Forest Degradation in Kenya: Impacts of Social, Economic and Political Transitions

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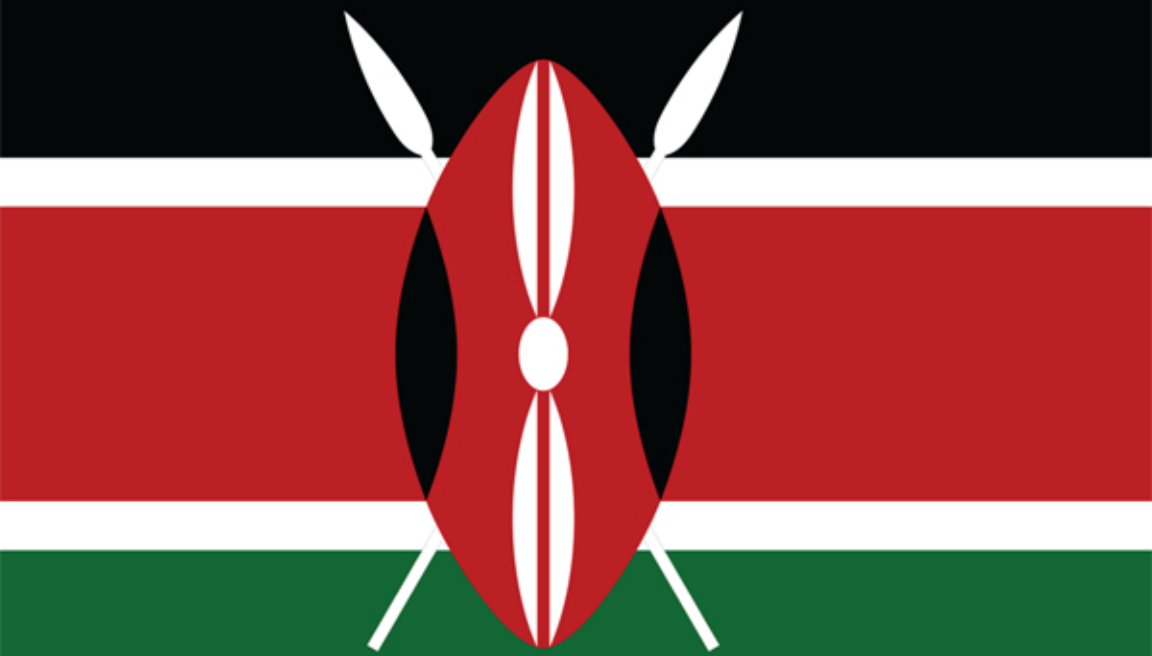

James W. Adoyo ⋄ Cole I. Wangai
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JAMES W. ADOYO
AND
COLE I. WANGAI
EDITORS

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PREFACE

In this book, the authors examine Kenya's current political, social and environmental issues. Topics discussed in this compilation include the mitigation and impacts of forest degradation in Kenya; fish biomanipulation of Kenyan lakes; the political and social dimensions associated with biotechnology regulation in Kenya; the developmentally disabled population in Kenya; status of Kenya's environmental management and protection challenges; and economic development and food security in Kenya.

Chapter 1 - Kenya covers a total land area of approximately 5.7million km2 between latitude 4°21' North and 4°28' South and longitude 34° and 42° East, bisected horizontally by the equator, and with diverse topography, hydrology and climate. The landforms range from the glaciated mountain peak of Mt. Kenya in central Kenya, which is almost under permanent snow cover, to upland plateaus in western Kenya, the coastal plains, and the vast savannah grasslands that dominate the rest of the country. It is divided by the Great Rift Valley that cuts across East Africa into the eastern part of the country dominated by Mt. Kenya and the Aberdare ranges (altitudes of between 4,000 – 5,200m) and the western region which slopes downwards from the Mau ranges and Mt. Elgon at an altitude of about 4,300m to the Lake Victoria basin at the far west. Within these physiographic areas, the country‟s hydrology is characterized by four major rivers (the Tana, Mara, Yala and Nzoia river basins), all originating from forested water towers (i.e. Mt. Kenya, Mau, Abaderes, Mt. Elgon and Cherangani hills). There are, however, many other smaller rivers that originate from the water towers that directly impact livelihoods of the local communities and the national economy. Kenya‟s rainfall depicts a bimodal regime with the rainfall peaks generally occurring in April/July (long rains) and October/November (short rains)

Chapter 2 - The self-described “social-ecologist”, Peter Drucker, said that what gets measured gets managed; a statement that could have welcomed political and social concepts into environmental matters. A case in point is the fish restocking (a type of fish biomanipulation) in many lakes in the world and with special reference in the tropics. However, due to the increased anthropogenic impacts and eutrophication of the aquatic ecosystem in the tropics (and in particular Kenya) is becoming increasingly apparent; the need for proper management strategies for a sustainable fishery is becoming non-negotiable. Under such a perspective, fish biomanipulation that was coined by Shapiro (1975) could be a self proclamation that the road from basic science to its application could be winding and the process laborious. Despite some positive results of fish biomanipulation in the temperate regions, this management approach seems to elicit ecological debate at political, environmental and social fora since its successes seems to be of short-term need. This paper reviews the fish biomanipulation process and principles, the successes and limitations; thereby highlighting on the need for defining theoretical explanations and their practical implications in the present scientific world. This is because details of the process have to be verified in the light of frequent future applications rather than on political and social undertones that damage the ecological wellbeing.

Chapter 3 - This article is written against the recent lighting episodes that killed over 40 people within a span of one week. Eight members of one family died after lightning struck their grass-thatched house in Mencheiwa village, Keiyo South District in the Rift Valley province of Kenya. Lightning is Kenya‟s most underrated weather-related hazard in terms of response, management and research. It's also the most unpredictable and every year, kills over 10 000 people and injures about 100 000. GIS is used to map the spatial distribution of the hazard. This article discusses what makes lightning so dangerous, and compares with other weather hazards? Also presented is a map showing the spatial and temporal distribution of lightning mainly in the Rift Valley, Nyanza and Western provinces and of lately Central province. From this study, it is clear most lightning casualties are rural populations. Sixty six percent of the 47 counties are in the high lightning hazard zones. This paper argues that lightning is so dangerous since it is hard to know just when and where it is likely to strike-or how it will behave when it does. The study recommends a number of management approaches, awareness campaigns, research as well as reinstituting a relevant organisation.

Chapter 4 - Biotechnology revolution is poised to benefit the world poorest only if controversies associated with safety are regulated

appropriately. These controversies have been confounded by conflicting interests of different stakeholders. Using Kenya‟s experience in developing a biosafety regulatory framework for management of biotechnology innovation, this chapter explores the political and social dimensions associated with biotechnology regulation in the context of a poor developing country. It finds that regulation attracts different responses and that the embedded controversies are context specific and have ramifications for translation of biotechnology science for pro poor development. In conclusion, it notes that biotechnology regulation requires a critical thought in relation to the handling of divergent perceptions held by stakeholders. Based on empirical insights generated from the Kenyan case, the chapter provides practice based recommendations for policy towards stimulating a productive biotechnology debate.

Chapter 5 - Kenya is geographically situated in East Africa and attained its independence from Britain in 1963. In 1964 the country‟s population was 9.1 million. Kenya‟s populace has since grown to 38,610,097 people according to the latest population census results carried out by the government in 2009. Mortality rate for children under 5 years was calculated in the same year to be about 84 for every 1,000 children. The United States‟ CIA Factbook ranks Kenya as the nation with the 44th highest infant mortality in the world. The average life expectancy of a Kenyan is 54 years. In addition, it estimated that in 2006 about 47% of Kenyans were considered poor at the national level. These people generally lived below the poverty line and survived on less than US$ 1 per day (Institute of Economic Affairs, 2011). IFAD (2011) further states that the country‟s Gross National Index (GNI) per capita stood at US$ 770 in 2009 while annual Gross Domestic Product (GDP) per capita in the same year was US$ 30, 200,251,314. In 2010, the United Nations Development Programme (2011) ranked Kenya at position 143 out of 187 countries. According to this report, the country had a very low Human Development Index (HDI) of 0.509. Despite these startling figures, the country is, nevertheless, reported to have recorded an impressive 115% gross enrollment in primary school as well as a high literacy rate of up to 85% of people aged 15 years old and above by 2008.

Chapter 6 - Environmental degradation is among the biggest problems that face many countries in Africa. Among the causes of environmental degradation in Kenya include climate change, unmanaged rapid population growth leading to destruction of forest cover to create new settlements, infrastructure development, dumping of waste including solid and e-waste and mining. Mining activities have been associated with exposure of radioactive materials to the environment while discharges of waste water from urban

settlements and farmlands have been associated with pollution of rivers and lakes. In recognition of the need for proper environmental management, the Ministry of Environment and Mineral Resources has led the way in developing legal and institutional framework to ensure environmental protection. Perhaps the most important was the setting up of the National Environment Management Authority (NEMA) under the Environmental Management and Coordination act (EMCA) No 8 of 1999 with the mandate of implementing all policies relating to the environment. NEMA became operational in the year 2002. The Ministry of Health, through the Radiation Protection board, has also been involved in measures to ensure radiation protection to workers and the general public. Measures to conserve the environment through development of Renewable Energy alternatives have also been given prominence in Kenya‟s Vision 2030 and the Ministry of Energy is already implementing some of these measures. Furthermore Kenya‟s new constitution has a Bill of Rights under which the right to a clean and healthy environment has been included in article 42. The constitution in article 69 also vests the responsibility of ensuring sustainable utilization, management and conservation of the environment to the state. However a lot more needs to be done in the implementation and enforcement of the various regulations and policies.

Chapter 7 - Kenya‟s gross domestic product (GDP) grew at an annual average of 6.6 percent from 1963 to 1973. Between 1974 and 1990, however, Kenya‟s economic performance declined. From 1991 to 1993, Kenya had its worst economic performance since independence. From 1994-96, Kenya‟s real GDP growth rate averaged just over 4 percent a year. Its economic growth rate declined from 1.4 percent in 1998 to a negative 0.3 percent in 2001. In 2000, GDP growth was negative, but improved slightly in 2001. Economic growth continued to improve slightly in 2002 and reached 1.4 percent in 2003; it was 4.3 percent in 2004, 5.8 percent in 2005 and 6.4 in 2006. However, this growth was not maintained in 2008 due to the post election violence after the December 2007 elections.

Chapter 8 - The main aim of this paper is to show that Kenya has made progress in institutionalising environmental governance, particularly following the Rio Conference on Environment and Development. Prior to the Rio Conference, environmental management was scattered in the line ministries with no clear focus on sustainable development. The paper shows that the country has elaborate legislative framework with instruments that can significantly contribute to sustainable environmental management. However, the implementation of the legislation faces a number of challenges including lack of policy on environmental management and weak capacity. It is evident

that serious concerted efforts must be directed at capacity building to make the legislative intentions of a good and healthy environment for all in Kenya a reality.

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Chapter 1

FOREST DEGRADATION IN KENYA: IMPACTS OF SOCIAL, ECONOMIC AND POLITICAL TRANSITIONS

Moses Imo*
Department of Forestry and Wood Science. Chepkoilel University College, Moi University, Eldoret, Kenya

1. INTRODUCTION

Kenya covers a total land area of approximately 5.7million km2 between latitude 4°21' North and 4°28' South and longitude 34° and 42° East, bisected horizontally by the equator, and with diverse topography, hydrology and climate (Jaetzold and Schmidt, 1983). The landforms range from the glaciated mountain peak of Mt. Kenya in central Kenya, which is almost under permanent snow cover, to upland plateaus in western Kenya, the coastal plains, and the vast savannah grasslands that dominate the rest of the country. It is divided by the Great Rift Valley that cuts across East Africa into the eastern part of the country dominated by Mt. Kenya and the Aberdare ranges (altitudes of between 4,000 – 5,200m) and the western region which slopes downwards from the Mau ranges and Mt. Elgon at an altitude of about 4,300m to the Lake Victoria basin at the far west. Within these physiographic areas, the country‟s hydrology is characterized by four major rivers (the Tana, Mara,

* Email: *mosesimo@mu.ac.ke.*

Yala and Nzoia river basins), all originating from forested water towers (i.e. Mt. Kenya, Mau, Abaderes, Mt. Elgon and Cherangani hills). There are, however, many other smaller rivers that originate from the water towers that directly impact livelihoods of the local communities and the national economy. Kenya‟s rainfall depicts a bimodal regime with the rainfall peaks generally occurring in April/July (long rains) and October/November (short rains)

The current forest cover (closed canopy, woodlands and bushlands) in Kenya is estimated at approximately 1.7% of the total land area (Wass 1996; Gathaara 1999), as compared to about 12% cover 200 – 300 years ago (Logie and Dyson 1962), making most observers to argue for years that the country has some of the most degraded forests in the world. Many descriptions of the extent of degradation have been used to illustrate such undesirable environmental conditions, for example using the case of the Mau forest complex. Though most of the assertions that Kenya‟s forests are highly degraded is true, depicting forest neighboring communities as the major problem is misleading because there are policies, rules, regulations and laws governing access and utilization of these forest resources yet degradation has continued uncontrolled over the years. To this extent, therefore, drastic decline in forest vegetation cover in Kenya can be attributed to many issues and factors, which are related mainly to rapidly increasing population along forest edges, extensive cultivation on virgin forest lands, increased commercial exploitation with more powerful technologies, climate change, poor governance, and changing societal needs and values as well as politically motivated excisions (KFMP, 1994). These trends have been compounded by systematic dismantling of local and indigenous systems and practices of forest resource conservation that had allowed sanctions for misuse such as taboos, customary regulations and rules (Kamugisha et al. 1997). While these trends may be attributed to these social, economic and political factors, classical forestry philosophies, thoughts and trends regarding forestry use and conservation appear to support the view that sustainable forest management is a technical and professional issue, which must be driven by people with knowledge and experience on the theory and practice of forestry.

It is important to recognize from the onset that the current state of Kenya‟s forests is a manifestation of the inability of forestry as an institution and professionals to respond to the increasing pace of societal needs, and changing perceptions of forest values. This can be attributed to many factors including lack of either the will to effect change, insufficient knowledge and experience, deficiency in problem analysis and solving skills, or inadequate scientific

foundations to support the desired change. Forestry in this sense is taken to be the skill, science and business of managing forested landscapes to sustain desired balance of values and environmental services from those landscapes, including management of trees in agricultural lands. Although Kenyan forestry has undergone many changes over the years, the rate of social, economic and political changes have lately exceeded the willingness or ability of professional foresters and forestry institutions to adapt to the dynamic changes in the sector. Consequently, there has been deviation from traditional professional forestry practice in which management decisions are based on established knowledge, experience and site-specific conditions, to the current situation whereby forestry decisions are rigid, populist, selfish, political and sometimes emotionally driven.

This chapter examines these issues in relation to how continued forest degradation in Kenya can be mitigated by forestry institutions and professionals in light of recent ecological, social, economic and political changes that have occurred in the country. The major argument is that sustainable forest management can only be achieved through re-orientating the forestry profession and its institutions to be more responsive to increasingly changing societal needs and perceptions of forests. These changes include empowering institutions responsible for forest governance such as the Kenya Forest Service and other advocacy groups, improving quality and relevance of forestry education and training to be able to impart not only scientific and technical knowledge but also recognize the importance of ethics and professionalism, and setting a forestry research and extension agenda that addresses the dynamic changes in societal needs beyond solving re-current problems. These changes should be accompanied by establishment of shared forest information tools, systems and data among stakeholders in order to guide the evolution of forestry practices towards specific desired societal goals and values.

The following is an overview of these issues and how they should be addressed for sustainable management of Kenya‟s forests. These issues range from how human population growth and socio-economic dynamics are impacting on changing land use types. The chapter then looks at the types and extent of forests in the country, evolution of forest management in Kenya in light of changing land uses, continued threats to forests, historical government response to the threats, and public perceptions on these issues. Finally, some of the most fundamental issues determining forest degradation in the country are highlighted.

2. POPULATION AND CHANGING LAND USE PATTERNS

Population, land use and livelihoods in Kenya are intricately intertwined. Generally, the people of Kenya rely heavily on land for their livelihoods. Consequently, as the human population continues to increase pressure on land resources will also continue to increase, perhaps even at much higher rates than has been experienced so far. According to the 2009 population census[1], there were about 39million persons in the country aggregated into 8.8 million households. At the current growth rate of about 3% pa[2], the number of people in the country can be expected to increase to about 60 million by the year 2030 (Figure 1), which will undoubtedly present a significant challenge to sustainable forest management and socio-economic development as envisioned in Kenya Vision 2030[3].

The population structure in Kenya also indicates that the country has a large number of young persons (half of the total population). According to the 2011 economic survey[4], for example, there were about 11.2 million people between the age of 15 - 29 years while 10.6 million under the age of 14 years. Given the current rate of unemployment, these youth will have to rely more on one or the other form of natural resource for their livelihoods.

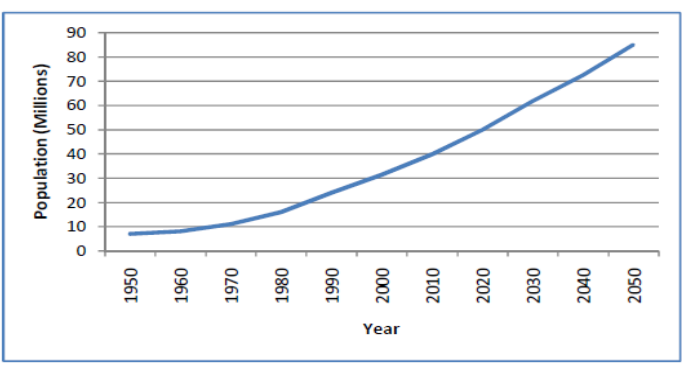

Figure 1. Past (1950 – 2009) and projected trends (2010 – 2050) in population growth in Kenya between based on the current 3% growth rate[2].

[1] Kenya Population and Housing census (2009), Ministry of Planning and National Development, Government of Kenya, Nairobi.
[2] National Economic Survey (2011), Kenya Bureau of Statistics, Nairobi.
[3] A long term government development plan to transform the country into a newly industrialized and middle income country providing high quality of life to all the citizens in a clean and secure environment.
[4] National economic survey (2011). Kenya Bureau of Statistics, Nairobi.

Unfortunately, this will have to be from some form of land resources, putting even greater pressure on forests.

Characteristically, more than 75% of Kenya‟s population is concentrated in the high potential areas (annual rainfall exceeding 1000 mm) comprising only 20% of the land surface (Jaetzold and Schmidt 1983), which are also the same areas where most closed canopy forests are concentrated. Because of the high population densities in these areas, there has been tremendous pressure on the forested areas for settlement, cultivation and grazing. In contrast, the vast majority of the country (80% of total land area) comprises of arid and semi-arid lands (ASALS) with annual rainfall of less than 1000mm, and characterized by low and sparse population and settlement patterns, low vegetation abundance, and with the main land use system being nomadic pastoralism. Settlement patterns are influenced mainly by the availability of water and pasture for livestock as well as the social and economic security concerns of the local communities, which to a large extent are inadequately provided by the state.

Urbanization is also creating devastating effects to Kenya‟s forests. There is currently high rural to urban migration with about 32% of the current population in Kenya classified as urban, and is expected to move to about 50% of the total population by 20305. Because of this pressure, settlements are more likely to encroach into areas currently occupied by agriculture, pasture, and forests as has happened with the attempted excision of Karura and Ngong Forests[6] just outside the City of Nairobi, and other environs like coffee farms in Kiambu, pasture lands in Athi River and Kitengela being converted to residential areas. Such areas need special policy and legal protection, otherwise will undergo devastating degradation.

Traditionally, forest biomass (fuel wood, charcoal) and hydropower are the major sources of energy for most households (both urban and rural) in the country. According to the government statistics5 about 67% of Kenya‟s population uses firewood while another 17% uses charcoal for cooking, which account for about 84% of the households in the country. Wood biomass is overwhelmingly used in the rural areas for cooking (86 % firewood, and 10% charcoal), while 74% use kerosene and a paltry 19% use electricity for lighting. This high dependency on wood fuel poses a great threat to forest conservation. It is therefore quite evident that for successful forest

[5] National economic Survey (2011), Kenya Bureau of Statistics, Ministry of Planning and National Development Nairobi Kenya.

[6] This attempt was however halted after public outcry, as explained later in this chapter.

conservation, the need for to exploit alternative sources of energy such as geothermal in the Rift Valley, wind power especially around Lake Victoria and Turkana, solar energy and coal deposits in eastern Kenya has never been so urgent.

As a major source of revenue for the country, tourism in Kenya is largely dependent on the rich diversity in wildlife. The number of tourists visiting game parks and reserves has been increasing steadily over the years. According to available statistics5, for example, the number of people visiting the National Parks and Game Reserves increased from about 1.5million in 1999 to about 2.5 million in 2007. It is significant to note that the country‟s foreign exchange earnings from tourism were only rated second to tea making the sector one of the largest contributors to the economy in 2010, a trend expected to be maintained to the year 2030. Most of these world attractive wildlife tourism sites are dependent on forests for either habitat or their water requirements. Within the Rift Valley for example, the Maasai Mara river, Lake Nakuru and Lake Elementaita tourism sites draw their water from the Mau forest complex. Other tourist sites include Mount Kenya forest, Aberdares ranges, Lake Bogoria, Shimba Hills, Saiwa swamp and marine parks at the coastal region. The beautiful coastal beaches are also protected by the expansive mangrove forests. The importance of these tourist attraction sites, therefore, emphasizes the need for conservation of the forested areas, which are also the major catchment areas.

Because of the importance of gender dimensions in the use and conservation of forest resources, it has been observed that in areas where women are involved in conservation activities the environments are well managed probably because of their closer involvement in the day-to-day activities in these areas than their male counterparts. Unfortunately, this involvement places a greater burden on the women than men as the former also spend most of their time searching for daily household needs such as food, water, firewood and childcare thus leaving little time for conservation activities. To achieve sustainability, there is need to mainstream gender issues into policies, plans and budgets and implement affirmative action that ensures effective participation of women in land use decision making at all levels.

3. TYPES AND EXTENT OF FORESTS IN KENYA

3.1. Forest Types

Many attempts have been made since the 1930‟s to classify Kenya‟s forests (Beentje, 1994). The major natural vegetation formations classified as forests (i.e. vegetation with overlapping canopy yet permitting considerable light penetration) include (i) edaphic forest formations (mangrove, swamp, floodplain, and riparian forests), (ii) montane forests (bamboo, dry and moist montane forests), and (iii) climax forest formations (moist evergreen or semi-deciduous forest, thickets with shrubs), which are closed formations that are difficult to penetrate and often interrupted with discontinuous grass and herbaceous layer, and woodlands made up of mixed grassland forest formations. Although the exact size of land in Kenya occupied by forests has not been determined with certainty, the area classified as state forests and therefore under the management of the Kenya Forest Service is known, and can be divided into four major forest zones, each covering a wide range of forest types (KFMP, 1994). These forest zones include (a) coastal forests covering about 66,700 ha of closed forest, with 16,000 ha of other woody plant associations (woodlands, thicket, wooded grasslands and bushlands); (b) dry forests covering about 163,000 ha of closed forests on isolated hilltops and along rivers, plus about 47,000 ha of other woody vegetation and bushlands; (c) montane forests covering about 387,000 ha of closed forest and about 361,300 ha of other related vegetation that has potential for growth to closed canopy status; and (d) western rainforest covering about 43,000 ha of closed forests and about 5,800 ha of other related vegetation.

Put together, these forests represent 1.7% of the total land area of Kenya mostly closed canopy natural forests (1.24 million ha) and forest plantations (0.65 million ha). The other forest formations include open canopy woodlands and bush lands, and woodlots on private farms. Of the closed canopy forests, they are distributed as follows (KFMP, 1994): montane forests (748,500 ha of natural forests and 102,800 ha of plantations); western rain forests (49,000 ha of natural forests and 18,000 of plantations); coastal forests (85,000 ha of natural forests and 3,200 ha of plantations); and dry zone forests (211,000 ha of natural forests and 8,200 ha of plantations). There is however some disagreement concerning what should be classified as "forest land". Like most countries in sub-Saharan Africa, no generally accepted forest classification system has been agreed upon, thus resulting in divergent views depending on nomenclature and inclination of the author.

Table 1. Total land area under forests in Kenya (5.5%) of the total land area

Land ownership	Total Land Area (ha)
Land under KFS Management	2,200,439
Land with forests under KWS	221,900
Large scale farms with forests/woodlands	140,000
Small scale farms with forests/woodlands	148,086
Community forests	539,300
TOTAL	3,249,725

Data source: KFMP (1994).

Specifically there is confusion as what vegetation type to be classified as a forest, and the ecological and management condition of the trees in terms of density and height of the vegetation for it to be designated as a forest.

3.2. Forested Lands

Most of the closed canopy forests in Kenya are gazetted (have been surveyed, demarcated and declared as forest reserves owned by the government) and managed by autonomous government agencies, mainly the Kenya Forest Service (KFS) and the Kenya Wildlife Service (KWS). The major implication of this is that the forests are government property, which regulates and controls access and use of all the forest resources, and that most benefits accrue to the state. The other forests located on Trust Lands are held in trust by the Local Government authorities on behalf of the indigenous communities, while the central government has limited control over forest resources in private land. The management of all these forests is provided for under the law[7] , which stipulates procedures and conditions for establishment, management and exploitation of all forest resources in the country. This Law also provides for procedures for establishment of a forest land irrespective of whether they have trees or not. The underlying philosophy behind this argument is the belief that forest lands should be primarily for growing trees because, if an area meant to grow trees carries ecosystems other than forests, then they will not provide the goods and services expected from a forest. For example, a bare land which has been gazzeted as a forest is not any different

[7] Kenya Forest Act 2005.

from a farmland, and therefore should not be classified as forest area. These issues are critical in policy formulation to avoid instances of forest degradation.

There are also other forested lands such as national parks and game reserves, and pastoral and rangelands whose management objectives are driven by other profit motives. Rural land owners also contribute to environmental conservation through growing and conserving trees on their farms for wood fuel, medicine and other cultural reasons. . In addition, the woody bushes in the semi-arid to arid areas support about half of the livestock in the country, thus sustaining the livestock industry and providing habitat and browse for wildlife. . The riverine, floodplain and hilltop vegetation equally play vital roles in regulating river flow and controlling flooding. They are traditionally the grazing grounds during the dry season and sources of some products such as fibers. From the perspective of the contributions these forests wherever they exist, qualify in every sense of the word for classification as forest lands. It should be noted that even lands under the management of the Kenya Wildlife Service qualify as forest lands because they are managed for the conservation of fauna and flora. Although the Wildlife Act prohibits exploitation of vegetation in these areas, a number of parks and reserves contain valuable wood resources that could be managed sustainably because of their crucial role in water and biodiversity conservation, as well as mitigation of climate change.

3.3. Trees on Farms

Trees on farms supply the bulk of fuel wood, poles and other wood products consumed by the people in rural areas. Whereas trees occupy a certain minimum area under the classical definition of forests, trees on farms occur in many forms and configurations such as woodlots, hedges, linear planting along boundaries, road sides and terraces, and intercrops among others. They also occur as individual trees dotting cropland, pastureland as agroforests and in homesteads as ornamentals. However, determining the area that these individual trees and other agroforests on farms occupy can be a complicated affair. While the conventional survey methods have been found appropriate in estimating areas under farm woodlots, these methods are usually inappropriate with respect to some tree formations on farms.

Out of these on-farm forestry practices, ornamental planting or homestead agroforestry is rarely utilized for wood products. Similarly, the hedges and a

few trees dotting farmlands cannot qualify as forests. Accordingly only linear planting in terms of boundary, roads, terraces and woodlots/woodlands can be counted as forests. Thus, boundary linear and woodlot woodland constitute the highest percentage number of trees found on farms. However their incidence is low since less than half of the farms counted has woodlots and over about 60% with boundary planting. Woodlots are generally planted in areas not suitable for cultivation or where there growing is considered as economic undertaking as in Maragoli area of Kakamega District. Therefore where they occupy a given minimum area, they have been considered as forests.

3.4. Importance of Kenya's Forests

From the above overview, it is evident that Kenya‟s forests are greatly diverse both in type as well as biodiversity (Sayer et.al. 1992). The importance of these forests can be viewed from various perspectives; namely global, regional, national and local values. Globally, Kenya is among the world‟s top 50 countries in terms of species richness with the highest number of total mammal species in Africa with forests forming most of their habitats It is estimated Kenya has some 1847 known species of amphibians, birds, mammals and reptiles, of which about 4.0% are endemic, meaning they exist in no other country, and 3.8% are threatened. Kenya is also home to at least 6506 species of vascular plants, of which 4.1% are considered endemic. Unfortunately, although some the indigenous forests more than 500 years old with unique habitats and important animal and plant species some of which are endemic to those specific sites, little is known about their biodiversity. Because these forest ecosystems and habitats are highly threatened, the Conservation International (IUCN) has designated some of these forests such the Eastern Arc Mountains, including Kenya's Taita Hills forests, among its top 25 global "hotspots" for urgently protection (Wass 1996). Besides biodervisty importance, the forests also help regulate climate change through carbon sequestration, which is currently a major global concern.

At the regional level, some of the most important rivers feeding into Lake Victoria originate form Kenya‟s forests such as Mau forest complex (Mara and Sondu Miriu rivers) Nandi forest (Yala river) and Mt. Elgon and Cherangani (Nzoia river) and originate from forests. The Lake, which is shared between Kenya, Uganda and Tanzania supports is a major source of livelihoods and socio-economies of the three countries as well millions of people in Northern Africa who depend on River Nile. At the national level, these forests provide

various ecosystem services including trapping and storage of rain water, recharging ground water tables, regulation of river flows and prevention of flooding. Forests are also known to help improve soil fertility through nutrient cycling, reduce soil erosion and sediment loads in river water, and help regulate local climatic conditions.

Although the contribution forests to the national economy are well appreciated no comprehensive assessment has been conducted in the country. Some selected studies have however established that the annual economic value of products and services from the Abardares forest including biodiversity were about USD 70 million8, the economic gains out of tourism, generation of hydroelectricity and productivity of the tea sector within the Mau forest complex exceeded USD 25 million annually. Way back in the 1990s before the ban on forest harvesting by the government, forestry and wood processing industries were estimated to provide direct employment to about 35,000 people and another 50,000 indirect employment (Gathaara, 1999). Despite these huge contributions to the Kenyan economy in terms of direct income and employment, forests continue to be undervalued leading to underfunding and poor management (Emerton and Karanja, 2001). For this reason, the current levels of investment on conservation activities are not commensurate with the actual contribution of the forests to socio-economic development.

At local community level, about 3 million people (8% of Kenya‟s population) live within 5km of forest boundaries, and are classified as forest-adjacent households (Kagombe, 1998; Imo et al, 2007). These households derive most of their livelihoods from forest related activities such as fuel wood, grazing, limited cultivation in plantation areas during site preparation for tree establishment. Some of these communities are also employed by the government as forest workers. Traditionally, some forests have been important for cultural ceremonies and as sacred sites to local communities, which has encouraged conservation of the forests.

The significance of forests to local communities is perhaps greatest in the dryland areas of the country, which constitute over 80 % of the total land area in the country. These areas are characterized largely by by thickets of thornbush, grassland and scattered trees mainly of Acacia and Commiphora species. The plains are dotted with isolated hills and low mountains, which help trap and hold clouds or force moisture-laden winds into higher altitude where cooling causes condensation and cause some little, brief and erratic

[8] National Economic Survey (2011), Kenya Bureau of Statistics, Nairobi Kenya.

rainfall (<500mm). For this reason, the hill tops hold unique islands of forests supporting different flora and fauna. The hilltops therefore form very critical and important water catchments and biodiversity conservation as well as play a role in climate change mitigation. These hilltops are particularly important to the local communities because forest cover moderates the effects of temperature and wind, and significantly changes the humidity regime. Temperature fluctuations are decreased, humidity is increased and wind speed slowed. The hilltop forests prevent the rapid run-off of rainwater so enabling it to slowly sink in and replenish springs and streams in the valleys, which are vital for the livelihoods of the local pastoral communities, their livestock and wildlife in these ecosystems.

4. THREATS TO FOREST ECOSYSTEMS IN KENYA

Forests are under extreme threat throughout Kenya, which can be linked directly to how different stakeholders and institutions perceive forest values. According to conservative estimates, Kenya lost an average of 12,600 hectares of state forests per year, between 1990 and 2000, an average of 1.4.% per year. It is however argued that floss in forest cover has since declined to less that 0.34% between 2000 and 2020 perhaps because of the current efforts by the government to mitigate forest degradation. In total, Kenya has lost about 186,000 ha of state forests, representing about 5.0% of its total forest cover. Unfortunately, these data are only indicative of vegetation cover, but information on other aspects of degradation and integrity such as forest structure, functioning and value are not available. All these forest ecosystem attributes are important in assessing the nature and level of degradation. It is also important to note that to this extent, trees are only part of the wider definition of forest ecosystems, and form only part of the larger assemblage of attributes or components influencing forest ecosystem structure, function and values. Other components include wetlands, wildlife, culture, beliefs and potential utility. These components, attributes and potential utilities for human welfare can be regarded to constitute to human biodiversity. Unfortunately, human activities such as direct harvesting of trees, introduction of exotic species, habitat destruction and environmental pollution, have caused dramatic loss of biodiversity in forested areas.

Although Kenya is endowed with diverse ecosystems ranging from montane forests, climax rainforests, dryland forests, wetlands, marine and freshwaters, the lifelines of almost all these ecosystems depend on the

sustainability of the forest component of our terrestrial ecosystems as supported by the five major water towers (Mau complex, Mt. Kenya, Mt. Elgon, Aberdare ranges and the Cherangani). Each of these forest ecosystems partly consists of natural vegetation with its own characteristic biodiversity that is largely determined by elevation and rainfall, and under its own unique environmental threat.

Overall, the major threats to these ecosystems can be attributed to increasing human population pressure and changing societal needs resulting in change in settlement patterns and sedentary livelihoods, expansion of croplands, encroachment involving clearing indigenous forests for subsistence and large scale agriculture, illegal logging, charcoal production and firewood collection, and increased grazing among other threats. The degree of threat, however, varies depending on the forest type and the socio-economic conditions of the specific forests locations, as explained in Table 3 below.

5. DEVELOPMENT OF FOREST MANAGEMENT IN KENYA

5.1. Historical Background

The history of forest management in Kenya dates back to the beginning of the 20th century. Table 2 is a summary of some of the key actions by the pre- and post-independence governments to regulate management of forests in the country, and was initially directed mainly development of forest plantations to meet the increasing demand for wood products with less emphasis on conservation. The first plantations of *Eucalyptus* species and Black Wattle (*Acacia mearnsii*) were intended to supply firewood to the then Uganda railway (Logie and Dyson). Afterwards, with a view to producing sawn timber, the various species of Cypress (*Cuppressus lusitanica* and *Cuppressus macrocarpa*) were planted (KFMP, 1994) using the *Taungya*[9] system of cultivation, which has commonly been referred to as the *shamba* system as described in detail in Box 1. By 1930, about 1.3 million ha of plantation forests had been established. Between 1945 and 1950 the area established had increased to 40,000ha.

[9] A system of forest plantation establishment in state forests in which forest neighbouring communities are allocated land for growing their crops in exchange for labor for forest plantation establishment in government forests.

Table 3. Threats to various forest types in Kenya

FOREST TYPE	KEY CHARACTERISTICS	MAJOR THREATS
Afro alpine forests	Occur at an altitude of over 3,800m and mainly of mountain scrublands and moorlands. Are found only at the peaks of Mt. Kenya, Mt. Elgon and the Aberdare ranges. These forests are characterized by freezing temperatures, strong wind, shallow wet or marshy peaty soils on rocks, and absence of climax tree species.	Because of these conditions, there is minimal human or animal activity and disturbance at these elevations. The major threat to these ecosystems is therefore likely to be the effects of climate change.
Bamboo woodlands and thickets	Occur at altitudes of between 2,100–3,300m as pure stands with closed canopies or patches, or in mixed stands with scattered trees but usually forming over 80% cover. This forest type is crucial because most rivers, streams and springs start from these ecosystems.	Most serious human and animal activities begin from this level. This, together with intensive harvesting of bamboo and other woody species, and cultivation activities makes the threat to these ecosystems severe.
Dry montane	Occur at altitudes of between 1,6000 – 2,500 m, with total annual rainfall of between 700-1,350mm. Found mainly on the drier but colder leeward slopes of mountains. These ecosystems are important sources of several rivers and springs.	Because of the low rainfall and cool temperatures, most threats are due to encroachment leading to illegal logging, grazing and charcoal making which also increases the risk fire. Cultivation is not so much attractive because of the low rainfall.
Moist montane forests	Occur at an altitude of between 1,000 – 2,500m, with annual rainfall of over 1,800mm. Found in the wetter (windward) slopes of the mountains. Have a continuous stand of trees over 10 m tall with	Because of the high rainfall, has attractive for settlements leading to severe degradation and biodiversity loss through illegal logging, grazing,

FOREST TYPE	KEY CHARACTERISTICS	MAJOR THREATS
	closed canopy, relatively moist or wet floor, usually with carpet forming *Selaginella kraussiana*, epiphytic ferns and, lichens. These ecosystems are important sources of several rivers and springs.	cultivation and settlements, charcoal production and fires. Much of these areas have been cleared of natural vegetation and converted to agricultural land and plantations of exotic species.
Climax forest formations	These located in the densely populated region of western Kenya (Mau forest complex, Nandi and Kakamega forests),coastal terrestrial forests (Taita Hills, Shimba Hills forests, and Kaya forests) These are closed canopy natural forests and plantations of mainly exotic species.	Encroachment because of pressure to subdivide the group ranches for irrigated agriculture. Overexploitation for fuel wood, timber, medicine and honey; fires. Increased human/wildlife conflict due competition for water and pasture due to proximity of the game park. Encroachment; excision.
Edaphic coastal forests	Mangrove forests along the coastline. Are breeding grounds for fish, and dispersal area the Marine park.	Fuel wood. Coral collection. Trampling on the corals by tourists. Mining and quarrying for building materials.
Dryland forests	Are low-lying plains covered by thickets of thornbush, grassland and scattered trees, mainly of *Acacia* and *Commiphora* species, and dotted with isolated hilltop forests.	The major threat to dryland forests is increased wind erosion, overgrazing leading to decreasing vegetation cover, and conflict over water and other resources.

At the end of the Second World War, a Development Committee was set up to consider how forestry development could be promoted. In 1955, D.

Table 2. Some major historical events and government actions that have shaped forest management in Kenya

FORESTRY DEVELOPMENT PHASE (Management paradigm)	DEFINITION AND KEY FEATURES	ACTION BY THE GOVERNMENT OF KENYA
Exploitative forestry (Before 1890)	Pre-forestry: Use of a forest resource without any explicit management activity to promote ability to renew desired values.	All forests were under customary management by local communities. This was to ensure forest conservation activities benefited the local communities.
Administrative forestry (1891 – 1932)	Early forestry: Use of laws and regulations with greater emphasis on timber production. Often did to not respect ecology and all other desired values from forests.	1891: Enactment of the 1st forest legislation to protect mangrove forests at the coast to extend protection of forests to include those along the Uganda railway line
		1900: Revision of the 1891 legislation to enable the 1891 legislation to cover all the forests along the railway line.
		1902: Establishment of the position of "Conservator of Forests" to oversee management of all regulated forests.
		1908: Gazettment of some forest blocks too enhance government regulation, control and management
		1908: Establishment of Eucalyptus and Black wattle plantations to supply wood fuel to the Kenya – Uganda railway.
		1932: Enactment of the first Forest Act in Kenya too outline circumstances under which various activities were to be carried out in forests by various stakeholders.
Ecological forestry (1933 – 1956)	Towards sustainable forest management: Greater emphasis was placed on non-timber values such as aesthetics, soil and water conservation etc.	1947: Revision of the Forest Act of 1932 to place more focus on the protective functions of forests..

FORESTRY DEVELOPMENT PHASE (Management paradigm)	DEFINITION AND KEY FEATURES	ACTION BY THE GOVERNMENT OF KENYA
Social forestry (1957 – 1988)	Application of Multiple use forestry concepts: ecologically based, multi-value, ecosystem management that respects the ecology and sociology of desired forest values.	1957: Preparation of the 1st Forest Policy paper outlining governemnt plans on forestry development in the country
		1967: Adoption of the 1st Forest Policy Paper in Kenya.
Breakdown in principles of social forestry leading to non-conformity to traditional evolution of forestry practices (1988 – 2004)	Manifestations of unprofessional conduct: Forestry professionals and institutions that serve society are changing more slowly than society"s expectations of those institutions, and forestry professionals are unable to adapt to the accelerating rate of change they encounter.	1986: Ban on the *Shamba* system to resettle communities outside of gazetted forests (which was against the societal wishes of the local communities).
		1986: Establishment of the Nyayo Tea Zones Development Corporation (NTZDC) by the Government to provide physical buffer zone between agricultural land and state forests. This was designed for protection, provision of alternative sources of income and employment.
		The above actions in 1986 were in conflict with each other, and were perhaps the genesis of the current conflicts in our forestry practice.
		1994: Development of the Kenya Forestry Master Plan,.
		1994: Revision of the forestry Policy to conform to the realities of forest management in the country with emphasis on community participation in forest management.
		1994: Re-introduction of the *Shamba* systems as Non-Residential Cultivation (NRC) to enhance plantation establishment and improve livelihoods of forest neighboring communities.
		1996: Revision of forest Technical Orders to update, elaborate and simplify previous ones that were difficult to implement under the changing circumstances.

Table 2. (Continued)

FORESTRY DEVELOPMENT PHASE (Management paradigm)	DEFINITION AND KEY FEATURES	ACTION BY THE GOVERNMENT OF KENYA
		1999: Ban on forest harvesting so as enhance conservation of forests through regulating saw millers who had abused forest resources.
		2001: Revision of the NRC guidelines (rules and regulations) to improve management of the NRC system.
		2002: Ban on NRC in all forests excepts Dundori and Bahati forests on experimental basis to avoid misuse of forestlands by cultivators .
Revisiting basic philosophies and paradigms of forest management. (2008 – present)	Consensus building: stakeholder consultations in view of continued forest degradation .	2005: Enactment of the Forests Act 2005 to provide a legal framework for forest governance in the country. A proposed Forest Policy, though not yet approved, outlines the key objectives of forest management in country.
		2007: Establishment of the Kenya Forest Service (KFS) to improve management of forests in the country in line with the proposed Forest Policy, and the enacted Forests Act 2005. This followed the abolition of the Forest Department in the then Ministry of Environment and Natural Resources.
		2008: Re-introduction of forest cultivation under a new scheme called "Plantation Establishment and Livelihood Improvement Scheme" (PELIS) to enhance plantation establishment and improve livelihoods of forest neghbouring communities.

Data Sources: Logie and Dyson, 1962; KFMP 1994; Wass 1995; Mogaka *et al* 2001; Wanyiri 2001; Imo *et al* 2007. Whereas these sources provided critical information, all interpretations and syntheses were the responsibility of the author.

Davis, the then Working Plans Officer in the Forest Department, prepared a plan for the planting of exotic softwoods (conifers) in Kenya (Logie and Dyson, 1962). The highlight of this plan was the proposal to plant 2,430ha per annum of exotic conifers, half of which were to be Cypress and the other half Pines (*Pinus patula* and *Pinus radiate*). Through this plan most exotic plantations were of Pine species, with a 6,000- acre target rate of planting reached in 1949.

Just before independence, the ministry of Natural Resources prepared a long term Forest Industrial Development Plan to guide investments in forest plantations and forest-based industries, particularly pulp and paper (KFMP, 1994). In 1969 and again in 1975 the World Bank arranged for external capital funds to be made available for industrial forest plantations. In this plan a targeted 136,000ha of timber plantations and 24,000ha of pulpwood plantations were to be established by 1980. In the course of implementing this plan, resident laborers who had been under the shamba system were given permanent employment under the civil service terms in 1975, even though no minimum daily tasks were stated for them. This later brought problems about the workability of the shamba system that have continued to persist to-date.

Accordingly, there has been a steady decline in the capacity of the government to manage forest plantations since the mid 1970s, mainly because of limited funding for plantation development, and adverse changes in staff attitudes, skills and motivation. Thus, ability to implement plantation establishment and maintenance activities and development of new rules to cope with changing conditions for environmentally appropriate and cost effective methods of plantation establishment. As a result, there has been declining state of plantation forests with large backlogs both in replanting and in other silvicultural operations. A review by Kagombe and Gitonga (2005) indicated that forest plantation coverage in Kenya had attained a peak of 160,000 hectares by 1994, but this was reduced by 40,000 hectares through excisions for settlement, and that today there are only 120,000 hectares of forest plantations remaining. Of this, only 74,000 ha were stocked, while planting backlogs stood at 46,000 hectares by the year 2002.

Although declines in plantation activities had often been attributed to the ban on the shamba system and unsustainable harvesting, inadequate funding for plantation development management was probably the major factor responsible for the then poor state of forest plantations. For example, the money made available for plantation development declined from as much as USD 4.5 million in 1996 to a paltry USD 0.3 million in 2000 (Kagombe and Gitonga 2005).

Box 1. Contributions of the *Shamba* system in the development of forest plantations in Kenya

The *Shamba* system was introduced in Kenya in 1910 as a modified form of the *Taungya* system used that has been used many decades in South East Asia. The system involves planting tree seedlings in combination with food crops by resident forest workers in newly cleared forestland in exchange for free labour for the government to tend tree seedlings over a period of 3 – 4 years. Farmers prepare clear-felled forestland for tree planting by first growing food crops (mostly maize, beans, potatoes, cabbages and carrots) alone for one cropping season, followed by crops and planted trees for 3 - 4 years, after which trees are left to grow alone. This planting sequence eliminates weed competition because tree-crop competition is minimized, thus ensuring maximum survival and growth of the trees and crops while farmers have access to productive forestland, thus reducing potential conflicts between local communities. This system was initially used to convert natural forests to forest plantations. After conversion of conversion of natural forests to plantations was stopped in 1979, the *shamba* system continued as Kenya"s preferred method of re-establishing harvested plantations, and has been successful until the mid 1980"s when it was banned due to the collapse of the regulatory and administrative structures as well as controversial policy decisions by the government.

The *shamba* system has undergone several positive and negative changes since it was first introduced in Kenya. From its inception until 1975, forest cultivators were integrated into forest management activities as resident workers. Each worker was then allocated a small piece of land within the forest (popularly known as *shamba*), which they cultivated and the produce was considered part of their emolument as they tended newly planted young trees. However, the system was revised in 1975 whereby all these resident workers were now required to pay rent for the *shamba*s they were allocated in the forest. Additionally, tenancy of the *shambas* was extended to other forest neighboring communities irrespective of whether they were forest workers. Consequently, the number of cultivators rose significantly, and effective supervision of the system became problematic. Most of the new cultivators who were not forest workers did not understand the system, and had little skills in tending young trees. They could, for example, damage roots of newly planted trees during weeding, over-pruning of young seedlings in order to reduce shading of their crops, and debarking to kill the seedlings. The result was significant reduction in tree survival and poor growth because of reduced photosynthetic at this early age.

The major benefit to the government that accrued from the *shamba* system was

mainly saving on costs that they would have been incurred during site preparation/clearing, staking, planting and weeding over the three year period that system is practiced in any one plot. The other benefit was the annual rent collected by the government from the leased *shambas*. This arrangement reduced estimated cost of plantation establishment within the first three years of planting was estimated to be more than half without the system. Other benefits to the government were higher seedling survival rates, greater protection from animal damage, reduced susceptibility to pests and disease, protection from fire damage. On the part of farming communities, they benefited from increased food production for their subsistence as well cash income from higher sales of the farm produce. Although the significance of the benefits varied from place to place depending on productivity, access to markets and crop management, most of the food crops produced benefited the neighboring urban centers. Despite its success since the introduction of plantation forestry in the country in early the 19th century, this system has since been reviewed to address concerns of various stakeholders in the sector, and is now called *Plantation Establishment and Livelihood Improvement Scheme* (PELIS). Like the *shamba* system, this new scheme allows forest neighboring communities to cultivate and plant food crops in clear felled areas for two to three years in combination with tree seedlings.

Although the situation had improved slightly to USD 1.2 million in 2004, this allocation was still inadequate to fund plantation management activities, which resulted in serious shortages the required labour for plantation establishment and maintenance activities such as protection from fire, animal damage and policing. However, from 2000 the government intensified replanting efforts with assistance from the newly re-branded Non-Resident Cultivation (NRC), in which farmers and selected private companies such as Pan African Paper Mills Ltd and Raiply Ltd were still allowed to operate in forested areas. These efforts reduced replanting backlogs, although planted areas have remained poorly maintained.

5.2. Evolution of Professional Forestry

The above historical events can be summarized into four key phases of forestry development as witnessed over the past few decades in Kenya, and are more or less a reflection of changing societal needs. Up to around the late 1980‟s, Kenya‟s forestry followed a general pattern of development as has been witnessed in many other parts of the world evolving from pre-forestry to

exploitative, administrative, ecological and finally social forestry (Kimmins 1996) as summarized in Table 3. Exploitative forestry simply means that the forest resource is utilized without any explicit management activity to promote or ensure the renewal of values that society desires from forests (Table 2). Although many communities have used local indigenous knowledge and experience during those pre-forestry days to practice sustainable exploitation of forest resources, past trends indicate that the capacity of the affected forests to renew the desired values often lags behind the rate of exploitation thus leading to resource depletion.

To prevent further depletion, there was a need to put in place laws and regulations to govern forest management in the country i.e. administrative forestry. This has been the case in Kenya between 1891and 1908 with the enactment of the first forest legislation by the colonial Government to protect mangrove forests at the coast and along the railway line, establishment of the position of Conservator of Forests to oversee management of all regulated forests in 1902, gazettment of the some forest blocks in 1908 and establishment of Eucalyptus and Black wattle plantations to supply wood fuel to the Kenya-Uganda railway (Table 2). Unfortunately, while this stage sustained most forest timber values at the time, most non-timber values such as aesthetics, soil and water conservation and biodiversity were not of major consideration. In the long term, it even failed to sustain timber values as earlier envisaged following the collapse of the whole forestry sector. This management approach has generally been unsuccessful many cases as it is either too simplistic or is applied too rigidly to respect ecological, biological or social and cultural diversity.

In order to accommodate increasing environmental concerns of ecological services of forests, as had happened in other parts of the world then, administrative forestry was replaced by ecological forestry in 1932 following the enactment of the first Forest Act in Kenya, that outlined circumstances under which various activities were to be carried out in forests by various stakeholders. This was revised in 1947[10] with more emphasis shifting to the protective functions of forests with greater emphasis on non-timber forest values and sustainable ecosystem functioning. This legislation concentrated on catchment protection and timber production, with strong government control and excluded local communities from decision-making related to changes in

[10] First policy on forests was formulated in 1957 and revised in 1967, after the enactment of the Forest Act

the use of forests. Unfortunately, even ecological forestry paid more attention to forests than the people or society it is supposed to serve!

The frequent failure of ecological forestry to sustain the changing balance of values desired by society has lead to the social forestry or also known as forest ecosystem management phase: ecologically-based, multi-value, forest ecosystem management based on the application of social and biophysical sciences in a way that respects the ecology and sociology of desired values. Here, the focus is on both the forest and the people. Social forestry emphasizes site-specific and value-specific concepts. This approach combines well with the concept of zonation, which involves spatial and temporal separation of certain values, for example forest compartments separated between timber values (intensive management) from non-timber values (less intensive management). Also, areas with longer ecological rotation (e.g. for biodiversity and water catchment conservation) can be separated from areas requiring shorter rotation (commercial timber production). . Unfortunately in Kenya, the problem starts here – conflict between society who demand most of these values simultaneously each forest ecosystem irrespective of their capacity to supply these values, , and the forestry institutions and professionals who insist on ecosystem management based on empirical evidence for decision making.

Successful implementation of ecosystem management of social forestry needs a combination of broad knowledge and experience including ecology, sociology and culture, as well as political considerations in both temporal and spatial scales relevant to forestry. Quite often, problems arise because forestry professionals and institutions approach complex issues in very simplistic ways, or they unnecessarily complicate simple problems! Problems are issues that do not get solved, while issues that get solved easily are not problems. A major reason why problems persist is that they may be very complex, and the solutions that are often offered are too simple. This partly explains why despite past efforts by government to reduce deforestation, forest degradation has continued to persist – most approaches have mostly been to simplistic for the problems at hand. For example, when government simply decides to ban shamba system, forest harvesting and charcoal production, it responded in a very simplistic way to more complex social, economic, cultural and political problems.

5.3. Recent Government Actions in Response to Perceived Threats to Forests

In an attempt to reverse the above threats on sustainable management of Kenya‟s forests, the government in recognition of the serious consequences of the above threats to forests in the country, the government has undertaken several policy and legal reform measures to enhance forest conservation. Some of these are discussed below.

Ban on the Shamba System of Cultivation

One of the most drastic measures by the government to conserve forests was a presidential decree in 1987 banning the shamba system following increased influx of forest neighboring communities to forest areas, and by in 1988 all forest cultivators were evicted from forest areas (Imo et.al 2007). Unfortunately, no arrangements had been made for continued plantation establishment activities. Together with retrenchments in the civil service in 1994 (which affected about 6,000 forestry staff), and the termination of the Kenya Forestry Development Project by the World Bank in 1998, the capacity of the government to re-establish and manage forest plantations was severely reduced resulting in dramatic increase in backlogs in forest plantation management activities (Wanyiri, 2001).

Consequently, all reforestation activities stagnated with less than 20% of clear-felled areas were replanted and 80% of replanted areas were not weeded (Kagombe and Gitonga 2005). To counter these developments, the system was reorganized and reintroduced in 1994 in selected forests (and later in all forest areas in the country) as Non-Resident Cultivation (NRC) where cultivators were not allowed to reside in forest areas. In attempt to integrate the NRC into the local community development programs, the government put the control of the NRC under the Provincial Administration and local politicians, who then had a leading role in allocating shambas in forest areas without any reference to foresters, which lead to serious abuse of the system.

The impact of the above was that larger areas of forests were being cleared for cultivation than scheduled for planting while planted trees were deliberately destroyed to make way for food production. Other problems were that NRC was being practiced in areas considered by the forest department unsuitable for cultivation, record-keeping was inadequate, the shambas were allocated indiscriminately, and stakeholder participation in implantation process was low. In order to streamline the system, the government established a task force in 2000 comprising Ministry of Environment and Natural

Resources, Kenya Forestry Research Institute, Kenya Wildlife Service and other government agencies to review the implementation of the NRC (Wanyiri et al 2001). This task force revised NRC guidelines, and a team was appointed to supervise its implementation. The controversy continued in March of 2004 when the Ministry of Environment and Natural Resources once again banned the system, but allowed it to continue on pilot basis in selected forests such as Dundori and Bahati forests in Nakuru district following pressure from the local communities and their political leaders.

The continued success in these pilot areas as opposed to areas where the shamba system was completely discontinued clearly demonstrated that it is possible that a forestland can be managed to produce goods and services under the multipurpose criterion even with other vegetation other than trees. Because forests are renewable resources, conservation activities must therefore recognize the importance of managing them under the concept of multiple purpose criterion incorporating forest products and services including wildlife, biodiversity conservation, leisure and tourism, and water. Central to all these objectives should be socio-economic and cultural interests of the forest neighboring communities, national economic development and other issues of international concern.

Establishmento of the Nyayo Tea Zones Development Corporation

In further attempt to reverse forest degradation, the government followed banning of the shamba system with the establishment of the Nyayo Tea Zones Development Corporation (NTZDC) in 1986 as a State Corporation to protect and conserve the country‟s gazetted forests. The main mandate of the corporation is to promote forest conservation by providing buffer zones of tea and assorted tree species to check human encroachment into government forest lands in various forest areas in the country. The driving philosophy behind this concept is that it reduces human encroachment into forests by enabling positive interactions between agricultural activities, forest conservation and communities living adjacent to the forests. Some of the income from these activities is used for participatory afforestation and conservation, as well as alternative livelihood schemes and direct employment. Unfortunately, this corporation operates only in tea growing areas and similar initiative is equally important and threatened forest ecosystems have not been explored.

Ban on Forest Harvesting

After years of forest destruction, the government imposed a blanket countrywide ban on logging in all state forests in that was gazatted in October

1999 so as to enhance conservation of forests through to regulating the operations of sawmillers who had abused forest resources and were not participating in any reforestation programs (Wasike, 2010). Although initially meant to last only three months, this was extended indefinitely in 2000. At the time the ban was imposed, the rate of replanting was a clearly below the rate of harvesting. It is currently estimated that about 46,000 ha of forest plantations that had been harvested before the ban have not been replanted for lack of labour and finance. Although the initial intention of checking wanton destruction of forests to improve the country‟s forest cover, it is now safe to argue that the logging ban has outlived its initial noble intention and is now doing more harm to environment and the socio-economy of the country.

According to the Kenya Forestry Service, and which is evident throughout the country, the ban has created, timber r scarcity, closure of over 300 saw-mills and the loss of over 50,000 direct and about 300,000 indirect jobs (Wasike, 2010). Additionally, about 42,000 ha of over-mature forest plantation valued at over USD 450 million have been degrading in the forest due to aging, disease such as heart rot, insect attacks, windfall and wildlife destruction. The risk of forest fires is also extremely high because these rotting trees provide ideal fuel for fire breakout. At the same time, there are approximately 20,000 ha of recently replanted forest plantations which are due for commercial thinning that could generate approximately USD 44 million for the government. The Kenya Forest Service has not been able to harvest approximately 38,000 ha of over-mature trees due to the ban. Because of continued unmet demand for wood products, the there has been undesirable environmental effects that have arisen from the ban on logging.

Trees on farms such as woodlots, boundary planting and agroforestry trees that were planted for conservation purposes are now harvested and used for purposes that they are not suited for. Timber shortage has also forced prices to up more than 400%, creating an incentive for illegal logging despite recent attempts by the KFS to strengthen policing and enforcement of the logging ban. Fortunately though, these shortages and high prices have given farmers incentives to venture into tree farming as commercial enterprises. Effects of these initiatives is yet to be felt, but there is consensus that the only way forward is to de-emphasize an administrative approach to the whole issue and focus on increasing timber supply to the market through lifting the ban. Since the imposition of the ban, there have been significant efforts made by KFS to restore forest cover and institute forest management plans, which include strict enforcement of Forests Act 2005 and improved governance among other.

Policy, Legal Re and Institutional Reforms

Kenya has in the past pursued a Sectoral approach to conservation and development, which has not succeeded in addressing the cross cutting environmental and conservation issues. Among the weaknesses of this approach has been that it has led to inconsistencies among institutional frameworks leading to further loss of the country's natural resources. In recognition of the need to involve more actors to ensure an integrated and harmonized conservation and management system for all natural resources, the Government has now seen a need for a national policy framework approach that is hoped to harmonize implementation of policies concerning management and conservation of natural resources including forests.

Most recently, government enacted the Forests Act 2005, which among other reforms established the Kenya Forest Service with the mandate to manage all forest resources in the country. Its core functions are to formulate policies and guidelines regarding the management, conservation and utilization of all types of forest areas in the country, manage all state forests and provisional forests in consultation with forest owners, protect all forests, promote capacity building in forest management, collaborate with individuals, private and public research institutions in identifying research needs and applying research findings. The other institution that is also involved in some aspects of forest protection is the Kenya Wildlife Service, which was with the mandate to promote wildlife conservation, protecting ecologically vulnerable ecosystems and wetlands. Despite all these interventions, forest destruction is still rampant in the country.

5.4. Public Perceptions on Forest Degradation

Because of the great awareness among the public on the vital functions of forests and the dwindling forest cover, there has been increasing support for forest conservation resulting in popular disapproval by the Kenyan public attempts by the government to convert gazette forests to any other use except for purposes of conservation (Gachanja 2003). Concerns related to frequent and devastating droughts and floods since the 1990, provision of water, hydropower, and the dependence of agricultural production on forests are some of the issues that have driving the public to support forest conservation. These concerns often led the public to protest any attempt by the government to convert forest land to private use through peaceful demonstrations, public meetings and civic education. Other measures by the public included legal

proceedings such as the one filed by an environmental lawyer, the Ogiek community inhabiting forest in the Mau complex, and some NGOs and civil society through private prosecution. Some of these suits were successful in stopping the government from altering, diminishing, alienating, clearing or allocating to any private developer, or to anybody, any part of excised forests.

Most of these efforts have been instrumental in halting private development on gazetted forest and bringing positive changes in the management of forest resources through improved governance, and policy, legal and institutional reforms, which have largely been participatory involving the public. For example, intervention by the public halting of a housing project within Nairobi"s Karura forest (an important recreational area for Nairobi residents) in 1998, de-gazetting of more than 67,000ha of forest land in various forests in the country, in 2001 and halting of proposal to allocate 5,000 ha of parts of the coastal Arabuko Sokoke Forest with rich diversity of bird species and ecotourism for settlement of people purported to be landless in contravention the Kenya Forestry Master Plan of 1994 (KFMP 9194). Other areas listed for excision were the Mau and Mount Kenya forests, which would have impacted negatively on all the services provided by these forests including water and biodiversity.

One of the major motivations for public concerns was the trend that most of such allocations would normally go to a few powerful senior government officials who would then sell the same unsuspecting public for profit. The enactment of the current Forest Act in 2005, which had a major contribution from the public, however has streamlined management of forest resources in the country. This legislation has made it difficult for the government to convert forest land into other uses except for forest development and conservation.

The overwhelming perception by the public that forests are critical to their livelihoods was instrumental in getting the public involved in fighting for their conservation. According to Gachanja (2003), most Kenyans were able to link forests with values such as water conservation, income generation, flood control, rainfall, food and medicine, grazing lands during the dry season, tourism development and biodiversity conservation (Gatere et al 2002). Sustained awareness creation through capacity building ensured that the public participate in decisions making, and subsequently avoiding conflicts over management of natural resources

6. SOME FUNDAMENTAL ISSUES

6.1. The Key Message

The most fundamental message from nature is that forests can exist sustainably in a wide range of conditions on a particular site, thereby offering many possible forest values. Another key message is that nothing is permanent in nature because any condition (social, cultural, economic, ecological and political) can change the sustainability for the wide variety of values and environmental services that we expect from forests. Unfortunately for Kenyan forestry, there has been a reverse in this traditional evolution of the forestry profession from the ultimate social forestry back to ecological, administrative or even exploitative forestry in some instances. The question therefore is: when did the rain start beating us? Why are we returning from socially acceptable, ecologically-based forestry to administrative and exploitative forestry with all the probability to deplete our resources? Why is Kenyan forestry being redirected back to the era of unsustainable exploitation or non-ecological administrative forestry? Who is responsible for these changes? Why have forestry institutions and professionals not done anything about these changes? In view of these concerns, the major issues of concern are elaborated below.

6.2. Mismatch in Stakeholder Expectations

The major stakeholders in the forestry sector in Kenya are the society (local, national and global communities), institutions of forest governance (government and its relevant agencies involved in forest regulation, research and education), civil society, and individual professional foresters who are expected to give technical guidance. From the discussion in previous sections, it is clear that there is significant conflict between societal expectations from forests on one hand and forestry institutions and professionals on the other hand, and that this conflict is largely responsible for forest degradation in Kenya. Two factors can be considered responsible for the major changes we observe today. First, is the issue of increasing population and its expectation of forest values and services from forest resources. Secondly, is the issue of changes in the quantity, quality and variety of values that society desires from forests over the years. Whereas of section of society is increasingly perceiving the forest values in terms of soil and water conservation, aesthetics and

recreation, biodiversity, and other cultural and religious values that many indigenous communities living within forests have treasured from time immemorial, others see emphasize the productive aspects of forests in terms of timber. Yet others view the forests as wasted land that should be converted to settlement and agricultural production. This last category of society has been the worst in terms of forest degradation because it is composed of powerful individuals with selfish interests.

Apparently, demands made by these groups on forests has surpassed the experience and knowledge of the present forestry institutions and professionals who are only willing to accept those changes that are supported by empirical evidence or science-based knowledge, which require long periods of time to accumulate. In the case of Kenya, whereas society is increasingly putting demands on forests, forestry institutions are not willing to act without empirical evidence. These conflicts can be described as a double-edged sword, whereby society gets dissatisfied because forestry as an institution has been unable to adjust to keep pace with societal needs. Foresters as professionals have also been unable to respond because of either a lack of the will to effect change (and have become part of the problem), lack knowledge and experience (because of inadequate training due to poor curriculum), lack of skills in problem analysis (because of practical exposure), and inadequate scientific foundations to support change.

The assertion in this chapter is that the future of Kenya‟s forestry lies on two basic responsibilities of forestry institutions and professionals: (i) to change the way in which forest landscapes are managed as the balance of desired values and environmental services from those landscapes change, and (ii) to reject practices that are inconsistent with the ecology and sociology of the desired values and services from forests. As the rate of change in society‟s expectations from forests and environmental services has increased, forestry as an institution (e.g., government laws, regulations, and policies) and professionals have often been either unable or unwilling to adjust to keep pace. This is what lead to the almost collapse of professional forestry in the country during the 1990s when forest governance in the country was a turf war between civil society and the political elite, a major conflict that disappointed professionals across the country. Nevertheless, it opened an opportunity for the reforms currently experienced in the sector.

6.3. Inadequate Concepts of Forest Values

Another issue of great concern is the apparent misunderstanding of what the philosophy of forestry is all about among the various stakeholders in Kenya i.e. what it is and what we want from it as a society. To achieve this, the Kenyan society must first recognize impacts of past actions, appreciate the current status, and then decide where we want to be in the future. In other words, we must define what kind of forestry we desire in the future before developing a set of management principles and objectives with both ecological and social/cultural dimensions of the forest areas in question. Previous discussion seems to suggests that this analysis has seldom been considered the competing stakeholders, and most decisions seem to be guarded by partisan section of the society. For example, concept of forest value lost meaning when the government, which is the custodian of all forests, decided to allocate public forest to powerful individuals for political reasons in late 1980s and the 1990s. On the other hand, the opposition of civil society to the establishment of exotic forest plantations for timber production simply because of obsession with biodiversity conservation without any regard to socio-economic development has been unsettling. Also, the rigid and slow response by the forestry institution and professionals to these challenges has been disappointing. These institutions have never resolutely demonstrated to society the true value of various forests in the country, their uniqueness and means for sustainable management.

In other words, until society gets to know what is being managed and for what purpose, the people would not be able to understand what the future forests are potentially able to be both bio-physically and socially. There must be an explicit recognition of the ecology and sociology of the ecosystem conditions that are both bio-physically possible and socially desirable for each specific forest area in question both qualitatively (value-based founded on emotions and beliefs) as well as quantitative (analytical, empirical, science-based).

7. WHERE DO WE GO FROM HERE?

Simply put, the country has been going nowhere between the late 1980s and most of the 1990s when all known paradigms of forest management were disregarded, and forestry related activates were basically similar to pre-forestry time. Fortunately with the enactment of the Forest Act 2005 and

passing of the new Constitution in 2010, there is hope that forestry institutions and professionals, society, civil society and politicians have agreed on common strategies after extensive consultations. . Key to all these is the need to clarify what forestry is all about, its philosophy, core goals and societal expectations and values from forestry related activities. Other issues that need clarification include professionalism and ethics, policy and decision making, and the role of various strategic actors especially the government who is still the custodian of all forest resources and their utilization in the country. In this section, these roles are elaborated within the context of declining Kenyan forestry and the need to reverse past trends.

a) Objectives of forestry should be people-centered: forestry is primarily about the mutual interactions between trees and humans, their needs and desires, and not fundamentally about bio-physical issues such as biodiversity and specific ecological conditions, even though these are understood to be important but of secondary concern, unless they have direct effect on humans. This illustrates why the Kenyan society must also understand that these social values cannot be sustained unless forestry is based on respect for ecosystem functioning, which must, therefore, be the foundation of forestry. Thus, forest managers must develop desired forest future scenarios for each forest landscape over ecologically meaningful time scales. For example, what the Ogiek community considers their primary value of the Mau forest is quite different from what the Kaya indigenous community at coast views of the Kaya forests, or the commercial timber merchant in exotic plantations. Each of these stakeholders have priority value that they expect from the forests they are associated with, and therefore are expecting some future forest they wish to develop. Without such clearly desired forest futures, there is little basis for judging the goodness or otherwise of forestry.
b) Another important issue is to clarify that the practice of forestry must produce the forest values as demanded by society. Forest practices must respect the ecology, economics and sociology of desired forest values. “Politically correct” and “flavor of the time” concepts about forests and forestry must not be allowed to overwhelm common sense, experience, and available science-based knowledge. We must not allow ideology and fundamentalism to take over forestry. This is one area that Kenya‟s forestry has perhaps suffered greatest setback over

the last two decades. The forest excisions, banning of shamba system and banning of forest harvesting from uninformed viewpoints by policy makers has had devastating effects on sustainable forest management to this day date. Though there have been some consultative policy and legislative initiatives, the full impacts of the intended objectives will take some time to be realized. No data is available so far.

c) There has been great and valid concern from society that forestry institutions and professionals as defined above have generally been part of the root causes of forest degradation in the country because of unprofessional conduct. Though most of these practitioners have undergone formal training in forestry and natural resources management, there is the perception that they must recognize professionalism by fulfilling their two basic responsibilities: to challenge and change inappropriate forest practices, and resist socially and ecologically inappropriate pressure from interest groups (environmental, political or otherwise). It requires foresters to consider the ethics of their profession, and to wrestle with the complex question of what good forestry is all about. Unfortunately, forestry professionals in Kenya were for most of the last three to four decades considered some of the most corrupt government officials. For a long time, the public has perceived them as to have been the major cause of forest degradation in country, a perception that is waning in the coming of the current reforms in the forest sector following enactment of Forest Act 2005, and the Constitution of Kenya 2010.

d) Although forestry in Kenya has undergone several evolutionary phases characteristic of development in forest management, there is no doubt that sustainable forest management in Kenya will depend on encompassing a mixture of several forest management paradigms, which should be adopted since each of these paradigms (especially in relation to forest ecosystem management, administrative forestry, and zonation,) have merits and demerits that are justifiable in the Kenyan context. Forest managers should examine ways of encouraging those combinations that will achieve economically the most desired forest values in the future for specific forest areas.

CONCLUSION

Kenya has a wide diversity and richness of forest ecosystem biodiversity ranging from the mountain forests, vegetation formation typical of climax tropical forests to grassland and coastal plains. These ecosystems are under severe threat from human disturbance associated mainly with increasing human pressure and possibly climate change. Unfortunately, attempts by the pre- and post-independence governments to exclude forest adjacent communities in forest management activities have not been successful. In contrast, policies that incorporated these communities have resulted in sustainable management of plantation forests, which in effect have also enhanced management of natural forests that have greater biodiversity and conservation objectives.

In addressing the issues raised above, the most fundamental question is whether there is a right way to manage Kenya‟s forests. As argued previously, sustainability is a function of many factors depending on our understanding of their history, current status, and ecological, economic, social and cultural characteristics of the forest. It is also dependant on the current and future needs of our societies, societal perception of the values and environmental services to be derived; how quickly society would want to change from the present forest conditions to the desired future condition, and the ecological and social consequences of different speeds of change. Political influences also play a significant role because of vested selfish interests. Consequently, different forests should be managed differently depending on the balance among different values we desire from them.

From these observations, Kenya‟s forest ecosystems can only exist and be sustained under a variety of biotic conditions. However, society must recognize that every forest is unique and with ultimate limits on what it can produce. As we move from the present into the future we must wrestle with the ethical dilemma of how to balance our personal emotional and aesthetic preferences with respect to forests against the needs and desires that we think others besides us and future generations will have? It would be equally unethical to replace our present indulgence by an indulgence of our present aesthetic, biodiversity or other preferences where our present knowledge suggests that this is inconsistent with the values we wish to pass on to the next generation. This requires professionally accumulated knowledge and experience.

Here is where forestry institutions and professionals should provide leadership to guide the current changes in forest management with a clear

statement that recognizes the ecology, economics, sociology and politics of forestry that we desire in the future, which is a key pillar of sustainable socio-economic development and poverty eradication as envisioned in Kenya Vision 2030[11]. This vision focuses on transforming Kenya into a medium income country by 2030 by prioritizing environmental quality and security (including forests) as the major driver of social and economic development. This has been acknowledged in the current national Constitution of Kenya 201012, which has further emphasized that the environment is a heritage that must be conserved and managed for the present and future generations. This can be accelerated by promoting access to and use of information, innovation and technologies, and improved forestry education at all levels, and promotion of alternative livelihoods and value addition to resources to reduce pressure on forest resources.

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Chapter 2

FISH-RESTOCKING OF LAKES IN KENYA: SHOULD SOLEMNLY BE AN ENVIRONMENTAL ISSUE

Aura Mulanda Christopher[1,2,*], Safina Musa[3], Murithi Njiru[5], Erick Ochieng Ogello[3,4] and Rodrick Kundu[6]

[1]Kenya Marine and Fisheries Research Institute, Mombasa, Kenya
[2]Laboratory of Marine Bioresource and Environment Sensing, Hokkaido University, Minato-cho, Hakodate, Hokkaido, Japan
[3]Kegati Aquaculture Research Station, Kenya Marine and Fisheries Research Institute, Kisii, Kenya
[4]Laboratory of Aquaculture and Artemia Reference Center (ARC), Ghent University, Gent, Belgium
[5]Chepkoilel University College, Moi University, Eldoret, Kenya
[6]Lake Victoria Environmental Management Project-Phase II, Kisumu, Kenya

[*] Correspondence: E-mail: auramulanda@yahoo.com and/or caura@kmfri.co.ke, +8180 3262 7822; +254721897555/+254738148401

ABSTRACT

The self-described "social-ecologist", Peter Drucker, said that what gets measured gets managed; a statement that could have welcomed political and social concepts into environmental matters. A case in point is the fish restocking (a type of fish biomanipulation) in many lakes in the world and with special reference in the tropics. However, due to the increased anthropogenic impacts and eutrophication of the aquatic ecosystem in the tropics (and in particular Kenya) is becoming increasingly apparent; the need for proper management strategies for a sustainable fishery is becoming non-negotiable. Under such a perspective, fish biomanipulation that was coined by Shapiro (1975) could be a self proclamation that the road from basic science to its application could be winding and the process laborious. Despite some positive results of fish biomanipulation in the temperate regions, this management approach seems to elicit ecological debate at political, environmental and social fora since its successes seems to be of short-term need. This paper reviews the fish biomanipulation process and principles, the successes and limitations; thereby highlighting on the need for defining theoretical explanations and their practical implications in the present scientific world. This is because details of the process have to be verified in the light of frequent future applications rather than on political and social undertones that damage the ecological wellbeing.

Keywords: lakes, biomanipulation, political, social, ecological, management, Kenya

INTRODUCTION

Biomanipulation is a technique used to restore water quality in eutrophied lakes (Benndorf et al., 2002; Perrow et al., 2002)). Eutrophication is the accumulation of nutrients, particularly phosphorous, in aquatic systems. The process does occur naturally in all water bodies but human activities accelerate the process. Intense nutrient influxes into lakes cause dramatic changes to lake dynamics. Planktivores become abundant and reduce zooplankton (Mehner et al., 2002). Larger sized zooplankton species are diminished leading to dominance by smaller sized species. The ratio of planktivores to piscivores widens, reducing the ability of piscivores to control planktivore populations. Planktivores also recycle phosphorous in lakes through excretion that directly influences algae production (Mehner et al., 2002). High concentrations of

phosphorous through external and internal nutrient loading promote algal blooms. Blooms harbour toxins that cause zooplankton and fish death, macrophyte decline, and a decrease in dissolved oxygen when they decay or die. Biomanipulation seeks to control blooms by increasing zooplankton populations to promote heavy grazing of algae (Benndorff et al., 2002). Majority of effort in rehabilitating eutrophication in lakes has been aimed at eliminating nutrient fluxes (Jeppesen et al., 2005). One of the better ways to reverse eutrophication is to reverse activities leading to increase in nutrients flux into the lake especially phosphorous (Benndorff et al., 2002). The method has great success especially with point source pollution, but it is expensive and enriched sediments may act as source rather than sink for phosphorus. With increased number of eutrophied lakes in the world, an alternative less expensive method of controlling eutrophication should be adopted. Little attention has been given to the possibility of restructuring the biological communities of the lakes as a direct approach to combating eutrophication. Benndorf et al (2002) argued that biomanipulation a relatively new technique may be an option to rehabilitation of eutrophied lakes. The concept was formally defined by Shapiro in 1975 (in Benndorff et al., 2002). He explained that Shapiro desired an alternative approach to lake restoration that relied less upon chemicals and engineering. Biomanipulation concept is not entirely new in lakes restorations. Caird in 1940 (in Benndorff et al., 2002) described a situation that occurred in a Connecticut pond; the pond suffered immense algal blooms and required copper sulfate treatments several times per year. The introduction of large-mouth bass into the lake eliminated the need for copper sulfate treatments and further observed the changes in the pond, but it is unclear if he fully understood how the large-mouth bass controlled the algae blooms. Perrow et al (2002) argued that biomanipulation is typically used in lakes that are small, shallow, and closed systems. He affirmed that biomanipulation tends to work well in shallow lakes since organisms are not spatially separated by depth. Also, nutrient levels are more static since losses to the hypolimnion are unlikely and believed that lakes need to be closed systems because organisms entering a lake through connections with other water bodies will inhibit the ability to control lake‟s fauna.

EUTROPHICATION OF KENYAN LAKES

Eutrophication of freshwater lakes through the enrichment of water by nutrients (mainly phosphorus and nitrogen), is an increasing problem

threatening lakes in Kenya (Mugidde et al., 2005; Kitaka et al., 2002). Lakes in Kenya suffer from point and nonpoint sources, with municipal sewerage and agriculture being the main source of anthropogenic phosphorus and nitrogen (Mugidde et al., 2005; Kitaka et al., 2002). The point source pollution in Kenya unlike most temperate regions has not yet been controlled (Kitaka et al., 2002; Mugidde et al., 2005). Factories and municipals continue to deposit their effluents into the lake unabated. The consequences of eutrophication are both environmental and socio-economical (Mugidde et al., 2005). This has resulted in major changes in the biological structure and dynamics of the lakes and often in a shift from a clear to a turbid state. Enrichment of the water has led to massive blooms of algae especially of the toxic blue-greens (Lung'ayia et al., 2000; Kitaka et al., 2002; Mugidde et al., 2005).

Ballot et al. (2009) pointed out that the proliferation of the blue-green algae in Lake Naivasha is an indication of eutrophic condition of the lake. Due to continued nutrient enrichment, Lake Naivasha has changed from eutrophic to hyper-trophic (Kitaka et al., 2002). In Lake Victoria, the primary productivity has doubled and the algal biomass has increased 8–10-fold, accompanied by a shift in the algal species composition (Lung'ayia et al., 2000). The chlorophyll-*a* concentration varies between 2 and 13 mg m^{-3} in the main lake and between 8.8 and 71 mg m^{-3} in the inshore waters (Lung'ayia et al., 2000), compared to 1.2–5.5 mg m^{-3} and 30 mg m^{-3} in the same waters in 1960 and 1961, respectively (Talling, 1966). The increase in chlorophyll-*a* concentrations and the higher abundance of the buoyant cyanobacteria have resulted in decreased water transparency. The average transparency values (expressed as Secchi depth) have decreased from 7.3–7.9 m for offshore stations and 1.3–1.45 m in Nyanza Gulf in 1927 (Worthington, 1930) to 1.1–1.38 m and 0.58–1.68 m in the same areas, respectively, during 1994–1995 (Lung'ayia et al., 2000).

Massive blooms of algae, especially the toxic blue-greens, are now a common occurrence in the Kenyan lakes. In lakes Victoria and Naivasha, anoxic water attributed to the use of oxygen by decaying flora is attributed to occasional fish kills (Ochumba, 1990). Increases in hypoxia might reflect a combination of increased nutrient levels and losses of phytoplaktivorous/detritivorous haplochromine cichlids (Lung'ayia et al., 2000; Kitaka et al., 2000; Ballot et al., 2009). Continued eutrophication and dominance by toxic cyanobacterial blooms may further lead to decline in aquatic communities including zooplanktons. It is estimated that about 30–50% of the oxygenated waters volume has been lost in Lake Victoria since the 1960s, which has reduced the fish habitat (Mugidde et al., 2005).

Tropical lake communities are dominated by zooplanktivorous fish communities such as cyprinids which increase with increase in abundant with increasing eutrophication, leading to a decrease in biodiversity (Jeppesen et al., 2005). Increase in cyprinids abundance not only further enhances the eutrophication of lakes by increased planktivory and recycling of nutrients from the sediments, but also decreases the resource value of the lake. Lake Victoria is now dominated by a pelagic cyprinid, *R. argentea* (Njiru et al., 2008; 2010).

ZOOPLANKTON COMMUNITY STRUCTURE

Most likely due to high predation by fish, the zooplankton communities in tropical and subtropical lakes are frequently dominated by small cladocerans (like *Diaphanosoma, Ceriodaphnia* and *Bosmina*), rotifers, juveniles and small copepodites among the copepods (Branco et al., 2002; Garcia et al., 2002).

Zooplankton communities in Kenyan lakes are dominated by small cyclopoid, cladocerans and rotifers (Mergeay et al., 2004; Mwebaza-Ndawula et al., 2005; Masai and Omondi, 2005). In Lake Victoria for example, copepods consist mainly of *Thermocyclops, Mesocyclops* and *Thermodiaptomus,* cladoecera comprise of *Diaphanasoma, Daphnia and Ceriodaphnia.* There has been a decline in large-bodied cladocera such as daphnids associated with increase fish predation which coincides with changes in fish compositions in the lake. There is noticeable seasonal zooplankton abundance in Lake Victoria, related to peaks and predation impacts of planktivorous fishes including *R. argentea* and juvenile fishes (Mwebaza-Ndawula et al., 2005). Low zooplankton densities coincide with high stocks of larval *R. argentea* during the month of July while in the deep offshore waters where pelagic densities are low, high zooplankton abundance occur (Mwebaza-Ndawula et al., 2005). Large bodied daphnia such as *Daphnia lumholtzi* is confined to the deep offshore waters where planktivorous fish densities are low (Mwebaza-Ndawula et al., 2005).

Lake Naivasha is devoid of specialised zooplanktivorous fish, and is therefore considered to have an incomplete aquatic food web (Mavuti, 1990; Hickley et al., 2002). The fish species introduced to Lake Naivasha are thought to have little impact on the large zooplankton (Mavuti, 1990) because of their mainly herbivorous, omnivorous or piscivorous diets. This view on the food web of Lake Naivasha contrasts with the long-term perspective offered by Mergeay et al. (2004), which suggested a significant influence of fish

predation on Daphnia community history in the lake. The juveniles, of these fishes are zooplanktivorous. For example, *Daphnia magna* was common in Lake Naivasha throughout the 19th and early 20th centuries, but disappeared (or was decimated beyond detection) within a few years after introduction of largemouth bass and cichlid fishes in the late 1920s. Because of its large size (2–5 mm), *D. magna* is especially prone to visual predation by fish. Whether fish stocking was the principal reason for the population collapse of *D. magna* in Lake Naivasha is uncertain, but it probably accelerated the process.

Mergeay et al. (2004) argued that both turbidity and macrophytes provide a refuge for Daphnia against fish predation, because of decreased visibility. Turbidity can also impact Daphnia negatively because of obstruction of the filter apparatus and the resulting decrease in feeding efficiency.

The recent reappearance of large-bodied Daphnia species (*D. magna, D. barbata, D. lumholtzi, Daphnia* sp. nov. type Limuru) after 20–110 years of absence can be explained by their release from fish predation, following a dramatic increase in turbidity caused by excess clastic sediment input from eroded catchment soils (Mergeay et al., 2004). The small-bodied species *D. laevis* has fared less well recently, presumably because the benefit of lowered predation pressure is counteracted by more pronounced negative effects of increased turbidity on this species and loss of submerged macrophyte beds which formerly served as predation refuge.

FISH BIOMANIPULATION APPROACHES

Radke et al (2002) noted that the premise behind biomanipulation is the manipulation of biotic components of a lake as opposed to conventional nutrient management. They added that the goal of water quality improvement is achieved through the manipulation of higher level consumers of a lake. They suggested two general biomanipulation approaches used to increase zooplankton populations: One method to increase zooplankton populations is to remove planktivores through a fish kill or removal. Rotenone, a powdered form of derris root in 5% formulation, is an effective piscicide used to restructure or eliminate certain fish communities.

Radke et al (2002) described that all fish are susceptible to its impacts but planktivores and benthivores are the main target. A dose of 1.0 mg 1^{-1} will achieve a complete fish kill. They noted that the dose can be altered to fit the level of fish kill desired. They cautioned that Rotenone application is mostly effective in warm weather (optimal water temperature of 20°C or above), but it

remains toxic in the lake for long periods of time in cold weather. However, they believed that fish removal can be accomplished through intense seining. Benndorff et al (2002) pointed out that Rotenone may produce undesirable side effects in the ecosystem and may affect untargeted fauna. This means that zooplanktons are killed and may not rebound for several months, causing a decrease in algae grazing rates. Benndorff et al (2002) believed that application prior to spawning of desired species will enhance the success of Rotenone use. For example, Rotenone should be applied in spring prior to large-mouth bass spawning. On the other hand, they argued that seining activities produce little success. Benndorff et al (2002) implied that seining may only be performed in shallow lakes with smooth bottoms. But, most lakes do not have smooth bottoms which lead to partial harvesting and tearing of the net. The technique is also costly since it is labor intensive.

Radke et al (2002) suggested the second method to increase zooplankton to be the direct stocking of faunal components of a lake. Piscivore stocking increases predation of planktivores. A decrease of planktivores leads to reduced predation of zooplankton and an increase in large filter-feeding zooplankton which exert a higher grazing pressure on phytoplankton. Larger zooplanktons are able to consume a wider range of algae types compared to smaller zooplankton (Starling et al., 2002). Reduction in algae and the resultant decline in nutrients improve water transparency and may allow growth of submerged vegetation. The vegetation further acts as filter of nutrients entering the lake and increase water quality. The macrophytes may also act as refuges for zooplankton increasing their populations (Helminen et al. 2002).

In their study, Meijer et al. (1999) found that when more than 25% of the lake surface is covered with submerged macrophytes the algal biomass is repressed by the macrophytes and water clarity increased. Nonetheless, the species composition of the macrophytes community may be important. Van Donk and Gulati (1995) found *Chara* can keep the water clear for a long period during the year, but *Potamogeton berchtoldii* may die off early in the summer increasing water turbidity. However, in practice it is difficult to unravel the specific mechanisms involved in clearing the water, since several processes occur simultaneously, and data-sets are frequently not detailed enough to sort between the alternative hypotheses (Meijer et al., 1999).

The desired fish composition is 30-40% piscivores which corresponds to a biomass ratio of 0.28 to 0.66 piscivores to planktivores. The average stocking rates of zooplankton are 4 million individuals (Benndorff et al., 2002).

Helminen et al (2002) noted that the success of piscivore stocking is limited. When used as the sole technique, stocking does not appear to provide long term effectiveness. One problem is the inability to stock the number of fish required to control abundant planktivore populations. Another problem to be related to is the nonexistence of spawning grounds and habitat requirements of piscivores in eutrophied lakes. Hence the way to increase the success of stocking is to perform a fish kill or removal prior to stocking to decrease planktivores.

BIOMANIPULATION IN KENYAN LAKES

Though extreme inputs of nutrients can nowadays be reduced and controlled, additional measures to reverse eutrophication may be needed. According to Mehner et al. (2002), biomanipulation is a widely accepted and frequently applied ecotechnology to improve the environmental and ecological quality of standing waters. These often involve biomanipulation, typically mass removal of zooplanktivorous fish- like the cyprinids. However, the success of biomanipulation has many times been limited or short lived mostly because the more subtle impacts of biomanipulation on the ecosystem-wide processes of lakes have not been thoroughly studied (Syväranta, 2008).

Introductions of fish species into an aquatic system is a type of "fish biomanipulation." A case in point is lakes Victoria and Naivasha in Kenya (Figure 1). In Lake Victoria, Nile perch, *Lates niloticus* (L), *Oreochromis niloticus* (L), *Oreochromis leucostictus* (Trewavas), *Tilapia zillii* (Gervais) and *Tilapia rendalli* (Boulenger) were introduced into the lake in 1950s and 1960s (Welcomme, 1967; Ogutu-Ohwayo, 1990). In Lake Naivasha, introduced species were largemouth bass, *Micropterus salmoides* Lacépède, blue spotted tilapia, *Oreochromis leucostictus* (Trewavas), Redbelly tilapia, *Tilapia zillii* (Gervais), common carp, *Cyprinus carpio* Linnaeus , straightfin barb, *Barbus paludinosus Peters, guppy*, *Poecelia reticulata* Peters and a crustacean, red-swamp crayfish, *Procambrus clarkii* (Girard) (Ojuok et al., 2008; Kundu et al., 2010).

Lakes Victoria and Naivasha scenarios offer the need to look at limitations and the successes of fish biomanipulation in the tropics and Kenya in particular.

Fish restocking is mainly done to improve production and conditions of the lakes based on decisions agreed upon by the social, environmental and

political spheres without considering the ecological consequences of such habitats. In Lake Naivasha, fish were introduced for commercial purpose and to fill vacant niches left by the extinction of endemic species (Britton et al., 2007; Ojuok et al., 2008).

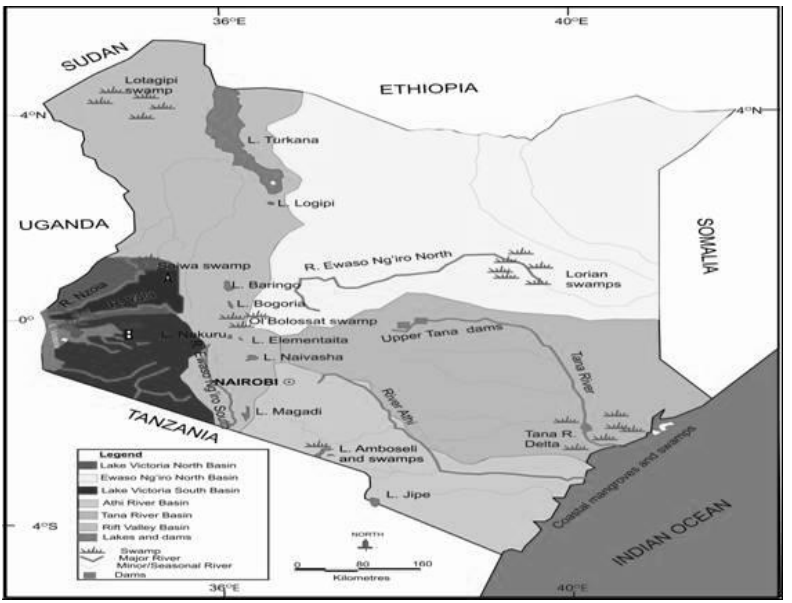

Figure 1. The location of Lakes Victoria and Naivasha in relation to other Kenyan lakes. Lake Victoria is the largest and borders Kenya, Uganda and Tanzania. Lake Naivasha is one of the Rift Valley lakes, near L. Elementaita.

Crayfish and common carp have greatly influenced the lake‟s water quality due to their feeding habits (Smart et al., 2002). Crayfish feeds on the macrophytes, while feeding behaviour of common carp stirs sediments and uproots macrophytes (Smart et al., 2002)

Nile perch introduced into Lake Victoria was mainly to convert the small bony but abundant haplochromines to suitable table fish (Ogutu-Ohwayo, 1990). The exotic tilapias were introduced to compensate for the decreasing catches of native tilapiines of *Oreochromis variabilis* and *O. esculentus rendalli* (Boulenger) (Welcomme, 1967). Introduction of Nile perch contributed to the decline of haplochromines biomass from >80% during the 1970s to <1% by the late 1980s, whereas the other native species were occasionally recorded in fish landings (Ogutu-Ohwayo, 1990; Njiru et al., 2010). Nile perch fed mainly on haplochromines (Witte et al., 2007).

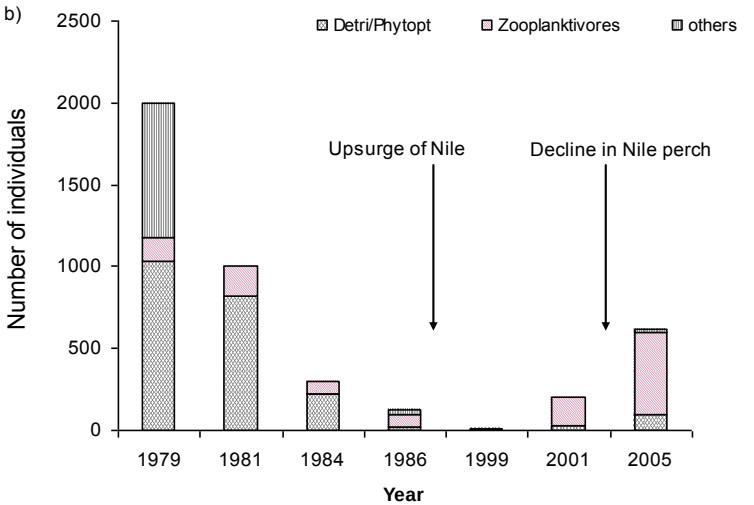

Figure 2. Trends in haplochromines catches in Lake Victoria, a) in overall bottom trawl catches. others = *Synodontis* spp, *Brycinus spp, Bagrus docmak,* b) trophic groups in Mwanza Gulf, Detri/Phytopt = detritivores/phytoplanktivores. others = trophic groupings (piscivores, insectivores). Source: Witte et al (2007).

The predation almost eliminated the detritivorous and phytoplanktivours haplochromines (Figure 2), with severe consequences on water quality. The native tilapias of *O. variabilis* and *O. variabilis* which fed on phytoplankton were also out competed by the more diversified feeder, *O. niloticus* (Welcomme, 1967; Njiru et al., 2010). Nile tilapia diet consists of a variety of food items including algae, fish and detritus (Njiru et al., 2004). The algal composition in the lake has also changed towards toxic and unpalatable cyanobacteria (Lung‟ayia et al., 2000).

LESSONS FROM TEMPERATE LAKES

Several lakes respond rapidly and positively to loading reductions; nuisance algal blooming and planktibenthivorous fish abundance decrease, while the percentage of piscivores increases as do water clarity and submerged macrophyte abundance. A study of 14 recovering lakes in Denmark (Jeppesen et al., 2005) showed that the phytoplankton and fish biomass generally declined, leading to an overall higher zooplankton:phytoplankton ratio, which

suggests that enhanced grazing pressure on phytoplankton results in clearer water.

Moreover, the biomass of planktivorous fish declined and the share of potential piscivores increased, most likely resulting in a stronger control by piscivores of planktivores. Accordingly, in most lakes the share of the large-bodied zooplankton *Daphnia* spp., which is particularly sensitive to predation by zooplanktivorous fish, and the body weight of *Daphnia* spp. and other cladocerans generally increased, further enhancing the grazer control of phytoplankton.

The improvements in lake water clarity are therefore a result of higher resource control of phytoplankton (lower availability of nutrients) as well as of enhanced predator control of planktivorous fish, cascading to the phytoplankton level via increased grazer control by large-bodied zooplankton. Several other lakes have exhibited a fast response to nutrient loading reduction (Perrow et al., 2002). However, positive effects cannot always be expected to occur, many lakes have proven to be highly resistant to loading reductions and have shown only little improvement (Jeppesen et al., 2005). For some lakes this reflects insufficient reduction of the nutrient input to trigger a shift to the clear water state. For example, significant and sustaining changes in the biological community and water transparency of shallow temperate freshwater lakes cannot be expected to appear unless the TP concentration has been reduced to a level below 0.05-0.1 mg P l^{-1} (Jeppesen et al., 2005), or for deep lakes below 0.02-0.03 mg P l^{-1} (Jeppesen et al., 2005). Even when the P loading has been sufficiently reduced, resistance to improvement is often observed. This resistance may be "chemical": P concentrations remain high because of P release from the sediment pool accumulated when loading was high (Jeppesen et al., 2005). Many years may pass before the surplus pool is released or permanently buried. The duration of this transitional period depends on, for instance, the duration of the period with high TP loading, the residence time and the phosphorus binding sites (like iron) supplied from the surroundings. In some cases this transient phase towards a new equilibrium has spanned several decades (Jeppesen et al., 2005).

Various methods have been used to reduce the internal loading of phosphorus (Jeppesen et al., 2005), including sediment removal and chemical treatment of the sediment with aluminum or iron salts. In stratified lakes also injections with oxygen or nitrate to the bottom layer or destabilization of the thermocline have been used. The resistance may also be "biological". In particular planktivorous and benthivorous fish contribute to biological resistance in shallow eutrophic lakes (Perrow et al., 2002). A continuously

high fish predation pressure prevents both the appearance of large herbivorous zooplanktons that would otherwise clear the water as well as diminishes the number of benthic animals stabilizing and oxidizing the sediment. Moreover, excretion of nutrients to overlaying waters from benthic-feeding fish or fish bioturbation of surface sediment may also play a role (Perrow et al., 2002).

To overcome the biological resistance by fish, various fish manipulation methods have been developed (Benndorf et al., 2002). One such method is the enhancement of top-down control of phytoplankton by selective removal of planktivorous fish; a method employed world-wide in the temperate zone. Removal of 75-80 % of the planktivorous and benthivorous fishstock during a 1-2 year period is recommended to avoid regrowth and to stimulate the growth of potentially piscivorous perch (Perrow et al., 2002; Meijer et al., 1999). An alternative or supplementary method to fish removal is ample stocking of 0+ pike (>1000 ha-1) to control newly hatched plankti-benthivorous roach and bream (Perrow et al., 2002). Others have used stocking of pikeperch (*Stizostedion lucioperca*), walleye (*Stizostedion vitreum*) and largemouth bass (*Micropterus salmoides*) (Benndorf et al., 2002). Opposite to the above-mentioned physico-chemical methods, fish manipulation is often cheap (Jeppesen et al., 2005) and therefore attractive, though its long-term stability is uncertain. The findings to date indicate that fish manipulation may have a long-term effect in shallow temperate lakes provided that the nutrient loading is reduced to a TP level below 0.05-0.1 mg P l^{-1} in the future state of equilibrium. However, if the nitrogen loading is low, fish manipulation may sometimes have a positive impact at higher TP concentrations (Jeppesen et al., 2005). The 0.05-0.1 mg P l^{-1} threshold is in accordance with the empirical data appearing in this range. However, temporary effects of fish manipulation can be obtained in lakes with high nutrient concentrations, but it seems unlikely that the effect will prevail in such lakes in the long term unless the abundance of planktivorous fish is repeatedly reduced. The TP threshold for positive effects to occur is most likely lower for deep lakes, but an accurate threshold has to be defined.

LIMITATIONS

Several factors indicate that fish stock manipulations would not have the same positive effect on the environmental state in tropical lakes as in temperate lakes. The fish stock in tropical lakes is often dominated by omnivorous species that feed on zooplankton but also consume phytoplankton,

periphyton, benthic invertebrates, and detritus. (Branco et al., 2000). Few piscivorous species are present and omnivorous fish generally dominate independently of trophic state. For example, Lake Victoria is dominated by *R. argentea*, feeding mainly on zooplanktons and several hundreds omnivorous cichlids occur. Lake Naivasha is dominated by omnivorous *C. carpio* which uproots macrophytes while feeding and *P. clarkii* which feeds on macrophytes (Ojuok et al., 2008).

In Lake Victoria, freshwater shrimps, *Caradina nilotica* (Roux) has increased tremendously in the last few decades (Mwebaza-Ndawula et al., 2005). The increase in low-oxygen tolerant *C. nilotica* indicate deterioration of the water quality and changes in food-web dynamics (Muggide et al., 2005). Increase in *C. nilotica* could prevent large herbivorous zooplankton from developing and this could partly explain the success of rotifers, and the high density of copepod nauplii in the lake (Mwebaza-Ndawula et al., 2005). Branco et al. (2000) observed similar changes in zooplankton composition in a coastal lagoon in Brazil. This predation pressure on zooplankton by invertebrates may represent a further limitation of the usefulness of biomanipulation in tropical and subtropical lakes.

In the temperate lakes, commercial and recreational fisheries target piscivores thus it possible to control their fishing to enhance their predation on zooplanktivorous fish. Fish species richness is often higher in tropical and subtropical lakes than the temperate ones. Lake Victoria has over 300 cichlid fish species and over 20 non cichlids (Njiru et al., 2008). The artisanal fishing in the tropics which targets the multi-species fishery instead of a few species renders biomanipulation difficult.

Fish reproduction, which in temperate freshwater lakes takes place once a year, occurs throughout the year in many subtropical and tropical lakes (Lowe-McConnell, 1991). As small fishes are more zooplanktivorous and have a much higher energy demand per unit of biomass than large fish (Kalff, 2002), the dominance of small fish in such high abundances leads to a higher predation pressure on zooplankton than in temperate lakes, where the effect of juvenile fish is typically strong mainly in mid-late summer (Jeppesen et al., 2005).

In addition, because recent biomanipulations have failed to prove that the simple fish–zooplankton–algae food chain is the only process involved in biomanipulation, the exclusive use of food-chain theory for explaining observed patterns has been drastically criticized: „„To some extent, the original idea of biomanipulation (increased zooplankton grazing rate as a tool for controlling nuisance algae) has become a burden"" (Mehner et al., 2002).

Removal of planktivorous fish or addition of piscivorous fish to a lake clearly affects lower trophic levels, but the effects may not necessarily be the ones predicted by the simple and appealing food-chain theory. The importance of other processes besides pure food-chain dynamics have been demonstrated mainly in shallow lakes since organisms are not spatially separated by depth (Mehner et al., 2002). Theoretical development has progressed in closer cooperation with lake managers than in the case of deeper lakes. Hence, the current issue of concern is to provide a useful guide for lake managers on applications, synthesis and connections between basic and applied research in fish biomanipulations, in relation to understanding the trophic cascade model (Benndorf et al., 2002).

Helminen et al. (2002) argued that the success of piscivore stocking is limited. When used as the sole technique, stocking does not appear to provide long term effectiveness; a case in point being the introduction of Nile perch in Lake Victoria in the 1960s (Njiru et al., 2008) and the fish introductions in Lake Naivasha (Litterick et al., 1979; Muchiri and Hickley, 1991; Britton et al., 2007). One problem is the inability to stock the number of fish required to control abundant planktivore populations. Helminen et al. (2002) gave another problem to be related to the nonexistence of spawning grounds and habitat requirements of piscivores in eutrophied lakes. He concludes that a way to increase the success of stocking is to perform a fish kill or removal prior to stocking to decrease planktivores; a phenomenon that still requires scientific verification since the underlying consequences could damage the environment ecologically.

According to Van de Bund and Van Donk (2001), the overall success of biomanipulation is debatable. They argue that some sources proclaim the approach as successful while others question its reliability (Welcomme, 2001). They believe that the relative young age of the concept makes it difficult to study long term effectiveness. They note that the experiments are typically less than five years and are not long enough in duration to determine dominant trends or causal relationships among the variables being manipulated. For example, they reaffirm that the loss of fish populations by a fish kill or removal will effectively increase macrophyte populations as well as zooplankton. Thus, through nutrient competition, abundant macrophyte populations are able to reduce algae growth. Therefore, they point out that the determination of whether phytoplankton is controlled by zooplankton or macrophytes is difficult to ascertain.

On the other hand, biomanipulation may produce positive results early in the study but may not five or ten years later. In a case study of Round Lake in

Minnesota, biomanipulation did produce the desired results for the first two years with improvement in each successive year but during the third year the lake began to digress to its previous denuded state (Mehner et al., 2002). Lastly, an argument is raised concerning zooplankton grazing rates of blue-green algae. Blue-green algae are a major problem in eutrophied lakes and it is questionable whether zooplanktons are able to use blue-green algae as a food source. Filtering of the algae may be impeded by its size and shape and may even clog the filtering apparatus of zooplankton (Mehner et al., 2002).

SUCCESSES

Nevertheless, biomanipulation was designed to be an alternative to nutrient management and may provide the long term effectiveness that nutrient management has failed to do in eutrophied lakes (Kalff, 2003). Nutrient management techniques ignore the biological interactions occurring in a lake which may be the primary cause of algae blooms and internal nutrient release (Mehner et al., 2002). Nutrient management approaches are ineffective in shallow lake environments due to internal nutrient loading and the impossibility to successfully reduce the external nutrient loads (Mehner et al., 2002). Phosphorous accumulates in sediments and is released through bioturbation, the churning of sediments by organisms, and during low oxygen levels (Kalff, 2003). Nutrient management techniques tend to work best in deep lake environments since nutrient loading is not a major factor (Mehner et al., 2002). Nutrient management techniques seek to control nutrient loading and nutrient levels.

Even though the arguments against biomanipulation are extensive, it is a relatively effective method of lake restoration in shallow lakes compared to nutrient management. Nutrient management techniques have to be repeatedly performed and are not final solutions to eutrophication problems in shallow lakes (Welcomme, 2001). Biomanipulation appears to produce desirable results in most instances. Unfortunately, the success in some cases is short term. Further research is necessary to enhance the stability of biomanipulation (Benndorff et al., 2002).

Starling et al. (2002) believes that a current restoration trend that may improve the reliability of biomanipulation is its integration with nutrient management. Hence, controlling nutrient levels along with food-web manipulation has the potential to create long lasting results because neither food-web interactions nor nutrients are the sole regulators of phytoplankton.

For example, controlling high phosphorous concentrations in shallow lakes will increase the success of piscivore stocking. He points out that in lakes with phosphorous levels above *ca.*100 g. p 1^{-1}, it is nearly impossible to alter piscivore rates. He affirms that a decrease in phosphorous levels through phosphorous inactivation or sediment removal prior to piscivore stocking will increase the survival of piscivores. Thus, combining the efforts of biomanipulation and nutrient management techniques may prove to be the future solution to eutrophication problems in shallow lakes in the tropics and in Kenya in particular.

WAY FORWARD IN KENYAN LAKES

Based on the differences in fish-zooplankton-macrophyte interactions in the tropics and in the temperate regions, it seems more difficult to provoke and not least maintain a trophic cascade effect in subtropical and tropical lakes than in temperate lakes, for which the concept of biomanipulation as a restoration tool was developed. Supporting this view, Nagdali and Gupta (2002) found positive, but only short-term cascading effects of a massive (>80%) kill (due to fungal infection) of the most abundant planktivorous mosquito fish (*Gambusia affinis*) in Lake Naini Tal, India. Zooplankton abundance increased significantly, phytoplankton biomass and productivity declined as did nutrient concentrations, resulting in higher water transparency. However, only 4 months later the abundance of mosquito fish, plankton and nutrients had returned to the level recorded in the previous year! In a study performed by Scasso et al. (2001), a slowly increasing abundance of larger species was observed after two years of biomanipulation involving removal of small planktivorous fish, without, however, inducing cascading effects leading to clear-water conditions.

Yet, only few studies have investigated the applicability of the biomanipulation theory to the tropical and subtropical freshwater ecosystems, and most of the existing ones have examined food interactions in eutrophic lakes and reservoirs with the aim to control cyanobacterial blooms via enhanced grazing by omnivorous fish such as silver carp (Starling et al., 2002). The results obtained indicate that omnivory and strong shifts in fish diet and in the fish and zooplankton composition jeopardize successful biomanipulation (Branco et al., 2000; Boulton and Brock, 2001), but more information on phytoplankton-zooplankton interactions in the tropics and in Kenya is needed before its potential can be fully elucidated. Moreover, the

absence of a native piscivorous fish culture in many tropical countries precludes the application of biomanipulation. There is a huge richness of fish species potentially useful for this purpose, but mass production for biomanipulation purposes has not yet been considered. Generally, aquaculture has so far focused on exotic species (i.e. common carp and grass carp) that have negative effects on water quality and biodiversity.

In many of the experiments undertaken in the temperate zone, an improvement in environmental state has, however, been recorded without the occurrence of a trophic cascade, i.e. without changes in the zooplankton species composition towards higher dominance of large-sized individuals and with it a higher grazing pressure on phytoplankton (Starling et al., 2002). Even without such a trophic cascade, a significant reduction has been observed in the occurrence of cyanobacteria, total phosphorus has declined and water clarity increased. These phenomena have been ascribed to reduced release of phosphorus from the sediment, not least due to the lower rate of fish foraging in the sediment following biomanipulation (Scasso et al., 2001). Biomanipulation may therefore potentially also reduce the nutrient release from the sediment in tropical lakes, but the dominance of small fish species and the improved growth conditions for cyanobacteria suggest that the effect might not be long-lasting. Therefore, a drastic reduction of the external nutrient loading seems to be the best way forward for restoring lakes also in the tropics, but clearly the scientific basis (e.g. nutrient threshold levels) on which to make decisions is yet too limited, suggesting the strong need for more research.

CONCLUSION

Generally, biomanipulation can be a very effective method for increasing the transparency of the water in a lake. Many biomanipulations have resulted in increased water transparency. However, basing on the above scientific piece of evidence, a generally better understanding of the complexity of lake food webs and the frequent application of biomanipulation as a lake restoration technique have emerged from the recent developments in biomanipulation research that solemnly make such work an environmental issue. As this type of research is not easily funded in most countries because of political and social conflicts, the results from public lake management programmes can help collect the necessary data. As it is today, many subtropical and tropical lakes such as those in Kenya are heavily eutrophied and biodiversity has declined,

and in the years to come it is to be feared that many other lakes in these regions will follow the same negative developmental pattern both as a consequence of the future economical development and climate change.

A point worth mentioning is that details have to be verified in the light of frequent future applications of fish biomanipulation in the tropics with examples being the Kenyan lakes. This could be because all relevant features may have not been adequately considered since not enough is known about the role of habitat heterogeneity (e.g. the ratio of littoral to pelagic habitats) or proportions of species in the fish community for long-term stability of manipulated systems (Mehner et al., 2002). Hence, a successful combination of biomanipulation and fisheries management could be based on four main steps that include: the definition of the main goals and a principal stakeholder analysis; an analysis of the nutrient situation (external load and internal concentration); planning and performing of the manipulation measures considering characteristics of the fish stock and management aspects (e.g. technical feasibility of mass removal, interests of fisheries, stocking measures, catch restrictions); and maintenance (adaptive management). If the respective targets and thresholds in fish biomass can be achieved in fish biomanipulation in the tropics and Kenya in particular, then improvements of water quality and satisfaction of fisheries stakeholders are very likely.

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Chapter 3

LIGHTNING: ONE OF KENYA'S MOST UNPREDICTABLE, UNDERRATED AND NEGLECTED YET SO DANGEROUS A NATURAL HAZARD

Samuel O. Ochola*
Department of Environmental Studies and Community Development
Kenyatta University, Nairobi, Kenya

ABSTRACT

This article is written against the recent lighting episodes that killed over 40 people within a span of one week. Eight members of one family died after lightning struck their grass-thatched house in Mencheiwa village, Keiyo South District in the Rift Valley province of Kenya. Lightning is Kenya¨s most underrated weather-related hazard in terms of response, management and research. It's also the most unpredictable and every year, kills over 10 000 people and injures about 100 000. GIS is used to map the spatial distribution of the hazard. This article discusses what makes lightning so dangerous, and compares with other weather hazards? Also presented is a map showing the spatial and temporal distribution of lightning mainly in the Rift Valley, Nyanza and Western provinces and of lately Central province. From this study, it is clear most lightning casualties are rural populations. Sixty six percent of the 47

* Email: s.ochola@yahoo.com

counties are in the high lightning hazard zones. This paper argues that lightning is so dangerous since it is hard to know just when and where it is likely to strike-or how it will behave when it does. The study recommends a number of management approaches, awareness campaigns, research as well as reinstituting a relevant organisation.

Keywords: Kenya, lightning, neglected natural hazards, thunder, disaster reduction

INTRODUCTION

Compared to other natural hazards like floods, drought, landslides and seismic hazards, lightning remains Kenya‟s most underrated weather-related hazard in terms of response, management and research. Floods for instance has researched extensively (Ochola 2009; Ochola *et al.* 2010; WMO *et al.* 2004) and Management manuals developed (Nippon Koei 2011) with relatively good community evacuation plans. Other hazards have been fairly researched and published in peer-reviewed literature. For instance earthquakes (Henry *et al.* 1990), landslides (Ngecu and Mathu 1999), drought (Hasternrath *et al.* 2010; McCabe 1987; Oba 2001; Ongwenyi *et al.* 1993; Vogel and O‟Brien 2006). Lightning continues to kill people in western parts of the country but lately also reported in the central regions, destroys property and leaves people with long-lasting fear during the raining seasons. The only notable exceptionis the study by Akello (1996), which outlined the history of lightning protection in Kenya addressing proneness in terms of Mean Thunder Days (MTDs) and the Flash Density (Flashes per km^2 per year), losses incurred in the period 1960-1980, protection of schools and residential buildings, protection of storage and transport facilities for petroleum products and of electrical and electronic equipment. Other isolated attempts to research and install lightning arresters have been attempted in East Africa by Unilever Tea Company in a Kericho, Limuru and Mufindi (Tanzania) tea estates (Akello and Ogada 2006). According to Akello and Ogada (2006), however, professional design of lightning conductors in Kenya started with the appreciation of Standard Codes of Practice. It was developed by the National Lightning Committee in 1989. It is a combination of many standards which were available at that time. Initially, it recommended that the designs be based on the Faraday Cone but was later changed to be on the Rolling Sphere Concept. The handicaps have been the absence of an enforcing agency to ascertain that the code is followed and the

committee became defunct due to several Kenyan reasons which are typical of such initiatives from the government. Ocholla and Gathuru (2011) recommended immediate need of mapping out the areas that are prone to lightning, a course that this study has taken up though at the national level which needs some downscaling to the relevant levels.

Since the 1980‟s the has not been major lightning-focussed studies with a tendency in most disaster-related studies and reports in Kenya to focus on floods, landslides and drought (UNDP 2005), while ignoring or underrating lightning a rather dangerous and unpredictable natural hazard that afflicts the country. This study was conducted against the recent lighting episodes that killed over 40 people within a span of one week. Eight members of one family died after lightning struck their grass-thatched house in Mencheiwa village, Keiyo South District in the Rift Valley province of Kenya. This event came right after a series of other strikes across the country and brings to questions; *where are the prevalent hot spot areas, what numbers are we talking about? Is there any trend and what level of management and research has been done?*

On the global scene, Price and Rind (1994) already reported the possible implications of past and future climate change on global lightning frequencies with results suggesting a 30% increase in global lightning activity for the warmer climate typical for Kenya. Other cases studies also exist for example comparing the causes of lightning-caused with people-caused fires in Spain (Vazquez and J.M 1998) and Canada (Podur *et al.* 2003). In light of climate change and variability, it is important to focus on managing the lightning hazard to minimise its negative consequences. Locally serious research on lightning hazard has stagnated since the 1980s with only a few outdated and those not from the expected qualified institutions and disciplines available in the public domain (Obiero 1998). Ocholla and Gathuru (2011), recently presented a conference paper on the status of lightning protection in Kenya. It therefore remains by large, an ignored hazard except the occasional appearance in Kenya‟s print and electronic media. This could partly be explained by lack of record currently available, as was the case in the past in the United States of America‟s Michigan State in the past (Shearman and Ojala 1999). No complete knowledge existed of the number of casualties caused by lightning in the United States. The compilation of lightning casualty statistics was not a simple problem, and there were many unresolved issues relating to definitions, procedures, and primary data sources. Shearman and Ojala (1999) outlined the problem, pinpointed limitations of data, and underscored the areas where more careful and uniform procedures could provide more consistent statistics. Lightning-related deaths in the state were

traced through Department of Public Health death certificates, and lightning injuries severe enough to cause hospitalization were examined through hospital discharge records. This method could be applicable in Kenya to some extent.

The report highlights on the need to take up a proactive strategy in the management of natural disasters in Kenya, which would improve the coping capacity of communities, lessen the impact and therefore improve the lives of Kenyans in the areas prone to harsh weather conditions.

LIGHTNING HAZARD

Lightning hazard and its effects are now well understood scientifically and globally (Flisowski et al. 2004; Gomes and Diego 2011; Montanya et al. 2004; Price et al. 2011; Renni et al. 2010; Szczerbinski 2003; Zafren et al. 2005) but myths still rein high among many communities. According to Gatewood and Zane (2004), from the time predating the written word there are descriptions of death and injury caused by lightning strikes. To this day, lightning is a source of awe, curiosity, inspiration, and fear. The brilliance, power, and destructive capacity of lighting have made it the subject for religion, superstition, politics, and, most recently, scientific investigation. de Souza et al. (2011) used computational intelligence techniques to assist complex problems concerning lightning in transformers in order to evaluate errors and minimise the failure rate of transformers. Lightning causes forest fires (Larjavaara et al. 2005), strike buildings at specific points and has been proven strike buildings depending on the height and geometry of the structure (Becerraa et al. 2007) particularly tall buildings over 60m (Alessandro and Gumley 2001), causes power outages (Ramirez-Vazquez et al. 2004), exhibit seasonal variation and associated with mountainous areas (Soriano and de Pablo 2002), high mortality, and significant long-term morbidity (Ritenour et al. 2008; Szczerbinski 2003). During lightning, people can be affected through direct flashes where the the victim absorbs the energy or by contact voltage also called side flash (Szczerbinski 2003). According to Gomes and Diego (2011) and Mahaney and Milner (2011), lightning is another cause of damage to communication and broadcasting towers since in most cases they are all-metal structures, which them prime targets of lightning that may come within their vicinity. Other adverse effects can be industrial and chemical facility accidents (Renni et al. 2010).

Causes of Lightning and Thunder versus Unravelling the Myths

The causes, physics and development of lightning is well documented by Gatewood and Zain (2004: 375-379) contrary to the many myths out there especially among the traditional African communities. A review of the ancient beliefs and attempts to explain lightning is well documented by Gatewood and Zain (2004: 369-371). Lightning is caused by an electric potential difference (a voltage) being created between one cloud and another, or between a cloud and the ground. There are complex charge transfer processes caused by cloud to ground (CG) lightning discharges in thunderclouds (Tao *et al.* 2009). A charge of electrons builds up on the higher cloud while a lack of electrons occurs on the lower part. When this buildup/lack is large enough, a large amount of energy has been stored. It all releases at one time, forcing an electric current through the sky and allowing the charges to equalise; it also turns most of that energy into heat and light which were we see as lightning. Thunder is created when the lightning passes. As the air is superheated by the lightning, it expands by a large amount and explodes under compression. However, after the lightning has passed and the energy dissipated, the area where it passed through is now at a lower pressure. This creates suction and air rushes in to fill the gap extremely quickly through rarefaction. Together these actions form a sound wave which we hear as the thunder. Lightning can be formed from cloud-to-ground, cloud-to-cloud or even volcanic eruptions. In the initial development stages, cloud-to ground (CG) flash rate usually rises rapidly, and then maintains a high value in the mature stage. In the dissipation stage, the CG flash frequency decreased rapidly (Feng and Hu 2011).

There are several myths among cultures and misconceptions also exist that must be corrected even within the scientific community. As Gatewood and Zane (2004: 371) agree, lightning is disquieting and alarming but it is equally misunderstood and misconceived. Some of the local Kenyan community misconceptions and beliefs about lightning are:

- That lightning is a red cockerel
- It strikes people wearing red clothes during a thunderstorm
- It strikes places where people are making loud noises during thunderstorms such as in schools and churches therefore people should remain quiet
- Lightning usually remain hidden in running water or pools of water in the period preceding a thunderstorm and that people who wade and swim in such water can b struck

- That lightning never strikes the same place twice. This falsely cheats people that once struck one of the homesteads or locality is safe for ever
- That lightning strikes only bad people
- That one can go to a magician to strike their enemies with lightning
- keeping religious symbols like crosses, swords and charms can prevent lightning strikes
- That places of worship and burial grounds of ancestors are never struck by lightning and
- That someone who has been struck remains electrified and should not be touched among others

Among the scientific community, several misconceptions exist regardless of the tonnes of information available to them in form of published literature. A common misconception is that a major cause of death is from burns, but only a small percentage of lighting victims actually sustain deep thermal burns.

The only immediate cause of death is from cardiac arrest (Cooper 1980). Most of the scientific misconceptions are well elucidated by Gatewood and Zane (2004). These included the fallacy that victims remain charged often denying them first aid or quick medical attention, that lightning only strikes when there direct clouds whereas the most dangerous strike is the period preceding the storm and after the storm (Copper 1995) cited in Gatewood and Zane (2004).

The pathophysiological details of lightning injuries and treatment are well presented by Gatewood and Zane (2004: 382-398) and and Zafren *et al.* (2005) and therefore need not to be further reviewed here. They should nonetheless be made part and parcel of Kenya‟s public education content as we manage this neglected but dangerous natural hazard.

Globally

One of the main causes of damages of wind power plants is by lightning the single largest cause of unplanned downtime in wind turbines, and that downtime is responsible for the loss of countless megawatts of power generation (Glushakow 2007; Paolone *et al.* 2007).

In Germany for example, 14% of the wind turbines in the mountain areas in the south are damaged by lightning (Rodrigues *et al.* 2009). Methods have been used to protect structures from lightning among them the „collection volume method" (Alessandro and Gumley 2001). The highest lightning flash frequency is 159 flashes per year in Central Africa (Figure 1).

It is clear from this map that the distribution of lightning flashes around the world is uneven. About 70% of all lightning activity occurs in the tropics. The greatest number of flashes per year is near the small village of Kifuka in the Democratic Republic of the Congo which gets an average annual flash rate of about 158 lightning bolts (NASA 2011).

Global lightning is divided between the three hot-spots, or chimneys, over the tropical land masses (Africa, South America and Southeast Asia), while tropical precipitation is more continuous around the tropics following the intertropical front (Price 2009). Carey and Buffalo (2007) also demonstrated that thunderstorms with predominantly positive lightning (often associated with severe weather) were more likely in a drier environment.

The above unexpected behaviour according to Price (2009), may be due to the differences in geography, meteorology, topography, or other factors in these regions.

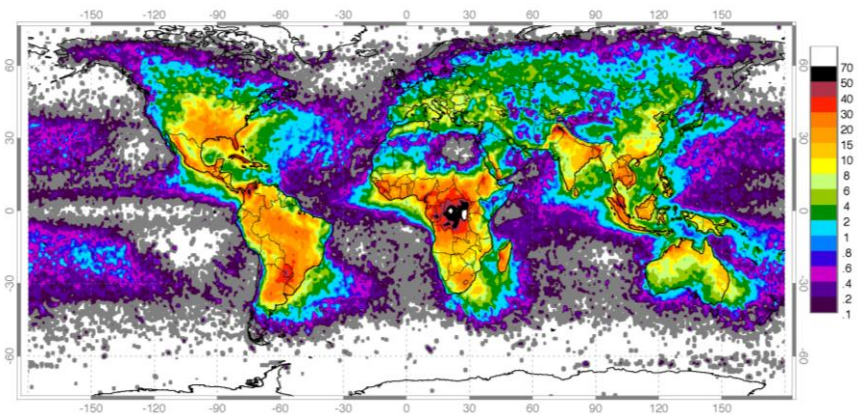

Figure 1. Global annual lightning flash rate (NASA 2011) The variations in colour displays the average annual number of lightning flashes per square kilometre.

In the tropics the intra-cloud flashes have been known to contribute to about 60% of the total lightning, than in temperate regions where the same percentage is about 30% to 40% (Gomes 1999). Williams and Satori (2004) studied the differences between tropical Africa and tropical South America

showing that their main difference in lightning activity was due to Africa being hotter and drier than South America.

The greater continentality of Africa is attributed to its greater elevation above sea level, and to the asymmetry of the synoptic scale delivery of moisture to the region. In addition, Williams *et al.* (2005) showed that in the present climate as the height of thunderstorm cloud base increased, so did the lightning activity. Higher cloud base implies drier surface conditions, which would support these observations.

In Asia, Singapore too, has one of the highest rates of lightning activity in the world. Lying near the Equator, the weather is hot and humid almost all year round. Conditions are favourable for the development of lightning producing thunderstorm clouds. It has an average of 171 thunderstorm days recorded annually.

Lightning and Climate Change

The Goddard Institute for Space Studies (GISS) general circulation model (GCM) is instrumental in studying the possible implications of past and future climate change on global lightning frequencies. Two climate change experiments were conducted: one for a $2 \times CO_2$ climate (representing a 4.2°C global warming) and one for a 2% decrease in the solar constant (representing a 5.9°C global cooling).

The results suggest a 30% increase in global lightning activity for the warmer climate and a 24% decrease in global lightning activity for the colder climate. This implies an approximate 5–6% change in global lightning frequencies for every 1°C global warming/cooling. Both intra-cloud and cloud-to-ground frequencies are modelled, with cloud-to-ground lightning frequencies showing larger sensitivity to climate change than intra-cloud frequencies.

The magnitude of the modelled lightning changes depends on season, location, and even time of day (Price and Rind 1994).

NASA now provides simultaneous measurements of both rainfall and lightning from space. The Tropical Rain Measuring Mission (TRMM) satellite has provided great insights into global lightning distributions (Christian et al., 2003), allowing us to examine the relationship between lightning and Earth's climate.

Several studies have looked at the relationship between lightning and precipitation in individual thunderstorms (Petersen and Rutledge 1998;

Piepgrass *et al.* 1982; Price and Federmesser 2006; Price and Rind 1994), with nearly all studies showing a positive correlation between rainfall and lightning activity. This is quite logical, since rainfall and electrical activity in thunderstorms are both related to the microphysics and dynamics of deep convective clouds (Williams *et al.* 1989). However, according to Price (2009), the opposite relationship is found when we look at regional lightning activity over long time scales. According to Gatewood and Zane (2004), before scientists had satellites to detect and measure lightning frequency, it was thought that there were globally 100 lightning flashes per second, an estimate that dates back to 1925. With satellites monitoring lightning frequency, it is now accepted that the global lightning flash frequency is on the order of 40 flashes per second. NASA has two different sensors that measuring flash frequency, the Optical Transient Detector (OTD), and the Lightning Imaging Sensor (LIS). Data from the OTD from 1995-2000 and the LIS from 1998 - 2005 has been combined and averaged to create an average annual lightning flash rate map.

Kenya's Background

Kenya lies between latitudes 5° North and 5° South and between longitudes 34° and 42° East on the eastern side of the African continent. It is bordered by Ethiopia and South Sudan to the north, the Indian Ocean and Somalia to the east, Tanzania to the south, and Uganda and Lake Victoria to the west (figure 1).

Its land area covers a total of 583 000 km^2. Kenya experiences a number of natural hazards, *(Kenya drought and desertification, floods, landslides, earthquakes and volcanic activity, terrorism, civil conflicts, industrial hazards and pollution, diseases and epidemics, livestock and wildlife diseases, traffic accidents, lightning, pest infestation, drugs and alcoholic beverages abuse and other hazards (GoK 2004)).* According to UNDP *et al.* (2002), the most common are weather related, including floods, droughts, landslides, lightening/thunderstorms, wild fires, and strong winds. Other hazards experienced in Kenya include HIV/AIDS, and conflict. In the recent past these hazards have increased in number, frequency and complexity. The level of destruction has also become more severe with more deaths of people and animals, loss of livelihoods, destruction of infrastructure among other effects resulting in losses of varying magnitudes.

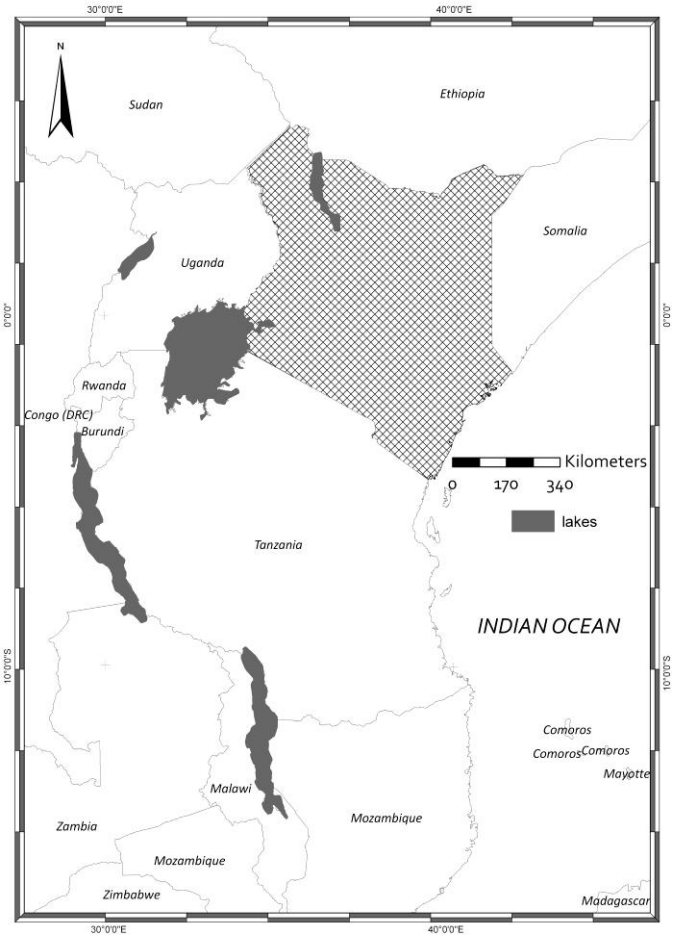

Figure 2. Location of Kenya.

Background of Lightning Hazard in Kenya

It has been generally viewed that western Kenya is synonymous with lighting with some areas experiencing about 240 days of lightning discharge per year (GoK 2004). Lightning has had disastrous effects causing death to human beings, animals, and destruction of buildings, telecommunication, power installations and electronic systems. Dating back the 1980s, the government of Kenya has tried to pursue strategies that could promote risk minimising technologies particularly formulation of a code of practice for

protection of structures from lightning attacks in addition to erecting arresters in strategic places without success.

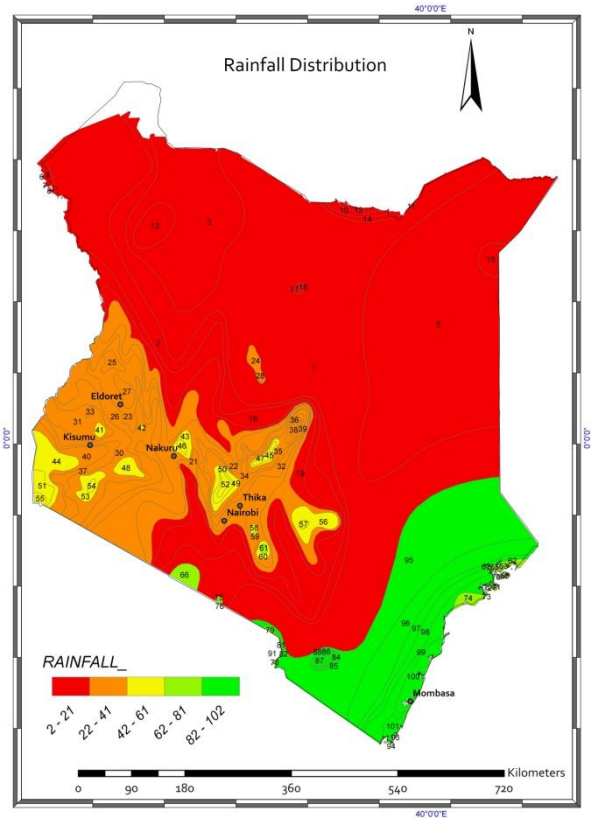

Figure 3. Rainfall distribuion map of Kenya. GIS map genrerated from datasets from the Kenya meteorological department.

Obiero (1998), is one notable M.A.Thesis that characterised thunderstorm hazards in the Lake Victoria basin of Kenya. It examied the relationship between thunderstorm frequency and other weather variables, analysing the storms' spatial and temporal variation, establishing the frequency characteristics of rainfall associated with the storms and assessing lightning severity in the area. The analysis involved multiple regression, coefficient of variation, Weibull formula and the lighting hazard indices respectively. The results indicated that each thunderstorm recording station had its own multiple regression models. The coefficient of multiple determinations from each station showed that the variables explained only a small fraction of the

variance in thunderstorm frequency suggesting that other uninvestigated factors could be responsible for the remaining variance. Although thunderstorm frequency was high in stations adjacent to the lake, a fact attributed to relative convective activities associated with the lake, the F-test tevealed no significant difference in the number of thunder days among the stations.

A monthly analysis of the storms' frequency showed each recording station had its own peak. The first peak was evident in Kisii during the month of March followed by Kericho in May. The third peak was observed in Kitale during the month of August. The least peak was evident in Eldoret. The Gumbel probability plots for annual maximum daily rainfall (Rmax) from thunder days extracted fromt the stations revealed Kisumu to have the highest Rmax while Eldoret had the lowest. This analysis has implications in the design of hydraulic structures in the area. In assessing lighting severity in the basin using the Lightning Hazard Index (LHI), Kisii and Nyamira districts which have recorded the worst thunderstorm tragedies were taken as case studies. Since the LHI considered only human casualties, an adjusted index, Overall Lighting Hazard Index (OLHI) was developed to accommodate other losses such as houses, livestock and trees. Both indices showed that lightning seriousness was high in areas with high population densities such as Keumbu and Nyamira Divisions. Although there was no significant difference between the two indices, the study has recommended the use of OLHI as it considers both loss of life property.The monthly distribution of the number of thunder days (see figure 1) shows a peak in April/May and November, with an average of 20 thunder days and a low of 4 to 6 days in the months of January and February respectively. The preferred time of the day for thunderstorm to occur is between 2 pm and 6 pm in the afternoon for all months of the year as diurnal heating and convection play an important role in thunderstorm development here (Obiero 1998).

METHODOLOGY AND ANALYSIS

Hazard mapping is an essential step in the determination of the past and potential locations at risk(Ochola 2009). An integrated approach based on a weighted criterion was used to develop the lightning hazard map. A digital elevation model (DEM) was generated from SRTM images (from the University of Maryland) for the whole country using ArcGIS® 9.2 in order to develop an elevation model of the country. In the lightning hazard assessment

process, three main stages are identified here namely; data collection, data management, processing, and analysis of results. The use of ranking and weighted index has been successfully used in the field of disaster risk reduction before (Tanavud *et al.* 2004). The purpose of the criterion weighting is to express the importance of each criterion relative to other criteria effectively employed. The more important criterion had the greater weight in the overall evaluation like was also applied to landslides by Pachauri and Pant (1992).From the data described above, a map was generated, applying a series of GIS tools using the ArcGIS® 9.2 software. The data was both digitised and georeferenced using the Projected Coordinate System: WGS_1 984_ UTM _Zone_36S. A slope map was generated from the DEM in percent and factored in the weighting.In this study, weighted ranking method was applied taking a whole range of parameters, DEM images and historical records unique to each district. A weighted index was assigned depending on NASA‟s Annual lightning flash rate, rainfall distribution, altitude above sea level, slope, number of casualties and strikes in the last decade. A factor based on the population density for each sub-location was then factored in through overlay with the resulting map in GIS. This technique is a numerical system based on physical factors, indirectly or directly related to lightning hazard in the country. The factors were weighted according to their relative importance to each other and to their expected importance in causing lightning. Each factor was ascribed a ranking value from 1 to 5. The higher the ranking value the more susceptible a particular factor is to lightning. The annual flash rate, rainfall and altitude were chosen as the most influential factors for evaluating the lightning hazard. Each factor was then partitioned into sub factors, each of which was given a ranking value (Table 1). For each factor, the weighted hazard ranking was obtained by multiplying its weight by the ranking value for the corresponding sub factor. The total estimated hazard, obtained by adding the weighted lightning rankings of all the factors, was classified into 3: low, medium and high zones.Similar to Gomes and Kadir (2011), other factors considered in the development of the lightning hazard were population density and urbanisation/settlement pattern of a each location. District-wise lightning death and damage records and information was used even thought they could only be from electronic and media sources. NASA has two different sensors that measuring flash frequency, the Optical Transient Detector (OTD), and the Lightning Imaging Sensor (LIS). Data from the OTD and the LIS was combined and averaged to create an average annual lightning flash rate(NASA 2011) which was then re-digitised and georeferenced. The resulting total maximum and minimum estimated hazard values were then classified for each

lightning hazard zone (maximum and minimum possible scores being 96 and 15 respectively from table 1). The results were then plotted in ArcGIS 9.2 and further an overly operation performed against the population density layer to produce the final lightning hazard map.

Table 1. Weighted lighting hazard ranking for Kenya

Factor	Weighting	Sub-factor	Ranking
1. annual flash rate	5	61-70 51-60 41-50 31-40 21-30 11-20 0-10 -1-10	8 7 6 5 4 3 2 1
2. rainfall distribution	4	82-102 62-81 42-61 22-41 2-21	5 4 3 2 1
3. altitude above sea level	3	>5000 4001-5000 3001-4000 2001-3000 1001-2000 0-1000	6 5 4 3 2 1
4. no. of casualties reported	2	>100 51-100 1-50 0	4 3 2 1
5. terrain slope (%)	1	91-100 81-90 71-80 61-70 51-60 41-50 31-40 21-30 11-20 0-10	10 9 8 7 6 5 4 3 2 1

RESULTS AND DISCUSSION

The Numbers

According to reports in the media over the last 4 years, lightning kills an average of forty people annually with the year 2010 alone recording 100 lightning deaths amid several injuries. In 2011 over 50 lives had been lost by end of November. From the analysis in this study, about thirty percent of Kenya‟s land area is classified as having a high lightning hazard. This on administrative terms corresponds to sixty six percent of the 47 counties whereas twenty three percent is under moderate lightning hazard classification representing 11 counties. The remaining 5 counties (11.6%) are in the low lighting hazard category. The big picture that needs to be taken into account is that nearly eighty nine percent experiences some form of lightning at one time or another but the fatalities have only been accounted for in counties. Most of the people, killed by lightning are villagers in rural areas who work in open fields. Therefore proper dissemination of knowledge on lightning protection and safety measures, down to village level, is essential to curb the death toll and other hazards to the human beings and live stock. Although a notable effort is made by the scientific community during the last several years to educate the public in the prevention of lightning disasters. Unilever Tea Company has also made significant contribution on its field operation. The companies have invested heavily in technology as well as management systems. Over 22,000 workers are benefiting from a safer work environment.

Over the last 4 years, several deaths have been reported with Butere/Mumias district recording the highest human casualties (30) followed by Kericho, Keiyo South and Kakamega districts in that order (figure 4). Nakuru district also recoded death of forty six pelicans. Other districts which have recorded deaths are Keiyo North, Bomet, Nandi South and North, Rongo, Kisii Central, Busia, Kericho, Narok, Vihiga, Kajiado, Laikipia, Nyandarua, Kiambu, Trans Nzoia, Mount Elgon and Nyamira. Some of the most observable features are that these lightning prone districts are either in the highlands, along the shores of Lake Victoria or are mostly distributed along the equator. These are areas in Kenya that are highly associated with convectional rainfall and receive rainfall adequately during the long and short rainy seasons. They are also the areas that happen to have the highest population densities in the country; therefore the population at risk is quite high. Injuries usually go unattended. For instance in Rongo district, even though only one child was killed in one strike, 28 other people sustained injuries.

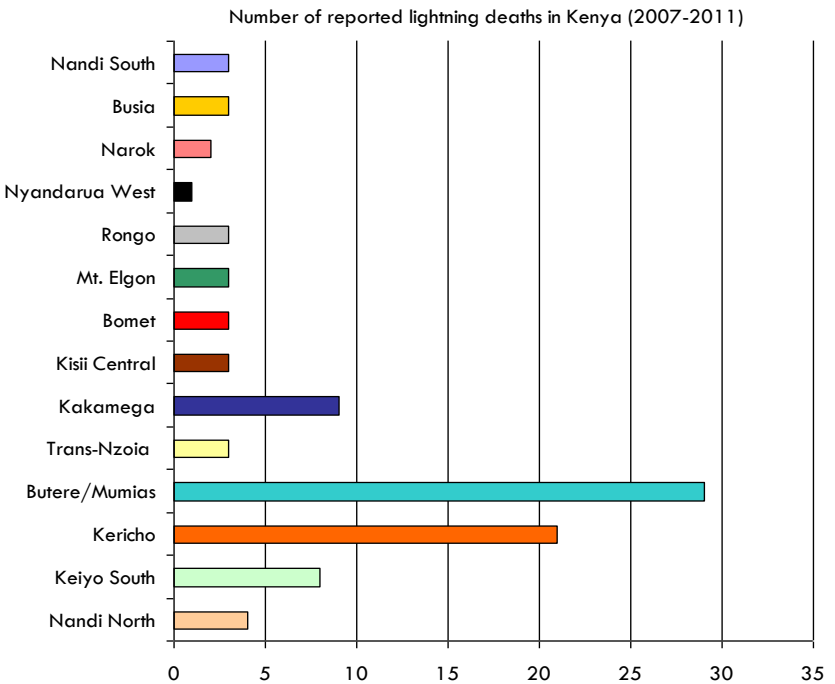

Figure 4. Number of report lightning fatalities in Kenya for the period 2007-2011 by district.

Another notable observation is that even though western Kenya, Nyanza and parts of Rift Valley are the known lightning-prone areas, parts of central Kenya and Nairobi City are both within lightning hazard zones and should be included when managing the hazard. Counties such us Nyeri, Kiambu, Meru, Embu, Tharaka Nithi, Kirinyaga in addition to Baringo, Marsabit and Samburu counties in the Rift Valley (figure 5). The injuries need to be further researched on as they usually pass without much public and media attention. For instance, we need to know the frequencies of injuries or even strikes that fall under the 6 categories of lightning strikes (direct strike, contact injury, side flash, ground current, upward streamer or blast injury) described by Ritenour *et al* (2008: 387). From the reports analysed most deaths are in the rural areas as compared to urban centres. Some of the factors that contribute to the high rate of lightning deaths in rural areas of Kenya include lack of easily accessible medical facilities and emergency care due to both the scarcity of hospitals/emergency care units and fast transportation, inadequacy of weather

forecasting and thunderstorm warning information relevant to the local communities in the right language and packaged to suit their lifestyles and small houses that fail to provide sufficient lightning safety and large areas of bare lands. Another factor is the rural lifestyle and daily chores and needs like bathing, collecting firewood or working in the farms. In deed, a number of children have been struck while out either playing or herding cattle in vast open fields. People in rural areas also have to cover long distances to the market or from in areas where they cannot find shelter. A number of deadly strikes also revealed large crowds taking shelter in churches and fall victims. Such large gatherings in small and crowded places increase the likelihood of rural population being victims.

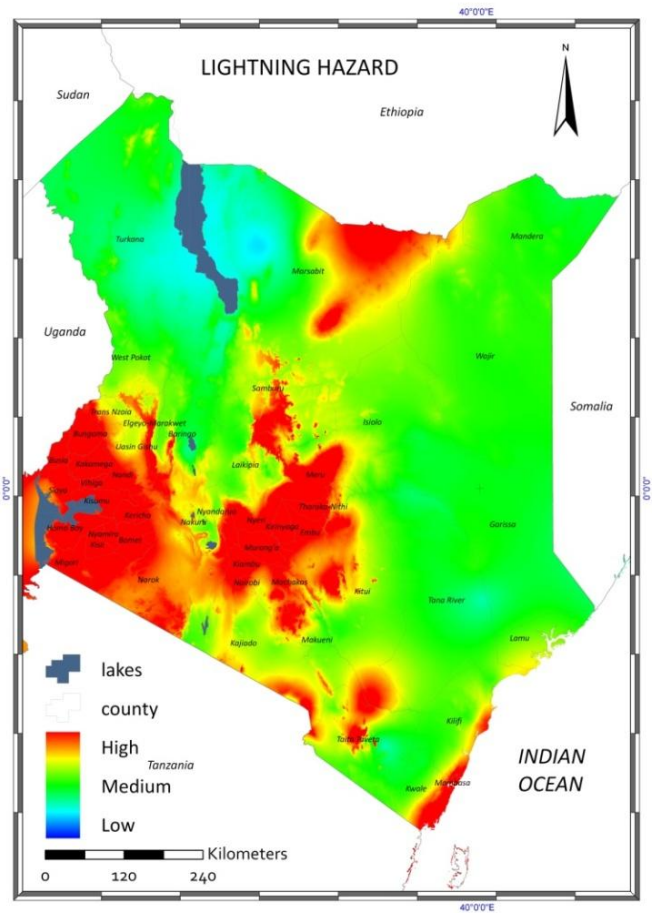

Figure 5. Lightning Hazard map for Kenya.

Proper lightning death statistics are not kept and where it is, the information is not very reliable and most often provides an under estimation of the casualties. Under such context, a reliable theoretical formula to estimate the lightning casualties per year in a given region is of a current need in planning safety promotion and anticipating future trends of lightning-related events. The rate of literacy influences the number of lightning victims in a given country through lack of awareness in the guidelines of lightning safety, lack of motivations to follow even known safety guidelines and misconceptions about lightning phenomenon (Gomes and Kadir 2011).

The Hotspots

The lightning-prone districts which have been reported to have fatalities in the past 10 years are in Nyanza, Western, Central and Rift Valley provinces.

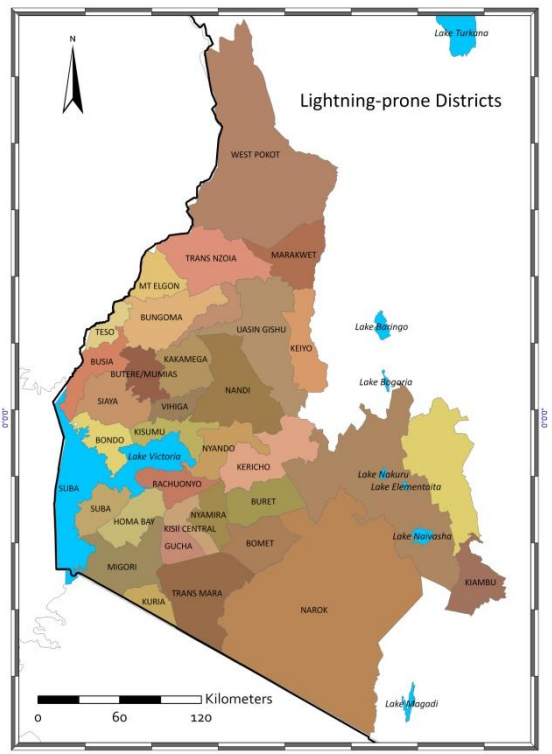

Figure 6. Lightning-prone districts in Kenya.

In Nyanza these include Kisii, Migori, Rongo, Nyamira, Kisumu, Bondo Saiya, Nyando, Muhoroni and Nyakach. Those in Rift Valley are Kericho, Bomet, Buret, Nandi South and Nandi North, Sotik, Uasin Gishu, Marakwet, Trans Nzoia, Keiyo South and Keiyo North, Narok, Nakuru, Nyahururu and Nyandarua West. Those in Western Province are Mumias, Kakamega, Busia, Bungoma, Lugari, Mount Elgon, Emuhaya and Vihiga whereas central Province includes Kiambu, Limuru and Murang"a (in the Nairobi environs). These districts are illustrated in figure 6.

CONCLUSION

Going by the findings from this study, lightning is persistently one of the leading causes of death caused by environmental or natural disaster in Kenya. In order to manage the hazard well, we must understand the physics of lighting and discount the innumerable myths, superstitions, and misconceptions surrounding lightning among our communities. Majority of the victims were rural populations and in places where children were either playing in the open area, herding cattle or large crowds taking shelter in churches or schools. There are a number of recommendations that need our attention. These are:

- There is need to further map lightning hazard in Kenya but downscaled below the national level at a scale that is more relevant to communities
- Increase public awareness and education on the hazard especially on the adoption of the "30-30 rule"(Gatewood and Zane 2004) in order to take precautions that will avoid injuries from lightning. This rule states that states that when the time between seeing lightning and hearing thunder is 30 seconds or shorter, persons are in danger and should be seeking shelter. Outdoor activities should not be resumed for 30 minutes after the last lightning is seen or the last thunder is heard. Because lightning can strike where there is no rain, people should not delay evacuation just because there is no rainfall.
- Further research is needed especially on the types of strikes and categories of injuries by victims
- Most of the interventions should be in the rural areas especially the poor.

- We need to develop a guide on what to do and what not to do during lightning in several languages and disseminate the same to all communities.
- The construction industry should also adopt the installation of lightning arresters in all building in the hazard zones and neighbouring areas but do so in line with the scientific knowledge that exist. For instance, it should be noted that just installing one arrester for a large building is not adequate. Care must be taken to find the most vulnerable point depending on the shape and height of the structure for each location as well as distances to other objects.

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Chapter 4

BIOTECHNOLOGY REGULATION AS A NECESSARY EVIL: EMPIRICAL LESSONS FROM KENYA

Ann N. Kingiri [1,*]
[1]African Centre for Technology Studies (ACTS),
Nairobi, Kenya

ABSTRACT

Biotechnology revolution is poised to benefit the world poorest only if controversies associated with safety are regulated appropriately. These controversies have been confounded by conflicting interests of different stakeholders. Using Kenya"s experience in developing a biosafety regulatory framework for management of biotechnology innovation, this chapter explores the political and social dimensions associated with biotechnology regulation in the context of a poor developing country. It finds that regulation attracts different responses and that the embedded controversies are context specific and have ramifications for translation of biotechnology science for pro poor development. In conclusion, it notes that biotechnology regulation requires a critical thought in relation to the handling of divergent perceptions held by stakeholders. Based on empirical insights generated from the Kenyan case, the chapter provides

* African Centre for Technology Studies (ACTS), Gigiri Court, Off United Nations Crescent P.O Box 45917 - 00 100 Nairobi. Tel +254 (0) 20 7126894/95 (ACTS office). +254 (0)722-346821 (personal cell phone). Email: ankingiri@gmail.com or annakingiri@yahoo.com.

practice based recommendations for policy towards stimulating a productive biotechnology debate.

Keywords: stakeholders, agricultural biotechnology sector, regulatory practice, integration, knowledge, Kenya

1. INTRODUCTION

The unprecedented pressure linked to globalisation and politics linked to safety and benefits of agricultural biotechnology[1] has challenged the development of this sector (Fukuda-Parr, 2006). Further, the integrated nature in which new technologies like biotechnology are undertaken has challenged the traditional science based methodologies of undertaking innovative research (Nowotny et al., 2001). Scientific communities can therefore no longer claim to be doing research within their traditional disciplinary domains since research has become increasingly trans-disciplinary spurred by increased collaborations (Gibbons et al., 1994). This means that, actors in an innovation system have to reflexively adapt to the changing knowledge production terrain but how they do this has not been given a lot of empirical attention.

This chapter argues that for economically effective application of emerging technological tools like biotechnology, the changing institutional terrain characterised by diverse knowledge production demands now more than ever before a change in normative way of dealing with controversies involved. In addition, management of the different types of knowledge emanating from multiple stakeholders besides scientists, and the regulatory setting that attracts multiple challenges will require multi-level skills on the part of policy actors. Using empirical data generated from regulation of biotechnology sector in Kenya, a holistic approach is recommended. This will consequently enhance productive ways of dealing with the multiple challenges

[1] Here I use the term biotechnology to mean the manipulation of living organisms to produce goods and services useful to human. I make distinction between traditional (or conventional) and modern biotechnologies. The traditional approach allows the development of new products (such as seed varieties) by the process of selection from genetic material already present within a species, while the modern approach develops products (such as seed varieties) through insertion of genetic material from different species into a host plant.

that confront this sector and prepare the stakeholders as the sector evolves towards commercialisation of emerging research products.

Research and capacity building development, commensurate with the market and societal demands are important in pushing agricultural innovation process for development (Hall, 2005). However, productive and impact driven research agenda cannot be realised unless the research nodes engage interactively with all stakeholders in the innovation process from production to consumption. In the case of modern biotechnologies, integration has been shown to promote and maximise effective use of resources (Hanlin, 2006). Integration however challenges the behavioural practice of actors. Empirical studies analysing experts‟ responses to new regulatory demands in modern biotechnology research suggest that the immediate challenge brought about by integration relate to knowledge management (Harsh, 2005; Kingiri, 2011c). Actors are confronted by multiple obligations related to individual and institutional values on the one hand, and on the other the scientific ethos that must be upheld in both scientific and regulatory practice.

This chapter explores the political and social dimensions associated with biotechnology regulation. It is informed by a case of new agricultural biotechnology first introduced in Kenya in early 1990‟s in the absence of a legal regulatory framework. This set rolling efforts by the government to institute a biosafety regulatory system to manage the initiated biotechnology research (Appendix 1). This regulatory process that co-evolved alongside the initiated biotechnology activities provides an exemplary context to investigate the social and political dynamics around biotechnology regulation (for a detailed account of this co-evolution process, see Harsh, 2005; Kingiri, 2010; Kingiri, 2011a).

The chapter is divided into several sections. The first section discusses the methodology and conceptual framework in which the empirical evidence is grounded. This is followed by a context section that situates the role of biotechnology regulation stakeholders in the broader science/society spectrum and the factors that impact their behaviour within this spectrum. This is followed by a narrative of knowledge production dynamics that draws on empirical data from regulation of Kenya‟s biotechnology subsector. The last sections revisit the agenda of this chapter by debating possible lessons for policy and practice in biotechnology revolution.

2. METHODOLOGY AND CONCEPTUAL FRAMEWORK

This chapter is grounded in empirical data and theoretical insights drawn from knowledge and innovation based literature.

2.1. Data Collection

The data informing the chapter‟s narrative are based on research conducted in Kenya between 2006 and 2011. Kenya provided an excellent context to understand knowledge production dynamics linked to both biotechnology research and biotechnology regulation, and how this generate value based tensions. The process of instituting a regulatory regime for management of biotechnology research involved among other activities the development of biosafety regulations. This process attracted a wide range of stakeholders making it possible to randomly select over 50 respondents who were interviewed in this study. These interviewees have been involved in biotechnology research and biosafety policy making in their various capacities as biological scientists and non-scientists. They were affiliated to organisations that have (or claim to have) a stake in modern biotechnology and biosafety arena ranging across researchers, policy makers, academics and nongovernmental organisations (NGOs) in both pro-biotechnology and civil society arenas.

Most of the interviews were conducted at the height of controversies involving legalisation of biotechnology activities in Kenya through formulation of a Biosafety Law (2006-2009). Interviews were structured in a way that yielded detailed understanding around the dynamics that shape the process of biotechnology regulation including regulatory policy making. The subjective views of the interviewees related to knowledge use in relation to biotechnology research and regulation, why they hold these perspectives and their behaviour related to regulatory process were the topic for interpretation. The qualitative data generated this way were analysed against secondary data linked to role of different stakeholders in the Kenya‟s biosafety regulatory process between 1998 and 2011 (Appendix 1). Direct observations were made during numerous biotechnology and biosafety fora held between 2007 and 2009 at the height of debate around formulation of the biosafety bill, and post Biosafety Act enactment period between 2009 and 2011.

2.2. Theoretical Background and Analytical Framework

To analytically situate this chapter in sound theoretical science and technology debates, discussion draws upon insights from knowledge literature. The emerging complex integration that characterise new technological innovations demands principles that are different from the linear, individualised and localised characteristics of the traditional basic sciences generated in research institutes or universities, and eventually taken up by government or industry for innovative purposes (a practice described as Mode 1 by Gibbons et al., 1994). These new principles are captured by Nowotny et al. (2001) as mimicking "socially robust knowledge" embedded in society and their needs (a practice described as Mode 2). This has changed the simplistic way of conceptualising knowledge as only emanating from the scientific experts and instead views other social experts as good stewards of knowledge (Nowotny, 2003). As Nowotny et al. (2001) argue, in Mode 2 practice, boundaries between "science and society are becoming more porous". These new knowledge insights associated with new role of science in society have become a good way of investigating role of stakeholders in development activities (Gibbons et al., 1994).

Analysis of broader political and social dynamics linked to biotechnology revolution including research and development (R and D) can benefit from these knowledge principles because of the diverse types of knowledge associated with different actors as experts and the multiple challenges that generate diverse forms of information and knowledge (Kingiri, 2011c). Moreover, modern biotechnology as a new form of science and technology is viewed in terms of globalised knowledge economy (Fukuda-Parr, 2006).

3. Factors Generating Tensions in the Changing Role of Knowledge and Society in Biotechnology Subsector

Factors that impact efforts of meaningful articulation of roles by the diverse actors in the biotechnology R and D as well as regulation have formed a reflexive debate in this area (Fukuda-Parr, 2006). For the sake of this chapter, these factors may coalesce around three but interrelated components; environmental imperatives and related uncertainties, the informed society and the changing knowledge economy. Analysis of these factors helps us

understand the challenges that confront development of biotechnology sector, and how they shape the embedded social and political dimensions associated with regulation.

3.1. Environmental Concerns

There are concerns that new technologies may harm the environment. Indeed social concerns for environmental have increased. This has called for management of uncertainty and increased demand for accountability. The Cartagena Protocol to the Convention on Biological Biodiversity attempts to provide a benchmark for this by harmonising and setting out procedures for risk assessments and public participation (CBD, 2000). Application of these procedures in decision making pertaining to environmental management is contested thus becoming normative subjects in biotechnology debates (Murphy and Chataway, 2005; Levidow, 2007). Efforts to confront these contestations have been confounded by what scholars in risk research call risk society (Beck, 1992). Dealing with environmental challenges therefore has exposed conflicting scientific and social rationalities (Murphy and Chataway, 2005). These challenges plead for a new way of integration to address complexities related to uncertainty and science communication challenges.

> "Finding solutions to environmental problems requires not only understanding of environment and threats to it; it also involves influencing the actions and behaviours of multiple societal actors." (Rusell et al., 2008)

3.2. Knowledge Society

According to Nowotny et al. (2001) and Gibbons et al. (1994), knowledge has become fluid and socially distributed. Consequently, information that has not undergone scrutiny and peer review is being generated and diffused at unprecedented rate due to the trandisciplinary nature of science and the advanced channels of communication. Moreover, scientific knowledge is no longer the only knowledge that drives dynamic innovation systems like biotechnology. Non-scientific knowledge and related views have become increasingly important. The traditional quality evaluation of scientific knowledge has shifted from peer review to encompass the societal review. What becomes legitimate is determined by what the broader society including

policy makers consider scientific and policy relevant. This has implications in that, sometimes the value of science in providing scientific solutions to complex and social problems conflict with some basic social values (Jasanoff, 2003). In such a scenario, scientific expertise has been threatened by diverse values, interests, conflicts and politics that characterise initiatives to come up with democratic models of public engagement (Jasanoff, 1990). This again calls for recontextualisation of how non-scientific or social issues should be integrated in public policy processes.

3.3. Changing Knowledge Economy and Integrated Biotechnology Innovation Terrain

There is no dispute that biotechnology science has prospects in addressing the many challenges in food production that confront Africa today (Juma and Serageldin, 2007; FAO, 2004). However, this form of science and technology is viewed in terms of globalised knowledge economy proposing partnerships and collaborations where commercial goal is predominant. In agricultural biotechnology revolution for example, many activities are driven by commercial imperatives leading to "knowledge commodification" where intellectual property may be in the hands of few actors, mainly multinationals (Russell et al., 2008). Again the very nature of biotechnology science as requiring advanced infrastructure and different kind of collaborations threatens the integration principle with regards to actors‟ involvement. For instance, scientific community may be constrained by research agreements to cascade their findings just anyhow (e.g. through publications for eventual use by other researchers and general public), yet most are within public institutions mandated to conduct research for public good (Beintema et al., 2003). In some cases, reports emanating from externally funded projects must be re-packaged in line with customer terms of reference (Waterton, 2005) and even so, not in a form that can pass peer review. This scenario with economic orientation changes the meaning and value of knowledge as well as the nature of learning and integration. However in the case of biotechnology especially in the African context, commercial imperatives must be analysed alongside regulatory concerns that have taken the centre stage in recent debates (Mugwagwa, 2008).

4. EMERGING REGULATORY PRACTICE IN KENYA AND IMPLICATIONS: ANALYSIS AND DISCUSSION

When agricultural biotechnology research was initiated in Kenya in early 1990"s, it triggered institution of a regulatory system for management of controversies associated with deployment of products of biotechnology. For almost two decades of biotechnology R and D and regulatory system transition, different stakeholders have been engaged in diverse ways. This has implications for knowledge advancement towards putting biotechnology products to use for the benefit of the poor.

4.1. Biotechnology R and D and Regulation Milestones in Kenya: An Overview

Considering that modern biotechnology embraces a wide range of applications including tissue culture, markers assisted selection and genetic engineering (GE), actual work involving advanced GE commenced in 1991. This started with engineering of a virus resistant sweet potato that obtained regulatory approval in 1998 (Odame et al., 2003). It is this product development initiative led by scientists that triggered the need for regulations (Sander, 2007). To date, several GE research initiatives have been evaluated in public institutions in conjunction with local and international partners. The crop activities include *Bt* maize and *Bt* cotton engineered for resistance to insect pests, cassava for resistance to viruses and sorghum for resistance to striga weed. Other initiatives include the transgenic sorghum and cassava fortified with nutrients and the water efficient maize for Africa (WEMA). The recombinant rinderpest vaccine initiative targeted control of rinderpest disease in cattle and other viruses in small ruminants. Since the approval of the first transgenic crop in 1998, no product has reached the farmers and the furthest the biotechnology activities have gone towards a product is the open field trials under regulatory confinement.

At the early stages of biotechnology research activities, Kenya opted to use the existing infrastructure, the Science and Technology Act (RoK, 1980) under the National Council for Science and Technology (NCST) to institute regulatory mechanisms through the drafting and adoption of the *Regulations and Guidelines for Biosafety in Biotechnology in Kenya* (RoK, 1998). Kenya signed and ratified the Cartagena Protocol in May 2000 and January 2002

respectively. This further obligated the government to put up regulatory structures to operationalise it. In an effort to institutionalise regulations as well as the biotechnology activities, *the National Biotechnology Development Policy* was drafted and later approved in 2006 (RoK, 2006). This was followed by different draft versions of the biosafety bill which eventually became Law in February 2009 (RoK, 2009).

Practical dynamics exhibited and experienced by stakeholders during this transition form the narrative presented next.

4.2. Role of Stakeholders and Associated Tensions

The way stakeholders in the science and public arena were engaged in regulatory decision making activities determined to a large extent the associated tensions. The heterogeneous community of scientists at policy, regulatory, academic and non government organisations (NGOs) arenas were engaged in various roles in biotechnology development and regulation. Firstly as experts in academic, policy, public and professional circles, they articulated multiple and conflicting roles as knowledge drivers in biosafety and biotechnology developemnt. They actually provided the much needed advisory role as experts in the policy arena. Secondly as policy targets, they were affected by biosafety regulations as innovators in biotechnology research. Finally as policy enforcers, they were involved in implementation of regulations as regulators and in guiding formulation of biotechnology policies as policy agents.

Overall, it was emerging that the scientific community articulated the "expert" role both as knowledge producers and knowledge users in the normative scientific practice and the regulatory practice respectively. This generated protracted tension from the civil society groups who claimed to be speaking for the general public.

The scientific communities on the other hand accused the civil society actors of hindering development of biotechnology science through their proactive advocacy that seemingly attracted the attention of the public and the policy makers.

4.2.1. Conflicting Interests

Kenya‟s regulatory process attracted many stakeholders. Consequently, depending on their beliefs in relation to biotechnology and biosafety, coalitions and collaborations (professional, disciplinary, academic and NGOs)

started emerging to pursue different policy and regulatory interests. Arguably within these coalitions, interests and beliefs" driven knowledge was being produced and disseminated in different ways through politically charged policy coalitions to influence policy change (for details see Kingiri, 2011a). The immediate drawback was the confusion that this caused to many actors particularly those in policy and public. In addition, the government preferred to consult scientists particularly in regulatory policy making, a move that was seen as a deliberate effort to exclude the wider public in the process. Moreover, the articulation of multiple roles by the scientific community mentioned above was confounded by conflicting obligations, values and interests at individual and institutional levels. Thus, according to the NGOs from civil society, scientists could not be trusted to propagate the interests of the Kenyan citizens. These NGOs on the other hand were perceived by scientists to be pursuing the interests of environmental NGOs in the developed countries who were purportedly funding their advocacy work.

4.2.2. Communication of Science to the Public

Due to uncertainty and risk underpinning deployment of biotechnology, confounded by media hype around modern biotechnology and biosafety, scientists in practice were held back from sharing their research findings with the wider public for fear of misinterpretation. Consequently, they preferred to report about beneficial aspects of biotechnology which they could substantiate rather than "perceived" risks that they could not explain or authenticate. The non scientists and public interpreted this seemingly biased reporting as reflecting a practice that was pursuing particular interests and values, disguised as fear of misinterpretation.

4.2.3. Challenges: Management of Diverse Knowledge and Adaptation of Stakeholders

Arguably, the emerging tensions associated with biotechnology regulation have challenged adaptation of actors (both scientists and public) in dealing with the embedded dynamic institutional terrain. In the backdrop of the associated tensions, the major challenge for policy makers and debatably a setback for biotechnology development is the management of diverse forms of knowledge emanating from the dynamic trans-disciplinary and multi-actors setting (Kingiri, 2010). This presents useful learning lessons for shaping a socially and economically viable biotechnology revolution as illustrated next.

5. Lessons for Responsible Regulation of Biotechnology: Rethinking Actors' Role in Knowledge Production, Learning and Practice

The process of establishing a regulatory infrastructure to govern biotechnology in Kenya was controversial based on the way participation of different stakeholders was advanced. It was a protracted process between the public represented by the civil society on the one hand, and the scientists backed by the government and pro-biotechnology NGOs on the other (see also Harsh, 2005; Kingiri, 2011a; Kingiri, 2010; Kingiri, 2011b). The scientific communities and the non scientific groups used different avenues to present and advance their viewpoints, with the media being utilised by both groups extensively (see also Kingiri, 2011a).

As others have noted (see for instance Hisano, 2005), biotechnology regulation and stakeholders" engagement are governance issues that work for or against the prominent discourse of biotechnology development for the poor. If we bring the debate to Africa, the issue here is biotechnology innovation and what it can do to address the broader issues of food security on the one hand, while on the other the uncertainty and fear about biotechnology still looms amongst the public. These issues are complex and strategies adopted to bring about a balanced and legitimate evidence based debate are important. The dynamics revealed in the Kenyan context are meant to make actors understand the ideological backdrop against which strategies for knowledge use must be based in biotechnology regulation. For instance, existing institutional settings are believed to impede private investments necessary for the international transfer of biotechnology innovations a view that is also shared by others (cf Kameri-Mbote et al., 2001). The unproductive suspicion amongst technology and knowledge suppliers on the one hand, and the users on the other, needs to be dispelled by balanced approaches to public policies. This is one way of ensuring that developing countries depart from the tradition of viewing technology partners financing projects as "being made up of profit propelled establishments" (*Ibid*).

Rethinking the role of stakeholders propels us to carefully make out alternative perspectives and frameworks to re-appropriate and redesign biotechnology regulatory processes and stakeholders" engagement to fit in the contextual aspects that confront Africa. All actors should not shy off from acknowledging that they have vested interests guided by values and beliefs

systems. Thus, multiple perspectives, interests and needs should be at the centre of the any proposed analysis and approach.

5.1. Learning, Interaction and Knowledge Use

Learning and consequently how knowledge is used is important for any productive technological innovation. Innovation systems and the growing literature in the new knowledge production terrain (Mode 2) provide rich concepts that can guide reconceptualisation of stakeholders‟ roles towards a meaningful process.

From system‟s thinking, learning which occurs within and across interactions is crucial to innovation. Actors embracing collaboration and integration are motivated by the systems thinking that is believed to be crucial in imparting learning and knowledge use. This approach to innovation has become influential in analysing developmental issues in agriculture in the context of developing countries (Hall, 2005; World Bank, 2006). According to Chataway and Hanlin (2008), collaboration actually synergises systems with actors consolidating resources (expertise, finances, and information among others). They argue that collaborations are spaces that enhance productive knowledge generation and opportunities for dissemination and communication.

Mode 2 thinking brings a different perspective of integration that leads to socially desirable knowledge (Nowotny et al., 2001).

> “Socially robust knowledge has three interrelated aspects: its is tested for validity outside as well as inside the laboratory; it is most likely to be achieved by involving an extended group of experts; it results from having been repeatedly tested, expanded and modified” (Nowotny, 2003).

There are many interpretations as to why socially robust knowledge production may be appropriate in an African context. The mistrust between proponents on the one hand (made of scientific community and technical experts) and opponents on the other (made of civil society and purportedly non-scientific experts) seems to suggest lack of faith in science providing authoritatively convincing solutions to societal problems (Russell et al., 2008). It also points towards the increased demand for non-scientific knowledge to legitimise risk assessment process in controversial and contested sciences (Jasanoff, 2003). However, as Nowotny (2003) asserts, it is not the reliability

of scientific knowledge that is being questioned. Rather it is the narrow context of validation and use in individualised and localised environment like research centres or universities where its quality review is limited to peers. In this narrow context, it has not been tested by the social, political, economic and cultural context under which it is generated and in which it is supposed to be used.

Evolving knowledge landscape leads to social integration of knowledge within institutional nodes that the scientific community operates under and across the society. Scientific experts and affiliated institutions are no longer the only nodes of knowledge and learning. This calls for meaningful relationships building and new ways of knowledge management in order for the increased knowledge emanating from these diverse nodes "to speak back to science" productively (Nowotny et al., 2001). The challenge is how this increased integration and learning can genuinely be democratic and innovative (Nowotny, 2003). New ways of addressing this challenge would augment the intensified calls for meaningful participatory and deliberative governance of biotechnology and related knowledge use (Lyall and Tait, 2005). These new ways however call for individuals" reflexivity which is "the process by which individuals involved in knowledge production try to operate from the standpoint of all actors involved" (Gibbons et al., 1994). This implies that stakeholders, depending on their role, can choose to be reflexive enough to accommodate genuine concerns and needs of others that come with changes in Mode 2 research terrain (Gibbons et al., 1994; Nowotny et al., 2001).

5.2. Building Capacity for Renewed Learning, Knowledge Use and Practice

The capacity discussed here relates to learning while the type of learning proposed here considers the view that actors share different beliefs systems (Sabatier, 2007) and hold different values (Jasanoff, 2003). Values and interests especially at the institutional level are known to impact policy integrations and governance of biotechnology (Murphy and Chataway, 2005).

The kind of knowledge generated in diverse institutional knowledge nodes (upon which experts derive their motivations) is both explicit and tacit and is strategically brought to bear on policy change. A question that may be posed relate to how this knowledge can be harnessed to impact positive and productive biotechnology revolution and regulation. This is where capacity building becomes important. The capacity proposed here is "multi-layered

skills" that is not only vertical and horizontal (within peers and related institutions), but also multi-dimensional that caters for different ways of learning to include divergently different interests and values (Lyall and Tait, 2005). The multiple skills proposed here will imply that the policy makers will look for viable ways of connecting the knowledge users and knowledge suppliers. This may be a gradual learning process crucial if a meaningful biotechnology revolution is to impact pro-poor development.

CONCLUSION

This chapter tried to look at controversies embedded in biotechnology regulation with a view of providing empirical pointers on how regulation as a necessary evil may be managed to promote biotechnology development. Certain insights and lessons were drawn from Kenya"s case. An integrated approach to dealing with knowledge was proposed, one that pays attention to the contextual issues that confront many African countries trying to manage knowledge associated with biotechnology research and regulation. The chapter has shown the importance of paying attention to the role of knowledge spurred by multiple perspectives in regulatory processes. For actors to manage the associated tensions, capacity building to acquire multi-layered skills would be paramount. This is one way of advancing the regulatory process in a meaningful manner that considers the recontextualised role of knowledge, learning and integration where all players have a role to play as experts and as stakeholders.

APPENDIX 1. KEY DEVELOPMENTS SURROUNDING KENYA'S BIOTECHNOLOGY REGULATORY PROCESS

Period	Activity
Prior to 2000, regulatory process was governed under the interim regulations of 1998 that provided for a National Biosafety Committee (NBC), replaced after 2009 by the National Biosafety Authority (NBA)	
The signing and ratification of Cartagena Protocol in 2000 and 2002 set various activities into motion.	
Jul 2002	Scientists and lawyers developed zero draft copies of the biotechnology policy and the biosafety bill after a two weeks meeting.
Mar 2003	1st discussion of the zero drafts of the biotechnology policy and biosafety bill by scientists and lawyers in a two-days meeting.

Period	Activity
Apr 2003	1st stakeholders" one-week meeting to discuss the draft copies.
Aug 2003	Two-days meeting with members of parliament to discuss the draft copies.
Nov 2003	One-week stakeholders meeting comprising of policy makers with majority being members of parliament to sensitise them on biosafety bill.
May 2004	A two-day study tour for parliamentary committees members to biotechnology facilities in Kenya to assess the biotechnology and biosafety capacity as they debated the bill in parliament.
Mar 2005	One-week meeting of seventeen experts (scientists and lawyers) to review both the policy and the bill.
Apr 2006	Interested stakeholders discussed the revised draft policy documents to identify any omissions for further input.
July 2006	Final reviewed documents presented to the Attorney General by the Minister for Science and Technology (SandT) for perusal before being presented to the cabinet.
Sep 2006	The policy and the bill approved by the cabinet.
22 Jun 2007	The bill is published in the Kenya gazette to solicit public comments.
22 Jun-11 Jul 2007	The period it remained in the public domain, ssignificant number of public comments received.
July 2007	A half-day stakeholders meeting to discuss the bill and be sensitization on its importance.
Aug 2007	One-week meeting by a committee of experts (three lawyers and five scientists) to review the comments from the public. The committee proposed a number of technically sound amendments to the bill.
Oct 2007	-The biosafety bill, 2007 tabled in 9th Parliament by Minister for SandT. It went through the 1st and 2nd reading. -Parliament was dissolved before the 3rd reading, hence further discussion ceased.
Feb 2008	NCST incorporated the proposed amendments to the biosafety bill, 2007 and consequently requested the Attorney General to re-publish the then biosafety bill, 2008.
27 Jun – 16 July 2008	Bill published in the Kenya gazette and put in public domain for comments. No public comments were raised.
July 2008	Biosafety bill, 2008 tabled in the 10th parliament by the newly elected Minister for SandT.
Nov 27 2008	The bill passed the second reading and moved to the committee stage of the whole parliamentary house.
9 Dec 2008	The bill passed after it was approved by the parliament.
12 Feb 2009	Presidential assent and finally bill became law. It was officially published in a special issue of the Kenyan gazette in Feb. 2009 as Biosafety Act 2009.
24 April 2010	The members of the new NBA established under the provisions of the Act are officially appointed through a Kenya gazette.
2010	Drafting of implementing regulations by technical and legal experts
12 April 2011	Stakeholders debate the three draft regulations: The Biosafety (Contained Use) regulations; Environmental Real ease regulations; and Import, Export and Transit Regulations.
1 July 2011	The draft regulations to implement the Act are finally approved by the acting Minister for Higher Education, Science and Technology.
14 July 2011	Cabinet approves importation of GM maize to avert food crisis in the country. This generates different and controversial reactions from proponents of GM technology and opponents of GM products.

Appendix 1. (Continued)

Period	Activity
Between 14 July and 20 July 2011	Numerous media reportage capturing divergent opinions around GM technology and related safety following the cabinet approval of GM maize importation. Many opponents question the capacity of the regulatory agencies and government to safeguard safety of the public in the event of unforeseen adverse effects following consumption. This raises questions around the role of regulation from the perspectives of the public versus the experts.

Source: Adopted from Kingiri (2011a) after updating.

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Chapter 5

INCLUSIVE DEVELOPMENT FOR PERSONS WITH DISABILITIES: RIGHTS AND CONTRIBUTIONS OF DEAF KENYANS

Christopher Johnstone[1], Tom Ojwang[1], Rachel Garaghty[1] and Joel Runnels[2]
[1]University of Minnesota, St. Pau, MN, US
[2]Global Deaf Connection, Minneapolis, MN, US

ABSTRACT

Kenya is geographically situated in East Africa and attained its independence from Britain in 1963. In 1964 the country‟s population was 9.1 million (Karanja, 1966). Kenya‟s populace has since grown to 38,610,097 people according to the latest population census results carried out by the government in 2009. Mortality rate for children under 5 years was calculated in the same year to be about 84 for every 1,000 children. The United States‟ CIA Factbook ranks Kenya as the nation with the 44th highest infant mortality in the world. The average life expectancy of a Kenyan is 54 years.

In addition, it estimated that in 2006 about 47% of Kenyans were considered poor at the national level. These people generally lived below the poverty line and survived on less than US$ 1 per day (Institute of Economic Affairs, 2011). IFAD (2011) further states that the country‟s

Gross National Index (GNI) per capita stood at US$ 770 in 2009 while annual Gross Domestic Product (GDP) per capita in the same year was US$ 30, 200,251,314. In 2010, the United Nations Development Programme (2011) ranked Kenya at position 143 out of 187 countries. According to this report, the country had a very low Human Development Index (HDI) of 0.509. Despite these startling figures, the country is, nevertheless, reported to have recorded an impressive 115% gross enrollment in primary school as well as a high literacy rate of up to 85% of people aged 15 years old and above by 2008.

EDUCATION SYSTEM

At independence, the government of Kenya singled out education as key to fighting identified three ills; disease, poverty and ignorance. Therefore, from the onset, education occupied a very strategic place in the country‟s quest for socio-economic development. Today, the Kenyan government still continues to attach great importance to education. This is underscored by the country‟s Vision 2030. In this economic blue print, the government identifies education as one of the cornerstones of its social pillar; therefore, it states the need to significantly invest in it in order to create sufficient human capital necessary for transforming Kenya into a "globally competitive and prosperous country with a high quality of life by 2030" (Government of Kenya, p. vii, 2007). Consequently, each financial year, a significant portion of the country‟s budget is allocated to education. For example in 2011/2012 financial estimates, the government set aside 5.7% of its total national budget to education, this being the largest single allocation to any ministry (Institute of Economic Affairs, 2011).

Soon after independence Kenya adopted the 7-4-2-3 system of education based on the British system. However, as the country sought to move towards industrialization, the government in 1984 overhauled the entire education system and replaced it with the 8-4-4 structure which put more emphasis on pre-vocational and technical education. This was largely intended to equip primary and secondary school graduates with skills for self-reliance (Government of Kenya, 2008). It was also to cushion the country from spiraling unemployment as well as position it for rapid industrialization.

Throughout the development of its education system, children already on the margins remained largely on the margins. This was especially true of children with disabilities. The Kenyan system of education has, until recently, lacked mechanisms for meeting the needs of children with education-related

disabilities in its regular schools, but has a long history of providing disability-specific schooling (e.g., schools for the Deaf[1], blind, and physically disabled).

PEOPLE WITH DISABILITIES AND EDUCATION

In recent years, the Kenya government has demonstrated increased commitment towards achieving inclusive education for all by ratifying and domesticating some of the international conventions on education and rights of people with disabilities. Article 27 of the new constitution Kenya promulgated in August 2010 clearly prohibits discrimination of persons on the basis of health status and disability. Earlier on in 2003, Kenyan parliament had enacted the Person‟s with Disability Act which provides for education for persons with disabilities. In addition, the government also later ratified the United Nations Convention on Rights of Persons with Disabilities in 2006 (Government of Kenya, 2008). It is, therefore, evident that currently there are several statutes in the country‟s laws which cater for people with disabilities in Kenya.

People with disability account for about 3.5% of the country‟s total population, with 647,689 being male, and 682,623 female (Government of Kenya, 2010). According to Mugo et al (2010), these figures could have been much higher were it not for the fact that the latest population census carried out in the country in 2009 only considered traditional forms of disability (physical, mental, hearing, visual, and speech). They further argue that the census did not also take into account people with disability living outside conventional housing. Of those captured by the data, 31% had self-care and physical disabilities, 25%, visual disabilities, while 14% had hearing impairment (Mugo et al, 2010). This marginalized group of people has, for decades, continued to remain at the periphery of the country‟s educational development. According to Kochung (2011), “education for children with disabilities was introduced in Kenya in 1940s and has been running parallel to general education system. However, the majority of students with disability are still not accessing education due to expensive separate education system among other reasons” (p. 147).

By 2004, Kenya had about 57 special schools run by the government with an enrollment of over 8,000 children with disabilities. There was another 103 integrated primary schools, 3 high schools for students with physical

[1] We use the capital letter “D” in Deaf to acknowledge Deaf Kenyans as both a disability and cultural group with a common language (Kenyan Sign Language).

disabilities, 2 high schools for those with hearing impairment and one high school for learners with visual disability. In addition, some of the vocational training schools, secondary schools and agricultural technical trade schools had integrated units for students with physical disabilities (International Labor Office, 2004). In 2004, the government estimated the number of children with special needs to be about 750,000. Out of these, only a paltry 14, 614 were enrolled in programs for children with disabilities, and a similar number in integrated schools. This is to say, about 90% of children with disabilities were not receiving specialized attention in school (Government of Kenya, 2004).

The government‟s policy of integrating children with disabilities into the mainstream school system saw a significant number of them move to regular schools. According to Mukuria and Gathogo (2006), integration has since been occurring of children with disabilities in regular schools at all levels of education.

However, those with hearing impairment mainly start integrating at the secondary level due to lack of adequate number of trained teachers in sign language at the primary level. To mitigate this problem, the government came up with a policy that made Kenyan sign language an official language in the country, and it was examined for the first time in 2010 national primary and secondary schools examinations (Government of Kenya, 2008).

ROLE OF NON-GOVERNMENTAL ORGANIZATIONS IN EDUCATION FOR PEOPLE WITH DISABILITIES

Several local Non-Governmental Organizations (NGOs) have for some time also been complementing government efforts in provision of education to people with disabilities in Kenya. A good example of one such organization is Kenya Society for Deaf Children (KSDC). Besides providing bursaries for deaf learners, it has constructed and equipped several schools for them. It also supported curriculum development, training, inspection and development of manuals for inspectors and teachers in schools for the deaf in Kenya (Wilson, 2006). Another NGO, Undugu Society of Kenya (USK), in collaboration with Deaf Child Worldwide, has also been working on a programme of including deaf street children in Nairobi in mainstream primary schools, or by providing them with vocational training or apprenticeship, as a way of rehabilitating them and getting them off the streets since January 2009 (Deaf Child Worldwide).

INCLUSIVE DEVELOPMENT

Despite governmental and civil society successes related to the education of all children (including children with disabilities), poverty remains at a high level in Kenya. To this end, international development partners have engaged in projects around the country, with varying stakeholder groups. One group who has been the focus of such international development work is persons with disabilities. Over the past several years, projects aimed at persons with disabilities have been informed by philosophical shifts about the role of persons with disabilities in national development.

The term "Inclusive Development" is based on the assumption that people with disabilities have faced historic barriers to inclusion in international development projects. As a result, they have not been equal beneficiaries or participants in international development programs and processes, which limits the overall success of poverty alleviation efforts in developing countries (Lord et al., 2010). Disability inclusive development (henceforth, inclusive development) on a large scale aims to meaningfully involve people with disabilities in all aspects of international development, including being equal recipients of benefits produced by development (Lord et al., 2010).

Inclusive development discourse hinges on a human rights model of disability, which gained momentum towards the end of the twentieth century with the emergence of the UN Convention on the Rights of Persons with Disabilities (CRPD) (International Disability and Development Consortium, 2004, 2005). Prior to the emergence of the human rights model, disability was treated principally as a medical issue and international work in developing countries focused on rehabilitation and disability prevention. While such disability-targeted programs certainly have a role to play in international development, alone they were deemed as not enough to ensure that people with disabilities are empowered to enjoy equal rights and rise out of poverty (Bualar and Ahmad, 2009) (World Bank, 2007).

Human rights advocates claim that people with disabilities are entitled to the same rights as those without disabilities, without exception. This claim arises in response to the pervasive discrimination that people with disabilities have faced all over the globe and has important implications for international development (International Disability and Development Consortium, 2004, 2005).

Inclusive development is situated in the philosophy that people with disabilities *have the equal right* to benefit from and participate in international development. Such rights are highlighted in the Kenyan case, where many

people with disabilities were not counted in the national census because they did not live in typical housing. Because of oversights that may be accidental or purposeful, people with disabilities in developing countries may be "invisible" to development practitioners and organizations. Disabled people who are hidden in their homes or in segregated institutions cannot participate or benefit from international development projects.

Inclusive development practice is also meant to address misconceptions about disability. For example, the belief that women with disabilities are not sexually active or capable of bearing children has led to their exclusion in many sexual and maternal health programs, including HIV/AIDS prevention, in developing countries. A growing body of research shows that women with disabilities are not only sexually active, but also at higher risk for gender-based violence and exposure to HIV/AIDS (Groce, 2003). The failure on behalf of the international development community to recognize that women with disabilities share the same health needs as non-disabled women has barred them from potentially life-saving programs. Finally, accessibility barriers also produce major limitations to the participation of people with disabilities in development.

A set of inclusive development practices has emerged to foster people with disabilities‟ involvement in development. These practices are based upon the principles of:

- Inclusion: People with disabilities should be included in all levels of development programs, from design to implementation to evaluation.
- Outreach: People with disabilities should be targeted in outreach strategies.
- Universal Design: Development programs should be designed to be accessible to all people.
- Involvement: Women and girls with disabilities, who often face multiple forms of discrimination, should be actively outreached and involved in programs.

(Heinicke-Motsch and Sygall, 2004)

In practice, these principles can be achieved through actions that have been identified and utilized with success. Context will always remain an important factor in determining which actions (or their variations) are best suited for a given situation, but the following practices are generalizable enough that they have been used with success in many different development contexts.

Ensuring access to international development projects for persons with disabilities requires foresight and planning. Improving the accessibility of development programs involves tackling problems such as negative attitudes, incorrect assumptions, unwelcoming environments, and lack of appropriate accommodations. In this respect, the accessibility of international development programs must be viewed holistically (Dutch Coalition on Disability and Development, 2005). Programs should be carried out in physically accessible environments and development projects, such as the construction of a well, latrine, school, or clinic, should follow internationally established principles of universal design. Often, low-cost modifications such as ramps, guide rails, appropriate signage, etc., can greatly enhance physical accessibility and facilitate the involvement of people with disabilities. Moreover, people with disabilities should feel safe and welcomed in development programs; disability-related stigma, common throughout the world, can severely hinder their participation so it is important to remain cognizant of attitudes that are barriers. For women and girls with disabilities who experience the "double burden" of gender- and disability-based discrimination, removing attitudinal barriers can be as important as removing physical barriers. Involving them in development processes is one way of empowering them as well as ensuring that programs are accessible to them. Data collection of information about people with disabilities is also important in strengthening inclusive development practices (USAID, 2010).

The remainder of this chapter will focus on an inclusive development project in Kenya aimed at supporting employment and educational outcomes for deaf Kenyans. The program, entitled "Cycle of Success" represents a collaboration between United States (US) and Kenyan-based NGOs and the Government of Kenya (GoK). The program was originally financially supported through the United States Agency for International Development.

GLOBAL DEAF CONNECTION'S CYCLE OF SUCCESS PROGRAM

Global Deaf Connection (GDC) is an international non-governmental organization that envisions equal and non-discriminatory education and employment for Deaf children and older youth. GDC typically works with Ministries of Education in the East African Community (EAC) to influence equitable policies, planning and practices that lead to an increase of Deaf

secondary school graduate and their entrance into tertiary educational programs.

GDC‟s Cycle of Success program aims to create equal rights access for qualified Deaf secondary school graduates to enrol in their national teacher training colleges through provision of: 1) scholarships, 2) sign language interpreters, 3) literacy tutors and 4) Deaf American mentors to guide them through their college experience. The Cycle of Success program also negotiates affirmative action policies with host government to hire the Deaf teacher college graduates to teach in public and private sector schools/units with deaf children. These Deaf teachers ultimately contribute to national development as teachers, role models and mentors for Deaf children.

The ultimate vision of GDC is to see at least one trained Deaf teacher in every Deaf school worldwide. Between 1997 and 2010 GDC partnered with US Agency for International Development (USAID), Ys Men International and Government of Kenya (GoK) to create the Cycle of Success blue print for in Kenya. The Cycle of Success program has been replicated at national teacher training colleges with USAID funding in Uganda and Tanzania. During the 13-year Cycle of Success program in Kenya, approximately 56 Deaf Kenyans graduated from teacher training college, of whom approximately 48 have been hired to teach Deaf children at private and public sector schools.

A Brief History on Cycle of Success

GDC‟s first cohort of Deaf Kenyan high school graduates enrolled at Kamagambo Teachers College, a private Seventh Day Adventist college. Kamagambo was originally selected to host the Deaf students because it was adjacent to Kuja Special Senior Secondary School for the Deaf, where most had attended high school. Negotiations between GDC and Government of Kenya later moved the Cycle of Success program to Machakos Teachers College (MTC). MTC is one of the oldest teachers training colleges in the EAC and at time of the Cycle of Cycle program had been selected by GoK to include blind and physically disabled students. It seemed a natural choice for GoK to host the Cycle of Success program at MTC.

The provision of supporting services has always been central to the Cycle of Success program. At the inception of the program, GDC reached out to Gallaudet University for groups of its own Deaf university students to volunteer and intern with the Deaf MTC students. This forum created an

opportunity to share Deaf education ideas and experiences between Deaf American and Africans across borders. It also gave the Deaf Kenyan college students a window into the wider world and international cooperation. With GDC assistance one Deaf MTC graduate secured a Nippon Foundation scholarship to studying his Bachelors and Masters degree from Gallaudet University.

Prior to 2006, GDC had taken on the hiring, training and payment for a cadre of Kenya Sign Language (KSL) interpreters to interpret MTC lectures for the Deaf students. In 2006, GDC negotiated with GoK about the sustainably and long-term future of Cycle of Success. By the end of that same year, GoK agreed to pay salary for the 6 KSL interpreters at MTC, through a special grant for MTC support staff. In 2010 USAID officially ended Cycle of Success funding and GDC fully handed over the program over to GoK. From 2010 forward, Deaf high school graduates paid for their own college tuition (the same as their hearing counterparts) while GoK continued to pay for their KSL interpreters.

As the numbers of Deaf Kenya teachers grew they organized mobilized themselves into Kenya Federation of Deaf Teachers (KFDT), which went onto register itself as its own non-governmental organization with GoK. KFDT has a board, which meets monthly at rotating locations to plan and implement continuing education activities.

The Deaf MTC students also organized themselves into a Deaf Club which too elects its own officials, liaises with MTC administration about equitable access to education and leads a KSL Club for hearing students to know the language.

Impact

An evaluation of the program, published in the *International Review of Education* in 2009, highlighted the impacts of this program on Deaf Kenyans. Program participants reported personal gains in three main areas: 1) skill development; 2) empowerment; and 3) employment. The first area of impact was on teaching skill development. While each of these categories is discrete, they also overlap in regards to a general improvement of the lives of teachers. One teacher commented:

> Before I was supported, I never used to have any money. Prior to the training I was used to 2000 Shillings (per month). It was not enough.

> Transport alone was difficult, but I accepted [my position in life]. But now I'm comfortable.

In this case, the project had an immediate financial impact on the teacher. The ability to earn income as a teacher got the teacher out of his home.

Another teacher demonstrated personal empowerment through taking pride in teaching, sharing knowledge of sign language with fellow teachers, and adding new elements to the curriculum (such as HIV training). In this case, the inclusion of a Deaf student in an international development program had impacts on both the person with a disability and her immediate community (some of whom, his students, were also Deaf).

> It has affected my life in many ways. If I was not sponsored, I would not be where I am now. I would be home [without work]. Now I am teaching Deaf children. I was teaching class 8 in [a Deaf school]. The children were happy to have a Deaf teacher. I was a role model because I was a Deaf teacher. We had meetings every Tuesday afternoon to learn sign language. The teachers were happy. I also helped the children by teaching HIV as a core curriculum. Sponsorship has helped me a lot. They have been a mentor and we hope they can teach us more skills.

Another teacher also mixed themes in his comments, describing a sense of financial empowerment and personal development and contribution back to the development of Kenya.

> After training now I am self-reliant, I have my desires and I am living well. I have been given the power to teach. The children understand me very well.

The ongoing mentorship provided by volunteers based in the United States demonstrated how the isolation often experienced by persons with disabilities in the developing world was broken through international mentoring programs. This particular teacher benefited greatly from gathering ideas from volunteers and others he met through mentorship contacts.

> …[W]e have mentor support that is there. I have benefited from this because volunteers with full experience came to Kenya and those people shared their ideas with us and it has helped us become good teachers so we can help children. Then this support program connected me with different people, for example the Deaf teachers in Kenya and outside Kenya. Through this, I have benefited from different ideas from different people. This has helped me to become a leader for the Deaf in Kenya.

For two teachers, the Cycle of Success was evident in their efforts made in teaching. Although much of the literature on inclusive development focuses on rights of persons with disabilities in international development efforts, the two examples below illustrate a new element of inclusive development: contribution. As a result of the financial and personal empowerment afforded to teachers in schools, two teachers demonstrated the contribution that persons with disabilities can make to national development. The quotes below demonstrate aspirations that teachers had for their students. These aspirations promote a new place in Kenya for Deaf populations, one that is consistent with policy but has been not yet fully realized.

> I am an example to many Deaf people in Kenya. I am a teacher and I have influenced the Deaf children to think big in their future. They can become big people in Kenya, take over the big jobs to help themselves and to help other people in the work…The disabled can work just like the able-bodied.
>
> I feel just working as a teacher of the children who are Deaf [is not enough]. I feel it would be good for me to be a board member for the voluntary counseling and testing center for the Deaf in [Western Kenya]. I am also the assistant secretary of [a Deaf advocacy organization].

DISCUSSION

Inclusive development is an innovation relatively new to international development literature and practice. Its philosophical roots are grounded in rights-based discourse for persons with disabilities. In this chapter, we described one program that purposefully included persons with disabilities in international development projects. By selecting Deaf students and supporting their teacher training, the Cycle of Success was successful in including an often marginalized population in international development efforts.

Further, the ongoing support from the Government of Kenya represents a positive trend in the actualization of human rights policy. Although recent policy shifts in Kenya have become more favorable to persons with disabilities, this population is often still in the margins and under-represented in national dialogue. By supporting the salaries of sign language interpreters at Machakos Teacher College, the GoK has provided Deaf students with at least an opportunity to access higher education and positive economic futures. Further investigations will still be needed to determine what the scholarship

needs are for Deaf students and if a steady flow of qualified students will continue without financial backing.

Despite ongoing challenges and commitments to the rights of Deaf Kenyans, what may be the most salient takeaway from this program and its impact on Kenya is the contribution of Deaf Kenyans to their own nation‟s development. GDC and its partners were highly successful in recognizing the rights of persons with disabilities to participate in international development efforts. Students graduating from Machakos have gone on to find employment in schools and are therefore more financially independent than ever in their lives. For some teachers, a consistent salary and an esteemed role in the community seemed impossible a few years prior.

What is most noteworthy in this case are the contributions that Deaf teachers are making to the next generation of youth. The cycle of success is indeed being realized in Deaf schools around Kenya, where Deaf teachers are providing strong role models to students, setting high expectations, and contributing to both school culture and community organizations. If the discourse on inclusive development has any shortcomings, it is in its failure to recognize the role of persons with disabilities in contributing to national development. The case of the Cycle of Success program in Kenya, with its requisite supports in the education system and from national policymakers, represents a novel way of thinking about persons with disabilities in international development. While rights are still paramount and facilitate inclusion in projects in the first place, the international development community should not lose sight of the numerous contributions persons with disabilities can make to improving development outcomes. Cycle of Success in Kenya is one model on which to build a new schema for development.

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Chapter 6

STATUS OF KENYA'S ENVIRONMENTAL MANAGEMENT AND PROTECTION

Robert Kinyua*

Institute of Energy and Environmental Technology,
Jomo Kenyatta University of Agriculture and Technology,
Nairobi, Kenya

ABSTRACT

Environmental degradation is among the biggest problems that face many countries in Africa. Among the causes of environmental degradation in Kenya include climate change, unmanaged rapid population growth leading to destruction of forest cover to create new settlements, infrastructure development, dumping of waste including solid and e-waste and mining. Mining activities have been associated with exposure of radioactive materials to the environment while discharges of waste water from urban settlements and farmlands have been associated with pollution of rivers and lakes.

In recognition of the need for proper environmental management, the Ministry of Environment and Mineral Resources has led the way in developing legal and institutional framework to ensure environmental protection. Perhaps the most important was the setting up of the National Environment Management Authority (NEMA) under the Environmental Management and Coordination act (EMCA) No 8 of 1999 with the

* Email: kinyua@fsc.jkuat.ac.ke, Tel +254 722 330488

mandate of implementing all policies relating to the environment. NEMA became operational in the year 2002. The Ministry of Health, through the Radiation Protection board, has also been involved in measures to ensure radiation protection to workers and the general public.

Measures to conserve the environment through development of Renewable Energy alternatives have also been given prominence in Kenya‟s Vision 2030 and the Ministry of Energy is already implementing some of these measures. Furthermore Kenya‟s new constitution has a Bill of Rights under which the right to a clean and healthy environment has been included in article 42. The constitution in article 69 also vests the responsibility of ensuring sustainable utilization, management and conservation of the environment to the state.

However a lot more needs to be done in the implementation and enforcement of the various regulations and policies.

INTRODUCTION

Environment generally refers to the surroundings. The natural environment refers to all living and non-living things that are naturally occurring on earth. Even though the natural environment has been evolving slowly with time, human activities have negatively interfered with the environment and affected the natural evolution. The Intergovernmental Panel on Climate Change (IPCC) in its second assessment report warned that the average global temperatures were likely to rise between 1.4 and 5.8 over the 21st century. Furthermore this would lead to average sea level rise of between 0.09 to 0.88m by the year 2100 (IPCC, 2001). Environmental degradation in Kenya has occurred through destruction of forests and riparian areas (leading to loss of biodiversity and the natural carbon sink provided by forests), excessive emission of green house gases by industries and vehicles (associated with global warming), Pollution by Solid waste (mainly municipal waste) and waste water, environmental radiation (both ionizing and non-ionizing) and noise pollution from the various informal industries. Kenya‟s high population growth rate (see figure 1) has resulted to a corresponding high demand for resources including agricultural land for cultivation and settlements, water, energy sources including wood and fossil fuels, and timber for use in the construction industry.

Kenya‟s development blueprint covering the period 2008 – 2030 (popularly known as vision 2030) recognizes the importance of a clean, secure and sustainable environment.

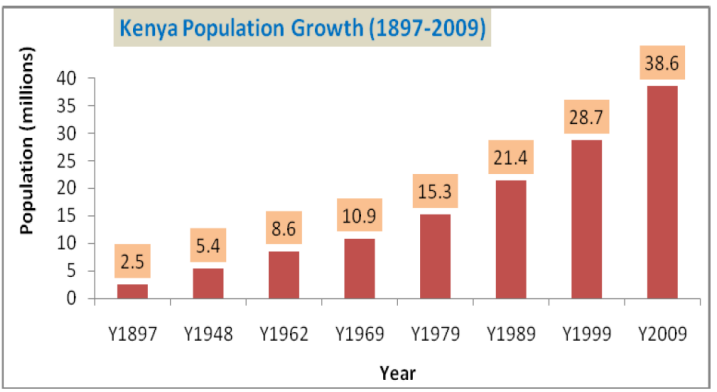

Figure 1. Kenya population growth during the period (1897 – 2009) (GOK, 2009a).

Among the environmental goals include raising forest cover from the present 3% and improving pollution and waste management. Various governmental and non-governmental organizations (NGO) are involved in Environmental protection in Kenya. The most visible governmental organization in this regard is the National Environment Management Authority (NEMA). It is established under the Environmental Management and Coordination Act (EMCA) No. 8 of 1999 and is mandated by the government to implement all policies related to the environment. It started operations in 2002. Among the NGO‟s, the Green Belt Movement, founded by the 2004 Nobel peace prize winner, the late Professor Wangari Mathai, stands out. It was established in 1977 and focuses mainly on environmental conservation by mobilizing grassroots support for reforestation and empowering rural women in Kenya. It is estimated that the organization has planted more than 40 million trees to date.

RENEWABLE ENERGY

Carbon based energy sources perhaps have the heaviest long term impact on the environment due to their emission of carbon dioxide and other pollutants during the combustion process. Carbon dioxide is a green house gas and has been associated with global warming and the resultant climate change. The Kyoto protocol to the United Nations Framework on Climate Change, of which Kenya is a signatory, agreed to reduce green house emissions by at least 5% below the 1990 levels by the year 2012 (Hoffman, 1998). Therefore any measures aimed at protecting the environment must include the search,

development and promotion of clean energy sources. Renewable energy sources offer a promising solution in this regard. These include solar (solar photovoltaic‟s and solar thermal), small and mini hydros, geothermal, wind and tidal energy.

Geothermal energy potential in Kenya is estimated at over 15000 MW even though only 209MW has been exploited at Olkaria (Olkaria I – 45MW, Olkaria II – 70MW, Olkaria III – 94) within the rift valley. Olkaria I and II are owned by the Kenya Electricity Generating Company (KenGen) while Olkaria III is owned by a private company, OrPower. The planned Olkaria IV is set to produce 140MW when completed. Exploration drilling has already commenced in the Menengai area and some wells are already discharging steam. Surface exploration is going on in Ebburu, Bogoria, Longonot, Suswa, Magadi, Baringo among other areas.

The wind energy potential is estimated at 12000 MW even though only 5.1MW is currently generated at the Ngong hills site near Nairobi by the Kenya Energy Generating company (KENGEN). For many years wind energy has been utilized in Kenya for water pumping using locally manufactured *Kijito* wind powered pumps. However their expense and high maintenance cost has resulted to their low penetration to poor communities.

The wind flow patterns in Kenya are mainly influenced by the large water bodies (see figure2)including the Indian ocean to the east, Lake Victoria to the west, and lakes Turkana, Nakuru, Naivasha, Bogoria, Elmentaita and Magadi, all situated in the rift Valley, the tropical monsoon winds and the mountains Kenya (5199m), Elgon (4321) and numerous hills. Throughout the year there is a strong low level air current over the northern part of Kenya known as the Turkana Jet (Asnani and Kinuthia, 1984). The channeling effect of the Kenyan and the Ethiopian highlands intensifies the flow of the North-Easterlies and the South-Easterlies resulting to the low level jet. The earliest feasibility study on wind energy potential in Kenya was done between 1974 and 1976 using meteorological data taken twice daily at a height of 2m. (Chipeta, 1976). Later, Oludhe (1998) used meteorological data taken 3-hourly and found out that some parts of Kenya including Marsabit, Lamu, Malindi and Mombasa have good wind energy potential. More recently Kamau (2010) has used long term data taken at 1-hour intervals and assessed the wind energy potential in Marsabit, Garissa, Lamu, Mombasa, Kisumu, Kericho, Nyeri and Nairobi‟s Eastleigh area. In particular Kamau et al (2010) have demonstrated the high potential of the Marsabit region - at the reasonable 100m hub height, power densities of between 1776W/m^2 and 2202W/m^2 can be realized. A 300MW wind farm is planned near Lake Turkana in northern Kenya.

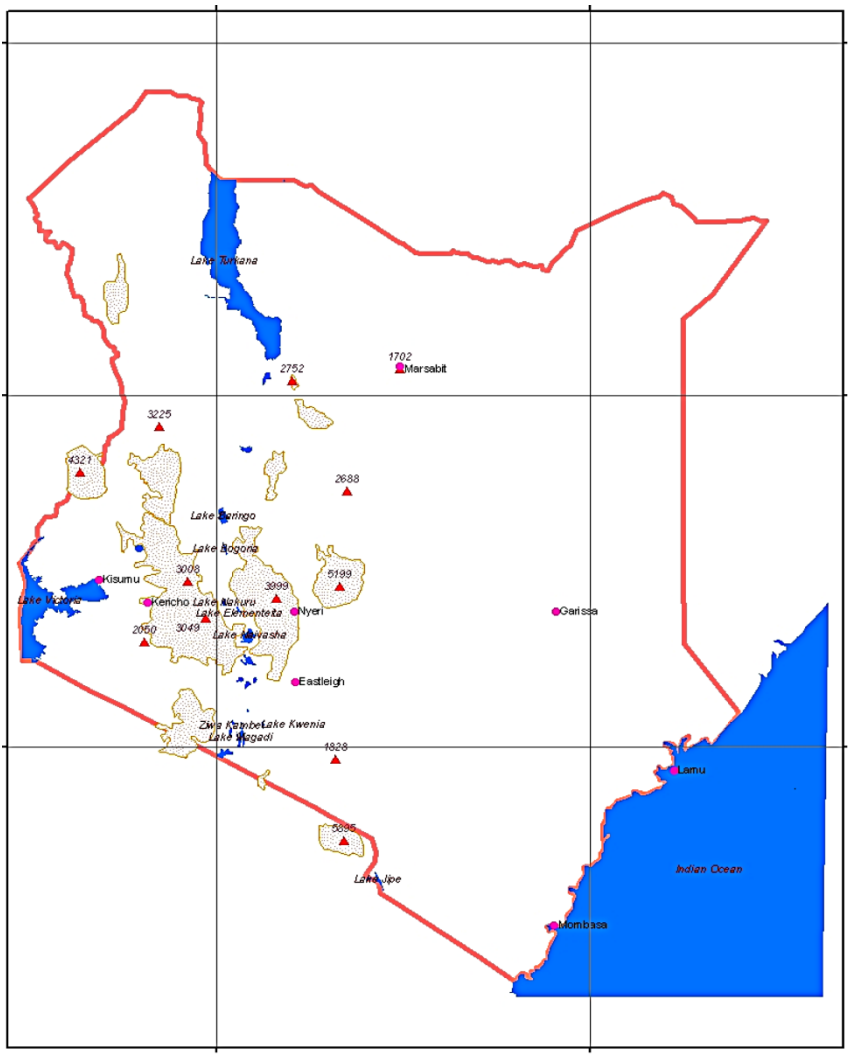

Figure 2. Map showing the Peaks and the large Water Bodies in Kenya (Kamau,2010).

Most of the country has high solar insolation. Ogallo and Runanu (1998), after studying the space-time characteristics of daily solar radiation as an indicator of the available solar energy potential, have shown that there is great solar energy potential in Western Kenya. Marigi (1999) applied advanced statistical and empirical techniques and concluded that most parts of Kenya have either moderate or high solar energy potential. Omwando (2011) has shown that Nakuru, within the rift valley, has average daily insolation of

6.9kWh/m^2. Solar PV technology has been used in homes, schools and dispensaries in some off-grid communities for a long time. However its use is not popular since the failure rate is high. This could be a result of low awareness of service requirements such as battery and panel care leading to abandonment of the technology when failure occurs. Solar thermal water heaters are also increasingly becoming common in urban households especially due to the high electricity costs. However their level of penetration has not been well studied. Recent studies on high temperature compound parabolic solar collectors have shown that they have great potential for steam production and possible electric power generation (Kawira, 2011).

The Kenya Tea Development Authority (KTDA) together with Greening the Tea Industry in East Africa (GTIEA) have been involved in the promotion and development of small hydros in the tea growing areas of Kenya. KTDA has already installed mini hydro power generating stations in a number of its factories. No work has been done on tidal wave energy in Kenya.

As a developing country, Kenya can claim carbon credits from industrialized countries after developing clean sources of energy as proposed in Article 12 of the Kyoto Protocol (UN, 1997).

WASTEWATER AND SOLIDWASTE MANAGEMENT

Regulating discharge of wastewater and securing safe drinking water are among the most important interventions for improving global public health and achieving sustainable development. Failure to treat waste water before discharging it into the environment has led to Pollution of rivers and Lakes which in turn has led to eutrophication of the water bodies and water borne diseases. Inadequate treatment of wastewater allows heavy metals, chemicals, bacteria, viruses and other disease causing pathogens to contaminate surface and ground water. The financial, environmental and social costs are expected to rise if no interventions are put in place.

Pit latrine is the most common method of excreta disposal in urban slums and rural areas of Kenya. This is perhaps due to the high poverty levels in these areas, its simplicity and low cost of construction. Pit latrines have been identified as a major source of contamination of wells with fecal matter through leachate (Molard et al, 1994). Bacteria, viruses and other micro-organisms and contaminants infiltrate surrounding soils and contaminate water sources. The pathogenic organisms in contaminated water are the most serious

sources of illness and death especially among young children in poor countries.

Excess amounts of heavy metals in waste have the potential to poison human beings (Enger and Smith, 1992; Barneji, 2005). In particular, lead poisoning has been associated with mental and physical development retardation (Kumar, 1994). Njogu et al (2010) have extensively studied pollution of Lake Naivasha, a Ramsar site. They report that farms have encroached on the riparian lands and discharged toxic materials, including organochlorine pesticide residues, to the lake through canals. As early as 1992, Mugucia et al (1992) had reported the presence of organochlorine pesticide residues in fish from the same Lake. Obviously nothing much has been done since then.

Many authors (Kimathi et al, 2011; Tumbo-Oeri, 1988) have shown that some common food crops grown along river banks and in marshy areas bio-accumulate heavy metals from polluted water bodies. In particular, Kimathi et al have shown that taro roots and leaves bio-accumulate Zinc, copper, Manganese, lead, Cadmium and chromium and concluded that taro plant, a tuber widely grown as a food crop in many parts of central and Eastern Kenya, has the potential for phyto-remediation of polluted wet areas. The authors recommended that the crop should not be cultivated for food in polluted areas where it would absorb the poisonous metals. The presence of heavy metals in the sampled areas was attributed to the presence of a number of motor vehicle garages along the river banks, the extensive use of cooper based fungicides in the surrounding coffee farms, runoff from an adjacent slum settlement and pollution from a saw mill set up near the river source.

Wastewater management in Kenya is regulated mainly through three acts of parliament. The Public Health act of 2005 is meant to ensure that water sources do not endanger public health safety. This is done through promotion of quality testing and treatment of water prior to use. The act also provides for the prosecution of offenders under the act, including water polluters. The Water act of 2002 among its other provisions criminalizes the discharge of waste water into water bodies without a discharge permit. The permit is issued if the regulator is satisfied that the discharge will not amount to pollution. Pollution is defined under the act as the alteration of the chemical, physical and biological characteristics of the water.

The Environmental Management and Coordination act (EMCA) of 2006 (water quality regulations) provides the effluent quality standards acceptable before discharge into the environment (EMCA, 2006a). It also provides guidelines for waste water use in irrigation and standards for irrigation water.

Under the act, anybody disposing wastewater is required to hold a permit for discharge and is required to continually carry out monitoring of the effluent to ensure compliance with the set standards. The EMCA waste management regulations (EMCA, 2006b) mainly deals with solid waste management while the EMCA controlled substances regulations (EMCA,2007) deals with control and management of hazardous substances.

Recently the Ministry of Environment and Mineral Resources together with the National Environment Management Authority (NEMA) launched guidelines for e-waste management in Kenya. The guidelines acknowledge that electrical and electronic waste pose a great environmental challenge due to the rapidly increasing quantities and the toxicity of some of the components used (NEMA, 2011). UNEP (2007) has estimated that Kenya generates 11,400 tonnes of e-waste from refrigerators, 2800 tonnes from television sets, 2,500 tonnes from personal computers, 500 tonnes from printers and 150 tonnes from mobile phones. The purpose of the guidelines is to assist the government, the private sector, learning institutions among others to manage e-waste in a manner that enhances environmental protection. Since e-waste is not expressly provided for in the existing regulations, the guidelines advise that e-waste may be classified as hazardous waste.

ENVIRONMENTAL RADIATION

There are two forms of radiation: ionizing and non-ionizing radiation. Ionizing radiation can ionize atoms and cause molecular instabilities and resulting tissue damage. Examples in this class include x-rays, alpha, beta and gamma radiations. On the other hand non-ionizing radiation has considerably lower frequencies and may not carry enough energy to cause ionization. Examples include microwaves, RF (radiofrequency) waves, ultraviolet and infrared radiation. However excessive exposure to non-ionizing radiation has been associated with nausea (Maneesh et al), fatigue, headache, sleep disruption and memory loss (Sin-Eng and Jit-seng, 2000). Abdel (2006) reported a change in performance of neurobehavioral functions of office workers working near base stations.

There has been a high rise in the number of mobile phone subscribers in Kenya fuelled mainly by the falling costs of mobile phones, low call and voice communication charges, increasing applications such as money and money banking services. The Communications Commission of Kenya, CCK (2010) estimated that there were 19.4 million mobile phone subscribers in Kenya in

2009 while the ITU (2009) estimated that by the year 2013 mobile phone penetration will reach 66.7%. CCK is Kenya‟s statutory regulator of all telecommunication services in the country. To support connectivity for subscribers the operators have constructed numerous base stations countrywide with more installations in densely populated areas. By 2008, the Radiation Protection board had estimated that there were about 4000 base stations in Kenya (RPB, 2008).

Ombati et al (2011) recently investigated the intensities of radiofrequency radiation from selected mobile phones and made an assessment based on the internationally established standards on non-ionizing radiation. Most of the mobile phones in use were found to emit radiofrequencies within the International Commission on Non-Ionizing Radiation Protection‟s (ICNIRP) safe exposure limits. No such studies have been reported on the safety levels of the radiation emitted by base stations.

On the other hand, ionizing radiation exposure could result from background Naturally occurring radioactive materials (NORM) from soils or rocks or from cosmic radiation entering the atmosphere from outer space. Technologically enhanced naturally occurring radioactive materials (TENORM) result from human activities such as mining, mineral processing, nuclear power generation, medical diagnostics and therapeutic procedures. In a nutshell TENORM is natural radiation exposure that could not occur without some technological activities, not designed to produce radiation, being undertaken. International guidelines for dealing with radiation are formulated and periodically updated by the International Atomic Energy Agency (IAEA) and the International Commission on Radiological Protection (ICRP) based on the risk factors. The recommended annual effective radiation dose limit for the general public is 1 millisievat (mSv) per year (ICRP, 1991). The first radiological survey in Kenya was reported by McCall (1958). He analyzed radioactive iron stones from parts of Kenya but did not find viable deposits of radioactive minerals. Later on Mangalla (1987) performed X-ray fluorescence analysis on sediment samples from Mrima hills in the coast province and found high concentration of thorium and rare earth metals. Patel (1991) in follow up studies established that the area is composed of weathered carbonatite rock associated with presence of radioactive elements. A radiological survey carried out in the Lambwe valley in Nyanza province established that the area has a high natural background radiation (Achola, 2009). However no studies on cancer incidences have been done in the two areas. Mustapha et al (2002) carried out a study on radon concentrations in drinking water and indoor air in some parts of Kenya. More recently an

assessment of radioactivity levels in the Tabaka soapstone quarries of the Kisii region showed low levels corresponding to excess lifetime cancer risk of only 0.07% (Kinyua et al).

Incidences of adverse radiation exposure due to TENORMs have not been documented in Kenya. Kinyua and Kiti (2006) carried out a study on radiation exposure levels on radiation workers (radiotherapy, diagnostics, nuclear medicine, agriculture and education) in Kenya using Thermoluminescent dosimetry technique. They found that the radiation exposure levels were within the levels recommended by the ICRP. Furthermore the exposure levels have been falling over the years, perhaps due to use of better technologies. The use of ionizing radiation in Kenya is regulated by the Radiation Protection Board (RPB) in the Ministry of Health. The RPB was established under an act of parliament and is charged with the responsibility of protecting the health and safety of people and the environment from the harmful effects of ionizing radiation. Among other committees, the board has a radioactive waste management committee which plays an advisory role to the board.

NOISE AND AIR POLLUTION

Sound consists of pressure variations that can be detected by the human ear. It is produced when bodies or air particles vibrate and is transmitted as a longitudinal wave. It is therefore a form of mechanical energy. The number of vibrations is measured as the frequency but if felt as the pitch. Audible sound ranges from 18Hz to 18kHz. On the other hand, noise is sound that creates unpleasantness and discomfort in people who listen to it. The unpleasantness and discomfort depends on the sound pressure level, the frequency of the sound vibrations, the duration of exposure and the susceptibility of the individual listener.

Noise has been associated with headache and stress (Sataloff and Sataloff, 2006), tinnitus (Phoon et al, 1993), and elevated blood pressure (Willich et al, 2006). Noise induced hearing loss can occur after years of exposure to high levels of noise. Acoustic trauma may also occur from a one time exposure to excessive sound pressure (Rabinowitz, 2000). In Kenya, open air informal industries (Commonly referred to as *Jua Kali*) consisting of metal fabrication and motor vehicle repairs, public bus parks and music stores generate considerable noise. Kimani (2011) has studied the noise exposure levels among workers in the metal fabricating sector in Nairobi, Kenya. He concluded that environmental workplace noise is a significant problem in the

Nairobi *Jua Kali* metal fabricating sector where noise levels ranged from 72.0 db to 113.8 db. Furthermore, 93.8% of the workers were found to be exposed to noise levels of 90db and above for more than 8hours daily. This is way above the 75db noise exposure level recommended by the World Health Organization for workshop and plant area (WHO, 1999). He also found out that most of the workers did not use hearing protective equipment due to their high cost and recommended duty exemption on the imported protective equipment and the use of work processes that reduce noise.

There are two key legislations that regulate noise pollution in Kenya. The Environmental Management and Coodination act of 2009 legal notice number 61 regulates the licensing procedures for activities likely to generate noise that may be a nuisance to other people. The Occupational Safety and Health act of 2007 (ROK, 2007) sets limits for noise exposure and requirements for noise control in workplaces. According to the act, no worker should be exposed to noise levels above 90db for more than 8 hours in a day.

In air pollution the pollutants may be gaseous, aerosol or solid particulate. There is need to control air pollutants sinsce they may be toxic, carcinogetic or in general have an adverse effect on the respiratory system. Air pollutants can be treated using various methods which depend on the type of pollutant. The most common are the cyclone collectors used to collect dry dust and powders and the fabric filter collectors used for removing dry particulate matter from gaseous streams. Others include scrubbers that absorb water soluble gases and fiberbed filters that coalesce and capture liquid contaminants such as aerosols or acid mists. A certain class of air pollutants can be removed using biologic methods (Robert, 1993). Not much work has been done in monitoring air pollution in Kenya even though vehicular emissions and industrial emissions are causing concern.

FOREST MANAGEMENT

In addition to providing food, raw materials and other resources, forests offer habitats for animals, plants and micro-organisms. Healthy forests soak in rain and prevent flooding. They also act as a carbon sink. The Mau, Mt Kenya, Mt Elgon, Cherangani and Aberdare forests are the major natural forests variously referred to as the water towers of Kenya. The forests face a continuous threat from irregular settlements and excisions in addition to illegal forest resource exploitation and the resulting degradation. Forest management in Kenya is mainly governed through the Forest act of 2005 even though

Kenya‟s forest policy was first written in 1957. The policy was meant to ensure sustainable forest exploitation as well as encourage afforestation and conservation. This was subsequently revised in 1968. The act allows local communities living adjacent to forests to play a role in forest management through community forest associations. These associations can then get into joint management agreements with the Kenya Forest Service. This was after recognizing that the livelihoods of the local communities were dependent on the forests. The communities use the forests for spiritual, cultural and material benefits – including food, water, medicinal herbs, firewood, fodder and construction materials. Despite the existence of applicable legislation, the Government of Kenya estimated that by 2009 the Mau forest complex had lost about 25% of its land to irregular excisions [GOK, 2009b].

CONCLUSION

It is evident that Kenya has developed very progressive environmental legislation and almost every aspect of the environment is covered. Even though NEMA has the overall responsibility for enforcement of applicable environmental legislation, there are other government agencies involved. These include the Public health ministry, the Local government authorities, the radiation protection board, the communications Commission of Kenya, the Kenya Police and the Judiciary. Weaknesses in enforcement may be a consequence of the general public sector apathy where corruption and cronyism take center stage. In summary, the high rate of population growth in Kenya coupled with low enforcement of applicable environmental legislation may be responsible for environmental degradation in Kenya. The situation may change when the new constitution is fully implemented and transparency in public sector appointments gains ground. It is highly recommended that the Kenya government immediately formulates a program for sustainable population growth.

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Chapter 7

ECONOMIC DEVELOPMENT AND FOOD SECURITY IN KENYA: THE SHAMBA SYSTEM*

Tabitha W. Kiriti-Nganga
University of Nairobi, Kenya

INTRODUCTION

Kenya‟s gross domestic product (GDP) grew at an annual average of 6.6 percent from 1963 to 1973. Between 1974 and 1990, however, Kenya‟s economic performance declined. From 1991 to 1993, Kenya had its worst economic performance since independence. From 1994-96, Kenya‟s real GDP growth rate averaged just over 4 percent a year. Its economic growth rate declined from 1.4 percent in 1998 to a negative 0.3 percent in 2001. In 2000, GDP growth was negative, but improved slightly in 2001. Economic growth continued to improve slightly in 2002 and reached 1.4 percent in 2003; it was 4.3 percent in 2004, 5.8 percent in 2005 and 6.4 in 2006 (Table 1). However, this growth was not maintained in 2008 due to the post election violence after the December 2007 elections.

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Kenya‟s population was estimated to be 35.5 million in the year 2005 (50.7 female and 49.3 male) with a growth rate of 2.4 percent per annum. Its economic performance in the last two decades has been far below its potential. Its income per capita in constant 1982 prices declined from US dollar 271 in 1990 to 239 in 2002 and rising to 481 in 2004. However, it fell to 464 in 2005 (UNDP 2006).

Table 1. GDP Growth Rate 1963-2007

Year	Growth Rate
1963-1973	6.6
1990	1.4
1994-1996	4.0
1998	1.4
2000	-0.2
2001	1.2
2002	1.1
2003	1.0
2004	4.9
2005	5.8
2006	6.4
2007	7.0

Source: UNDP, Human Development Reports [Various Issues].

Unemployment stands at close to 15 percent of the labour force and youth unemployment accounts for 45 percent of this total. The deterioration in Kenya‟s economic performance has aggravated the problem of poverty that is estimated to have an incidence of 56 percent (Republic of Kenya 2003) although this fell to 49.7 per cent in 2005 (Republic of Kenya 2007; Kenya Integrated Household Budget Survey 2005/06).

The incidence of poverty varies from one province to another. In 1994, the North Eastern Province recorded the highest level at 58 per cent; the Eastern had 57 per cent, the Coast province 55 per cent and Nyanza 42 per cent while Central recorded the lowest level of 32 per cent. By 1997, poverty had increased rapidly and its distribution pattern changed with Nyanza recording the highest level 63 per cent, followed by the Coast 62 per cent, Western and Eastern 59 percent, Rift Valley 50 percent and Central 31 per cent. In 2005, Central still recorded the lowest poverty at 30.4 percent, Coast at 69.7 percent;

Eastern at 50.9 percent; North Eastern at 73.9 percent, Nyanza at 47.6 percent; Rift Valley at 49.0 percent and Western at 52.2 percent.

The incidence of poverty also varies from rural to urban areas. In 1997, it was estimated that 75 percent to 80 percent of the poor live in the rural areas. In the rural areas, food related poverty was estimated at 51 percent while absolute poverty was 53 percent. In urban areas, food related poverty was estimated at 38 percent while the absolute poverty was 49 percent. The overall national incidence of poverty stood at 56 percent. In urban areas, Kisumu recorded the highest 63 percent, followed by Nairobi 50 percent, Nakuru 41 percent and Mombasa 38 percent. In 2005, rural poverty stood at 49.1 percent while food poverty was 47.2 percent. In Urban areas, absolute poverty stood at 33.7 percent while food poverty stood at 40.5 percent (Republic of Kenya 1994-2007). The number of poor increased from 3.7 million in 1972-73 to 11.5 million in 1994. Thereafter, numbers increased to 12.5 million in 1997 and in 2005 the number of poor people living below the poverty line reached some 16.7 million.

FOOD SECURITY

Food security means that all people, at all times, have physical and economic access to sufficient, safe, and nutritious food to meet their dietary needs and food preferences for an active and healthy life (FAO 1996a). According to Barraclough (1996) food security is the access to food for a healthy life by all people at all times. According to the Food and Agricultural Organisation (FAO1996) and the World Food Program in Collaboration with the United Nation High Commission for Refugees (WFP/UNHCR 1997) food security is a basic human right, which extends to the right to safe food and information about the content of food eaten. It is more important than producing a sufficient volume of food in a given country or region. In other words, it is people's entitlement to available nutritious and safe food over time. This therefore means that there has to be adequate distribution of food or purchasing power to obtain it as articulated by (Sen 1981, 1994 and 1996; Eicher and Statz 1986; FAO 1996; Pretty, et al. 1996). Chambers (1988); Davies and Leach (1991) and Maxwell (1991) argue that food security is a part of livelihood security at the individual, household, community, and national levels.

Maxwell (1991); Maxwell and Freundenberger (1992); Barraclough (1996) and FAO (1996) contend that for a country to have food security, it has

to have reliable capacity to produce and store food. It also has to ensure equity in access to food and to productive resources for all individuals and groups, as determined by entitlement (i.e. the ability to buy, exchange, or acquire food and gain access to or control of productive resources). It also has to ensure sufficiency (in food quantity) or ability to cope with insufficiency. Apart from this, there has to be nutritional security at the household level (i.e. adequate protein, energy, micro-nutrients, and safe food for all household members, including women, men and children); ensure socially and environmentally sustainable food production and distribution over time; and also ensure low risk and vulnerability to economic and ecological fluctuations.

FOOD INSECURITY

Food insecurity is exhibited by famines and food emergencies brought about by food production decline. More importantly for this definition, food insecurity has a temporal dimension: chronic (or long-term) food insecurity occurs when a population has continuously inadequate consumption. Chronic food insecurity arises from conditions of poor food production, limited incomes and poor health. Current (or transitory) food insecurity occurs when a population suffers a temporary decline in consumption. Current food insecurity can result from instability in food production, food prices, household incomes and health conditions.

The reasons for food insecurity are many and may include war, poverty, inadequate agricultural technology, inappropriate policies, high population growth, environmental degradation and poor health. Food aid is also a determinant of food security. Sub-Saharan Africa and Asian countries have been the largest recipients of food aid, receiving more than 60 per cent of the total food aid in the last 16 years.

Hunger in Kenya could also be due to households having insufficient resources to purchase the food they need from available supplies. This is dependent on the level of income and its distribution among households. High income inequality reflected in the Gini coefficient of 0.445 in 1997 compounds the problems of chronic hunger in Kenya. Maintenance of a reasonable the growth rate of the economy and development of the rural/agricultural sector can reduce inequality in income distribution.

Despite the strong growth in food production in the world during the last decade, SSA is the only region where the number of hungry people has risen, over 19% during the last decade. In 2002-04, roughly 350 million people,

more than half of the region‟s population, fell into this category. The region‟s production of grains and root crops (staple foods) grew at a rate of 2.4 per cent per year.

However, SSA‟s population growth rate negated these gains in production. Table 2 shows food availability and food gaps for Sub-Saharan African countries.

Table 2. Food Availability and Food Gaps for Kenya (1988-2007)

Year	Grain production	Root production (grain equiv.)	Commercial imports (grains)	Food Aid receipts (grain equiv.)		Aggregate availability of all food
---1000 tons---						
1988	3453	452	0	86		3396
1989	3399	513	71	89		3625
1990	2723	485	296	65		3764
1991	3033	480	136	186		3817
1992	3085	500	359	288		3809
1993	2220	524	312	236		2986
1994	3520	524	1080	111		4307
1995	3130	541	291	56		3986
1996	2730	549	668	32		3716
Projections						
				Food gap*		(without food aid)
				SQ	NR	
1997	3030	555	753	256	245	3876
2002	3599	602	788	174	162	4463
2007	4025	652	860	316	302	4951

NB: SQ stands for status quo and describes the amount of grain equivalent needed to support 2002-04 levels of per capita consumption.

NR stands for nutritional requirement and describes the amount of grain equivalent needed to support nutritional standards.

Source: United States Department of Agriculture, Economic Research Services, Food Assessment 2005.

Kenya‟s annual growth in calories consumption between 1992 and 2002 was only 1.13 and its share of cereals in diet was 47.7 per cent. In 2015 Kenya will have a nutritional food gap of 1,140 thousand tons while the distribution gap in 2015 will be 1,776.

From the above analysis, it can be said that progress toward achieving the 1996 World Food Summit goal of reducing hunger in Kenya by half by 2015

has been constrained by slow growth in domestic food production, global population growth and high food prices, inadequate financial capacity to import, income inequality and misuse of resources hence turning more acres of land which would have hitherto been used for food production into deserts.

Climate change and its impact on general livelihood in the world have forced developed countries to look for alternative sources of clean energy. The shift from agricultural production to the lucrative business of biofuels has seen food literally being used to fuel industry and automobiles. Biofuels such as ethanol are produced from renewable biological resources like corn. In addition to trying to reduce pollution, developed nations sought biofuels to counter high oil prices. Oil prices are being driven up by increased demand from industrialised and industrialising countries, against declining supply caused mainly by resource depletion and political instability in source markets. These high prices are mostly felt in developing countries where the system of food production and distribution is heavily dependent on oil and other fossil fuels for processing, packaging, storing and transportation.

FOOD INSECURITY IN KENYA

The agricultural sector recorded a slow growth of 2.3 per cent in 2007 from 4.4 per cent recorded in 2006. The growth was largely attributed to delayed long rains and low volumes of short rains in 2007 (Republic of Kenya 2008). The main food stuffs consumed in Kenya are maize grains and maize flour, beans, sorghum and millet, potatoes, and fish. However, the staple foods are maize and beans. Table 3 shows the trend in production of some selected foodstuffs.

From Table 3, it can be seen that maize production declined by 6.1 per cent to 32.5 million bags in 2007 from 34.6 million bags recorded in 2006. Similarly, production of beans declined by 40.7 per cent to 3.5 million bags compared to 5.9 million bags in 2006. The production of wheat declined by 40.9 per cent between the year 2005 and 2007. The decline could be attributed to the delay in long rains and the low volume of short rains received in the growing zones.

Food insecurity in Kenya is both an acute and chronic problem. One of the leading causes of food insecurity in Kenya is population growth (approximately 2.758 per cent in 2008) which puts pressure on food availability.

Table 3. Yearly Production of Some Selected Foodstuffs in Kenya (1997-2007)

Food Item	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Maize (million bags	20.6	27.3	25.0	25.0	30.6	26.0	28.0	29.0	32.3	34.6	32.5
Beans (million bags	1.6	3.0	4.0	3.7	4.1	4.0	4.0	3.2	4.3	5.9	3..5
Irish Potatoes (million tons)	1.1	0.9	1.6	1.1	1.5	0.9	1.0	1.1	1.0	0.8	1.0
Milk intake (million litres)	240	126	180	137	148	178	203	274	340	361	423
Sorghum (million bags	0.7	0.9	1.2	0.9	1.2	0.8	0.8	0.8	1.7	1.6	1.8
Millet (million bags)	0.26	0.37	0.4	0.4	0.5	0.6	0.6	0.7	0.6	0.8	0.9
Wheat (tonnes)	125.8	177.1	55.4	73.8	81.5	60.1	75.6	88.3	128.7	106.1	112.9

Source: Republic of Kenya, Economic Survey (Various Issues).

Kenya has almost been self sufficient in the supply of meat, milk (excluding butter), eggs, fish and other sea foods and other animal products over the last six years. Similarly, almost 100 per cent of vegetables and vegetable products consumed in the country were obtained from domestic production. This also applies to the domestic supply of starchy roots such as potatoes, cassava and yams whose supply nearly meets demand.

However, Kenya has not been self-sufficient in production of cereals including maize, wheat, rice, millet and sorghum. In 2005, the self sufficiency rations for cereals and vegetable products stood at 79.6 per cent and 81.8 per cent respectively.

Kenya imports a number of foodstuffs usually to supplement domestic production or in cases where the commodity is not available locally. Cereals (excluding beer), vegetable products, sugar and sweeteners, spices, and fish and sea food are the main commodities imported. In the period 2000-2005, the import dependency ratio for cereals has been on the decline, ranging from 19.5 per cent in 2002 to 31.5 per cent in 2000 and stood at 21.0 per cent in 2005. The country‟s dependency on imports of sugar and sweeteners was 24.4 per cent in 2005 (Republic of Kenya 2007).

AGRICULTURE AND FOOD SECURITY IN KENYA

Land is the main asset in agricultural production and generally, limited availability of productive land is a major constraint to increased agricultural production. Kenya has an area of about 587,000 square kilometres of land area, of which 11,000 and 576,000 square kilometres are water and land mass respectively. Only about 16 per cent of the latter is of high and medium agricultural potential, largely because it receives adequate and reliable rainfall. The rest falls under arid and semi arid lands (ASALs). Land tenure in Kenya is classified into three broad categories, namely: communal land, government trust land, and the private land (owned land, by individuals, groups or companies).

The climate of Kenya varies with its location within Kenya. The climate along the coast is tropical. This means that rainfall and temperatures are high throughout the year. The further one moves to island area, the more arid the climate that one gets. An arid climate is nearly devoid of rainfall and temperature swings violently according to the relevant time of the day/night.

Kenya‟s terrain is composed of low plains that rise into central highlands that are, in turn, bisected by the Great Rift Valley. The lowest point in Kenya

is at sea level on the Indian Ocean. The highest point on Kenya is 5,199 meters above sea level at Mt. Kenya.

The two main rivers are the Galana and the Tana. However, the Ewaso Nyiro is a very important river supplying water from Mt. Kenya to the northern part of Kenya.

Natural resources that are found in Kenya include limestone, soda ash, salt, gemstones, fluorspar, zinc, diatomite, gypsum, wildlife and hydropower. In 2003, only 8.17 per cent of the land was arable. Permanent crops occupy 0.97 per cent of the land. Other uses make up the rest of Kenya's land.

Arable land includes land defined by the FAO as land under temporary crops (double-cropped areas are counted once), temporary meadows for mowing or for pasture, land under market or kitchen gardens, and land temporarily fallow. Land abandoned as a result of shifting cultivation is excluded. Only 1030km² of Kenya's land is irrigated.

The main feature of Kenya‟s agriculture is domination of small-scale farmers who account for 75 per cent of total agricultural production and 70 per cent of marketed agricultural output. Production is carried out on small land holdings averaging 2-3 hectares mainly for both dairy and beef subsistence and commercial purposes. Large-scale farming is practiced in Kenya on farms averaging 50 hectares and above and accounts for 30 per cent of marketed agricultural production.

The communities in arid and semi-arid lands of the country are particularly vulnerable to food insecurity because of the recurring natural disasters of drought, livestock diseases, animal and crop pests, and limited access to appropriate technologies, information, credit, and financial services.

Kenya is a low-income food deficit country, and it is a regular importer and occasional exporter of grain. The biggest deficit in absolute terms has been in coarse grains such as maize, and beans and in such other cereals as wheat and rice, which are the leading staple in the country. This lack of self sufficiency in national food production equates to a serious indicator of food insecurity given the importance of subsistence agriculture and pastoralism as a proportion of rural household livelihoods and the minimal purchasing power of such households.

One of the factors that have led to low food production in Kenya, is the small amount of land under production (arable land). Farmers are also facing a crisis of inadequate knowledge caused by slow technology adoption and low rates of knowledge dissemination by the researchers and extension agents. Selective and single sectoral food production also contributes towards food insecurity. Kenya has always advocated for maize production as food is

always seen in terms of availability of maize products. This has made people to only select production of what they consume, not thinking of producing for the market, i.e., market oriented production.

Most farmers in Kenya always farm as a tradition, and not as an enterprise, leading to land depletion problems and wasteful land use - since they do not carry out proper utility of land as a resource. Cash crop farming has dominated most arable areas, not giving room for subsistence farming of other crops, as there are no policies to encourage subsistence agriculture in places where cash crop farming is practiced (Kiriti and Tisdell 2004).

Low food production has major effects on nutrition for all people young and small. For example, during the period 1996-2004, 22.8 per cent of children under the age of 5 years were undernourished in Kenya and the probability at birth of not surviving beyond 40 years between 2000 and 2005 in Kenya was 44.8 per cent (UNDP 2006). The Republic of Kenya (2000) also shows that 37 per cent of children had stunted growth or too short for their age and 6 per cent were wasted or too thin for their height.

Marketing and distribution of agricultural products contributes to food insecurity for example, some areas may have a surplus production, whereas others may have an extreme deficit. This requires improvement in infrastructure so as to reduce production and marketing costs. There is also the need to reduce market barriers on the export market to allow small holder farmers to participate freely.

ENVIRONMENTAL DEGRADATION AND FOOD SECURITY IN KENYA

Westing (1991) and OECD (1996) define environmental security as a state in which an ecosystem is able to support the healthy pursuit of livelihoods by the people living in that system. It entails the rational and sustainable use of natural resources and safe disposal of wastes, as well as protection from pollution and abuse and the conservation of biological diversity.

Output from forestry in Kenya has declined because of resource degradation. Overexploitation over the past three decades has reduced the country‟s timber resources by one-half. At present only 2 per cent of the land remains forested, and an estimated 50 square kilometers of forest are lost each year. This loss of forest aggravates erosion, the silting of dams and flooding,

and the loss of biodiversity. Among the endangered forests are Kakamega forest, Mau forest and Karura forest.

Kenya‟s forests are rapidly declining due to pressure from increased population and other land uses. With most of the country being arid and semi-arid, there is a lot of strain on the rest of the land since the economy is natural resource based. The productive area, which forms about 20 per cent of the country‟s area falls in the medium and high potential agro-ecological zones and is under agriculture, forest and nature reserves. According to FAO Forest Resource Assessment 1990, Kenya is classified among the countries with low forest cover of less than 2 per cent of the total land area. The dwindling forest cover has a severe effect on the climate, wildlife, streams and human population especially forest dwellers.

Table 4. Forest Plantation Area, 2002-2006 (000 Hectares)

Type of Forest	2002	2003	2004	2005	2006	2007
Indigenous Trees	12.3	12.3	12.3	12.3	12.3	12.3
Exotic Trees	89.4	92.5	98.7	98.7	98.7	98.7
Total	101.7	104.8	111.0	111.0	111.0	111.0
Fuel Wood and Poles						
Exotic Trees	19.3	20.3	21.3	21.3	21.3	21.3
Total Area	121.0	125.1	132.3	132.3	132.3	132.3

Source: Republic of Kenya (2008).

In Kenya, the continued interference with forest cover resulting in reduced water catchments and conflicts of access to forest resources between forest managers and adjacent communities remain the major challenges facing the forest sub-sector. Since 2004, the area under forest plantation has remained unchanged at 132.3 thousand hectares as there have been no excisions or opening of new areas for forest development as shown in Table 4. The area under indigenous and exotic forests also remained unchanged at 12.3 and 98.7 thousand hectares respectively.

The main environmental factor behind food insecurity in the country is deficient rainfall. The vulnerability of a household or area to food insecurity is determined not only by the amount of rainfall a place receives but also the seasonality of the rainfall. There is universal agreement that the riskiness of the environment is the major factor impacting upon the food security status of the household. Drought is seen as the main cause of food insecurity in Kenya (FEWS 1995; Save the Children Fund-UK 1997; IGADD, 1990). FEWS (1998) classified the majority of marginal agricultural areas as well as the

pastoral areas as highly risky environments. The impact of drought or low rainfall in food crop production in Kenya is aggravated by the fact that food production in Kenya is rain-fed (Mbithi 2000). Low production due to drought leads to increased fluctuations in food availability. Drought also leads to high mortality as well as poor body condition of livestock and therefore low livestock prices (Government of the Netherlands/Government of Kenya (DRIRP) 1996; Save the Children Fund-UK 1997). These factors erode purchasing power of households, which directly affects their food security.

The water hyacinth weed proliferation on Lake Victoria reduced the food security of the fishing households. Fishermen who had no access to large boat could not catch fish in the weed-covered shorelines. Fishing communities therefore suffered income loss. The weeds led to severe flooding on the lakeshores, which further led to severe destruction of crops during the 1997/1998 short rains (FEWS 1998). The worst affected areas included Kisumu, Homa Bay, Rachuonyo, Siaya and Busia.

FOOD SECUTITY AND THE SHAMBA SYSTEM

Kenya‟s shamba system or „taungya‟ originated in Burma and was introduced in Kenya by the colonial government in the early 1900s. Its objective was to provide cheap labour for plantation development in Kenya. Since then, the system has been used intensively to establish exotic plantation in many parts of the country, especially in the provinces of Central and Rift Valley. At the beginning, cleared forest was allocated to smallholders for cultivation. After one season, seedlings were planted and the farmers were allowed to plant their crops at the same time. This continued during subsequent seasons until the plantation was established.

The system was seen as the best approach to plantation development since very little financial resources were used, but it has contributed to food security, provided lands to the landless, and ensured continued and systematic re-afforestation of cleared forest lands.

Politicians initially supported and replicated the shamba system in their regions. However, it later metamorphosed into a conduit for excising forest land and allocating it to individuals. Politicians, under the guise of protecting the landless and the shamba system allocated their families and clans, huge chunks of the forest land. In some cases, communities from outside the areas near forests were given land and the original beneficiaries driven out. Such irregularities created conflict and hostilities between and among local

communities, politicians and government personnel. As a result, farmers deliberately manipulated the performance of planted seedlings, either by de-barking or cutting the roots of saplings to ensure continued tenancy of the land for subsistence crop production.

Gradually, the abuse of the system has led to intense and unregulated cultivation in forests. Forests were exploited for timber and opened to grazing. Indigenous forests were encroached and riverines cultivated. In 1985, the government banned the system, especially in key water towers, including Molo, Timboroa, Mau, and Bahati forests. In some places, the system continued due to political patronage, and despite the ban, forest encroachment was unabated. In 1986, the government used the Nyayo Tea Zone development approach to control forest encroachment in areas adjacent to Mau and the Aberdares forest. These tea buffer plantations were expected to stem the increasing trend in cultivation encroachment.

The Nyayo Tea zones however, promoted illegal logging by local communities and tea factories for processing purposes. In 1993, the President lifted the ban on the shamba system because the government could not cope with the backlog in its re-forestation program. Even after the ban, cleared forest land was never replanted. A study by the Kenya Forest Working Group and Kenya Wildlife Service (KWS) in (2003) revealed that over 75 per cent of clear-felled plantations in Mt Kenya, Imenti and Ngare Ndare had not been replanted with trees, although these areas are under the shamba system. Similarly, only 21 per cent of clear felled plantation forest land on the margins of the Aberdares Range Forest was replanted with trees (Kenya Wildlife Service 2003).

The mortality rates of tree saplings have also been very high, with tree survival in shamba zones declining dramatically in the second and third year of cultivation. Surveys in areas where the shamba system was practised at the margins of Kakamega, South Nandi and Mt. Elgon forests show that tree sapling survival declined from 90 per cent in the first year to less than 40 per cent in the third and fourth years (Awiti, et al. 2004).

Replacement planting efforts are also constrained by lack of seedlings. The margins of indigenous forest in the neighbourhoods of the shamba system zones are also the most active frontiers of deforestation. For instance, 4 per cent and 19 per cent of forest cover has been lost in Aberdares range and Mt. Kenya respectively due to cultivation encroachment (Kenya Wildlife Service 2003).

Awiti et al. (2004) observed that farmers cultivating in shamba zones towards the Kakamega and South Nandi Forests had extended their farms by

about 30 meters into the forest between 1990 and 2003. These are catalysed by markets, factors influencing expansion of agricultural land, politics, and lack of boundary enforcement by government agencies. In 2002, a newly elected government reinstated the ban on the shamba system, arguing that it had caused forest destruction by encouraging squatters to settle in forests. However there were proactive political leaders who wanted the shamba system allowed to continue. As a result of pressure by such leaders, a pilot project was commissioned in Ndundori forest in the Subukia area of Nakuru in September 2004.

It can be argued that the shamba system has since matured into a political strategy. Since its inception, the government‟s attitude manifests its limited ability to deal with the difficult forest management challenges fuelled by landlessness, poverty and food insecurity. Matching political interests and environmental conservation objectives most often threatens the status quo. Weaknesses within the interface between conservation and development provide the rationale for proponents of the shamba system, politicians, and forestry professionals to advocate its re-introduction.

The first reason is the inability of the Forest Department to finance reforestation or afforestation programs. The ban on the shamba system caused a reforestation backlog of 30,000 hectares due to limited financial resources for forest management. In Kenya, the cost of planting a hectare of trees and financing the establishment of plantations is Ksh.3000 and Ksh.27000 respectively. Under the shamba system, these costs would be greatly reduced, as smallholders would continue weeding and looking after the young seedlings for about 3 to 4 years.

The secondly, reason is the ability of the Shamba System to offer an interim solution to the squatter crises that has remained unresolved around forests in Central Kenya and Rift Valley Province especially in the Mau and Subukia areas. It is expected that with the ongoing land policy reforms, a long-term solution to the nagging land crisis will be provided.

The third is the capability of the Shamba System to provide a traditional method of achieving household and national food security. The supply deficits of Irish potatoes, carrots and beans to urban areas were attributed to the ban on this system in 2003. Without the resident-cultivation system, a food deficiency is expected in areas where the arrangement had been in place.

The fourth is the problem of national security posed by the social and economic impacts of forest eviction and prolonged ban of the shamba system. Former forest evictees and unemployed youths are more likely to engage in illegal activities, including robbery in towns.

Despite the strengths and advantages of the shamba system however, it is noted that continued reliance on forest land for agriculture by farmers as well as their tendency to agitate for extended tenancy and poor attitude towards reforestation (manifested in destructive activities such as debarking of saplings) were the main reasons for its failure. New forms of partnerships and adoption of integrated approaches to national resource management can provide opportunities for improving the shamba system. The adoption of innovative approaches like reward mechanisms in some catchments could come with prescriptions for improved land and land-based natural resource management.

CONCLUSION

From the foregoing, we have seen that Kenya has been suffering and continues to suffer from food insecurity. Arable land is scarce and the available land is not enough to produce enough food and it is also unequally distributed. This led to people entering the forests and practicing non-residential farming through the shamba system while others have actually settled in the forests leading to degradation and deforestation.

Kenya should develop a clear policy in order to eliminate corruption regarding harvesting of forest products and allocation of forestland for private development. The government should also promote development of agro-forestry and encourage community participation in efficient management of forests. This will be complemented with continued re-afforestation including private sector participation to ensure the attainment of the minimum required forest coverage of 10 per cent and increase food production at the same time to reduce food insecurity.

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Chapter 8

REVIEW OF ENVIRONMENTAL GOVERNANCE IN KENYA: ANALYSIS OF ENVIRONMENTAL POLICY AND INSTITUTIONAL FRAMEWORKS*

Caleb Mireri*† *and Sammy Letema
Department of Environmental Planning and Management,
Kenyatta University, Nairobi, Kenya

ABSTRACT

The main aim of this paper is to show that Kenya has made progress in institutionalising environmental governance, particularly following the Rio Conference on Environment and Development. Prior to the Rio Conference, environmental management was scattered in the line ministries with no clear focus on sustainable development. The paper shows that the country has elaborate legislative framework with instruments that can significantly contribute to sustainable environmental management. However, the implementation of the legislation faces a number of challenges including lack of policy on environmental

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† E-mail calebmireri@yahoo.com.

management and weak capacity. It is evident that serious concerted efforts must be directed at capacity building to make the legislative intentions of a good and healthy environment for all in Kenya a reality.

1. INTRODUCTION

Rio Conference on Environment and Development in 1992 gave environmental management major impetus. Member states of the United Nations committed themselves to the principles of sustainable development as per Agenda 21. Sustainable environmental management is an integral part of Agenda 21. Following the conference, member states of the United Nations of which Kenya is one, committed themselves to initiate processes to institutionalise good environmental governance for sustainable development. As part of its commitment to the UN Conference, Kenya implemented National Environment Action Plan (NEAP) in 1994 to provide a basis for up-scaling environmental management in Kenya. NEAP process culminated into Environmental Management and Co-ordination Act (EMCA) of 1999, which came into force in 2002.

Prior to the promulgation of EMCA in 1999, environmental issues had no *Locus Standi*. Environmental management issues were dealt with by several sectors in different ministries and good environmental governance was not highly prioritised. In cases of violations to the environment affecting the public generally, then the person who had an interest and right to sue was the Attorney General and not a private citizen. EMCA has created instruments for good environmental governance with potential to create a clean and healthy environment if only it is effectively and efficiently implemented.

Environmental Management and Co-ordination Act (EMCA, 1999) states that environment includes the physical factors of the surroundings of human beings including land, water, atmosphere, climate, sound, odour, taste, the biological factors of animals and plants and the social factor of aesthetics and includes both the natural and the built environment. The Act defines environmental management includes the protection, conservation and sustainable use of the various elements or components of the environment. The National Environment Management Authority (NEMA), however, have officers up to district levels and thus in the divisions, locations and sub-locations are absent. Moreover, NEMA officers lack transportation facilities, which is central to their effective in enforcement, compliance and violation of environmental rights or damage to the environment. This paper, therefore,

examines environmental policies and institutional framework in Kenya since independence. Despite good progress made in environmental governance in Kenya, especially passage of Environmental Management and Co-ordination Act, the implementation of the Act is faced with serious challenges of weak capacity and lack of policy framework.

2. HISTORICAL PERSPECTIVE OF ENVIRONMENTAL GOVERNANCE IN KENYA

Since independence in 1963, Kenya has formulated a whole range of policy and legal requirements geared towards environmental management. The environmental issues prior to 2002 were however handled by over 20 line ministries and departments dealing with environmental matters. These included among others Ministry of Environment and Natural Resources (MENR), the National Environment Secretariat (NES), the Forest Department, the Kenya Wildlife Service (KWS), and the Permanent Presidential Commission on Soil Conservation and Afforestation. Currently there were more than 70 different laws that either directly or indirectly apply to environmental management including Forest Act, Wildlife Management and Conservation Act, the Factories Act, Water Act, Agriculture Act, and Chiefs Act.

Moreover, the policies and regal requirements are not to be found in one body of policy document or statute or law, but in various national development plans, sessional papers, presidential decree/statements and Acts of Parliament.

The principal environmental agency prior to commencement of National Environment Management Authority (NEMA) in 2002 was NES. NES, however, lacked legislative mandate, autonomy and technical competence to lead an effective national environmental policy formulation. Furthermore, NES was largely ineffective in implementing many of its mandate including promoting and enactment of laws and regulations, enhancing enforcement of legislation, and encouraging scientific research (Juma et al, 1996 in Mugabe et al, 1997). Attempts were made to enhance the coordination role of NES via establishment of Inter-Ministerial Committee on Environment (IMCE), which was coordinated and chaired by MENR. However, IMCE operated in an *ad hoc* basis and lacked legislative mandate. Furthermore, the MENR, which housed and chaired the committee‟s activities had limited capacity and did not

have much influence over other ministries, which were guided by their sectoral policies and interests.

Table 1. Major Environmental Events and Laws in Post Independent Kenya

Events	Year
Sessional Paper No. 10 on African Socialism and its Application to Planning in Kenya	1965
Presidential Decree of 390Km^2 area in Amboseli area for wildlife conservation, which culminated in declaration of Amboseli as National Park in 1975	1971
National Development Plan (1974-1978)	1974
National Environment Secretariat	1974
Wildlife Conservation and Management	1976
Sessional Paper No. 3 on National Policy for Wildlife Conservation and Management	1976
Ministry of Environment and Natural Resources	1979
Forest Act of 1942, Amended in 1982	1982
Presidential Decree declaring aloe species protected	1986
Wildlife Conservation and Management (Amendment)	1989
Green Towns Project aimed at localising Agenda 21 (1992-1996)	1992
National Environmental Action Plan	1994
Physical Planning Act	1996
National Development Plan (1997-2001	1997
Environment and Development Policy	1999
Environmental Management and Coordination Act	1999
Ministerial Position Paper on Environmental Considerations in Land-Use Planning and Management	2000
Waste Management Regulations	2006
Water Quality Regulations	2006

Sessional papers and national development plans were major sources of policy since their was no environmental policy in place. The Sessional Paper No. 10 of 1965 on African Socialism and its Application to Planning in Kenya stated that "heritage of future generations depends on the adoption and implementation of policies defined to conserve natural resources and create physical environment in which progress can be enjoyed. The thoughtless destruction of forests, vegetation, wildlife, and productive land threatens our future and must be brought under control". The 1974-78 National Development Plan articulated the need to manage the environment for ecological, socio-cultural and economic reasons. It recognised the lack of appropriate institutional arrangements and policies as the main factor limiting environmental management: "Not only are the various arms of the government

in disagreement or in confusion but there are no clear policies providing for environmental management and well established and coherent institutional system to implement the policies" (Juma et al, 1996). The 1997-2001 National Development Plan recognises the underlying causes of environmental degradation. It observed that: envireonmental management tools, including laws relating to the management of internationally shared resources, cross-border issues, environmental economics and accounting , and environmental impact assessments, have not been adequately developed for effective environmental management. In the plan the government makes a commitment to achieve successful environmental management through: implementation and enforcement of environmental laws; provision of economic incentives and penalties to encourage sustainable use of natural resources and ecological functions; increasing resource allocation for environmental management; making adjustments in taxation to promote sustainable use of natural resources; and instituting pollution charges (RoK, 1996).

Serious efforts to improve environmental governance in Kenya followed the Rio Conference on Environment and Development in 1992. Kenya as a signatory of Agenda 21 on sustainable development initiated the process of better environmental management beginning with National Environment Action Plan (NEAP) in 1994. The key components of 1994-1999 National Environment Action Plan (NEAP) are:

- Formulation of a national environment policy correlating the environment with economic development;
- Involving local communities and local authorities in formulating renewable resource management policy;
- The need for environmental impact assessment; monitoring of all development projects, including agriculture, irrigation, land allocation and tourism; and
- Review of tax laws to incorporate conservation measures.

The numerous central government agencies with overlapping, poorly coordinated, and limited capacities; and lack of strong local government environmental institutions hamper the development, implementation and enforcement of environmental policies and laws (Mugabe et al, 1997). The inherent weaknesses in sectoral policies led to the formulation of National Environmental Management and Coordination Act (EMCA) of 1999 in order to harmonise all the sectoral laws. However, EMCA did not lapse the existing sectoral laws. Moreover, National Environment Management Authority is

located in the MENR, and thus may face the same problems as NES, which when it was housed in the MENR, it lost its powers to coordinate other ministries as well.

3. STATUS OF ENVIRONMENTAL POLICY

There is no comprehensive and coherent environmental protection policy in Kenya. The legislation exist without the policy. At the moment the government is in the process of formulating environmental policy. Whereas the policy should precede the legislation, in the case of Kenya the legislation is being implemented in the absence of policy framework. Nevertheless, some local authorities have prepared by-laws on environment management in their areas of jurisdictions. Moreover, the private sector enterprises i.e. industries, hotels, real estates developers as well as corporate bodies have prepared environmental management plans to meet ISO certification as well as comply with NEMA regulations by undertaking environmental impact assessment and audit for new and existing projects respectively.

Existing policies are fragmented and sectoral in nature, thus do not provide an enabling environment for other players i.e. line ministries, lead agencies and civil society to orient their activities towards common national environmental policy framework. Whereas we have a comprehensive environmental legislation promulgated in 1999, however, other sectoral statues that touch on environment were not amended and revised accordingly. Each sector or agency, therefore, sought to expand its authority leading to power struggles which result in the disruption of environmental management process. As such, environmental issues are uncoordinated and viewed as sector specific resulting in duplication of efforts, thus their effectiveness is marred. As such, Kenya has been unable to provide the necessary inter-sectoral policy for integration and co-ordination of environmental management.

4. HIGHLIGHT OF KEY LEGISLATIVE PROVISIONS OF ENVIRONMENTAL MANAGEMENT AND CO-ORDINATION ACT (EMCA)

General Principles of Environmental Management

Kenya‟s environmental legislation also known as Environmental Management and Co-ordination Act (EMCA) was passed into law in 1999 and came into force in 2002. EMCA provides for the creation of National Environment Management Authority to co-ordinate the various environmental management activities being undertaken by the lead agencies and promote the integration of environmental considerations into development policies, plans, programmes and projects with a view to ensuring the proper management and rational utilization of environmental resources on a sustainable basis for the improvement of the quality of human life in Kenya.

The general principle of EMCA as provided for in Section 3 of the legislation states that every person in Kenya is entitled to a clean and healthy environment and had the duty to safeguard and enhance the environment. The entitlement to a clean and healthy environment under subsection (1) includes the access by any person in Kenya to the various public elements or segments of the environment for recreational, educational, health, spiritual and cultural purposes. Other principles governing environmental management in Kenya are:

a) public participation in the development of policies, plans and processes for the management of the environment;
b) the cultural and social principle traditionally applied by any community in Kenya for the management of the environment or natural resources in so far as the same are relevant and are not repugnant to justice and morality or inconsistent with any written law;
c) international co-operation in the management of environmental resources shared by two or more states;
d) inter-generational and intra-generational equity;
e) the polluter-pays principle; and
f) the precautionary principle.

Administration of Environmental Legislation

EMCA (1999) Section 9 (1) creates National Environmental Management Authority. The object and purpose for which the Authority is established is to exercise general supervision and co-ordination over all matters relating to the environment and to be the principal instrument of Government in the implementation of all policies relating to the environment.

The Act, sections 24 and 25 respectively creates National Environment Trust Fund and Restoration Fund to facilitate environmental Management. The object of the Trust Fund shall be to facilitate research intended to further the requirements of the environmental management, capacity building, environmental awards, environmental publications, scholarships and grants. The object of the Restoration Fund shall be as supplementary insurance for the mitigation of environmental degradation where the perpetrator is not identifiable or where exceptional circumstances require the Authority to intervene towards the control or mitigation of environmental degradation.

The Act (Section 28) creates instruments to cushion the environment from environmental degradation. The Environmental Authority shall create a register of those activities and industrial plants and undertakings which have or are most likely to have significant adverse effects on the environment when operated in a manner that is not in conformity with good environmental practices. The Minister responsible for finance may, on the recommendations of the National Environment Council, prescribe that persons engaged in activities or operating industrial plants and other undertakings identified under subsection (28.1) pay such deposit bonds as may constitute appropriate security for good environmental practice. The Environmental Authority may, after giving the operator an opportunity to be heard, confiscate a deposit bond where the operator is responsible for environmental practice that is in breach if the provisions of this Act, and the Authority may in addition cancel any licence issued to the operator under this Act if the Authority is satisfied that the operator has become an habitual offender.

Section of 30 of the Act creates Provincial and District Environment Committee, which shall – (a) be responsible for the proper management of the environment within the province or district in respect of which they are appointed. (b) perform such additional functions as are prescribed by this Act or as may, from time to time, be assigned by the Minister by notice in the Gazette. The creation of environmental governance structures only up to the district level makes it difficult to reach the grassroots.

The formation of Complaints Committee under Section 32 of the Act is one of the important instruments for public participation in environmental management. The functions of Complaints Committee includes to investigate (i) any allegations or complaints against any person or against the NEMA in relation to the condition of the environment in Kenya; and (ii) on its own motion, any suspected case of environmental degradation, and to make a report of its findings together with its recommendation thereon to the National Environment Council.

Environmental Planning, Protection and Conservation

EMCA part IV creates instruments for environmental planning, specifically National Environment Action Plan Committee, preparation of National and District Action Plans after every five years to guide environmental management. EMCA part V has specific provisions to protect and conserve the environment, especially river, land, and wetlands, protection of traditional interests, hill tops, hill sides, mountain areas and forests, and conservation of biodiversity.

The Act (Section 57.(1)) provides for the use of fiscal instruments for the protection and conservation of the environment. The government can levy tax and other fiscal incentives, disincentives or fees to induce or promote the proper management of the environment and natural resources or the prevention or abatement of environmental degradation.

Environmental Impact Assessment and Monitoring

Part VI of the Act makes provisions for the preparation of an environmental impact assessment (EIA) for projects, which are likely to have negative impacts on the environment. Section 58 (1) states that notwithstanding any approval, permit or license granted under this Act or any other law in force in Kenya, any person, being a proponent of a project, shall, before submit a project report to the Environmental Authority before undertaking or causing financing, initiating or implementing by another person as specified in the Second Schedule (list of projects requiring EIA) to this Act. Environmental monitoring is an integral component of environmental management. Section 69. (1) states that, the Environmental Authority, in consultation with the relevant lead agencies, monitors:- (a) all environmental

phenomena with a view to making an assessment of any possible changes in the environment and their possible impacts; or (b) the operation of any industry, project or activity with a view to determining its immediate and long-term effects on the environment.

Environmental Restoration, Conservation and Easement Orders

Part IX of the Act provides for environmental restoration orders, environmental conservation orders and environmental easements empowers the Environmental Authority to issue environmental restoration order to: restore the environment; prevent any action that can cause harm to the environment; award compensation for environmental damage; and levy a charge for environmental restoration. An environmental restoration order may contain such terms and conditions and impose such obligations on the persons on whom it is served as will, in the opinion of the Environmental Authority, enable the order to achieve all or any of the purposes specified in the order.

An environmental restoration order shall be issued to – (a) require the person on whom it is served to restore the environment as near as it may be to the state in which it was before the taking of the action which is the subject of the order; prevent the person on whom it is served from taking any action which would or is reasonably likely to cause harm to the environment; (b) award compensation to be paid by the person on whom it is served to other persons whose environment or livelihood has been harmed by the action which is the subject of the order; (c) levy a charge on the person on whom it is served which in the opinion of the Authority represents a reasonable estimate of the costs of any action taken by an authorised person or organisation to restore the environment to the state in which it was before the taking of the action which is the subject of the order. An environmental restoration order shall specify clearly and in a manner which may be easily understood:- (a) the activity to which it relates; (b) the person or persons to whom it is addressed; (c) the time at which it comes into effect; and (d) the action which must be taken to remedy the harm to the environment.

The object of an environmental easement is to further the principles of environmental management by facilitating the conservation and enhancement of the environment through the imposition of one or more obligations in respect of the use of the burdened land. An environmental easement may be imposed on and shall thereafter attach to the burdened land in perpetuity or for a term of years or for an equivalent interest under customary law.

5. CRITIQUE OF THE ENVIRONMENTAL LEGISLATION

EMCA has useful instruments for environmental management. Important instruments provided are: EIA, environmental restoration orders, environmental easement orders and environmental conservation. Effective implementation of the legislation can significantly contribute towards a clean and healthy environment. However, the legislation suffers from slow rate of implementation. The environmental legislation was passed into law in 1999 and took effect in 2002, but up to now it is yet to be fully operationalised. This is blamed in part on inadequate financial allocation for the establishment of structures. As a result, the environmental offices lack adequate number of personnel with the right mix of skills and knowledge. It is not uncommon to find district environment offices run by one environment officer lacking transport and other basic services to effectively oversee environmental management in an often expansive area. Despite good legislative provisions, its full benefits cannot be realised in the face of weak enforcement.

EMCA is a co-ordination framework relying on the goodwill of lead agencies for implementation. Environmental Authority co-ordinates environmental management, while implementation of implementation of environmental management is undertaken by lead agencies. NEMA does not have a mechanism to compel lead agencies to implement environmental management decisions. In many cases, lead agencies have their own legislative mandates to implement as such environmental management is seen as an incidental activity. It becomes even more difficult in cases where decisions of environmental authority conflicts with that of lead agencies. In such cases, it is unlikely to expect much needed co-operation of the lead agencies.

NEMA generates revenue as provided for in the Act, but it cannot directly spend such monies on environmental management. This occurs even in circumstances where state financial allocations for environmental management falls far below projected expenditure. The Environmental Authority generates revenue from sources such as Environmental Impact Assessment application and waste management. At the moment, NEMA is required to submit its revenue to the central government, and it can only spend allocations from the exchequer. One way of improving environmental governance is to allow the environmental authority to spend most of its revenue. This will even motivate to it to harness resources for better environmental management.

There is evidence of conflicting mandate of the environmental authority. The law states that NEMA is a co-ordination agency, but it is also involved in actual implementation of projects in some cases. This has been a source of

conflict with some of the lead agencies. For example, for example EMCA empowers NEMA to management waste water while at the same time Water Act empowers Water Resources Management Authority to manage not only water resources but also waste water. This can potentially cause conflict among state department, thus hamper effective implementation of the policies and legislation.

EMCA creates environmental management structures only up to the district level making it difficult to co-ordinate grass root organizations. EMCA provides for District Environmental Committees as the lowest environmental management unit while Kenya‟s administrative structure evolves to Divisional, Locational, Sub-locational and Village levels. It implies that lawfully, the government cannot create environmental management structures at these lower levels making it difficult to effectively reach grass root communities.

The environmental legislation provides for community participation in environmental management. However, there are no mechanisms to ensure that community participation is effectuated. This is mainly because regulations, guidelines and standards for the each of the legislative provisions have been developed. For example, the Act states that those likely to be affected by a proposed project should be fully consulted during an EIA process, but there is no mechanism to ensure that this is realised.

CONCLUSION

Following the Rio Conference on Environment and Development, efforts have been made by the Kenya government to institutionalise environmental management. As a result, the Kenya government passed into law Environmental Management and Co-ordination Act in 1999. The environmental legislation has useful instruments, which when fully implemented can contribute to sustainable environmental management. Efforts have been to implement the Act and integrate environmental concerns in the development process. The implementation of environmental legislation is ongoing and it is unknown when it will be fully implemented. The Act is not yet fully implemented. Effective implementation of the Act is hampered by weak capacity and inadequate financial allocation by the state.

In order to scale up environmental management in Kenya, there is need to focus on capacity building of environmental authority, lead agencies and other key stakeholders. Capacity building should focus on recruiting and retaining

adequate supply of personnel with the right mix of qualification; supply of requisite equipment and other facilities and popularising good environmental governance among the lead agencies. These will require long-term commitment of political leadership.

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