CHAPTER 7
FRESH WATER, COASTAL AND MARINE RESOURCES

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Introduction

Kenya's economy is dominated by the agricultural sector; although only 20 percent of the country's total land area has sufficient fertility and rainfall to be farmed. Kenya's principal cash crops include tea, horticultural produce and coffee while maize is the staple food. The production of maize however, is subject to sharp rainfall-related fluctuations, with production down-turns periodically necessitating food aid. In 2004 for instance, more than 1.8 million Kenyans required food aid due to drought and water stress.

Lately water availability has worsened due to climate change and variability, rising population pressure and destruction of wetlands and the wider catchment areas. This chapter therefore reviews Kenya's freshwater resources including the country's fresh water per capita endowment, Kenya's coastal and marine resources, the key policy issues and opportunities that can be harnessed to help meet the Vision 2030 goals before proposing strategies for the improved management of these resources.

Status of freshwater resources and coastal ecosystems

Kenya has a total area of about 582 646 km^2. Water occupies about 1.9 percent or 11 230 km^2. The rest, equivalent to 571 416 km^2 is covered by land. 80 percent of Kenya's land area is arid or semi-arid (ASALs), implying that only 114 283 km^2 of Kenyan land can be profitably used for rain fed agriculture. There is however, a large potential for agriculture in the ASALs if the required investments in irrigation, water storage and water harvesting infrastructure are made.

Kenya's freshwater resources are represented by lakes, rivers, swamps, springs as well as dams, water pans and groundwater. Kenya's annual freshwater resources endowment is estimated to be 20.2 BCM (billion cubic metres) or 548 m^3 per capita per year. This is much lower than the comparative figures for Uganda (1 273 m^3) and Tanzania (2 035 m^3) (World Bank 2010) and the UN recommended threshold of 1 000 m^3 per capita per year. Figure 7.1 illustrates the global renewable water resources per capita. This has serious implications for tourism, agriculture and industry which are Vision 2030's flagship projects because raising their contribution to Kenya's economic growth will require these sectors to consume substantially more water.

Surface water resources

Kenya's surface water resources are distributed within five drainage basins: the Tana, Athi, Ewaso Ng'iro north, Rift Valley and Lake Victoria Basin. Figure 7.2 shows these drainage basins while Table 7.1 provides

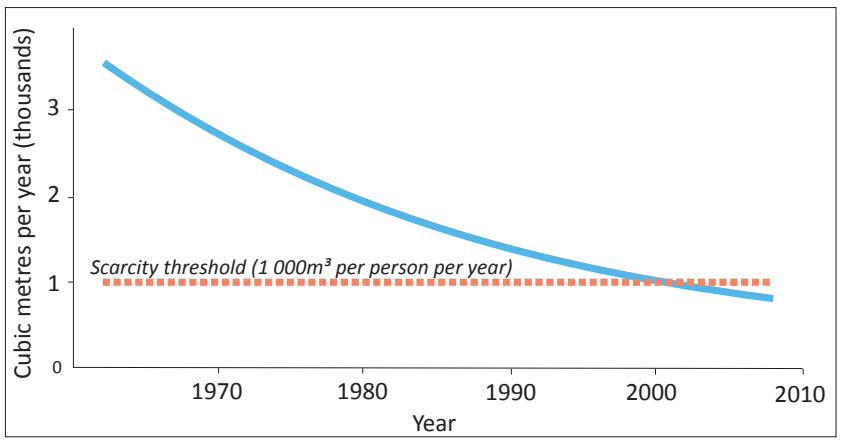


Figure 7.1: Global renewable water resources per person Source: FAO 2010

A group of Hippopotami cooling off in Lake Naivasha: Kenya's water bodies are habitats to a myriad of plants and animals.

Christian Lambrects/UNEP

Figure 7.2: Kenya's main drainage basins

Source: WRI 2007

Drainage basin	Area (km^2)	Annual rainfall (mm)	Surface Water (10^6 m^3)	Surface water abstraction		Ground water (10^6 m^3)	Total water ($10^6 m^3$)	% of total water resources potential
				10^6 m^3	%			
L. Victoria	46 229	1 368	11 672	254.3	2.2	116	11 788	54.1
Rift Valley	130 452	562	2 784	46.8	1.7	126	2 910	3.4
Athi River	66 837	739	1 152	133.1	11.6	87	1 239	4.3
Tana River	126 026	697	3 744	595.4	15.9	147	3 891	32.3
Ewaso Ng'iro North	210 226	411	339	42.1	12.4	142	481	5.8
Total	579 770	621	19 691	1 071.7	5.44	618	20 309	99.9

Table 7.1: Average annual water availability and utilization per drainage basin

Sources: GoK 1992, GoK 1998

an overview of the renewable water resources. The table also indicates Kenya's surface and groundwater resources' distribution and water abstraction levels for each of the five drainage basins.

Lake Victoria Basin

The Lake Victoria basin covers about 8 percent of the total area of Kenya but accounts for over 54 percent of the national freshwater resources. The quantity of water in Lake Victoria is regulated by rainfall, evaporation and inflows and outflows from the lake basin. The main outflow is through the Nile River to the north. The main inflows from the Kenyan catchment include the Sio, Nzoia, Yala, Nyando, Sondu-Miriu, North Awach, South Awach and Gucha-Migori rivers. The other inflow is from the Akagera River whose source is in Rwanda. Table 7.2 shows the balance between the lake's water inflows and outflows.

Average 1950-2000	Flow (m^3s^{-1})	Percentage
Inflows		
Rain over the lake	3 631	82
Basin discharge	778	18
Outflows		
Evaporation from the lake	-3 330	76
Victoria Nile outflow	-1 046	24
Balance	33	

Table 7.2: Balance between water inflows and outflows of Lake Victoria

Source: NEMA 2007

Data on the levels of Lake Victoria have been collected consistently since 1896. The key factors influencing lake levels are natural and are mostly related to inflows and outflows. Three striking water level regimes have however been observed in the last 104 years. They are

Table 7.3: Historical water levels of Lake Victoria

Year	Month	Level in m.a.m.s.l*	Height above 1923 level (m)
1923	March	1133.19	0.00
2006	January (10th)	1133.46	0.27
2005	October	1133.66	0.47
1961 (before the flood)	January	1133.70	0.51
2004	September	1133.99	0.80
1994	February	1134.18	0.99
1994	October	1134.21	1.02
1986	September	1134.26	1.07

* m.a.m.s.l. stands for metres above mean sea level

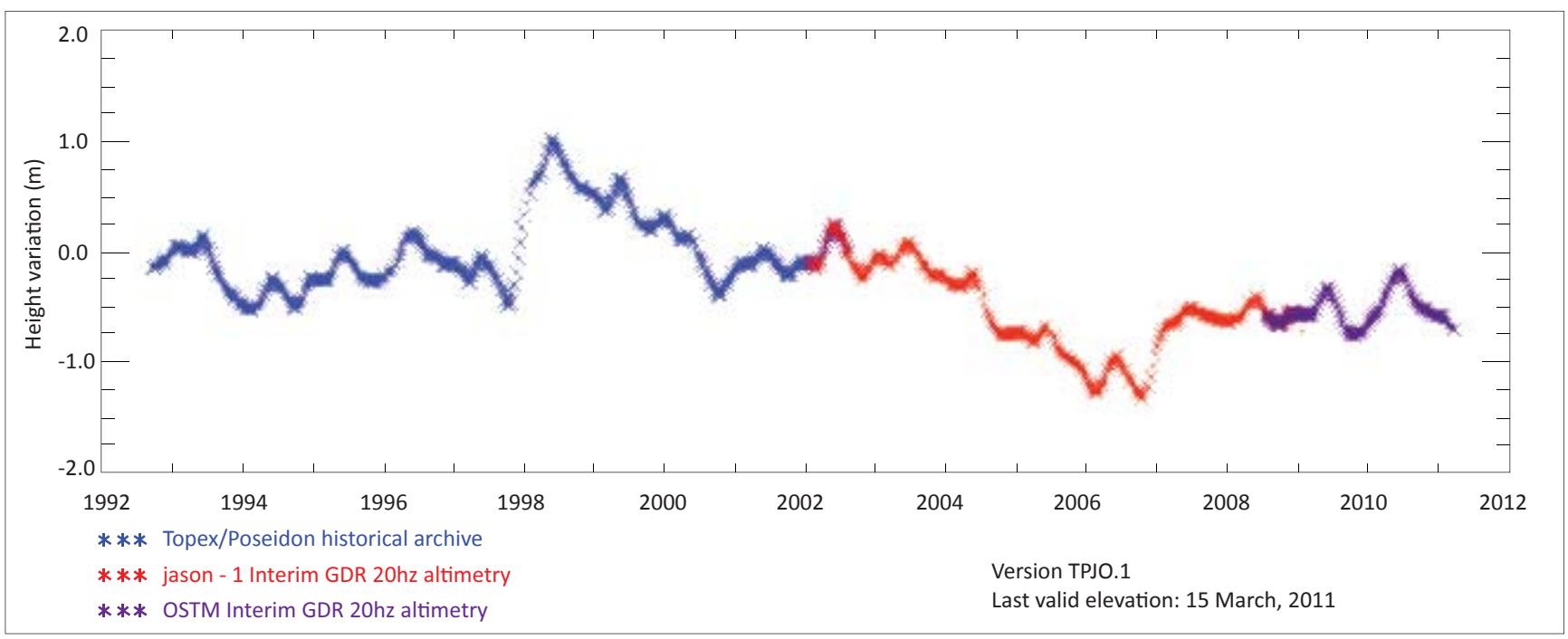
1900-1961 when water levels were low, 1961-2002 when levels were high following the 1961 floods, and the post-2002 regime which has tended towards the pre-1961 regime. The 2005/06 levels were the lowest experienced since the floods of 1961/62 and the lowest level recorded in January 2006 was slightly above the lowest ever level recorded in March 1923. Table 7.3 and Figure 7.3 highlight the trends.

The Rift Valley Basin

This basin consists of a number of closed basins and covers an area of about 130 452 km^2. It encompasses the basins discharging into Lake Turkana in the North through the Turkwel and Kerio rivers and those draining into Lake Natron in the south through the Ewaso Ng'iro South River. The smaller lakes such as Baringo, Bogoria, Nakuru, Elementeita, Naivasha and Magadi also form individual basins. The Kerio River is the main river in the Rift Valley basin with a total length of 354 km. It has an average width of about 5.7 m, mean depth of 0.21 m and the mean flow is 4.47m^3/second.

Figure 7.3: Fluctuation in the water level of Lake Victoria. Height Variations from TOPEX POSEIDON Jason-1 and Jason-2 OSTM Altimetry

Source: USDA 2011



Lake Baringo at night.

Nearly all the major lakes in Kenya are found in the Rift Valley. Their water quality varies from fresh (Lakes Naivasha and Baringo), through brackish (Lake Turkana) to saline (Lake Magadi). Lake Naivasha is a Ramsar site and supports a significant flower-based horticultural industry and some fisheries. It also provides water for domestic and livestock use. The source of water for the steam used by the Ol Karia geothermal power plant is thought to originate from this lake through subterranean seepage. The environs of Lake Naivasha, including its rich biodiversity, are highly attractive for tourism. Unfortunately, the use of the lake's resources, notably its water and riparian lands, are largely uncontrolled and have led to its pollution and declining water levels as shown in Figure 7.4.

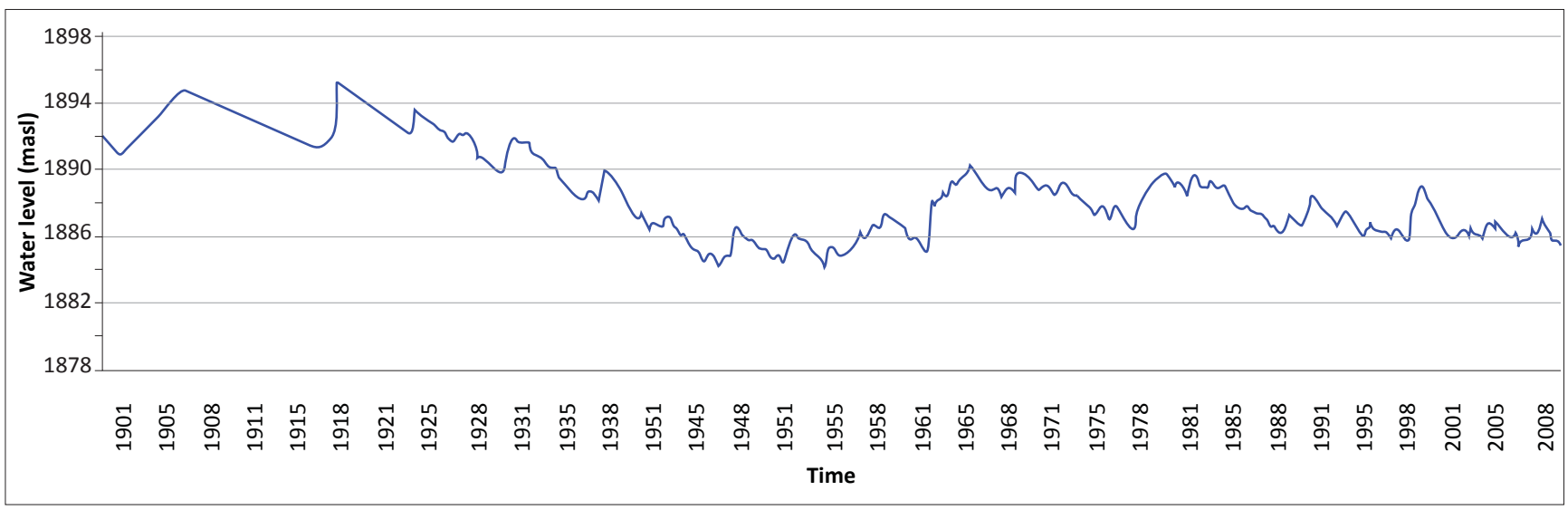
Athi River Basin

The Athi River Basin measures approximately 67 000 km^2. The basin comprises the southern part of Kenya east of the Rift Valley and drains the southern slopes of the Aberdares Range and the flanks of the Rift Valley, as well as the North Eastern slopes of Mount Kilimanjaro before draining into the Indian Ocean through the Athi River. The

Lake Magadi—a saline lake in the Rift Valley basin.

Figure 7.4: Long term water levels of Lake Naivasha. It can be noted that the water levels have been declining and the lowest levels were recorded between 1945 and 1955. As from 1987, there has been a gradual decrease with a spike in 1997/98 due to the El Niño phenomenon

Source: WRMA 2009



Mount Kenya's Lake Alice.

upper portion of the Athi river basin is a high potential agricultural and industrial area and covers major urban centres like Nairobi and Mombasa. The Athi River measures approximately 591 km, and has an average width of 44.76 m, average depth of 0.29 m and average flow rate of 6.76 m^3/second.

Tana River basin

The Tana River basin measures approximately 127 000 km^2. The basin drains the eastern slopes of the Aberdares range, the southern slopes of Mount Kenya and the Nyambene hills before discharging into the Indian Ocean through the Tana River. Like the Athi River Basin, the River Tana basin drains an area that is highly populated and urbanized. Portions of the basin include agriculturally high potential areas despite the fact that about 80 percent of the basin is located in the ASALs. The Tana River is a major source of hydropower and currently has an estimated installed capacity of 480 MW out of its total estimated potential of 960 MW.

River Tana measures approximately 1 050 km in length and has an average width of 39.3 m, a mean depth of 2.5 m and an average flow rate of 41.98 m^3/sec. Its mean annual discharge at Garissa is 5 BCM. Minimum levels were recorded in 2000 and 2009, correlating with the severe droughts experienced then. Figure 7.5 shows the trend in water levels over a 20-year period.

Some of the problems afflicting this river basin are water shortfalls arising from excessive abstraction, pollution and water conflicts between upstream and downstream users.

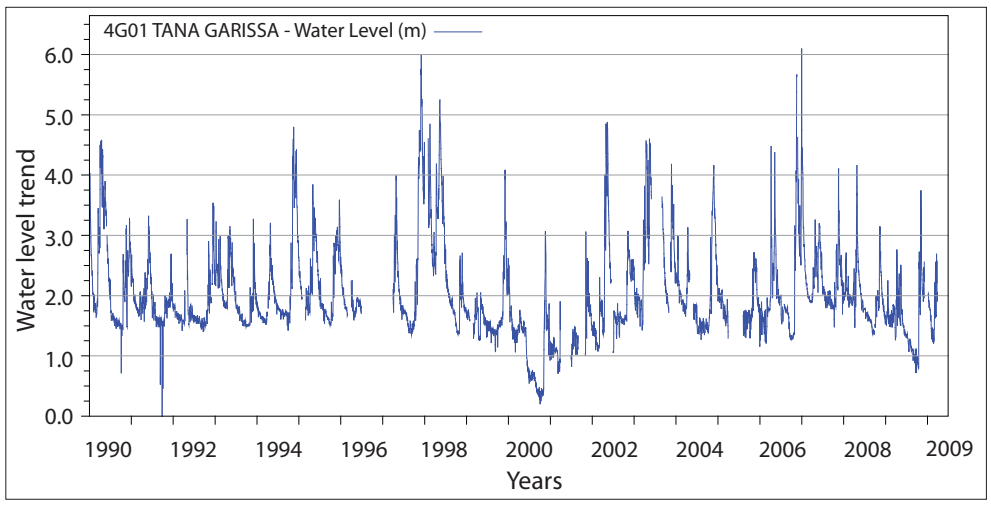


Figure 7.5: Water level trend over 20 years for River Tana measured at Garissa. Note the low levels in 2000 and 2009

Source: WRMA 2009

Ewaso Ng'iro North River Basin

The Ewaso Ng'iro North river basin covers an area of 209 000 km^2. It is found in the Northern part of Kenya, and drains the northern slopes of the Aberdares Range and Mount Kenya. Even during the flood season, the river's waters are absorbed into the Lorian swamp, though in some years, its flow continues into Somalia. In this basin, there is increasing demand for irrigation water, which in turn raises the prospect of water conflicts.

Groundwater resources

Besides surface water, Kenya is also endowed with groundwater resources. As indicated earlier, the annual quantity of renewable groundwater is about 10 percent of the renewable surface water. Areas that receive low rainfall and runoff such as Ewaso Ng'iro basin are largely dependent on groundwater as a reliable source of water. Groundwater is also an important supplementary source in urban centres such as Nairobi, Mombasa and Nakuru.

Main groundwater aquifers in Kenya

The main groundwater aquifers in Kenya are closely linked with four major rock systems. These are the volcanic rocks; the basement metamorphic rocks; intrusive igneous rocks; and the quaternary sedimentary rocks. The volcanic and quaternary geological formations are particularly rich in groundwater.

Kenya's groundwater potential is extremely variable, both spatially and temporally, in quality and quantity and in terms of the level of the water table and depth. Recharge varies from less than 5 percent of the annual rainfall in the arid and semi-arid lands where evapotranspiration losses are high, to 30 percent in areas of deep sandy soils, coral limestones and unconsolidated rocks where evapotranspiration losses are low. In humid and semi-humid regions, recharge rates may be higher.

Classification of aquifers

The various aquifers in the country have been classified into broad categories with respect to their perceived importance. The classification helps in determining the quality and quantity of each aquifer in light of its value and vulnerability to different management regimes. The classification is shown in Table 7.4.

Class	Description	Examples
Strategic aquifer	Aquifer used to supply significant amount/proportions of water in a given area and for which there are no alternative resources, where such resources would take time and money to develop, significant transboundary aquifers	Sabaki, Tiwi, Nairobi, Central Merti, Nakuru, Kabatini, Lake Naivasha, Lamu Island
Major aquifer	High-yields aquifer systems with good quality water	Daua and Elgon volcanics
Minor aquifer	Moderate-yield aquifer systems with variable water quality	Mandera Jurassics
Poor aquifer	Low to-negligible yield aquifer systems with moderate to poor water quality	Aquifers in Basement rocks
Special aquifer	Aquifer systems designated as such by WRMA	Isinya

Table 7.4: Classification of Kenya's aquifers

Source: National Water Master Plan report 1992

Estimated groundwater potential in BCM/year safe yield *	Estimated abstracted groundwater in Mm^3 per year	Per cent of available exploitable groundwater that is abstracted
1.04	0.18	17

* Safe yield is the amount of water that can be abstracted without causing undesirable effects to the aquifer

Table 7.5: Estimated potential compared with amount abstracted

Source: GoK 1992

Groundwater development and use

It is estimated that the country's hydrogeology allows for an economic exploitation of the groundwater resources at an annual safe yield of 1.04 BCM of which only 0.18 billion BCM per annum is currently being extracted (Table 7.5). For sustainable utilization of groundwater resources, it is important that studies are conducted to determine the current abstraction levels for aquifers in different parts of the country and to encourage such exploitation where quality and quantity allow.

Wetlands resources

According to the Environmental Management and Coordination Act (Wetlands, Riverbanks, Lakeshores and Seashores Management) Regulations 2009, wetlands are: 'areas permanently or seasonally flooded by water where plants and animals have become adapted; and include swamps, areas of marsh, peat land, mountain bogs, banks of rivers, vegetation, areas of impeded drainage or brackish, salt or alkaline; including areas of marine water the depth of which at low tide does not exceed 6 metres. It also incorporates riparian and coastal zones adjacent to the wetlands'. This is similar to the definition contained in the Ramsar Convention (1971) which defines wetlands as 'areas of marshes, peat lands, floodplains, rivers and lakes, and coastal areas such as salt marshes, mangroves, and seagrass beds, but also coral reefs and other marine areas no deeper than six metres at low tide, as well as human-made wetlands such as waste-water treatment ponds and reservoirs'. Based on the Ramsar convention, wetlands are classified into three main types:

- Inland wetlands including permanent and seasonal rivers, inland deltas and floodplains, lakes, ponds and marshes
- Marine/coastal wetlands including open coast, coral reefs, estuaries, deltas, mangrove forests, and lagoons.
- Artificial or man-made wetlands including reservoirs, aquaculture ponds, excavations, waste water treatment ponds, irrigation canals and rice fields.

The source of the Mzima Springs is a natural reservoir under the Chyulu Hills. Rainwater percolates through the volcanic lava rock and spends many years underground before emerging at Mzima.

Christian Lambrects/UNEP

Figure 7.6: Location of wetlands in Kenya

Source: KWS 2010

From this classification, Kenya has been found to have six classes of wetlands: marine, estuarine, lacustrine, palustrine, riverine and human made wetlands. A general location of these is shown in Figure 7.6.

In terms of the water sector, wetlands play a fundamental role in maintaining climatic and hydrological stability. Natural wetlands also provide life-supporting services by moderating local climate, regulating stream flow, improving water quality through sediment filtration and absorbing heavy metals and other toxic pollutants and reducing flood risk downstream. They also help to recharge ground water and augment stream flows. Recharges in major wetlands occur through rainfall precipitation. These services make clean water available to people. Thus, wetlands are important sources of water for human consumption, agriculture and watering of livestock and wildlife. They recharge aquifers thereby raising the water table and making groundwater easily available for domestic and industrial use as well as for agricultural activities.

Coastal resources

Kenya's 608 km coastline extends from Somalia's border at Ishakani in the north, to Vanga at the Tanzanian border in the south. The coastal region is endowed with rich natural resources that play a critical role in fostering economic development. Such resources include beaches for recreation, fisheries resources, mangrove forests and cultural diversity.

Attribute	Quantity
Length of coastline	608 km
Exclusive Economic Zone	118 sq km
Number of marine Protected Areas (MPAs)	10
Average annual marine fish catch (wild catch and mariculture)	7 000 tonnes

Table 7.6: Kenya's coastline at a glance Source: NEMA 2009

Table 7.6 contains an overview of Kenya's coastline. A number of ecosystems occur along the coastline. These include mangroves and other coastal forests, seagrass beds, sand dunes and sandy beaches and coral reefs.

Coastal forests and mangroves

The mangroves and coastal forests of Kenya characterize the low lying inter-tidal areas and system of low ridges between 100 and 300 m in altitude respectively. The coastal forests in particular, thrive on complex, mostly infertile soils inland. Coastal forests characteristically occur where humidity is high throughout the dry season. The forests have a canopy span of up to 7 m, covering about 139 000 ha and with lowland forest patches, woodlands, bushlands and thickets. The main forests in the coastal area include Arabuko Sokoke (41 000 ha) and the Shimba Hills system (19 260 ha). Others are smaller patches ranging from 10 to 2 000 ha and mainly consist of the 'Kaya,' sacred forests of the Mijikenda communities. These forests exhibit high levels of diversity and endemism. Arabuko Sokoke forest, for example, is home to six rare and endemic bird species.

Riverine forests on the other hand, depend on flooding from coastal rivers, including the Tana River. They are a unique forest type in the coastal zone, providing habitats for rare species of primates, such as Red colobus monkeys. Their extent, however, has been reduced by extensive damming and over-abstraction of the coastal river's waters for farming, which has reduced flooding. This is threatening both the forests and the species they harbour.

Mangrove forests occur along the coast in the intertidal area between the land and the sea. Landward, mangroves are found adjacent to coastal terrestrial forests, while seaward, they coexist with seagrass beds and coral reefs. Kenya's mangrove forests and coastal wetlands are concentrated on the northern coast around the Lamu archipelago and the permanent Tana/Sabaki River estuaries, with smaller wetlands in the mouths of semi-perennial and seasonal coastal rivers on the South Coast, at Shimoni-Vanga, Funzi and Gazi Bays, and Port-Reitz, Tudor, Mtwapa, Kilifi and Mida Creeks.

The total area of mangroves in Kenya has been estimated at between 53 000-61 000 ha, with 67 percent occurring in Lamu district, and 10 percent each in Kilifi and Kwale districts. It is estimated that 10 310 ha of mangrove forest have been lost due to conversion to other land uses, overexploitation and pollution. There are 9 mangrove species found along the East African coast. All these occur in Kenya although the dominant ones are *Rhizophora mucronata* and *Ceriops tagal*. Other rarer species include *Heritiera littoralis* and *Xylocarpus moluccensis*.

Mangrove forests are nutrient-rich environments which promote a variety of food chains and function as nursery and feeding grounds for fish and invertebrates. Many of these species spend part of their lifecycle in coral reefs, seagrasses and open waters. The mangrove trees are also important for shoreline stabilization and provide wood fuel and building materials for both rural and urban coastal populations.

Mangrove forests in the Manda Bay, Lamu.

Eugene Apindi Ochieng

Seagrass beds

Seagrasses occur in extensive beds that cover the largest proportion of shallow reef slopes, and form an important habitat for many species living in them and adjacent systems. Twelve seagrass species are found in Kenya. *Thallasondendron ciliatum*, which forms monospecific stands, is the dominant one. Its canopy structure provides habitats for small and juvenile fish and invertebrates. Other common seagrass species found in the country are *Halophila ovalis, Halophila minor, Halophila stipulacea, Halodule uninervis, Halodule wrightii, Syringodium isoetifolium, Cymodocea rotundata, C. serrulata, Thalassia hemprichii, Zostera capensis* and *Enhalus acoroides*.

Seagrasses show clear zonal patterns with water depth, sediment structure and exposure to air and sunlight during low tide. Species that are tolerant to exposure are found higher up on the intertidal, while those that cannot withstand exposure occur submerged in pools of water. Seagrass beds are important foraging grounds for endangered species such as dugongs and marine turtles. They are also important habitats for fish species like rabbit fish, surgeon fish and parrot fish. Various species of shellfish and sea cucumbers are also found in seagrass beds.

Sand dunes and sandy beaches

Sandy beaches are found all along the coast and most notably along parts of the coastline dominated by terrigenous sediment and without fringing reefs, near the Tana and Sabaki rivers and northwards towards Lamu. These areas have high dunes generated by wind-blown sand

Fagasan/Flickr.com

A star fish in seagrass during low tide in Tiwi beach, Mombasa.

from the beach. The largest dunes occur within the Tana River delta, reaching 50 m above sea level, covering an area of 1 300 km^2. Sand dunes support a rich diversity of wildlife and other natural resources. Their sand is generally of terrestrial origin and is deposited by the river.

Beaches are important habitats for species such as sea turtles, which lay their eggs in upper-beach environments, as well as shorebirds and migratory birds. However, because they are at the fringe of land and sea and offer easy access to the sea, they have become areas of intense economic activity, habitat modification and user conflicts. These have negative impacts on vulnerable species like sea turtles, which spend a critical part of their lifecycle on the beaches.

The Kipini Conservancy located in Lamu and Tana River districts forms a continuous mosaic of highly diverse habitats including sand beaches, dunes, bush land thickets, grassland, woodland, and forest.

Christian Lambrects

Coral reefs

Coral reefs are among the most productive of all marine ecosystems. They provide a habitat for numerous species, including turtles, dugong, whale sharks and others. Their essential ecosystem services, such as protecting the coastline from ocean waves and hosting many biodiversity species, exposes them to numerous threats. Coral reefs support coastal artisanal fishing which is dominated by local and migrant fishermen using hand- or wind-powered boats (such as local dhows and dugout canoes) and fishing gear adapted from traditional gears, including basket traps, spears (both hand and powered), nets and hand lines. As a result of extensive exploitation due to little or no regulation, and the use of destructive fishing techniques, the reefs in Kenya have been generally over-fished and are suffering degradation.

Opportunities for sustainable management

Water is central to the economic development of Kenya. Government should therefore put in place measures to increase supply and ensure more efficient management of Kenya's scarce freshwater resources. Kenya's safe yield of surface water resources has been assessed at 7.4 BCM per annum while that of groundwater is estimated at 1.04 BCM per annum. In 1998 water extractions were estimated at about 13-19 percent of the assessed safe yield potential, amounting to between 1.1 to 1.6 BCM per annum.

In 2005, surface and ground water extractions were estimated to be 1.6 BCM per annum, indicating an extremely low level of development of the available water resources. Although Kenya is classified as a water scarce country, there is still scope for extensive water development. Water development may include non-consumptive uses like hydroelectric power generation.

Coastal and marine resources also contribute immensely towards the economic development of Kenya through tourism, fisheries, shipping and port activities which have positive outcomes for the delivery of Vision 2030, the country's long-term development blueprint. Tourism and shipping are the highest contributors to the coastal economy, contributing 45 and 15 percent respectively. Artisanal fishing lands 95 percent of the total marine catch, contributes 6 percent to the coastal economy, and is the main source of livelihood for more than 60 000 households. The proportion of the contributions of different activities' to the coastal economy is shown in Figure 7.7.

Development of hydropower and irrigation potential

In Kenya, access to electricity is normally associated with a rising quality of life. The current hydroelectric power potential of Kenya's waters has not yet been fully exploited. Currently, only 719 MW has been developed against a potential of 6 000 MW. This latent potential will need to be harnessed if Kenya is to deliver the 10 percent annual economic growth rate promised by Vision 2030.

Expansion of irrigated land has the potential to increase cropland substantially and to boost agriculture that was previously wholly dependent on rainfall. The National Water Master Plan identifies an irrigation potential of almost 540 000 ha based on 80 percent dependable flow. In spite of the increase in the area under irrigated

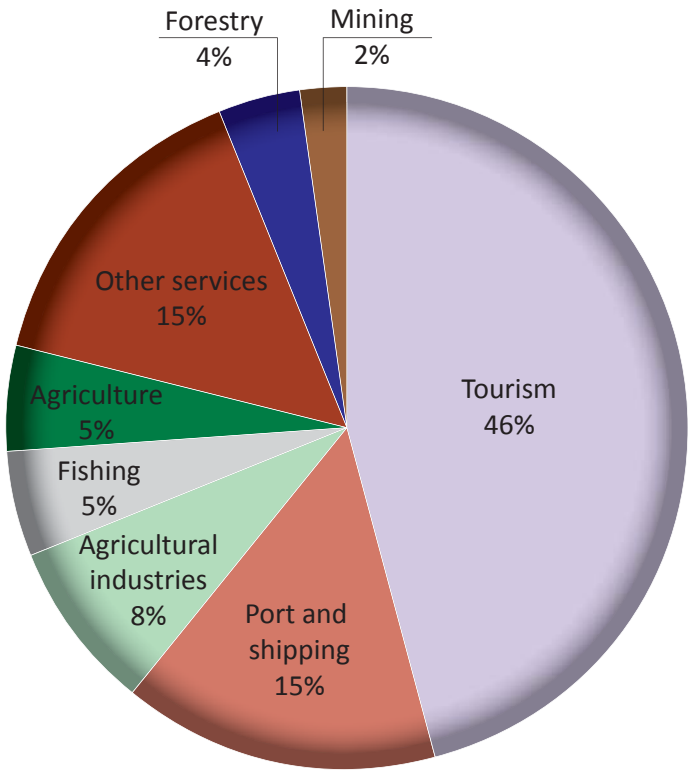


Figure 7.7: Principal economic activities and their contribution to livelihood and income for coastal populations

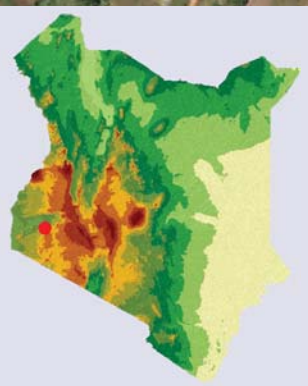
Source: NEMA 2009

agriculture from 52 000 ha in 1985 to 105 000 ha in 2003, the potential has not been fully developed due to the high cost of infrastructure. The target was to bring 192 640 ha of potential irrigable land under irrigation by 2009 and to subsequently increase it by 10 000 ha annually to a maximum of 1.2 million hectares including drained lands.

To meet the diverse demands for clean energy and water, the government, in Vision 2030, has proposed the development of several large and medium-sized multipurpose dams. The latter can be put to varied uses such as hydroelectric power generation, irrigated agriculture, water supply, flood control, recreation, inland navigation and fish breeding. For instance one of the flagship projects of Vision 2030 is the Magwagwa Dam Multipurpose Development Project on the Sondu River. It has a hydroelectric power generation potential of 120MW, the potential to provide irrigation for 15 000 ha of land and to supply adequate water to a population of approximately 600 000.

Basin approach to water resources management

The country has adopted a basin-based approach to water resources management. This is a holistic methodology that provides for regulated use of the water resources for the benefit of communities while preserving the integrity of ecosystems. Under this approach, restoration and rehabilitation of river basins is key to addressing water pollution and ensuring delivery of clean water to users. The Water Resources Management Authority (WRMA) uses the river basin as its focus, and is charged with the responsibility of integrating the management of such basins, and including stakeholder groups in the management structure. The sector intends to increase regular monitoring of water resources from the current 30-40 percent to 70 percent in order to identify areas that need attention before serious deterioration occurs. The Catchment Management Strategies for all the water basins in the country were gazetted in 2009.



Electricity generation—Sondu Miriu River, one of the six major rivers in the Lake Victoria basin, drains a total area of 3 470 km^2 in the Western part of Kenya. The river originates from the western slopes of the Mau Escarpment and flows through a narrow gorge, penetrating the Nyakach Escarpment. It then meanders into the Odino falls before entering the flood plains of Nyakwere where it drains into the Winam Gulf of Lake Victoria. The Sondu Miriu Hydro Power Project is a 60MW power project based on a run-of-river diversion from a

weir structure on the Sondu Miriu River above the Nyakach Escarpment. The water from the intake weir is conveyed via a 6.2 km underground tunnel before dropping to the power station via a 1.2 km penstock. The tail water then passes through an open channel for about 5 km to the 20MW Sang'oro power plant before discharging back to the Sondu Miriu River.

Unlike other hydropower projects in Kenya, Sondu Miriu Hydro Power Project does not have a major dam and associated large reservoir but relies on the flow of the river with only a small storage capacity at the intake, thus reducing its environmental impacts.

At the regional level, in 2010, the Nile Cooperative Framework Agreement was signed by six of the ten Nile Basin Countries namely; Kenya, Uganda, Tanzania, Rwanda, Burundi and Ethiopia. Such cooperative approaches provide a mechanism for coordinated management of the water resources and help to integrate the diversity of interests in shared basins.

A supportive legal and policy framework

Government has put in place a supportive legal and policy framework that will ensure the sustainable development of water resources. The vision for the water and sanitation sector is '*to ensure water and improved sanitation availability and access to all by 2030*.' To achieve this, Vision 2030 spells out measures to be undertaken to enable universal access to water and improved sanitation by 2030. Some of the specific strategies include improving the management of water resources, enhancing storage and harvesting capacity, constructing multipurpose dams as well as water and sanitation facilities in order to cater for the growing population. It has also defined flagship projects that will enhance the achievement of the water-related MDGs.

The new Constitution provides for the right to water and sanitation and recognizes environmental management as critical to achieving sustainable development. The Constitution also underscores the need for sustainable utilization, exploitation, management and conservation of the environment and natural resources as well as ensuring ecologically sustainable development including the protection of ecologically sensitive areas.

A number of other laws also provide for good water resources management. The Water Act 2002 has specified relatively clear roles at different levels for water resources management and development. Sections 42 and 55 EMCA (1999), which is the framework environmental law, provide for the sustainable management and utilization of wetlands and aquatic resources. There are also several sectoral statutes that have provisions on land use relevant to this sector. These include the Local Government Act, Physical Planning Act, Agriculture Act, Forests Act, Wildlife (Conservation and Management) Act, Mining Act and the Heritage Act (Monuments and Antiquities Act). In addition to addressing other issues, these laws provide for environmental protection and conservation within the relevant sector, with several subsidiary pieces of legislation prescribing land use standards to control environmental exploitation.

Coastal tourism

The main tourist attractions at the coast are its sandy beaches, marine parks and reserves, terrestrial game parks and reserves and an intriguing cultural setting which blends African, Arab, Portuguese and Western ways of life.

Tourism is the leading foreign exchange earner in Kenya and is expected to be a major contributor to attaining Vision 2030's economic pillar goals. In addition, income from tourism-related economic activities is an important and reliable source of revenue for the central government and local authorities. Between 2005 and 2007, tourism contributed an average of 9.2 percent to the GDP annually. However,

Fishing nets on Watamu Beach.

John & MeiKots/Flickr.com

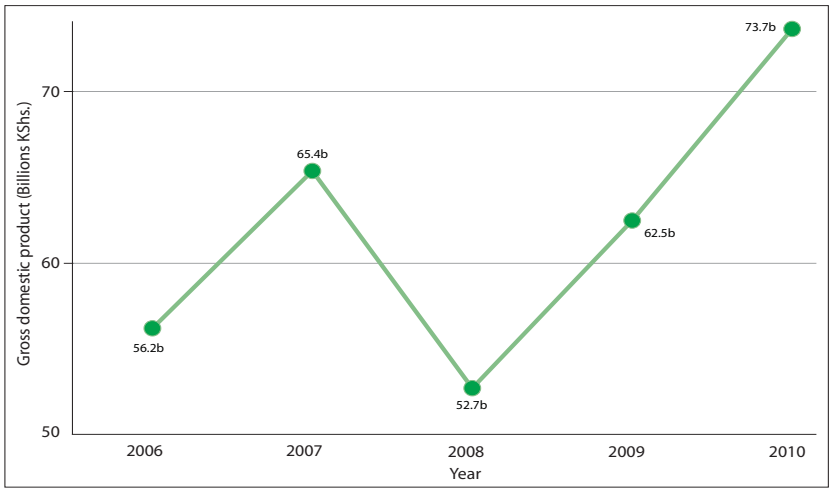


Figure 7.8: Overall tourism earnings, 2006 to 2010

Source: GoK 2011

in 2008, the sector witnessed one of its worst performances in recent history. This was mainly as a result of the political violence that erupted in the country in the wake of the disputed 2007 general elections. As a consequence, tourism earnings decreased from KSh 65.4 billion in 2007 to KSh 52.7 billion in 2008, representing a 19.2 percent drop. The volume of international arrivals also dropped sharply by 33.8 percent from 1.8 million in 2007 to 1.2 million in 2008. This was attributed to cancellations of reservations and termination of ongoing holidays as a result of the ensuing political uncertainty. Figure 7.8 shows the contribution of the tourism sector to the GDP from 2006 to 2010.

Coastal tourism contributes up to 68 percent of the total tourism earnings in Kenya. In most cases, half of the tourists to Kenya (47.6 percent of all bed-nights occupied in 2008) visit the coast with the country's north coast being the preferred destination. The sustainable use of the country's coastal and marine resources will therefore be crucial to meeting the economic and improved welfare goals enumerated in Vision 2030.

Coastal fisheries

There are two main types of fisheries: capture and culture fisheries. Traditionally, coastal communities have depended on capture fisheries and mangrove exploitation. Kenya is endowed with rich inshore marine fisheries and the most productive fishing areas are the North coast including Lamu, Kiunga, Kizingitini, Faza, the Sabaki Estuary and Tana River Delta, and the south coast especially the Funzi-Vanga complex.

Artisanal fishing that is undertaken in the inshore waters is labour-intensive and thus provides employment and livelihood sources to thousands of fishermen and their families. Estimates indicate that over 10 000 fishermen are directly engaged in artisanal fishing that accounts for about 95 percent of the total marine catch.

Mariculture, which is the culture of marine organisms, is increasingly being taken up by the residents of the coastal region as an income generating activity. There are three types of mariculture which can be undertaken along the coast; pond culture on land behind mangroves, suspension culture (cage and raft) in sheltered waterways that are of sufficient depth, and rack culture in the shallow intertidal areas. However, hydrologic conditions and other factors make large areas of mangroves in Kenya unsuitable for pond culture. For instance, only 3 950 out of 54 000 ha (7.3 percent) of the total mangrove area is considered suitable for the development of brackish-water shrimp farming. The common mariculture systems used in Kenya include small earthen ponds, drive-in mud crab cages, pen culture, Acadja Net Enclosures and down ponds.

Ports and shipping

Maritime transport of goods and passengers accounts for 15 percent of the coastal economy. The Mombasa Port at Kilindini is one of the largest and most important ports along the entire East African coast. The port serves Kenya and the landlocked neighbouring countries such as Uganda, Rwanda, Democratic Republic of Congo and South Sudan. The total number of ships that docked at the Mombasa Port averaged at 1 772.8 during 2004-2008. Cargo traffic handled in the port increased steadily from 12.92 million to 16.42 million deadweight tonnes over the same period. The volume of traffic handled at the port of Mombasa in 2008 was 16.4 million tonnes compared to 16.0 million tonnes in 2007, a 2.8 percent increase. 19.1 million tonnes were handled in 2009 and 19 million tonnes in 2010. The trend in the amount of cargo handled at Mombasa port from 2006-2010 is shown in Figure 7.9.

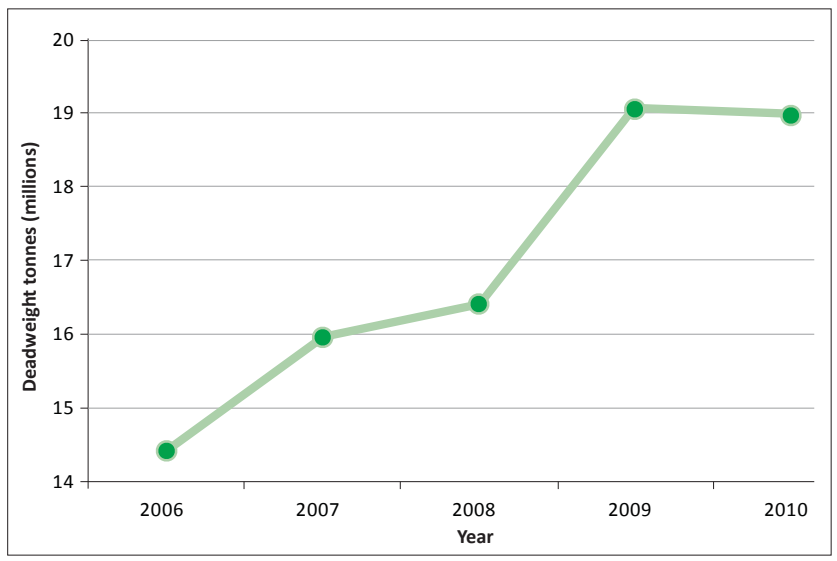


Figure 7.9: Trend in the amount of cargo handled at the Port of Mombasa

Source: GoK 2011

Challenges facing freshwater and marine resources

A number of factors are impeding the sustainable development of the country's freshwater and marine resources. These include the ever increasing population and attendant water demand, overexploitation, wetlands and the wider catchment degradation, climate change and variability, marine pollution, shoreline changes and erosion, and emerging economic considerations.

Water scarcity

While the 2.9 percent annual growth in the country's population has led to a corresponding increase in water demand, the water supply has largely remained static. This calls for appropriate measures to meet the growing water demand for domestic and agricultural use. The renewable freshwater availability per capita has been declining over time and although it stands at an already low 548m^3, it is projected to fall to 235m^3 by 2020 (GoK 2010b). Acute water scarcity is often associated with a range of water-borne diseases such as diarrhoea and cholera. Because an unhealthy population cannot be productive, water scarcity is likely to adversely affect the attainment of the Vision 2030 economic, social and political goals.

The country's water resources are not evenly distributed in time and space primarily because 80 percent of the country is classified as ASALs. In addition, floods and droughts occur more frequently. As a result, poor Kenyans are seldom concerned about protecting the natural environment leading to water resource and catchment degradation.

There is therefore a clear link between water resources management and community livelihoods. Unless poverty and population issues are incorporated in water management, any attempts to achieve sustainable water resources management are doomed to failure. Appropriate interventions are therefore called for in order to make Kenya more water secure.

Wetlands degradation

The demands placed on wetlands are contributing to their deterioration. The contributory factors are poverty, rapid population growth, unsustainable agricultural practises, urban development, pollution, catchment degradation and climate change-induced stressors.

Wetlands are nutrient-rich ecosystems with high productivity, thus making them suitable for agriculture. During the dry season, wetlands are the only distinct areas with quality pasture and provide fall-back for livestock dependent populations. The pressures on the water resources and quality extend well beyond the administrative boundaries. Indirect impacts can result in downstream eutrophication and sedimentation and changes in geomorphology and flow regimes.

Wetlands are habitats to many different species including some that are endemic, endangered, and threatened such as haplochromines, Sitatunga antelope and papyrus. Most of the wetlands' species are cherished and valued by local communities and are therefore vulnerable to overexploitation, with some being on the brink of extinction.

The relatively flat terrain associated with river floodplains and estuarine wetlands make them easier to urbanize and 'develop' than upland areas, resulting in a concentration of human developments there. This has resulted in a progressive direct loss and indirect degradation of coastal and floodplain wetlands. Impacts are not just limited to lowland wetlands. Often the ecological footprint of unsustainable developments can extend over a considerably large area. Encroachment into wetlands has, for instance, been known to influence local and regional climates through the creation of urban heat islands. Impervious surfaces can alter sensible and latent heat fluxes and recent research findings have suggested that cities may also significantly affect local and regional precipitation regimes. Progressive urban sprawl, therefore, has the potential to impact the natural environment, and wetlands in particular, far beyond formal municipal boundaries. However, it is important that the increased urbanization that is expected to accompany the devolution envisaged by the Constitution does not accelerate the degradation of the country's wetlands, otherwise this will imperil the actualization of the Vision 2030 goals.

Urban wetlands for instance are threatened in two principal ways. The first is through the direct conversion of wetlands to planned and unplanned built up areas. This is leading to acute problems associated with pollution, drainage issues, direct biodiversity habitat loss, overexploitation of wetland plant and animal species by urban and peri-urban residents and the increased prevalence of invasive alien species. The second threat is from watershed-related impacts of urban development, including increased demands for water, increasing diffuse and point source pollution and the need for greater agricultural production to support the burgeoning urban population. These all comprise the 'ecological footprint' of cities and adversely impact

Waste materials pollute the Nairobi River as it flows past the Dandora municipal dumpsite in Nairobi.

Christian Lambrects

wetlands even though these may be far from the urban centres. As agriculture is the backbone of the Kenyan economy, its strong growth is crucial to the delivery of Vision 2030, particularly its economic pillar goals. However, it is important that wetlands' integrity is not compromised while seeking to improve agricultural productivity in line with the Vision 2030 targets.

Water quality and pollution

Pollution of the water resources is a major problem. It creates health hazards, destroys ecosystems, adversely affects biodiversity and reduces industrial capacity through costs arising from the removal of pollutants. Industrial effluent, agricultural chemicals, municipal sewage and sediment load from soil erosion are some of the sources of pollution. Soil erosion arises from unsustainable land and water use practises. Physical-chemical analyses of surface waters show a high concentration of dissolved and suspended matter particularly at the beginning of rainy seasons. Table 7.7 highlights pollution discharge load into surface water by sector from domestic, industry and agricultural sources.

Table 7.7: Pollutant discharge load into surface water by sector Source: NEMA

Pollution source	Typical BOD* level of raw effluent, mg/l	Typical COD level of raw effluent, mg/l
Industry		
Coffee pulping	3 000 - 9 000	3 000 - 28 000
Textile	1 500	3 300
Leather tanning	1 500	
Paper and pulp	1 500	
Slaughter house	1 400	2 100
Fruit canning	2 000	
Milk processing	1 000	1 900
Domestic		
Domestic waste	500	
Agriculture		
Cattle pen washings	1 500	
Pig sty slurry	15 000	
Poultry manure	30 000	

*BOD stands for biochemical oxygen demand.

Catchment degradation

Catchment degradation is a major problem which is undermining the sustainability of water resources because it results in increased runoff, flash flooding, reduced infiltration, erosion and siltation. Degradation of the environment in the drainage basin results in the decline of springs, streams and rivers with catastrophic consequences for human wellbeing and environmental integrity. The main causes of catchment degradation include population pressure and deforestation resulting from destruction of natural vegetation through such activities as poor farming practises (over-cultivation and over-grazing), poorly assessed developments like infrastructure, forest excision for settlement, wood fuel, illegal logging and human encroachment. Other issues that contribute to catchment degradation include excessive abstraction of surface and groundwater, soil erosion causing turbidity and siltation, high nutrient levels causing eutrophication of lakes, dams and pans and pollution from toxic chemicals, including agricultural pesticides and heavy metals.

The degradation of catchment areas leads to chronic and long term problems. These are not always apparent because of the incremental nature of the degradation and the fact that the effects are often felt at a distance (in time and space) from the time and source of degradation. Table 7.8 summarizes the water quality situation for the different drainage basins in Kenya.

Costs of freshwater resources degradation

The costs associated with degradation of water resources include those for maintenance of infrastructure, health impacts, treatment of urban water supply and reduced fisheries production. According to Mogaka et al (2002), estimating the costs of water resources degradation is not easy due to inadequate monitoring data and lack of a scientifically validated understanding of the processes that link pollution and the impacts. The authors however present some guidelines for costing

Table 7.8: Water quality for the different drainage basins Source: Ministry of Water and Irrigation, Water Quality and Pollution Control Division

Basin	Surface water quality	Groundwater quality
Lake Victoria	The lake has fresh water. Rivers exhibit variable seasonal quality—the water in the rivers is turbid, coloured and silt laden during the rainy seasons. In the upper reaches, water is of good quality.	Over 90 percent of boreholes drilled have good water quality, which is fresh and free from high levels of dissolved salts.
Rift Valley	Only L. Naivasha has fresh water. The other lakes in the basin have brackish to saline waters. In the upper parts of the rivers, water is of good quality but in lower parts there is high siltation and agricultural pollutants affect water quality.	Mostly fresh, neutral, soft and free from colour and turbidity. 50 per cent of tested borehole waters have fluoride levels above 1.5ppm.
Athi	In the upper reaches, water is of good quality during the dry periods, but gets very turbid during the rainy season. Water quality deteriorates downstream due to pollution from municipal waste, domestic sewage, industrial effluents and agricultural activities.	Over 50 percent of boreholes contain hard and saline water. Along the coastal area, sewage pollution and seawater intrusion affect water quality. High local variations occur in quality. Parts of the basin have high fluoride levels, hardness and high iron and manganese contents.
Tana	Generally of good quality. Pollution from municipal sewage, agrochemicals and siltation affects some rivers in this basin. Quality deteriorates gradually downstream.	Generally fresh and free from colour and turbidity. Hardness varies from soft to moderately soft. High fluoride levels in parts of the basin.
Ewaso Ng'iro	River water has high turbidity due to agricultural activities.	Water often hard with variable salinity levels. Nitrate contamination has been detected and is due to accumulation of livestock waste at watering points.

Issue	Effects	Associated costs	Estimated annual costs (Ksh millions)
Soil erosion	Siltation	Increased maintenance cost for minor dams/ pans	62.0
		Reduced life of pumps leading to abandonment of water supplies	20.0
Catchment degradation	Increased flooding downstream	Health effects (for instance Kano, Budalangi)	3.5
Water quantity	Crop production	Reduction in crop production	165.0
	Lowered water table	Increased pumping costs for groundwater	
Water quality	Water treatment	Cost of urban water treatment	853.0
	Fisheries	Reduced fisheries production	1 162.0

Table 7.9: Costs of water resources degradation Adapted from Mogaka et al 2002

the effects of water resources degradation based on estimates from particular sites. Table 7.9 illustrates some of the estimated costs although most appear to be very conservative.

Governance of transboundary waters

Kenya shares a number of important surface and groundwater resources with her neighbours—Ethiopia, South Sudan, Tanzania, Somalia and Uganda as shown in Table 7.10. Altogether about 54 percent of Kenya's water resources are shared with other countries. Kenya provides about 45 percent of surface water inflows into Lake Victoria, and hence to the upper Nile. Some of the challenges with transboundary water bodies threaten sustainable use and regional cooperation. For instance, the impacts of climate change and variability such as drought result in a decrease in water availability, competition over water and cause political instability. Because the political, social and economic pillars of Vision 2030 are interrelated as the 2008 post-election violence demonstrates, any potential sources of water tension must be urgently addressed in order to avert regional and national political uncertainty.

Water body	Shared with
Lake Victoria	Uganda and Tanzania
Lake Natron	Tanzania
Lake Turkana (River Omo)	Ethiopia
Lakes Jipe and Chala	Tanzania
Mara River	Tanzania
Rivers Umba and Lumi	Tanzania
Rivers Sio, Malaba and Malakisi	Uganda
Daua River	Ethiopia and Somalia
Merti Aquifer	Somalia
Kilimanjaro aquifer	Tanzania

Table 7.10: Water bodies shared by Kenya with her neighbours

Increasing water demand and accessibility

The government is facing enormous challenges in providing water and sewerage services to its increasing population. The most authoritative estimate for water demand is the admittedly dated 1992 National Water Master Plan (NWMP). It assesses demand for rural and urban domestic water supply, irrigation, livestock, industry, fisheries and wildlife.

At 73.6 percent, irrigation accounts for the highest water demand as can be seen from Table 7.11. In 1990, it was estimated that domestic water demand (both rural and urban) was 1 105 000 m^3/day. This demand was expected to rise to 1 918 000 m^3/day in 2000 and to 3 068 000 m^3/day in 2010. Irrigation water demand was predicted to rise from 3 965 000 m^3/day in 1990 to 7 810 000 m^3/day in 2000 and 11 655 000m^3/day in 2010. This increase was based on the assumption that the planned 160 irrigation schemes would all be implemented and that the current rates of water use would prevail. However, by the year 2000 only about 15 percent of the irrigation schemes had been developed. Livestock water demand also did not rapidly increase as projected. It had been estimated that it would rise from 326 000m^3/day to 621 000m^3/day over the 20-year period (1990-2010).

Category	Demand ('000 m^3/day)		
	1990	2000	2010
Residential water demand	1 105	1 918	3 068
Livestock water	326	427	621
Irrigation	3965	7 810	11 655
Industry	219	378	494
Grand Total	**5 615**	**10 533**	**15 838**

Table 7.11: Water demand projections up to the year 2010 Source: GoK 1992

The National Water Master Plan 1992 also highlighted several demand centres where there was or would be water deficits. These demand centres are mainly urban centres and include Nairobi, Mombasa and Kisumu, Kakamega, Eldoret, Nakuru and other smaller towns.

Domestic water demand

Domestic water demand is expected to continue growing. For example by 2030, it is expected that the total projected domestic water demand will have increased four times from the 1990 figure. Conservative estimates have placed the demand at 3 700 000 m^3/day and 4 700 000 m^3/day in 2020 and 2030 respectively.

A rural water treatment project in Kisii.

Basin	Irrigation potential (ha)	Currently developed areas 2(ha)			Total estimates
		Centrally managed public schemes	Smallholder-community-based schemes	Private commercial schemes	Developed areas (ha)
Tana	205 500	10 500	23 400	32 300	66 200
Athi	40 000	2 600	8 200	12 500	23 300
Lake Victoria	200 000	4 150	32 300	11 500	47 950
Rift Valley	64 000	1 400	7 200	16 500	25 100
Ewaso Ng'iro	30 000	250	15 400	4 700	20 350
Total	539 500	18 900	86 500	79 500	184 900

Table 7.12: Irrigation potential by basin in Kenya

Source: National Water Master Plan 1992, Ministry of Water and Irrigation (MWI) and Interim Report on Irrigation and Drainage Master Plan, 2009

Irrigation water demand

It is estimated that Kenya has an irrigation potential of 539 000 ha with 75 percent of this potential lying in the Tana River and Lake Victoria basins. In addition, the country has a potential of 600 000 ha that can be developed through drainage and flood protection. With water harvesting and storage interventions, the irrigation potential could increase to more than 1.3 million ha. The country has therefore not fully developed her irrigation potential yet this is vital if agriculture, which is the mainstay of the economy, is to help attain and maintain the 10 percent GDP annual growth rate. If the total irrigation potential had been developed, the water demand for irrigation was projected to rise from 3.9 MCM/day in 1990 to 8.1 MCM/day in 2010 putting pressure on other water uses. Table 7.12 shows the irrigation potential by basin, while Box 7.1 lists the different categories of irrigation development by management criteria.

The slow pace of development of the sector is mainly due to lack of appropriate national policy direction, low stakeholder participation and limited financial investment. Under Vision 2030, the aim of the Ministry of Water and Irrigation is to increase the area under irrigation to 300 000 ha by 2012. In order to develop a significant proportion of the potential for irrigated agriculture, strategies and projects should consider the following interventions:

- promote soil and water conservation;
- increase water storage infrastructure, and especially the enforcement of the 90-day water storage regulation;
- support the formulation of an agricultural policy to optimize water use in flood plains;
- ensure water use efficiency which should match or surpass the global average efficiency of 32 percent;
- enhance water harvesting; and
- encourage water reuse especially for irrigation.

Climate change and extreme climatic events

Climate change threatens the very survival of species and the integrity of ecosystems yet all life forms are dependent on the latter. Global warming has led to increased precipitation in some areas, with other regions experiencing severe droughts.

An increasing frequency of climate extremes like floods and droughts is aggravating the state of the available freshwater resources. Climate phenomena often cause widespread flooding particularly in the low-lying areas. For instance the El Niño rains that fell towards the end of 2009 and continued until April/May 2010 led to unprecedented levels of soil erosion, siltation and flood-related damage to infrastructure and an increased incidence of water-borne human diseases. Drought is also an increasingly recurring phenomenon and its impact on the quantities of freshwater resources is usually devastating, resulting in declining lake levels, changes in the flow regimes of rivers, negative impacts on the environment and loss of ecosystem functioning.

Box 7.1: Categorization of irrigation development by management criteria in Kenya

- Centrally managed (public) irrigation schemes: These are irrigation schemes developed and managed by National Irrigation Board (NIB) or by Regional Development Authorities (RDAs). They account for 18 percent of the developed irrigation potential.
- Smallholder irrigation schemes: These are schemes owned and managed by communities or individual farmers. The schemes are developed by farmers on their own or in partnership with other stakeholders. They account for about 42 percent of total irrigation schemes in the country.
- Private commercial farms: These are privately owned and run mainly for the production of horticultural crops such as vegetables and flowers. These schemes employ capital intensive technologies and account for the remaining 40 percent of the total irrigation development.

Source: GoK 1992, GoK 2009b

A section of a road in Baringo damaged by floods.

Eugene Apindi Ochieng

Lamu is an ancient Swahili settlement. It is one of Kenya's oldest towns and a World Heritage Site.

Land based pollution arising from agricultural activities in the hinterland, domestic and industrial waste from urban settlements and storm water run-off pose significant threats to the marine environment. Poor waste management practises, especially in urban centres also pose a public health risk. There was extensive mangrove die-back in a number of areas. Mwache Creek, a peri-urban mangrove forest in Mombasa, experienced mangrove death covering about 500 ha, while in the Lamu archipelago, extensive dieback of mangroves was reported in Dondori creek. In addition, it is reported that the 1997/8 El-Niño caused 50-80 percent mortality of coral reefs due to bleaching, following an abrupt rise in sea water temperature (NEMA 2009). Currently, there are inadequate mechanisms to address emerging issues affecting the coastal zone from climate-related occurrences such as droughts, floods, tsunamis and storm surges. More research and monitoring programmes are required so as to adequately inform the management of the coastal zone resources.

Marine pollution

Land based pollutants from agricultural activities in the hinterland, domestic and industrial waste from urban settlements and storm water run-off are major sources of pollution to the marine environment. Poor waste management practises, especially in urban centres, pose a public health risk. The major sectors contributing to marine pollution in Kenya include agriculture, coastal developments, processing industries, mining, transportation and energy. Oil spills originating from oil tanker accidents, and hazardous waste from petroleum refineries and shipping activities also pose considerable threats to the coastal and marine environment. These diverse pollutants impact various habitats, including coral reefs, mangroves, seagrass beds, beaches and ground water aquifers along the coast. Marine pollution adversely affects the tourism sector. And because the Kenyan coast is a popular tourist destination, marine pollution is bound to make the Vision 2030 goal of making the country one of the top ten long-haul tourist destinations in the world a much more difficult task.

Shoreline changes and erosion

Increasing human activities along the coastal strip exert more pressure on the shoreline. The main impacts of these activities include loss of coastal land and infrastructure through coastal erosion and accretion. Shoreline erosion poses a continuous threat to the coastal infrastructure, necessitating expensively engineered protection measures and sometimes even the abandonment of hotel developments. Coastal erosion is widespread along areas where unconsolidated deposits form in the low-lying environments. Lamu town, Mambrui and many ancient villages of the Lamu archipelago that were built on ancient deltaic settings are threatened by coastal erosion (Kairu and Nyandwi 2000). Further, the narrow, southern low-lying coastal belt, the beach areas and the coastal mangroves are affected by erosion.

Coastal shoreline change causes destruction to fishing grounds, fish landing sites, beaches, turtle nesting areas, and properties adjacent

the shoreline. Destruction and loss of coastal and marine habitats is a result of unsustainable exploitation, poor land use practises, encroachment and unplanned and unregulated human settlement and urban development.

Ground water quality in wells and boreholes also declines due to increased intrusion of salt water into underground aquifers. Other challenges are presented by salt mining, human encroachment on sea turtle nesting sites, and land tenure and ownership issues. In addition, declining water quality and inadequate sources of potable water are serious constraints to the socio-economic development of the coastal area.

Degradation due to new/emerging economic activities

Economic opportunities like mining of titanium in the Msambweni area of Kwale county are expected to cause profound reductions in faunal diversity, habitat degradation and transformation in the coastal region. The proposed titanium mining project will have a high impact on indigenous plant diversity and ethnobotanical resources, since vegetation will need to be removed before mining can commence. The planned ship loading facility at Shimoni will also lead to habitat loss, and the forest fragmentation will likely result in great loss of biodiversity (Ojiambo 2002). Accidental oil spills and siltation from dredging activities are also likely to cause habitat loss. While these economic activities have the potential to provide local people with jobs that would lift them out of poverty in line with the Vision 2030 aspirations, it is important that these welfare improvements are not achieved at the expense of ecological integrity. It will therefore be critical that the Environmental Management Plan is adhered to in terms of rehabilitation and remedial measures, so as to mitigate habitat and biodiversity loss. Table 7.13 provides a summary of the causes, impacts and results of human activity along the coast.

Poorly planned and uncoordinated coastal developments are a common sight. They occur as a result of a sectoral approach to planning and management. They are further compounded by inadequate partnerships and cooperation between government and non-government stakeholders at the local, national and regional levels in the development and management of the coastal zone. Inadequate communication, education and awareness on coastal zone management issues and weak institutional and legal frameworks that do not adequately address the complex multi-sectoral problems facing coastal areas are also contributory factors.

Table 7.13: Causes, impacts, and consequences of coastal degradation and loss of habitats

Source: GEF 2002, King 2004

Root causes	Impacts	Consequences
Social drivers		
•Increase in population •Lack of alternative livelihoods •Cultural attitudes •Increase in commodity prices •Lack of education and awareness •Community alienation/marginalization	•Poor regeneration capacity •Loss of biomass •Increased resource conflict •Loss of system productivity •Habitat fragmentation	•Loss of cultural heritage •Loss of revenue •Loss of livelihood •Increased poverty
Economic drivers		
•Land transformation for agriculture; salt works, etc. •Water abstraction •Increased market demand •Foreign markets and international trade •Tourism development	•Habitat fragmentation •Increased erosion and sedimentation, •Deterioration of water quantity/quality •Decline in harvestable resources •Loss of aesthetic value	•Loss of biotic integrity and threat to biodiversity •Invasive species •Disease outbreaks •Loss of revenue •Increased poverty
Climate change and natural phenomena		
•Increased greenhouse gases •Increased sea surface temperature	•Increased rainfall and flooding •More frequent droughts •Drying of rivers •Diseases •Coral bleaching •Loss of tourism opportunities	•Loss of biotic integrity and threat to biodiversity •Reduced biomass •Loss of revenue •Increased poverty
Governance		
•Little understanding of the values of ecosystem services •Inadequate financial mechanisms and support at all levels •Inappropriate/outdated legislation •Insufficient public involvement •Poor enforcement of legislation •Inadequate data to support sustainable utilization •Inadequate implementation of available regulatory instruments	•Unsuitable exploitation of living resources •Undervaluation of ecosystem services •Limited ability to think beyond immediate needs •Diminishing livelihoods	•Decline in harvestable resources •Decreased revenue •Increased conflicts •Increased poverty

Strategies for the management of freshwater, coastal and marine resources

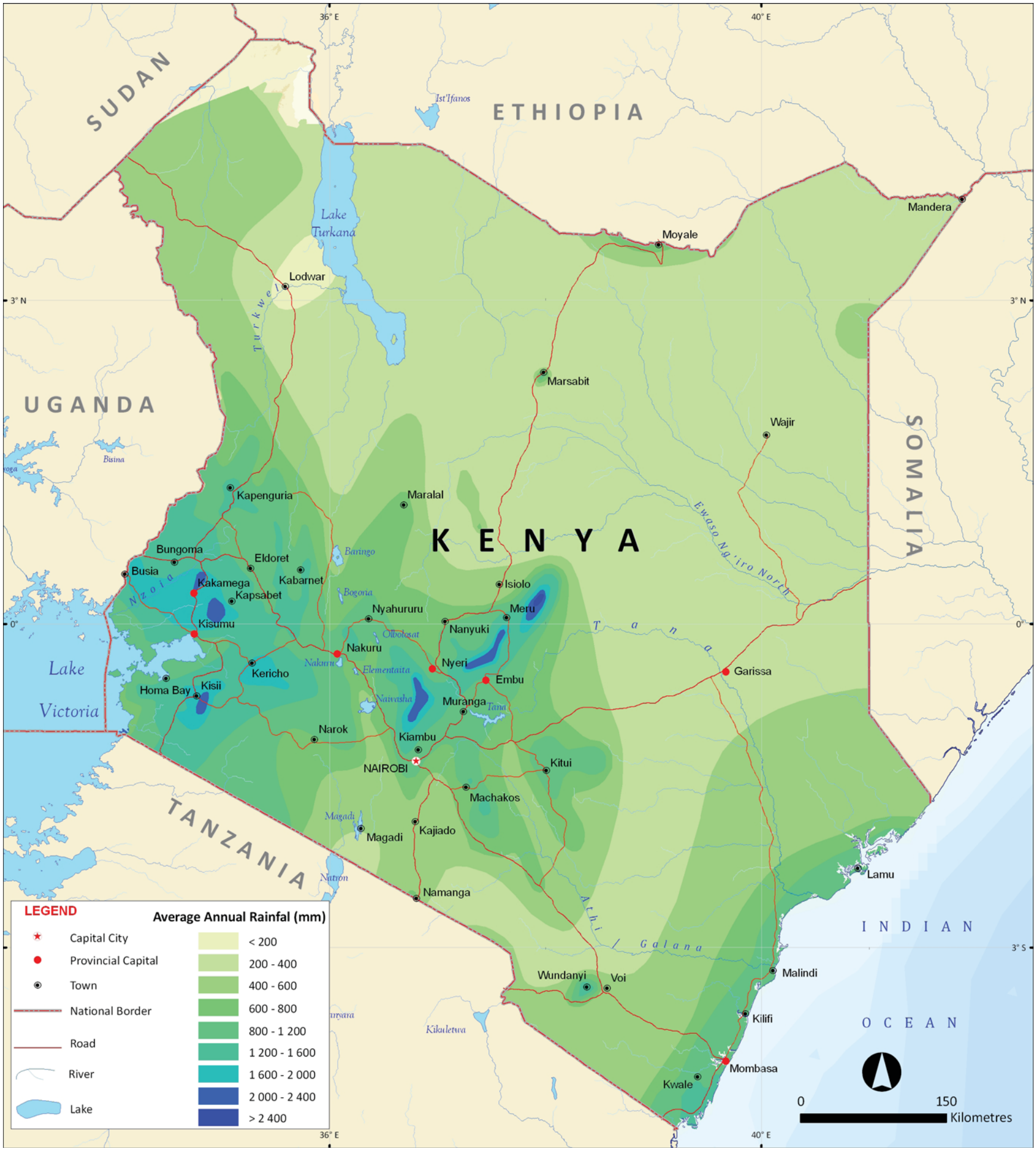
Strategies for the management of freshwater resources

There are several issues and challenges that need to be taken into account as the government attempts to undertake sustainable water resources management. First, Kenya has a limited fresh water endowment. Second, the country experiences wide climatic variations both in time and space. There is considerable spatial variability in rainfall received ranging from 250 mm per year in the arid areas to over to 2 000 mm per year in the mountainous areas. About two thirds of the country receives less than 500 mm of annual rainfall, as shown in Figure 7.10. The country is experiencing an increased incidence of droughts and floods which now occur every three to four years.

Third, the water distribution in the basins is also highly uneven. The highest water availability is found in the Lake Victoria basin which accounts for more than 50 percent while the lowest is in the Athi river basin system. As such, water demand in some urban centres is met by water abstracted from different drainage basins. For example, Nairobi receives the bulk of its water supply from the Tana River basin and this accounts for 15.9 percent of the water abstracted from that basin.

Figure 7.10: Distribution of mean annual rainfall

Source: ILRI 2010



Fishing boats on the shores of Lake Victoria, at Luanda K'Otieno, Siaya County.

To achieve the targets envisaged in Vision 2030, there must be a marked increase of water supply and sanitation services. This is particularly important for the economic activities such as agriculture, industry and tourism as well as education, health, housing and urban development. Despite their important role, Kenya's water and wetland resources face enormous challenges. These mostly manifest themselves in water pollution due to unsustainable farming practises as well as industrialization, urbanization and wetland degradation.

The strategies to improve water and wetlands management should include the protection of the five 'water towers' where most of Kenya's surface water originates, better management and utilization of transboundary water resources, improved management of groundwater sources and improved water storage capabilities. Other interventions should be geared at enhancing information and knowledge management, better funding of the water sector, incorporating gender and health concerns into water resources management and implementing a range of water sector reforms that should also include the wetlands sector.

Better management and utilization of transboundary waters

As already indicated, over half of Kenya's water resources—both ground and surface—are shared with her neighbours. Managing transboundary water resources obviously presents more challenges than national waters. For example, even though the Lake Victoria basin is one of the water surplus areas of Kenya, because the lake is a shared resource, large-scale use of its water resources must be attended by cooperation among the basin countries. In this regard, the Lake Victoria Tripartite Agreement signed by Kenya, Uganda and Tanzania established the Lake Victoria Environment Management Project (LVEMP) whose primary goal is to rehabilitate the Lake Victoria ecosystem.

On the wider front, the Nile Basin Initiative (NBI) provides the basis for cooperation of all riparian countries in the development of the water resources of the Nile Basin. The emphasis is on the need for equitable sharing of the benefits, the sustainability of water resources and the need to build trust and cooperation among riparian countries. This culminated in the signing of the Nile Cooperative Framework Agreement by Kenya, Uganda, Tanzania, Rwanda, Burundi and Ethiopia in 2010.

Improved management of groundwater resources

Although groundwater is widely available, its exploitation and use are largely limited by poor water quality, overexploitation, saline intrusion along the coastal areas and inadequate knowledge of the occurrence of the resource. For instance, in the ASALs where surface water is scarce, groundwater plays an important role in the local livelihoods. Contamination or over-abstraction of groundwater in the ASALs therefore has serious consequences for domestic and livestock needs. Major issues in groundwater management stem from the fact that, compared to surface water, the resource is remote and needs more sophisticated tools for assessment, monitoring and regulation. The situation is compounded by the fact that ground water processes are very slow and any damage to an aquifer may take decades to be remedied either naturally or artificially.

Some interventions have been undertaken in the management of the Nairobi and the Lamu sand dune aquifers. With regard to the Nairobi aquifer, a preliminary study was carried out in order to develop a Water Allocation Plan. The Lamu sand dunes aquifer encroachment was addressed by holding a stakeholder meeting which proposed that the area be gazetted as a groundwater conservation area.

Improved water storage capabilities

Consistent and reliable supply of water is required to counter the effects of climate change and variability. Inadequate harvesting of water has resulted in certain parts of the country having a lot of water during the rainy season and little or none during the dry season. The current water storage of 4.079 billion m^3 out of the available renewable water of 20 billion m^3 is dismally low especially when compared to countries with similar climatic regimes such as South Africa (756 m^3 per capita), China (2 486 m^3 per capita), Brazil (3 255 m^3 per capita) and Australia (4 729 m^3 per capita). Improving rainwater harvesting and storage infrastructure is therefore highly recommended especially in the ASALs which experience frequent droughts.

Sector	Linkages
Tourism	• Resort cities, premium parks, niche products – These will require additional water and expansion of water and sanitation infrastructure • Wildlife – Kenya's wildlife, a key attraction to tourists, requires water for survival
Agriculture	• Irrigation – Development of irrigation will increase demand for water as more land is brought under cultivation • Livestock – Water demand in ASALs will be met by constructing water conservation structures (dams and water pans) and drilling of more boreholes
Wholesale and retail trade	• Modernization of new retail markets – District-based retail markets require water and sanitation services, as will new supermarket chains
Manufacturing	• Special Economic Zones – Manufacturing processes require water supply and waste water disposal systems. Agro-processing is one of the highest consumers of water • SMEs – SME parks will also consume additional water and require sanitation services.
Health	• Improved Health – Since about 80%of all communicable diseases are water-related, access to safe water and sanitation to households will be required to improve health standards.
Environment	• Degraded catchment areas – Degraded water resources will be reclaimed to boost supply • Pollution – Industrial effluents and agricultural chemicals affect water quality, increase cost of treatment and endanger lives
Governance	• Cohesive society – Equitable distribution of water resources will help establish a more cohesive society since lack of water has been a source of conflict in the past

Figure 7.11: Linkages between water and other economic and social sectors

Enhancing information and knowledge management

A reliable water management information system should be put in place. This is because it is important to continuously measure and record water resources data, including their quantity and quality and the various human and other factors which affect the resource. Yet, the water resources monitoring network has undergone marked deterioration. At a national level, only 22 percent of the registered hydrometric stations were operating by 2001. The status of the hydrometric stations in Kenya is shown in Table 7.14. In order to provide a basis for planning and management of water resources, the water assessment and monitoring networks for surface and groundwater quantity and quality need to be urgently rehabilitated and improved. Further, scaling up research in the water sector is essential if the country is to achieve its long-term water resource management targets. This is in light of the linkages between water and the other economic and social sectors which are highlighted in Vision 2030 and are reproduced in Figure 7.11

Table 7.14: Status of hydrometric stations in Kenya

Source: GoK 2004

Drainage Basin	Registered stations	Stations operating by 1990	Stations operating in 2001	% reduction from registered stations
L. Victoria	229	114	45	80
Rift Valley	153	50	33	78
Athi	223	74	31	86
Tana	205	116	66	67
Northern Ewaso Ng'iro	113	45	29	74
National	923	399	204	78

Better funding of the water sector

Budgetary allocations for water have traditionally been low although this has recently improved as is evident from Figure 7.12. Adequate and sustained funding is vital for the rehabilitation and expansion of the water supply and sewerage systems in Kenya.

Incorporating gender and health into water resources management

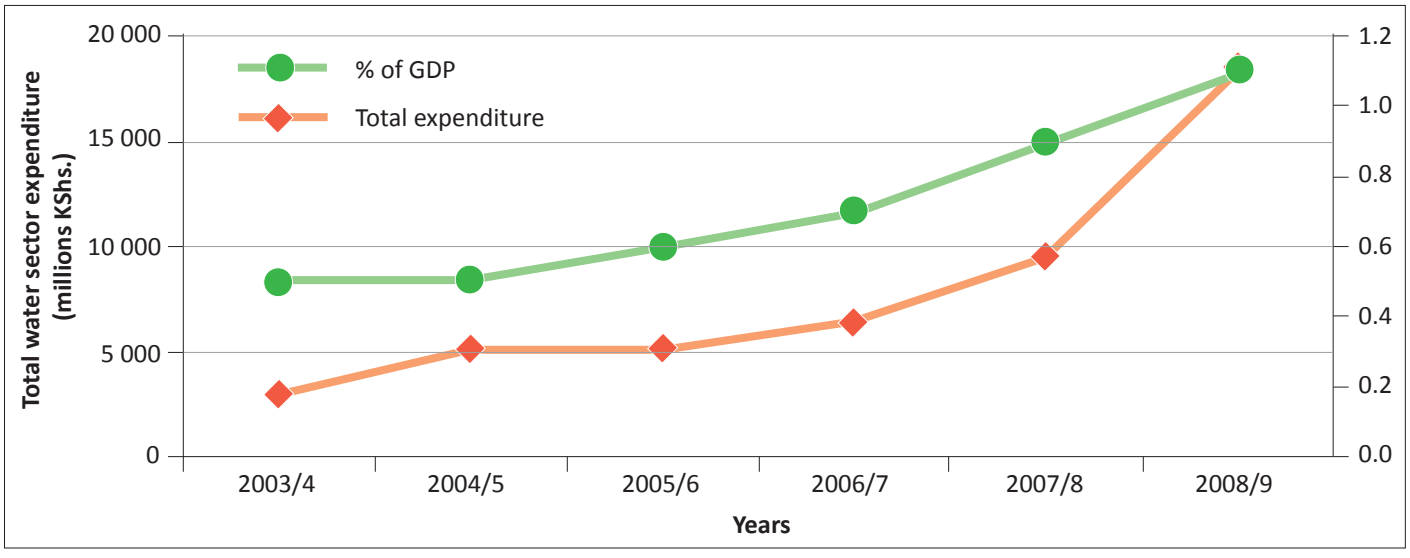
There is a lack of a gender focus in water policy formulation and implementation. Issues of water scarcity generally affect women and girls more than men and boys, in both urban and rural settings. This is because fetching water for domestic use in Kenya is mainly the responsibility of women and girls. However, sometimes men will take the livestock to the water source and might also collect water if it is for sale or if they are employed to do so. In times of extreme hardship, men may assist in the collection of water for domestic use, but they will bring it back using a donkey or bicycle while women have to use their heads and backs. The government has made attempts to raise the level of participation of women and the youth in the water sector through the community water based organizations and Water Resources User Associations (WRUAs).

Improving water, health and sanitation

Water supply and sanitation have an important bearing on public health. Improved access to water and sanitation leads to improved health, reduced health costs and more productivity as employees take less sick-leave. It is estimated that 80 percent of all communicable diseases are water-related and hence constitute a major portion of health care expenditure. Benefits of improved water services and sanitation therefore include averted health related costs, which is a gain to the economy but also benefits individual households. However, the fairly high prevalence of HIV/AIDS presents additional health burdens. For example, aging grandparents who have been left to take care of

Figure 7.12: Budgetary allocations for the water sector financial years, 2003/4-2008/9

Adapted from: GoK 2010



their orphaned grandchildren are often too weak to carry sufficient water from the water points. Government, NGOs and community based organizations (CBOs) should institute targeted mechanisms to ensure access to water for this vulnerable category.

Water sector reforms

Following the operationalization of the 2002 Water Act, management of water resources has been separated from water development and services delivery. The Ministry's role now focuses on policy formulation, implementation and monitoring. The management of water resources is now spearheaded by the Water Resources Management Authority (WRMA) created under the Water Act 2002. Before the Act came into effect, water resource issues were not considered a priority because all efforts and financial resources were directed towards water development, and operation and maintenance of the existing water supplies. Water services regulation and provision are now undertaken by the Water Services Regulatory Board (WASREB) and eight Water Services Boards. Thus a direct result of the water reforms over the past decade was the creation of various institutions, each with distinct roles and functions covering policy and supervision, regulation and service delivery. These are outlined in Table 7.15.

Government interventions in the sustainable management of wetlands

The Environmental Management and Coordination (Wetlands, Riverbanks, Lakeshores and Seashores Management) Regulations 2009

In order to domesticate the Ramsar Convention (1971), the government gazetted the EMCA (Wetlands, Riverbanks, Lakeshores and Seashores Management) Regulations 2009 in February 2010. These regulations emphasize the sustainable utilization of wetlands in a way that is compatible with the maintenance of natural ecosystem properties. Box 7.2 lists some of the activities that are permitted in wetlands under these regulations. These regulations are guided by the following principles:

- Wetland resources shall be utilized in a sustainable manner compatible with the continued presence of wetlands and their hydrological, ecological, social and economic functions and services
- Environmental impact assessment and environmental audits are mandatory for all activities likely to adversely impact wetlands
- Special measures are essential to promote respect for and preserve indigenous knowledge, innovations and practises that are relevant for the conservation and sustainable use of biodiversity. These measures should also ensure equitable sharing of the benefits arising from the utilization of such knowledge, innovations and practises
- Sustainable use of wetlands should be integrated into the national and local land use plans
- Public participation in the management of wetlands
- International cooperation in the management of transboundary environment resources
- Enforcement of the 'the polluter- pays' principle
- Enforcement of the precautionary principle.

Box 7.2: Activities permitted in wetlands

The Environmental Management and Coordination Act (Wetlands, Riverbanks, Lakeshores and Seashores Management) Regulations 2009 specify a number of activities that are permitted in the wetlands to ensure their sustainable management. These include:

- Subsistence harvesting of papyrus, medicinal plants, trees and reeds
- Cultivation provided that the cultivated area is not likely to adversely affect the wetland
- Fishing subject to the provisions of the Fisheries Act
- Collection of water for domestic use
- Hunting subject to the provisions of the Wildlife (Conservation and Management) Act
- Small-scale fish farming, and
- Grazing.

Table 7.15: Roles and functions of the various institutions with a water mandate under the Water Act (2002)

Institution	Function
Ministry of Water and Irrigation	Policy formulation, implementation and monitoring
Water Appeals Board (WAB)	Deals with conflict resolution within the sector as specified under the Water Act (2002)
Water Services Regulatory Board (WASREB)	Regulates water and sewerage services provision including: issuing of licences; and, setting service standards and guidelines for tariffs and prices
Water Resources Management Authority (WRMA)	Regulates water resources issues including: water allocation; source protection and conservation; water quality management; and pollution control and international waters
Water Services Trust Fund (WSTF)	Mobilizes financial resources for development and rehabilitation of water and sewerage services infrastructure especially to poor and under-served areas
Regional Water Services Boards (WSBs)	Manages water and sewerage service provision in respective regions by: contracting WSPs; developing water and sewerage facilities; regulating water services and tariffs; and procuring and leasing water and sewerage facilities
Kenya Water Institute (KEWI)	Provides training, research and consultancy services in the water and irrigation sector
National Water Conservation and Pipeline Corporation (NWCPC)	Contracts construction of dams and pans, bore holes and rehabilitation of flood canals on behalf of the Ministry of Water and Irrigation
National Irrigation Board (NIB)	Develops, promotes and improves irrigated agriculture through sustainable exploitation of available irrigation and drainage potential. Develops and manages national irrigation schemes.

Rehabilitation of the Nairobi River includes cleaning the river banks.

Inventory and mapping of wetlands in Kenya

The Ramsar Convention recognizes the importance of national wetland inventories as tools for informing policy and in order to ensure their conservation and wise use. Further, inventories are also important for identifying sites suitable for inclusion in the List of Wetlands of International Importance (the Ramsar List), for quantifying the global wetland resource as the basis for assessment of its status and trends, for identifying wetlands suitable for restoration, and for risk and vulnerability assessments. In Resolution VII.20 (1999) the Contracting Parties recognized the importance of maintaining a comprehensive national inventory as vital for achieving the wise use of wetlands, including policy development, identification and designation of Ramsar sites, documentation of wetland losses, and identification of wetlands with potential for restoration. It also encouraged the collection of information for the management of shared wetlands, including those within river basins or coastal zones.

Based on the above, Kenya is currently undertaking a national wetlands inventory and mapping exercise in order to come up with a wetland database that should inform these wetlands' sustainable management and policy development. The multi-stakeholder sub-committee mandated for this task is coordinated by the Ministry of Environment and Mineral Resources (MEMR) through the Department of Resource Surveys and Remote Sensing (DRSRS). Another taskforce has been constituted by the same ministry to undertake catchment profiling.

Draft National Wetlands Conservation and Management Policy

The formulation of the draft policy is in recognition of the importance of wetlands nationally. The draft policy also seeks to fulfil Kenya's obligations under the Ramsar Convention. The overarching objective is to ensure sustainable use of wetlands, riverbanks, lakeshores and seashores in order to enhance their ecological and socioeconomic functions for posterity. The draft policy aims:

- To establish an effective and efficient *institutional and legal framework* for integrated management and wise use of wetlands,
- To *enhance and maintain functions and values derived from wetlands* in order to protect biological diversity and improve livelihoods,
- To *promote communication, education and public awareness among stakeholders* in order to enhance their appreciation and participation in wetland conservation,
- To carry out d*emand-driven research and monitoring on wetlands* in order to improve the scientific information and knowledge base,
- To enhance *capacity building within relevant institutions* and for the individual personnel involved in the conservation and management of wetlands,
- To establish a *national wetlands information management system and database,*
- To promote *innovative planning and integrated management approaches* towards wetlands conservation and management in Kenya, and
- To *promote partnership and cooperation* at the regional and international levels for the management of transboundary wetlands and migratory species.

Draft Integrated Coastal Zone Management Policy

EMCA (1999) requires NEMA to develop an Integrated Coastal Zone Management (ICZM) plan to guide sustainable coastal development. The ICZM approach is one that aims to balance environmental conservation and development interests in coastal zones. A properly constituted ICZM framework empowers all stakeholders including government, NGOs, the private sector and local communities, to ensure equitable and sustainable use of coastal and marine resources and ecosystems. In so doing, it improves decision-making processes, enhances community participation, minimizes resource-use conflicts, promotes local coastal management programmes, and helps the country to meet its regional and international obligations such as those under the Nairobi Convention, the Convention on Biological Diversity (CBD) and the United Nations Framework Convention on Climate Change (UNFCCC).

The goal of the country's draft ICZM policy (2010) is 'to guide the sustainable management and equitable use of coastal and marine resources of Kenya.' Its specific objectives are:

- To ensure that ecological values of the coastal zone are fully integrated into the planning, management and use of coastal resources,
- To conserve and manage critical coastal ecosystems, habitats and species,
- To improve the knowledge base on sustainable coastal zone management, and
- To develop and support education and information programmes to promote coastal zone conservation, protection and management.

Conclusion and recommendations

Kenya's freshwater, coastal and marine resources collectively constitute a considerable natural resource and their sustainable use is a prerequisite to the delivery of Vision 2030. This is because these resources support manufacturing, agriculture, tourism and other important economic activities that are vital to Kenya's long term development. Besides making a major contribution to the GDP and being a major driver of the 10 percent annual economic growth rate anticipated by Vision 2030, tourism is the country's principal foreign exchange earner.

Kenya's renewable freshwater resources amount to only 20.3 BCM. A large proportion of these water resources is confined to about one fifth of the country rendering several regions severely water stressed or water scarce. Kenya's water deficiency will be exacerbated further with the implementation of Vision 2030 if no remedial measures are instituted because demand for water from all the economic and social sectors will increase. Other challenges will emanate from the country's high population growth rate, climate change and the transboundary nature of more than half (54 percent) of the country's water resources.

In light of the above, the following interventions are proposed in order to sustainably manage Kenya's water and marine resources:

- **Effective management of water catchment areas.** This should involve formulation of and harmonization of policies on land use for agriculture, wildlife, environment, industry and forests, and for improved coordination in catchment management.
- **Increased availability of water to deficit areas** through inter-basin transfers and construction of large water storage structures and optimum development of groundwater resources.
- **Development of all irrigable land in order to realize food security and economic development and to ease pressure on the existing cultivated lands.** This is in light of the fact that agriculture is slated to remain the backbone of the Kenyan economy and increased agricultural productivity will be vital to the attainment of the Vision 2030 goals, including improved welfare for the citizens.
- **Establishment of collaboration and cooperation mechanisms** allowing for catchment-wide approaches in management of international water resources in order to benefit the basin/ riparian countries.
- **Initiation and improvement of applied water research in important areas** such as application of appropriate and modern technology in water resources management, effective and efficient methods of catchment protection, pollution control, conservation and water use efficiency particularly in agriculture.
- **Development and implementation of an ICZM policy and legislation on coastal and marine resources** that will harmonize many of the issues contained in the various sectoral laws, EMCA and other regional and international conventions.

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