 90kg bags under storage on the farm. Most of these were directly placed on floors.

Table 2: Fungi presence on maize produce among the farmers/middlemen, and their awareness on aflatoxin risks.

			N (% Total)
Fungal presence	Farmer	None	11 (35.5%)
		Yes	5 (16.1%)
	Middleman	None	13 (41.9%)
		Yes	2 (6.5%)
	Total	None	24 (77.4%)
		Yes	7 (22.6%)
Awareness on aflatoxin risks	Farmer	Yes	6 (19.4%)
		No	10 (32.3%)
	Middleman	Yes	14 (45.2%)
		No	1 (3.2%)
	Total	Yes	20 (64.5%)
		No	11(35.5%)

A variance test between the farmers and middlemen shows that there is a significant difference in their levels of awareness *(p=0.006)* on risks of aflatoxin.

Plate 1 below shows some post-harvest storage facilities commonly used in the study area; and the Aspergillus fungus, which is known to produce the lethal aflatoxin that contaminates the grains on which it grows.

farm post-harvest drying is rare. This could be the reason for the observed higher gain moisture levels among farmers than middlemen. For longer storage, farmers dry the harvested maize in the unshelled form (on cobs) either kept in houses or designated stores (Plate 1a-b). Farmers believe that maize stored while still on cobs is less prone to spoilage than the shelled ones, due to aeration. They also believe that the cob itself helps in absorbing moisture from the corn. In shelled maize, the grains become tightly packed thus prevent air circulation within, in which case extra labour has to be employed to spread the maize in the sun (often for several days) until safe moisture levels are attained. Similar observations have been made in Thailand by Semple *et al,* (1992). Research indicates that if the wet grain cannot be dried within 72 hours,

aflatoxin contamination can easily arise (Fung and Clark, 2004).

Plate 2: Some of the maize being dried on canvas along the roadside.

Threats and impacts on food security

Spoilages at farm level commonly occur when farmers obtain a bumper harvest, beyond the capacity of their storage facilities. This leads to some of the produce being stored in make-shift, unsuitable sheds. Some of the spoilage however seem to occur away from the farms when large-scale dealers buy a lot of maize when prices are still good, leading to storage problems. When rains coincide with the harvest seasons, as has been the case in the last three years, most purchase becomes wet and is usually stored in large rented godowns. The large volumes purchased hinders the dealers from properly dry the grain before storing. Some of the middlemen admitted to mixing spoiled purchases with the good ones to avoid bearing the losses, as the spoiled maize will have a diminished quality and value, thus un-sellable.

There have been no verifiable deaths reported in the north-rift region in relation to aflatoxicosis. However, it was observed that spoilage of produce due to moulding was becoming prevalent. About 37.5% (6 of 16) farmers reported losses associated to rotting and moulding. The losses ranged between 10% and 30% of harvested grain. One of the immediate threats is where 19.3% (6 of the 31) admitted to feeding animals with moulding or spoiled produce. This is likely to increase chronic exposure to aflatoxins through animal products. It has been proven that meat and milk from exposed animals may contain traces of aflatoxin, which if ingested over long periods can lead to cancers (O'Keeffe, 2003; Patten, 1981).

Conclusion and recommendations

The aflatoxin risks in Kenya appear to be gaining recognition in the last few years since the 2004 case in which over 120 persons died. In the North-rift region of the country, the risks have not been properly internalised, due to lack of harsh experiences associated with aflatoxicosis. There seem to be some level of ignorance (32%) on aflatoxin risk, especially from interior farmers. Middlemen on the other hand were found to show a greater awareness (45%) on aflatoxin. There was also higher frequency of farmers with mould of their stored harvest (16.1%) than middlemen (6.5%). Although the impacts on food security of individual household is still minimal and vary from year to year, the greatest threat lies in the long-term chronic exposure to aflatoxins through animal products.

It is therefore recommended that farmers be educated on the risks of aflatoxins through a strengthened agricultural extension system. This should ensure farmers are advised of best methods of grain storage, detection and precautions of handling maize suspected to be contaminated, and deposal of contaminated produce. The use of moulded maize as animal feed should highly be discouraged. Drying is a process of simultaneous heat and moisture transfer. Where sun-drying conditions may not be effective due to weather, chemical treatment against the Aspergillus fungi should also be encouraged.

The public in general, should also be advised agonised purchasing and/or consumption of moulded maize.

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International Journal for Disaster Management & Risk Reduction Vol. 1 No. 2, **pp** ***X-Y*** July 2008 ISSN: 1992-2744

ARTIFICIAL NEURAL NETWORKS FOR COMPUTING FACTOR OF SAFETY AS DELINEATION FOR TAKING-OFF DOMAINS IN LANDSLIDE ZONES

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Abstract

The many cases of landslides in Kenya in the recent past have raised a lot of concern. While the loss of life from landslides in most places may solely be blamed on poor land use patterns. It is possible to use scientific computations to determine possible taking-off domains of such landslides hence providing a basis for warning populations living on landslide prone sloppy areas. The paper looks into the use of Artificial Neural Network (ANN) for computation of factor of safety (FS) as an embodiment of all causal factors for landslides.

A desktop computation based on secondary data has been undertaken leading to the conclusion that ANNs provide a suitable way to predict factors of safety within any given region. Observing the behaviour of the factor of safety over time and space would give an indication of probable failure and thus act as a delineation of the taking-off domains in landslide prone areas.

Introduction

There are many approaches to assessing slope stability and landslide hazards. The most widely used include (Montgomery and Dietrich, 1994): (a) field inspection using a check list to identify sites susceptible to landslides; (b) projection of future patterns of instability from analysis of landslide inventories; (c) multivariate analysis of factors characterizing observed sites of slope instability; (d) stability ranking based on criteria such as slope, lithology, land form, or geologic structure; and (f) failure probability analysis based on slope stability models with stochastic hydrologic simulations.

It is generally noted that in landslide zones, debris flow source areas are strongly controlled by surface topography through shallow subsurface flow convergence, increased soil saturation, increased pore pressures and shear strength reductions (Montgomery and Dietrich, 1994). The determination of a numerical factor (Factor of safety) that embodies all the above mentioned factors, as a quantification of the capacity of a slope to withstand failure, is widely accepted as a way of evaluating slope stability in landslide zones.

The parametric computation of the factor of safety (FS) is based on the infinity slope stability model that has it origins in the earlier works of Haefeli (1948) and Taylor (1948). This model assumes an infinitely long failure plane parallel to the ground surface with a perched ground water surface parallel to and coincident with the ground surface. The equation for the factor of safety based on this model is (Blake *et al*., 2002):

$$FS = \frac{c' + (\gamma - m\gamma_w) z \cos^2 B \tan \phi'}{\gamma z \sin B \cos B} \quad (1)$$

where FS is the factor of safety, c' is the cohesion intercept, z is the vertical depth of the slip surface, B is the slope angle, γ is the unit weight (density) of the soil, γ_w is the unit weight of the water, m is the fraction of z such that mz is the vertical height of the groundwater table above the slip surface, and ϕ' is the angle of shearing resistance. In a nutshell, the factor of safety may be

considered as a resultant of complex interactive functions of the respective quantities i.e. unit weight, cohesion, slope angle, slope height, pore pressure and angle of shearing resistance.

Based on practical applications in soil mechanics, there are various breakpoints (*FS* = 1.5, 1.25, 1, 0.5, 0.0) where slopes exhibiting these factors are classified from stable to unstable respectively. Fig. 1 outlines an example of how broad stability clusters may be classified in terms of the factor of safety. The selection of break points (1.5, 1.25, 1, 0.5, and 0.0) is subjective, requiring judgment and interpretation in terms of cluster definitions. Hence the use of the terms "stable", "moderately stable", "quasi-stable", "lower threshold slope zone", "upper threshold slope zone" as descriptions of the slope behaviour with deteriorating stability over time.

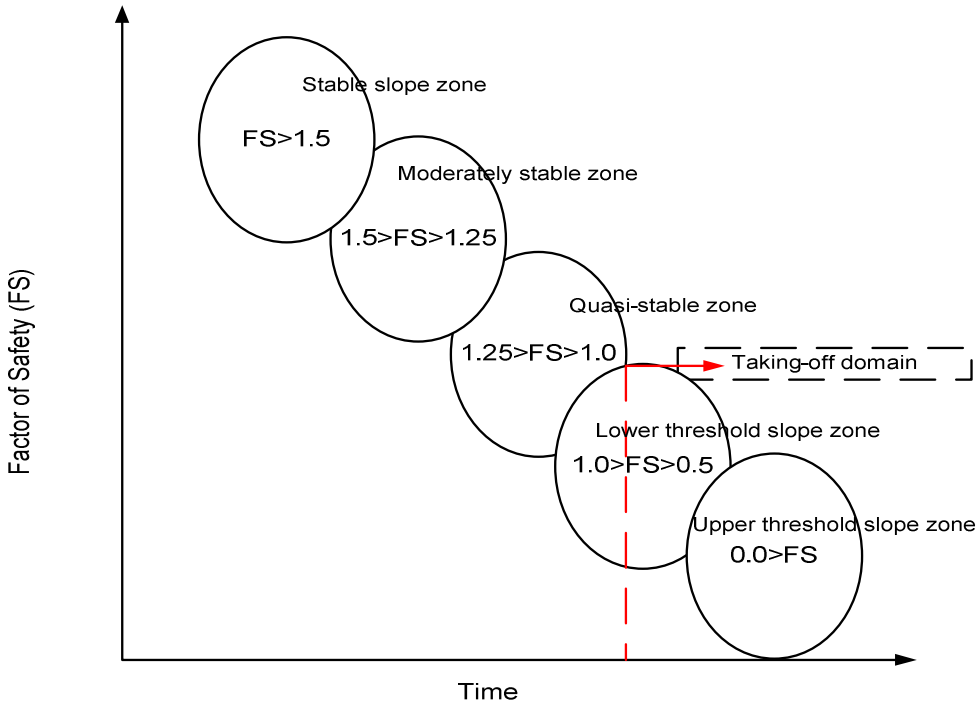

Fig. 1: Factor of Safety as stability clusters

Modelling FS with Artificial Neural Networks

Modelling slope stability may be successfully carried out using either mechanical, like the model stated above or statistical approaches. Under the statistical methods falls "intelligent computation methods" e.g. Artificial Neural Networks (ANNs) that lend themselves useful for all modelling purposes.

An ANN is a system consisting of a large number of interconnected simple processors: the artificial neurons. These neurons interact in a manner analogous to those of the human nervous system, such that when given input and output parameters depicting a certain event, they are able to emulate the mechanism which produced the event through a learning process.

The most common configuration of the neural network is composed of three layers, an input layer, an output layer and one or more hidden layers (Fig. 2). A class of neural networks known to be capable of learning complex input-output mappings is the multilayer feedforward network

(Cybenko, 1989). Here, the input is fed forwards through the networks layers to the output. The input neurons receive and process the input signals and send an output signal to the other neurons in the next layer. Each neuron has an activation function and a threshold function, which can be continuous, linear or non-linear functions. The signal passing through the neuron is transformed by weights which modify the functions and thus the output signal that reaches the following neuron. Modifying the weights for all neurons in the network, changes the output. Once architecture for a specific network is defined, weights are calculated recursively through a learning process so as to represent the desired output-output relationship.

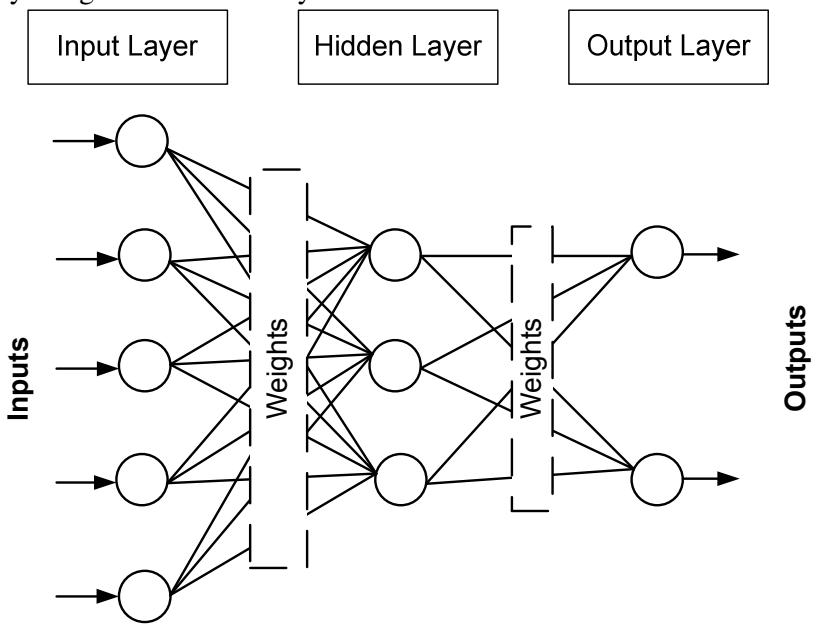

Fig. 2: A multilayer feedforward neural network

Considering the factor of safety as simply a function of all the parameters used in the physical model in (1), we have;

$$FS = W \begin{pmatrix} \text{unit weight} \\ \text{cohesion} \\ \text{internal friction angle} \\ \text{slope height} \\ \text{pore pressure ratio} \\ \text{slope angle} \end{pmatrix}$$

This is in essence an input-output mapping, it therefore allows us to use ANNs for determining the relationship between the factor of safety and the contributory factors i.e., given a set values of contributory factors as inputs and corresponding factors of safety as outputs, the function *W* can be determined using an ANNs training process.

Sample computation

To demonstrate the use ANNs in computing the factor of safety, a set of 46 input and output variables collected from literature were used to train a neural network. Parameters used were taken from different regions of the world as compiled in (Sah et al., 1994). The input variables constituted; unit weight, cohesion, internal friction angle, slope angle, slope height, and pore pressure whilst the factor of safety is taken as the output, see Tab. 1.

Table 1: Input and output variables

Input variables	Range
Unit weight	12-28
Cohesion (kPa)	0-100
Inter. friction angle(°)	0-45
Slope angle(°)	20-53
Slope height (m)	6-115
Pore pressure ratio	0.11-0.5
Output variables	Range
Factor of safety	0.67-2.05

A MATLAB® based backpropagation neural network model was developed for the task. A 6-10-1 network was applied i.e. the architecture constituted of 6 input neurons (for input variables), 1 hidden layer with 10 neurons, with tan-sigmoid transfer function and 1 output neuron with a linear transfer function. The Levenberg-Marquardt algorithm was used for training. The training stopped after 998 iterations after meeting the required error goal. The variation of error with the number of network trials resulting from the training data is displayed in Fig. 3. The sum squared relative error reduces sharply at first and gradually stabilizes after 500 iterations. Fig. 5 shows the comparison of the target and computed outputs from the final results of the network. It can clearly be seen that apart from two patterns all the modelled values of FS closely fit the target values

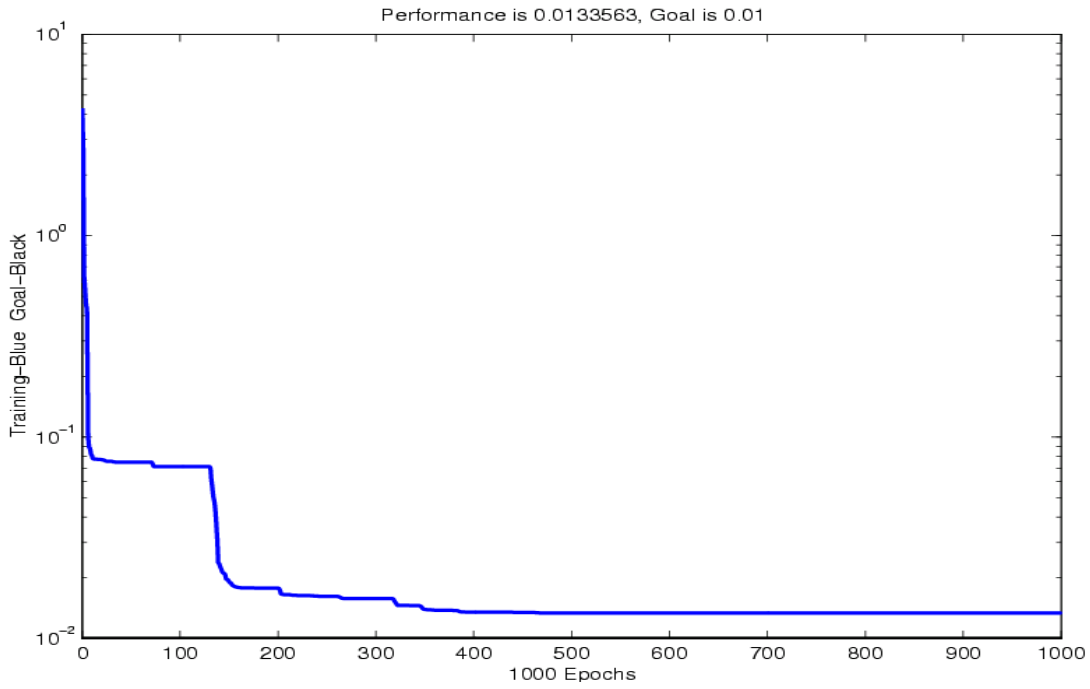

Fig. 3: Variation of sum squared relative error in FS prediction

The performance of the trained network was measured by how much the computed values deviated from the target values, whereby a regression analysis between the network response and the corresponding targets was performed.

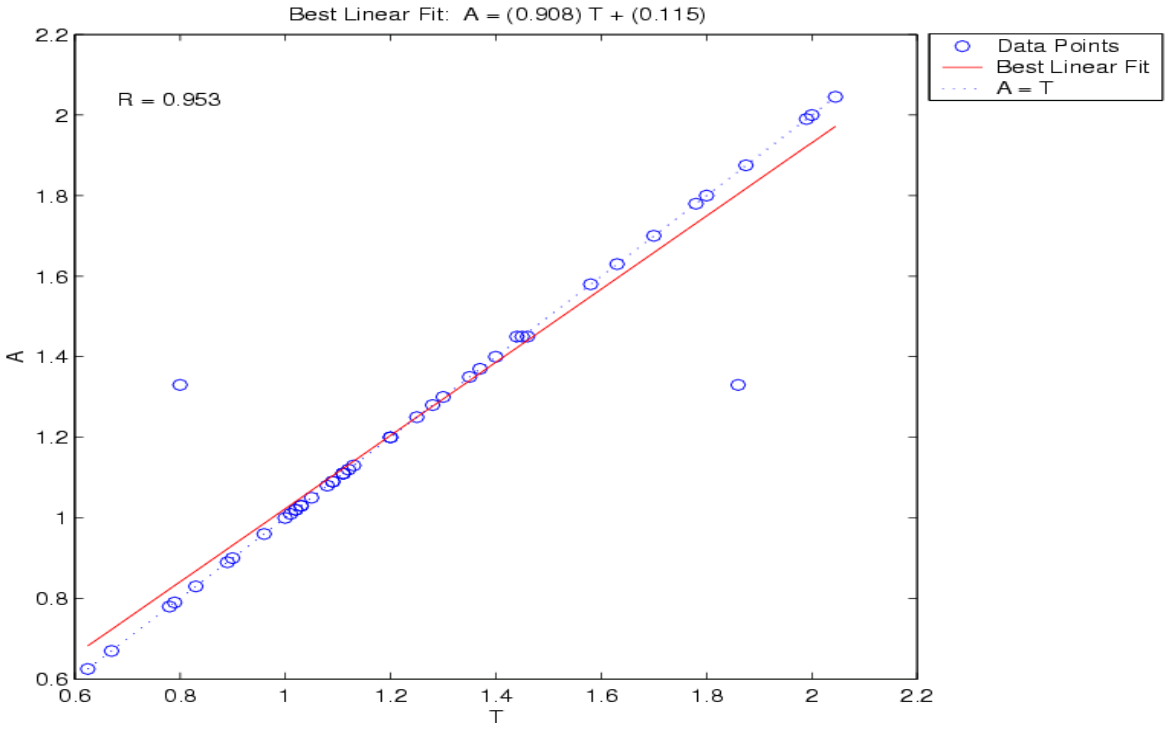

Fig. 4: Regression between outputs and targets

Fig. 4 illustrates the graphical output of the analysis. The network outputs are plotted against the targets as open circles. The effectiveness of ANN training is exemplified by the high correlation (R=0.953) between the network output values and the target values. This implies that the determined weights intrinsically describe the mapping between the contributory factors as inputs on one hand and corresponding factors of safety on the other, as outputs.

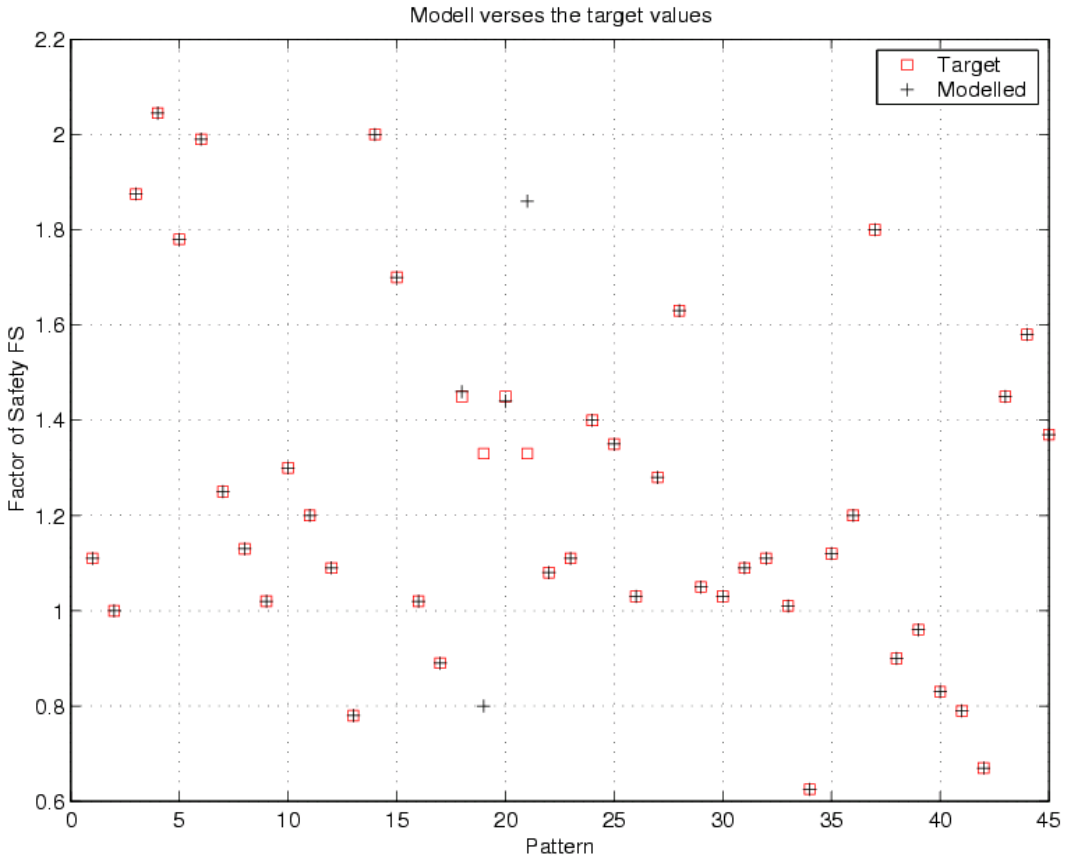

Fig. 5: A comparison of computed and targeted FS variables

Remarks

The example computed here has shown the capability of artificial neural networks to compute an input-output mapping. The end results of using artificial neural networks are optimized weights. The weights constitute a global function that may be used independently to determine the factor of safety given the contributory factors or their derivatives. By incorporating a wider variety of samples from the test regions in the OASYS project, we may be able to predict factors of safety within these regions. Using the classification outlined in section 1, the behaviour of the factor of safety over time would give an indication of probable failure and thus act as a delineation of the taking-off domains.

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International Journal for Disaster Management & Risk Reduction Vol. 1 No. 2, **pp** ***X-Y*** July 2008 ISSN: 1992-2744

ESTIMATING PARAMETERS OF IHACRES CONCEPTUAL MODEL FOR TANA BASIN, KENYA

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ABSTRACT

This study involves the development of methodologies for a priori parameter estimation of conceptual rainfall-runoff models in ungauged catchments. First, IHACRES, a lumped conceptual rainfall-runoff model was calibrated to six catchments within the upper Tana basin to obtain a set of model parameters that characterise the hydrological behaviour of the basin. Then, catchment characteristics representing topography, soil and land cover were derived from spatial data using GIS. By correlating these two datasets, equations which related the model parameters to catchment characteristics were developed. The estimated parameters were used to simulate streamflow in a validation catchment within the same region and the goodness of fit evaluated. Simulated streamflow fitted well with the observed streamflow. The r^2 value was 0.67 while the Nash-Sutcliffe efficiency value was 0.68. This methodology can be used to estimate streamflow in ungauged catchments.

Keywords: *Conceptual model; IHACRES; Hydrological model; Regionalization; Runoff hazard, Ungauged Catchments, Kenya*

INTRODUCTION

Accessibility to daily streamflow data at is an operational requirement for water resources management. Streamflow data is required for the design of hydraulic structures, stream habitat assessment and for disaster management in the control and forecasting of floods and low flows. Many catchments in developing countries are ungauged making streamflow data inadequate and unreliable. Rainfall-runoff models with appropriate model parameters provide an alternative means of obtaining streamflow data provided that historical rainfall measurements are available. Several modelling approaches have been developed for this purpose one of which is regionalization. In this approach, simulation of streamflow in ungauged catchments is achieved by developing models for gauged catchments and linking their parameters to physical catchment attributes through multiple regression. This enables the estimation of model parameters for the ungauged catchments in the same geographic region if their physical catchment attributes can be determined or estimated. Catchments with similar physical characteristics generally show similar hydrological behaviour and it is therefore possible to provide a regional parameter set where model parameter values vary with measurable catchment characteristics (Seibert, 1999). Better simulation results are obtained if the selected catchments are in the same geographic region where there is minimal variability in hydrological processes (Onyando *et al.,* 2005). Most regionalization studies have focused on catchment attributes related to topography e.g. slope, drainage density, and vegetation, while others have taken climate into account using climate characteristics, e.g. mean rainfall and average temperature. Various regionalization methods have been used to simulate streamflows in ungauged catchments using models of variable complexity (Post and Jakeman, 1996, 1999; Sefton and Howarth, 1998). However, such studies have been limited in Kenya. Onyando and Sharma, (1995), Onyando and

Chemelil, (2004) and Onyando *et al.,* (2005) have reported successful simulation of streamflows using event based rainfall and runoff data and semi-distributed and lumped models. The main limitation of regionalization as a method of estimating streamflows in ungauged catchments is the need for data from many catchments in the same region (Kokkonen, 2002) which, while giving meaningful relationships between model parameters and catchment attributes (Schaake *et al.,* 1997) increases the variation of climate and physiography thus introducing more variables in the regression analysis (Siebert, 1999). The objective of this study was to estimate parameters of a simple lumped conceptual rainfall-runoff model and apply them in daily streamflow simulation for sub-catchments of the upper Tana basin. The rainfall-runoff model used was IHACRES.and was applied to six catchments ranging ranging in size from 49 km^2 to 600km^2.

DESCRIPTION OF STUDY AREA

The study area (Figure 1) which is 6678 km^2 lies between longitudes 36.58°E and 37.54°E and latitudes 0.16°S and1.20°S . The altitude ranges from1000m to 4000m. The upper parts of the basin receive about 1200-2400 mm of rainfall annually while the lower parts receive about 800-1200mm (Jaetzold and Schmidt, 1983). Mean annual potential evaporation rates are about 900-1700 mm. The area is drained by several perennial streams such as Chania, Thika, Maragua, Rwamuthambi, Sagana, and Gura that originate from the western slopes of Mt Kenya and the eastern slopes of the Aberdare ranges. Soils in the basin are predominantly fertile clay-loams of volcanic origin that have high infiltration rates, are resistant to erosion and are highly permeable. They are suited for coffee and tea growing, and hence the area is densely populated with intensive rainfed and irrigated agriculture. Consequently demand for water is high and river water is abstracted at several points to supply water for towns and farms.

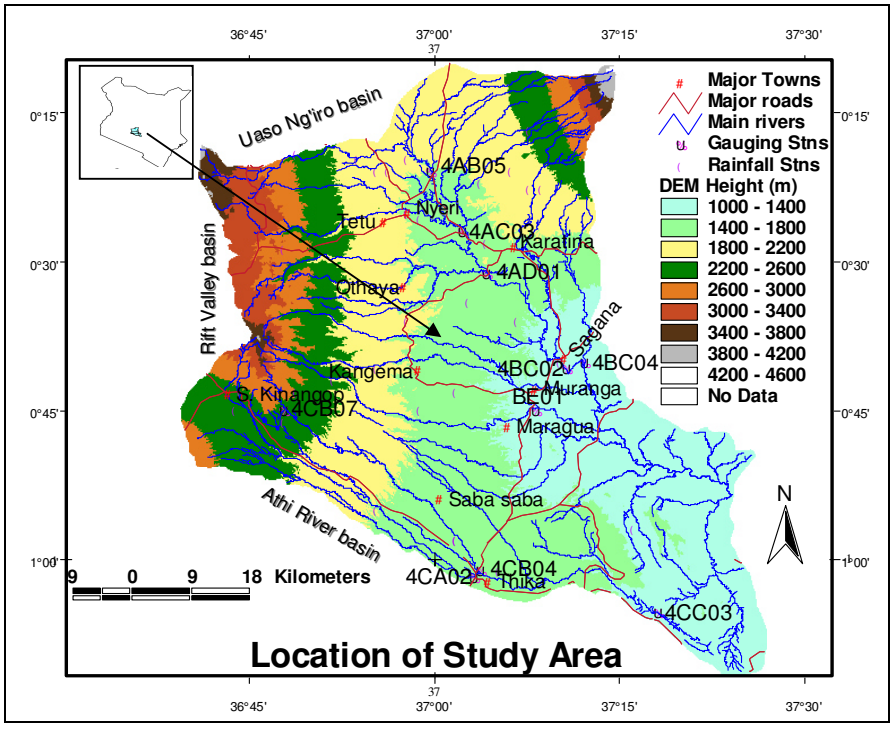

Figure 1 Location, relief and drainage map of study area

METHODOLOGY

The rainfall-runoff model

IHACRES is a conceptual, lumped parameter hydrological model that uses only rainfall and temperature data as inputs. It is continuous flow model based on the unit hydrograph principle. A time step of an hour, a day or even a month can be used as desired.

IHACRES consists of two modules in series. The first module is a non-linear loss module that converts rainfall to effective rainfall, defined as that part of rainfall that leaves the catchment as streamflow. The second module is a linear unit hydrograph module that represents the transformation of effective rainfall to streamflow. It allows a flexible configuration of linear stores in parallel and/or series (Figure 2); the stores are identified from the time series of rainfall and streamflow data. Depending on the configuration, the model is defined by a maximum of just six parameters, making it relatively simple in structure compared to other conceptual rainfall-runoff models. The six parameters may be considered as dynamic response characteristics (DRCs), as together they can be used to predict hydrologic response of a catchment.

The parameters are calibrated prior to simulation by comparison with observed streamflow data (Jakeman and Hornberger, 1993). During calibration, four of the model's parameters *c* (increase in catchment wetness index per unit rainfall in the absence of any decrease due to evapotranspiration), τ_q (the recession time constants for quick flow), τ_s (the recession time constant for slow flow) and v_s (the proportional volumetric contribution of slow flow to total streamflow) are determined directly from the raw rainfall, streamflow and temperature data, while the other two parameters τ_w (the rate at which catchment wetness declines in the absence of rainfall) and *f* (temperature modulation factor) are calibrated using a trial and error procedure, optimizing the model fit to the observed data.

The model assumes a linear relationship between effective rainfall and streamflow. A catchment wetness index, S_k which indicates the potential of the catchment to produce streamflow from rainfall is therefore computed at each time step. It varies from zero to unity depending on the antecedent rainfall and the rates of water loss to evapotranspiration and streamflow. A zero value indicates a relatively dry catchment with rainfall falling at this time producing no effective rainfall while a value of unity indicates that the catchment is relatively saturated and all rainfall falling at this time will become effective rainfall.

The index S_k is given by:

$$S_k = \frac{r_k}{c} + \left[1 - \frac{1}{\tau_w(t_k)}\right] S_{k-1} \quad (1)$$

where c is the parameter that determines the impact that a unit input of rainfall has on the catchment storage, r_k is rainfall and $\tau_w(t_k)$ is the time constant (days) of catchment losses at daily mean temperature t_k (°C) according to:

$$\tau_w(t_k) = \tau_w \exp(20f - t_k f) \quad (2)$$

where τ_w is the time constant (days) of catchment losses at 20°C. The constant 20°C. is a reference temperature chosen depending on conditions in the study area and may therefore vary while *f* is a factor describing the effect of a unit change in temperature on the loss rate. Effective rainfall u_k is then calculated according to:

$$u_k = \frac{1}{2}(s_k + s_{k-1})r_k \quad (3)$$

The percentage of rainfall, that becomes effective rainfall in any time step, varies linearly (between 0 and 100 %) as the catchment wetness index varies (between 0 and unity). For calibration, the model requires time series of rainfall, streamflow and a surrogate variable representing evaporation.

The catchments

The study area was delineated into six sub-catchments using a 90m by 90m digital elevation model and the established river gauging stations as outlet points. The delineation criteria was based on the need to cover a wide range of locations and morphological types and for each catchment to be generally less than 600 km^2 in order to reduce uncertainties that may result from lumped handling of rainfall. Streamflow in the selected catchments was assumed to be unaffected by large scale abstractions, storages or effluents. It was assumed that the selected for the selected subcatchments, the characteristics were representative of the statistical population of catchments in the study area both geographically and in parameters space.

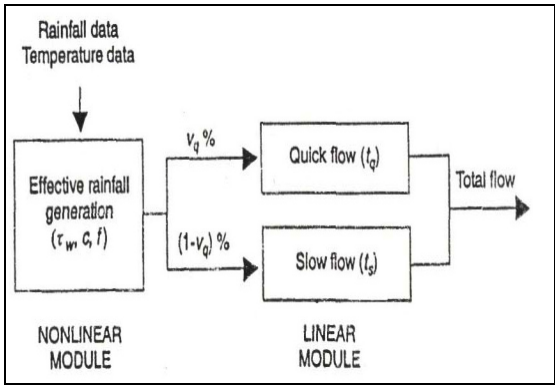

Fig 2: Schematic representation of the IHACRES model (Source: Kokkonen *et al.,* 2003)

Hydrological data

Streamflow data measured at six gauging stations 4AC03, 4BC02, 4BC04, 4BE01, 4CB07 and 4CB04 (Fig. 1) for the period 1970-1975 was obtained from the Ministry of Water and Irrigation. The period, 1970-1975 was selected because of the good quality data that was available. Rainfall data observed at 16 rainfall stations for the same period was obtained from the Kenya Meteorological Department. Monthly temperatures were obtained from Kalders (1988) while areal rainfalls were computed using the Thiessen polygon method.

Model calibration and validation

The model was calibrated using trial and error method during a common period of observation 1970-1975. For each catchment areal rainfall, streamflow and monthly temperature data were used to calibrate and validate the model. The period of record was divided into three non-overlapping two year calibration periods. Selection of a two year calibration period (Jakeman et al., 1993) allowed each model to be exposed to some inter-annual variability while ensuring that the hydrological response of the catchment does not change dramatically during the period. It also balanced the problem of variance and bias. Shorter calibration periods generally yield model parameters with very high variance while longer calibration periods are likely to encompass changes in the system such as a shift in the stage discharge rating curve (Sefton and Howarth, 1998)

Calibration was therefore done for two-year periods (1970-1971, 1972-1973 and 1974-1975). Since IHACRES assumes an initial catchment wetness index of zero, each calibration period was made to start and end on a low flow and hence January was selected as the starting month for all calibrations. A model validity test was performed which involved keeping the parameter sets obtained during calibration constant and running the model in simulation. The parameters of the model that performed well with all catchments were adopted as the dynamic response characteristics (DRCs) of these catchments and related with their physical attributes. Sensitivity tests were also carried out in order to analyse calibration errors. Since the IHACRES model package automatically determines the values of parameters τ_q, τ_s, v_s and c, it was only the two parameters f and τ_w that were varied during calibration.

Derivation of Physical Catchment Descriptors (PCDs)

Physical catchment indices were derived from topographical, soil and land cover maps to represent topography, soil and land cover. Based on low correlation with other indices and wide availability, 14 indices were selected. IHACRES being a conceptual model does not have parameters that can be directly determined from field measurements. The inclusion of time variant indices meant that hydrological response of the catchments can be influenced by changing land use an implicit assumption being that the relationships between the DRCs and PCDs were constant and that change in land use did not affect the processes governing the responses of these catchments. The PCDs used in the analysis were quantified as follows:

Drainage density was obtained by dividing the total stream length within the catchment by its area. Mean catchment elevation and slope were computed from the DEM using Arc View GIS package. Stream gradient was determined by dividing the total length of the main stream with the elevation difference between its highest point and the outlet point. Catchment area is the area draining to the catchment outlet and was determined using Arc View GIS. Land use information was derived from Africover maps. The area of each land use type in a catchment was divided by the respective catchment area to obtain dimensionless index. The same applied to soils data obtained from the digital terrain data base of East Africa (FAO, 1997). Due to lack of quantifiable geological data, geology was omitted as a PCD. Climate was also omitted since IHACRES is capable of filtering out any effects arising from different climatic descriptors, Kokkonen *et al.,* (2003)

Development of DRC-PCD relationships.

Based on data from six catchments, relationships were developed. This involved inspection, correlation analysis, principal component analysis, stepwise and multiple regressions. Principal component analysis was carried out to identify those variables that explained a large proportion of the PCD variance while stepwise regression was performed to identify those PCDs with the strongest statistical relationship with DRCs. Finally, for each DRC, the variables suggested by the correlation analysis, principal component analysis and stepwise regression were combined in a multiple regression model such that each DRC was expressed in terms of PCDs as shown below:

$$y(k) = \beta_o + \beta_1 x_1(k) + \beta_2 x_2(k) + \text{----------} + \beta_p x_p(k) + \varepsilon(k) \quad \text{----------} \quad (4)$$

With k = 1, --------, N

Where:

y (k) represents DRC; $x_1(k)$, $x_2(k)$-------- xp(k) denotes the PCDs in the k^{th} model simulation; N represents the total number of catchments; β_o, β_1, β_2----------β_p denotes the ordinary regression coefficients obtained by minimising the regression residual ε and p is the number of PCDs used in the regression model.

The quality of the resultant regression model was judged by its ability to estimate the dependent variables for observations on independent variables not used in estimating the regression coefficients. The resultant regression equations are as shown in Table 1.

Table 1: DRC-PCD relationships for the estimation of DRCs from PCDs

DRCs	Optimized multiple regression equations of DRCs in terms of PCDs
f	$0.013+5.233RL_2+3.895M_2$
τ_w	$-76.702+0.505Dens+40.946R_2+50.884RL_2$
1/c	$162.052+1373.537M_2$
τ_q	$-8.181+178.720Gradient+9.810M_2+14.201AG_1$
τ_s	$65.647-0.056Area+596.878S\_Gradient-20.363R_2$
ν_s	$0.426+1.680AG_1$

These equations were used to re-calculate the model parameters for the calibration catchments and to estimate model parameters for the validation catchment. The estimated DRCs for the calibration and validation catchments did not vary greatly from the calibrated values and hence the resultant streamflow prediction for the validation catchment was fairly accurate and fitted well with the observed streamflow.

RESULTS AND DISCUSSIONS

The models calibrated over the period (1974-75) were found to characterise well the hydrologic response of these catchments as they performed well over the validation period (1970-73). The calibration R^2 ranged from 0.58 to 0.85 while the simulation R^2 ranged from 0.55 to 0.77. The Nash-Sutcliffe efficiency ranged from 0.78 to 0.91 during calibration and from 0.77 to 0.88 during simulation showing that the model fitted well to observed data. The model parameter set calibrated at 1974-75 were therefore adopted as the dynamic response characteristics (DRCs) of these catchments. The correlation matrix of PCDs showed the existence of multi-collinearity and principal component analysis was performed to identify those variables that explained a large proportion of the PCD variance. Using Kaiser (1959) criterion of an Eigen value of one or more as the cut-off value, the rotated principal component analysis (RPCA) extracted four principal components which together accounted for 94.74% of the variance between PCDs and can be categorized as D_Dens, AG_1, R_3, Slope, Elevation and M_2 (component 1), Area, AG3B, R_2 (component 2), Gradient, R_1 and AG_3 (component 3) and RL_2 and FR_2 (component 4). The PCDs that correlated well with the model parameters were considered major drivers of catchment hydrological response while those without significant correlations meant that their hydrologic effects if any were masked by more powerful drivers of catchment hydrologic response. The major drivers of catchment hydrologic response were identified as stream gradient, drainage density and soil type M_2 which is predominant in the area

Table 2: Factors, Eigen values and proportion of common variance

Factors	Eigen values	Proportion of common variance (%)	Cumulative proportion of common variance (%)
1	5.34	38.12	38.12
2	3.30	23.54	61.67
3	2.42	17.27	78.94
4	2.21	15.81	94.74
Total	13.27	94.74	94.74

Estimation of daily streamflows

Time series plots of observed and estimated streamflows for the validation catchment (figure 3) show that the estimated models compare well with the calibrated models at the gauging station (4AD01) giving an R^2 value of 0.67 compared with calibration value of 0.68. The established DRC-PCD relationships are therefore valid and can be transferred to ungauged catchments within the region for estimation of model parameters leading to streamflow simulation.

Model performance evaluation

The ability of the model to predict daily streamflows in ungauged catchments was evaluated by computing the Nash Sutcliffe (1970) efficiency (E) for the predicted and measured streamflows for the calibration and validation catchments. The model fitted well to both calibration and validation catchments with E>0.5 for all the catchments. The results therefore indicate that estimated model parameters can be used to simulate catchment hydrological response.

Conclusions and recommendations

From the results of this study relationships developed between hydrologic response characteristics and physical catchment descriptors from gauged catchments can be used to make model parameters estimations for simulating daily streamflows in ungauged catchments given an appropriate rainfall and temperature time series. This is necessary for providing hydrological data required in many water resources planning and management interventions. It is recommended that the study be repeated using a larger number of catchments that explore a wider geographical space. This will hopefully improve the established DRC-PCD relationships so that the results can be applied with greater confidence. The results of the study may also be ascertained using more complex models

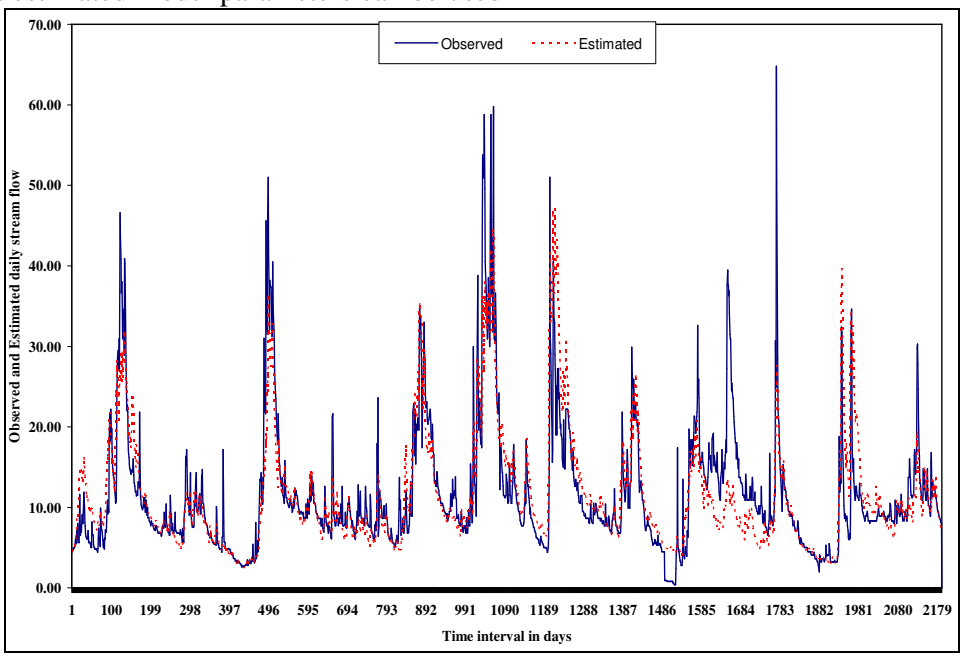

Figure 3 Observed and Estimated Streamflows for Station 4AD01 (1970-1975)

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International Journal for Disaster Management & Risk Reduction Vol. 1 No. 2, **pp** ***X-Y*** July 2008 ISSN: 1992-2744

EDUCATION AND PEACE IN CONFLICT SCENARIOS: THE CASE OF MT. ELGON REGION IN KENYA

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ABSTRACT

Education and Peace are identical twins. The absence of one implies vacuum for the other. Importantly, neither can take place in the absence of the other. Both education and peace are core ingredients for personal and collective development. They occur in the absence of violence and war. Unfortunately, the Mount Elgon region in Western Kenya has not known continued peace for several decades. For instance, since 1963, violence, battles and civil wars have recurred among the inhabitants who include: Sabaots, Bukusus, and Itesos. The major source of fighting seems to be land ownership and cultural rites. Repercussions of the fights have been devastative in nature: loss of human life, cattle rustling, rape, closure of learning and health centers, Internally Displaced People (IDPs) camping in schools among other centers, desertion of farms, divorce and total destruction of homes among others. All people in the region are negatively affected and this has spilled over to neighboring regions. There is no peace. Lack of peace negatively affects educational processes. There is need for urgent and sustainable resolution of the conflict in Mount Elgon region. This can be achieved through, for example, development of meaningful infrastructure and industries in the region, teaching and learning peace education, and acceptance of multiculturalism as a normal human phenomenon; there is hope.

Key words: Conflict, Culture, Education, Peace, Violence.

Introduction

Education is a social process designed to enlighten its recipients. The people who are involved in the process require aspects such as time, space and peace.

Conflict is a state of incompatibility (Rosse and Rosse, 1981; Bedeian, et. al., 1981). It is like traffic light which shines green to alert you to drive on yet at the same time it shows red, warning you to stop (Achoka, 1994). Conflict may occur at a personal, group, community, or national and international levels. Conflict has both negative and positive effects. From the positive point of view, conflict alerts people about the presence of an uncomfortable condition that needs to be addressed (Miles, 1976; Crane and Wanicki, 1983).

At the same time, conflict inherently provides situations that render themselves vulnerable to negative repercussions such as hatred, violence and/or war. Consequently, whenever conflict occurs, it adversely affects educational processes. Cases of conflict in Southern Sudan, Northern Uganda, Somali, Kosovo, Rwanda and Iraq speak for themselves. The violence with which negative conflict was associated sent many people fleeing for their lives others died of course. The sufferings that followed included disruption of education and all other social processes in all affected nations and the world at large.

In Kenya, the Mt. Elgon conflict and violence scenario is not a new occurrence. Fighting, maiming, killing, and disruption of social fabric in this region first occurred in 1971 (UNICEF, 2007) in response to conflict caused by land crisis. The current flare of violence started in the second half of 2006 and appears to not only take long to end but also increased in intensity of sufferings inflicted upon the victims especially women, girls, and children (Mutai, 2007).

In this article are contained synopses of: (a) Theoretical framework. (b)Some causes of

conflict and violence (c) Contemporary scenario in Mt. Elgon region (d) Implications of conflict for education and peace in Mt. Elgon, Kenya. (e) Conclusions (f) Suggested way forward.

Theoretical Framework

Analysis of contents in this article are buttressed by the Conflict Theory whose proponents include (Wikipenda, 2007; Kahn et. al., 1964; Gross et. al., 1958). The theory states that the society or organization functions in a manner such that individual participants and/or groups of people struggle to maximize their benefits. This theory is mostly applied to explain conflict between social classes such as the poor and the rich or between ideologies such as capitalism and socialism. The theory attempts to refute functionalism theory which considers that societies and organizations function so that each individual and group plays a specific role, like organs in the body (Achoka and Nasongo, 2008).

The essence of conflict theory is best epitomized by the classic pyramid structure in which the elite dictate terms to the larger masses. It is argued in this theory that all major institutions, laws, and traditions in the society are designed to support individuals/groups which have traditionally been in power or are perceived to be superior in the society. Accordingly, anything that challenges the control of the elite is considered deviant or morally reprehensible. Importantly, this theory may be applied on both the macro or micro levels in society (ibid).

In short, conflict theory seeks to catalogue the ways in which those in power struggle to perpetuate their positions (ibid). In other words, social class competition plays a key role in conflict theory. The theory has four basic assumptions:

1) **Competition**
That competition over scarce resources such as money, leisure, and sexual partners is at the heart of all social relationships. Accordingly, competition rather than consensus is characteristic of human relationship.

2) **Structural inequality**
That inequalities in power and reward are built into all social structures. Individuals and groups that benefit from any particular structure strive to see it maintained.

3) **Revolution**
That change occurs as a result of conflict between social class competing interests rather than through adaptation. It is often abrupt and revolutionary rather than evolutionary.

4) **War**
That even war is unfair to the societies involved, as well as it may set an end to whole societies.

From the above principles, conceptually one envisages individuals/groups of people although living in society at the Mount Elgon region, they however experience incompatibilities among themselves. One wonders what the source of conflict and violence could be. In accordance with this article's theoretical framework, the discomfort could be derivatory of competition over resources, or feelings of discrimination and inequalities of some sort (Hoy and Miskel, 1987) which render revolution and war inevitable sequential events.

Historically conflict and violence have their sources within the society affected. Some sources could be social, political, economic, or all of these. In the next section, we shall explore an overview of some general causes of conflicts and violence.

Some Causes of Conflict and Violence: An Overview

Since conflict implies incompatibility, it thus has bearing on a person's/people's culture. Culture, that is, a person's way of life, influences and shapes our knowledge, feelings, attitudes, beliefs, values, views, experiences, and interactions with other

people. In situations where common culture reigns, society enjoy homogeneity of the above aspects. In heterogeneous society, people contend with cultural diversity. This later scenario seems to be the case in most societies worldwide. This is occasioned by frequent intermingling of people from different cultures into the "global village" of our times. Hence, to-day we see the appearance of multicultural societies at the community, national, and international levels. In short, since cultural diversity is apparent in our lives, then, cultural understanding is concurrently a necessary part of our daily experiences. Short of this paradigm, people suffer conflict/violence. For instance, a baby who does not like staying wet may cry to alert his/her handler to change the linen. Or, an angry individual may verbalize the cause of his/her anger (conflict) while searching redress. When positive actions are taken, peace is inherently re-established and in most cases, progress is registered, thanks to useful/positive conflict (Duff, 1993). Importantly, this is how man advances in life both individually or collectively. No-wonder conflict is indispensable in human existence (Achoka, 1994).

Be that as it may, conflict between and/or among people may occur due to misunderstanding in areas of resources, needs, values, or goals. For instance, disagreement over scarcity or too much personal property such as land, animals, and/or children has potential to disintegrate into conflict and if not resolved, violence and/or war may occur. Also, disagreement over common resources such as water, roads, or schools may deteriorate into volatile situations that are susceptible to violence and/or war. Of necessity therefore, individuals pay attention to both personal and common properties/resources with a view to avoid tensions/conflicts, see illustration in Figure 1.0.

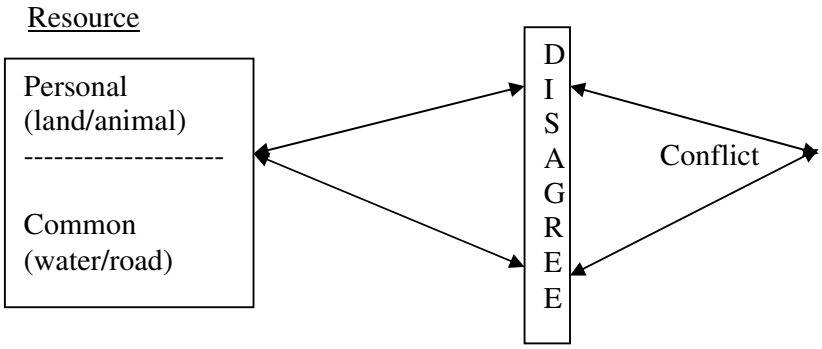

Figure 1.0: Resource – conflict.
Source: Developed by Author from Literature.

In the area of needs, people care about their personal dignity and self-esteem. If one is insulted or ignored, s/he suffers personal identity conflict. Naturally, people want to be respected and appreciated. Short of these, affected persons experience conflict; that is, incompatibility between expectation and reality in identity. In addition, when one is excluded from either a relevant friendship or group in society, s/he feels left-out. Consequently, the individual suffers conflict from lack of inclusion; the ego is negatively affected. Moreover, man has what we may call here, "Achievement Need". This need causes the individual to feel fulfilled as s/he identifies with personal achievements that are equally appreciated by significant others. Thus, conflict in the needs domain may be caused from three dimensions as illustrated in Figure 2.0.

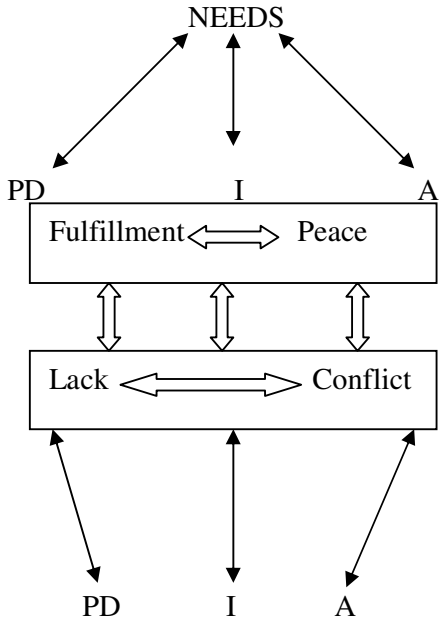

Figure 2.0: Group/Individual Needs – Conflict.
Source: Developed by Authors from Literature.

Key:
PD = Personal Dignity
I = Inclusion
A = Achievement

Furthermore, distorted goal/value achievement can lead to conflict and/or violence. For instance, lack of the girl-child education achievement due to disturbances in the environment may cause conflict within, between, and/or among the affected people. Even unfair play such as if your friends steal, you may not agree with them if you regard stealing as an immoral rite. But, you may not wish to abandon your friends. At such juncture, one suffers value-conflict within the community/society, see Figure 3.0.

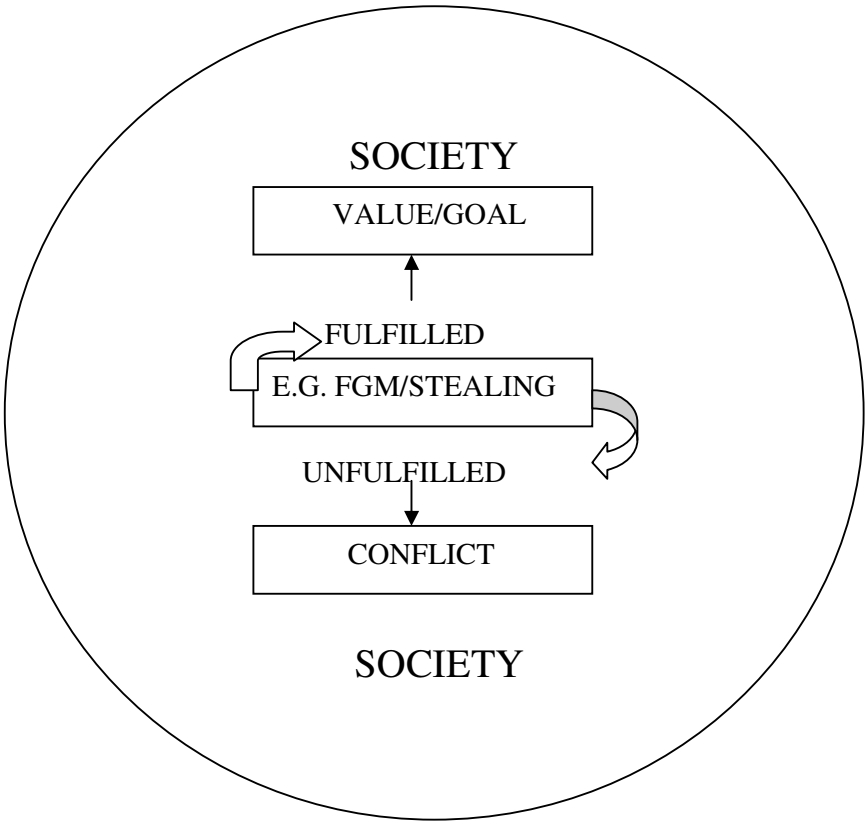

Figure 3.0: Value/Goal – conflict.
Source: Developed by Authors from Literature.

True to say, causes of conflict for a person are therefore many. The cause may singly or collectively affect a person/people. If the cause is not effectively addressed, one suffers conflict and this could lead to violence and/or war. Effects of such wars include: displacement of persons, maiming and/or killing of people, as well as disruption of social fabric in the affected region(s). Nevertheless, conflict is not always devastative. If, for instance, incompatibility between or among people is amicably resolved, the effect of the same is positive redress for the parties involved. This is what is desirous of all peace-loving people the world over. The following section throws light on the current conflict scenario in the Mt. Elgon region of Western Kenya.

Contemporary scenario in Mt. Elgon Region: Synopses

Mount Elgon region is in Western Kenya. The region consists of Mount Elgon which is an extinct volcano on the border of Uganda and Kenya. The mountain is named after the "Kony" who are one of the four Sabaot clans who once lived in huge caves on the southern side of the mountain. The mountain is the catchment area for several rivers such as the Suam, Nzoia, and Turkwel. The town of Kitale is in the foothills of the mountain. The area around the mountain is protected by two Mount Elgon National Parks – one on each side of the international boarder (Kola, 2007).

In their lifestyle, the Sabaots resemble the Maasai people who live in the Great Rift Valley of Kenya and Tanzania. For this

reason, the first Europeans to visit the Sabaots, called them Elgon Maasai.

Map of Kenya showing Mt. Elgon District

Key

Mt. Elgon District

Conflicts in the Mount Elgon area started long time ago. For instance, in 1963, the Sabaots and Bukusus clashed over land, cattle rustling, and cultural rites (IRIS, 2007). The cause of such tribal clashes recurred between the two warring tribes for many years. However, the clashes were usually short lived with bearable consequences. From the 1990s, the duo-tribal clashes took a new turn. They involved more tribes, such as the Iteso, and to some extent, it was noted that politicians were also involved given that from 1992 Kenya became a multi-party state. Accordingly, consequences of the battles were severe. For the first time ever, women survivors spoke loudly about the severe consequences of the battles in terms of death especially to women and children; cattle-rustling; and, unfair land demarcations (CNT, 2007). Other long-term effects included: stagnated development, educational impoverishment (as most teachers were non-sabaots and they fled the region!), broken marriages, burnt homes, deserted farms(UNICEF, 2007) not to mention silent anger, fury, and enemity among the warring tribes.

The present conflict scenario in the Mt. Elgon region started around September 2006 (Mutai, 2007). Disagreements over land allocation and cultural rites led to conflict and the subsequent violence. Effects of the on-going fightings are devastative. For instance, by end of March, 2007, over 150 people had been killed, 120 wounded, hundreds others injured and over 50,000 displaced especially in Cheptais and Kapsokwony divisions (Mutai, 2007).

It has been reported that at least 158 people had been killed, 149 injured, approximately 66, 816 people (11, 136 families) left homeless while 1,621 families had been displaced in neighbouring Bungoma District. Some of the more able families had moved to Kitale and Transmara districts (KRCS, 2007). In addition, several cases of cattle rustling in Cheptais and Kopsiro divisions had been reported. Communities in the Mt. Elgon region live in fear since a night hardly passes without them experiencing gunshots. More people are affected by change of climate (cold weather) and malnutrition related cases leading to death of over 40 persons in Kimabole, Cheptais, Kimaswa, Tuikut, Kebei and Kopsiro areas (ibid). Some of the death cases especially children, had not been reported or registered at the hospital but had been buried within the community.

The Internally Displaced Persons (IDPs) had worked for alternative settlements among their relatives or rental houses in the market centers. A one-roomed house can accommodate about five families and this indicates that shelter is a major problem. Some residents had requested to be settled in camps since it is increasingly difficult to live with relatives or pay rent. Many more families had camped in temporary shelters in compounds of churches, schools, mosques, and markets with little or no sanitation and hygiene facilities (Kitau, 2007). Rape of women and children had occurred. Over one hundred cases of separated families had been reported (Opondo et al, 2007, UNICEF, 2007).

Health facilities had been strained beyond their capacity with many workers abandoning their duties and migrating to neighbouring Kimilili and Bungoma districts where they operate from daily to their work stations at Kapsokwony. There are limited health facilities and personnel in the health centers, compelling the few health workers to work round the clock to attend to the patients. Immunization services have been interfered with. There is a sharp drop in Ante-Natal clinic and VCT attendance. Loss of shelter, clothing, and bed nets, overcrowding and poorer nutrition are all contributing to an increase in pneumonia, malaria, enteric fever and sexually transmitted infections. Shortage of food due to crop destruction is eminent. Since beginning of 3rd term, 2006, some schools in the area had never opened. The schools serve 4,705 children, and usually have 70 teachers. Enrolment in a further six schools in the area fell from over 3,800 in 2006 to just over 1,200 in 2007 (UNICEF,2007). At the same time, 28 schools in other parts of the district had recorded high enrolment due to influx of families displaced by the violence. The loss of livelihood is leading children in secondary schools to drop out because their parents cannot cover the high cost of education in Kenya (Achoka, 2003).

By end of March, 2007, over thirty schools in the region had closed because of insecurity. This event has put a strain on the few remaining schools which are grappling with shortage of teachers, classrooms, desks, and learning materials (Opondo et al., 2007). According to several reports, violence in the region is taking a terrible toll on children. Many of them had died as a result of appalling living conditions that have exposed them to disease and poverty (UNICEF, 2007).

Attendance in primary schools had plummeted to unacceptable levels. This disruption of education activities is denying children their right to education as enshrined in the Children Act (Republic of Kenya, 2001). A UNICEF report in April, 2007 notes that in Mt. Elgon district there reigns a climate of intimidation. Violated families and individuals cannot report their attackers for fear of further violence (KRCS, 2007). In particular, cases of rape are hardly reported. They first occurred in December, 2006 and escalated in January and February, 2007. Most victims suffer in silence due to threats of death issued by perpetrators of this heinous crime. Moreover, it is reported that some youngsters are recruited into militia

groups by force. Formal schooling and peace have become illusive to these victims.

In the section that follows, we explore the implications of the situation in Mt. Elgon Region for Education and Peace in the region and Kenya.

Implications of Conflict and Violence for Education and Peace in Mt. Elgon Region/Kenya

As earlier noted, tranquility or peace is a pre-requisite for education processes. Conversely, conflict, turmoil, violence, and war do not further education. In Mt. Elgon Region since the second half of 2006 conflict and violence have been the order of daily existence. Closure of schools implies that many learners are forced to drop out of schools due to violence. Others fall out because of lack of financial and social sponsorship. The girl-child in particular is most endangered as she is exposed to several hazards including rape, STIs, pregnancy, FGM, and early marriage. Many school drop outs are victims of child-labour. The overall education implication is perpetuation of illiteracy and semi-literacy, poverty and ignorance for the affected age-group in the population.

On the national scale, the government is inconvenienced because it cannot achieve its millennium goal of education for the citizenry. Besides, Kenya's dream to be industrialized by the year 2020 is likely to be thwarted. As well, her desire to meet the international protocol that established Education For All (EFA) since 1990 and in which she is a signatory is threatened with abortion. Moreover, so long as the violence in Mt. Elgon Region persists, it remains Kenya's betrayal of the Universal Declaration of Education in 1948 which made education a basic human right. Furthermore, the violence is denying children their right to education as declared in the Children's Act (Republic of Kenya, 2001). One wonders, what is the future of such victims in this twenty-first century Hi-Tech global village?

In addition, the burning of homes and destruction of crops in the region are signals of a lack of peace in the Mt. Elgon Region. It is practically impossible to carry on educational processes in such and similar scenarios. Thus, Kenya's dream of industrialization by 2020 made hopeless while, her desire to achieve Education For All (EFA) is threatened with failure.

The very facts that some schools have closed down, others are destroyed/vandalized, some suffer under enrolment, while others are over enrolled mean that the education processes are hampered and distorted. In any case, some of the teachers and learners are direct victims of the violence. These happenings further devastate the already teacher-understaff problem and other related issues. No meaningful acquisition of knowledge, skills and attitudes can occur amidst life threatening violence such as is the Mt. Elgon region.

Conclusions and Recommendations

No doubt, Mt. Elgon is suffering conflict and violence on a large scale. Whereas conflict has both positive and negative repercussions, the Mt. Elgon region is seemingly besieged more negatively than positively. All people in the region are negatively affected. Moreover, effects are felt in the neighboring regions such as Bungoma District and Kitale region.

Lack of peace in the region has negatively impacted educational processes. Most teachers in the region are non-locals. They have fled the region. Most learners and their parents/families have been forced into "exile" in the neighboring lands, market/administrative/church centers.

Many homes as well as schools and health centers are destroyed. The people of Mt. Elgon region are in dire need of peace instead of war. War hinders education. Without education, there can never be development whether individually or communally. How can ignorant people better survive in contemporary global village?

The need for peace education and acceptance of multi-culturalism as a normal human phenomenon in present societies cannot be overemphasized for the Mt. Elgon region. But, who will initiate the process? There is hope, however. For instance, more emphasis is needed on educational processes that encampass formal, informal and non-formal types of education. This means that community centers of human activities such as schools, churches, barazas, and markets should be used to transfer education for individual and community development.

As well, to end the over 40 years of conflict and violence in the Mt. Elgon region, it is herein suggested that all efforts should be made to establish the actual root cause of disagreements among the inhabitants with a view to emphasize peaceful coexistence at the expense of destructive wars.

It is also noted that aggressive action to teach peace education and multi-culturalism should begin as early as kindergarten level and be emphasized throughout all the learning processes.

Moreover, closer relations with neighboring communities should be enhanced in order to effectively deal with elimination of exchange of firearms, cattle-rustling and hibernation of criminals. It is also suggested that in a bid to rehabilitate inhabitants of the Mt. Elgon Region, development of infrastructure and large-scale industries in the region could lure able-bodied people into meaningful economic pre-occupation at the expense of conflicts and violence. This would go a long way to re-establish individual's and communities' respect and worth. Such virtues, it is hoped, would facilitate peaceful coexistence among the various communities in the Mt. Elgon Region.

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International Journal for Disaster Management & Risk Reduction Vol. 1 No. 2, **pp** ***X-Y*** July 2008 ISSN: 1992-2744

SECURITY IN THE POST COLD WAR WORLD ORDER WITH REFERENCE TO THE HORN OF AFRICA

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INTRODUCTION

The starting premise of this article is to counter the claim that nation states can maintain regional peace and, therefore, global tranquility on the basis of multilateral institutions that depend on the use of military coercion. Instead we contend that a concept of security based on interstate relations tends to minimize the fact that the state itself has historically been a source of insecurity among its citizens.

We apply the concept of human security (Wilkin, 1999: Salih, 1999; Ofuho, 2004: Chweya, 2004) in order to contribute to the debate regarding the threat, use and control of military force to encompass non-conventional concerns such as ecology, human rights and social capital. These concerns, if not properly addressed, can pose similar threat to human survival. We contend that security can be equated with citizenship for it is a condition that individuals enjoy.

We chose the Horn of Africa to test hypothetical questions pertaining to the institution of sovereignty in the new world that came as the result of the demise of the cold war in the late 1980s. The new world order that was deemed to provide opportunity for peace and stability in the Horn of Africa gave way for new forms of hegemonic instability and conflict. In order to understand the dynamics at play, we analyze the cold war period with the view to bringing out more clearly the historical threads in the story.

THE COLD WAR PERIOD

During the cold war, the states of the Horn of Africa were the scene of superpower rivalry between the Soviet Union and the Untied States, supported by the Eastern and Western blocs, respectively. Ethiopia, for instance, fell under Soviet influence at the end of the imperial regime in 1974 and remained so until the defeat of the Mengistu regime by the Ethiopian Peoples Revolutionary Democratic Forces (EPRDF) in 1991. From 1956 to 1969, Sudan was under the influence of the United States and the Western bloc countries, particularly Britain, its former colonial power. The May 1969 military coup d'etat brought Sudan under the influence of the Soviet Union, but from 1977 to 1989 Sudan changed its ideological orientation and returned to the influence of the United State and its Western allies. The Siad Barre military coup of October 1996 had created a socialist Somalia under the influence of the Soviet Union. Following the Somali defeat in the war against Ethiopia (1978), Somalia reverted to US influence, which continued until the collapse of the Somalia state in 1991 (Salih 1999: 129).

Unlike other countries in the Horn of Africa, Djibouti retained a strong French military presence under the Djibouti-French Cooperation Summit. Although Djibouti has not featured prominently in the politics of the Horn of Africa, its political instability exhibits patterns similar to the rest of the sub region. Today Djibouti has some of 350,000 inhabitants, 35 percent of whom are Afar and 65 percent Somali. The distribution is markedly different from that in 1977, when Djibouti gained independence from France: at the time there were almost equal numbers of Somali and Afar. Since 1981, however, Djibouti has been plagued by political rivalry between the two nationalities, a situation directly affected by its geographical position and ethnic makeup (Tadesse, 2007; 23 – 25). The Afar insurgency in the northern part of the country has been influenced by historical ties with the Eritrean and Ethiopian Afar, whereas the present population imbalance is a direct result of the civil war in Somalia and Djibouti's proximity to the northern border of the Republic of Somalia (now the northern boarder of the Republic of Somaliland and the Ethiopian-Somalia (Salih, 1999:130).

The Horn of Africa represents a reverse of the theory of hegemonic stability (Keohane 1996) in which superpower hegemony deepens rather than lessens political stability. During the cold war, external hegemony was militated by the continued dependence of these countries on the former colonial powers. Ethiopia was independent at the onset of the Cold War, but Sudan, Somalia, and Djibouti which gained their

independence in 1956, 1967 and 1977 respectively, were still under the influence of their former colonial powers (Britain in the case of Sudan and Somalia and France in the case of Djibouti). All three countries are largely dependent on external development and military aid. Furthermore, these are conflict-ridden countries whose recent history is peppered with inter and intrastate wars, such as the civil war in Southern Sudan (1995 to 2005) and the Eritrea war of independence (1962-1991). There were also internal conflicts between the Ethiopian State and the several liberation fronts, among which were the Oromo Liberation Front (OLF). Tigary People's Liberation Front (TPLF). Western Somalia Liberation Front (WSLF) and Afar Liberation Front (ALF). The protracted Somali-Ethiopian war (1978-1988), gave rise to the development of organized Somali Liberation fronts such as the Somali National Movement (SNM), the United Somali Congress (USC), and the Somali Salvation Democratic Front (SSDF). Ironically, it was these very liberation fronts that heralded the collapse of the Siad Barre regime and whose internal conflicts contributed significantly to the total collapse of the Somali state in 1991(Tadesse, 2007: 58 – 67).

The artificiality of the borders erected by the colonial powers and the coexistence of similar nationalities across the borders of the countries of the Horn of Africa (Oromo, Somali, Nuer, Beni Amir, Afar and many more) only magnifies the difficult of dealing with these conflicts as national conflicts. Insurgency and national liberation movements were supported by rival states to discredit their opponents, depending on their ideological orientation (capitalist or socialist). An exception was the war between Somalia and Ethiopia (1978), in which both were initially supported by the Soviet Union. However, when the Soviet Union chose to support Ethiopia, Somalia switched its allegiance to the United States, a situation that persisted until the collapse of the Somali State in 1991. Similarly, Sudan supported the Eritrea Liberation Front (EPLF) and several other Ethiopia based liberation fronts against the Ethiopian government: the Mengistu regime of Ethiopia supported the southern-based Sudan People's Liberation Army (SPLA) and its socialist-oriented wing, the Sudan People's Liberation Movement SPLM) in the war against Northern Sudanese hegemony (Mohammed Salih. 1991: Harbeson, 1995).

The persistence of internal interstate conflicts increased the dependence of the countries of the Horn of Africa on the superpowers that exerted tremendous political leverage over them. Clapham (1996) observes. "The search for outside resources to maintain domestic power structure was central to the foreign policies of the great majority of the African states". In the Horn of Africa case, he argues. "Where the conventions of territoriality never fully applied, internal ethnic or religious divisions were still harder to insulate from the structure of the regional or global alliances … Domestic and regional policies were no more than parts of the same equation" (Clapham, 1996:65-66). Consequently, political instability has been exacerbated by the extent to which some of the Horn countries were able to play one superpower against the other depending, at times, on internal political factors. As indicated, neither the alliances between the countries of the Horn of Africa nor those between them and the superpowers were permanent, with the exception of Djibouti (still under French patronage), which has remained firmly under Western influence. It is also important to note that during the countdown to the collapse of the Eastern bloc and Soviet Union, Ethiopia was the only country in the Horn of Africa that was still within the orbit of the Soviet Union. By the onset of unipolarity, virtually all the countries of the Horn of Africa were strong advocates of the ethos of neoliberalism and market economy principal with the exception of Sudan, which advocates a Muslim fundamentalist system of government. This leads us to analyze the situation in the Post Cold World Order.

MISSED OPPORTUNITY FOR PEACE IN THE POST COLD WAR WORLD ORDER

In common with most other regions contested by the superpowers during the cold war, the countries of the Horn of Africa have been experiencing political turmoil of alarming proportions. The decline of bipolarity has not reduced the intensity of the civil wars in Djibouti, Sudan and Somalia. Most conflicts have in fact taken on new magnitudes and dimensions. The civil war in Sudan, for instance, not only continued but was further complicated by the split of the SPLA in 1991 into Garang and Machar factions and government and the SPLA and SPLM factions, the situation of the refugees and internally

displaced peoples continued to pose serious human security issues, including famine, food shortages, malnutrition, disease, and human rights abuses by the warring factions Young, 2007: 99).

Although the post-cold war order contributed to the collapse of the Siad Barre regime in Somalia and the Mengistu regime in Ethiopia, the reactions of the two countries to the post cold war order differed considerably. The Somali civil war continued amid frustrations and mistrust between the south and the north, the Somali National Movement (SNM) proclaiming independence of the self-declared Republic of Somaliland in the north. Even in Somaliland, however, there have been sporadic conflicts among the various power contenders (Salih and Wohlgemuth 1994). The collapse of the Somalia State and Somaliland's declaration of independence have in a sense restrained Somali nationalism and its quest for the creation of Greater Somalia, that is the unitary state of the Somalia people in Somalia proper (north and south) northern Kenya, western Ethiopia and Djibouti. Both Somalia and Somaliland have introduced elements of Islamic sharia laws, although they have not declared themselves Islamic states. Ethiopia, keen to prevent Islamic fundamentalist groups from operating near its fragile borders with Somalia, has used artillery and air bombardment to destroy the bases of the Islamic groups inside Somalia, culminating in the invasion and occupation of Somalia in January 2007, a move facilitated by the US (*Sunday Nation, January 14, 2007)*

The silent civil war between the government of Djibouti and the Afar opposition continued, and the Republic of Somalia ceases to exist amid a brutal civil war between the warring factions. Ethiopia is still largely peaceful after Eritrea's independence in 1993 but continues to face strong opposition from the Oromo Liberation Front and its claims for an Oromo State (Oromiyia). Fears of worsening Sudano-Ethiopian relations surfaced following an attempt by the Sudan-based Muslim extremists to assassinate President Hussni Mubarak of Egypt, in Addis Ababa in 1994. This was sufficient cause for the Ethiopian government to reopen the offices of the SPLA and allow Sudan opposition groups and liberation movements, including the SPLA-SPLM, to operate from Ethiopia. The presence of large numbers of Somali refugees represents a further element of political instability, as does the emergence of more than thirteen Somali political organizations with various demands ranging from independence to federalism or regional autonomy (Medhanie, 1994). The Ogaden Liberation Front and Western Somali Liberation Front are still active using hostile and at times military confrontations to solve outstanding political issues.

Three years after independence, Eritrea was at loggerheads with the Sudan government, accusing it of supporting the Eritrean Islamic Jihad, a militant Islamic group that calls for the introduction of Islamic Sharia laws and the Islamization of the Eritrean state. As a result, Eritrea became the centre of the Sudanese northern-based opposition outside Sudan. Since 1994 Eritrea has offered military support to the Sudan National Democratic Alliance (NDA), a coalition of political parties that oppose the National Islamic Front (NIF) government of Sudan. The government of Eritrea handed over the Sudan Embassy in Asmara to the Sudanese opposition forces (Medhanie, 1994).

In January 1997, the Sudan government accused Ethiopia and Eritrea of supporting the rebels' offensive in eastern (Kassala Province) and southern (Blue Nile Province) Sudan. Ethiopia and Eritrea support the Sudan opposition and liberation movements and in retaliation the Sudan government supports the Ethiopian and Eritrean opposition (Medhanie, 1994).

The Eritrea-Djibouti nexus has also played a different role in the post-cold war order. The Djibouti government shifted its position from harboring the Afar Liberation front against the Mengistu regime, fearfully of a potential alliance among the Djibouti Afar, Eritrean Afar and Ethiopian Afar. The collapse of the Somali state and the declaration of independence by the Republic of Somaliland means that Djibouti is less threatened by territorial claims of the Republic of Somalia over Djibouti as part of the Greater Somalia. In spite of internal political instability, Djibouti remains the headquarters of the Intergovernmental Authority on Drought and Development (IGADD), which was established in 1989 by Djibouti, Ethiopia, Kenya, Somalia, Sudan and Uganda and was joined by Eritrea after its independence in 1993. IGADD was originally conceived by its drought prone founding member states as a way of coordination measures to combat the effects of drought and

desertification. It was changed to the intergovernmental Authority on Development (IGAD) (Okoth, 2004:50). The U.S. administration had been increasingly in favor of using IGAD to find a solution to the southern Sudan civil war that effectively ended in 2005 and Sudan's complex problems with Eritrea. This in a sense gives Djibouti a political weight that some countries, such as Kenya, consider in appropriate to its size and economic potential.

Briefly, the post cold war world order heightened the expectation of the people of the Horn of Africa for peace and prosperity. However, most civil wars continued, new problems emerged and others resurfaced under new forms and structures. The current situation negates the orthodox realist and liberal security positions, as the states of the Horn of Africa neither are in control of the direction of their domestic affairs nor have the necessary powers to influence the structure of international relations into which they have been locked. The states of the Horn of Africa continue to deteriorate and can hardly be called power maximizers. Worst of all they have not been able to yield any tangible benefits from the prosperity promised by the new world order. The greatest disappointment to the people of the Horn is that the post cold war world order has not produced development, security or political stability. In the midst of failed states that cannot even practice the minimum requirements of sovereignty, they were subjected and hence further compromised by heavy handed, ill-thought-out multilateral interventions that have in some instances aggravated rather than improved the situation (Okoth, 2004: 50).

In terms of ill-considered humanitarian interventions, the US-led UN intervention in Somalia was the epitome of all that could go wrong. Following the collapse of autocratic regime of Siad Barre in Somalia, the country fell into the hands of the main rebel forces, the south based United Somali Congress (USC) and the north based Somali National Movement (SNM). The civil war regained momentum, particularly with the withdrawal of SNM to its northern power base at (Hargesa, the capital of the self declared Somaliland) and the internal power struggle and split of the USC into the factions of Mohammed Farah Aideed and Ali Mahdi. In December 1992, famine and the deterioration of the security situation contributed to the deaths of an estimated 250,000 people. When the ensuing fighting between the Somali factions prevented the delivery of relief food, a US-led UN intervention force code named Operation Restore Hope was authorized by the US administration. The UN version of this was the United Nations Intervention Force (UNIF) which after stiff resistance in Mogadishu became the United Nations Operations in Somalia (UNOSOM I and UNOSOM II). According to Lyons and Samatar (1995:33-34) "The US mission to the United Nations argued that Somalia provided the opportunity to increase UN credibility in peace keeping in the post cold war era, a policy advocated by Bush as part of this New World Order".

Many positive and negative evaluations of the humanitarian intervention in Somalia have already been published. Omar and de Waal (1994) highlighted human rights abuses by the UN intervention forces: Prendergast (1995) reported on the failure of the UN intervention forces to reach out to the Somali peoples: Okafor (1996) described the intervention as an oppression by the United Nations against an African people: Malanczuk (1993) questioned the legitimacy of the use of force by the United Nations: and Williams (1995) focused on the moral dilemmas surrounding the UN intervention and gave detailed accounts of the reasons surrounding the UN failure to fulfill its mandate.

The case of the US led UN intervention in Somali stands as testimony to the failure of neomultilateralism under the new world order to live up to its expectations. According to Prendergast (1995), the UN troops left Somali with more to be done than when they had arrived. In "Toward a Taxonomy of Failed States", Jean-German (1996:469) argued that the new world order enhanced the decay of Somalia and other states such as Rwanda, Liberia and Haiti. These negative aspects of neomultilateralism expose one of the foundations of the new world order, leading some to argue that it is founded on the supremacy of a system of global governance dominated by the United States and what it calls its Western allies (i.e. those countries that emerged victorious from World War II). This distinct post-World War II sentiment has been reinforced by the arrogance exhibited by victorious states the world over, including those which heralded the collapse of the Eastern bloc and the emergence of unipolarity.

Humanitarian intervention has also been justified under the pretext of protecting human rights: sadly, however, there have been reports of UN forces committing human rights abuse against civilians in Sudan and Somalia (Omar and de Waal, 1994). In Sudan, Operation Lifeline Sudan did not contribute to any improvement in the human rights situation either inside or outside the war zone. In fact, reports on Sudan (Africa Watch, 1990:- Amnesty International, 1995: and Merheb, 1995) revealed an unprecedented increase in human rights violation in the war zone, both by government and rebel forces. The greatest failure of Operation Lifeline Sudan was its lax attitude toward human rights violations in southern Sudan while it carried out its mandate of feeding the hungry.

With these points in mind, one cannot help but agree with Okafor (1996:225) in concluding that the failure of UN interventions such as those in Sudan and Somalia can be explained by (1) the structural exclusion and selective application of international law and the involvement of the United Nations in oppression (2) the resultant undermining of the legitimacy of the global system of governance, reduction in the state's voluntary compliance with international normative requirements and (3) impairment of the UNs ability to cultivate local support. The total situation ineluctably results in the perpetuation or multiplication of human misery and oppression.

At least three main conclusions can be drawn from humanitarian interventions in Somalia and Sudan. First, multilateral institutions can neither replace the functions of the state nor reconstruct the state institutions they have directly or indirectly participated in destroying. Second, multilateral institutions often undermine the state's normative rules without offering an alternative with which the populace can identify. Third, most multilateral institutions are undemocratic; thus they do not offer an example of democratic governance to the subjects of the intervention, whom they are attempting to rescue from the tyranny of military dictators or authoritarian regimes. Although humanitarian intervention may save lives in the short run, the long term consequences may include new forms of hegemony and dependence (Okafor, 1996:225).

The states and people of the Horn of Africa have been duly compelled to choose between total collapse through civil wars or political survival with an uncertain future. Both choices have been detrimental to human security and have at times augmented insecurity. One cannot, therefore, assume that the security of citizens has been enhanced as a result of the new world order or its misconceived global security designs. In fact security has either worsened or remained at pre cold war levels. The states of the Horn of Africa have been engulfed in perpetual civil war and famine to the detriment of or causing the total collapse of some states as Somalia. At the same time, failed states increase the prosperity for conflict and social unrest, so that the interplay between state insecurity and citizen insecurity has increased during the Post-Cold War era. In essence, global security as conceived by the new world order has not trickled down to the impoverished people of the Horn of Africa (Salih, 1994).

The manifestations of human insecurity in the post cold war world order can be attested to by examining a number of parameters that show whether the states of the Horn of Africa are better prepared to provide an enabling environment and social safety nets for their citizens, including the satisfaction of their basic needs. Four points should be made clear from the outset; all countries of the Horn of Africa are producers of primary products and are predominant: second, like other underdeveloped regions, the Horn of Africa's agricultural policies have an inherent bias toward cash-crop production to the detriment of food security (Salih, 1994): third, the states of the Horn of Africa are still largely dependent on rudimentary technology and have the lowest per hectare production rates in the world: fourth, invariably, the industrial sector is small (2 to 6 percent of the GDP at most) and overly dependent on imports or capital, technology, and raw materials. If the post cold war world order is to bring desirable changes to the people of the Horn of Africa, the starting point in cementing the ethos of neomultilateralism, market liberalism, democracy, peace and prosperity is to address these issues.

Economically, the countries of the Horn of Africa have not done well even at the macroeconomic indicator level, on which the new global order tends to congratulate itself; *(1)* In 1994, per capita income either declined (Sudan and Somali) or stagnated (Ethiopia, Djibouti and Eritrea) *(2)* Ethiopia is the only

country with improved DDP growth rate (from –10 in 1990 to 9.1 and 1.8 in 1994): all other countries are experiencing negative growth rates *(3)* the 1990 – 1994 data shows that reserves in the months of imports were stagnant, ranging from 0.4 months in Sudan to 1.8 months in Djibouti and 3.4 months in Eritrea to 5.9 months in Ethiopia. *(4)* Ethiopia is the only country that received direct foreign investment (US$100 million) in 1994. The rest are still dependent on dwindling official development assistance (de Klerk, 2007: 153).

The situation in underdeveloped countries shows that a reduced role for the state in managing public risk and opportunity contributes to reduced responsibilities for the redistribution mechanism necessary for replenishing the social capital on which the state depends. A debilitated state that fails in its function (as guardian of the public good as protector of peace and order and as sovereign over its territory) invites social conflict and political instability (Buzan, 1983). A decline of state control over sovereignty also contributes to the decline of the state's capacity to influence national events. It derails its agenda from development to the bare maintenance of peace and order, often by using extra-jurisdiction rules, including the abuse of human rights and even engagement in civil wars as has been described earlier. Both situations as in the case of the Horn of Africa induce insecurity at state and citizen levels.

CONCLUSION

The new world order has brought a shift from external military hegemony to a global conformity that has failed to induce significant changes on the Horn of Africa's regional political dynamics or to improve the mutual security of states and citizens. By and large, discourse has prevailed that has drawn on a dominant discourse that justifies and hence reinforces the making of new enemy images. Moreover, invisible barriers at the national or regional level are manifested in real struggles and wars fought by the dispossessed, the displaced, the hungry and the victims of human rights abuses. We share the view that as far as human security is concerned, the post-cold war order has produced meager changes in lives of the moral majority, which bore the brunt of the Cold War injustices.

In the Horn of Africa, the so-called global unipolarity has been transformed into regional bipolarity represented by secular states (Djibouti, Eritrea and Ethiopia) and Islamic oriented states (Somalia and Sudan). This bipolarity attracts limited global interest because of the regions insignificant economic contribution to and political power in the post cold war world order. In contrast, the secular states have in many ways been used by external forces to contain the Islamic states leading to a conflict situation similar to that of the cold world order as exemplified by the January 2007 incident when the US used Ethiopia to flush out the radical Islamists before launching its own (US) revenge attacks on Somalia (East African, January 15th – 21st, 2007). Finally we concur with Chweya (2004:48) that antagonistic approach to peace and security that mainly involved the accumulation of state power and employment of military solutions to conflict resolution or to the pursuit of national interests has increasingly given way to new cooperative approach depicted in IGAD meditation efforts in the Horn of Africa.

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International Journal for Disaster Management & Risk Reduction Vol. 1 No. 2, **pp** ***X-Y*** July 2008 ISSN: 1992-2744

MUSHROOM PRODUCTION TECHNIQUES AND UTILIZATION FOR ENHANCED FOOD SECURITY IN LAKE VICTORIA BASIN

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Abstract

In many African countries wild mushrooms have been used as food since time immemorial. The technology of mushrooms cultivation is new to Africa. Commercial mushroom growing commenced in countries much later. Farmers became interested because of extra income this venture provided and the nutrition, food security and medicinal aspect. The growing of mushrooms entirely relies on organic residues as substrates such as sugarcane bagasse, banana leaves, saw dust, water hyacinth and maize straw, which are less pollinating to the environment.

This study was carried out in Kakamega and Vihiga districts of Western Province, Kenya, with a pilot mushroom production unit at Masinde Muliro University of Science and Technology (MMUST). The study area has favourable climate for mushroom growing. The results revealed that mushroom growing was a suitable undertaking given the sizes of` land per household. The survey showed that spent mushroom substrate increased fertility when incorporated in the soil. The results show that housing for mushroom growing is expensive but could be made cheaper by using local materials.

Key words:

(1) efficacy of mushroom cultivation, (2) environmental constraints, (3) food security, (4) small scale farming, (5) substrate preparation

Introduction

In sub-Saharan Africa, millions of rural people suffer from chronic poverty, socio-economic marginalization, food insecurity and devastating impact of HIV/AIDS epidemic. Food security – defined as the access of all people at all times to the food they need for an active and healthy life, in Lake Victoria basin was for a long time, naturally maintained by the country' traditional agricultural systems. Agriculture and tourism are the most prominent economic activity, contributing to 75% of all income generating ventures. Kakamega forest is the main tourist attraction due to its varied biodiversity. Food security in the area is therefore of great concern that needs appropriate farming technologies. Mushroom farming is one of technologies whose development for use by the poor farmers in the rural set up could enhance incomes, create employment and increase food availability and accessibility.

However, with rapid population growth and rampant environmental degradation, resultant loss of biodiversity in food production has hardly been adequate. This has caused food insecurity which has at times been mitigated through the use of indigenous foods, traditional vegetables namely: vegetables-of which mushroom is prominent one, cereals, grain legumes, fibre crops, oil-seeds, root crops and animal proteins. Indigenous food crops provide a stable, cheap and locally available source of food to alleviate hunger and nutrition to majority of rural households in Lake Victoria Basin (Sigot *et al*., 2008). Food security is a chronic problem in the Lake Victoria Basin region. This has contributed to rampant poverty and hunger among the residents of this region despite good farming climate. One option is to strengthen the existing means of food accessibility and affordability by turning to the use of indigenous foods. Small-scale mushroom production presents an opportunity for famers and is an option for farmers without

much land. Mushroom production play an important role in managing farm organic and medicinal fungi. The substrate may then be composed and applied directly back to the soil (Sigot *et al*., 2008). However, mushroom production is labour and management intensive. It is completely different from growing green plants. Mushroom do not contain chlorophyll and depends on other plant material (the "substrate") for their food. It takes a considerable amount of knowledge, research, planning, and capital investment to set up a production system. Mushrooms are vulnerable to weed invasions and insect pests.

The study was designed to identify the impact of mushroom cultivation on food security plus the constraints and opportunities facing mushroom farmers in Kakamega and Vihiga districts so as to develop tailor made solutions to address specific constraints. No study has been hitherto conducted to document, validate and develop solutions to address constraints, including environmental, and opportunities in the context of commercial mushroom cultivation for food security in the Lake Victoria Basin region. A gap, therefore, exists to be filled by this study and thus justified Kakamega and Vihiga districts its undertaking.

The overall objective of the study was to investigate the efficacy of mushroom cultivation as an approach towards reducing food insecurity among rural farmers in the Lake Victoria Basin of Kenya by identifying constraints, including environmental, and opportunities in the context of food security.

Literature Review

Mushrooms have been consumed and utilized by African communities for a long time (Munyanziza 2004). Although they form a significant part of the traditional diet in many African families, mushroom eating culture is not widely practiced; in spite of the fact that Africa is home to one quarter of the world's mushroom species many of which could be cultivated. Most widespread mushrooms grow naturally in coastal forests of Kenya and Tanzania (Munyanziza and Olderman 1996). These mushrooms are produced by fungi which live in symbiotic relationship with various coastal trees such as mangroves, miombo woodlands and others (Robertson and Luke, 1993). In the Lake Victoria region mushroom cultivation was introduced in Kakamega district at Shibuye village by the Rivendall Mushroom project and spread to Vihiga in 1999 (Lindstrom and Fergerholm, 2000). Here, oyster mushroom (*Pleurotus ostreatus*) which is very liked by the local community, was used. Mushrooms could be grown by poor households in Kakamega and Vihiga districts in a sustainable way to create a livelihood, improve nutrition and increase women participation in agriculture (Kongere 2007). In Kakamega local communities use, as substrate, sugar cane bagasse, banana fibre, maize straw, and maize`cobs, which after use are put back on the field as good compost (Oteno, 1996). Mushroom compost or spent mushroom substrate has been used elsewhere in the world as popular organic materials to establish and maintain lawns and sports fields, gardens and reclaim land (Findanza, 2007). ZERI (2004) has introduced the use of water hyacinth (*Eichornia crassipis*) as waste materials to spawn mushrooms. ZERI grows oyster mushroom (*Pleurotus ostreatus*) and Reishi mushroom (*Ganoderma lucida*) using water hyacinth as substrate. Nairobi River Basin Programme (NRBP), in collaboration with University of Nairobi's School of Biological Sciences introduced mushroom growing at Ngong Road forest in which sawdust and wood shavings are used to grow mushrooms.

According to KEMGA (2000), the objectives of growing mushrooms should ideally cover: (a) improvement of living conditions of farmers by increasing production and productivity, (b) promoting self-reliance among members in respect of planning, production and marketing, (c) finding solutions collectively to constraints which smallholders cannot personally

achieve, (d) assisting members in obtaining modern technologies and products which are capable of increasing agricultural production and materials necessary for their livelihoods easily at fair prices and (e) improvement and production of value addition on mushroom chains. These objectives did not address the efficacy of mushroom cultivation as an approach towards reducing food insecurity. Hence, such important information for the farmers was overlooked.

Materials and Methods

The study area

The study was carried out in Kakamega and Vihiga districts of Western Province and piloted at Masinde Muliro University of Science and Technology (MMUST). The population in the two districts varied from 886 to 1000 persons per square kilometer. These districts are endowed with well-drained soils and two rainfall season, that is, long rainfall season (March-June) and short rainfall season (October-December). Small scale farming in the two districts is popular due to less land available for large scale farming. Kakamega and Vihiga districts are the most densely populated areas in Kenya. Farmers have very small plots on which to practice farming most of them are dedicated to maize (*Zea mays* L.), indigenous vegetables, bananas (*Musa* L.), tea (*Camellia sinensis*) or sugar cane (*Saccharum officinarum*). The study, involved baseline survey and visits (including on environmental impact of mushroom cultivation), and covered Shinyalu and Ikolomani divisions, both in Kakamega district and Sabatia division in Vihiga district. The two districts (Kakamega and Vihiga) have high agricultural potential with 90% of land in the upper midland 1 (UM1) agroecological zone. The districts lie between 1,300 and 1,800 metres above mean sea level with well drained soils of dystric acrisols and humic nitrisols (Jaetzold and Schmidt, 1983). The districts receive two rainfall maxima from March to June (long rains) and from October to December (short rains). The area receives mean annual rainfall amount of between 1,800 and 2,000 mm, and an average annual temperature of 20.3^{o} C.

Sampling frame and procedure

During field surveys farm households were interviewed purposively to collect the data on mushroom growing using structured questionnaires composed of open-ended questions. Farmers who grew mushrooms and stopped and those still carrying on with mushroom cultivation were subjected to face-to-face interviews. A sample of 40 farmers in Kakamega and Vihiga were interviewed. The data collected comprised demography and farming systems, types of mushroom grown, growing techniques, spawn used and its sources, growing substrates used and information sources for mushroom growing.

During field visits the areas that had production potential of mushrooms and prevalence of mushroom farming activities were purposively selected. A total of forty (40) farmers, 20 from each district, were chosen. Structured questionnaires and in-depth interviews were administered to household heads to obtain data on mushroom production methods, constraints faced and their effect on food security. The key informant interviews were carried out on only 3 out of 30 farmers in Shinyalu and 2 out of 16 in Ikolomani who grew oyster mushrooms in Kakamega and Vihiga districts to establish environmental constraints of growing mushrooms. The data collected from the 5 key informants covered type of mushroom grown, materials used for spawn, substrate storage, housing used, type of mushroom dryers and environment in dark room during colonization.

Pilot project of mushroom cultivation

A pilot commercial mushroom production unit was set up at MMUST in a mud-walled and grass thatched house to simulate on-farm characteristics and where mushroom is cultivated. This unit was suitable for small holder farmers. It compared the suitability of

two locally available substrate materials which used sugar cane bagasse and dry banana leaves. Wheat bran, molasses and lime were supplemented in the ratio of 5%, 5% and 1 % respectively with 89% being soil to enhance colonization and provide necessary nutrients. The substrate was soaked for 30 minutes in a solution of water containing lime and molasses then drained before adding wheat bran. Small polypropylene bags measuring 10" by 15" were filled with 1 kilogram of substrate each. Open ends were then tightly tied using rubber bands and packed in metallic drum with 30 litres of water and placed on metal rack. A metal lid was then fixed and tightened in such a way that it did not allow air flow except through small punctured holes. The substrate was then steamed under pressure for 4 hours, after which the bags were placed in a clean room for cooling.

The surface spawning technique was used to spawn the mushrooms and then incubated for 21 days in a complete dark room with limited ventilation at a room temperature of 25^{o}C to colonize before they were transferred to growing room. Adequate lighting and ventilation were provided in growth room through openings in the house and room temperatures lowered to 20^{o} C. The humidification trenches in growing house were flooded with 40 litres of water every three days to maintain high humidity and misting of the room at same frequency.

Results and Discussion

Demography

Although the land tenure system was freehold the majority of respondents aged between 20 and 30 did not have land title deeds. The average land sizes were found to be between 0.86 and 1.1 ha in Vihiga and Kakamega respectively. The survey established that 20 % respondents owned more than one piece of land which they bought or inherited. The survey further established that only 30% of respondents practiced agriculture in a large scale, the rest were small scale. Most land sizes however, were not adequate to cater for family food needs. There was a decreasing trend of food sufficiency for the preceding 5 years as reported by 80% of respondents. This was caused by low levels of soil fertility inherent in the region due to continuous cropping, coupled with inadequate fertilizer application. The survey found that majority of farmers practiced mixed farming in which they mainly kept local breeds of cows as well as subsistence farming. The survey further established that 75% of respondents interviewed used family labour for planting, weeding and other crop/animal maintenance practices. Such labour was not adequate and often these farmers used hired labour.

Mushroom production

The results established during the survey that 10% of the respondents still grew mushrooms but on a small scale. Others had stopped due to various reasons. Thirty (30) percent were aware of requirements for mushroom growing but found the construction of an ideal mushroom production house expensive. Eighty (80) percent of respondents found Oyster mushrooms easier and inexpensive gourmet mushrooms to grow. Ninety (90) percent of respondents found the local mushroom species ("*obwova*" and "*Shiamechere*") to be tastier than Oyster Mushroom, but the former seeds were unavailable and could only be gathered in the wild. Optimal growing mushroom growing cycle in Vihiga and Kakamega districts were found to be about 70 days with the start of mushroom production varying between 30 and 40 days.

Mushroom production housing

The survey established that houses with double brick walls which were plastered inside were preferred since moisture retention was critical in mushroom growing. Plastic foam sheets were also be used on the walls, while the roofs were thatched with grass, straw, tiles and so on. The space between the roof and wall was completely sealed while the floor was cemented and

sand poured on it and watered to keep the room moist. The shelves were made of double rows to allow for watering and picking space. The polythene bags and wooden trays were found to be popular cropping containers for mushroom growing. The wooden trays were found to be advantageous because the density of fill could be achieved within a room growing space, which made harvesting easier. Ninety (90) percent of respondents preferred black plastic bags, because they were inexpensive portable and easy to dispose. The bags also had the advantage of keeping the mycelium in total darkness during spawn run. Wooden trays were not popular due to high cost of wood.

Constraints to mushroom production

The survey found that the constraints which cut across the mushroom growers included unavailability of quality spawn which affected the yields of mushroom in the two areas; lack of diverse or sufficient mushroom growing information, which made people to rely on the experience of other farmers; and lack of appropriate facilities to grow mushroom, such as sterilization equipment and mushroom house. The survey further found that people preferred local variety to the oyster mushrooms even though the latter were widely disseminated. Other constraints included: pests and diseases and lack of marketing, and spawn quality.

The survey to establish environmental constraints revealed that most farmers used corrugated iron-roofed houses that provided a lot of heat leading to high temperatures and low humidities- conditions that were not appropriate for mushroom growing. The farmers did not maintain the optimal favourable temperatures of between 15 ^{o} C and 25 ^{o} C, which could be achieved by hanging either a wet sisal sack or blanket to moisten the room periodically.

In addition substrates were not put in slant position, as situation that not only reduced sprouting of mushrooms but also increased rate at which substrates lost moisture through evaporation. Most farmers did not have proper housing and dark rooms. This over-exposed substrates and led to their decomposition, which affected the rate of colonization.

Substrate preparation and mushroom production

The survey found that farmers in Vihiga preferred one hour sterilization because it was cheaper in terms of time used and cost of fuel wood. Those in Kakamega preferred the method of substrate preparation because they were effective in destroying micro-organisms and minimized risk of contamination and subsequent yield losses. Seventy-five (75) percent of the response preferred to sterilize their substrates for 3-4 hours in polypropylene bags because they were cheaper as opposed to large sugar sack. The survey further found that farmers in Kakamega used sugarcane bagasse because it was readily available in sugar factories and jugarries. Crop residues were used in mushroom growing because they were only available after harvests. Two popular production methods found during survey were: the long hanging of polypropylene bags and horizontal shelves. The latter accounted for 25% in Vihiga and 60% in Kakamega because it spreads the risk of contamination. It was also good for continuous harvesting due to large number of bags.

The survey found that 5% of farmers practiced tray cultivation and 10% bagasse blocks. The farmers in Kakamega preferred mixing bagasse and banana stalks when growing oyster mushrooms, which they found increased yields. The two media were readily available on their banana and sugarcane farms.

The effect of mushrooms on household food security in Vihiga and Kakamega

The results on the household food security, which implied the supply and accessibility of the household to food it needed for an active and healthy life, found that mushroom cultivation earned them extra income that they used to purchase other foods they needed and as guarantee for credit. Hence, a part from selling mushroom, they ate them for good nutritional values and as extra source of proteins.

Pilot mushroom cultivation at MMUST

The results of pilot mushroom cultivation at MMUST found that colonization was better and faster in sugarcane bagasse than banana leaves, and hence higher yields. Ninety eight (98) percent of 500 bags of bagasse substrate successfully completed colonization without being contaminated as compared to 10% for banana leaves and number of bags. The high contamination rate in banana leaves was attributed to that fact that the banana leaves substrate was exposed to rain and had been stored most for 3 weeks before planting. This encouraged invasion by pathogenic fungi and bacteria (Arnold, 1996). Sugar cane bagasse was stored under dry conditions and had contamination rate of 25%, which was economically viable.

Disposal of used substrates

The survey observed profitable disposal of wasted substrates by the farmers in Kakamega and Vihiga. The substrates were found to have high humus content; hence they were fully utilized by removing the polythene bags and incorporated them in vegetable plantation, thus increasing soil fertility. Some farmers preferred to dry the substrates (bagasse) and use them as fuel in energy saving charcoal stove (jiko). This reduced fuel costs during sterilization process of mushroom growing. This was also a very friendly initiative to the environment.

Common pests and diseases of mushrooms in Vihiga and Kakamega

The survey established that most farmers did not take utmost care at all stages of mushroom production right from preparation. This exposed mushrooms to common pests such as *Sciarids*, *Phorids* and *Macetophila Sp.* and most serious disease called *Trichderma Sp.* Hygiene and sanitation were the necessary control measures for pests and diseases. The survey established that farmers avoided commercial pesticides due to rising concerns over food safety and health risks associated with them.

Conclusions

It can be concluded from this study that land availability and inherent low levels of soil fertility as a result of continuous exploitation with little fertilizer application contributed to decreasing trend of food sufficiency. Ideal mushroom production house was expensive but could be constructed cheaply by using local materials such as mud house thatched with grass, straw and tiles and cemented floor to provide conducive environment for mushroom growing. General lack of information to enable farmers to access modern methods of growing mushrooms and sterilization equipment, ideal and cheap housing, marketing of mushrooms, spawn quality and avoidance of pests and diseases. Corrugated iron-roofed house was not suitable as it raised internal air temperatures and lowered humidities.

It can also be concluded from that study that many kinds of substrates could be used although farmers in Vihiga and Kakamega preferred sugarcane bagasse because it enhanced colonization, thereby resulting into higher yields. Mushroom growing provided extra income in addition to giving good nutritional values to the farmers.

The pilot mushroom in MMUST grown under ideal conditions produced 98% colonization and high yields in bagasse substrate; although careful handling (proper hygiene and sanitation) was necessary to avoid pathogenic fungi and bacteria. infections One way of substrate disposal

was to incorporate residues into the soil to improve soil fertility. The residue would be dried and used as fuel wood to provide energy for sterilization of mushroom growing environment.

Recommendations

More research endeavors are hereby recommended on:

a) the efficacy of mushroom cultivation in the wider Lake Victoria region;
b) identifying constraints and opportunities that pertain to food security in the context of food security;
c) effect of mushroom cultivation on household incomes, employment and food security via establishment of pilot project within MMUST and the local community to validate various constraints and opportunities.
d) the best methods to dispose wasted substrates
e) different materials to use as substrates, for example, wood shavings, water hyacinth, and others.
f) various pests and diseases of mushrooms grown in the Lake Victoria Basin.
g) identification of wild mushrooms and their domestication for food security
h) marketing opportunities for different types of mushrooms grown in the Lake Victoria region.

Acknowledgement

The authors are grateful to the farmers Mr. Amos Lusega, Mrs. Racer Makokha, Mr. & Mrs. Electine and Stephen Shamalla and Mr Innocent Khabamba for their active participation during the data collection. The authors are indebted to MMUST for availing funds for this study.

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International Journal for Disaster Management & Risk Reduction Vol. 1 No. 2, **pp** *X-Y* July 2008 ISSN: 1992-2744

REMOVAL OF COLIFORM AND SOLIDS IN A TROPICAL CONSTRUCTED WETLAND

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ABSTRACT

Pilot scale studies were conducted to determine the performance of a subsurface horizontal flow constructed wetland in the tropics in the period April to July 2003. The wetland located at Jomo-Kenyatta University of Agriculture and Technology (JKUAT), Kenya, had sewage treatment works consisting of four cells set in parallel each 22.5m^2. Three of the cell had gravel and in two of the cells with gravel the tropical macrophyte *Cyperus Papyrus* was introduced. The wetland received a continuous feed of settled sewage from a primary facultative pond. Performance of the wetland was evaluated in terms of removal of bacterial pathogens and suspended solids. This was done under different hydraulic loading rates. Fecal coliform removal in the wetland of up to three log units was realized. The removal was found to be influenced by the influent coliform count and not the hydraulic retention time. When fecal count in the influent was less than or equal to 2 log units 99.9 % removal was realized. A moderate removal rate of up to 50 % for Total Suspended Solids (TSS) was obtained. The loading rates deduced from the study for TSS was 122 Kg/Ha.d.

Key Words: *Alternative wastewater treatment, Subsurface horizontal flow (SSF), Macrophyte*

Introduction

In the field of wastewater treatment, the three categories of human enteric organisms of greatest consequence in producing disease are bacteria, viruses and amoebic cysts (Tchonabouglas, 1990). One objective of wastewater treatment is to eliminate these pathogenic organisms, from the wastewater. Unfortunately, these organisms, which are highly infectious, are responsible for many thousands of deaths each year in areas with poor sanitation, especially in the tropics. The need for utilizing cheap, effective, alternative technologies such as constructed wetlands in wastewater management is essential in such circumstances (Okia, 2000). Several study reports have demonstrated the potential of natural and constructed wetlands in reducing the population of various types of pathogens to very low concentrations and with reduced public health risk. Based on reduction in indicator species, pathogens are thought to be removed in both surface flow (SF) and subsurface flow (SSF) wetlands (Watson et al, 1989; Gersberg et al, 1989). Performance data for small municipal constructed wetland systems in North America and Europe showed reduction in coliform ranges from 82 % to nearly 100 % (Watson et al, 1989).

The processes responsible for the reduction of pathogen population in wetland treatment systems are known to be controlled by a combination of physical, biological and chemical factors (Gersberg et al, 1989). Viruses may be adsorbed by soil, the treatment media and organic litter, or deactivated because in time they die when outside the host. Bacteria are removed by sedimentation, ultraviolet radiation, chemical reactions, natural die-off, exposure to biocides released by the plant roots, and predation by zooplanktons. The contribution of each of the above routes is suggested to be a function of wastewater flow rates, nature of the macrophytes and type of the wetland.

A potential problem of suspended solids is that they can lead to the development of sludge deposits when untreated wastewater is discharged in the aquatic environment. In the Subsurface flow (SSF) wetlands, wastewater suspended solids are removed primarily by filtration through the substrate media.

Objectives of study

The specific objectives of this study were;

(i) Determination of fecal bacteria and Total suspended solids removal efficiency, in a subsurface horizontal flow constructed wetland under tropical conditions.

(ii) Determination of the effect of hydraulic loading/ hydraulic retention time and the fecal coliform decay rates, in a single cell subsurface flow constructed wetland.

Materials and method

The pilot wetland was built in such a way that only controlled and measurable quantities of wastewater and rain were the inputs into the system. The wetland consisted of four cells set in parallel, each with an area of 22.5m^2. The macrophyte *Cyperus papyrus* was introduced into two of these cells in the month of October, in 2002, using clumps at a spacing of 0.75m by 0.75m. Prior to the planting of the macrophyte, wastewater had been introduced in the wetland in the month of September.

The wetland cells were 7.5m long and 3m wide (Fig 1). They had vertical sides and a bottom horizontal slope of one percent. Cells a, b, and d were filled with gravel to a depth of 0.6m. The gravel ranged in size from 9-37mm, with a porosity of 45 % and a hydraulic conductivity Ks = 4050 m^3/m^2.d. Cells a and d were vegetated while cell b was unvegetated and cell c was a pond. Cells b and c acted as the control.

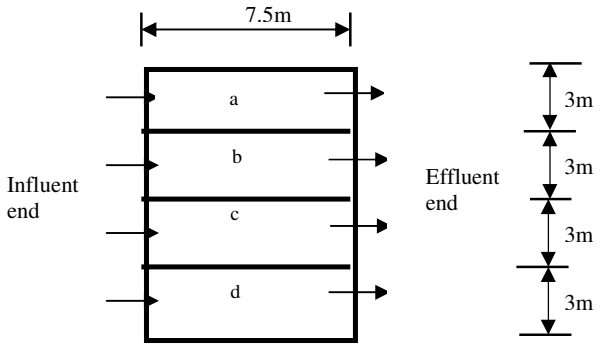

Figure: 1 Plan layout of the pilot scale constructed wetland.

The experimental work on performance evaluation of the wetland for pathogen removal was based on the use of indicator organisms, specifically fecal coliforms as described in standard methods (APHA, 1995). Influent and effluent samples used in the investigation were grab samples taken weekly at between 0700hrs-0900hrs, as wastewater was continuously loaded into the wetland cells. Sampling involved:

(a) Determining the flow rate at the inlet and outlet of the cells: Volumetric method- using a beaker and stopwatch.

(b) Sampling at the influent point of the cells using cleaned/ sterilized glass containers.

(c)Taking effluent samples from each of the 4 cells using cleaned/ sterilized glass containers

Sterilized glass bottles were used for sample collection throughout the study period. The membrane filtration technique was used. In the laboratory, sample sizes were determined according to standard method recommendation for secondary effluent. The samples were filtered through a cellulose nitrate membrane filter of a pore size of 0.45µm after which the membrane was placed on an absorption pad soaked in lauryl sulphate tryptose broth solution. Samples were incubated at 44$\pm$0.2^{o}C hrs for 24 hrs and thereafter, all characteristically yellow

colonies were counted as fecal coliforms. The results were expressed as number of organisms in 100 ml of the sample. Determination of the total suspended solids was through gravimetric method- filtering with GF/A filter paper and residue dried at 103-105^{o}c.

Experimental results

The pollutant concentration ranges in the wastewater fed into the pilot scale constructed wetland are given in Table 1.

Table 1: Pollutant concentration range in the primary facultative pond effluent at JKUAT treatment works (April-July 2003)

Parameter	Mean*	Standard Error	Range
TSS (mg/l)	57.6	5.7	26.5-96.8
FC (Count /100ml)	1415	799	150-8250

*(Mean based on 15 sampling occasions)

Fecal coliform removal

High influent and effluent fecal coliform counts were observed after rainfall events. Effluent fecal coliform concentrations from the pilot scale constructed wetland are given in Table 2.

Table 2: Fecal coliform effluent concentration range from the wetland cells

Cell	A	B	C	D
FC (Count/100ml)	0-1250	0-550	100-2750	0-900
Mean*	125	65	640	135
Standard error	156	54	260	96

*(Mean based on 15 sampling occasions)

The average percentage Fecal coliform removal from the pilot scale experiment is given in Fig. 1 The control cell b exhibited higher removal than the rest of the cells.

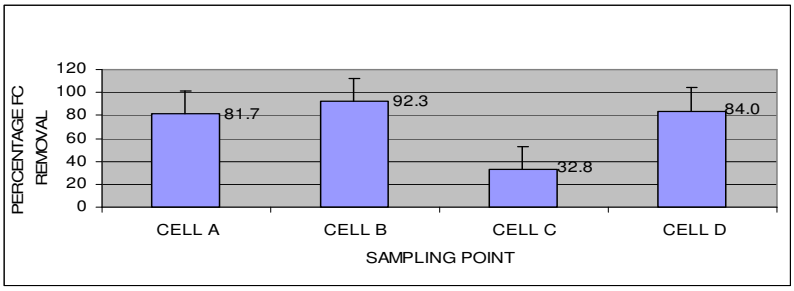

Figure: 1. Average percentage fecal coliform removal

Effect of hydraulic retention time on fecal coliform removal was evaluated using data generated during sampling, at the different hydraulic loading rates applied. The Fecal coliform count in the effluent from the pilot scale experiment did not appear to depend on the retention time as depicted in Fig 2 a-c below. Equally, it was not analytically possible to determine the coliform decay rates using the experimental data.

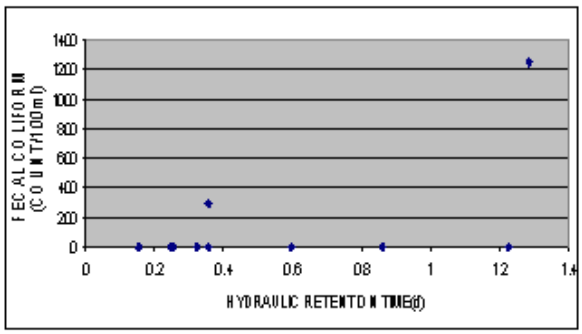

Figure: 2 a Fecal coliform count in the effluent of cell a Vs hydraulic retention time

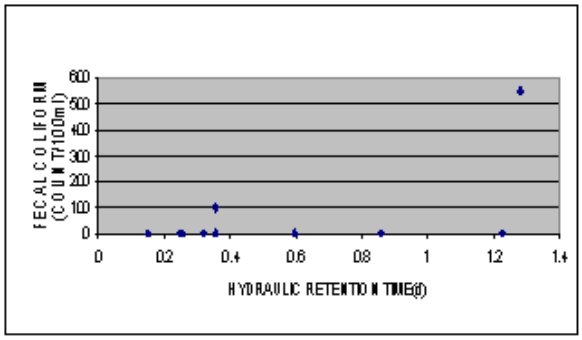

Figure: 2 b Fecal coliform count in the effluent of cell b Vs hydraulic retention time

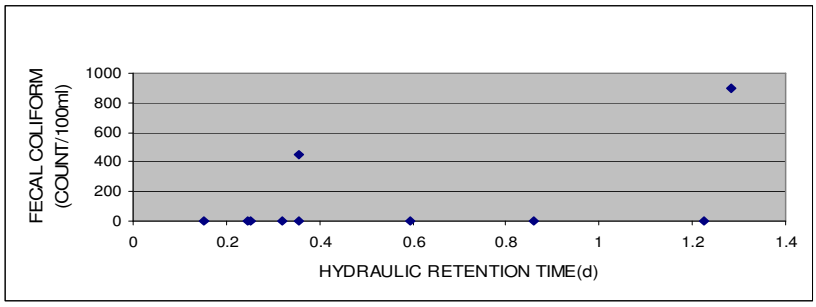

Figure: 2 c Fecal coliform count in the effluent of cell d Vs hydraulic retention time

Total suspended solids (TSS) removal

Table 3 shows the TSS effluent quality ranges from the pilot scale cells.

Table 3 TSS effluent quality ranges in the pilot scale experiment

Cell	A	B	C	D
Effluent TSS(mg/L)	1-66.5	1-62	13-80	2-75.5
Mean*(mg/L)	31.3	29.5	47.1	32.5
Standard error of mean	5.4	5.3	5.2	5.6

*(Mean based on 15 sampling occasions)

Moderate removal rates were observed for TSS as depicted in Fig 3. Cells with gravel had better removal than the control c which had a pond format. However the difference in performance among the cells with gravel (a, b and d) was not significant statistically at 5% significant level

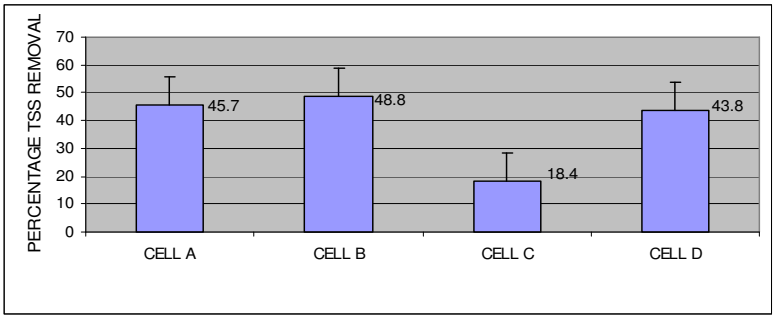

Figure: 3 Average percentage TSS removal in the pilot scale experiment

The influence of the mass loading of TSS on its removal rates in each of the cells was evaluated graphically as shown in Fig 4(i-iv). The mass loading rate was computed as the product of influent pollutant concentration and the hydraulic loading rate. All the cells had a positive correlation between the loading rate and removal rates.

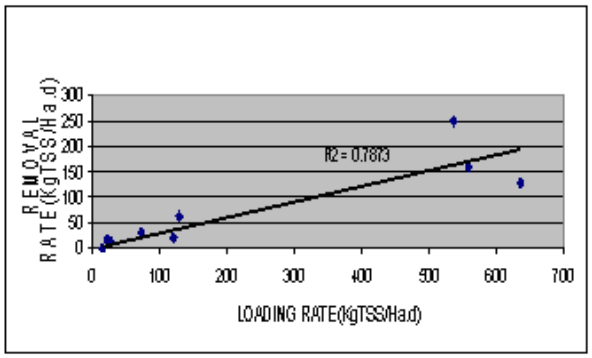

Figure: 4(i) TSS removal rate vs loading rate for cell a

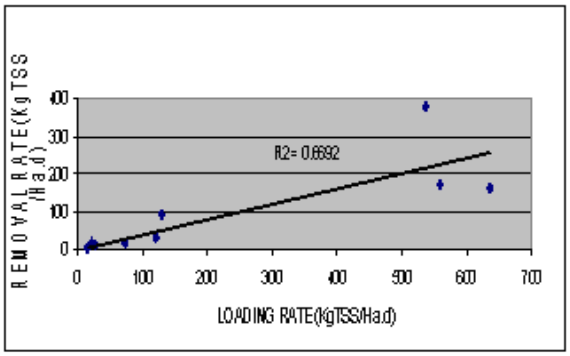

Figure: 4(ii) TSS removal rate vs loading rate for cell b

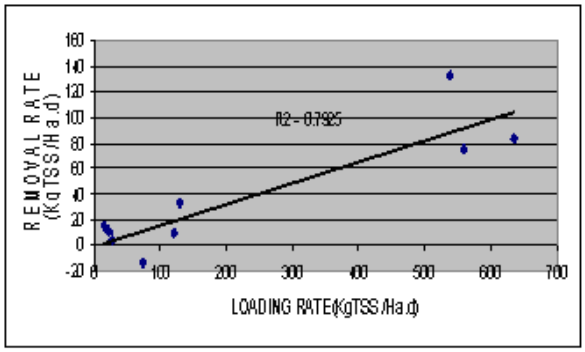

Figure: 4(iii) TSS removal rate vs loading rate for cell c

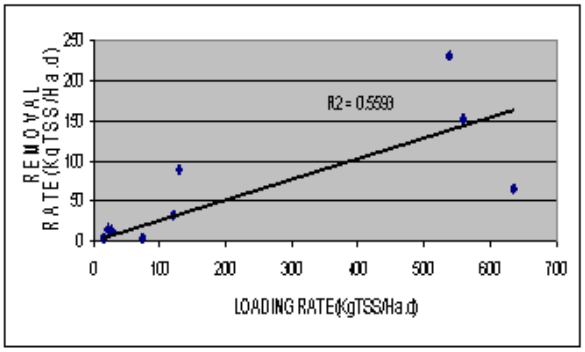

Figure: 4(iv) TSS removal rate vs loading rate for cell d

The maximum applied loading rate at which a linear relationship between loading Vs removal rate was sustained was adopted as the loading rate value for the cell. A TSS loading rate of 122 Kg/Ha.d was determined for all the cells.

The individual retention times for each cell were computed and values plotted against the corresponding percentage TSS removal in each cell as shown in Fig 5.(a-c). No clear pattern was observed in this case, suggesting that filtration, which is the main TSS removal mechanism in constructed wetland

and gravel beds is not entirely time dependent.

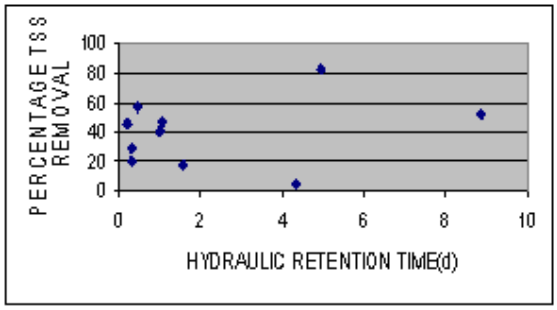

Figure: 5.a Percentage TSS removal Vs hydraulic retention time for cell a

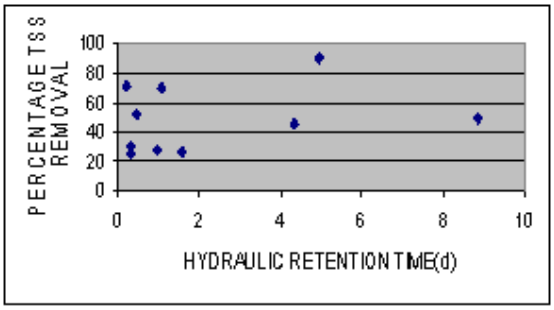

Figure: 5.b Percentage TSS removal Vs hydraulic retention time for cell b

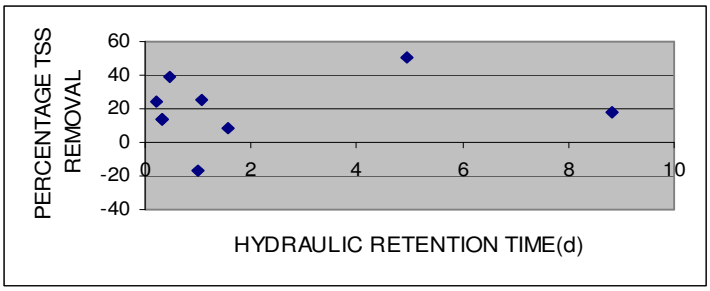

Figure: 5.c Percentage TSS removal Vs hydraulic retention time for cell d

A regression equation was fitted to quantify the removal of TSS in the wetland based on information obtained for the vegetated wetland cells from the pilot experiment: $C_e = 0.10\ C_i^{1.35}$, within the following Limitation; 26.5 mg/L<C_i<96.75mg/L, 0.05m/d<q<1.18m/d, N=15, R^2= 0.3 Where, C_e = Effluent TSS concentration, C_i = Influent TSS concentration, q = Hydraulic loading rate

Discussion

The variance in fecal coliform removal observed in the effluents of the pilot scale wetland cells, demonstrates the role played by the substratum-root matrix in fecal coliform removal. Higher fecal counts were determined in the effluent of cell c (which had a pond format) compared to the effluent of cells a, b and d. These observation may be explained by the strong interaction that existed between the flowing wastewater and the gravel media in cell b and gravel root-matrix in cells a and d. This promoted the physical processes, namely entrapment and attachment through which the fecal coliform are removed. These processes also identifiable with the removal of suspended solids, together with other subsequent chemical and biological degradation processes are responsible for the reduced fecal coliform numbers in cell a, b and d. These interactions are either non-existent or minimal in the free water column. Consequently the possible pathways were diminished, hence the high fecal populations present in the effluent from cell c. From these observations it can be concluded that maximum interaction between substratum-root matrix and wastewater is necessary for increased reduction in fecal bacteria. Channeling and surface flow would significantly reduce the performance of a subsurface flow wetland system.

The averaged percentage coliform removal in the unvegetated bed was higher compared to that of the vegetated gravel bed. This is attributable to the fecal coliform partitioning in the total suspended solids of which better removal was observed in the unvegetated cell.

The typical removal efficiencies obtained in the gravel beds during the course of the study (> 99.9%) are only comparable to those reported for activated sludge systems and stabilization ponds. The wetland system however, have the advantage of low investment and operating cost, and hence a viable alternative system of wastewater treatment.

Filtration, which is not entirely time dependent, was the main mechanism responsible for the removal of suspended solids as depicted in Fig 5. (a-c). Removal of this pollutant was significant as far as secondary treatment of domestic wastewater. The analysis done for TSS loading rate gave values of 122 $KgHa^{-1}day^{-1}$. This highlights the potential of subsurface horizontal flow constructed wetlands to polish pretreated wastewater with minimum area (land) requirements in the tropics.

Conclusion

Subsurface horizontal flow constructed wetland systems can effectively remove Fecal coliform and total suspended solids in pretreated domestic wastewater under the tropics conditions.

The empirical relationships developed in this study can be used in the rational design of subsurface wetlands for conditions similar to the ones under which this study was conducted. More work needs to be undertaken to establish scale related relationships and confirming the likely maintenance schedule for the wetlands.

Acknowledgment

The authors would like to acknowledge Mrs. Purity M. Kibetu of the Department of Civil engineering, Jomo Kenyatta University of agriculture and Technology (JKUAT) for kindly allowing them to use her pilot scale subsurface horizontal flow constructed wetland to conduct the pilot study.

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International Journal for Disaster Management & Risk Reduction Vol. 1 No. 2, **pp** ***X-Y*** July 2008 ISSN: 1992-2744

PSYCHOLOGICAL AND SOCIOLOGICAL IMPACT OF DISASTERS: VICTIMS AND INTERVENERS

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ABSTRACT

The purpose of this paper is to show the psychological and sociological impact of disaster on both victims and interveners. The objectives were to examine the impact of disasters on victims and interveners. Method used was library research of studies conducted in disaster areas and experiences of the authors. The interventions used to assist those who suffer psychologically and sociologically as a result of a disaster include reduction of stress of the environment, counselling services, Critical Incident Stress Debriefing (CISD, Outreach services, Consultation services, Follow – up services, Community education and formation of Support groups and compensation are also discussed. Findings show that people suffer psychological effect that is usually hidden but has far reaching implications on the mental well being of those affected by a disaster. The sociological impact is also discussed as it is necessary for the healing of the victims and the interveners.

Keywords*: stress, trauma, impact, mental state, depression*

Introduction

Disasters leave psychological wounds that are often hidden, long term and wide spread (Norris *et al* 2002). Disasters can cause serious mental health consequences for victims who take the form of Post Traumatic Stress Disorder (PTSD) and others which have been less investigated (Gibbs 2006). The physical impact of a disaster is visible; however, the psychological impact is not so eminent.

Disasters include duration, loss of personal life, property damage, helplessness, gruesome sights, personal injury and injury to loved ones, displacement from one's home, availability of social support and sounds and smells. These factors may differ in a flood as contrasted to an earthquake, bomb blast or fire or between one victim's experience and the other.

Traumatized individuals take time to heal and sometimes hiddenly. The affected individuals often develop into survivors who at times are assisted by the community to heal.

Disasters cause emotional stress and trauma, destroy homes, businesses and damage agriculture. They jolt economies and markets at times causing an economic imbalance in society and reducing people to paupers.

PSYCHOLOGICAL PERSPECTIVE

Psychological Trauma

Psychological trauma overwhelms an individual's ability to cope and leaves that person fearing death, annihilation, mutilation or psychosis (Kim 2006). The individual is physically, emotionally and cognitively overwhelmed. A person may develop a number of emotional problems depending on the impact and experience of the individual. Factories burning down due to bursting of a boiler or bomb blast that occurred in Kenya and Tanzania in 1998 leaving two hundred people dead and several others injured, affected many families. The effect is that every anniversary people want to view the place where the disaster occurred so as to remember their loved ones (Daily Nation 2006).

Psychological support deals with basic human feelings and needs such as shock, loss, bereavement and powerlessness. Psychological trauma is a very common phenomenon after any disaster. People are traumatized, shaken and desperate to talk.

Professional helpers are accessible and survivors are willing to talk about their experiences. A study conducted after a flood revealed that although many appeared to be coping well seven years later, they still revealed their hidden wounds when they were interviewed (Echterling 2006). The survivor has to cope with the constant reminder of traces of distraction, the economic hardships and losses that continue even years later.

Echterling (2006) revealed that nearly all of the victims reported post traumatic stress symptoms which included re- experiencing trauma, avoidance to cut out the memory completely and to reduce anxiety. These symptoms decreased over time but some were deep and enduring, for example, 37% of direct survivors still reported these symptoms seven years later. This can be linked to bomb blast victims in Nairobi Kenya who still mourn 8 years later and view the event as if it occurred only yesterday. The anniversary of this disaster evokes vivid memories of the incident and spurs reflections on its meaning and place in one's life (Daily Nation 2006,). It prods one to review changes that have taken place during the year which stirs the original feelings and reactions to reemerge. For some survivors, the anniversary is accompanied by feelings of frustration, hopelessness and disappointment because they must acknowledge their situation which could be long lasting problems or permanent ones for those who were maimed and were disabled by losing their eye sight or parts of limbs. It is argued here that it is not only those who survive that encounter all these. Friends, relatives and other members of the community also experience some form of guilt, anxiety, fatigue and other symptoms of post traumatic and chronic stress. Clergy who are more directly involved suffer psychological wounds. Bradfield et al (1989) showed that 69% complained of fatigue, 53% felt burn out and 66% reported feeling guilty about not doing enough for the survivors. Echterling *et al* (1992) state that six years later, clergy reported that the long term impact includes distress and pain. This indicates that the distinction between disaster helper and disaster victim is minimal because everyone becomes a survivor of the disaster. Echterling (*ibid)* further posit that many appeared to be coping but revealed hidden wounds during the follow-up interviews.

A study was conducted on subjects from Belarus a region that was affected by the Chernobyl disaster and another socio-economically comparative but unaffected region in the Russian Federation where the reactors of a nuclear power plant exploded causing radioactive contamination (Havenaar *et al* 1997). People suffered from health problems which were linked to psychological stress related to the disaster. Findings showed that the Chernobyl disaster had a long term impact on psychological well being, health related quality of life and illness behaviour (Havenaar et al ibid). In another study conducted in 1979 after the nuclear reactor in Pennsylvania exploded, findings showed that psychological distress can be measured six (6) years after the event.

Arnette (2005) states that after tsunami in Southeast Asia, "you could literally walk into entire villages that would be permeated with the smell of death just because of the extent of destruction. It is a life changing situation because of seeing and smelling death." This was said after experiences from Rwanda genocide, the collapse of World Trade Centre in New York and earthquake in India.

Psychopathology resulting form disasters

Studies on Post Traumatic Stress Disorder (PTSD) (APA 2000) have shown that victims re-experience the traumatic event usually in a flashback or nightmares. Some avoid situations and stimuli that could awaken the trauma by numbing ones feelings or withdrawing from others. Others experience sleep difficulties, irritability and find difficulties in concentrating.

According to Norris et al (2002a), 36% of the respondents suffered from depression, the second most common psychiatric problem. Anxiety showed 32%, while health concerns showed 23%. Alcoholism and drug abuse were also found to rise after a disaster although they were not fully investigated.

It has been observed that people who first respond to disasters and disaster workers are at special risk for PTSD and other negative emotional consequences (Gibbs et al 2002a). Workers who dealt with the aftermath of the September 11th disaster of the World Trade Centre showed that they had very high levels of stress due to working with dead bodies and body parts, which defines to horror. Gibbs (ibid) further argues that disaster workers' experience of a disaster is more long term than that of the victims, for example when they dig into the rubble and do not find people nor bodies that could be identified, they experience helplessness and lack of control.

SOCIOLOGICAL PERSPECTIVE

People generally adapt to the situation after the disaster, for example, they experience panic, wander aimlessly and being dependent. This could be seen to be true in the case of the 1998 bomb blast whereby some people wandered and found themselves in areas they had not planned to go.

People lose personal belongings or jobs which results into widening of trade or government budget deficits, increased poverty, high dependency ratio, disability due to maiming or burns, stigma due to cultural beliefs which in some communities suggest that it is a punishment for wrong doing, loss of land crops, ill health or death in the family or working partners. Others contemplate suicide as they feel the disaster was a warning and therefore they do not deserve to live.

Norris et al (2002a) state that 13 of the 14 samples, which investigated socio-economic status and lower income showed that lower economic status was associated with increased post-disaster distress. Individuals who live in poverty tend to have fewer resources available to them to pay attention to the effects of disaster. They ignore consequences which later lead to explosives within them, depression or psychiatric problems.

It was noted that middle aged adults appear to be the most affected group by disasters. This age group may have more burdens and stresses such as caring and providing support for a family in the aftermath of a disaster (Thompson *et al* 1993). Expectations are high as they are considered more able to provide financial, emotional and physical support to the victims.

Social network characteristics also influence vulnerability, for example, lack of social support may lead to greater post disaster distress (Udwin et al 2000). These risk factors do not operate in isolation but interact with other variables such as gender and ethnicity. Ethnicity is cited as a factor in the developing world in managing post disaster stress (Norris et al 2002a). People tend to cluster around their own ethnic groups for support, as they tend to distrust other groups. This was evident during the ethnic clashes in Molo and other parts of Rift Valley in Kenya (Daily Nation 2006). Survivors tend to seek emotional help from relatives, neighbours, friends or clergy.

Gender

Norris (ibid) state that 94% of 49 studies have shown that female survivors of disasters were more seriously affected than were the males. This view was supported by Belle (2000) who postulates that women more often live in poverty than men in post disaster adaptation. This can be explained in terms of gender differences in expressing their feelings or emotions. Nolen - Hoeksema (1990) argues that women are more likely than men to acknowledge psychological symptoms and to report them. Males may suppress feelings of psychological distress because of the

expectation that men must be strong and capable (Wolfe & Kimerling 1997). Men are more likely to express their feelings through alcohol and drug abuse rather than showing symptoms like depression and anxiety (Myers *et al* 1984). Women are more likely to show higher rates of depression and anxiety disorders than men. They expect to be supported but when it fails they suffer from depression. This puts them at a higher risk for disaster related distress. It has been observed that men cope using individual and immediate decision-making mechanisms while women use their social network to process and work through problems Kawachi *et al* 2000). Women's PTSD symptoms have been shown to increase as their available social support decreases, a finding which does not work the same for the men (Pulcino et al 2003).

In the traditional set up women's roles have been those of care giver, a role which may lead to increased stress levels in the aftermath of a disaster. The extra stress of taking care of children and the home may fall entirely on them. Norris et al (2002a) posit that being a mother was associated with higher disaster related distress, as they are more likely to provide care for others besides their children. Women engage more in collective behavior than men and when they provide this support they are further exposed to the trauma through contact with others (Wayment (2004). It is very devastating for the woman when she provides support services to others after a disaster but does not get an equal amount of social support back especially in coping styles (Wayment ibid).

Cultural influence has an effect on coping mechanisms of minority groups. Members of a minority who may have experienced discrimination, prejudice or oppression can be more psychologically vulnerable on how to express their trauma. Allen (1996) suggests that the African Americans who have had oppressive experiences may become hyper vigilant to perceived threats and this in turn could result in the expression of traumatic symptoms. This was evident during the Katrina Hurricane in Atlanta, USA (Daily Nation 2006). Expression of PTSD in response to a disaster is culturally consistent. Among the African American and Latino cultures, family ties are emphasized and there is strong reliance on the family for social support (Chia et al 1994). Disruption to the family or social network can lead to loss of available support for minority group members, which leads to increased stress that comes with the obligation of tending to others' needs. This situation also leads to loss of outside sources of support (Kaniasty & Norris 2000). This can be argued the same for families in the African context as we look up to the extended family for both material and emotional support, failure of which leads to stress.

Fatalism, a tendency to attribute the causes for things to God, may lead to poor psychological outcomes in response to distress because one's personal power is perceived as minimal. Lee (1999) found that African American and Hispanic students often received information about the cause of the hurricane that was inconsistent with western science but sometimes consistent with fatalism. Belief in fate hampers preventive measures as people feel there is nothing they can do about it. This leaves the groups more vulnerable as they tend to do nothing and leave everything to fate when they could possibly have done something to avert the disaster or escape in due course.

APPROACHES/INTERVENTIONS

Reduce the stress of the environment

Emergency preparedness entails avoiding constructing houses in flood prone areas such as Kano plains in Nyando, and Budalang'i Busia Kenya, influence administration to persuade insurance to provide cover or prompt payments of benefits to the victims after the disaster. Psychology should also be involved in the planning efforts.

Secondary prevention

Psychologists should conduct rapid screening after disasters and begin interventions immediately for the affected families to express their grief so as to reduce stress. This was applied in Kenya after the bomb blast and New York plane crush on the World Trade Centre (Daily Nation 2006, Gibbs 2002).

Traditional psychotherapy requires victims to revisit the trauma of the disaster experience. Victims confront their feelings about their experiences. Visiting the site of the disaster re kindles the memories and when they cry and talk about it, it has a therapeutic effect. This has been practiced in many traditional set-ups in Kenya.

Norris *et al* (2002a) postulate that tertiary prevention in the Caplan model involves preventing further deterioration of those already emotionally disturbed. It is multi-dimensional and could be best applied to many more situations of disaster management (Gibbs 2002).

Community education

Community Education should involve public media, newspapers, television and radio stations to provide information on managing stress, handling reactions of children and preparing for possible disasters in future.

Outreach services

Interveners make their services easily accessible and available by going to disaster sites, emergency shelters and assistance centres (Echterling 2006). Interveners must frame their services in acceptable terms for example, 'to hear the survivors story' and offer information, support and help in handling the stress. If a survivor tells a story it is a healing experience that should be counted as necessary. The survivor gets a chance to face and acknowledge, accept and ventilate emotions. This process aids the survivor to recognize the magnitude of what has happened and its consequences. Listening to this story helps the survivor to cope with the events and feel less alienated. Non professionals should be trained to become outreach workers. They can identify families in distress who need referral or formal counselling. They help survivors handle stress in a healthy and positive way.

Provision of counselling services is another form of intervention. Most counselling approaches tend to be solution focussed with an emphasis on the victim's strengths and finding appropriate solutions to the problems they face. However, active problem solving strategies are more effective than passive ones, because there are no good solutions to the crisis regardless of the individuals coping strengths. There is a perception that needing and taking help from a counsellor is stigmatizing (Wosyanju 2005, Jenkins 1998).

Critical Incident Stress Debriefing (CISD) a model developed by Mitchell (1982) has been adapted lately as it has received great attention. It is applied to victims, family members and rescue workers. It involves introduction, facts about what happened in the crisis, thoughts, feelings, symptom, teaching/information about stress and stress management and re –entry (Mitchell & Everly 2000).

Financial support through settlement of medical bills, material resources and infrastructure social networks, coping style resources which vary according to gender and culture could be adopted. Resource support can assist families to relocate to temporary housing or locate a missing family member.

Consultation services

This involves consulting with the areas emergency services, volunteer disaster workers, schools, churches and community agencies. Support focuses on the personal needs of the survivor while training handles the stresses of a disaster. Helpers can monitor and manage their own stress to avoid a situation of 'two victims' instead of one. Interventions should collaborate with clergy and others to give meaning to these experiences. Consultation with school

officials can address how to meet students' immediate emotional needs when they return to school, but also to prevent absenteeism and poor academic performance (Echterling 2006).

Follow – up services

Disaster counselling programmes are usually short term and interveners may fail to appreciate the impact of chronic stress. Survivors' chronic stress requires ongoing information, support and counselling. Survivors are not responsive to follow-up efforts if the relationship is not based on trust and acceptance. Survivors should be helped to cope with 'anniversary effect' by focusing on inspirational memories they have, positive experiences and changes that have occurred and realistic challenges they face.

Support groups

Interveners should organize support groups for survivors to give them opportunities to share their stories with one another to exchange information and ideas, to offer encouragement and support one another. By sharing experiences, they realize they are not alone in having these chronic stress reactions. They practice interpersonal skills such as self disclosure and assertion.

Conclusion

Disasters can cause severe psychological disturbance with many victims experiencing PTSD, depression and anxiety. Disasters leave psychological wounds that are often hidden long term and wide spread. Disaster interveners help all survivors to carry on recovery process by providing outreach, consultative, support and follow –up interventions. Few interventions have been developed for the needs of children and thus there is need to address these interventions to their parents. Interveners and victims are both affected psychologically and sociologically.

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International Journal for Disaster Management & Risk Reduction Vol. 1 No. 2, **pp** ***X-Y*** July 2008 ISSN: 1992-2744

THE ETHICAL DILEMMA IN HIV TESTING: VOLUNTARY COUNSELING AND TESTING (VCT) VERSUS COMPULSORY TESTING

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Abstract

In September 2000, the United Nations Millennium Summit agreed on a set of time bound and measurable goals aimed at combating poverty, hunger and other social ills. The sixth goal of that Millennium Summit is to combat HIV and other diseases by 2015. The Summit, among other things, recommended HIV testing to be scaled up. Due to the rising number of new infections world wide and due to the number of patients presenting late at health facilities with advanced HIV, calls have been made for a more pragmatic approach to containing the disease, with mandatory testing gaining increasing attention.

This paper examines the ethical dilemma involved in mandatory HIV testing by arguing that although it may be of utilitarian value to the society, it involves infringement on the patients' human rights, particularly, the right to privacy. Consequently, the paper recommends that, although, HIV testing is crucial for effective prevention, making it mandatory may not be feasible. What is important is the removal of the key barriers to HIV testing including the lack of access to ARV therapy, the inadequate health workforce, the culture of poor use of health services and the widespread stigma and discrimination associated with HIV.

Keywords*: HIV, HIV Testing, Compulsory HIV Testing, Utilitarianism.*

Introduction

As the AIDS epidemic continues to claim lives, the issues of testing, confidentiality, and refusal to care for seropositive patients generate increasing debate and concern among health care workers, legislators, and the general public. Protecting the uninfected from exposure to HIV, providing adequate medical care and counseling to HIV-positive persons, and preventing discrimination are necessary and immediate goals.

It is a truism that effects of HIV are felt all over the world. As Musa Dube (2003: vii) writes:

> *Given that HIV/AIDS affects everything and, I want to believe, everybody, the strategy adopted for the struggle against this epidemic is "a multi-sectoral approach". This means that HIV/AIDS is everybody's business. Each individual, institution, community, religion, department, sector, ministry, discipline and, indeed, each nation must address…the struggle against HIV/AIDS.*

Central to the above quotation is the view that "HIV/AIDS is everybody's business." Dube's argument is that irrespective of discipline and orientation, we "must address…the struggle against HIV/AIDS." The foregoing fact was captured by// the September 2000 United Nations Millennium Summit which agreed on a set of time bound and measurable goals aimed at combating poverty, hunger and other social ills. The sixth goal of that Millennium Summit is to combat HIV and other diseases by 2015. The Summit, among other things, recommended HIV testing to be scaled up.

All of us agree that HIV testing is an important intervention, and that all people should have access to HIV testing. We are in general agreement that we should also know our status; but we don't agree on how testing should be initiated and conducted. That it is important to scale up HIV testing is not a point of contention; however, diverging views exist concerning the question of how testing should be done. Epidemiologic studies involving HIV (human immunodeficiency virus) antibody testing create ethical dilemmas, particularly about

notifying asymptomatic seropositive subjects. Four study designs address this problem: mandatory notification, optional notification, anonymous testing, and blind testing. No single design consistently optimizes the trade-off between valid and ethical research. Each strategy differs substantially from the others in its effect on response rates, bias, ability to perform longitudinal studies, numbers of subjects who learn their test results, and the number of subjects counselled about HIV risk reduction (Gostin and Curran: 1987). The above four methods can be condensed into two. The first is Voluntary Counselling and Testing (VCT) and the second Mandatory HIV testing (MHT).

Voluntary Counselling and Testing (VCT) entails individuals making informed choices to go for HIV test without being coerced by anyone to do so. However, many writers including Richard Elliot argue that VCT has failed since it is not rapid and efficient enough given the urgency of scaling up access to treatment. He claims that making testing routine and compulsory will reduce HIV related stigma. In any case there is already enough awareness of HIV in high-prevalence countries that counselling will add little marginal benefit and enough to justify the cost implications.

Compulsory HIV Testing, on the other hand, entails programmes which force individuals to undergo an HIV test irrespective of whether they like it or not. AS Clestus Chukwu (2003) notes, "many people in their desperate concern about the pandemic believe that a compulsory HIV test imposed by a government can help to ease the threat posed by HIV/AIDS." First, it is believed by many that such a move is likely to reduce the risk of spread of HIV since the infected would be known in public and that treatment would be much effective since the infected would have been known anyway. The second, there is a growing concern of the frustration that global efforts to prevent HIV spread is being outpaced by its spread. The number of new infections worldwide remains high (4.1 million in 2005) with some regions previously unscathed experiencing rising incidences of HIV (UNAIDS: 2006). The number of patients presenting late at health facilities with advanced HIV/AIDS is also a cause of concern. In general, there is a growing sense of frustration that global efforts to prevent HIV/AIDS are being outpaced by the spread of the pandemic (Steinbrook: 2006). Consequently, calls have been made for a more pragmatic approach to containing the disease, with routine and mandatory testing gaining increasing attention (WHO: 2007).This is not a new phenomenon as it has occurred in India and China (AIDS Conference: 2006). . The US Centers for Disease Control and Prevention (CDC) recently proposed a new approach for HIV testing in adults, adolescents and pregnant women under which testing will be routinely offered in all health-care settings. No signed consent from patients would be required under this new proposal; the general consent for medical care would be considered sufficient to encompass consent for HIV testing (Bayer: 2006).

HIV testing and its treatment seem to be inextricably linked, since one leads to the other. There is no doubt that even without treatment, testing and knowledge of one's HIV status could activate behavior modifications that may reduce the risk of transmission of the virus. Hence, there is need for scaling up HIV testing. However, there is an apparent dilemma involved in HIV testing. Either we accept to offer VCT which so far has "proved ineffective" or we offer more drastic means of scaling up HIV testing here referred to as mandatory testing and eliminate among other thing, stigma. Whichever position we uphold, the conclusion must be that HIV testing needs to be scaled up.

It should be noted that entailed in both sides of the issue at hand is the assumption that human beings are capable of yielding the advice they would get after they have been tested. As C. B. Peters (2005: 116) reports:

> *So there is a lot of ethical advising around. Some advise abstinence,*

> *others condoms, while others ABC. The advising seems to be based on the assumptions that {a}advise by itself is absolutely sound and therefore bound to succeed, and {b}that human being are capable of following all good advice .*

Peters adds that in such an approach we tend to neglect the need to be analytical and reflective enough to subject the entire phenomena to critical analysis .What Peters has observed above might apply to the discussion at hand. There is need to subject HIV testing to philosophical analysis so as to clearly understand what is meant by "scaling up of HIV testing." Analysis is one of the fundamental tasks of philosophy. It takes the concepts that we daily use in common life, analyze them and determine their precise meanings (Onkware: 2002). In the first place clear and accurate knowledge of anything is an advance on a mere general familiarity with it. This philosophy is analyzed to present its necessary and sufficient conditions to determine its precise meaning. Such a process is called philosophical analysis. Historically, the first philosopher to explicitly centre interest on the activity of analysis was G.E .Moore, who greatly influenced philosophy in the first half of the 20th century (Popkin, 1986). Philosophical analysis is the process of clarifying the meaning of questions and answers by searching for the necessary and sufficient conditions which determine the meaning of a term (*ibid*.). What is a necessary condition? Copi and Cohen (1990) have observed that a necessary condition for the occurrence of a specified event is a circumstance in whose absence the event cannot occur. A necessary condition is that condition without which that event cannot occur .It is as they say in Latin, a *conditio sine qua non*. A sufficient condition, on the hand, is a circumstance in whose presence, the event must occur. For example boarding a car is in itself sufficient for one to reach Nairobi from Kisumu. The function of analysis is to make the question precise so that we will know how to reply to it. Consequently, we subject "HIV testing" to clarify the philosophical issues entailed thereof.

Conceptual Framework.

This paper is presented from the utilitarian point of view. Utilitarianism is an ancient philosophy whose core tenet is, "the belief that we ought to do what produces the greatest overall good consequences for everyone not just for me" (Hinman, 2000:5). Utilitarianism, also known as ethical universalism is, "the view that an action is morally right if it would bring or give the greatest befit in terms of the balance of good over evil" (Chukwu, 2003:113).William Frankena (2001:15-16) adds:

> *…utilitarianism takes the position that the ultimate end is the greatest general good- that an act or rule of action is right if and only if it is, or probably is, conducive to at least as great a balance of good over evil in the universe as a whole as an alternative would be, wrong if it is not, and obligatory if it is or probably is conducive to the greatest possible balance of good over evil in the universe.*

Frankena's formulation of utilitarianism finds ancestry in the exponents of utilitarianism including Jeremy Bentham and John Stuart Mill. The two are often acknowledged as the pioneers of utilitarianism. Simply put, this theory teaches that we determine the greatest good by examining the various courses of action open to us, calculating the consequences that produce the greatest overall good consequences for everyone. In other words, utilitarianism asks people to set aside their own individual interest for the good of the whole. It is also asking us to do whatever produces the most good. However, utilitarians disagree among themselves as to what constitutes the "good"; the disagreement varying between pleasure, happiness, beauty and truth (Wolff 1998).

Assumptions

For the purpose of this article, it is assumed that:

1. Most people regard compulsory HIV as ethical.
2. Most people regard compulsory HIV testing as unethical.

In other words, ethics can only make sense in its advising if there is general agreement on the advice it offers. More often than not, this general agreement is lacking because of the following reasons. First, there are the overlapping areas of theological ethics, philosophical ethics and religious ethics (Peters: 2005).Second, defining ethics is in itself problematic. Some, including Popkin and Stroll (1986) would define ethics simply as a cord or set of principles by which men live. Oruka defines it as a philosophical inquiry into the moral language and principles about values (Oruka: 1990). Commenting on the foregoing definitions, Peters (2005) reports that it would appear that ethics basically concerns relationships-not only intra-human relationships, but relationships of human beings with the world of nature, a view captured by Chukwu(2003:39) when he writes:

> *… there has been a deliberate but gradual enlargement of matters that fall within the province of contemporary ethics. Who would image that trees, landscapes, animals, rocks, rivers, dumping of industrial wastes/pollution, would some day acquire moral values as they have done in our times. But now world summits are held on environmental conservation while many philosophers are now preoccupied with environmental ethics.*

Third, ethics is full of a vast complex of ethical theories which have been variously classified as either "objective" versus "subjective", "classical" versus "modern", or "deontological", "consequence" and "motivist" ethical theories (Porter:1995). Any application of ethical theory as a justification for or not compulsory HIV testing would have to grabble with the most appropriate ethical theory. Fourth, there is the question of ethical approaches. The three most common approaches are: the descriptive, the prescriptive and the analytical. The first concerns elucidation of various ethical theories; the second concerns various professional ethics including medical ethics among others while the third concerns logical analysis of ethical statements and moral judgment (Moore and Stewart: 1994). This article's approach is the third one since HIV testing is an element of medical ethics.

While working out an ethical theory in the context of HIV testing one would have to meander through this ethical jungle and identify smooth ways which lead to a set of ethical theories relevant to the context of HIV testing. Discussion on this theory is controversy-laden; hence, beyond the scope of this article. The purpose of this article is basically to make a point regarding the applicability of this moral theory in the context of HIV. If we went by this theory, then we would prefer compulsory HIV testing at the expense of VCT since the former seems to yield more results than the latter. However, the problem with a compulsory HIV testing lies in the dialectic between the individual's freedoms and privacy versus the combined welfare of the society.

THE RIGHT TO PRIVACY DILEMMA

The subject of right is one that has been of particular interest to moral philosophers since 1948 when the United Nations Declaration of Human Rights was signed by the member states of the United Nations. Here, the central issue was on *human rights*. The phrase human rights were then limited to the political rights of the citizen against those of the government (O'Byrne:2003). The concept of rights, however, has been recently extended to apply to several other areas including animal, environment and even trees (Shivji: 1990).

According to Cranston (1973), human right is defined as a universal moral right, something which all men, everywhere at all times ought to have, and which no one can

be deprived of without grave affront to justice. Central to Cranston's view is the idea that the rights of man or human rights are names given to these elementary rights, which are considered to be indispensable for the development of the individual. One of the civil rights in the United Nations Charter on Human Rights is the right to privacy (Article 3). One of the human rights that every individual would love to enjoy in a democratic state is the right to privacy (Chukwu: 2003). In the words of Hinman (2000:39):

> *In constitutional law, the right to privacy seems to have two distinct senses. First, certain behaviours-such as sexual intercourse-are usually thought to be private; the government may not infringe on these behaviours….Second, some decisions in an individual's life-such as the choice of a mate or a career- are seen as matters of individual autonomy****....***

Central to the above quotation is the view that individuals should be left to exercise his will. The question which then arises is: does the society have any moral authority to deprive persons suffering from HIV the right to privacy?

If government opted for mandatory HIV testing a dilemma emanates. Etymologically, dilemma is from the Greek *dis* (twice) and *lemma* (assumption or premise) meaning a form of argument consisting of two hypothetical propositions, and one disjunctive proposition and the conclusion being either a disjunctive or a categorical proposition (Sinha: 1990). If the government decides to go for mandatory HIV testing, then it will be faced with this dilemma as presented by Chukwu (2003:99): The dilemma arises out of the fact that the government will need to take drastic measures of quarantining the HIV patients if it's to help curb the spread of the disease. This is the assumption underlying mandatory HIV testing.

1. *To quarantine HIV victims would lead to unintended immoral consequences to the victims, their relatives and the society.*
2. *Failure to take the decision to quarantine them would cause unintended havoc to the society and state. Thus, the compulsory HIV test exercise would become a futile project and a waste of national resources.*

A reconstruction of the foregoing dilemma would read as follows. If the government does not quarantine the persons who have tested HIV positive then they are will spread HIV and thereby infringing on other peoples' rights; but if the government quarantines the persons who have tested HIV positive then the rights of these people are infringed upon in the name of common welfare. Thus, we are in a dilemma.

There are three ways by which dilemmas are addressed. The first is to escape through the horns of the dilemma which entails showing that there is another alternative, which is to show that, the opponent's "either …or" is not exhaustive. Consider the following example drawn from Henry J. Ehlers (1976: 105) where it is reported that the Caliph Omar said:

> *If these books contain the same doctrines as those of the Koran, they are unnecessary. If they contradict the doctrines of the Koran, they are pernicious. But they must do one or the other. Therefore, in either case, they should be destroyed.*

To escape between the dilemma one would point that the "either…or" is not exhaustive by showing that there are books, such as Euclid's geometry, which do not fit in the said "either …or". They are amoral.

The second way by which one would escape the dilemma is to take the dilemma by the horns, that is, taking one of the alternatives and showing that the consequent does not necessarily follow. Zeno of Elea is reported to have argued that motion is impossible. He argued thus:

> *If a body moves, it must move either where it is, or where it is not.*
>
> *But it cannot move in the place where it is; and it cannot move in a place where it is not.*

Therefore, motion is not possible.

Plato took one horn of this dilemma and said, "But a body can move in the place where it is. Witness a spinning top."

The third way by which one would escape a dilemma is to construct a counter dilemma with a contradictory conclusion. Here is an example drawn from Ehlers (*Ibid.*). The Greek Sophist Protogoras is reported to have made an agreement with a pupil Euathlus, to teach him the art of pleading at law, on condition that one-half the fee was to be paid when the instruction was completed, and the other half when Euathlus had won the first case in court. Euathlus paid the first half but put off beginning practice. Protogoras finally brought suit for the remainder of the fee, offering this dilemma to justify his position:

> *If Euathlus loses this case he must pay me, because that will be the judgment of the court; if he wins he must pay me as the contract provides.*
> *But he must either lose or win.*
> *Therefore in any case he must pay the fee.*

Euathlus countered with the following dilemma.

> *If I win the case in court, I will not have to pay, for such will be the judge's decision; if I lose it, according to the contract I will not yet have to pay.*
> *But I must win or lose.*
> *Therefore in any case I will not have to pay.*

The question of HIV testing is exactly of this nature; since whichever option we take we are faced with undesirable consequences of either harming the society by not quarantining the HIV patients or harming the HIV patients by quarantining them. We are in a dilemma.

REBUTTAL

Applied to the topic in discussion, either mandatory HIV testing is encouraged or not encouraged. The foregoing dilemma can be countered in the following manner. Given the weakness of health systems in many countries, in particular the acute shortage of health personnel, it is incomprehensible that mandatory testing per se would lead to any drastic improvements in HIV/AIDS prevention or treatment. Rather than calling for routine or mandatory testing, the limited access to health professionals which is seriously undermining HIV prevention, treatment and care in these countries should be addressed. Again, unless the current stigma and discrimination associated with HIV/AIDS is seriously addressed, any policy of mandatory testing could even be counter-productive by driving people away from health facilities if they know they will be tested. Consequently, the conclusion which is inevitable is that compulsory testing is unnecessary. When examined keenly, compulsory HIV testing results in the treatment of HIV patients as objects not persons. As Peters (2005) 119-120, writes:

> *Persons living with HIV/AIDS suffer not only from the tragic fete of the pandemic, but also from the tragic dilemma of which they may not always be aware….The first aspect of the dilemma is…"involuntary objectification." A person living with HIV/AIDS is reduced to a mere object. He or she becomes an object of other people's care, love, counseling, and even moral advice….The second aspect… is their encounter with nihilism. By this I mean that a PLWHA may fail to see any meaning or purpose in anything, whether good or bad.*

For this reasons compulsory HIV testing should not be allowed since it is not only immoral but is also a crime against humanity since it contravenes the UN Charter on Human Rights.

CONCLUSION

Although HIV testing is crucial for effective prevention, making it mandatory may not be feasible. What is important is the removal of the key barriers to HIV testing. In particular, the lack of access to ARV therapy, the inadequate health workforce that has incapacitated many health systems in many countries, the culture of poor use of health services and the widespread stigma and

discrimination associated with HIV/AIDS must be tackled. To paraphrase Chwuku (2003) HIV/AIDS to a large extent is a behaviour-induced epidemic, and like all such epidemics the object of prevention lies in individual behaviour changes which cannot be brought about by a policy of mandatory testing alone.

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International Journal for Disaster Management & Risk Reduction Vol. 1 No. 2, **pp** *X-Y* July 2008 ISSN: 1992-2744

INTERVENTIONS IN ARID AND SEMI-ARID LANDS' AGRICULTURE AS MEANS TO DISASTER PREPAREDNESS IN KENYA

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Abstract

Over the last two decades, Kenya has been experiencing serious sequences of rain failure in arid and semi-arid lands (ASAL) that make up 70 percent of the country's land mass. Northern Kenya, which is disproportionately ASAL, has bone the brunt of this rain failure as evidenced by the loss of human lives, livestock and property. In the foregoing scenario, there should be concerted efforts to cushion vulnerable people and communities from the vagaries of weather. This paper discusses the various interventions necessary for mitigation, prevention and management of uncertainties faced by ASAL dwellers. The paper recommends that development actors must be proactive in managing disasters through innovative means in the ASAL areas' agriculture sector, particularly through adopting relevant early warning mechanisms.

Key words: *Disaster Preparedness, Arid, Semi-Arid Lands, agriculture, interventions and Kenya*

Introduction and Background

Natural disasters are a major contributor to global food insecurity, particularly in areas prone to drought, flooding and agricultural pest outbreaks. As a result it is important to institutionalize disaster mitigation activities in order to buffer the impact of crises on the poorest, and reinforce their capacity to emerge from a crisis with their livelihood system intact. This was recognized by the World Food Summit (1996), which recommended support for disaster prevention and preparedness as one of the priority areas.

Evaluations of humanitarian aid for the African famines in the mid-eighties emphasized that short-term relief interventions act only to save lives, and do little to promote longer-term recovery and improve people's livelihood options (Anderson and Woodrow, 1993). Development interventions in zones of recurrent disasters that specifically address a population's productive capacities have been identified as an essential component of disaster prevention.

It was felt that disaster mitigation activities relate primarily to development assistance. The importance Member States attach to strengthening the capacity of the United Nations system in disaster reduction has been stressed in recent documents and in the formulation of future system-wide options for disaster reduction in the concluding phase of the International Decade for Natural disaster Reduction (IDNDR).

A disaster is a situation where impacts occur on populations that are vulnerable to those impacts: "events which give rise to casualties and/or damage or loss of property, infrastructure, essential services or livelihoods on a scale which is beyond the normal capacity of the affected community to cope with unaided" (UNDP, 1991).

Mitigation includes both prevention and preparedness: "all measures taken to reduce the damage, disruption and casualties" of a hazard. In relation to crop failures resulting from natural disaster, mitigation has been defined as: identifying areas and sectors of the population most vulnerable to food insecurity; preparing contingency plans to improve response time; promoting sustainable livelihoods through support to local production systems; and introducing viable income-earning opportunities (Hill, H. (1992).

Disaster preparedness is synonymous with "readiness" or measures that allow societies and aid agencies to respond rapidly to emergency needs. This includes: Early Warning Systems

(EWS); hazard and/or vulnerability assessments; contingency planning exercises; planning for enhanced logistical capabilities; and disaster training and awareness.

Prevention (although the term "disaster reduction" is sometimes preferred) includes structural and non-structural measures to impede the occurrence of a hazard or to reduce the resulting damage and casualties.

A famine early warning system *(FEWS)* can best be defined as a system of data collection to monitor people's access to food, in order to provide timely notice when a food crisis threatens and, thus, to elicit appropriate response (Davies et al., 1991).

Monitoring "access to food" may be interpreted as the straightforward monitoring of food production. The definition includes the ultimate objective of an early warning system (EWS): to elicit an appropriate response.

Recognizing an early warning system

EWSs can be classified according to the level at which they operate, which strongly influences how a EWS is designed. The objectives of EWSs at different levels can range from global allocations of food aid to the targeting of a variety of interventions to individual households or villages. Rather, the challenge today is how best to integrate systems operating at different points in the hierarchy to provide a better and more comprehensive information system.

Famine-oriented vs. food-security-oriented EWSs

The majority of EWSs fall into the "famine-oriented" camp, especially national-level EWSs set up in Africa in the wake of the 1984-85 famine in the Sahel and Horn of Africa; at that time the overriding objective was to prevent such a catastrophe from happening ever again(Davies et al., 1991). The challenge is how to broaden the remit of EWSs, away from a restricted famine orientation, while still maintaining the capability to warn of large-scale famine, should it occur.

As a generalization, local-level EWSs are usually the least "famine oriented," and the most "food security oriented," partly because they are not so strongly linked into the international relief system, and partly because they are often part of a development, rather than relief, project or program.

Constraints on the Effectiveness of an EWS

Ownership of information; Who "owns" an EWS is critical to how the information is used. An EWS which is entirely "owned" (conceived, staffed, and funded) by a national government is unlikely to hold sway with international donors. The information upon which the international donors depend usually has to have the imprimatur of the Food and Agricultural Organization (FAO) or the World Food Programme (WFP) in order to be viewed as credible (Buchanan-Smith and Petty, 1992). This can seriously undermine a national EWS, and can be wasteful of planning time if national EW information is held in abeyance until the respective UN agency has done its own harvest- or food-needs assessment.

Simplified use of a single indicator; While many EWSs have become increasingly sophisticated and have developed multi-indicator models, it is perhaps surprising to find that information-users pay so much attention to a single indicator, the harvest assessment. Frequently, other indicators have warned of deteriorating food insecurity long before the harvest assessment results are available, but they have not triggered response decision-making.

The influence of crisis indicators; Crisis indicators are signals of the failure to respond in time. Lack of synchronization between need and donor-level bureaucratic procedures; the timing of donor decision-making is frequently too late to ensure that food aid - the usual relief response - can be delivered from Europe or the US to beneficiaries in Africa, before the start of the "hungry season."

Reasons for and Approaches to Needs Assessments

A post- disaster needs assessment involves diagnosing the nature and magnitude of a disaster once it occurs (FAO,2002). Relief and rehabilitation initiatives are, in essence, the management of information and resources, based on assessments and reports; if officials are to make effective decisions about the deployment of resources it is essential that they are properly informed.

In the past, needs assessments have been absent from many post- disaster seed initiatives, as is reflected in the paucity of literature on the subject. Critiques have increasingly been put forth arguing that intervening agencies have missed or mis-diagnosed the most important issues in relief and rehabilitation (Longley,

2001). Critics claim that many needs assessments disproportionately concentrate on food requirements, with a diagnosis of food insecurity implying seed insecurity. Additionally, these assessments tend to establish the formal seed sector structures without attempting to understand the potential role of local seed systems in disaster recovery. Consequently, these projects enhance the productivity of one component of the farming system as opposed to the resilience of the entire system (Ahmed et al, 2001).

In response to these critiques and problems, there is a growing body of literature emphasizing the importance of practicing holistic needs assessments that aim to accurately represent the diverse components of local farming systems and lead to more inclusive planning for post-disaster interventions. Presumably seed capacity building initiatives would have been more effective in this situation if the primary stakeholders played a larger role in the needs assessment (Ahmed et al, 2001).

O'Keefe and Kirby (1997) describe how widespread famine was declared without adequate supporting evidence during Kenya's drought in the early 1990's. This resulted in multiple inefficiencies as well as conflicts between local communities and relief agencies (O'Keefe and Kirby, 1997). In some cases the overriding agenda of agencies may obscure the accuracy of the needs assessment and adversely affect the outcome of relief and rehabilitation initiatives (Haugen 2001). Poorly conducted and unsuitable needs assessments are a critical issue for exploration as in some cases they have resulted in the intended beneficiaries becoming dependent upon external support and aid (Hill, 1992).

There are several methodologies put forth for conducting this initial planning component concerning timing, inter-agency coordination, participatory research methods and building data collection methods into existing institutions in the affected region. With respect to timing of needs assessment, there are strong arguments supporting ongoing assessments as crucial to successful long-term recovery as supported by (Betrand et al. 1989; ADPC 2000; Pottier, 1996) who asserted that initiatives should aim to use iterative diagnostic and evaluative tools that can be adapted on an ongoing basis. Agriculture and seed systems are constantly changing and adapting to dynamic markets, land intensification, natural resource degradation and the potential of future disasters.

Inter-agency coordination at the needs assessment stage is a prerequisite for successful recovery operations. Coordination implies understanding, assessing and evaluating the impact of previous seed and relief (i.e. food) interventions and looking at current support provided by other agencies (Mengistu 2001). Reports from both Kenya and Rwanda illustrate the detrimental consequences arising from lack of agency coordination; these include competition and contradicting assessments of seed availability and drought conditions (Pottier, 1996).

Contrasting discourses in international development, neither local participation nor stakeholder involvement has been explored extensively in a post- disaster agricultural context.

Existing and pre- disaster physical structure of farmer systems, local knowledge and its role in maintaining agricultural sustainability, feasibility of facilitating access to seeds, targeting and stakeholder identification, normally existing informal and formal seed channels, social, gender, cultural and class relations in the farming system, the natural environment (land mines, soil fertility), the situation of displaced individuals, coordination with other areas of disaster recovery and relief ,livelihood recovery ,selection and multiplication for seed distribution (if required) ,the impact of the disaster upon all of the factors aforementioned ,transition to long-term development (Longley, 2001)

The Pre-Disaster and Contemporary Farming Systems

Firstly, an understanding of the pre- disaster and contemporary farming systems is vital to guide relief and rehabilitation planning. In the initial planning stages, many agencies assume that farmer seed systems have completely collapsed or were inadequate to begin with.

Secondly, characterizing the disaster and understanding how it has impacted upon the farming system are essential components of needs assessments. Several disaster impacts that should be assessed include the speed of its onset, whether it is a situation of acute or chronic stress, the geographic scope of the impacts, the

scale of population affected, geographic population movements, environmental degradation, changes in wealth distribution, and changes in social relations in the community and the loss of diverse assets (Remington 2001; Mengistu, 2001). The distinct combination of impacts will likely necessitate very different repertoires of development relief interventions.

Thirdly, in post- disaster management understanding social and economic relations between and among men and women is critical to needs assessments. Arguably, crisis situations are never gender neutral. Given the discrepancies of disaster impacts upon men and women and their distinctly different roles in the agricultural sector, it is not surprising that men and women exhibit different coping strategies and prioritize different needs in post- disaster situations.

Finally, re-accessing and strengthening seed channels is an important part of ensuring seed availability and successful recovery (Remington, 2001). Almekinders argues that understanding the local and formal seed systems and the complex relations between these sectors will help reveal if there is an absolute scarcity of seeds (2001).

Biodiversity Issues Related to Seed Choice in Relief and Rehabilitation Interventions

Crop diversity is portrayed as an essential prerequisite for productive agricultural ecosystem and sustainable livelihoods in developing countries (Bushamuka, 1998). Growing different varieties and diverse crops helps farmers to fine-tune their farming systems to local environmental conditions, to maintain food security and to utilize crop related benefits (Bushamuka, 1998). Consequently, agricultural biodiversity is integrally linked with post-disaster rehabilitation and relief initiatives (Sperling, 1997). Despite aims to the contrary, in seed relief efforts many agencies have had negative impacts on crop diversity (De Barbentane, 2001).

Most writers reviewed agreed that the starting point for post- disaster seed rehabilitation is to understand farming community's pre- disaster situation. Disaster agencies are dependent on the seed's natural multiplication rate and successful yields if regional breeding programs are pursued. This raises the question of what type of seed is appropriate if seeds of local varieties cannot be obtained. Several writers question if agencies are then justified in helping the country to take a 'technological jump' and implement modern seed technologies where otherwise local varieties would have been chosen (Remington 2001).

In each of these situations, facilitating the recovery of the farming system to pre-war levels is problematic. Reasons for this may be the perceived lack of time in disaster relief or the perceived lack of farmers' knowledge to make an informed choice.

Several writers argue that restoring biodiversity and long-term productivity to farmer systems requires more than a straightforward substitution or reintroduction of seeds (Pottier 1996; Sperling 1997; Bushamuka, 1998).

Bushamuka notes the effects of socio-cultural and socio-economic factors on the diversity in farming systems. Agricultural relief and rehabilitation policies are often guided by the assumption that populations depend on crops from commercial farming. Post-disaster interventions should take into account the relation of these forces to agricultural biodiversity in relief and rehabilitation measures (Sperling 1997). A disproportionate concentration on the formal seed system can potentially result in a transfer of the site of knowledge creation and seed maintenance away from local communities and to centralized control by intervening agencies.

Conclusion

The paper concludes that a needs assessment should be conducted in a holistic manner to give representation to the diverse aspects of the informal and formal seed sectors, with an emphasis on understanding the strengths of the pre-war and current farming systems. Alternative needs assessments and monitoring methodologies should also be integrated into post-disaster recovery in a way that the planned activities can meaningfully respond to changing conditions in the farming system. The implication of this is that development practitioners should not plan interventions without sufficient knowledge of the entire interconnected components of the farming system in ASAL areas.

Recommendations

Early intervention in Kenya is particularly important in areas of recurrent natural disasters where reduced coping capacities among

vulnerable groups can exacerbate the impact of even a moderate hazard.

Efficient and effective communication is key to data collection, processing, dissemination, and interaction (feedback) with the users and the public. Technology has developed very fast for many monitoring and early warning activities. The use of computer-friendly software is increasing in the developed world, although the basic disaster preparedness information exchange facilities are not available in Kenya.

Analyzing the needs of populations in disaster - prone areas, together with past performance and the effects of disaster response, is imperative if mitigation and not just a rapid response are to be carried out.

With recurrent natural disasters Kenya government is faced with a fluid situation and a relatively inflexible funding mechanism. As Kenya government development programming is intended to include prevention activities, the funding should reflect the flexibility needed to respond quickly to recurrent natural disasters.

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International Journal for Disaster Management & Risk Reduction Vol. 1 No. 2, **pp** ***X-Y*** July 2008 ISSN: 1992-2744

EVALUATION OF CRITERIA FOR USE IN DETERMINING GROWING SEASON ONSET DATES IN THE KENYAN LAKE VICTORIA BASIN

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Abstract

This paper presents evaluation of criteria to be used in advising farmers on the planting dates in Lake Victoria Basin. The criteria were evaluated using relative yield over a 30 days period following sowing computed by means of soil water balance technique. Crop failure or a false start to the season is indicated by a relative yield rate of less than 35%. Due to the high ratio of computed relative yields in the region, the threshold values were varied from 35% to 75% in order to capture the failure rates. Using this method, onset dates were determined for 26 stations spatially distributed in the basin. Daily rainfall and mean daily evaporation data for a period of 20-30 years starting from 1970 were used. The criteria for accumulated rainfall depth over a specified period were evaluated. The tested criteria using RAIN software included; the accumulation of 20 mm of rainfall in 3 days, accumulation of 40 mm in 4 days and accumulation of 60 mm in 6 days. Comparison made between the accumulated depth criteria and those based on root zone depletion equal to readily available water (RAW) in 4 days and the soil moisture content at field capacity (SMC) in 4 days showed that the accumulation of 40mm in 4 days criterion compared well with (RAW) criterion but the SMC criterion gave delayed onsets in most cases. Results reveal that the accumulated depth criterion of 40mm in 4 days can be used as an operational criterion.

Key words: *onset criteria, rainy season, evaluation, Lake Victoria Basin*

INTRODUCTION

In the tropics food is raised mainly under rainfed agriculture to feed the rapidly growing population. The Kenyan Lake Victoria basin, which is located within the tropics, has a high agricultural potential for both subsistence and plantation farming. The agricultural activities in this region are mainly dependent on rainfall occurrence. For rainfed agriculture, problems for farmers arise in the yearly variation of onset, cessation and duration of the growing season. Sivakumar (1988) carried out an analysis of long-term daily rainfall data for 58 locations in the southern Sahelian and Sudanian climatic zones of West Africa, the study showed that a significant relationship exists between the dates of onset of rains and the length of the growing season. This analysis has important applications in crop planning as well as disaster planning and forms an initial step in concepts such as "Response farming" or "Weather responsive crop management tactics" for drought prone West Africa. Oladipo and Kyari (1993) investigated the fluctuation in the onset, cessation and length of the growing season in Northern Nigeria. The results indicated that the trends in the length of the growing season are more sensitive to large inter-annual fluctuations in the start of the rains than to variations in the cessation dates.

In order to promote rainfed agricultural planning, the normal dates of onset of rainy period in particular regions in the tropics would be quite vital. Previous work on rainfall onset has employed different techniques depending on the rain generating

mechanisms of the region in question. Ilesanmi (1972) empirically formulated the onset, advance and cessation of the rains in Nigeria. Oshodi (1971), using a simple pentade method, arrived at similar isochrones of the onset of the rains in Nigeria. Various criteria have been employed in different parts of the world to predict the onset of the growing season in the respective regions. Nicholls (1984) used a wet season onset index in determining beyond reasonable doubt, the existence of the predictability of seasonal rainfall in Australia. Calooy (1981) used autoregression models in predicting the seasonal rainfall of Bangladesh and India respectively. In the determination of onset of the growing season, the (FAO, 1978) bases the beginning of the growing period on the start of the rainy season. This occurs when the first rains fall on soil, which is generally dry at the surface and has a large soil moisture deficit. Lineham (1983) used water balance method in determining the onset and cessation of the rainy season in Zimbabwe. FAO (1978) defined the start of the growing season as the date when the precipitation exceeds half the potential evapotranspiration. Matari (1993) carried out a study aimed at predicting the seasonal rainfall from the onset, cessation and length of the growing season in Tanzania. The results of his study indicated that it is possible to estimate with reasonable accuracy the average onset date, length of growing season and the seasonal rainfall of Tanzania. Raes *et al.* (2004) carried out an evaluation of first planting dates recommended by criteria used in Zimbabwe by means of a soil water balance model. The criteria included: the AREX criterion of the Agricultural Research Extension (25 mm rainfall in 7 days), and the MET criterion of the Department of Meteorological services (40mm in 15 days). A third criterion DEPTH (40 mm in 4 days), based on the farmers' practices was introduced and recommended for operational use by the farmers. In this study an evaluation of criteria for determining growing season onset dates is done using the relative yield over the initial growth stage of 30 days from sowing (Allen et al., 1998). The results are then used to determine the onset dates for the long and short rains.

MATERIALS AND METHODS

Study area

The study was carried out in the Lake Victoria Basin which lies in the western part of Kenya in latitude between 1^0 30'N and 2^0 00's and in longitude between 34^0 00'E and 35^0 45'E with a total area of about 48,000 Km^2. The region is bordered by Uganda in the West and by Tanzania in the South, and demarcated by the water divides in the North and the East. Administratively, Nyanza and Western Provinces, and the Western Parts of Rift Valley province fall in this region (Figure 1). The region is an area of high agricultural potential for both subsistence and plantation farming. The agricultural activities in this area are mainly under rainfed conditions. There area two main rainfall seasons, the long rains which occur from mid march to May and the short rains which occur from mid October to early December are experienced in most parts of Kenya. The rains are usually associated with northward/southward movement of the inter-tropical convergence zone (ITCZ).

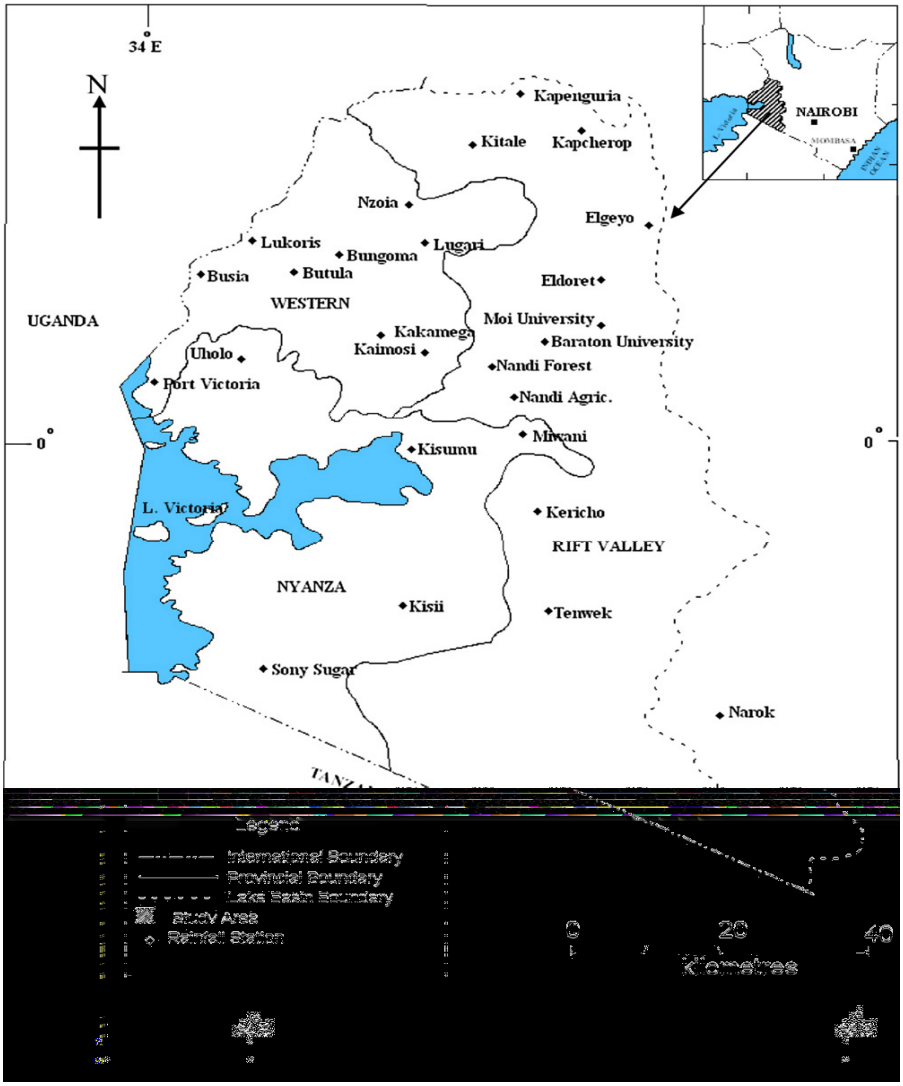

Figure 1- Location of study area.

Climatic data

Daily rainfall records and mean daily evaporation from 26 meteorological and rainfall stations were collected for an average period of 20-30 years from the Kenya Meteorological Department headquarters. The location of the stations is indicated in Figure 1. Moi University (15 years) and South Nyanza Sugar Factory (18 years) were incorporated to enhance the stations network. The records spanned from 1970 to 2003 apart from Baraton University station, which spans from 1960 to 1987. The mean monthly reference evapotranspiration (ET_0) was derived from class A pan measurements (E_{pan}) by using a representative pan coefficient for each of the eight meteorological stations which had evaporation data (Allen et al., 1998). Since only 8 stations provided pan evaporation data, it was necessary to estimate data for the other stations. The estimation of data was based on the homogeneous zonation of the Lake basin established by Ogallo (1980), Ogallo (1989) and Agwata (1992). Evaporation data is conservative and therefore this estimation was representative for the region.

Onset Criteria

In this study three appropriate criteria using RAIN software (Kipkorir, 2004) for analysis are considered. The first is based on accumulated rainfall of at least 40 mm received during a maximum of 4 successive days from new rains (Raes *et al*., 2004). Sensitivity analysis was performed for the criteria by varying the accumulated rainfall in the range of 20 to 60 mm for a maximum period in the range of 2 to 6 successive days. The second is based on root soil moisture content being at field capacity (SMC), during a maximum of 4 successive days from new rains. The third is based on root zone depletion being less than or equal to readily available soil water (RAW) in the root zone during a maximum of 4 successive days from new rains. RAW is considered equal to 50% of the total available water (TAW) in the root zone and the root zone depth is 25 cm.

Evaluation of rainfall onset criteria

Before applying any of the criteria for the current study, evaluation to determine the suitable criteria was done. This was done for the three cases, which included the accumulation of 20 mm over 3 days (Sivakumar, 1988), 40 mm over 4 days (Raes, et.al., 2004) and 60 mm in 6 days. In the analysis relative yield linked to the initial growth stage of 30 days from planting was used to determine the crop performance (Doorenbos and Kassam, 1986). The relative yield is computed using daily soil water balance model in the RAIN software. Simulations for the three criteria showed that the lowest relative yield index for most stations was high, over 0.5 apart from Elgeyo- Forest and Eldoret Met stations, which was less than 0.5.

As a result of this observation, the threshold relative yield values were varied from 35 to 75 % in order to determine crop failures at the different threshold levels. The selection of a criterion for particular stations was based on the number of failures linked to the tested criteria. Less failure qualified the criterion under consideration. Adjusting threshold values up to 75% was only done to enable the selection of the suitable criteria for different stations. A period of 30 days is the average length for the initial growth stage of several annual crops (Allen et al, 1998). The length of the period is further justified by the fact that farmers often make final adjustments to plant population (by thinning) and add fertilizers when they are sure that the crop is likely to survive the critical stage. These adjustments are made approximately 30days following crop germination (Stewart, 1990).

RESULTS AND DISCUSSIONS

Evaluation of onset criteria

The selection of suitable criteria for each station was done as described earlier. It was however observed that in some cases either two or all the three criteria tied. In such cases the criteria that qualified was based on the relative yield ratio. The one that had the highest relative yield was selected. However in cases where this was inapplicable, the criteria that came next to the one with the highest failure rate in ascending order was selected. This was done mainly in cases where both the accumulation of 40 mm in 4 days and 60 mm in 6 days qualified, and then the 40mm in 4 days criterion was selected. These results are summarized in Table 1.

Table 1: Evaluation of the criteria using threshold relative yield at the end of initial stage

Station	Criteria days.mm	Lowest Y_a/Y_m	No. of Failures for various threshold (Ya/Ym) 35%	55%	75%	N (Events)	Selected Criteria
Baraton	3, 20	0.753	0	0	0		
	4, 40	0.675	0	0	1	25	3,20
	6, 60	0.563	0	0	5		
Kaimosi	3, 20	0.504	0	1	2		
	4, 40	0.797	0	0	0	24	4,40
	6, 60	0.752	0	0	0		

Bungoma Water	3, 20 4, 40 6, 60	0.631 0.831 0.930	0 0 0	0 0 0	5 0 0	34	4,40
Butula Mission	3, 20 4, 40 6, 60	0.772 0.831 0.831	0 0 0	0 0 0	0 0 0	32	4,40
Busia Farmers Training	3, 20 4, 40 6, 60	0.537 0.804 0.904	0 0 0	1 0 0	2 0 0	32	4,40
Eldoret Met.	3, 20 4, 40 6, 60	0.418 0.258 0.381	0 1 0	4 7 6	14 17 16	29	3,20
Elgeyo Forest	3, 20 4, 40 6, 60	0.251 0.291 0.253	4 1 3	10 4 7	19 10 18	32	4,40
Narok Met.	3, 20 4, 40 6, 60	0.600 0.595 0.595	0 0 0	0 0 0	4 4 4	33	4,40
Moi University	3, 20 4, 40 6, 60	0.544 0.491 0.531	0 0 0	2 2 1	4 4 5	15	3,20
Kakamega Met.	3, 20 4, 40 6, 60	0.510 0.746 0.734	0 0 0	1 0 0	2 1 1	32	4,40
Kisii Met.	3, 20 4, 40 6, 60	0.726 0.922 0.922	0 0 0	0 0 0	1 0 0	32	4,40
Kitale Met.	3, 20 4, 40 6, 60	0.738 0.738 0.723	0 0 0	0 0 0	1 1 1	24	4,40
Kapcherop	3, 20 4, 40 6, 60	0.308 0.488 0.569	1 0 0	5 1 0	5 5 6	30	4,40
Kapenguria	3, 20 4, 40 6, 60	0.454 0.514 0.510	0 0 0	3 2 2	8 6 5	15	4,40
Kisumu Met.	3, 20 4, 40 6, 60	0.722 0.722 0.925	0 0 0	0 0 0	3 1 0	34	4,40
Lugari Forest	3, 20 4, 40 6, 60	0.408 0.669 0.712	0 0 0	3 0 0	8 3 2	31	4,40
Lukoris Disp.	3, 20 4, 40 6, 60	0.603 0.803 0.700	0 0 0	0 0 0	2 0 1	23	4,40
Miwani Mill	3, 20 4, 40 6, 60	0.632 0.788 0.760	0 0 0	0 0 0	3 0 0	16	4,40
Nandi Agric.	3, 20 4, 40 6, 60	0.768 0.735 0.855	0 0 0	0 0 0	0 1 0	23	4,40
Nandi Forest	3, 20 4, 40 6, 60	0.772 0.914 0.770	0 0 0	0 0 0	0 0 0	21	4,40
Nzoia Forest	3, 20 4, 40 6, 60	0.616 0.892 0.723	0 0 0	0 0 0	1 0 1	24	4,40
Port Victoria	3, 20 4, 40 6, 60	0.589 0.589 0.703	0 0 0	0 0 0	3 2 2	18	6,60
Sony- Sugar	3, 20 4, 40 6, 60	0.701 0.847 0.847	0 0 0	0 0 0	1 0 0	10	4,40
Tenwek	3, 20 4, 40 6, 60	0.433 0.638 0.638	0 0 0	2 0 0	10 3 3	30	4,40
Uholo-Camp	3, 20 4, 40 6, 60	0.632 0.512 0.541	0 0 0	0 1 1	1 1 1	33	3,20
Kericho-Hail	3, 20 4, 40 6, 60	0.553 0.797 0.797	0 0 0	0 0 0	2 0 0	26	4,40

The established onset criterion for each station was then used to determine the onset dates for the respective stations and the results tabulated as shown in Table 2. These results indicate the expected onset dates for the long and short rains at the various stations within the lake basin region .

Table 2: Long rains and short rains onset Julian days for the study area

Station	Long Rains					Short Rains				
	VL	L	N	E	VE	VL	L	N	E	VE
Baraton	96	86	82	79	71	225	220	218	215	210
Bungoma	106	93	88	83	73	246	239	237	234	227
Busia Far.	94	90	87	85	80	265	249	242	235	221
Butula Mis.	92	85	81	78	70	261	244	238	231	216
Eldoret	108	96	91	86	76	299	291	288	284	276
Elgeyo For.	103	96	93	90	81	307	302	301	299	294
Kaimosi	112	99	94	89	79	220	208	204	199	189
Kakamega	97	85	80	76	66	226	213	207	202	190
Kapcherop	117	105	99	94	82	294	290	289	287	284
Kapenguria	114	99	93	87	76	294	291	290	289	287
Kisii	88	79	76	73	66	262	244	236	229	212
Kisumu	95	91	89	87	81	315	314	313	313	311
Kitale	110	97	91	87	76	301	295	292	290	284
Lugari	109	97	92	87	78	292	289	288	286	283
Lukoris	107	92	86	80	69	307	301	298	296	290
Miwani	100	85	80	75	64	312	309	308	306	303
Moi Univ	106	98	95	91	84	300	293	290	288	281
Nandi Agr.	97	92	89	87	80	309	306	304	303	300
Nandi For.	108	96	92	87	77	296	294	294	293	291
Narok	53	24	12	0	338	-	-	-	-	-
Nzoia For.	115	100	94	89	77	227	224	223	222	219
Port Vic.	92	89	88	86	83	315	314	314	314	313
Soni Sugar	95	83	79	74	65	268	242	231	221	200
Tenwek	84	71	66	61	48	246	243	242	240	237
Uholo	88	80	76	73	66	248	234	228	221	205
Kericho	94	83	78	74	65	231	225	223	221	215

V.Early

Onset Departures: *very early (VE-80%), early (60%), normal (N-50%), late (L-40%), very late (VL-20%)*

NB: Narok experiences one rainy season

Comparison of onset dates obtained using the three criteria

A comparison of onset dates obtained using the three criteria (accumulated rainfall of 40mm in 4 days, RAW and SMC) showed that the results obtained from the accumulated 40mm in 4days rainfall compared well with those obtained from RAW. The onset dates obtained from the two criteria agreed in most cases or were within a difference of one week (7-10 days). However the onset dates obtained from SMC generally came later. This shows that the use of this criterion generally gives delayed onsets of up to 3 weeks, which would shorten the length of the growing season. The results also reveal that in some cases all the three criteria gave the same dates of onset, further strengthening the selection of the accumulated rainfall criterion for use as an operational criterion for the region. These results are presented in Table 3.

Table 3: Comparison of dependable onset dates (day/month) obtained using three criteria

Station	40mm in 4days Criteria					RAW Criteria					SMC Criteria				
	VE	E	N	L	VL	VE	E	N	L	VL	VE	E	N	L	VL
Baraton	6/3	16/3	23/3	31/3	14/4	12/3	23/3	31/3	7/4	18/4	16/3	28/3	5/4	14/4	27/4
Bungoma	7/3	19/3	29/3	9/4	27/4	11/3	24/3	2/ 4	9/4	19/4	15/3	27/3	4/ 4	14/4	30/4
Busia Farmers	17/3	24/3	28/3	2/4	8/4	7/3	19/3	28/3	7/4	23/4	7/3	2/4	9/4	12/4	28/4
Butula Mission	6/3	16/3	22/3	29/3	8/4	5/3	18/3	26/3	2/4	12/4	5/3	18/3	26/3	2/4	12/4
Eldoret Met.	11/3	23/3	1/ 4	11/4	29/4	12/3	28/3	6/4	15/4	27/4	11/3	25/3	3/ 4	12/4	25/4
Elgeyo Forest	15/3	27/3	3/ 4	10/4	18/4	7/3	18/3	26/3	5/4	20/4	8/3	19/3	27/3	6/4	22/4
Kaimosi	13/3	25/3	4/ 4	15/4	3/5	14/3	26/3	5/4	15/4	3/5	20/3	1/ 4	9/4	18/4	1/5
Kakamega Met.	1/3	12/3	21/3	31/3	17/4	2/3	16/3	24/3	31/3	9/4	4/3	17/3	26/3	6/4	21/4
Kapcherop	14/3	30/3	9/4	20/4	13/5	18/3	28/3	4/ 4	12/4	25/4	23/3	1/ 4	8/4	15/4	27/4
Kapenguria	9/3	23/3	3/ 4	15/4	6/5	7/3	21/3	30/3	9/4	22/4	1/3	20/3	30/3	11/4	1/5
Kericho	1/3	11/3	19/3	29/3	13/4	7/3	14/3	19/3	25/3	2/4	2/3	13/3	21/3	31/3	15/4
Kisii	2/3	10/3	17/3	24/3	5/4	23/3	6/3	15/3	25/3	11/4	27/2	5/3	18/3	28/3	13/4
Kisumu	20/3	25/3	30/3	3/ 4	9/4	6/3	18/3	27/3	4/4	17/4	9/3	21/3	28/3	5/4	17/3
Kitale	10/3	23/3	1/ 4	13/4	1/5	20/3	30/3	6/4	12/4	20/4	20/3	2/4	11/4	18/4	29/4
Lugari	12/3	24/3	2/ 4	12/4	29/4	22/3	1/ 4	8/4	14/4	22/4	20/3	1/ 4	11/4	20/4	5/4
Lukoris	3/3	16/3	27/3	9/4	30/4	14/3	21/3	26/3	30/3	5/4	10/3	20/3	26/3	1/ 4	9/4
Miwani	26/2	11/3	21/3	2/4	22/4	4/3	16/3	25/3	4/4	21/4	12/3	23/3	31/3	6/4	15/4
Moi University	21/3	29/3	5/4	11/4	22/4	7/3	20/3	30/3	8/4	22/4	8/3	21/3	31/3	9/4	23/4
Nandi Forest	12/3	23/3	2/ 4	12/4	29/4	2/3	15/3	25/3	8/4	22/4	9/3	22/3	31/3	10/4	26/4
Nandi Agric.	16/3	25/3	30/3	4/4	11/4	6/3	20/3	30/3	9/4	26/4	8/3	22/3	31/3	11/4	27/4
Nzoia Forest	11/3	24/3	4/ 4	16/4	7/5	13/3	25/3	4/4	14/4	29/4	13/3	28/3	9/4	21/4	9/5
Port Victoria	22/3	26/3	29/3	1/ 4	4/4	24/3	3/ 4	9/4	15/4	23/4	16/3	24/3	29/3	3/ 4	10/4
Sony- Sugar	28/2	11/3	20/3	29/3	15/4	3/3	13/3	20/3	29/3	11/4	3/3	13/3	20/3	29/3	11/4
Uholo –Camp	4/3	11/3	17/3	24/3	4/4	10/3	20/3	27/3	5/4	19/4	12/3	21/3	28/3	5/4	18/4
Tenwek	8/2	24/2	7/3	18/3	¾	28/2	10/3	18/3	26/3	7/4	4/3	17/3	25/3	2/4	11/4
Narok	29/10	19/12	12/1	3/2	16/3	21/11	20/12	10/1	1/ 2	8/3	26/11	4/1	28/1	21/2	24/3

Onset Departures: *very early (VE-80%), early (60%), normal (N-50%), late (L-40%), very late (VL-20%)*

CONCLUSION

The study has identified suitable criteria for determining the rainfall onset for the lake basin region. The evaluation of the criteria indicated that the use of the accumulation of 40 mm of rainfall in 4 days from new rains is suitable for determining rainfall onset in the region and can be used as an operational criterion. To formulate practical guidelines for farmers, the 40 mm in 4 days criterion is transformed into a wetting front criterion in terms of linear depths for different soil types. The farmer will therefore be expected to observe the wetting front, which should approximate to the initial rooting depth for the crop in question (25 cm for maize crop). When these conditions are achieved, sowing can be done. This could reduce the risk taken by farmers during early sowing, that results from false insets.

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International Journal for Disaster Management & Risk Reduction Vol. 1 No. 2, **pp** ***X-Y*** July 2008 ISSN: 1992-2744

EFFECTS OF FLOODS ON CROP FARMING: A CASE STUDY OF BUDALANGI DIVISION, KENYA

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Abstract

Floods are extreme weather events that occur when water rises to overflow on land that is not normally submerged. Flood is one the major natural disasters affecting man and his environment In Kenya, floods have been declared a national disaster. Budalangi Division, which lies in the floodplains of Rivers Nzoia and Yala experiences floods every year. This has resulted in decline in agricultural production. The inhabitants of the division are threatened by food insecurity and high poverty levels because of cumulative effects of floods. This paper examines the how floods affect crop farming in Budalangi Division of Busia district, Kenya.

Introduction

Floods normally occur when there is significant excess of water over a relatively short period that rises to overflow on land that is not normally submerged (Ayoade, 1988). Most of the floods are climatological in nature, i.e. they are caused by extremely high rainfall amounts. Hewlett identifies five major types of floods: the long-rain floods, snowmelt floods, frozen-soil floods, tidal floods and flash floods (Hewlett, 1969).

Kenya has experienced major floods in 1937, 1947, 1951, 1957-58, 1961, 1977-78, 1997-98 and 2003. They have become annual phenomena in the lower reaches of nearly all rivers draining into Lake Victoria (Ojany and Ogendo, 1973; Abira, 1997; Huho, 2007). Floods are associated with the majority of disasters in Kenya and are mainly caused by climatic related factors. Human related attributes exacerbate their magnitude and magnify their extent of destruction (IGAD and DMCN, 2002). Budalangi Division experiences flash floods from River Nzoia on annual basis destroying planted croplands and causing livestock deaths (LBDA, 2003).

Direct and indirect effects of floods on local and national economy include reduction in family income, decline in business production and industrial enterprises, inflation and unemployment. Cumulative frequency of occurrence of various hazards is a consideration that farming communities throughout the world have taken into account, usually by basis of experience and intuitive reasoning as they decide on what type of and intensity of agricultural or livestock farming to employ in a region susceptible to floods (DMC, 1995).

STUDY AREA

Budalangi Division is in Busia District of Western Province of Kenya and borders Lake Victoria to the west. The division has a total area of 306.5 square kilometers of which 120 square kilometers is under water (Figure 1). This division has two rainy seasons, the long rains which start in March and continues into May and the short rains which start from August through October. Dry spells are from December to February (KRCS, 2003; BDDP, 1997-2001). The division has a mean annual rainfall of 800 mm.

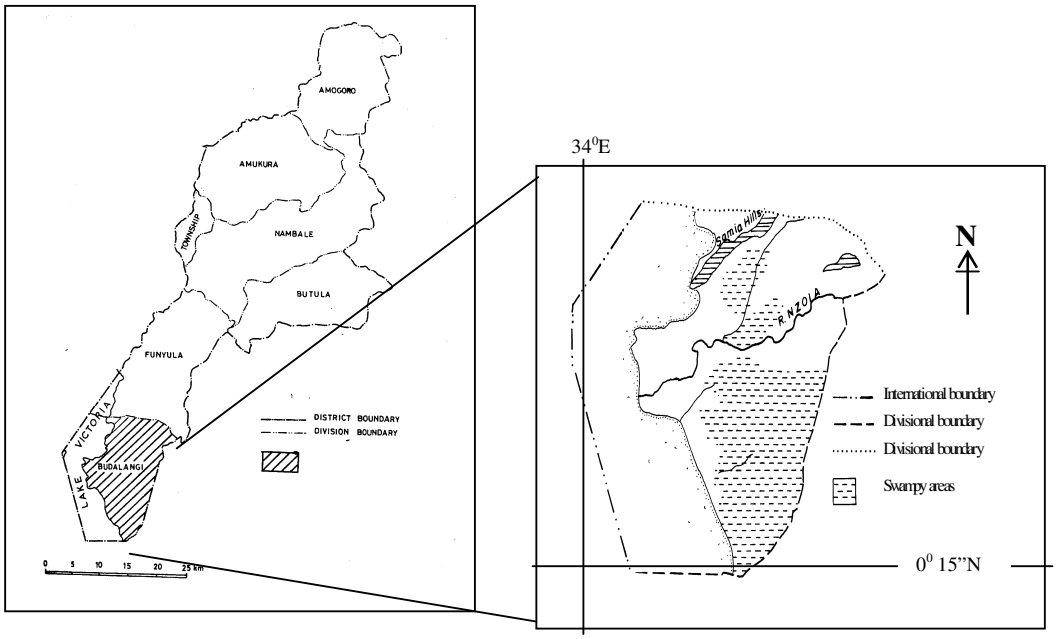

Figure 1: Location and size of Budalangi Division, Busia District (*Source*: KRCS, 2003)

Budalangi Division lies in the low-lying swampy tracts of the country very much prone to flooding. It embraces the Yala/Nzoia lowlands, which is broken by irregular water channels and small lakes with glassy islands, hence forming a floodplain. Much of the southern parts of the division are covered by the Yala Swamp. Two major rivers, Rivers Nzoia and Yala, which traverse the division, are the source of flash floods in the area (Ojany and Ogendo, 1973; KRCS, 2003).

Methods of Data Collection and Analysis

Daily water level data was obtained from ministry of water, hydrology section, Siaya District for period between 1990 and 2003 for River Nzoia Gauging Station (RGS) 1EF01. The rating curve starting from 16/06/1979 was used to compute river discharges for up to the year 2003 since it was the latest computed. Annual peak flows, flood frequency curve and magnitudes were established. Data on effects of floods on crop production was collected through the use of questionnaires, interviews and personal observations. Questionnaires were used to collect quantitative data while in-depth interviews collected qualitative data. A total of 160 respondents were interviewed from all the six locations of Budalangi Division. Correlation coefficient was used to establish the relationship between flood magnitudes and crop production.

Discussion

Floods in Budalangi Division

Rainfall in Budalangi Division is not sufficient to cause floods; rather it is the heavy rainfall in the upper catchments (Elgon Downs, Kitale and Eldoret regions) and middle catchments (Bungoma region) that results in overtopping of River Nzoia in its lower reaches and rising of water levels in the Yala Swamp. Flooding is exacerbated by not only human activities such as breaking of dykes but also by the character of Lake Victoria of being slow in absorbing water from the rivers sending it back to the nearby floodplain (KRCS, 2003).

Budalangi Division experiences floods when the River Nzoia flows are as high as 245.70

cubic meters per second (m^3/s) (LBDA, 2003). Between 1990 and 2003, water levels measured from RGS 1EF01 indicated that annual peak flows ranged between 296.76 m^3/s and 493.60 m^3/s (Table 1). The table reveals that there have been floods in the division between 1990 and 2003 but of varied magnitude. This agrees with Thompson and Turk (1995) assertion that many streams flood regularly, some every year and that a given stream floods to a higher level in some years than in others. Generally, there has been a gradual increase in flood magnitudes in the recent past.

Table 1: Annual flood series of River Nzoia at RGS 1EF01 (*Source*: field data)

Year	**Annual flood discharges (M^3/s)**	**Year**	**Annual flood discharges (M^3/s)**
1990	370.47	**1997**	401.08
1991	346.00	**1998**	391.17
1992	415.01	**1999**	334.33
1993	326.58	**2000**	296.76
1994	365.56	**2001**	335.30
1995	322.71	**2002**	396.13
1996	298.67	**2003**	493.60

Annual flood magnitudes of 296.76m^3/s had a recurrence interval about 1.07 years (Table 2). Annual flood magnitudes of 493.60 m^3/s (the highest magnitude for the period studied) are rare and expected to occur once in an average of fifteen years. Dury (1981) observes that floods of high recurrence interval are of great magnitude. The study established that in any given year, the percentage probability of annual flood magnitude exceeding 296.76 m^3/s was 93. 2% while that of 493.9 m^3/s was 6.7%.

Table 2: Recurrence intervals of annual flood series of different magnitudes (Source, field data)

Year	**Annual Floods discharges (m^3/s)**		**Rank order**	**Frequency interval (Years) n+1/r**
	Recorded	**Relisted**		
1990	**370.47**	493.60	1	**15**
1991	**346.00**	415.01	2	**7.5**
1992	**415.01**	401.08	3	**5**
1993	**326.58**	396.13	4	**3.75**
1994	**365.56**	391.17	5	**3**
1995	**322.71**	370.47	6	**2.5**
1996	**298.67**	365.56	7	**2.14**
1997	**401.08**	346.00	8	**1.88**
1998	**391.17**	335.30	9	**1.67**
1999	**334.33**	334.33	10	**1.5**
2000	**296.76**	326.58	11	**1.36**
2001	**335.30**	322.71	12	**1.25**
2002	**396.13**	298.67	13	**1.15**
2003	**493.60**	296.76	14	**1.07**

Floods in Budalangi Division are seasonal. The onset of floods coincides with the beginning of long rains in April and May as shown in Figure 2. About 72% of the total number of years for the period studied experienced high flows in the month of April whereas 85% of the total number of years had high flow peaks in the month of May. The month of May experiences the highest number of days with high flows in most of the years. During short rains, the month of September experiences the highest number of high flow days resulting in floods.

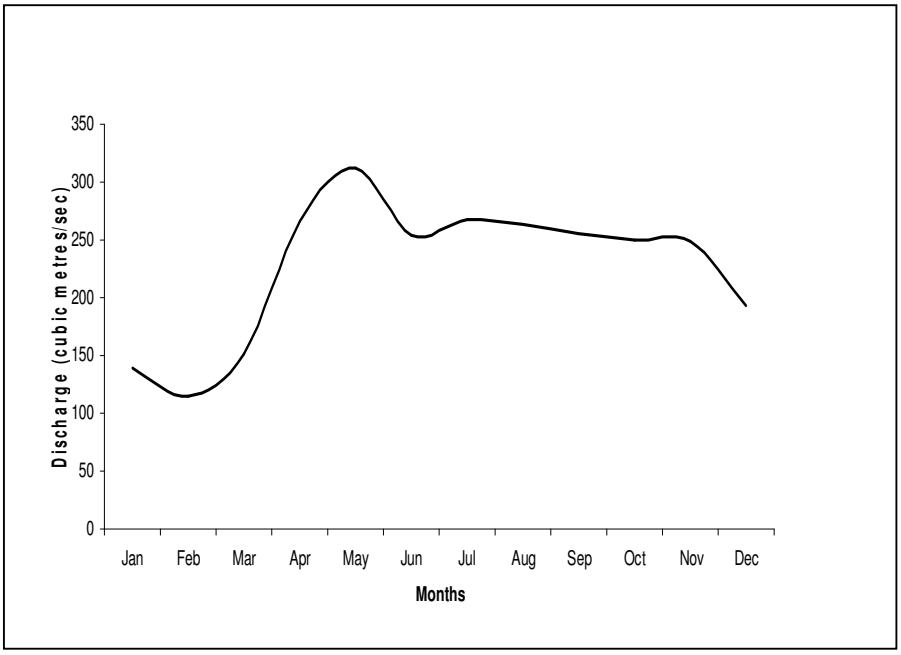

Figure 2: Mean monthly discharge trends for period 1990-2003 (Source: Field Data)

Floods and Crop Farming

Crop farming is the most important economic activity in Budalangi Division. Land preparation takes place in the month of February while planting begins in March which in most cases marks the beginning of the long rains. Harvesting takes place from the month of June. Very few people engage in farming activities after their first harvest because of lack of enough rain to facilitate proper growth of crops.

Much emphasis on crop farming is on subsistence than commercial farming. The major types of food crops grown are maize, beans, sorghum, cassava, finger millet and sweet potatoes. Cash crop farming is practiced by about 25 percent of all the farmers (GOK, 2002; Were and Soper, 1986). The main cash crop grown is cotton. Tomatoes, kales, and onions, though subsistence, are also grown majorly for commercial purposes. However, the number of cotton farmers has continually declined due to the collapse of ginneries in the area and the near collapse of the cooperative societies that help farmers market their produce. This is attributed to poor government policies governing cotton production and marketing which dates back in the late 1980s (Were and Soper, 1986). Grove (1989) observes that villagers left on their own have little incentive to work hard on cash crop farming knowing that the money they will earn is worthy very little and so they simply grow enough for food for their own needs.

Most of the farmers in the division till small plots of land that measure less than half an acre. Most of the fertile lands, of between two and eight acres per household, are situated in the lowlands that are either permanently or seasonally flooded. Floods have demoralized farmers. As a result some farmers opt to cultivate small portions of land to reduce losses incurred during floods while others abandon farming waiting for government relief assistance. Farmers hope to embark on proper crop farming when flood problem will be solved (Huho, 2007). This confirms Volker (1989) idea that flood protection during the rainy season is an absolute necessity to cultivate and grow dry land crops.

Lack of planting seeds hinders sustainable crop farming. Previous destruction of crops, which they depend on as the source of seeds leaves farmer with no seeds to plant. Farmers prepare land without seeds hoping to get some from the government or the non-governmental organizations (NGOs) operating in the division. The little income they get from other sources, say small-scale businesses, cater for the most immediate needs such as food, clothes and medical care thus unable to buy seeds. This has force some farmers to abandon crop farming and engage in fishing, basketry, brick-making and even brewing of illicit alcoholic drinks.

Increase in pests in the division has led to reduction crop production in the division. The expansion of Yala Swamp and flooded lands that have been left fallow for long duration of time, have led to growth of dense swamp vegetation cover close to the farmlands. This creates good habitats for pests. Swamp vegetations house wild pigs, porcupines, hares, birds and monkeys that destroy planted crops. These animal pests destroy either cereals or root crops while in the farms. Hares, for instance, destroy germinating crops such as beans and maize while birds, which have been on an increase, destroy sorghum and millet when ready for harvest. There have been changes in the grade of cotton (i.e. from higher to lower grades) produced in the division. This has been attributed to attacks by pests such as bollworms and beetles, which stains cotton yarns into either yellow or black colour. Dense vegetation that grows near the farmlands, during floods, creates good habitats for these harmful insect pests that destroy cotton bolls, lowering its grade. (Division extension officer, personal communication). The number of people who engage in cotton farming has greatly reduced over years.

Flood events come with food and non-food relief assistance from the government and well wishers. This has caused the dependency syndrome among the inhabitants of Budalang'i Division. Dependency on relief assistance from has hindered active crop farming activities. Most of the inhabitants rely on relief food than producing food from their farms. They prefer living in flood camps even after floods subside in order to continue receiving the assistance. Some farmers opt not to prepare their lands so that they can continue to benefit from relief assistance.

Effects of Floods on Selected Food Crops

There has been a consistently low production in food crops in Budalang'i Division leading to food shortages. This has been partly attributed to inundating of crops during the growing season or before the harvest, increase in crop pests and diseases and drought events. Inundation of land during the growing season has complete destructive effects on agricultural production (DMC, 1995). For instance, the year 1998 and 2003 experienced severe floods which led to extremely low agricultural production (Table 3).

Table 3 Annual yields for selected crops in Budalang'i Division (*Source:* MoALD, 2004)

Year	**Crop yields in tons**			
Crop type	**Maize**	**Sorghum**	**Beans**	**Cassava**
1997	2341	1697	1633	1479
1998	1502	902	17	710
1999	1221	560	147	3630
2000	3630	800	540	3248
2001	2230	860	1100	2010
2002	1350	599	297	840
2003	63	100	91	177

There exists a negative relationship between flood magnitudes and different crop yields in the study area. When flood magnitudes are high, the crop yields are low in the division. Among the crops examined, maize was greatly affected by floods than other crops. A very strong negative correlation coefficient of -0.796 was established between flood magnitude and maize production (Table 4).

Table 4: Relationship between flood magnitudes and maize production (*Source*: Field data)

Crop type	**Maize (in tons)**	**Flood magnitude (m^3/s)**
1997	2341	401.08
1998	1502	391.17
1999	1221	334.33
2000	3630	296.76
2001	2230	335.30
2002	1350	396.13
2003	63	493.60

Correlation coefficient (r)= - 0.796

This strong negative correlation coefficient was attributed to (i) maize, being the staple food crop in the division, is planted in plenty on both flood prone areas and higher lands. In the event of floods, large tracks of maize plants in the low-lying areas are inundated and, (b) due its inability to withstand water for long durations. Maize roots die and rot within a short period of water logging (Division extension officer, personal communication). In 1997, floods inundated land after maize had been harvested. The El nino rains that caused havoc country wide started in the month of October in 1997. This explains why the year 1997 had high maize yields. Calculations of coefficient of determination indicate that floods and the related effects have contributed up to 63.4% reduction in maize production in Budalangi Division. Other factors factors such as drought, use of uncertified seeds and peoples' attitude contribute to a decrease of up to 36.6% of maize production.

A weak negative correlation coefficient of -0.293 in relation to flood magnitude and sorghum production was established (Table 5). This implies that floods affects up to 8.6% of the sorghum production in the division. This was attributed to its ability to withstand waterlogged soils making sorghum more resistant to floods than maize. Droughts, taste and preferences, use of poor quality seeds, among others causes explains over 91% of decrease in sorghum production in Budalangi Division.

Table 5: Relationship between flood magnitudes and sorghum production (*Source*: Field data)

Crop type	Sorghum (in tons)	Flood magnitude (m^3/s)
1997	1697	401.08
1998	902	391.17
1999	560	334.33
2000	800	296.76
2001	860	335.30
2002	599	396.13
2003	100	493.60

Correlation coefficient (r)= **- 0.293**

Beans are early maturing crops and when planted early enough flood events rarely affect them. Sometimes late preparation of land and lack of seeds have however led to destruction of been crops by flood while in the farmland. Due to its ability to mature early, floods of lesser magnitudes have lesser impact on bean production (Table 6). A weak negative correlation of -0.192 was therefore established. The coefficient of determination indicates that floods directly affect up to 3.7% of bean production in the division. More flood resistant sorghum varieties are continuously being introduced in the division.

Table 6: Relationship between bean crop production and flood magnitudes (*Source:* Field data)

Crop type	Beans (in tons)	Flood Magnitude (m^3/s)
1997	1633	401.08
1998	17	391.17
1999	147	334.33
2000	540	296.76
2001	1100	335.30
2002	297	396.13
2003	91	493.60

Correlation coefficient (r)= **- 0.192**

Cassavas are drought resistant and are mostly grown on drier highlands. People living in lowland plant small portions of cassava since they prefer maize than cassava. Therefore, floods affect lesser acreage of cassava in lowlands than that of maize. On higher lands, cassava is rarely directly affected by floods. Indirectly cassavas are affected through pests bred in vegetated flood areas. A very weak negative coefficient correlation of -0.114 was therefore established between flood magnitudes and cassava production (Table 7). This implies that floods have led to 1.3% reduction in cassava production in Budalangi Division. Over 98% of reduction in cassava production in Budalangi division can be explained by other factors such as drought, peoples' attitude and preference and taste.

Table 7: Relationship between flood magnitudes and cassava production (*Source:* Field data)

Crop type	Cassava (in tons)	Flood Magnitude (m^3/s)
1997	1479	401.08
1998	710	391.17
1999	3630	334.33
2000	3248	296.76
2001	2010	335.30
2002	840	396.13
2003	177	493.60

Correlation coefficient (r)= **- 0.114**

Conclusion and Recommendations

Crop production has decreased over the years in Budalangi Division partly because of the effects of floods. Years with high flood magnitudes and longer flood duration seems to have experienced very low crop yields. This has been as a result of inundation of croplands hindering timely planting and/ or destruction of already planted crops. Low crop production, in the years without floods, has resulted from the unwillingness of the farmers to prepare the lands for crop production in fear of the return of floods, lack of seeds, lack of capital and droughts. Some farmers also tend to depend on relief assistance from the government and other donors than farming. Late planting of early maturing crops due to lack of seeds and late land preparation have caused inundation of crops that could have otherwise been harvested. These factors have led to continued low crop production in the division. The effect of floods on different crops varies with from one type of crop to the other. Crops with low resistance to water logging such as maize are mostly affected while those with higher resistance such as sorghum are less affected. However, due to taste preference, inhabitants continue planting maize increasing the risk of food insecurity.

The study recommends that there should be a proper planning of relief measures and emergency assistance. Unless relief measures and emergency assistance are properly designed they encourage persistence occupancy and reluctance to accept more rational adjustments. Some people in Budalangi Division prefer staying in flood camps even after floods subside in order to continue getting assistance from the government. Introduction of some measures such as distribution of assistance to only those people who return back to their farmlands when floods subside would encourage people to go back to their farmlands. Provision of planting seeds during the planting seasons, only in years when floods cause massive destruction, and later reduced amount of relief assistance depending on flood situations in the division will encourage people to work in their farmlands. This will not only be cost effective to the government but also will discourage over-reliance of the inhabitants on relief food hence work on their farms when floods are not there.

Consistent education, on various crop varieties that are resistant to water logging and have the same nutritive value as the preferred crops, should be encouraged. Demonstration field should be set up to emphasize on the need to change the crop types and varieties. Clearing of vegetated farmlands will lessen the number of pests that destroyed planted crops. Clearing of such lands will not only reduce the number of pests but will also lead to faster evaporation of floodwater. Such lands could latter be used as pasture if farmers fear planting crops. This will reduce dependency on relief assistance.

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International Journal for Disaster Management & Risk Reduction Vol. 1 No. 2, **pp** *X-Y* July 2008 ISSN: 1992-2744

FROM DISASTER RESPONSE TO POVERTY REDUCTION

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Abstract

Prior to the UN International Decade for Natural Disaster Reduction, IDNDR, (1990-1999), the focus for disaster management was on disaster response and emergency relief activities. The IDNDR yielded the International Strategy for Disaster Reduction (ISDR), which brought a shift in disaster management strategy from emergency response and relief to Disaster Risk Reduction (DRR) strategy. DRR involves foreseeing danger and making appropriate and timely actions to reduce the risk or mitigate the impact of the impending disaster. In this paper we argue that poverty reduction is the main pillar in realizing the disaster risk reduction. We echo the argument that the surest way to improve the quality of environment is to empower the community economically, socially and politically. We conclude by stating that disaster management can be done sustainably by strengthening the communities.

Keywords*: disaster response, disaster risk reduction, sustainable development, poverty reduction*

Introduction

Prior to the UN International Decade for Disaster Reduction (1990-1999), the focus for disaster management was on disaster response and emergency relief activities. This involved making preparatory arrangements for the specific disaster event so that after the disaster has occurred, the resulting causalities, injuries and disruption of physical facilities were kept to a minimum. Emergency relief relies on humanitarian activities that are taken immediately after a disaster has occurred, and its main aim is to save lives. Therefore, Disaster Response (DR) and Emergency Relief (ER) are event based activities which are taken after a disaster has occurred. These are the major cornerstones of traditional disaster management.

Disaster Risk Reduction

On the other hand, Disaster Risk Reduction refers to foreseeing danger and taking measures either to prevent or mitigate the impact of the danger through adequate preparation and effective response. In other words, Disaster Risk Reduction strategy involves identification of hazards; forecasting of impending events which are likely to cause damage to life, property, infrastructure and the environment; processing and dissemination of warnings or instructions to the appropriate authorities or populations; and making appropriate and timely actions to reduce the risk or mitigate the impact of the impending disaster.

It is worth emphasizing that Disaster Risk Reduction is neither a humanitarian nor an exceptional event. DRR has more to do with development than with humanitarian assistance. Hence for it to obtain stable, predictable and long term resources, DRR has to compete with other development agenda such as health, education and infrastructure. But because humans respond more to things that are "urgent' than things that are "important", activities under DRR are given less attention since development issues are usually not urgent. Therefore, for DRR to attract more attention and funding, it is has to be perceived as a humanitarian activity, and not a developmental activity (Valency 2005).

Kenyan Case

Kenya as a country has made a substantial efforts towards reducing the occurrences of hazards, magnitudes of hazards and impacts of disasters. Efforts by different stakeholders towards ensuring the achievement of this objective yielded a draft national disaster policy of 2002. This policy is yet to be translated into law after approval by parliament. The country recognizes that the key component in Disaster Management is Disaster Risk Reduction. To develop the Disaster Risk Reduction Strategy, a bseline survey was carried out to establish the status of disaster risk reduction in Kenya. The underlying factors that enhance disasters in Kenya include: low levels of political commitment, lack of institutional frameworks for DRR; very limited capacity in risk identification; poor knowledge management; poor governance; and uncoordinated and limited emergency response (GoK 2008). It is quite fortunate that the factor of poverty reduction as a fundamental measure to reduce disaster impacts is addressed by the Government of Kenya.

Sustainable Development

Sustainable Development is the use of resources within the environment efficiently without compromising the availability of these resources for the future generations. The three pillars of sustainable development include: social development, economic development and wise environmental management. Disaster Risk Reduction strategy is inseparable from sustainable development. Therefore for an effective DRR strategy, more efforts should be directed towards sustainable development policies which take into account the potential risks for disasters. All should plan to reduce these risks; involving everyone and producing not just help but hope (ISDR 2002).

The Paradigm Shift from DM to DRR

Since the 1970s to date, the number of, and the costs of major disasters worldwide have continued to rise. Furthermore, the type and complexity of natural disasters have continued to expand. In contrast, the number of deaths during the corresponding period has decreased tremendously. But to counter the threats due to increased number and complexity of disasters, many different approaches have been designed in order to deal with natural disasters. Some of approaches have variously been called: Emergency Assistance, humanitarian assistance, Civil defense, Civil protection, disaster protection or homeland security.

During the World Conference on Natural Disaster Reduction in Yokohama in May 1994, the World nations produced the so-called "Yokohama Strategy and Plan of Action for a Safer World". The document contained ten principles which were expected to be adopted by all nations of the word in order to effectively deal with natural disasters. The overall goal of the strategy was for each nation to adopt a holistic approach focusing on risk and vulnerability; and the concept of risk reduction or disaster risk management. This was the beginning of the shift in disaster management, popularly known as the 'Paradigm Shift' Figure 1. The shift refers to the development from emphasis on protection against hazards, to emphasis on awareness, assessment and management whereby disaster risk reduction is highlighted and integrated into the broader context of sustainable development and related environmental management. Whereas the traditional Disaster Management focused on preparedness for response, DRR policies focus on a twofold aim, namely (i) to enable societies to be resilient to natural disasters and (ii) to concurrently ensure that the development efforts do not increase vulnerability to these hazards. DRR is multidisciplinary working through political, professional institutional and public collaboration.

Requirements for DRR

Despite the current improvement in DRR strategies, there are some gaps or constraints which need to be addressed before the strategy can produce worthwhile results.

Some of these gaps include (i) Lack of clear cut policy and effective strategy for disaster prevention, response and rehabilitation (ii) Lack of integration of DRR programmes into sustainable development (iii) Inadequate resource commitment to DRR and management and (iv) Limited national or public ownership of DRR and Management programmes.

Poverty Reduction Initiatives

Poverty has been identified as one of the major causes of man-made disasters in many countries (Odei 2005). This is especially true for several reasons. Firstly, the rural poor peasants degrade and over exploit the environment through poor agricultural and husbandry practices. Secondly, poor people over exploit forests through firewood collection and charcoal making in order to eke out bare existence. Thirdly, natural hazards including earthquakes, droughts, sand storms, floods, tend to hurt poor people more because poor people normally inhabit areas with poor drainage, steep field slopes, poor infrastructure, poor housing and poor sanitary facilities. Panayotou, 2000, poses a very important question, "What is the relationship between a steady increase in incomes and environmental quality? For some social and physical scientists (Georgescu-Roaegen, 1971 and Cleveland, 1984), higher levels of economic activity require larger inputs of energy and material, and generate larger quantities of waste byproducts. Therefore, to save the environment and even economic activity from itself, economic growth must cease and the world must make a transition to a steady-state economy. At the other extreme, are those who argue that the fastest road to environmental improvement is along the path of economic growth; with higher incomes comes an increased demand for goods and services that are less material-intensive, and for improved environmental quality that leads to the adoption of environmental protection measures. Indeed, Beckerman (1992) states that the surest way to improve one's environment is to become rich. Therefore, one of the most effective strategies of fighting disasters involves implementation of the Poverty Reduction strategies (PRS). In this paper we adopt the second thought: that poverty reduction is the core pillar in reducing disasters. This concept of emphasizing poverty reduction is consistent with the five principles of the Hyogo Framework of Action (HFA) in ISDR, 2007; making disaster risk reduction a priority, improving risk information and early warning, building a culture of safety and resilience, reducing the risks in key sectors, and strengthening preparedness for response. It is evident poverty reduction and economic empowerment is the key factor in order to realize these strategies.

Social Mobilization, DRR and Poverty Reduction

Social mobilization is a key strategy for DRR and poverty reduction. This approach involves organization, training and equipping community based Disaster Volunteer Groups (DVGs) made up of young men and women, to assist in the identification of risks, prevention and management of disasters and to undertake poverty reduction and community development programmes. There is an intrinsic relationship among disaster reduction, sustainable development and poverty eradication as expressly stated in the Hyogo Declaration (2005). It is on this basis that we suggest that the modification of paradigm shift in disaster management from Disaster response to poverty reduction as shown in Figure 1.

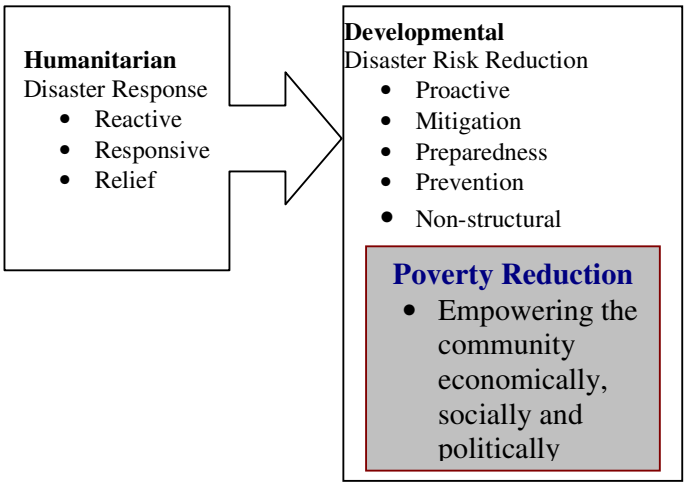

Fig. 1: The Paradigm shift from Humanitarian relief to Poverty Reduction

Community Based Disaster Volunteer Concept

Community Based Disaster Volunteer Concept aims at ensuring active community participation in Disaster Management processes. The objectives of this approach include (i) to mobilize and train the youth and the unemployed for the purpose of equipping them with the necessary technical knowledge to enable them participate effectively in Disaster management, employment generation, and community development (ii) to sensitize local communities so that they in turn identify potentials and strengths for development, decision making, and community livelihood development (iii) to assist poor communities to develop employment and social amenities such as schools, wells, dams, roads, health centres, etc. (iv) to encourage communities to understand and participate in government programmes and activities. Therefore, DVG concept can be regarded as a poverty reduction strategy to assist volunteers to undertake income-generating activities. The concept entrains volunteers who are mostly unemployed and economically deprived into the mainstream of economic activities to enable them take advantage of opportunities created by government interventions under national poverty reduction strategy. DVG concept serves as a channel for public education in areas of health, bushfire, prevention, tree planting, HIV and Aids, environment and governance.

Conclusions

Earlier approaches to Disaster Management had inherent shortcomings especially because they were not people centred. They instead laid emphasis on preparation of plans to respond to the disaster when it occurred by providing emergency relief. Later on in the 1990s, there was a paradigm shift from focusing on response and emergency relief to a more proactive approach of disaster risk reduction. Disaster risk reduction emphasizes awareness, assessment and management of disasters. More importantly, disaster risk reduction activities are integrated into the broader context of sustainable development and related environmental management. Concurrently, poverty has been identified as one of the major causes of man-made disasters. Therefore, one of the best approaches of fighting disasters is through poverty reduction. This is best done through community based disaster volunteer groups.

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