Chapter 21

Floods in Kenya

Alfred Opere
Department of Meteorology, University of Nairobi, Nairobi, Kenya

1 INTRODUCTION

Floods and droughts, associated with extreme climate events, have very devastating effects on almost all socioeconomic activities and are very common in many parts of Africa. Flooding in its most immediate form can inundate farms and villages and disrupt transportation networks, ultimately affecting food security and market distribution systems. Comprehensive, up-to-date information describing hydrologic conditions is therefore needed to anticipate and mitigate flood impacts on populations targeted for assistance. Available ground-based measurements of stream flow and rainfall are at present inadequate to provide comprehensive monitoring of regional flooding.

In Kenya, the hazards and impacts of floods were demonstrated by the 1997/1998 *El Niño* episodes. These floods led to severe loss of life (human and livestock) and property, destruction of infrastructure, disruption of the communication networks and large losses to the economy. They were also associated with land degradation (soil erosion), silting of hydropower dams and destruction of power lines. The recovery from the effects of these weather-related phenomena will take a long time, as national economies were seriously weakened. The recent Budalang'i floods in western Kenya also led to massive destruction of property and displacement of people.

Floods are a result of overflow in river banks and can cause enormous damage to loss of life and property including crops and infrastructure. These are common phenomena and are costly natural disasters. Floods are short-lived events that can happen suddenly, sometimes with little or no warning. They usually are caused by intense storms that produce more run-off than an area can infiltrate and store or a stream can carry within its normal channel. Rivers can also flood when dams fail or landslides temporarily block a channel.

Unlike droughts, defined by Palmer (1965), which has a slow onset, floods are rapid onset disasters. Flood hazards resulting from too much rainfall have resulted into disasters in Kenya. Examples are areas of Kano Plains in Kisumu County, Budalang'i in Busia County and the lower parts of the Tana River are

Developments in Earth Surface Processes, Vol. 16. http://dx.doi.org/10.1016/B978-0-444-59559-1.00021-9

susceptible to floods (The Republic of Kenya, LBDA & JICA, 1992). Arid and semi-arid areas of the country also experience flash floods. It is important to quantify the magnitude of floods that are often described by the size of a flood corresponding to a particular recurrence interval. By studying a long period of flow records for a stream, it is possible to estimate the size of a flood that would, for example, have a 5-year recurrence interval (called a 5-year flood). A 5-year flood would occur, statistically, once every 5 years.

Floods can occur at any time, but weather/climate patterns have a strong influence on when and where floods occur, Smith (2002). The land management practices in the upper catchments may also contribute to the enhancement of surface water run-off and flooding and an unplanned human occupation in the lowland can also enhance the damages due to flooding. In 1997/1998, the *El Niño*-associated floods affected many parts of Kenya, causing destruction to property, loss of lives, famine and waterborne disease epidemics. With inadequate preparation for the *El Niño* floods, national resources were overstretched in the response phase. The *El Niño*-induced floods of 1997–1998 caused some US $151.4 million in public and private property damage. This figure does not include the number of people who lost family members, savings, property and economic opportunities. Extreme climate events such as droughts and floods have adverse effects on all forms of life. The degree of the effects depends on the resistance and resilience of the affected communities.

Floods have adverse effects on health and health service in terms of disease outbreaks and the capability to reach people when roads are not passable. The congestion in the camps also poses a big health challenge in terms of communicable diseases. Flooding is associated with diseases such as malaria, typhoid and bilharzia (*schistosomiasis*). Interference with culture as seen in congestion of households with children of up to 15 years hurdled with their parents in the camping structures also contributes to social and health problems. Floods also enhance environmental degradation and destruction of homesteads. It also destroys the normal economic production, distribution of goods and food harvests.

In many low-lying areas around the mouths of the rivers and natural swamps, the inundation lasts for weeks, leading to total loss of crops. The worst affected are the poor who inhabit the flood plains and riverine lands to eke out a meager living from agriculture, livestock farming and fisheries. Because of poverty, lack of education and poor rural infrastructure, they are the most vulnerable to floods and post-flood consequences. The floods severely limit and hamper the developmental process, further increasing the vulnerability of the rural society and thereby perpetuating and increasing the incidence of poverty. Stagnant floodwater also causes vector-borne diseases, which result in high incidence of morbidity with consequent loss of alternative employment opportunities. An exception is made by farmers whose cropping practice relies on flood-recession agriculture like in the low lands of the

Tana delta and in other countries: for these communities the flooding is beneficial to their agricultural production and thus to their economy.

In most cases though people from inundated areas move to makeshift relief camps where they cluster together. Such makeshift homes soon become slums creating social problems and unhygienic conditions, which are conducive for the spread of contagious diseases and sexually transmitted diseases. Often, women and young girls are the worst sufferers.

2 HISTORY OF THE MAJOR FLOODS IN KENYA

Some of the past major floods in Kenya and associated impacts are highlighted in the following sections.

2.1 The *Uhuru Floods* of 1961

Uhuru Floods represents one of the early attempts of studies initiated for the purpose of studying the extent and magnitude of the flooding menace that inundated extensive low lying areas and caused widespread damage and destruction of existing infrastructures; dams, bridges, homesteads etc. as well as other facilities that existed then in Kenya. Other noteworthy flood events occurred in 1963/1964, 1968, 1977/1978, 1982, 1985 and 1990. These floods mainly hit the Lake Victoria basin and the coastal areas of the *Athi*, *Lamu* and *Tana* River basins; however, the detailed features are not well documented.

2.2 The El Niño Floods of 1997/1998

The hazards and impacts of the *El Niño* rains of 1997/8 demonstrated to Kenya the severe devastation of floods. The floods caused the loss of life of human and livestock, disrupted socio-economic activities due to the extensive damage to property, infrastructure and communication facilities, DMCN (2004). Further, the floods were also associated with land degradation, increased soil erosion with the consequent silting of hydropower dams and erosion of riverbanks, which affected water intake facilities and river gauging facilities, which are the basis for the operation of the National Hydrological Services in the country. The flow-measuring structures washed away by the floods included weirs, water-level gauges and data loggers. These facilities assist hydrologists to capture river level fluctuation data and this type of data forms the basis for the water sector resource management and development.

Among the intervention measures undertaken to ameliorate the impact of the *El Niño* were:

- The rehabilitation of river gauging stations washed away by floods. This was a project spearheaded by World Bank where several stations were rehabilitated.

- The installation of self-recording water-level data loggers at a number of sites to assist in the collection of river water level.

2.3 The April/May 2003 Floods

In this season, Kenya experienced massive flooding in the Western Province at Budalang'i and the lower reaches of the Nzoia River and in Nyanza Province at Ahero within the lower Nyando River basin. Further, the heavy rains that caused the flooding led to water supply disruption in urban and rural centres and washing away of river gauging facilities constructed along the rivers.

Among the most notable observations of the April/May 2003 flooding were:

- Complete inundation of the Budalang'i area and the Nyando River floodplain downstream of Ahero Town as a result of breaching of the dykes in the Nzoia and Nyando Rivers, respectively.
- Washing away of data loggers, water-level recorders, river gauging structures and bridges, affecting communication and flow monitoring activities in the field.

3 FLOOD HAZARDS IN KENYA

In Kenya, floods hazards are a recurrent phenomena. However, these flood hazards turn into disasters only in few places in the country. The most commonly affected places are the floodplains of the major rivers such as the lower Tana River, the lower Nzoia River at Budalang'i plains and the lower Nyando River at Kano Plains.

Figure 1 presents the significance of flood hazards in relation the other types of hazards in Kenya.

Epidemics (especially due to malaria but also due to HIV/AIDS, as explained before) have reached alarming levels in the recent past. There are, therefore, elaborate initiatives to curb the scourge of epidemic disasters in the country. On the other hand, while floods seem to have about the same prevalence in Kenya as droughts, droughts affect many more people than floods. This is illustrated in Figure 2.

Nevertheless, due to the existence of generally functional drought management strategies in the country, droughts disasters are not as devastating as flood disasters. This illustrated by Figure 3.

These figures confirm the fact that there is an urgent need for the development of flood disaster mitigation strategies in the country. Due to the key role that climate, and particularly climate change and variability, plays in the development of flood disasters, it is important to understand the changes in climate over the country and especially over western Kenya where flooding causes untold suffering and also acts as a poverty creation catalyst.

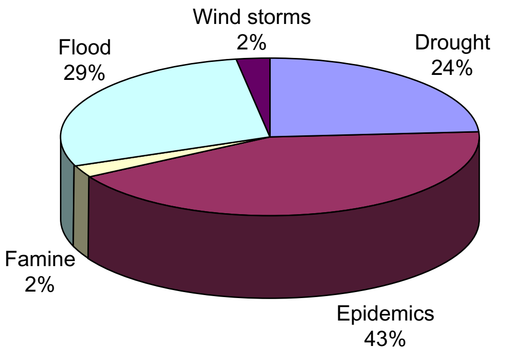

FIGURE 1 Comparison of the prevalence of hazards in Kenya.

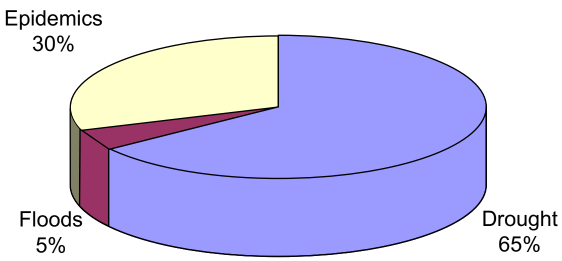

FIGURE 2 The percentage of people affected by the different types of hazards in Kenya.

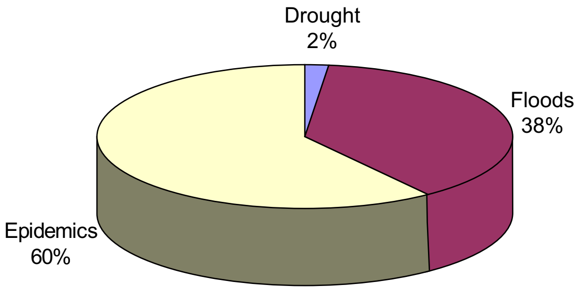

FIGURE 3 People killed or affected adversely by the different types of hazards in Kenya.

4 IMPACTS OF FLOODS IN KENYA

Two case studies are here described in details, both linked to the April/May 2003 floods and both in Western Kenya: the case of floods in Budalang'i and the case of Kano Plain.

4.1 The Case of Floods in Budalang'i

Budalang'i division lies on the shores of Lake Victoria partly on the mouth of Yala River but mainly on the mouth of River Nzoia. River Nzoia is one of the largest rivers in western Kenya. The main stream of the river flows from the western side of the Elgeyo Escarpment (Sergoi, Sosiani and Kipkelion tributaries) and the Cherangani Hills (Chepkotet and Kaisungur tributaries) from an elevation of approximately 2286 m above mean sea level. Its tributaries, which flow from the high slopes of Mount Elgon, attain maximum elevation in the river's basin and are estimated at about 4300 m above mean sea level. The tributaries in Mount Elgon include Kuywa, Sioso, Ewaso, Rogai and Koitobos.

The average basin elevation is estimated at 1917 km above mean sea level, while the length of the mainstream is 275 km from source to mouth. The river follows the 275 km course with a mean slope of 0.010% from its source to discharge into Lake Victoria at about 1000 m above sea level. It enters the lake a short distance to the north of the Yala Swamp. The upper catchment is a high rainfall zone having a mean annual rainfall of between 1500 and 1700 mm per annum, while the flood plain is a low rainfall zone with mean annual rainfall below 800 mm per year.

The total catchment area drained by the basin's river network is about 12,950 km^2 when measured from Lumbwa Ferry area. Of this about 90.8% (11,667 km^2) is composed of a land area, which is relatively flat, with fairly deep soil, continuous vegetative cover, and shows a relatively stable landscape. The mean slope of the basin is 0.071%. The remaining land area is either covered by swamp (5.4%), areas of localized instability, sheet or gully eroded areas or steep sloping areas with rock outcrops.

Budalang'i has a total population of about 56,000 people (1999 Census), who inhabit the region mostly affected by floods. Of this, 54% of the total population is made up of women, while 60% is made up of children between 0 and 14 years. The population at the time of study was concentrated in 10 camps located in 7–8 sites. The entire Budalang'i has 6 administrative divisions with 6 locations and 18 sublocations. The areas affected by rivers Nzoia and Yala, which divide Budalang'i into two sections, suffer a lot during the over flooding of these rivers since the dykes no longer contain the floods as required.

The accumulation of many years of sediment in the river bed has made the channel of the river course to be above the general level of the flood plain as a result overbank flow across the 400–600-m-wide dykes causes massive flooding. The width of the channel decreases gradually from about 50 m at 140 km inland to around 40 m in the upper reaches of Kakamega, Bungoma, Trans Nzoia and Uasin Gishu Districts where the altitude is high and the slopes are steep. The sediment accumulates and reduces the capacity of river channel so that the river overflows the banks forming the delta.

The flow regime of the Nzoia is varied and is occasionally as low as 20 m^3/s and with extreme floods that may surpass 1100 m^3/s, which is the proposed protection level for the dykes for a 25-year, return flood. Siltation is heavy. Earlier estimates of siltation rates by Italconsult are in the order of 158 tonnes per day; however, recent assessments by Lake Basin Development Authority (LBDA) for the period 2000–2003 put it at 574 tonnes per day, which is thrice the Italconsult value. The discharge varies from a low flow of 2.8 m^3/s to a 100-year flood flow of 930 m^3/s.

The soils of the floodplain in the lower reaches of the Nzoia River are all alluvial. The river meanders in the floodplain depositing silt during seasonal floods. The major parts of the floodplain contain black cotton soils, while other areas have coarse textured sand silt mixture. In some places, there exist saline soils. The upper Nzoia Basin contains extensive seasonal swamp areas in the high and medium rainfall zones that are mainly utilized for grazing due to poor drainage. Once the river bursts its banks, the resultant flooding displaces close to 30,000 persons every rainfall season. People are usually evacuated to safer higher grounds during floods. Entire homesteads are swept away, property and crops worth hundreds of thousands of shillings are lost and many people perish as rivers break their banks, rendering large areas of land inaccessible. The floods enhance poverty, because crops and businesses are destroyed, (Oyugi et al., 2003).

However, basic needs are not readily available for those living in the camps. Moreover, the problem is further compounded by increased waterborne diseases like typhoid and malaria, increased shortage of food, limited environmental sanitation, low school attendance and increased poverty as most farmers have lost their livelihood. Livestock are weakened due to difficulties to access grazing grounds. Food shortages persist for a much longer time as the farming land remains underwater and is not possible to cultivate for another 6 months.

The lower reaches of River Nzoia are flat lands with low gradients. All the six locations in Budalang'i Division are perennially affected by flooding. These are, namely, Bunyala East, West, South, North and Central and Khajula location. Traditionally, the people have settled in the flood plain and this has meant that the people are directly affected by the perennial flooding. The April 2003 floods displaced 4000 families or about 24,000 people, covering an area of 60 km^2 with people moved to camps on higher areas and relying on food relief.

This situation has arisen after breaching of protection dykes that were constructed by the Ministry of Water from 1977 to 1984. The works involved construction of 32.8 km of earthen dykes (16.6 km in the southern side and 16.2 km) on the northern side that required a replacement of 690,000 m^3 of soil. They were designed for 25-year flood protection of 750 m^3/s. Now the dykes are occasionally overgrown with vegetation, breached at 20 points and have outlived their life of 20 years. The budgetary maintenance requirements are therefore high and have been diminishing annually.

A report given to the government in 1992 after the assessment of the area proposed an irrigation scheme as the solution to the unending flood menace.

The report said that a dam is needed to be constructed to trap the excess water that overflows the river. This would be followed by the construction of two canals, one in the northern riverbank measuring 40 km and the other on the southern side measuring 35 km, draining water onto the flat farms for irrigation. 'The project could cost about $20 million if implemented'. It is evident the present course of the river is highly unstable and could change from one moment to the next after a flood, if no protective works are provided.

The 2003 floods in Budalang'i saw nearly 24,000 out of a population of 56,000 people displaced (source: IFRC, 2003). Some 10,000 of these have been accommodated in the DO's camp, necessitating health emergency measures to control possible outbreaks of waterborne diseases. Scarcity of water sources and the contamination of pipes and borewells aggravated an already acute problem. Fishing and farming are the major economic activities in Budalang'i. Due to the floods and concentration in the camps, the economic activities are greatly disrupted.

4.2 The Case of Floods in Kano Plains

The main Nyando River, which traverses Kericho, Nyando and Kisumu Districts, has a total catchment area of 2606 km^2 and is 148 km long. Its main tributary, the Ainomutua River, drains 845 km^2. The flow regime of the Nyando is varied and has occasionally been as low as 2 m^3/s and with extreme floods above 850 m^3/s. Siltation is heavy. Earlier estimates of siltation rates by Italconsult are in the range of 685,000 tonnes per annum; however, recent assessments by LBDA for the period 2000–2003 are fourfold higher than the Italconsult findings.

A recent survey by a team of experts from the ministry has established that the peak discharges of the Nyando have reduced. The 1983 estimates obtained by Italconsult for the 25- and 50-year return period flows were 1100 and 1300 m^3/s but the 2003 estimates by the team are 776 and 879 m^3/s, respectively. This is in contrast to sediment loading, which has been found to increase threefold. The main rivers in the low plain are the Kibos and the Nyando. The other smaller rivers are Luanda, Nyaidho, Miriu and Awach.

The source of the river system is in Kericho and Nandi Districts, which lie above 2000 m above sea level with a mean annual rainfall of between 1800 and 2000 mm. The river basin has steep defined courses in their upper reaches, but on reaching the flat low-lying areas near the lake, they meander and periodically overflow their banks before terminating into swamps neighbouring the Lake Victoria. The vegetation of the upper catchment is mainly forest (*Tinderet* Forests), while the middle catchment may be classified as vegetative, that is, scattered trees and grass, which has greatly been modified by clearing, cultivation and burning due to human settlement. The total basin catchment area is 4484 km^2, which includes the Kano Plains 3356 km^2. The Kano Plains with an area of 73,000 ha comprise 13,000 ha of swamp and 25,000 ha proposed for paddy irrigation. The 45-km stretch inland from the lakeshore is rather flat.

The width of channel and the dykes is about 200–250 m. The agricultural irrigation schemes like the Ahero Scheme are found here. This is also the area where serious flooding occurs. The accumulation of many years of sediment in the riverbed has reduced the capacity of the river with time.

Drainage channels and ponding are common. Further inland near the Nyando and Kericho District border some 75 km away, the slope changes and the river width reaches 40 m, occasionally meandering. Few settlements are found in the valleys bottom. However, the people practise subsistence and livestock farming. Further inland are the highland areas of Kericho District where the channel is V-shaped and the altitude high and the slopes are steep. The low plain experiences a mean annual rainfall of 1260 mm, most of it falling between March and May and with a smaller peak between September and November. Extreme droughts occur in January and February. Severe convectional rains occur on lakeshores. The mean annual maximum temperature ranges from 25 to 30 °C, while the minimum is 9 to 18 °C. The soils are recent alluvial, medium to heavy clays, of poor drainage and structure and are therefore well suited for rice production. There have been two irrigation schemes managed by the National Irrigation Board, namely,

a. Ahero—860 ha under pumped water from river Nyando with 490 tenants and
b. West Kano scheme—810 ha with 500 tenants and irrigation water pumped from Lake Victoria and drainage water pumped back to Lake Victoria.

The Nyando River, which traverses the Kano Plains and covers a large area of the lower plains, is the most notorious for frequent flooding. The flooding results in social distress, health hazards, disruption of human settlement, loss of harvests, building and infrastructures and a general malaise of the population. This prevents any progress from being made in the development of this high potential Kano Plains. Before 1925, the so-called Nyalenda, Nyamware, Kawino, Kadhiambo, Bwanda and Middle Jimo areas were a stable lakeshore land with fishing and small-scale farming activities. In March of the same year, the lake regions experienced exceptionally heavy rains and many homes were abandoned and people settled in the upper lands. The situation did not last long and after a few years, life returned to normal along the lakeshore. The famous Uhuru rains of early 1961 saw the lake level remaining relatively high (approx. 1136 m above mean sea level), which combined with peak floods of 1963, 1968, 1977 and 1985 have had the cumulative effect of turning large shore lands at the deltas of the rivers into permanent swamps.

The Nyando River basin has extensive catchment areas that for the most part lie in zones of heavy rainfall. At the outlets of the major rivers are large swamps. The rivers begin to deposit their load of silt and suspended matter gathered from the catchment areas. Over the years, excessive siltation of the river in the basin has resulted in an overflow. Some limited embankments have recently been constructed but are contributing to the rise in the riverbed, increasing the risk of catastrophic floods. These annual floods result in inundation of large tracts of cropped land, displacement of thousands of people and damage to infrastructure.

The total area annually vulnerable to flooding is 15,000–20,000 ha. This area comprises the Kakola, Onjiko and Kochogo locations of Nyando District. Available data suggest that progressively greater flooding is being caused by smaller flow in the rivers concerned. For instance, a flow of the Nyando River of 850 m^3/s in 1962 apparently resulted in flood conditions no worse than was produced in 1970 by a flow of 600 m^3/s. Variation in the level of the Lake Victoria is a cause of flooding on the lower part of the Kano Plain. During the past 15 years, the level of the Lake Victoria has been up by about 1.40 m, impeding the discharge of the floods into the lake. Besides the regular flooding of the Kano Plain caused by the overflowing of rivers, the plain regularly suffers from impeded drainage.

According to records available from 1999 to date (2003), it has been observed that the lake fluctuates by about 4 cm and is on a rising limb and has permanently inundated a broad strip of land around the shore, thereby worsening the channel hydraulics and the hydrology of inflowing tributaries. The water table is shallow ranging from 3 to 10 m in some areas in the plains. Shallow wells and hand-dug wells are common sources of water supply.

5 VULNERABILITY INDICES FOR THE FLOOD-PRONE AREAS

The interrelationship between flood hazard, flood vulnerability and flood disaster is shown in Figure 4a, while the interrelationship between hazard, vulnerability and disaster is also illustrated in Figure 4b.

The vulnerability of a water resource system to climate change is a function of a number of physical features and social characteristics, Mutua (2001). The physical features associated with maximum vulnerability of water resources in a region include:

- the marginal hydrologic 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; and
- deforestation, which allows increased surface run-off, increased soil erosion and more frequent significant flooding.

The social characteristics that increase vulnerability of water resources 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;

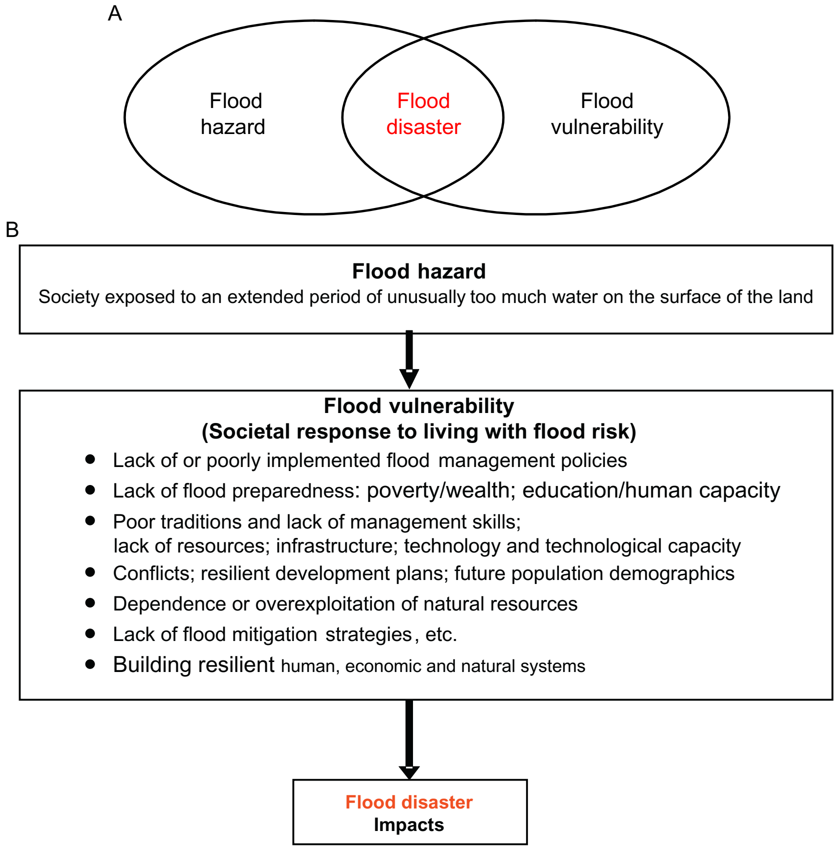

FIGURE 4 (a) A flood disaster occurs when a flood hazard happens within a community that is highly vulnerable. (b) Multiple indices representing different aspects of flood vulnerability can be derived from various physical, societal, economic and environmental factors.

- lack of appropriate and empowered institutions;
- absence of appropriate land-use planning and management;
- high population densities and other factors that inhibit population mobility; and
- increasing demand for water because of rapid population growth and conservative attitudes towards risk, that is, 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 and human-related factors. The natural factors 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.

5.1 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, and 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 are factored in all the water resources management practices and policies in order to mitigate the adverse effects of disasters in the water resources sector.

5.2 Geology and Topography

The geologic characteristics of an area are known to influence the drainage patterns, the nature of soils and 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 run-off 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 run-off.

The topography of a region also determines land-use patterns and 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).

5.3 Population Pressure and Settlement Patterns

Settlement patterns are partly influenced by population pressure. In urban areas, there is a 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.

5.4 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 (Lake Basin River Catchment Conservation and Rehabilitation, 1987). Vegetation cover is essential since it retards the flow of surface run-off, thus encouraging more water to infiltrate into the soil and replenish soil moisture. The recharge of ground-water 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 run-off to river channels. Lack of effective urban planning mechanisms promotes development of slums and other residential structures, which discharge sewage and domestic wastewater into river channels, thus degrading important water catchment areas.

5.5 Lack of Regulatory Systems

The enforcement of regulations governing settlement in zones designated as flood prone has been a major problem in Kenya in that the enforcement is weak, partly due to weak institutional capabilities to enforce regulations. Similarly, there is no effective coordination between different government departments and nongovernmental organizations, resulting into waste 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 is encouraging the influx of rural poor into urban areas in search of better opportunities.

This has led to overcrowding in urban areas, severely overstraining the existing housing, health, water supply, sewage and educational and recreational facilities. Most of the present facilities in urban areas were designed 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 more vulnerable to flooding.

5.6 Poverty

According to the 1997–2001 National Development Plan (GoK, 1997), out of the estimated population of 29 million people, 11 million people live below poverty line and 3 million are unemployed. This means that more than 40% of the population in Kenya lives below poverty line. The poverty in Kenya has increased in the recent past due to low productivity of the agricultural and industrial sectors. The dependency ratio is also extremely high. Studies show that areas prone to floods have high incidences of poverty.

Poverty is encouraging 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.

5.7 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 who lack access to medical facilities. This has promoted high morbidity caused by waterborne 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.

5.8 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 cater for a smaller population. Road traffic has increased tremendously in the recent past, leading to rapid deterioration of roads which were designed for much smaller loads. Thus, lack of access to a 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 the vulnerability of the society is quite complex especially when one is looking for cumulative stresses induced by interannual 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. Figure 5, in next section is a flood hazard map showing high potential areas for flood risks in Kenya.

6 FLOOD HAZARDS MAP FOR KENYA

A flood hazard map shows the areas over given regions that have the potential to flood. These are usually areas along riverbanks, lakeshores, wetland boundaries and arid and semi-arid areas which receive episodic rainfalls and which are generally flat and without adequate surface drainage. The spatial-extent of such areas depends on the severity of the flood event. The severity is often measured in terms of the return period of the flood under consideration. Return periods of 20, 50 and 100 years are often used in developing flood hazard maps. Physics-based rainfall run-off models are particularly useful in delineating flood prone areas in a given region.

In the western parts of Kenya, for example, serious flooding is usually experienced on the lower parts of the major rivers which flow into Lake

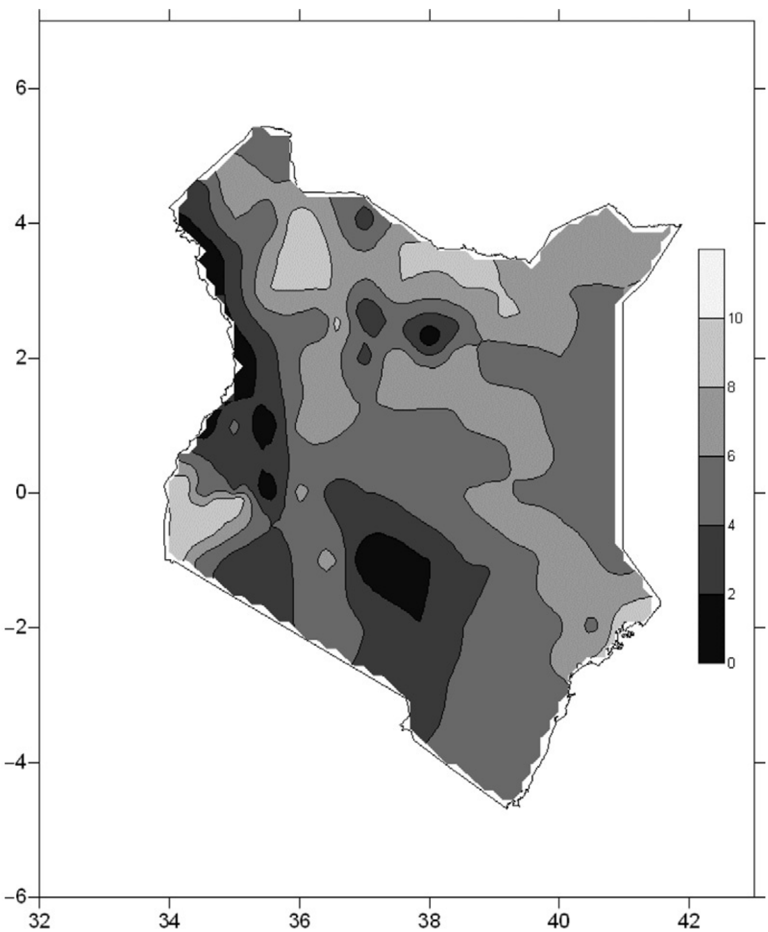

FIGURE 5 Flood vulnerability map of Kenya on a scale of 5 with low vulnerability at low values.

Victoria especially rivers Nzoia, Nyando, Kuja and to some extend near the mouth of river Yala. The Budalang'i and Kano plains are the most notorious and flood prone areas in western Kenya. In an attempt to reduce the flooding menace in the Budalang'i area, flood dykes were constructed on the banks of the Nzoia River just before it enters into Lake Victoria. The construction of the dykes created a sense of security amongst the riparian communities, who then have began settling more permanently in the areas where they had lived on sedentary basis before the construction of the dykes. This condition has therefore brought serious flooding impacts in this region considering the fact that the design of these dykes has proved to be faulty and fails very often.

REFERENCES

DMCN, 2004. Coping with Floods in Kenya: Vulnerability, Impacts and Adaptation Options for the Flood Prone Areas of Western Kenya, DMCN-UNEP project report, 2004.

Government of Kenya (GoK), 1997. National Development plan (1997–2001).

Lake Basin River Catchment Conservation and Rehabilitation, International Council for Research in Agro-forestry, Annual report, Nairobi, Kenya, 1987.

Management of flood control disaster in the Lake basin Development Authority (LBDA) with special reference to Kano Plains—a structural approach, LBDA, 2002.

Mutua, F.M., 2001. Report on the Impacts of climate change on Water Resources in the Kenya.

Oyugi, A., Ong'ang'a, O., Awange, J.L., 2003. Poverty reduction: a challenge for Lake Victoria basin. Osienala, Kisumu, Kenya.

Palmer, W.C., 1965. Meteorological drought. Research Paper No. 45, U.S. Department of Commerce Weather Bureau, Washington, DC.

Smith, L.A., 2002. What might we learn from climate forecasts? Proc. Natl. Acad. Sci. U.S.A. 99, 2487–2492.

The Republic of Kenya, LBDA, and JICA, 1992. Feasibility studies on Kano Plains Irrigation Project vol. 1, vol II-1, and vol II-2.