

# Land Use Systems Approach to Sustainable Land Management

## Land Use Hydrology in Kenya

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### 1. Abstract

The development of a comprehensive land use policy in Kenya is seen as the first step to achieve sustainable development goals free from environmental degradation and soil and water depletion. The paper attempts to explain the problem areas affecting these natural resources and the remedial measures being undertaken to control and protect these vital resources. An example is given as a case study of environmental depletion and successful protection and preservation to its original self with increased groundwater storage coefficient.

Community participation is emphasized as a driving force to the future development strategy, starting from project inception, planning, implementation, monitoring, evaluation and consumption. This is opposed to central planning and implementation where the people used to take such projects as "Government free services". The paper stresses the need to sensitize the community the importance of conserving the environment in which they live in.

### 2. Introduction

Kenya covers an area of approximately 587,900 km<sup>2</sup> and 576,000 km<sup>2</sup> is land surface of which 461.400 km<sup>2</sup> (80%) is classified as arid and semi-arid lands (ASAL). The remaining 115.300 km<sup>2</sup> is of medium to high potential suitable for general agriculture. This classification is based mainly on average annual rainfall and evapotranspiration.

The high and medium potential lands are devoted to crop and milk production, while much of the ASALS are largely used for extensive livestock production such as ranching, pastoralism as well as a habitat for wildlife both in and outside the national parks and some reserves.

The medium and high potential areas also contain important water catchments and certain habitats rich in biodiversity which are not included in the protected areas. Most of the perennial drainage basins originate from these areas.

Land use in Kenya is controlled by several factors, which include climate, soils, labour, technology and markets. The land cover/land use types can be broadly grouped into two main categories, namely: - those occurring in medium to high rainfall and high potential areas and those occurring in the ASALS. The medium to high rainfall areas are used for agriculture and daily farming, support forests, lakes,

urban centers and industry. They support 80% of Kenya's population. The cashcrop in these areas follow ecological patterns defined by temperature limits.

The ASAL areas, as mentioned earlier, occupy about 80% of the total land area, supports up to 20% of the country's population and about 50% of the country's livestock herd. A major portion of the country's wildlife resources occurs in these areas. They contribute 3% of the annual agricultural output and 7% of commercial production.

### **3. Kenya's Hydrology Systems**

Kenya's 576,000 km<sup>2</sup> of the land surface comprises of 13,396 km<sup>2</sup> of water surface. This water surface comprise of a number of small lakes with fluctuating limits as well as part of Lake Victoria and most of Lake Turkana. Only 3,831 km<sup>2</sup> of Lake Victoria is in Kenya while most of Lake Turkana lies in Kenya. Kenya's coastal line extends approximately 402 km along the Indian Ocean and the recently declared 200 nautical mile exclusive economic zone of Indian Ocean is controlled by it.

A small percentage of the water surface area is covered by surface drainage. This drainage is determined primarily by the Rift Valley, which roughly bisects the highland zone from North to South. Within the Rift Valley, drainage is into a chain of lakes, which have no surface outlet. West of the Rift Valley rivers drain into Lake Victoria. To the East, rivers follow a southeasterly course into the Indian Ocean.

In some areas, topography and rainfall - runoff regime have created many semi-closed, poorly drained or overflow areas that retain a substantial amounts of runoff which originate on the unslope areas.

On groundwater, the country is divided into three broad areas. These are volcanic rocks, precambrian metamorphic basement rocks and precambrian intrusive rocks and sedimentary rocks.

The volcanic rocks cover 26% of the country, more commonly in the western half of Kenya. Groundwater sources occur in old land surfaces, which are weathered zones between successive lava flows that signify periods of quiescence. Fractures, faults, fissures and joints are also useful. Water is mainly of bicarbonate type with low total dissolved solids. Local pockets of high fluoride are believed to be of volcanic and fumarolic origin.

The precambrian rocks cover an area which is approximately 17% of the country and are widely distributed in the central, western and north western parts of Kenya. Water in these areas occurs in deep horizons of faults, and fractures. Aquifers are generally unconfined and yields and water levels vary within rocks.

The sedimentary rocks cover 55% of the country, predominantly in the eastern parts. These areas have loose and permeable sediments. The aquifers are shallow and unconfined and most of them are generally saline. The salinity results from accumulation of solute evaporite minerals within the sediments.

### **4. Water Resources**

The country receives a mean annual rainfall of 621 mm. this mean translates to an annual volume of 360,000 million cubic meters of rainfall.

The rainfall contributing to surface and groundwater resources ranges from 250 mm to 750 mm in the arid and semi-arid areas and from 1000 mm to 1690 mm in the coastal belt, the highlands and the Lake Victoria Basin. But the actual contribution is less due to evapotranspiration.

The surface water potential from perennial rivers is estimated at 19,590 million cubic meters, which is about 18% of the national annual rainfall.

On the other hand, the groundwater potential is estimated at 619 million cubic meters, 31% of which is in deep seated aquifers exploitable through boreholes and 69% located in shallow aquifers exploitable through shallow wells.

The water requirements of the country was estimated to be 1,148 million cubic meters (mcm) or approximately 6% of the available water resources in the country in 1990 and 3,096 mcm or 15% in the year 2010.

## **5. Land Use Patterns Affecting National Water Use**

There are two main aspects of water use that are crucial for national water master plan, vegetative cover and forest land use cover

### **5.1 Vegetative cover**

The vegetative cover in the tropics profoundly affects the surface runoff. The runoff coefficient generally depends on (among other parameters) the type of vegetation in the area. The runoff from the land on the other hand, determines the amount of water flowing in streams and rivers. The vegetative cover controls the amount of soil that can be washed downhill by the rainwater. The amount of soil carried through runoff determines the sediment load in rivers, streams, and springs and also the rate of silting of dams and pans.

### **5.2 Forest land use**

It is estimated that in 1987, there were 1,700,000 hectares of forested land area in Kenya. The annual growth rate for forests during the 1978-1983 plan period was expected to be 78%. In spite of this increase, the present forest cover in the country is less than 3%.

Wood fuel provides about 65% of the nation's energy requirements and 95% of the rural energy needs and is expected to maintain this position well into the next century. The current consumption stands at about 5.4 tons of oil-equivalent, mainly in form of fuel wood and charcoal. This demand has led to the process of clearing once forested areas causing a serious decline in the yields of many springs throughout the country. This is mainly due to inefficient utilization technologies and poor forest management.

Currently, the country is facing a charcoal/fuelwood crisis, since most forested land is being cleared and settled for agriculture and urbanization. The harvesting of trees for charcoal has moved to more ecologically fragile areas, impacting negatively on soil and water resources.

### **5.3 Land Use Planning and Policy**

Kenya's natural resources such as water, rocks and minerals, soils, plants, animals and various ecosystems are increasingly under pressure from unsustainable use. This can result in pollution, soil erosion, resource depletion and extinction. The country therefore, faces major challenges in planning for sustainable natural resource management in the face of limited arable land, water and minerals resources, rapid population growth, poverty and a limited financial capital base. All these are compounded by degradation of the environment on which development depends.

In order to achieve a sustainable management of the land resources, the land use policy must provide a system of laws, rules, regulations and practices that govern the rights and obligations of the land owners together with appropriate guidelines in optimal utilization of available land. There are good reasons for land use planning, among them being need to identify changes required in land use practices which will increase productivity and opportunities, to decide where the changes should be and to avoid misuse of the land resources.

The government having recognized these problem areas has come up with the following recommendations to be incorporated in the national land use policy:

- Review land use legislation and planning with a view to increasing productivity, protecting water catchments and the fragile ecosystem, and reducing land use conflicts
- Place greater emphasis on conservation of undamaged resources (such as indigenous forests and functioning wetlands) than on rehabilitation
- Involve local communities in resource management and incorporate indigenous management whenever appropriate
- Integrate conservation in development planning
- Plan for long-term as well as short-term consideration, especially environmental impacts

These recommendations were arrived at after a hard experience of diminishing natural resources especially the forests and soil erosion due to population pressure in high potential areas.

In some areas where general education and western influence has been introduced, there is public awareness on environmental conservation and improvement on natural resource use. On that basis, the government has introduced various public education and awareness programs through audio-visual aids and publications on the need to conserve the environment.

## **6. Case Study**

When balance of nature is readily upset in the tropics, her forces when out of balance are more violent than those of temperate countries where much of scientific experience is based. Advances in both human and veterinary medicine in our country have promoted rapid increases in population. The increasing population has led to destruction of forests to give way to human settlement through tree felling, charcoal burning, burning of topsoil and vegetation and overgrazing. The unfavourable weather that leads to long, dry spells aids the vigorous termite populations to consume dry matter in marginal areas.

The resulting uncovered soil from these five causes is beaten by violent storms that carry the top soils to rivers creating overloaded streams that form swamps. These swamps are then unskillfully drained and cultivated during the dry season. The cultivation of these swamps removes the natural flood controls of these rivers resulting in the rivers moving in torrential flows in a few hours. There is thus no time for surface water infiltration to recharge the groundwater aquifers to sustain national water supplies. The cultivation of four to five years in the settlement derived from the natural forests can thus cause serious environmental and economic damage including among others, pollution by agricultural chemicals, industrial wastes, uncontrolled animal wastes and suspended matter from soil erosion in sloppy areas to the remaining diminishing water supply systems.

This diminishing water supply systems is exemplified in the Ewaso Nyiro North River Basin, which continues to recede downstream as a result of intense cultivation and uncontrolled irrigation in its headwaters, leaving the lower plains dry. This has resulted in accelerated desertification, salinization of groundwater aquifers that were directly or indirectly recharged by the river, and environmental degradation. Lack of good grazing lands and freshwater points for both human and livestock consumption in the lower ASAL (arid and semi-arid lands) has given rise to economic wars of survival called "cattle rustling".

In recognition of this problem, the government through the District Focus for Rural Development, has encouraged the people to conceptualize, plan, implement, monitor and evaluate water and forestry projects that are beneficial to them. Several strides have been made in these areas, especially in high and medium potential regions where land tenure systems have been intensified and privatized. Individual land owners have adapted modern soil and water conservation systems to check on soil erosion, and the result has seen enormous increases of forest cover and soil fertility and high food production. Through the success of this land tenure system, the government is continuously reviewing its structures related to land use systems in order to encourage our people to conserve water and forests for posterity.

Forests have been recognized as the main contributors of stream recharge and regulation. Studies done in two extensive types of forests have shown that they are highly efficient in the absorption of intense rainfall and in regulation of stream flow. Rainfall of 75 mm in one hour on a wet catchment has produced no run-off whatsoever from 30 acres of forest in a 5% slope, while annual average flood flow from two forested catchments is less than 2% of the rainstorms that produce it. This regulating effect assisted by deep and permeable soils is normally affected by the long drought so that stream flow difference in the wet and dry seasons ratio is 20:1, respectfully. With our limited resources to build storage reservoirs, we are critically dependent on dry weather flow what we call "normal flow". Indications are that this ratio is dependent upon land use and improper land use such as overgrazing may result in ratios of 3,000:1.

The people in high and medium potential areas have realized their mistakes of mismanaging the land resources, and are now intensively using the services of agricultural extension workers and research results to plant softwood tree seedlings along the land parcel boundaries and if possible, along the contoured terraces. This has been found to greatly improve surface water percolation into underground aquifers in addition to improved soil conservation in hilly areas. This had led to increased productivity and high carrying capacity in well managed areas like Machakos (a semi-arid area East of Nairobi City) and Meru in Eastern Province, and rejuvenation of streams volume in Central Province of Kenya.

## **7. Conclusion**

It is reasonable to conclude that where regional and national water supplies affected by land-use decisions the later must be made on hydrological rather than on political grounds. The time scale for catchment area research studies can be shortened by providing adequate funds and staff for intensive land use and land cover study in Kenya. Such studies require full-time specialists who will interact and provide prompt advice to the stakeholders and part-time co-operation with other related technical departments.

The results of land-use changes in temperate countries need physical and practical verification in tropical conditions since these changes may not be applicable and practical in a tropical climatic setting.