

**THE IMPACT OF NATURAL DISASTERS, DUE TO ENVIRONMENTAL
CHANGE, ON THE LIVELIHOOD OF THE LAKE VICTORIA BASIN**

LAKE VICTORIA ECOSYSTEM OUTLOOK

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1. BACKGROUND

The major forms of disasters include: Droughts, Floods, Terrorism, Landslides, HIV/AIDS and disease epidemics, Transport accidents, Fires/industrial hazards and pollution. There are other extreme outbreaks of diseases, such as cholera, malaria, typhoid and meningitis, which have become threats as a result of HIV/AIDS.

The focus of this paper is on the natural disasters, which are rampant within the lake Victoria basin and are related to extreme weather and climate events such as droughts, floods and strong winds, among others. Extreme weather and climate events influence the welfare of the society and entire economy of the country with droughts and floods having the highest adverse effects. The sectors that experience the immediate effects include agriculture, health, and water resources among others.

Droughts and floods contribute to the most devastating natural hazards in the basin, which often translate into disasters in the riparian countries. Droughts affect food production, availability of water, and generation hydroelectric power for industrial and domestic consumption. The majority of short falls in food supply recorded in 1928, 1933-34, 1937, 1939, 1942-44, 1947, 1951, 1952-55, 1957.58m 1984/85 and 1999-2000 could be easily associated with rainfall deficits experienced in the respective years. The intensity, duration and total magnitude of the rains are some of the key factors affecting the agricultural production. The droughts may also lead to outbreak of some unique diseases including those related to water scarcity.

On the other hand floods lead to the displacement of communities, and distraction of the infrastructure and crops. Like droughts, they also lead to outbreak of diseases. Floods are attributed to the heavy rainfall over the catchments upstream; Rivers often burst their banks and submerge the neighbouring farms and houses. This result in displacement of people, destruction of homes, granaries, farmlands, road network, schools and grazing land. Most of the displaced families moved to higher grounds where they put up in makeshift camps. The state of water supply and sanitation is very bad for the community

affected in addition to the increased density of mosquitoes due to the stagnant water resulting in an upsurge of water borne diseases.

The effects of excess rainfall (floods) over a locality for a given time period are very devastating leading to loss of life and property. During floods people lose their lives, others are displaced, there is destruction of property/crops, destruction of infrastructure, inaccessibility to clean water, siltation of arable lands, water borne diseases among others. Once the people are displaced from their homes, they are forced to live in camps, which in one way or the other leads to increased instances of HIV/AIDs.

Many times, people are caught unaware when these extreme climatic events strike leading to huge losses.

Droughts differ from other natural hazards in several important ways:

- Slow-onset, creeping phenomenon that makes it difficult to determine the onset and end of the event;
- Duration may range from months to years;
- No universal definition;
- No single indicator or index can identify precisely the onset and severity of the event;
- Impacts are generally non-structural and difficult to quantify;
- Spatial extent is usually much greater than for other natural hazards, making assessment and response actions difficult, since impacts are spread over larger geographical areas;
- Impacts are cumulative;

2. STATUS OF LAKE VICTORIA ECOSYSTEM, INCLUDING DRIVERS AND PRESSURES RELEVANT TO FLOOD DISASTERS

The vulnerability to flood disasters is a function of a number of physical features and social characteristics. The Physical features associated with maximum vulnerability of flood disasters in the basin include:

- The marginal hydrological and climatic regime;
- High rates of sedimentation leading to reduction of reservoir storage;
- Topography and land-use practices that promote soil erosion and flash flooding conditions

- Deforestation, which allows increased surface runoff, increased soil erosion and more frequent significant flooding.

The social characteristics that increase vulnerability to flood disasters include:

- Poverty and low income levels that prevent long term planning and provisioning at the household level,
- Lack of water control infrastructures,
- Inadequate maintenance and deterioration of existing infrastructure,
- Lack of human capital skills for system planning and management,
- Lack of appropriate and empowered institutions,
- Absence of appropriate land-use planning and management,
- High population densities and other factors that inhibit population mobility,
- Increasing demand for water because of rapid population growth, and Conservative attitudes toward risk, i.e. unwillingness to live with some risks as a trade-off against more goods and services.

It should be noted that flooding poses serious threats to pollution of both surface and ground water resources in an area.

The key indicators of vulnerability and risks in the water resources sector as mentioned earlier can be grouped as both natural as well as human-related factors. The major drivers leading to flooding include climate, topography and geology while the human-related factors include settlement patterns, land-use patterns and pressures, migration patterns, population pressure, degradation of water catchment areas, unsustainable water supply, poverty and access to health and social services. These are briefly discussed in the sections below:

2.1 Climate

Of all the relevant factors in climate, precipitation is the main cause of disasters in the water resources sector. Abundant precipitation can lead to disasters such as flooding, water pollution, soil erosion, dam breaks as well as water related disease outbreaks and

famine. On the other hand, scarcity of precipitation in areas, which ordinarily receive it, can lead to drought, water scarcity, loss of vegetation, loss of livestock and wildlife, famine and general suffering of people living in the affected areas. It is important that the characteristics and predictive potential of rainfall is factored in all the water resources management practices and policies in order to mitigate the adverse effects of disasters.

85% of the water entering the lake does so from precipitation directly on to the lake surface, the remainder coming from rivers which drains the surrounding catchment. The most significant of these rivers, the Kagera, contributes roughly 7% of the total inflow. Some 85% of the water leaving the lake does so through direct evaporation. The remaining 15% leave largely by way of the Victoria Nile, which leaves the lake near Jinja in Uganda, and flows via the Owen Falls, Lake Kioga, and the Murchison Falls to join the outflow from Lake Albert.

Although human impacts on the lake basin environment may now eclipse the events taking place, climate factors could be reinforcing environmental degradation in the lake basin. . In the case of the Nyando River Basin in Kenya, interviews with local people suggest that many of the major soil erosion problems either started or were dramatically accelerated in their development during the early 1960's. Prevailing conditions during the early 1960's may then have been such that the basin was essentially primed for massive erosion/sedimentation during a period of extraordinarily heavy rainfall in the region. This is of particular concern as we can only speculate what might happen now, should we witness the return of a rainfall period of the magnitude observed during the 1960's.

2.2 Geology and Topography

The geological characteristics of an area are known to influence the drainage patterns, the nature of soils as well as land use patterns. For instance, heavy rainfall is more likely to cause flooding in low-lying regions occupied with clay formations because clay formations have low infiltration capacities and therefore surface runoff is generated rapidly. The same heavy rainfall in zones occupied by sandy soil will not cause

significant flooding since rapid infiltration of rainfall reduces the likelihood of generation of high volume of surface runoff.

The topography of a region also determines land-use patterns as well as the patterns and intensity of erosion and landslides. It influences the gradient of rivers such that in areas with steep slopes, water flows rapidly into river channels. In such cases, the flood stage of a river is reached rapidly. In flat plains, the gentle slope reduces the velocity of flow leading to formation of meanders and flood plains. Water in such areas is not transported rapidly and tends to pile up making the low-lying zones more liable to flooding (e.g. Kano plains in Kenya).

2.3 Population Pressure and Settlement Patterns

Settlement patterns are partly influenced by population pressure. In urban areas there is tendency for the slums to develop in areas, which have been designated as flood-prone zones. Settlement on steep slopes as well as cultivation on such lands also tends to increase the vulnerability of the community to landslides. This also increases possibility of increased rates of soil erosion particularly where overgrazing and deforestation have reduced vegetation cover. Modification of river channels through channel straightening can lead to rapid flow of water into streams thus promoting rapid increase in water level in rivers. Flooding of the low-lying areas often follows this.

2.3.1 High Population Growth

The Lake Victoria Basin (LVB) now supports one of the densest and poorest rural populations in the world, with densities up to 1200 persons per square kilometre in parts of Kenya (Hoekstra and Corbett, 1995). The first systematic population surveys for Kenya, Tanzania and Uganda, were conducted during the late 1940's. The 1948 estimate for Kenya, for example, is given at 5.7 million inhabitants (Lury, 1969). The current estimate is 28.4 million inhabitants giving an approximate population doubling time of 22.1 years. This means that the population of Kenya has doubled approximately 3.3 times in the time required for the water in Lake Victoria to turn over once. Moreover, population densities in the lake basin portions of Kenya, Tanzania, Uganda, Rwanda and

Burundi are well above their respective national averages, indicating doubling times that are probably considerably shorter than the respective national averages.

National population growth rates, though declining due to the HIV/AIDS pandemic and other diseases, remain among the highest in the world and the populations in the five riparian countries are expected to double again over the next 25-35 years (UNPB, 2000). More specific projections and scenarios for Lake Victoria Basin will be needed in order to provide realistic year 2050 land and water degradation scenarios based on which various management and policy options could be evaluated.

2.4 Poor Land-use and Degradation of Catchment Areas

Poor land-use activities characterized by deforestation and clearance of bushes and other vegetation is the major cause of catchment degradation. Cultivation on steep slopes without applying soil conservation measures promotes soil erosion and rapid generation of surface runoff. Vegetation cover is essential since it retards the flow of surface runoff thus encouraging more water to infiltrate into the soil and replenish soil moisture. The recharge groundwater aquifers also take place through infiltration and deep percolation of rainwater.

Other causes of the degradation of catchment areas include poor construction of roads and footpaths, which are sources of sediments carried by the surface runoff to river channels. Lack of effective urban planning mechanisms promote development of slums and other residential structures which discharge sewage and domestic wastewater into river channels thus degrading important water catchment areas.

The land use within the basin is primarily small-scale subsistence agriculture and large-scale sugar cultivation in parts of lake Victoria basin in Kenya. Subsistence crops include Maize, Sorghum, Pulses and Tuber crops. In the plains Cotton is grown and Rice is grown further downstream. Livestock raising is also a main agricultural activity with large areas left for pasture. One of the critical factors affecting land-use management is land tenure. The residence period of land users on a particular piece of land could

influence their attitudes towards good land-use practices, which could promote environmental conservation. Generally land in Kenya is either under customary tenure, freehold, leasehold, and trust hold or government land. The impact of each of the tenure systems depends on land-use activity.

In many parts of the basin especially in the flood prone areas, there is large-scale destruction of forests and watershed degradation due to unscientific and unregulated land use causing increased flood hazard over the years. Heavy sediment loads brought down by rivers from denuded hilly catchments and consequent aggradation of the river beds in lower reaches decreases the carrying capacity of the rivers and consequent rise in flood levels. Most farmers engaged in agriculture in steep hill slopes violate the relevant provisions of the Agriculture Act.

Excessive encroachment of the “river reserves” by The people and “overstocking” of livestock far in excess of the carrying capacity of the land, and climate changes were also seen as the factors contributing to increased flood hazard. Some participants blamed both the government and the people – the government for lack of seriousness and coordination in dealing with hazard and people for lack of awareness and slow response to the situation.

2.5 Lack of Regulatory Systems

The enforcement of regulations governing settlement in zones designated as flood-prone has been a major problem in the riparian countries in that the enforcement is weak partly due to weak institutional capabilities to enforce regulations. Similarly, there are no effective co-ordination between different government departments and non-governmental organizations resulting into wastage of resources and duplication of effort. The uneven development in the country particularly the huge difference in the living standard of urban and rural areas are encouraging the influx of rural poor into urban areas in search of better opportunities.

This has led to overcrowding in urban areas, severely over-straining the existing housing, health, water supply, sewage, and educational and recreational facilities. Most of the present facilities in urban areas were designed to cater for a small elite population during colonial times. Lack of housing and inability to access more decent housing has encouraged development of slums in areas, which are more liable to flooding. This makes the urban population around the lake more vulnerable to flooding.

2.6 Poverty

Poverty encourages people to dwell in slums located in flood-prone zones of the urban areas. It has also contributed to the limited application of better land-use practices and soil conservation methods in rural areas. Cultivation in these areas is thus done by using unsustainable indigenous technology, which provides low yields and exposes soil to erosion hazards. Also, it has encouraged the conversion of swamps and wetlands into settlement and agricultural lands thus subjecting the population to the risks of flooding.

2.6.1 High Levels of Poverty

Lake Victoria directly or indirectly supports 28 million people who produce an annual gross economic product in the order of US\$ 3-4 billion (or 107–143 \$US GEP per capita). Over the 1965-95 period growths in per capita income levels in Kenya, for example, averaged $2.4\% \pm 2.6\%$ (95% CI) per annum (World Bank Development Indicators, 1998). Even at the most optimistic end of this range (i.e., 5% growth per year), income doubling from 386 (in 1995) to 772 \$US per capita (1984 eqv. US\$) would be expected to take about 14 years. Under prevailing economic conditions, such a scenario seems highly unlikely, and even if it were to occur, Kenya would still rank in the lowest third of countries on a per capita income basis by current standards.

In Kenya for example, the Welfare Monitoring Survey implemented in 1994, showed that the incidence of “hard core” poverty was between 40% and 50% in three Lake Basin districts (Bungoma, Busia and Kericho) and between 30% and 40% in four Lake Basin districts (Bomet, Nyamira, Vihiga and Kakamega). Hard core poverty was defined as total expenditure of less than Ksh 703 per adult equivalent per month (Central Bureau of

Statistics, 1998) and is thus a much stricter standard than the dollar-a-day rule used by the World Bank. It is currently unknown how these figures will project to the future in a lake basin-wide context, and there is thus a need to collate income as well as other relevant poverty indicators in other parts of the basin. Unfortunately, most such statistics are compiled at the national-level, and are generally difficult to disaggregate toward sub-national entities.

The main occupation of the flood plain dwellers is agriculture, livestock farming and fishery. Due to poor quality inputs and unscientific techniques being used in these occupations the income levels are low. Market access for the products is hampered due to poor road network and condition of roads, but to a large extent due to poor marketing mechanism.

Subsistence agriculture, pastoralism and agro-pastoralism support about 21 million people in the basin (est. from data by Deichmann, 1994) with average incomes in the range of US\$ 90-270 per annum (World Bank, 1996). In view of the pervasive poverty among farming communities in the basin (see above), the use of inorganic fertilizer is limited, and primary productivity is closely linked to the inherent productive capacity of the soil. It is unlikely that fisheries, subsistence agriculture and extensive (agro)-pastoralism in their current forms will be able to support food and income requirements under the projected population doubling scenario over the next 25-35 years. Substantial investments in market infrastructure, roads, soil fertility recapitalization, education, fisheries management, conservation and human and veterinary healthcare will be necessary for sustainable intensification and economic growth in the region.

2.7 Limited Access to Proper Health Care and Social Services

Poverty has also made it difficult for a large percentage of the urban and rural people lack access to medical facilities. This has promoted high morbidity caused by water-borne and water-related diseases, which are otherwise treatable. This is made even worse by the inability of the government to provide highly subsidized access to public health facilities. Lack of an effective public health system is making people more liable to epidemics associated with the occurrence of extreme climatic events such as floods and droughts.

Lack of social amenities in both rural and urban areas is also thought to contribute to the low level of preparedness of the local population to handle disasters. This is particularly so given those facilities for dissemination of information to the general populace are often inadequate or completely lacking in certain areas. Thus community mobilization is a difficult task, which is not easily achievable in periods of emergencies.

2.8 Poor Communication Infrastructure

Availability of good communication and transport network is essential in the management of disasters. These include telephone links, roads, railways, airports and airstrips. These are essential for evacuation of population during periods of emergencies. However, the current telephone network is poor and most rural areas are not linked to an efficient telephone system. In addition road and railway network in most places is not in good condition and thus access to zones, which are usually affected by droughts and floods, is problematic.

The problem of communication has been made even worse by the fact that the present telephone and road network was designed to cater for much smaller population. Road traffic has increased tremendously in the recent past leading to rapid deterioration of roads, which were designed to take much smaller loads. Thus lack of access to reliable communication network has increased the risks and vulnerability of the population to extreme climatic events since the affected population cannot be mobilized rapidly. It should be noted that quantifying of the vulnerability of the society is quite complex especially when one is looking for cumulative stresses induced by inter annual variability and long-term climate changes. It will require multiple indices representing the different aspects of vulnerability including the coping mechanisms and adaptive capacity, hazards exposure, ecosystem sensitivity, land use and land use changes.

The state of the current climate is however critical in planning the basic coping and adaptive capacities.

3. IMPACT OF FLOOD DISASTERS

The direct impact of floods were mentioned in general terms such as loss of human lives and livestock, damage to standing crops, loss of personal property and damage to rural infrastructure. Indirect impacts were grouped as loss of income, disruption and set back to on going development programmes, outbreak of water and vector borne diseases during and after floods, disruption of normal family life. The problems of women, children, old and the infirm were brought out quite clearly.

The women are invariably over-worked since they have to manage the usual domestic chores under sub-normal conditions in the relief camps. The most physically stressful tasks are those of fetching water and fire wood and taking care of the ailing members of the family – often ignoring their own morbidity.

The stressful conditions in the relief camps were highlighted unanimously. These included sexual abuse of women by anti-social elements, exploitation of children through child-labour and general neglect of the old and infirm. The criteria of distributing relief supplies to family as a unit encouraged child marriages. Segregation of family members was mentioned as one of weaknesses of the relief operations.

The participants were unanimous about certain beneficial effects of flooding such as improved soil fertility and increased availability of fish in the river and flooded areas. They however had no idea as to how the prevention of flooding and the benefit of increased fish harvest could be harmonized.

Environmental impacts can be grouped under the following main categories:

- (i) Pollution of wells and bore wells
- (ii) Bank erosion
- (iii) Lateral shifting of river channels
- (iv) Silting of river beds
- (v) Loss of top soil (soil erosion)
- (vi) Displacement of wildlife

- (vii) Destruction of Natural vegetation
- (viii) Wanton cutting down of trees for fire wood around the relief camps

5.2 Vulnerability of People To Floods

“Cultural attachment” to the land and their unwillingness to move to safer places can be an avenue for vulnerability to floods. Poverty and lack of awareness about options for enhancing income, and lack of advance flood warning system at the village/community level were perceived as the other key factors contributing to their vulnerability. Fishermen, in particular, were seen to be the most vulnerable since their occupation required them to live close to rivers and flood plains. Box1 indicates the flood situation in Budalangi (Kenyan side of the basin) during May 2003.

Box1: Case of Budalangi floods in May 2003

Ironically, downpours do not cause most of the floods in Budalangi. Rather it is the heavy showers upstream, which are then carried down to the plain from Mount Elgon by the Rivers Nzoia and Yala. The water carried by the two rivers from areas as far away as Trans Nzoia, Uasin Gishu and the Western Region of Kenya is meant to flow into Lake Victoria.

During flash floods, Lake Victoria is slow in absorbing the excess water, and instead sends it back, imprisoning the inhabitants of flat areas like Budalangi.

The entire homesteads were swept away, residents and animals displaced, property and crops worth hundreds of thousands of shillings were lost and many people perished as rivers broke their banks, rendering large areas of land inaccessible. The floods created poverty, because crops and businesses were destroyed. The contamination of pipes and bore-wells aggravated an already acute problem.

The region's already battered infrastructure became further dilapidated, with schools being submerged, thereby disrupting the education of many children. Those schools that were not affected became heavily congested.

Out of Budalangi's population of 53,000, nearly 25,000 were displaced. Some 10,000 of them were accommodated in the DO's camp, necessitating health emergency measures to control possible outbreaks of malaria, Bilharzia, cholera and other water-borne diseases.

4. INTERVENTIONS

Flood protection measures like Construction of dykes, installation of a **flood** warning system, resettlement and construction of a reservoir are measures that can be taken to solve the problems of flooding.

Protection of springs and shallow water wells, increased coverage of urban and rural domestic water supply and sanitation services, development of new supplies and reduction of losses in the distribution systems are measures that can be taken to correct the inadequate water supply and sanitation.

Reforestation, improving land management practices, zoning of conservation areas for protection, improving quality sampling frequencies, setting up and recommending standards for effluent discharges to be maintained by industries, proper application and use of fertilizers and pesticides are measures that can remedy the environmental degradation problem.

4.1 Priorities In Flood Protection

Establishment of accurate and early warning system with linkages up to the community levels was projected as the first priority option in flood management. Equally important was preparation of contingency plans for evacuation and relief measures. Land use regulation through legislative and administrative measures to reduce and regulate use of flood plains for various economic activities..

Among the structural measures, construction and maintenance of dykes and drainage channels are top priority options. Afforestation and “conservation” of catchments, development of pastures and land use regulations are measures that can reduce flood discharges in rivers.

4.2 Monitoring and surveillance of Flood Situation

Following action points can also be considered:

- Intensification of hydromet data collection

- Setting up early warning system at the community level.
- Situation analysis.
- Intervention.
- Monitoring and evaluation.
- Dissemination of information to all stakeholders.
- Establishing teams to monitor climatic changes and water levels in rivers
- Identifying vulnerable points in the dykes.
- River gauge readers to be trained to explain the significance of water level to the community.
- Dyke management committees to be charged with the responsibility of bush clearance, identifying weak spots and repair of dykes and regulation of floodgates.

4.3 Simple measures for flood mitigation

Some of the efforts that do not require a lot of investment but only mobilization and coordination include:

- Removing bushes from dykes can pay high dividends because bushes cause cracks and seepage. In the absence of strong dykes, emphasis ought to be placed on disaster preparedness through contingency planning measures.
- Training and sensitization of the people in rescue efforts and understanding early warning climate systems, so as to inform residents to move to higher grounds before the floods hit, are critical contingency plans.
- Preparing qualified nurses, drilling bore holes for safe drinking water and ensuring that sanitation is of a high standard and properly maintained to check for disease outbreaks. It is up to the Ministry of Works to ensure that roads are passable, since this can be a big impediment during rescue efforts.
- It is during such floods that food scarcity becomes critical. However, the residents need to be educated to plant short-term crops or crops that can withstand floods. It would be prudent to relocate schools to temporary shelters in other areas to maintain learning continuity and minimize congestion during flooding.

- Floods can be conquered if all stakeholders work together in pushing through effective long-term strategies.

4.4 Disaster Management

- Empower the Disaster Management Committees with necessary skills, equipment and financial resources.
- Stockpile emergency supplies at strategic locations.
- Train the communities to act on receipt of advance warning. They should have dedicated transport arrangements for quick evacuation.
- Community participation in camp committees to oversee sanitation, general welfare of the people and distribution of relief supplies and safe drinking water.
- Provide the community with communication equipment.

4.5 Operation and Maintenance Of Flood Management Works

The responsibility of operation and maintenance of flood management works should be transferred to the local communities who should form management committees for the purpose. The community groups should be given training in operation and management and provided with appropriate communication equipment

5. POLICY, LEGISLATIVE AND INSTITUTIONAL REFORMS AND CAPACITY BUILDING

- The existing legislations are top-down and do not reflect the views of the target group (community).
- Relevant provisions of various legislation need to be provided to communities in simple language.
- Participatory approach at all stages of planning, implementation, monitoring and evaluation. Roles and responsibilities of all stakeholders should be clearly defined to avoid duplication of effort.

- Community to be involved in data collection, post disaster response and implementation of plans.
- Knowledge base and capacity of NGOs and CBOs should be enhanced through training programmes
- Formation of a National, Regional Flood Management Boards that specifically deal with natural
- Establish disaster contingency fund.
- Allocation of funds for maintenance of dykes.

6. FLOODS: OPPORTUNITY FOR ECONOMIC PROSPERITY?

Economic power is the ability to purchase food, stay healthy and live in comfort. Floods are known to cause food shortages, malnutrition, diseases and other economic hardships. The economic hardships brought about by floods do result in poverty to majority of the affected communities. Wealth creation and poverty alleviation are issues given prominence in the economic recovery strategies for many Governments.

It has been highlighted that poverty in the flood prone areas is high. Every little effort made by communities in the flood prone areas to improve their well-being is normally swept away by floods, which have become more frequent. It is internationally agreed that the economic base of an individual can influence his vulnerability to natural disasters. A strong economic base improves the resistance of an individual to natural disaster. Hence, in addressing the flood-related disasters in the affected areas, attention must be given to wealth creation.

The economic activities of the communities in the flood prone areas of within the basin include fishing, crop farming and livestock farming. Crop farming is disrupted in a flood situation since the crops grown in most areas are those that cannot be sustained in floods.

Efforts need to be made to convert the floods into a bumper crop harvest by introducing crops that can survive the floods. The animals are often shifted to dry areas during flooding. However, livestock farming is not a major engagement of the communities in

the flood prone areas. The herds are small and not economical. The flood plains are also important for pastoral activities since the fertile lands in the plains are good for the development of abundant pasture. The livestock farming therefore needs to be promoted by introducing the breeds that can withstand the flood conditions and are economically productive.

Fishing forms the major economic activities in the flood prone area. It has been observed that fish becomes more abundant during floods. The abundant fish is good for providing protein to households during a flood disaster. However, since floods destroy roads and fish landing bays, the available fish is only consumed in the camps. It does not reach the market due to poor road infrastructure and lack of storage facilities.

The proposed wealth and poverty alleviation strategies that would reduce the vulnerability of the communities to floods include to:

- Enhance the fishing industry by improving the fishing gears, providing storage and improving the road infrastructure;
- Improve the fish farming in the affected areas;
- Introduce horticultural farming as well as new crop varieties that cannot be affected by floods;
- Encourage horticultural activities in the flood prone areas;
- Encourage afforestation and agro-forestry to provide wood for use and for commercial purposes.
- Encourage livestock farming by introducing breeds that are adaptable to the climates of the regions and are economically viable

7. STRATEGIES FOR DROUGHT MITIGATION

Droughts are part of the climate system and are therefore not preventable. However, drought disasters are preventable. Coping with drought hazards can be developed through adequately addressing the answers to the following three questions:

- How frequently or extensively does a certain type of drought occur in a given region?

- What are the vulnerabilities and expected losses, which are associated with that type of drought?
- What are the costs for implementing the plausible strategies or options for mitigating the disaster that can be caused by that type of drought?

Strategies and drought mitigation options that are set to address the above questions involve integration of a wide spectrum of drought issues such as enhanced drought monitoring, drought research and forecasting, drought risk and vulnerability assessments, capacity building, drought awareness and education and dissemination of drought information. The use of such strategies aims to reduce vulnerability of the drought prone communities by either altering their land use practices or by modifying the drought severity through provision of the required water supplies for food production or through the implementation of relief programmes that enhance water and food securities on both short and long-term basis. The slow onset of drought combined with drought forecasting capabilities also enables the implementation of contingency plans and measures in advance of the occurrence of the drought. The improvement in recent years in the seasonal and long-term climate predictions, such as those issued by many national and regional institutes in Africa, including the Drought Monitoring Centers have assisted in the implementation of drought disaster mitigation and effective contingency plans.

There are many other types of drought coping mechanisms. Some of these which have been found to be important in drought-coping include:

- Encouraging the use of drought resilient crops
- Strengthening land tenure policies to discourage settlements in marginal lands
- Revival of traditional customs, traditions and land-use practices that are important in the mitigation of the severity of droughts
- Relocation of communities to other areas, which are less drought-prone.

8. EARLY WARNING FOR FLOODS AND DROUGHTS

Before the advent of modern scientific methods, some communities around the lake realized that some animals, birds, insects and plants had the capacity to monitor and

detect the changes in the atmospheric conditions and learnt their behaviours as a way of predicting the future climate.

8.1 TRADITIONAL METHODS

The populations with low-level technological cultured development learnt much from the behaviour of plants, animals and insects with high body sensitivity and instincts. They also mastered the positions of stars, the sun and associated shadows and the moon, the wind strength and direction and the cloud position and movement and the lightning patterns. The knowledge about past disasters and climate in the region are the accumulated experiences that have been handed down to generations through oral traditions.

The Luos, Abasuba and Abaluhya live in the Lake Victoria Basin and the surrounding highlands. The low altitude areas of the Lake Victoria Basin experience two major rainfall seasons, March – May (Long rains) and October – December (Short rains). The “long rains” are the most reliable in the low altitude areas of the basin. The neighboring highlands have rainfall almost throughout the year with the peaks in March – May, June – August and October – December.

Due to the importance of weather and climate to the communities around the Lake, the communities had to develop traditional methods for monitoring and predicting weather and climate. The sailors had to master the winds over the Lake. These communities also believed in “rain making” and capability to influence lightning as an inherited and spiritually provided talent.

Traditional indicators among the Luos, of Kisumu District

Among the Luo community, the rainfall indicators used include plants, animals, insects, wind, clouds, temperature, stars, the moon, and wetlands (thidhya). Some of the indicators and their signs are listed below.

8.1.1 Plant indicators

A number of plants are used as indicators. They are listed below.

- . Manera (*Terminalia brownii*) is a tree, which normally grows very big and shades the leaves to signal dry conditions.
- . Ngowo (*Ficus sur*) drops its leaves twice a year.
- . Waa (*Tamarindus indica*) also drops/ shades its leaves twice a year
- . Yago (*Kigelia africana*) drops/ shades off its leaves thrice a year
- . Ober (*Albizia coriaria*) shades its leaves once a year
- . Saye (*Acacia gerrardii*) shades its leaves twice a year
- . Bongu (*Ficus ovata*) shades its leaves twice a year
- . Opok (*Terminalia mollis*) shades its leaves once a year
- . Amboro shades its leaves twice a year
- . Juelu shades its leaves twice a year.
- . Olemb-ajwa and Olemb-ochok bloom their flowers twice a year
- . Ruga shades its leaves once a year.
- . Ochuoga (shades off its leaves twice a year showing both long and short rain seasons)
- . Siala shades its leaves thrice a year, but others maintained that Siala shades its leave only twice a year.

The shading of leaves is an indication of water stress associated with dry conditions. The trees shade the leaves to reduce evapotranspiration and would put on the leaves when the rains approach. Some plants used to monitor seasons include:

- . Otonglo seasonal plants are available during wet/ rainy seasons and Ayila/ Aila plants are very abundant during the long rains/ wet season, and are also common along the riverside or hilly bushes. The Ayila plants are only in abundance during the long rainy seasons and appear for a short time during short rainy season.
- . Ruga - falling of white flowers.
- . Yuoma (*Erythrina excelsa*)
- . Orembe – when it starts shading off red flowers, the planting season would commence because the wet/ rainy season is just about to start.
- . Oluoro chieng’ (a shrub) as the name suggests occurred only during wet/ rainy season and dry up quickly during dry season.

- . Awayo eaten by children grazing is also seen only during rainy season
- . Maup-pap (Rhamphicarpa) commonly found in Angugo plain and between Ong'oche and Othoch-rakuom and between Nyatike and Ong'er comes up with the slightest sign of rain.
- . Anyim, the seed may stay in the soil for years when the rainfall is not sufficient for it to grow.
- . Nyalwet-kwach is a shrub, usually used as medicinal plant, but is disappearing first because of burning of forests. Kasigo-jaleny-thee (is a plant which share the name with oil pot) and Odo-do are also sensitive to dry weather and dry up early even before the rain disappears completely.

8.1.2 Insect indicators

- . The presence of Aguyo (butterfly) presence in large numbers created controversy; some members argued that their presence act as an indicator for drought continuity whereas others argued the opposite.
- . Safari Ants also acting as an indicator of seasonal change created controversy; some elders argue that Safari ants and termites carry food and store it just before heavy rains start, while others argued that ants would carry food and store before the onset of dry season.
- . Chwer Ngwen (termites) showed the reduction of rainfall and the approach of drought.

There are five types of army ants (Ngini-ngini) that are used as indicators. They include:

- . Katalang' – black large poisonous ants
- . Tho-morno – red large ants
- . Omonyio – medium size ants rather harmless
- . Ong'ino – small red ants
- . Ong'ind kombe kombe – the large dark red tree ants.

These ants' movements are good indicator of wet/ rainy season approaching and when transporting food or their eggs is a clear indication of the closeness to a rainy season.

However, there are controversies on the particular season the ants transport their food and eggs.

- The presence of Agoro ants signals a sign of continuous rain season.
- The appearance of Oyala ants sometimes shows no rains on that particular night; however, rains are still falling
- The appearance of Onyoso ants showed continuity in rains.
- When Kungu (Armyworms) appear, people long for rain, which would normally make them grow quickly.

All the above are known insects associated with rains or wet season. When dry season approaches only ants and butterflies are seen frequently.

8.1.3 Wind, Clouds and Temperature

The direction and strength of wind is used by the communities to mark the beginning of rains and possible performance. The whirlwind(Kalausii-in Nyanza) is a clear indicator of approaching wet season. However, strong easterly winds (Komadhi) marks dry spell and in years when it sustains itself beyond March the communities in the Lake Victoria basin expect a poor March-May rainfall season.

8.2 MODERN METHODS

Forecasts of hydrological hazards such as widespread flooding are increasingly being based on computer modeling. A hydrologic model was developed and calibrated for use in the Lake Victoria basin. Other hydrological models have been developed for other parts of the basin. However, most of these models are for design purposes and must be adjusted or tuned for use in real-time flood prediction. This is far from being a reality in the basin. Attempts have been made to use seasonal rainfall forecasts to identify areas of either significantly above-normal seasonal rainfall or areas, which are likely to receive heavy episodic seasonal rainfall to identify the flood-hazard prone areas in the region during the given season.

For drought, prediction is still heavily reliant on monitoring of observed patterns of monthly and seasonal rainfall, stream flow, reservoir and ground water levels, and soil

moisture. Widespread drought evolves relatively slowly when compared with floods and may persist for months or years and it can be difficult, if not impossible, to predict its end. During drought situations, it is difficult to implement many remedial actions and those measures, which can be taken, are often site and situation specific. Statistical approaches are more relevant for the development of predictive tools for large geographic regions on monthly and seasonal time scales. Statistical techniques offer promise for increasingly useful forecasts of the onset, severity and duration of drought. The potential benefits of accurate forecasts on these time scales are evidently enormous.

8.2.1 Purpose of forecasting for flood control

Forecasts should be timely

- ◆ So that there is enough time to evacuate people from the possible flood areas
- ◆ To enable the heightening and reinforcement of dikes, dams and other flood control structures in the lower reaches of a stream well in advance
- ◆ To make rational dispatch of the reservoirs, to release water from the reservoir storage or interlock the flood peaks in lower reaches, so as protect flood control structures and ensure flood discharge in the lower reaches of a stream
- ◆ To have enough time to send flood control materials and emergency squads to the areas prone to flooding
- ◆ To have enough time to check flood control equipment in the cities and to clear the obstacles in the flood paths of the lower reaches of a stream.

9. CONCLUSIONS

Some major pressures on the lake environment which lead to natural disasters include: High population growth rate, poor land use practices, high rates of sedimentation arising from poor land use practices, changing rainfall patterns

Climate information and products form an important component for disaster reduction and sustainable socio-economic development in the basin. Climate extremes are recurrent and the only way to reduce impacts is to reduce risks through enhanced preparedness and improved economic base of the communities. Early warning systems for specific disasters should be put in place and the modern methods should integrate traditional

methods. The capacity of the communities to utilize early warning information should be strengthened.

Environmental protection through proper land use practices must be encouraged and relevant policies that protect land degradation must be enforced.

Communities need to be sensitized that disasters can be turned into economic gain other than viewed as a calamity.

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