Ministry of Water, Sanitation and Irrigation

Lake Victoria South Integrated Water Resources Management and Development Plan

KENYA WATER SECURITY AND CLIMATE RESILIENCE PROJECT

Implementation Support Consultancy (ISC) to Support Strengthening of Water Resources Management and Planning

August 2020

WORLD BANK GROUP

Credit from IDA

Lake Victoria South Integrated Water Resources Management and Development Plan

KENYA WATER SECURITY AND CLIMATE RESILIENCE PROJECT

Implementation Support Consultancy (ISC) to Support Strengthening of Water Resources Management and Planning

FINAL

Prepared for:

Ministry of Water, Sanitation and Irrigation

Water Resources Authority

Contacts:
Water Resources Authority
The Chief Executive Officer,
Mohamed M. Shurie
Email: info@wra.go.ke

Prepared by:

Implementation Support Consultancy (ISC) to Support Strengthening of Water Resources Management and Planning

aurecon in association with:

CEA, DHI, Otieno Odongo & Partners Consulting Engineers, PEGASYS, RTI International, Rural Focus, WATER4LIFE, IEc Industrial Economics, Incorporated

August 2020

Project report number: C6-4

Recommended citation:

Aurecon AMEI Limited. 2020. *Lake Victoria South Integrated Water Resources Management and Development Plan*, Final Report. Technical Report prepared for the Ministry of Water, Sanitation and Irrigation, Republic of Kenya, by Aurecon AMEI Limited, Ebéne, Mauritius, 264 pp.

Map disclaimer:

In compiling reports for purposes of the Project, the Consultant used maps available in a reputable international GIS database. The Consultant is neither required to verify the accuracy of such map data nor required to warrant the accuracy thereof. Discrepancies between the data and actual data cannot be excluded, but it will not impact the outcome of the report or affect the quality thereof.

Image source: Andbeyond "Masai Mara Tours and Lodges'. Available online at https://36aizl3w7551i7pmd-42qlm93-wpengine.netdna-ssl.com/wp-content/uploads/sites/5/karibu-kenya-safari.jpg

E

Executive Summary

Executive Summary

E1. Background, context and objectives

The water resources of Kenya, a water-scarce country, are currently threatened on various fronts. Addressing this, demands capacity for comprehensive water resources management and planning, coupled with extensive investment in climate resilient water infrastructure.

In order to align the water sector in Kenya with Kenya's 2010 Constitution, the 2016 Water Act was promulgated in Sep 2016. The Act recognises that water related functions are a shared responsibility between the National Government and the County Governments. To give effect to the constitutional requirement for devolution of functions from National to County level, the Government of Kenya has embarked on a wide-ranging water sector reform programme.

The Act prioritises water user categories, outlines an array of institutional shifts and established the new Water Resources Authority to protect, conserve, control and regulate the management and use of water resources through supporting the Cabinet Secretary in the establishment and implementation of a National Water Resources Management Strategy. The Water Resources Authority responsibilities include the formulation and enforcement of procedures and regulations, policy development, water abstraction permitting and collecting of water use fees. The critical importance of proper water resources planning and management is evident in relation to Kenya's Big Four Agenda: Food security, Manufacturing, Affordable universal health care and Affordable housing.

The Government of Kenya received financing from the World Bank toward the cost of implementing the Kenya Water Security and Climate Resilience Project Phase 1 (KWSCRP-1), to be implemented through the Ministry of Water, Sanitation and Irrigation. This Consultancy covers Sub-component 2.2 *Strengthening Water Resources Management and Planning* of the KWSCRP-1. The overall objective of this Consultancy is to strengthen WRA's capacity in terms of tools, skills and infrastructure to deliver on its mandate for water resources management and regulation in the country.

A key set of deliverables under Sub-component 2.2 is the development of six Basin Plans for the six main river basins in Kenya. This document constitutes the Integrated Water Resources Management and Development Basin Plan for the Lake Victoria South (LVS) Basin. Integrated Water Resources Management considers the environmental, social and economic aspects of a river basin, and ensures that these aspects are integrated into an overall management strategy. It aims to achieve a sustainable balance between the utilisation, development and protection of water resources.

The main objective of this Plan for the LVS Basin is to provide a clear pathway for the sustainable utilisation and development of the water resources of the LVS Basin. The Plan provides a description of the current state of the basin, establishes a shared vision for the future development of the basin and identifies key strategic areas and actions for effective development and management of the basin's water resources. It draws information from relevant existing plans, sectoral perspectives and strategies, incorporates comprehensive inputs from various stakeholders and presents updated information based on analytical tools developed as part of this Consultancy.

In conjunction with stakeholders in the basin, a Vision for the sustainable development of the LVS Basin was developed, which reads as follows:

A sustainably conserved and climate resilient basin providing equitable ecosystem services through integrated water resources management by 2040

E2. Biophysical environment

The LVS Basin has a catchment area of 26 906 km^2 and is in the western part of the country. It borders Tanzania to the South and Lake Victoria to the East. Although the Basin only covers about 5.5% of Kenya's total area, the population density is high and the Basin houses about 19% of the country's total population. The major towns in the Basin are Kisumu, Kisii, Migori, Kericho, Homa Bay, Bomet and Kehancha. The Basin receives the second highest rainfall in the country, after the LVN Basin. Although significant surface water resources are available in the catchment, its temporal and spatial distribution often cause challenges.

The LVS Basin topography ranges from the Mt. Londiani peak at 3 000 masl to the shores of Lake Victoria at 1 130 masl. Generally, most of the basin is gently sloping. The Basin is divided into 32 sub-basins, 1GA to 1LB. The basin is characterised by the Nandi escarpment north-east of Kisumu and the Mau Forest Complex along its north-eastern border with the Rift Valley Basin from where its major rivers originate, including the Nyando, Sondu, Mara and Gucha rivers, The Mara River crosses the border into Tanzania in the Masai Mara National Reserve. Collectively, these 4 rivers drain almost 80% of the Lake Victoria South Basin. The remainder of the basin is drained by smaller catchments discharging into the Winum Gulf of Lake Victoria.

The LVS Basin faces the north-eastern side of Lake Victoria, which is the largest freshwater lake in Africa. The Lake is a shared water resource between Kenya, Tanzania and Uganda. The main wetlands in the Basin are associated with the Migori, Nyando and Sondu Miriu Rivers originating in the Mau Forest Complex. The Nyando (Kusa) Swamp, located at the mouth of the Nyando River, is covered with dense papyrus beds and is home to many rare bird species. The Swamp provides filtration to sediments and pollutants which are carried down the rivers towards Lake Victoria, and the papyrus is the source of livelihood for the local communities.

The LVS Basin is one of two basins in Kenya which drains to Lake Victoria. The Lake Victoria Basin is in the upstream part of the Nile River Basin and is shared among five countries. The Lake Victoria Basin falls under the equatorial hot and humid climate with a bi-modal rainfall pattern. Average annual maximum day temperatures vary from 15°C to 37°C across the basin, while the average annual minimum night temperatures vary from 3°C to 23°C. The central and northern parts of the LVS Basin receive higher rainfall, with some areas receiving a MAP as high as approximately 1900 mm, while the MAP reduces to less than 1000 mm in the southern parts of the basin. The mean annual precipitation across the basin equals 1 316 mm. Two periods of rainfall occur during the year, namely the long rains between March and May, and the short rains from October to November. The climate change analysis which was undertaken as part of this Consultancy showed a general increase (between 4% and 6%) in mean annual rainfall across the LVS Basin by 2050, while extreme temperatures are also expected to increase by up to 1.3 °C by 2050.

Flooding occurs in the LVS Basin, particularly in the Kano Plains, parts of Nyakach within the Nyando river basin, parts of the Awach Tende River basin and the Lower Gucha-Migori River basin. The main issues associated with floods in the LVS Basin are a reduction in channel conveyance due to sediment deposition, inadequate institutional capacity to deal with disasters, minimal water storage infrastructure to mitigate the effects of floods and droughts and inadequate real-time data collection.

The vegetation cover in the LVS Basin is mainly mosaics of forest and evergreen vegetation, with mountain forest vegetation in the highlands. The forests in the basin comprise a critical part of the LVS hydrological ecosystem and have numerous economic, social, cultural and ecological values, as they provide essential goods and services. Human encroachment is threatening the forest reserves in the basin and there has been a significant loss of vegetation cover.

The LVS Basin contains several environmentally protected areas. The Mau Forest Complex, located in the northern part of the catchment, is one of the country's main water towers. It is important to conserve the Mau Forest Complex as it is the main water source of the major rivers in the LVS Basin. Other protected areas include the Ndere Island and Ruma National Parks, The Masai Mara National Reserve and several National Sanctuaries. The KWTA is responsible for the management of areas considered to be water towers for downstream water supply. The LVS Basin has 1 Water Tower and 10 non-gazetted Water Towers.

Land use in the LVS Basin includes forest, grassland/rangeland and agricultural use. The Basin has a high population density and scattered urban and built-up areas. The dominant land use in the Basin is rain-fed agriculture and rangeland. The productivity is low due to land fragmentation and rainfall variability. There are certain areas on steep slopes where land use is unsuitable for crops.

E3. Socio-economic environment

The total population of the LVS Basin in 2019 was estimated as 8.57 million, which is equivalent to a very high population density of 319 persons/km^2. The overall population of the Basin is expected to increase significantly by 2040, where the urban population is expected to increase while the rural population is projected to decrease.

Water plays a key role in the socio-economic environment in the LVS Basin. It is of critical importance for the agricultural sector, which is the mainstay of Kenya's economy, for industries, health, tourism and for improving the standard of living.

The formal sector in the LVS Basin consists of both public and private enterprises which have been legally established or are listed with the registrar of companies. Most formal employment is in the urban centres although there is also formal employment in rural areas. The informal sector, also known as *jua kali*, employs 31% of the labour force in LVS Basin and covers all small-scale activities that are semi-organised, unregulated and use basic technologies. This sector provides employment for both rural and urban dwellers. Small-scale irrigation and pastoralism make up a large portion of the employment in the LVS Basin.

Almost 50% of the total population in the Basin is supplied directly from unimproved drinking water sources. Only 12% of the population receive piped water from a WSP, while about 40% receive water from boreholes and springs (Water Resources Management Authority, 2013). The majority of the urban and rural populations make use of septic tanks and pit latrines for sanitation. There are currently no sewerage systems in place in the rural areas, and only 4% of the urban population has access to formal sewerage systems (Water Resources Management Authority, 2013).

It is anticipated that flooding risks would increase in the basin due to urbanisation and the effects of climate change and that the increase in temperatures due to climate change would provide an environment conducive for malaria vectors to thrive. All counties in the basin experience malaria.

E4. Key issues and challenges

The water resources of Kenya are currently threatened by many issues. These include catchment degradation, pollution, inadequate monitoring networks, minimal integrated basin planning and management, water availability and supply issues, inadequate capacity (number of staff, skills, equipment and finances), uneven spatial and temporal distribution of water resources, anthropogenic encroachment on environmentally sensitive areas, inadequate flood and drought management and various other issues. In addition to the above issues, the LVS Basin has location-specific challenges and issues which, coupled with its unique basin characteristics, are an important consideration for effective water resources management and planning at basin and sub-basin level.

The specific issues for the LVS Basin were identified and prioritised during a two-day workshop with key stakeholders under four main categories:

Table E1: Main categories under which key issues in LVS Basin were classified

▪ Biophysical issues	**Climate:** Inadequate flood preparedness; Inadequate drought preparedness; Climate change **Environment**: Poor land use and catchment management; Natural vegetation loss; Biodiversity loss
▪ Socio-economic issues	**Demographics**: Population growth; Education levels; Poverty **Economics:** Economic activity; Employment; Livelihoods **Standard of living**: Water supply and sanitation; Food security; Disaster preparedness
▪ Water resources availability, management and development issues	**Surface water resources**: Spatial and temporal variability; Inadequate protection; Poor water quality **Groundwater resources**: Inadequate protection; Poor water quality **Inadequate water resources infrastructure**: Bulk water supply and transfers; Lack of formal irrigation schemes; Insufficient water supply schemes; Funding for future projects **Hydromet:** Inadequate monitoring network and monitoring **Water allocation and use**
Institutional issues	**Institutional arrangements**: National policies and legislation; National institutions; Basin and sub-basin institutions; County governments; Partnerships and engagements **Enabling environment** **Transboundary and trans-county issues**

E5. Water availability and water quality

The total LVS Basin natural surface water runoff equals 6 770 MCM/a. Almost 80%% of this originates from the Nyando, Sondu, Mara and Gucha-Migori rivers, i.e. 14% from the Nyando (932 MCM/a), 21% from the Sondu (1 431 MCM/a), 12% from the Mara (810 MCM/a) and 31% from the Gucha-Migori (2 085 MCM/a). All of the above rivers drain into Lake Victoria, except the Mara River which flows into Tanzania.

The annual groundwater recharge for the LVS Basin was estimated at 2,095 MCM/a, with a sustainable annual groundwater yield of 292 MCM/a. This is higher than the Kenya National Water Master Plan (NWMP) 2030 sustainable groundwater yield estimate of 203 MCM/a for the LVS Basin. However, whereas the NWMP 2030 assumed sustainable yield as a percentage of recharge (10%), the groundwater assessment which was conducted as part of this Consultancy estimated sustainable yield based on regional and secondary permeability and topography.

Projected sub-basin precipitation and temperature changes under climate change scenario RCP 4.5 were superimposed on the hydrological model of the Lake Victoria South Basin to assess the potential impacts on runoff. The natural runoff in the basin is expected to decrease in most sub-basins by between 1% and 3%, with some sub-basins staying unchanged or slightly lower or higher. The total surface water runoff from the LVS Basin is projected to decrease with 1.4% to 6 674 MCM/a under RCP 4.5. Even though rainfall is projected to increase, the expected increase in temperature and associated potential evapotranspiration, will thus result in a net reduction in surface water runoff from the basin. In the longer term, the effects of climate change are expected to increase recharge and available groundwater in the LVS Basin. It was found that the recharge in the basin will increase by 3% to 2 154 MCM/a, while the potential groundwater yield is expected to increase by 4% to 303 MCM/a under RCP 4.5.

The total current estimated water demand (2018) in the LVS Basin equates to 633 MCM/a as shown below. Most of the water is needed for domestic / industrial use and irrigation.

Table E-2: Current (2018) water requirements in the Lake Victoria South Basin per main sector

Sector	Total (MCM/a)
Irrigation	**256**
- Small scale / Private	183
- Large-scale	73
Domestic and Industrial	**300**
– Urban centres	92
– Basin-wide	208
Livestock	**62**
Other	**15**
Total	**633**

The 2018 water balance in the LVS Basin in terms of natural surface water runoff and sustainable groundwater yield, the ecological reserve and current (2018) water demands in the LVS Basin is summarised below. The current water demand constitutes about 9% of the total water resources available for use. It is important to realise that although the total annual demand is less than the total annual average runoff being generated in the basin, supply deficits often occur during dry years and/or the dry season, when the demand exceeds availability of water in the rivers at specific locations.

Table E-3: Lake Victoria South Basin water balance (MCM/a)

	Surface water	Groundwater	Total
Natural / Available water	6 770	292	**7 062**
Ecological reserve	(316)	-	**(316)**
	Total		**6 746**
	Water demand (2018)		**(633)**
	Balance		**6 113**

The scenario evaluations which were undertaken as part of this Study concluded that the expected growth in urban centre water demands by 2040 will result in a reduction in supply reliability to the urban centres. A priority for the development of water resources in the LVS Basin should therefore concern improved water supply to the main urban centres including Kisumu, through the provision of storage and/or inter-basin transfers. Except for a reduction in the areas of some of the proposed run-of-river schemes, the full extent of planned large-scale irrigation development in the LVS Basin should be feasible, but this will require the construction of large dams to ensure an acceptable reliability of supply. It is proposed that the Amala Irrigation Scheme should not be implemented due to concerns about water quantity and quality impacts on the downstream Masai Mara National Reserve and the Serengeti National Park in Tanzania.

The scenario analysis highlighted the importance of water demand management being implemented in all urban areas, while irrigation efficiencies should also be improved. Such a future constitutes the recommended sustainable development future for the basin. Under this scenario, the total future (2040) water requirement in the basin is projected as 1 989 MCM/a as detailed in Table E4. This represents a significant increase compared to the 2018 water demand in the basin. The additional water which will be required to meet future demands in the LVS Basin is less than the estimated remaining surface water and groundwater resources potential which is still available for development in the basin. However, to optimise the use of available water in basin will require the development of infrastructure for storage and regulation.

Table E4: Projected future (2040) water demands in the Lake Victoria South Basin

Sector	Total (MCM/a)
Irrigation	**850**
- Small scale / Private	426
- Large-scale	424
Domestic and Industrial	**834**
- Urban centres	374
- Basin-wide	460
Livestock	**161**
Exports	**123**
Other	**21**
Total	**1 989**

Water quality in the Lake Victoria has declined due to undesirable activities happening upstream in the LVS Basin. The result is water hyacinth infestation which blocks major navigation routes, interferes with fishing, hampers dam operations and threatens the lake ecology. Rangelands are also increasingly being converted to agro-pastoralism, which leads to a loss of natural protective vegetation cover, leading to increased erosion during rainy seasons. Unsustainable farming practices and poor management of croplands is evident in the catchment.

The LVS Basin currently has 50 recorded stream flow monitoring stations, although it is highly likely that this number was much higher in the past. Of these, only 38 are known to be currently operational. There is currently one operational lake monitoring stations in the LVS Basin at Kisumu (Lake Victoria). Currently, the water quality monitoring programme operated by WRA faces the challenges of inadequately qualified and trained staff, as well as an inadequate operational resources to facilitate regular sampling and laboratory analysis. In addition, because of inadequate equipment, the laboratories are only able to carry out limited analyses. Currently (2018) there are 18 groundwater monitoring boreholes in the basin, 73 surface water quality monitoring stations, and 26 effluent monitoring stations in the LVS Basin.

E6. Current water resources development and water allocations

There is only one existing dam in the LVS Basin, viz. the Sondu-Miriu Dam on the lower Sondu River. The dam, with a storage capacity of about 1 MCM, is used for hydropower production. Various other small dams and pans occur throughout the Basin with a combined storage of 5.3 MCM/a. Existing hydropower installations in the LVS Basin include Sondu Miriu Dam with an installed capacity of 60 MW and further downstream, the Sangoro Hydropower Scheme with an additional capacity of 21 MW using the tailwater of the Sondu Scheme. Gogo Falls hydropower station, which is essentially a run-of-river installation, is located on the lower Gucha River with an installed capacity of 2 MW. There are currently no inter- or intra-basin transfers in the LVS Basin.

The use of groundwater in public water service providers (WSPs) in the LVS Basin is very limited. However, some WSPs supplement surface water supply with groundwater. Small-scale groundwater sources (community boreholes and protected and unprotected shallow wells and springs) are widely utilised for rural water supply and in some municipal areas. Large-scale water users (categories B, C and D) are normally captured in the PDB system, while shallow wells or springs that utilise pumps from point water sources (with smaller abstraction volumes) are usually overlooked. Groundwater use in the LVS Basin is currently estimated as 67 MCM/a.

The total crop area in the LVS Basin is estimated at close to 600,000 ha, mainly consisting of rain-fed crops. Of this area, less than 5% is estimated to be irrigated at present (2018). The total current (2018) irrigated area in the Lake Victoria South Basin is estimated as 16 616 ha. Of this, about 5 500 ha is large scale irrigation. This represents an increase of about 26 % compared to the total 2010 irrigation area of 13 200 ha as determined in the NWMP 2030 and confirms the increase in irrigation in the basin.

The WRA uses the permitting system as a tool to regulate the use of water resources in Kenya. Water permits, as captured in the Permit Database, reflect the current allocation of water to different user categories. In accordance with the daily flow exceedance threshold approach to determine water available for allocation, as per the current WRA Guidelines for Water Allocation, a high level analysis was conducted to assess the surface water allocation status in the LVS Basin - based on sub-basin hydrology developed as part of this Consultancy and current allocation volumes extracted from the Permit Database. The analysis showed that sub-basins in the middle and upper Mara catchment as well as in the Gucha-Migori catchment are currently over-allocated, i.e. either the Normal Flow component (available for domestic and industrial use) and/or the Flood Flow component (available for irrigation use) has been exceeded by the current allocation volumes in these respective categories as reflected in the Permit Database.

E7. Evaluation of scenarios

Scenario evaluation was undertaken to assess different development and management scenarios and to identify a sustainable development pathway for the LVS Basin which will provide an acceptable trade-off between minimising environmental and social impacts and maximising socio-economic benefits. Scenarios were defined as detailed below. Note that all future scenarios represent a 2040 horizon.

- Scenario 0: Baseline

The Baseline Scenario represents the current (2018) conditions in the LVS Basin and provides a baseline against which future scenarios are evaluated. The scenario reflects existing water resources development and infrastructure, current water demands, no climate change impacts and also assumes non-compliance with the Q95 Reserve due to lack of monitoring and enforcement.

- Scenario 1: Lack of funding / Business as usual with irrigation development

This scenario represents the "do nothing" case - a possible worst-case scenario. It assumes that there is no further investment in water resources infrastructure and development including large-scale irrigation. Yet, growth in water demands up to 2040 across all sectors are assumed to be in line with projections (urban, domestic, industrial, livestock, small-scale irrigation). A continuation of the deteriorating trend in terms of vegetation loss in the catchment is also assumed (10% reduction by 2040 due to deforestation and overgrazing). Similar to Scenario 0, non-compliance with the Q95 Reserve due to inadequate monitoring and enforcement is assumed. Climate change impacts are incorporated in the water resources model.

- Scenario 2: Full development

The full development scenario is the same as Scenario 1, except that funds are now available to implement all of the major dams and large-scale irrigation schemes as identified in various studies and plans and by stakeholders. In essence this scenario evaluates the availability of water and the ability of the identified storage and transfer schemes to reliably supply future demands, specifically the significant large-scale irrigation and the projected increase in urban and rural demands. It evaluates the trade-off between potential socio-economic benefits due to the water resources developments, and negative environmental and social impacts. As funds are now available, compliance with Q95 as the ecological reserve is assumed. However, similar to Scenario 1, vegetation loss at 10% across the catchment is still assumed due to the focus on large scale development in the basin.

Two sub-scenarios were defined under Scenario 2:

- Scenario 2A: With climate change impacts
- Scenario 2B: Without climate change impacts

- Scenario 3: Sustainable development

This scenario represents a scaled-back version of Scenario 2 towards a sustainable development future, i.e. balanced water resources development which limits environmental and social impacts yet provides meaningful socio-economic benefits linked to the development of water resources with a reliable supply of water. This scenario aims for reduced sediment through reforestation, the successful implementation of a 20% reduction in future urban demands through water demand management, a reduction in large scale irrigation areas which are unproductive, and improved irrigation efficiencies.

The criteria which were adopted for the sustainable development of water resources in the LVS Basin include:

- Improving the assurance of supply to above 90% for urban, domestic and industrial users, taking into consideration the projected increase in water demand by 2040
- Improving and/or maintaining a high supply reliability for irrigation and livestock users, compared to the current (baseline) supply reliability, taking into consideration the projected increase in irrigation areas and livestock numbers by 2040
- A 10% improvement in forested area by 2040
- Successful implementation of a reduction in future urban demands through water demand management (-20%)
- Improved irrigation efficiencies: 60% for small scale and 80% for large-scale schemes

Three sub-scenarios were defined under Scenario 3:

- Scenario 3A: With Q95 as environmental flow requirement
- Scenario 3B: With EFlow holding flows as environmental flow requirement
- Scenario 3C: Same as 3A, except:
    - Amala Dam and Sand River Dam releasing EFlows as minimum environmental flow releases to mitigate the environmental impact in the Mara River downstream
    - Amala Irrigation Scheme no longer implemented to mitigate potential water quality and quantity impacts in the Mara River downstream
    - Areas of proposed run-of-river irrigation schemes reduced:
        - Ahero / West Kano: New area 4 150 ha
        - Kisumu Clusters: New area 0 ha
        - Nyabomite: New area 1 000 ha
    - Londiani Dam to Itare Dam transfer no longer implemented. Instead Londiani Dam will transfer water to subbasin 1JC to meet future demands of Kericho.
    - Bosto Dam no longer implemented due to environmental concerns.
    - In addition, it assumes that smaller dams and pans as well as groundwater abstraction will be implemented at local/sub-basin level to alleviate domestic, livestock and small-scale irrigation water shortages during the dry season.

In order to provide a scientific-based, transparent and consistent approach towards the evaluation of water resources development and management alternatives (scenarios) in the LVS Basin, analytical tools were developed. These tools include: (a) tools which assess erosion risk and sediment yield; (b) climate analysis tools which project changes in precipitation and temperature across the basin; (c) tools which classify ecological river condition and estimate variable environmental flow requirements; (d) water resources models, including a rainfall-runoff model, which simulate water availability and demands and the movement of water through river networks and water infrastructure associated with different levels of water resources development, and; (e) a macro-economic tool which, at a coarse level, assesses the impacts of alternative water resources development scenarios in terms of macro-economic sectors.

For the evaluation of scenarios, indicators were defined, categorised as environmental, social or economic indicators, and quantified based on response functions. These functions quantify how interventions affect the direction of change in environmental, social and economic performance, and measure the magnitude of that change through defined relationships or linkages between water resource driven processes (i.e. model outputs) and impacts or benefits. Typically, these response functions are based on empirical relationships derived from observed data, on physically based conceptual models which describe indicator responses in relation to physical parameters or on statistical indices or relevant values extracted from output time series. In order to assess relative impacts and benefits related to the defined water resources development scenarios, criteria, derived from indicators, were used to compare and evaluate different combinations of scenarios using multi-criteria analysis.

The evaluation of development and management scenarios provided useful information towards informing the strategy for the sustainable development of water resources in the LVS Basin. The main outcomes of the scenario evaluation with relevance to water resources development in the basin are summarised below:

- The supply deficits for current urban and rural domestic demands as well as small scale irrigation demands typically go up to 40%, mainly due to shortfalls during the dry season.
- The significant expected growth in urban and rural domestic water demands by 2040 will result in a reduction in supply reliability to these users. A priority for the development of water resources in the LVS Basin should therefore concern improved water supply to meet existing and especially future urban and rural demands through interventions towards improving water availability and assurance of supply. This demands a combination of new storage dams, importing water for Kisumu via an inter-basin transfer from LVN, water demand management measures, conjunctive use depending on groundwater availability and quality, as well as consideration of measures for rainwater harvesting.
- Itare Dam on the Itare River, an upper tributary of the Sondu River, will be able to supply towns in Bomet and Nakuru counties in the LVS Basin, while a significant volume of water will be available for transfer to Nakuru Town and other smaller towns in the adjacent Rift Valley Basin via an inter-basin transfer in line with the current planned transfer capacity of 41 MCM/a.
- Amala Dam on the Amala River, an upper tributary of the Mara River will be able to divert a significant volume of water to the Ewaso Ng'iro South River in the Rift Valley Basin for the generation of hydropower in line with the current planned transfer capacity of 82 MCM/a.
- In order to reduce the predicted loss in storage in the proposed large dams in the basin due to sedimentation, catchment management measures and programmes should be implemented in the upstream catchments where erosion risk has been identified as high.
- To improve current and future reliability of supply to towns and rural settlements outside of the major urban centres, for livestock as well as for supply of small-scale irrigation, new or additional storage (dams and pans), as well as local groundwater development need to be promoted.
- Except for a reduction in the areas of some of the proposed run-of-river irrigation schemes, the full extent of planned large-scale irrigation development in the LVS Basin should be feasible. This will, however, require the construction of large dams to ensure a high reliability of supply viz. Magwagwa, Nyando/Soin-Koru, Gogo Falls and Ilooiterre dams. It is proposed that the Amala Irrigation Scheme not be implemented due to concerns about water quantity and quality impacts on the downstream Masai Mara National Reserve and the Serengeti National Park in Tanzania
- Climate change is expected to result in increased rainfall and temperatures; however, the net impact will be less water availability and increased irrigation demands. This highlights the importance of providing storage and the need for water demand management.
- It is recommended that water demand management is implemented in all urban areas, while irrigation efficiencies should also be improved.
- The availability of water for use within the basin will be severely impacted by the introduction of variable minimum environmental flows as opposed to the current Q95 minimum constant flow. Careful consideration should be given to resource classification and how this will impact water resources availability. However, it is evident that significant and variable environmental releases (in excess of Q95) have to be implemented at Amala Dam and Sand River Dam to ensure the health of the downstream Mara River as it passes through the Masai Mara National Reserve and into the Serengeti national Park in Tanzania.

E8. Proposed development pathway

The essence of the proposed water resources development plan for the LVS Basin, up to 2040, is to improve the reliability of supply to Kisumu and other urban centres; to provide storage for the expected growth in basin-wide urban water demands; to ensure a reliable water supply for the expansion of existing, and the proposed new, irrigation developments in the basin; to implement the identified schemes which will export water to the Rift Valley Basin; to improve existing and future water resources availability for smaller towns and basin-wide domestic, livestock and small-scale irrigation water demands; and to unlock socio-economic development through multi-purpose water resources development projects in the basin, including flood control schemes. This will necessitate the construction of small-scale and large-scale storage, transfer and regulation infrastructure and increased groundwater abstraction. In addition, water demand management will be required for both small and large-scale irrigation and for urban centres.

E9. Water resources development investment plan

The following specific interventions are proposed:

- Construction of Magwagwa Multipurpose Dam on the Sondu-Miriu River in Nyamira County to generate hydropower, to supply domestic and industrial demands in Nyamira, Homa Bay and Kisii counties, to supply water for large scale irrigation development on the Kano Plains and for flood control along the lower Sondu River.
- Implementation of the Bunyunyu Dam Project on the upper Gucha River in Kisii County to supply water to Kisii Town and other surrounding towns in Kisii and Nyamira counties.
- Construction of Soin-Koru (Nyando) Multipurpose Dam on the Nyando River close to Muhoroni on the border of Kisumu and Kericho Counties. The dam will meet the following purposes: supply water for a proposed large-scale irrigation scheme along the Nyando River; improve the reliability of supply to the existing West Kano and Ahero Irrigation Schemes; support flood control along the lower reaches of the Nyando River; and improve domestic water supply to roughly 1.71 million inhabitants in various towns in Kisumu and Kericho counties
- A Multipurpose Dam at the existing Gogo Falls Hydropower Station on the lower Gucha River in Migori County should be constructed to increase the existing installed hydropower capacity at Gogo Falls, while simultaneously making water available for large-scale irrigation expansion along the lower Gucha-Migori River.
- In order to improve the reliability of supply to Kisumu Town, in light of persistent water quality problems with the existing Lake Victoria abstraction, and to ensure that the expected growth in water demand is met, Kibos Dam on the Kibos River in Nandi County, upstream of Kisumu, should be constructed. In addition, some of the water of the planned inter-basin transfer from the Nandi Forest Dam in Lake Victoria North Basin to the Oroba River in LVS should be released into the Kibos River upstream of the planned Kibos Dam to augment the supply to Kisumu. However, it is important to note that the construction of Nandi Forest Dam is quite controversial due to its potential impact on the Yala Swamp and the South Nandi Forest.
- Construction of Londiani Dam on the Kipchorian River, an upper tributary of the Nyando River, in Kericho County to meet the urban demands of Londiani and Kipkelion towns. An intra-basin transfer from this dam to the adjacent Yurith River catchment to the south should also be constructed as a more reliable water source for Kericho Town.
    - Itare Dam on the Itare River, an upper tributary of the Sondu River, in Nakuru County, will supply water to towns in Bomet and Nakuru counties in the LVS Basin as well as to Nakuru Town and other smaller towns in the adjacent Rift Valley Basin via an inter-basin transfer (tunnel).
    - Amala Dam on the Amala River, an upper tributary of the Mara River, should be implemented to supply domestic and livestock demands in parts of Bomet and Narok counties. In addition, the dam will divert water through a tunnel to the Ewaso Ng'iro South River in the Rift Valley Basin for the generation of hydropower. Significant environmental releases would have to be

made from this dam to ensure the health of the downstream river as it passes through the Masai Mara National Reserve and into the Serengeti national Park in Tanzania.

- Ilooiterre Dam on the middle Migori River should be constructed to meet domestic, small-scale and livestock water requirements in the surrounding areas of Narok County as well as to supply the towns of Kehancha and Migori further downstream. In parallel, the dam will ensure water availability for the proposed Ilooiterre Irrigation Project upstream of Kehancha Town.
- To meet the future domestic and industrial demands of other towns and rural areas as well as livestock and small-scale irrigation water demands within the remainder of the LVS Basin, additional storage should be provided through the construction of additional dams and pans, and through the construction of more boreholes.
- Implementation and enforcement of the Q95 flow downstream of proposed dams and large-scale irrigation schemes to maintain the ecological health of the rivers. For future dams in the Mara River catchment, environmental flows using advanced approaches should be determined and implemented.

The following dams in the basin have been planned but are controversial. Further specialist studies are therefore required.

- The planned Bosto Dam in Bomet County is proposed to have a capacity of 30 MCM for supplying local county demands. However, environmental activist groups are strongly opposing the construction of the dam on the Kipsonoi River inside the South West Mau Forest, which is a biodiversity hotspot and Kenya's most significant catchment. Analyses undertaken as part of this Consultancy have shown that future water demands in Bomet County can be supplied from run-of-river abstractions, groundwater and by constructing additional small dams and pans, and Bomet Dam might therefore not be necessary.
- Norera dam is proposed to be constructed on the Mara River, while Mungango and Silibwet dams are proposed to be constructed on the Nyangores River, a key tributary of the Mara River. All three dams will mainly be utilised for irrigation. The proposal of these dams on the Mara River, in addition to Amala transfer scheme and the Borenga dam in Tanzania, have spurred strong retaliation from environmentalist groups. The dams could drastically impact the Mara River during the dry season, thus threatening the Serengeti ecosystem further downstream, damaging habitation, and disrupting the migration routes of wildebeest, zebras and gazelles (Muchira, 2019). In addition, there has been several clashes between the Tanzanian and Kenyan government regarding the proposed three dams on Kenya's section of the Mara River. These dams would reduce flow to the proposed Borenga dam further downstream in Tanzania.

A phased project investment plan linked to the development of water resources infrastructure in the LVS Basin is included as Table E5.

Table E5. LVS Basin Water Resources Development Investment Plan

Proposed Infrastructure Development - Water Resources, Hydropower & Large-Scale Irrigation							Expenditure (USD Million)	
Scheme	Storage / Transfer Volume	1:10 yield (MCM/a)	Purpose: Water Supply	Purpose: Hydropower	Purpose: Flood Control	Purpose: LS Irrigation	Feasibility ESIA / Design	Capital
Multi-purpose Dam Projects	Capacity						**262**	**1747**
Magwagwa	445 MCM, 115 MW	284	💧	💧	💧	💧	107	710
Soin Koru / Nyando	87 MCM	57	💧		💧	💧	38	252
Ilooiterre	14 MCM	8.5	💧			💧	8	55
Gogo Falls	464 MCM, 15 MW	603		💧		💧	71	470
Nandi Forest Dam	220 MCM, 50 MW	165	💧	💧	💧	💧	39	260
Intra-basin Transfers							**6**	**40**
Londiani Dam to Sub-basin 1JC	8 MCM/a	-	💧				6	40
Inter-basin Transfers							**182**	**1215**
Nandi Forest Dam (LVN) to LVS	189 MCM/a	-	💧	💧		💧	45	300
Itare Dam (LVS) to RV	41 MCM/a	-	💧				109	725
Amala Dam (LVS) to RV	82 MCM/a	-		💧			29	190
Dams - urban centres / flood control / HP							**98**	**652**
Kibos	26 MCM	14.2	💧		💧		20	132
Bunyunyu	6.3 MCM	19.5	💧				7	47
Sand River / Naikara	1 MCM	0.42	💧				2	12
Londiani	25 MCM	16	💧				13	89
Amala	175 MCM	68		💧			44	296
Itare	20 MCM	13.1	💧				11	76
Small dams / pans & Boreholes							**68**	**453**
Dams and pans	154 MCM	-	💧				53	355
Groundwater (Boreholes)	203 MCM/a	-	💧				15	98
Large Scale Irrigation Schemes (cost excl. associated dams)							**128**	**854**
Nyando	3 000 ha	-				💧	9	59
Nandi Forest	7 300 ha	-				💧	22	144
Lower Kuja	10 000 ha	-				💧	30	197
Ilooiterre	3 000 ha	-				💧	9	59
Ahero / West Kano	4 150 ha	-				💧	12	82
Nyabomite	1 000 ha	-				💧	3	18
Kano Plain	15 000 ha	-				💧	44	296

Scheme	Phasing (Year) 2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
Multi-purpose Dam Projects																					
Magwagwa	53	53	237	237	237																
Soin Koru / Nyando												38	126	126							
Ilooiterre									8	28	28										
Gogo Falls							35	35	157	157	157										
Nandi Forest Dam													20	20	87	87	87				
Intra-basin Transfers																					
Londiani Dam to Sub-basin 1JC					6	20	20														
Inter-basin Transfers																					
Nandi Forest Dam (LVN) to LVS													45	100	100	100					
Itare Dam (LVS) to RV	Cost included in Rift Valley Basin Plan																				
Amala Dam (LVS) to RV	Cost included in Rift Valley Basin Plan																				
Dams - urban centres / flood control / HP																					
Kibos		20	66	66																	
Bunyunyu			7	24	24																
Sand River / Naikara												2	12								
Londiani				13	45	45															
Amala	Cost included in Rift Valley Basin Plan																				
Itare	Cost included in Rift Valley Basin Plan																				
Small dams / pans & Boreholes																					
Dams and pans	27	27	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19
Groundwater (Boreholes)	7	7	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Large Scale Irrigation Schemes (cost excl. associated dams)																					
Nyando														9	30	30					
Nandi Forest														22	48	48	48				
Lower Kuja									30	66	66	66									
Ilooiterre												9	30	30							
Ahero / West Kano																12	41	41			
Nyabomite																			3	9	9
Kano Plain		22	22	99	99	99															
O&M Cost	0	0	8	19	30	35	36	36	41	48	55	57	62	69	76	83	88	90	90	91	92
Total Annual Cost (USD Million)	**87**	**129**	**364**	**481**	**463**	**222**	**115**	**96**	**259**	**321**	**328**	**195**	**318**	**398**	**364**	**383**	**287**	**154**	**117**	**124**	**125**

E10. Integrated Water Resources Management and Development Plan for the LVS Basin

In order to comprehensively and systematically address the range of water resources related issues and challenges in the LVS Basin and to unlock the value of water as it relates to socio-economic development, ten key strategic areas were formulated for the LVS Basin as shown below.

Table E6. BASIN PLAN - Key Strategic Areas and Objectives

Key Strategic Area		Strategic Objective
1	Catchment Management	To ensure integrated and sustainable water, land and natural resources management practices
2	Water Resources Protection	To protect and restore the quality and quantity of water resources of the basin using structural and non-structural measures
3	Groundwater Management	The integrated and rational management and development of groundwater resources
4	Water Quality Management	Efficient and effective management of water quality to ensure that water user requirements are protected in order to promote sustainable socio-economic development in the basin
5	Climate Change Adaptation	To implement climate change mitigation measures in the water resources sector and to ensure water resource development and management are adapted and resilient to the effects of climate change.
6	Flood and Drought Management	To establish and guide a structured programme of actions aimed at ensuring the prevention of, mitigation of, timeous response to, and recovery from, the harmful impacts of floods and droughts across the Basin or specific catchment area.
7	Hydromet Monitoring	An operational and well-maintained hydromet network supported by effective and functional data management and information management systems
8	Water Resources Development	To develop water resources as a key driver for sustainable economic and social development
9	Strengthened Institutional frameworks	To achieve an appropriate balance between operational functionality and the need for effective oversight and governance.
10	Enabling environment to support effective institutions	Improved regulatory responses to strengthen catchment based water resources management

Based on the analyses which were undertaken, interactions with stakeholders and the results of the scenario evaluations, strategic themes and strategies were defined under each key strategic area along with a prioritised implementation plan for the development and management of the water resources of the basin. Table E7 summarises the estimated budgets linked to the proposed activities under each Key Strategic Area.

Table E7 Summarised BASIN PLAN budget under the 10 Key Strategic Areas

Key Strategic Areas and Themes		Budget (USD Million)				
		2020-2022	2022-2025	2025-2030	2030-2040	**Total**
KSA 1	Catchment management Promote improved and sustainable catchment management Sustainable water and land use and management practices Natural resources management for protection & sustainable use Rehabilitation of degraded environments	5.5	31.3	27.5	20.2	**85**
KSA 2	Water resources protection Classification of water resources Reserve determination Determine Resource Quality Objectives Conserve and protect ecological infrastructure	0.3	0.8	1.8	1.9	**5**
KSA 3	Groundwater management and development Groundwater resource assessment, allocation and regulation Groundwater development Groundwater asset management Conservation and protection of groundwater	5.0	45.1	37.4	50.8	**138**
KSA 4	Water quality management Effective data collection, information generation, dissemination, knowledge management Promote sound water quality management governance Efficient and effective management of point and nonpoint sources of water pollution	3.8	24.8	71.1	94.6	**194**
KSA 5	Climate change adaptation and preparedness Understand impacts of climate change on water resources at appropriate spatial scales Climate change mitigation Climate change adaptation	3.9	10.4	10.3	7.1	**32**
KSA 6	Flood and drought management Flood management Drought management	6.6	27.6	3.2	5.6	**43**

Key Strategic Areas and Themes		Budget (USD Million)				
		2020-2022	2022-2025	2025-2030	2030-2040	**Total**
KSA 7	Hydromet monitoring Improved monitoring network Improved information management	1.0	13.6	10.0	6.0	**31**
KSA 8	Water resources development Surface water resource assessment, allocation and regulation Water resources planning Water storage and conveyance Groundwater development Hydropower development Water for agriculture Water based tourism and recreation Non-conventional water resources Water resources systems operation	204	1 507	902	1 559	**4 173**
KSA 9	Strengthen Institutional frameworks Promote improved and sustainable catchment management Guidelines, codes of practice and manuals	4.7	2.6	2.7	2.0	**12**
KSA 10	Strengthen enabling environment to support institutions Develop institutional capacities to support improved IWRM&D	5.3	9.0	4.4	6.0	**25**
Total		240	1 672	1 070	1 753	**4 735**

E11. Roadmap for the Basin Plan

In order to ensure the successful implementation of the strategies and actions presented in the LVS Basin Plan as well as effective monitoring and evaluation thereof, institutional role players need to be coordinated, key institutions linked to implementation need to be strengthened, imminent infrastructure feasibility and impact assessments need to be started, the knowledge base presented in the basin plan needs to be expanded on, and financial resources need to be mobilised. In parallel, implementation of critical as well as longer-term activities must begin as soon as possible. These four steps provide a roadmap to take the implementation of the Basin Plan forward.

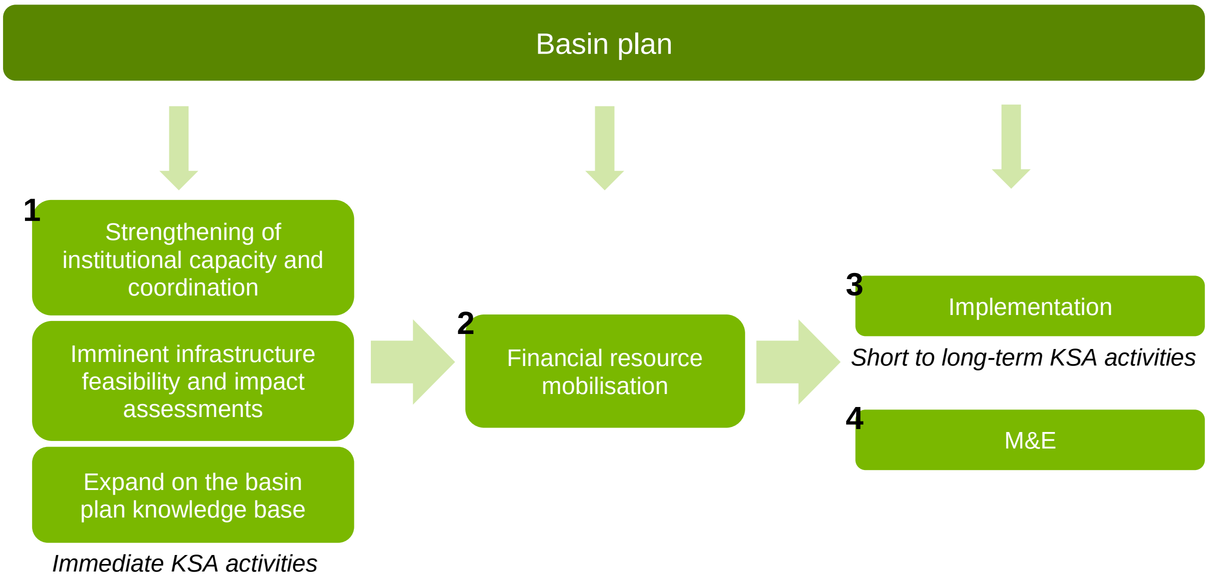


Figure E1: Roadmap for implementation of the Basin Plan

Contents

1 Introduction 1

1.1 Background and context 1

1.2 Objectives of the LVS Basin Plan 3

1.3 Approach to the development of the LVS Basin Plan 3

1.4 Structure of the LVS Basin Plan 4

2 Overview of the Basin 6

2.1 Introduction 6

2.2 Bio-physical 8
2.2.1 Physiography 8
2.2.2 Climate 19
2.2.3 Environment 23

2.3 Socio-economics 28
2.3.1 Demographics 28
2.3.2 Economy 29
2.3.3 Standard of living 31

2.4 Water resources management 32
2.4.1 Surface water resources 32
2.4.2 Groundwater resources 38
2.4.3 Current water requirements 41
2.4.4 Current large-scale water resources infrastructure 44
2.4.5 Water balance 47
2.4.6 Surface water allocations 50
2.4.7 Water quality 51
2.4.8 Existing hydrometeorological monitoring network 52

3 Institutional Overview 57

3.1 Legislative, Policy and Institutional Framework 57
3.1.1 National policies 57
3.1.2 Legislation 60
3.1.3 National institutions 61
3.1.4 Basin and sub-basin institutions 63
3.1.5 County governments 65
3.1.6 Partnerships and engagement 66

3.2 Existing Development Plans and Sectoral Perspectives 67
3.2.1 Introduction 67
3.2.2 National Water Master Plan 2030 67
3.2.3 Catchment management strategy 67
3.2.4 Sub-catchment management plans 68
3.2.5 County integrated development plans 69
3.2.6 Regional development plans 72
3.2.7 Projects planned by Water Works Development Agencies 72
3.2.8 Sectoral perspectives 73

4 Key Issues, Challenges and Trends 79
4.1 Introduction 79
4.2 Stakeholder engagement 79
4.3 Biophysical issues 81
4.3.1 Environment 81
4.3.2 Climate 86
4.4 Socio-economic issues 89
4.4.1 Demographics 89
4.4.2 Economy 91
4.4.3 Standard of living 92
4.5 Water resources availability, management and development issues 95
4.5.1 Surface water resources 95
4.5.2 Groundwater resources 98
4.5.3 Water resources infrastructure 101
4.5.4 Hydro-meteorological monitoring network 102
4.5.5 Water allocation and use 102
4.6 Institutional issues 102
4.6.1 Institutional arrangements 102
4.6.2 Enabling environment 106
4.6.3 Transboundary and trans-county issues 109
5 Vision and Scenario Evaluation 112
5.1 Introduction 112
5.2 Vision for LVS Basin 112
5.3 Conceptual approach towards the evaluation of water management interventions 112
5.4 Interventions and drivers 113
5.4.1 Biophysical 113
5.4.2 Socio-economic 114
5.4.3 Water resources 115
5.4.4 Institutional 117
5.5 Scenario definition 117
5.5.1 Scenario 0: Baseline 118
5.5.2 Scenario 1: Lack of funding / Business as usual with irrigation development 118
5.5.3 Scenario 2: Full development 118
5.5.4 Scenario 3: Sustainable development 118
5.6 Scenario analysis 123
5.6.1 Definition and quantification of indicators 123
5.6.2 Multi-criteria analysis 125
5.7 Scenario evaluation 129
5.7.1 Sustainable development pathway 129
5.7.2 Climate change impact analysis 130
5.7.3 Environmental flow impact analysis 131
6 Key Strategies and Themes 133
6.1 Introduction 133
6.2 Catchment Management 134
6.2.1 Introduction 134
6.2.2 The key principles of Catchment Management 134
6.2.3 Key catchment management issues in the LVS Basin 138
6.2.4 Strategy 144
6.3 Water Resources Protection 152
6.3.1 Introduction 152

6.3.2 Classification of water resources and resource quality objectives ... 153
6.3.3 Water resources protection in the LVS Basin ... 155
6.3.4 Strategy ... 156

6.4 Groundwater Management ... 158
6.4.1 Introduction ... 158
6.4.2 Groundwater use ... 159
6.4.3 Groundwater resource potential ... 161
6.4.4 Proposed aquifer classification ... 161
6.4.5 Key groundwater issues and challenges in the LVS Basin ... 166
6.4.6 Strategy ... 171

6.5 Water Quality Management ... 175
6.5.1 Introduction ... 175
6.5.2 Water quality standards and guidelines ... 176
6.5.3 Key water pollutants and pollution sources ... 177
6.5.4 Water quality status in the LVS Basin ... 183
6.5.5 Strategy ... 189

6.6 Climate Change Adaptation ... 193
6.6.1 Introduction ... 193
6.6.2 The changing climate in Kenya ... 194
6.6.3 Climate change impacts, hazards and vulnerabilities in Kenya ... 195
6.6.4 Strategy ... 197

6.7 Flood and Drought Management ... 198
6.7.1 Introduction ... 198
6.7.2 Characteristics of floods and droughts in the LVS Basin ... 199
6.7.3 Drought-prone areas in the LVS Basin ... 200
6.7.4 Existing flood and drought management measures and response plans ... 200
6.7.5 Key achievements, challenges and constraints ... 203
6.7.6 Strategy ... 205

6.8 Hydrometeorological Monitoring ... 210
6.8.1 Introduction ... 210
6.8.2 Issues related to hydrometeorological monitoring in the LVS Basin ... 210
6.8.3 Hydromet monitoring network design ... 211
6.8.4 Strategy ... 222

6.9 Water Resources Development ... 224
6.9.1 Introduction ... 224
6.9.2 Current water demands, resources development and supply reliability ... 224
6.9.3 Water resources development potential ... 225
6.9.4 Future water requirements ... 225
6.9.5 Proposed water resources development plan ... 226
6.9.6 Project investment programme ... 232
6.9.7 Strategy ... 237

6.10 Institutional Strengthening and Enabling Environment ... 239
6.10.1 Introduction ... 239
6.10.2 Institutional framework and challenges ... 239
6.10.3 Strategy ... 240

7 Way Forward ... 245

7.1 Introduction ... 245

7.2 Key Outcomes ... 245

7.3 Context ... 246
7.3.1 Linkages with the sustainable development goals ... 246
7.3.2 Linkages with other plans ... 246

7.4 Roadmap for the Basin Plan ... 247
7.4.1 Immediate actions ... 247

7.4.2 Financial Resource Mobilisation 252
7.4.3 Implementation 253
7.4.4 Monitoring and Evaluation 253

8 Conclusion 260

9 References 261

10 Annexures 266

Annexures

Annexure A: Analytical tools
Annexure B: Data at sub-basin level
Annexure C: Basin Planning: Policies, legislation and institutions
Annexure D: Stakeholder information
Annexure E: Implementation Plans
Annexure F: Costing

Figures

Figure 1-1: LVS Basin location map 2
Figure 1-2: Conceptual approach to basin planning 3
Figure 1-3: Key stages in development of LVS Basin Plan 4
Figure 2-1: Overview map of LVS Basin 6
Figure 2-2: Counties within the LVS Basin 7
Figure 2-3: Elevation zones in the LVS Basin 8
Figure 2-4: Slope categories in the LVS Basin 9
Figure 2-5: Landforms of the LVS Basin 9
Figure 2-6: Soils in the LVS Basin 11
Figure 2-7: LVS Basin Inherent Soil Erosion Risk (C and P factors not included) 13
Figure 2-8: LVS Basin Potential Soil Erosion Risk 13
Figure 2-9: The geology of the Lake Victoria South Basin 17
Figure 2-10: The drainage network and sub-basins of the LVS Basin 18
Figure 2-11: Major wetlands in the LVS Basin 19
Figure 2-12: Mean annual precipitation across the LVS Basin 20
Figure 2-13: Baseline temperature and precipitation in the Lake Victoria South Basin 20
Figure 2-14: Visualisation of GCM predictions of temp (top) and rainfall (bottom) for Africa by 2100. 21
Figure 2-15: Change in Annual Precipitation, Maximum and Minimum Temperature by 2050 22
Figure 2-16: Project Tmax anomalies in the LVS Basin by 2050 (RCP 4.5) 23
Figure 2-17: Vegetation cover in the LVS Basin 24
Figure 2-18: Protected areas across the LVS Basin 26
Figure 2-19: LVS Basin land cover and use map 27
Figure 2-20: Sustainability of current land use in the LVS Basin 28
Figure 2-21: Natural mean annual runoff and seasonal flow patterns at key nodes in LVS Basin 34
Figure 2-22: Flow seasonality Index per sub-basin 35
Figure 2-23: Annual flow variability in the Mara River where it crosses the border into Tanzania 36
Figure 2-24: Unit runoff per sub-basin 37
Figure 2-25: Runoff coefficient per sub-basin 37
Figure 2-26: Climate change impacts on natural runoff in the LLVS Basin 2050 (RCP 4.5) 38
Figure 2-27: Estimated annual potential groundwater recharge in the LVS Basin 40
Figure 2-28: Estimated annual groundwater potential in the LVS Basin 40
Figure 2-29: Irrigated crops in the LVS Basin (RCMRD Kenya Crop Mask, 2015) 42

Figure 2-30: Present-day (2018) water requirements across the Lake Victoria South Basin 45
Figure 2-31: Surface water balance per sub-basin 48
Figure 2-32: Current-day water availability and use in the LVS Basin 49
Figure 2-33: Surface water allocation status per sub-basin (2018) 51
Figure 2-34: Locations of operational stream flow gauging stations in the LVS Basin 54
Figure 2-35: Locations of operational meteorological stations in the LVS Basin 55
Figure 3-1: WRA Offices and sub-regions in the LVS Basin 64
Figure 4-1: Example of outputs from the workshop for the LVS Basin 79
Figure 4-2: Frequency of identified key issues in the LVS Basin 80
Figure 4-3: Key issues framework 80
Figure 4-4: Tree loss and tree gain for LVS Basin according to Global Forest Watch 84
Figure 5-1: Scenario Evaluation (adapted from Kusek & Rist, 2004 and World Bank, 2008) 112
Figure 5-2: Approach to scenario development and evaluation 114
Figure 6-1: Illustration of good (left) and poor (right) state of both land and water resources 134
Figure 6-2: An example of the interconnected links of land degradation 135
Figure 6-3: The interaction of different management strategies for Catchment Management 136
Figure 6-4: Illustration of water and land use activities within a catchment 137
Figure 6-5: Catchment management considerations in LVS Basin 144
Figure 6-6: The different levels of water resources protection in Kenya 153
Figure 6-7: Water resources management cycle 154
Figure 6-8: The seven steps to determine water resource classes and resource quality objectives . 155
Figure 6-9: The total water resource, comprised of the Reserve and allocatable resource 155
Figure 6-10: Water resource protection considerations for LVS Basin 157
Figure 6-11: Proposed aquifer classification of the LVS Basin 162
Figure 6-12: Mogusi river at Nyakoe market, downstream of old bridge on Kisii – Kisumu road 186
Figure 6-13: Water quality monitoring stations in LVS - turbidity (a), TDS (b), PO_4 (c) and NO_3 (d). 188
Figure 6-14: Flood management plan for LVS Basin 206
Figure 6-15: Kericho sub-region: Proposed flow and met monitoring network 212
Figure 6-16: Kisii sub-region: Proposed flow and met monitoring network 213
Figure 6-17: Kisumu sub-region: Proposed flow and met monitoring network 213
Figure 6-18: Kericho sub-region: Proposed surface water quality monitoring points 215
Figure 6-19: Kisii sub-region: Proposed surface water quality monitoring points 216
Figure 6-20: Kisumu sub-region: Proposed surface water quality monitoring points 216
Figure 6-21: Proposed Lower Awach Kano and Nyando flood early warning hydromet network 221
Figure 6-22: Proposed Lower Gucha Migori River flood early warning hydromet network 221
Figure 6-23: Proposed Lower Sondu flood early warning hydromet network 222
Figure 6-24:Proposed developments, dams and transfer schemes in the LVS Basin 228
Figure 6-25: Diversion weir on Kajulu River 229
Figure 7-1: Integration of the SDGs into the LVS Basin Plan 246
Figure 7-2: Roadmap for implementation of the Basin Plan 247

Tables

Table 2-1: Description of main soil types found in the LVS Basin 10
Table 2-2: Soil Classifications for LVS Basin 12
Table 2-3: Current classification of aquifers in the Lake Victoria South Basin 16
Table 2-4: Major forested hills in the LVS Basin 24
Table 2-5: The important and protected areas in the LVS Basin 25
Table 2-6: Economic activity of each county 29
Table 2-7: Livelihood activity of each county 31
Table 2-8: Irrigated areas per sub-basin (2018) 42
Table 2-9: Current (2018) water requirements in the Lake Victoria South Basin per main sector 44
Table 2-10: Key information for the Sondu Miriu Dam 44
Table 2-11: Existing large-scale irrigation schemes 46
Table 2-12: Groundwater contribution to meeting water demand in the LVS Basin (%) per sector 46
Table 2-13: Current (2018) Lake Victoria South Basin water balance (MCM/a) 47
Table 2-14: Current stream flow monitoring stations in LVS Basin 52

Table 2-15: Number of water quality monitoring stations in the LVS Basin (2018) 53
Table 2-16: Surface water quality parameters currently analysed...53
Table 2-17: Groundwater quality parameters currently analysed...53
Table 3-1: Guiding National Environmental Policy principles for basin planning.................................59
Table 3-2: National level public entities that have relevance to basin plans 62
Table 3-3: WRA sub-regions, offices and CMUs in the LVS Basin 64
Table 3-4: Objectives of the LVS CMS 68
Table 3-5: Key aspects of the CIDP...69
Table 5-1: Potential water resources development projects - dams and hydropower........................116
Table 5-2: Potential water resources development projects - transfers 116
Table 5-3: Potential water resources development projects - large-scale irrigation...........................117
Table 5-4: Scenario definition 120
Table 5-5: Structured indicators for evaluation of water management interventions..........................123
Table 5-6: Indicators used for scenario evaluation 124
Table 5-7: Criteria used for scenario evaluation 126
Table 5-8: Scenario evaluation criteria 127
Table 5-9: Criteria weightings 128
Table 5-10: Scenario scores and ranking for the full and sustainable development comparison 129
Table 5-11: Scenario scores and ranking for the climate change comparison...................................131
Table 5-12: Scenario scores and ranking for the environmental flow comparison 131
Table 6-1: Key Strategic Areas and Objectives 133
Table 6-2: Catchment management institutions operating at a local level in the LVS Basin 139
Table 6-3: Land institutions operating at local level in the LVS Basin and relevant issues................140
Table 6-4: Biodiversity institutions operating at local level in the LVS Basin and relevant issues 141
Table 6-5: Governance operating at local level in the LVS Basin and relevant issues 143
Table 6-6: Strategic Framework - Catchment Management...144
Table 6-7: Key water resources protection areas in the LVS Basin 156
Table 6-8: Strategic Framework - Water Resources Protection 157
Table 6-9: Proposed classification of aquifers in the LVS Basin 163
Table 6-10: Surface water contamination from gold mining in the Migori area 167
Table 6-11: Groundwater contamination in the Macalder Gold Mine area (mg/L) (Okoth, 2011) 167
Table 6-12: Strategic Framework – Groundwater management...171
Table 6-13: Kenya and WHO Standards for drinking water quality 176
Table 6-14: Kenya Effluent Discharge Standards into water bodies and sewers...............................176
Table 6-15: Major Point Sources of Pollution in LVS main rivers 184
Table 6-16: Strategic Framework - Water Quality Management 189
Table 6-17: Priority climate change actions (Government of Kenya, 2018c) 194
Table 6-18: Potential climate change impacts in Kenya (adapted from GoK, 2018)..........................195
Table 6-19: Strategic Framework - Climate Change Adaptation 197
Table 6-20: Widespread Kenyan droughts during the past two decades 200
Table 6-21: Levels of flood and drought management envisaged for the LVS Catchment Area (Water Resources Management Authority, 2015a) 202
Table 6-22: Strategic Framework – Flood and drought management 206
Table 6-23: Proposed surface water monitoring network for the LVS Basin 212
Table 6-24: Proposed water quality monitoring network for LVS Basin 214
Table 6-25: Proposed baseline and first priority stations for LVS basin 214
Table 6-26: Flood prone areas across Kenya proposed for the installation of FEWS........................219
Table 6-27: LVS FEWS – Proposed telemetric stream flow gauging stations....................................220
Table 6-28: LVS FEWS – Proposed telemetric meteorological stations 220
Table 6-29: Strategic Framework - Hydrometeorological Monitoring 222
Table 6-30: Current (2018) water demands in the LVS Basin 224
Table 6-31: Future (2040) water demands in the Lake Victoria South Basin 225
Table 6-32: Water resources development plan for the LVS Basin..227
Table 6-33: Proposed large scale irrigation areas 231
Table 6-34: Additional storage and groundwater development to meet 2040 basin-wide demands..232
Table 6-35: Scheme multi-criteria analysis - Decision matrix 234
Table 6-36: Ranked water resources development schemes...235
Table 6-37: LVS Basin Water Resources Development Investment Plan 236
Table 6-38: Strategic Framework – Water resources development 237
Table 6-39: Strategic Framework – Institutional Strengthening..241

Table 6-40: Strategic Framework – Enabling environment to support effective water resources planning and management....242
Table 7-1: Implementation plan role players....248
Table 7-2: Immediate implementation activities linked to institutional strengthening....249
Table 7-3: Summarised Basin plan budget under the 10 Key Strategic Areas....255
Table 7-4: Monitoring and Evaluation example....258
Table 7-5: Monitoring and Evaluation example sheet....258

Abbreviations and Acronyms

AAS	Atomic absorption spectrometry
AGR	Artificial groundwater recharge
AMP	Aquifer Management Plan
ASAL	Arid or Semi-Arid Land
ASDS	Agricultural Sector Development Strategy
ASM	Artisanal and small-scale mining
ATAR	Adaptation Technical Analysis Report
BCEOM	French engineering consultancy, now part of EGIS International
BCR	Borehole Completion Record (old WAB 28; current WRMA 009A or B)
BH	Borehole
BOD	Biochemical Oxygen Demand
BWRC	Basin Water Resource Committee
CA	Conservation agriculture
CAAC	Catchment Area Advisory Committee
CBA	Cost-benefit analysis
CDA	Coast Development Authority
CFA	Community Forest Association
CG	County Government
CIDP	County Integrated Development Plan
CITES	Convention on International Trade in Endangered Species of Wild Fauna & Flora
CMS	Catchment Management Strategy
CMUs	Catchment Management Units
COD	Chemical Oxygen Demand
CORDEX	Coordinated Regional Climate Downscaling Experiment
CRA	Commission on Revenue Allocation
CRBC	China Roads and Bridge Corporation
DCF	Drought Contingency Fund
DEC	District Environmental Committee
DEF	Drought Emergency Fund
DEM	Digital Elevation Model
DFID	Department for International Development (United Kingdom)
DHI	Danish Hydraulics Institute
DNAPL	Dense non-aqueous phase liquid
DO	Dissolved Oxygen
DSS	Decision Support System
DWF	Dry Weather Flow
EC	Electronic conductivity

EDC	Endocrine disrupting chemical
EDE-CPF	Ending Drought Emergencies Common Programme Framework
EEZ	Exclusive Economic Zone
EIA	Environmental Impact Assessment
EMCA	Environmental Management and Coordination Act
ENR	Environment and Natural Resource
ENSO	El Niño–Southern Oscillation
EPC	Export Promotion Council
EPV	Export Production Village
EPZ	Export Processing Zone
ERS	Economic Recovery Strategy
FAO	Food and Agriculture Organization (agency of the United Nations)
FEWS	Flood Early Warning System
FEWS NET	Famine Early Warning Systems Network
FMCF	Forest Management and Conservation Fund
FRF	Flood Response Forum
GCA	Groundwater Conservation Area
GCM	Global Climate Model
GDE	Groundwater dependent ecosystem
GDP	Gross Domestic Product
GIS	Geographical Information System
GMP	Groundwater Management Plan
GoK	Government of Kenya
GW	Groundwater
GWMATE	Groundwater Management Advisory Team (2002-2011), supported by the World Bank group
HQ	Head-quarters
ICZM	Integrated Coastal Zone Management
IDA	International Development Association
IPCC	Intergovernmental Panel on Climate Change
ISGEAG	Improving Sustainable Groundwater Exploration with Amended Geophysics
IUCN	International Union for Conservation of Nature
IWRM	Integrated Water Resources Management
IWRMDP	Integrated Water Resources Management Development Plan
JICA	Japan International Cooperation Agency
KCCAP	Kenya Climate Change Adaptation Programme
KCDP	Kenya Coastal Development Programme
KCSAS	Kenya Climate Smart Agriculture Strategy
KEWI	Kenya Water Institute
KFS	Kenya Forest Service

KMD	Kenya Meteorological Department
KNBS	Kenya National Bureau of Statistics
KNCPC	Kenya National Cleaner Production Centre
KSA	Key Strategic Area
KWSCRP	Kenya Water Security and Climate Resilience Project
KWT	Kenya Wildlife Trust
KWS	Kenya Wildlife Service
KWTA	Kenya Water Towers Agency
LAPSSET	Lamu Port-South Sudan-Ethiopia Transport
LIMS	Laboratory Information Management System
LPG	Liquefied Petroleum Gas
LSRWSS	Large Scale Rural Water Supply Scheme
MAE	Mean Annual Evaporation
MAP	Mean Annual Precipitation
masl	Metres above sea level
MAR	Mean Annual Runoff
MCM	Million Cubic Metre
MEMR	Ministry of Environment and Mineral Resources
M&E	Monitoring and Evaluation
MoWI	Ministry of Water and Irrigation
MoLPP	Ministry of Lands and Physical Planning
MoLRRWD	Ministry of Land Reclamation, Regional and Water Development
MoWD	Ministry of Water Development
MTPs	Medium Term Plans
MWSI	Ministry of Water, Sanitation and Irrigation
NAP	National Adaptation Plan
NAS	Nairobi Aquifer Suite
NAWARD	National Water Resources Database
NCCAP	National Climate Change Adaptation Plan
NCCRS	National Climate Change Response Strategy
NDEF	National Drought Emergency Fund
NDMA	National Drought Management Authority
NDMU	National Disaster Management Unit
NDOC	National Disaster Operations Centre
NEMA	National Environment Management Authority
NEP	National Environment Policy
NERA	National Electrification and Renewable Energy Authority
NET	National Environmental Tribunal
NGO	Non-Governmental Organisation
NIA	National Irrigation Authority

NLC	National Land Commission
NMK	National Museums of Kenya
NPEP	National Petroleum and Energy Policy
NPS	Nonpoint source
NRW	Non-Revenue Water
NWC&PC	National Water Conservation and Pipeline Corporation (now the National Water Harvesting and Storage Authority)
NWHSA	National Water Harvesting and Storage Authority
NWMP	National Water Master Plan
NWQMS	National Water Quality Management Strategy
OECD	Organisation for Economic Co-operation and Development
O&M	Operating and maintenance
PDB	Permit Database
POPs	Persistent organic pollutants
PPP	Public Private Partnership
PV	Photovoltaic
RCP	Representative Concentration Pathways
RO	Regional Office
RQOs	Resource Quality Objectives
RUSLE	Revised Universal Soil Loss Equation
SANBI	South African National Biodiversity Institute
SCMP	Sub-Catchment Management Plan
SEA	Strategic Environmental Assessment
SME	Small and Medium Enterprise
SOPs	Standard operating procedures
SRO	Sub-Regional Office
SSWRS	Small Scale Rural Water Supply Scheme
TA	Transboundary aquifer
TAMS	Tibbetts-Abbott-McCarthy-Stratton (first National Water Master Plan, 1977)
TNC	The Nature Conservancy
USAID	United States Agency for International Development
UWSS	Urban Water Supply System
W/S	Water Supply
WAP	Water Allocation Plan
WASREB	Water Services Regulatory Board
WASSIP	Water Supply and Sanitation Improvement Project
WKCDD&FMP	Western Kenya Community Driven Development and Flood Mitigation Project
WFP	World Food Programme
Wp	Watt peak
WRA	Water Resources Authority

WRM	Water resources management (also integrated WRM)
WRMA	Water Resources Management Authority
WRUA	Water Resource User Association
WSB	Water Services Board
WSP	Water Service Provider
WSSP	Water Sector Strategic Plan
WSTF	Water Sector Trust Fund
WT	Water Tribunal
WWDA	Water Works Development Agency
WWF	World Wildlife Fund
μS/cm	micro Siemen per centimetre

01

Image source: Victor Ochieng 2009. 'Kisumu Skyline'. Available online at https://www.flickr.com/photos/kija-na/3190621403/

Introduction

1 Introduction

1.1 Background and context

The water resources of Kenya, a water-scarce country, are currently threatened on various fronts. Addressing this, demands capacity for comprehensive water resources management and planning, coupled with extensive investment in climate resilient water infrastructure.

Under the guidance of the Economic Recovery Strategy, the Kenyan economy resumed a path of rapid growth. The Strategy expired in 2007 and the updated long-term vision to guide development in Kenya is the **Kenya Vision 2030** (Government of Kenya, 2007a). The aim of this Vision for the water and sanitation sector is *"to ensure water and improved sanitation availability and access to all by 2030"* while aiming to transform Kenya into *"a newly industrialising, middle income country providing a high quality of life to all its citizens in a clean and secure environment*".

The critical importance of proper water resources planning and management is also evident in relation to Kenya's **Big Four Agenda**: Food security, Manufacturing, Affordable universal health care and Affordable housing.

As set out in the **Constitution of Kenya** (2010)**,** the national government is responsible for water resources management through the **Ministry of Water, Sanitation and Irrigation (MWSI)** as the sector leader taking responsibility for policy development. The constitution also introduced a decentralised system of 47 county governments. To align the water sector with Constitution of Kenya (2010), the **Water Act** (No. 43 of 2016) was promulgated in September 2016. It recognises that water related functions are a shared responsibility between the national government and the county governments and that water resources are vested in and held by the national government in trust for the people of Kenya. To give effect to the constitutional requirement for devolution of functions from national to county level, the Government of Kenya has embarked on a wide-ranging water sector reform programme.

The Water Act prioritises water user categories, outlines an array of institutional shifts and established the new **Water Resources Authority (WRA)** to protect, conserve, control and regulate the management and use of water resources. WRA also supports the Cabinet Secretary in the establishment of a National Water Resources Management Strategy. WRA responsibilities include the formulation and enforcement of procedures and regulations, policy development, water abstraction permitting and collecting of water use fees.

The Government of Kenya received financing from the World Bank toward the cost of implementing the **Kenya Water Security and Climate Resilience Project Phase 1 (KWSCRP-1)**, to be implemented through the Ministry of Water, Sanitation and Irrigation. KWSCRP-1 is made up of two components, namely:

- **Component 1: Water Resources Development**. This component supports climate resilience and water security for economic growth by financing water investments and by building a longer-term investment pipeline.
- **Component 2: Effective Water Sector Institutions**. This component aims to support the current water sector institutions as well as the preparation, implementation and full function of the new and proposed legal and institutional framework resulting from the alignments with the 2010 Constitution. Ultimately, it aims for improved management and development of Kenya's water resources for its growth and development.

This Consultancy covers Sub-component 2.2 *Strengthening Water Resources Management and Planning* of the KWSCRP-1. The overall objective of this Consultancy is to strengthen WRA's capacity in terms of tools, skills and infrastructure to deliver on its mandate for water resources management and regulation in the country. Kenya's water sector reforms, including WRA's broadened mandate for water resources management, planning and regulation, have introduced new functions that require new capacities within WRA and its de-centralised structures. Existing capacities also need strengthening to address water resources development and management issues in a knowledge-driven manner. The scope of this Consultancy therefore aims to strengthen WRA's capacity to deliver on core functions that are new, have been expanded, or have in the past not been delivered on. A key set of deliverables under Sub-component 2.2 is the development of one Basin Plans for each of the six main river basins in Kenya as shown in Figure 1-1, namely Lake Victoria North, Lake Victoria South, Rift Valley, Athi, Tana and Ewaso N'giro North. This document constitutes the Basin Plan for the Lake Victoria South (LVS) Basin.

Figure 1-1: LVS Basin location map

1.2 Objectives of the LVS Basin Plan

Integrated Water Resource Management (IWRM) considers the environmental, social and economic aspects of a river basin, and ensures that these aspects are integrated into an overall management strategy. It aims to achieve a sustainable balance between the utilisation, development and protection of water resources.

The main objective of this Basin Plan for the LVS Basin is to provide a clear pathway for the sustainable utilisation and development of the water resources of the LVS Basin. The Basin Plan provides a description of the current state of the basin, establishes a shared vision for the future development of the basin and identifies key strategic areas and actions for effective development and management of the basin's water resources. The Basin Plan draws information from relevant existing plans and strategies, incorporates comprehensive inputs from various stakeholders and presents updated information based on analytical tools developed as part of this Consultancy.

1.3 Approach to the development of the LVS Basin Plan

The conceptual approach to the development of the Basin Plan for the LVS Basin is described schematically in Figure 1-2.

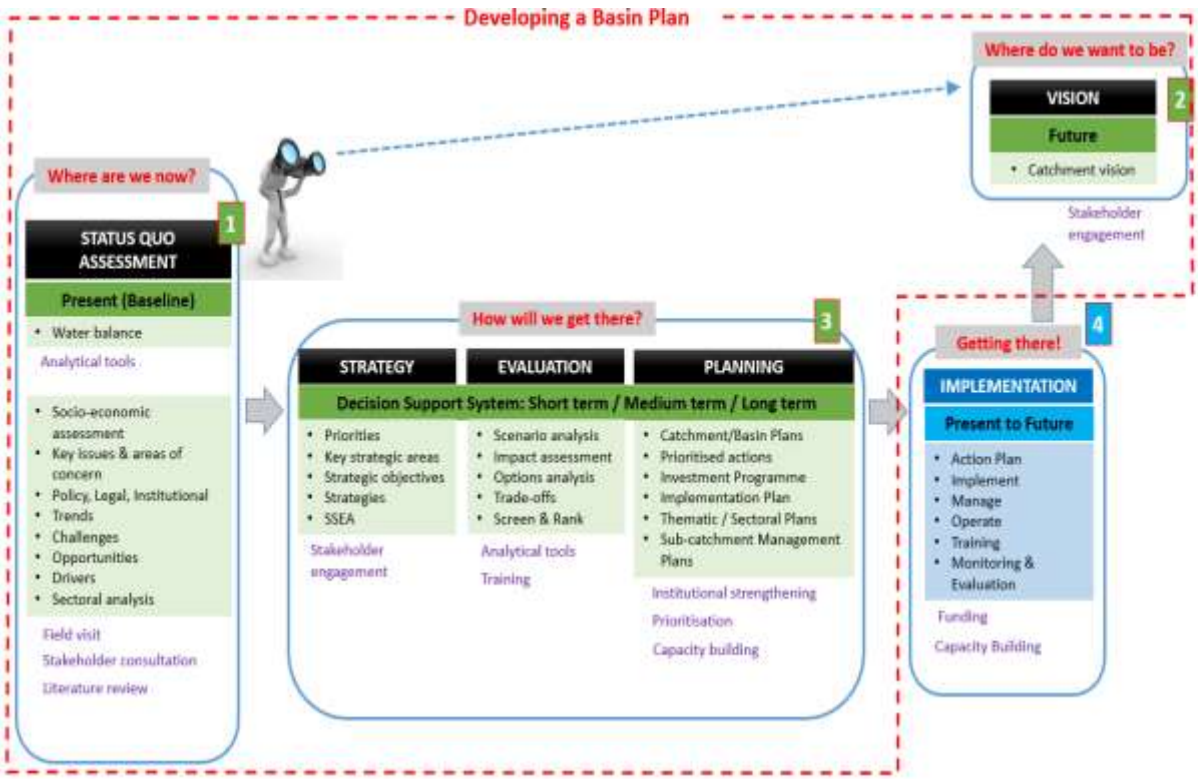


Figure 1-2: Conceptual approach to basin planning

Key elements related to the development of the Plan were to collect and review relevant data and information including the identification of key issues and challenges, to develop analytical tools for decision support, to consult the various stakeholders and organisations involved in the development, management and use of water resources in the basin, to develop a strategic framework for planning and management of water resources and to undertake comprehensive scenario evaluations. Stakeholder involvement at national and basin level was a focus area in the development of the Basin Plan.

Figure 1-3 displays the key stages in the development of a Basin Plan for the LVS Basin.

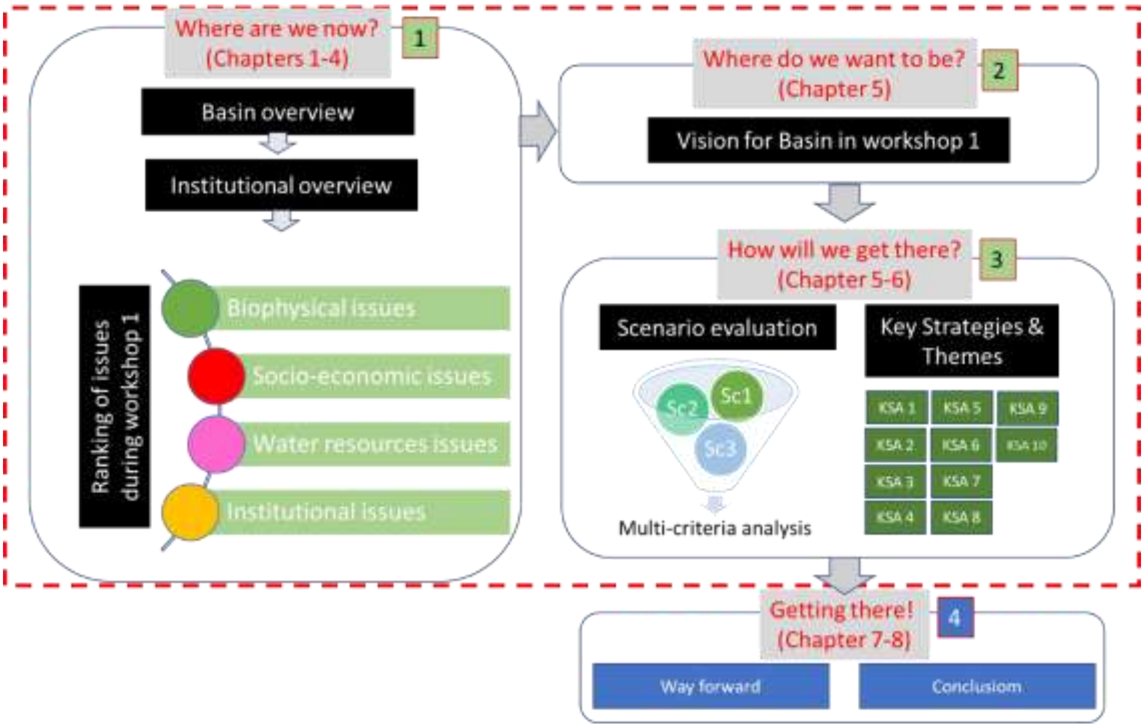


Figure 1-3: Key stages in development of LVS Basin Plan

1.4 Structure of the LVS Basin Plan

This report is structured as follows:

Section 2 provides an overview of the basin including basin characteristics, the bio-physical and socio-economic environments, information on water availability and demands, existing water resources infrastructure, water balances, water quality and the existing hydrometeorological network.

Section 3 presents the current legislative, policy and institutional framework in relation to water resources management as well as summarises the existing development plans and sectoral perspectives which link to water resource planning, management and development in the basin.

Section 4 highlights the key issues, challenges and trends in the basin.

Section 5 covers the vision for the basin and outlines the evaluation strategy and analysis of scenarios, the approach to scenario development and the outcome of the scenario evaluation process.

Section 6 presents the Integrated Water Resources Development and Management Plan for the basin. It provides the strategic framework for sustainable water resources development and management in the basin. Key strategic areas and objectives along with prioritised themes and strategies are provided.

Section 7 provides a way forward for the Basin Plan. This includes key outcomes, context, actions, budgets and a roadmap for implementation of the Basin Plan.

Section 8 provides a conclusion for the Basin Plan.

Section 9 lists the references.

Image source: Magical Kenya 2014 'Kisumu'. Available online at http://www.magicalkenya.com/wp-content/uploads/2014/08/kisumuimg2.jpg

02

Basin Overview

2 Overview of the Basin

2.1 Introduction

The LVS Basin has a catchment area of 26 906 km^2 [1] and is located in the western part of the country. It borders Tanzania to the South and Lake Victoria to the East. Although the Basin only covers about 5.5% of Kenya's total area, the population density is high and the Basin houses about 19% of the country's total population. An overview map of the LVS Basin is shown in Figure 2-1.

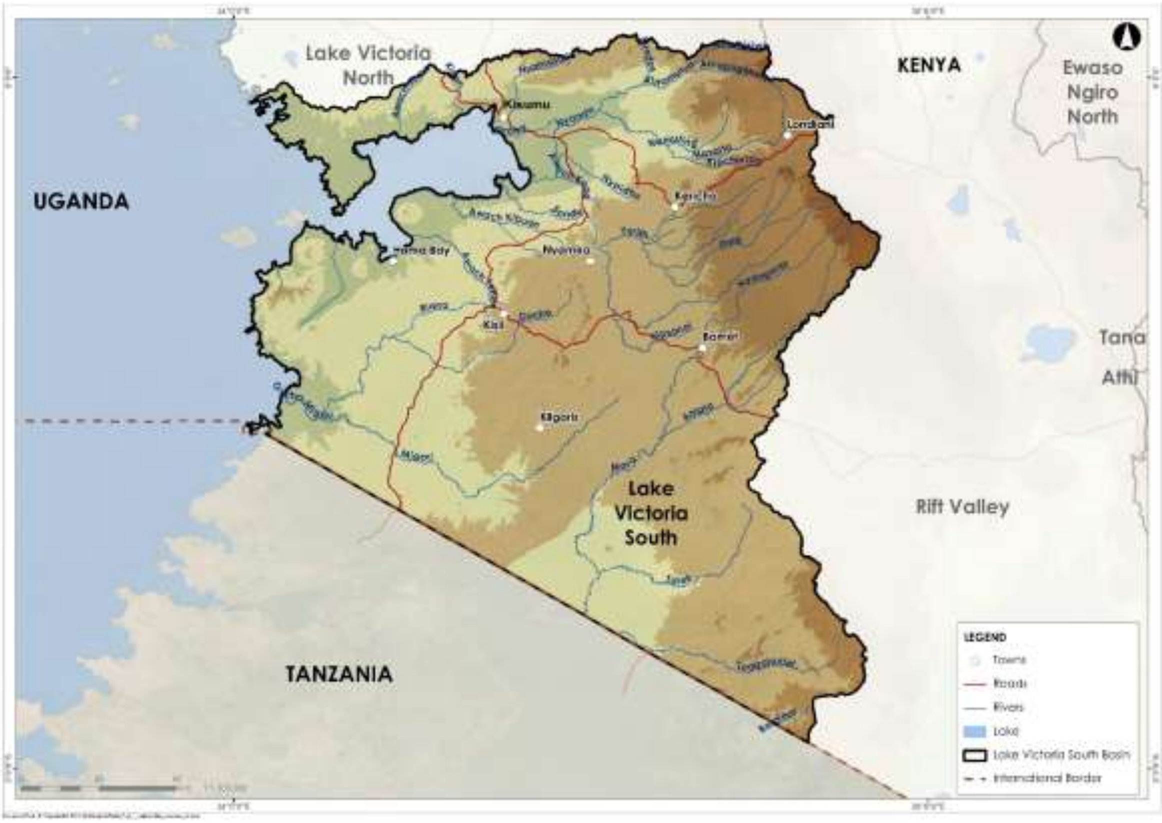


Figure 2-1: Overview map of LVS Basin

The LVS Basin includes 13 counties, seven of which are fully enclosed within the basin (Figure 2-2) and the other six cross counties cross hydrological boundaries. The counties within the Basin include Siaya, Vihiga, Kisumu, Nandi, Uasin Gishu, Kericho, Nakuru, Bomet, Nyamira, Kisii, Homa Bay, Migori and Narok.

[1] Data from JICA. 2013. *NWMP 2030*. Datum: WGS 1984 Projection: UTM zone 37N

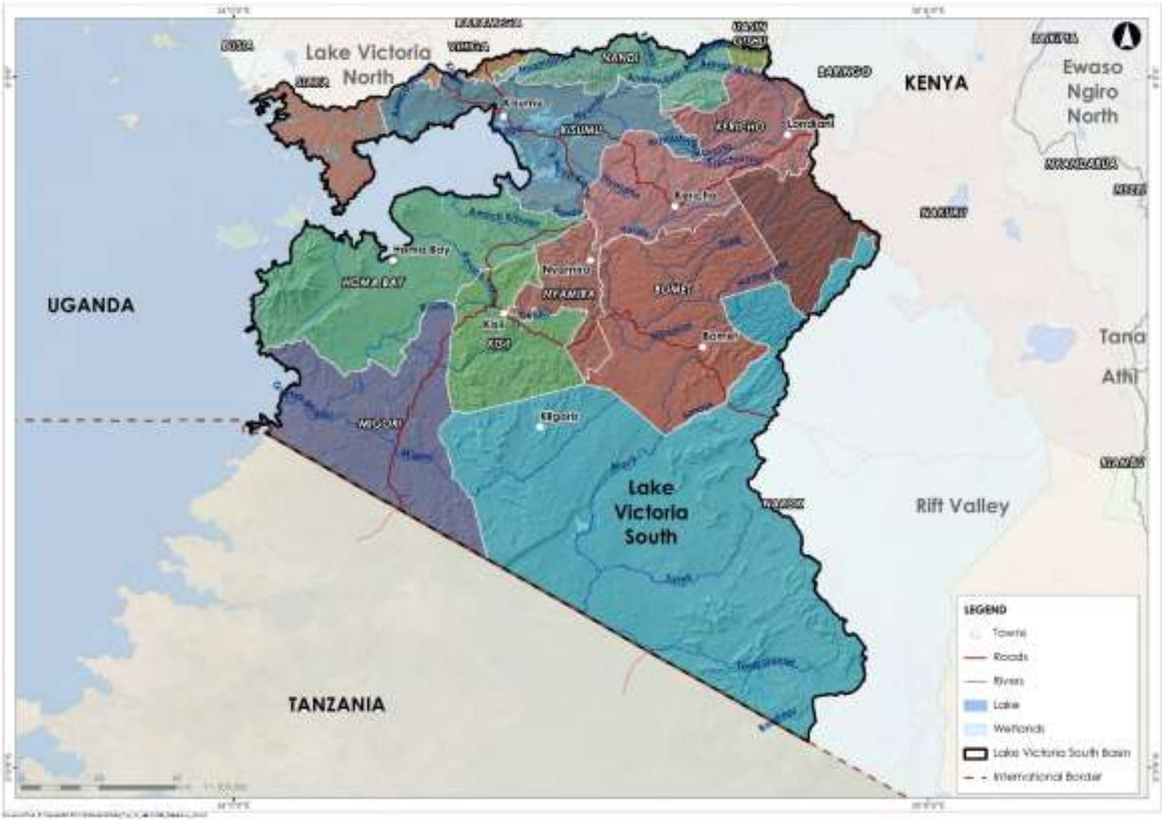


Figure 2-2: Counties within the LVS Basin

The major towns in the LVS Basin are Kisumu, Kisii, Migori, Kericho, Homa Bay, Bomet and Kehancha. The LVS Basin receives the second highest rainfall in the country, after the Lake Victoria North (LVN) Basin. Although significant surface water resources are available in the catchment, its temporal and spatial distribution often cause challenges.

2.2 Bio-physical

2.2.1 Physiography

2.2.1.1 Topography and landforms

The LVS Basin topography ranges from the Mt. Londiani peak at 3,000 masl to the shores of Lake Victoria at 1,130 masl (Figure 2-3).

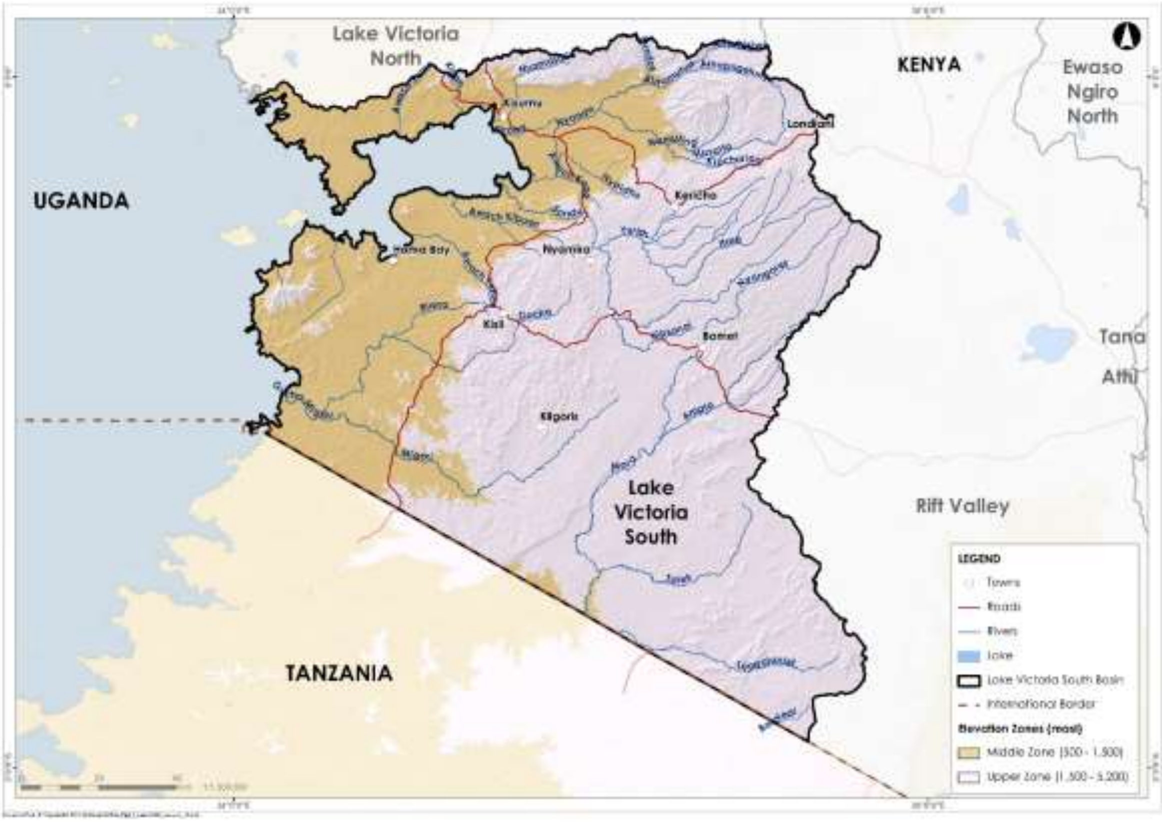


Figure 2-3: Elevation zones in the LVS Basin

The terrain slope categories within the LVS Basin are shown in Figure 2-4. Generally, most of the basin is gently sloping. Most of the Basin consists of mountains and footslopes in the upper zone of the Basin with the rest of the Basin being Plateau or Plain landforms. Nyando River and wetlands occur in a sedimentary depression landform. Figure 2-5 displays the dominant landforms in the LVS Basin.

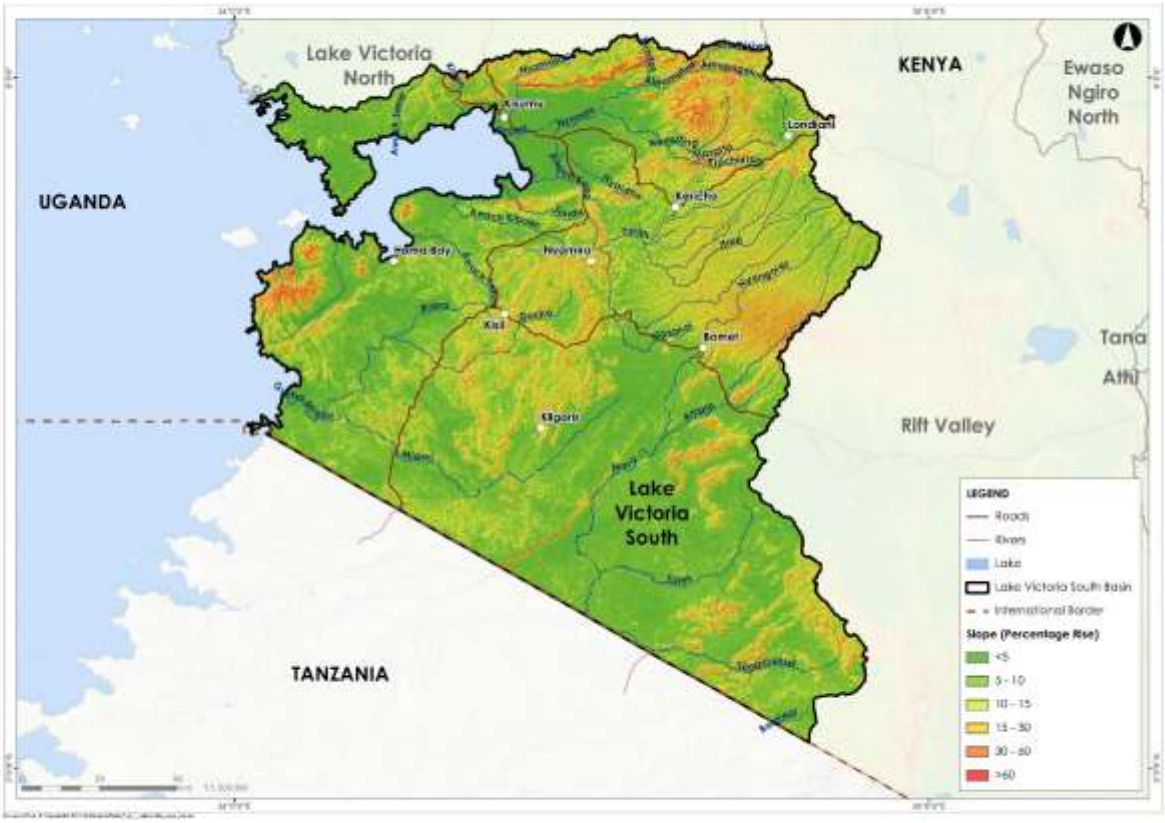


Figure 2-4: Slope categories in the LVS Basin

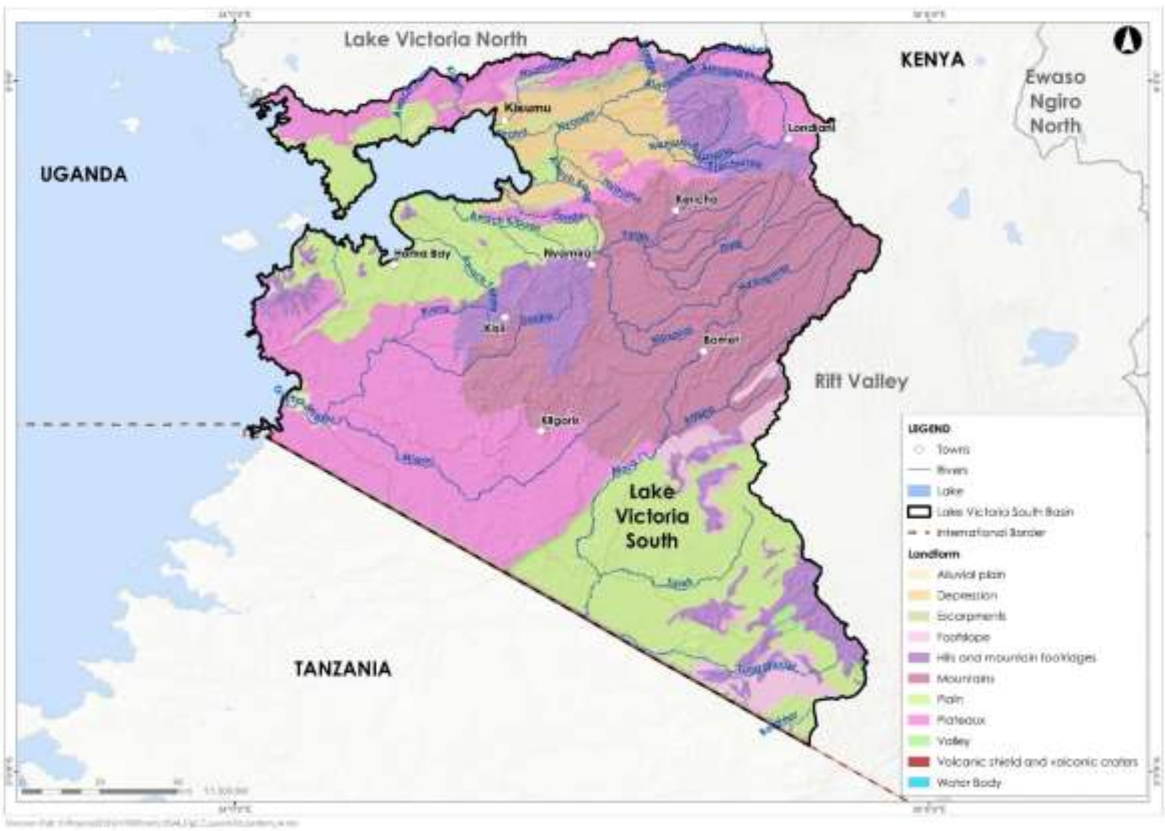


Figure 2-5: Landforms of the LVS Basin

2.2.1.2 Soils

The Soil Atlas of Africa (Jones, Breuning-Madsen, Brossard, *et al.*, 2013) was used as a reference for the soil types found across the LVS Basin due to its detailed soil mapping base. The main soil types found in the LVS Basin are shown in Figure 2-6 and soil types are indicated in Table 2-1 with corresponding soil classifications provided in Table 2-2. The soils in the southern parts of the Basin are mainly Planosols, which have a poorly structured surface layer over a permeable layer; acidic Umbrisols; and Vertisols, which contain swelling clays. There is a deposit of Silandic Andosols on volcanic material in the western part of the catchment. The rest of the catchment is made up of various soil types, mainly Planosols and deep red Nitisols.

To assist with the assessment of erosion risk in the Basin, a GIS-based erosion risk tool was developed based on the Revised Universal Soil Loss Equation (RUSLE) (refer to **Annexure A1**). The outputs of the tool provided both potential soil loss (i.e. inherent erosion risk) and estimated soil loss (i.e. accounting for vegetation cover and land management). When comparing the inherent soil erosion risk (Figure 2-7) to the potential soil erosion risk (Figure 2-8) it is apparent that vegetation cover in protected areas and gazetted forests provides significant protection from soil erosion. Protected areas and gazetted forests have very low rates of erosion, although at the foot slopes of Gembe, Rangwe and Gwasi below the gazetted forest has less vegetation cover which influences the higher erosion rates.

Table 2-1: Description of main soil types found in the LVS Basin

Soil Type	Description
Planosols	Characterised by a subsurface layer of clay accumulation. Occur in low-lying areas that can support either grass or open forest vegetation.
Umbrisols	Characterized by a surface layer that is rich in humus but not in calcium available to plants, owing to high rainfall and extensive leaching that lead to acidic conditions.
Vertisols	Characterized by a clay-size-particle content of 30 percent or more by mass in all horizons of the upper half-metre of the soil profile, by cracks extending downward from the land surface, and by evidence of strong vertical mixing of the soil particles over many periods of wetting and drying.
Silandic Andosols	Andosols are highly porous, dark-coloured soils developed from parent material of volcanic origin
Nitisols	Nitisols are defined by a significant accumulation of clay and by a blocky aggregate structure. Influenced by iron oxides, high water content and biological activity. Considered to be the most inherently fertile of the tropical soils because of their high nutrient content and deep, permeable structure.

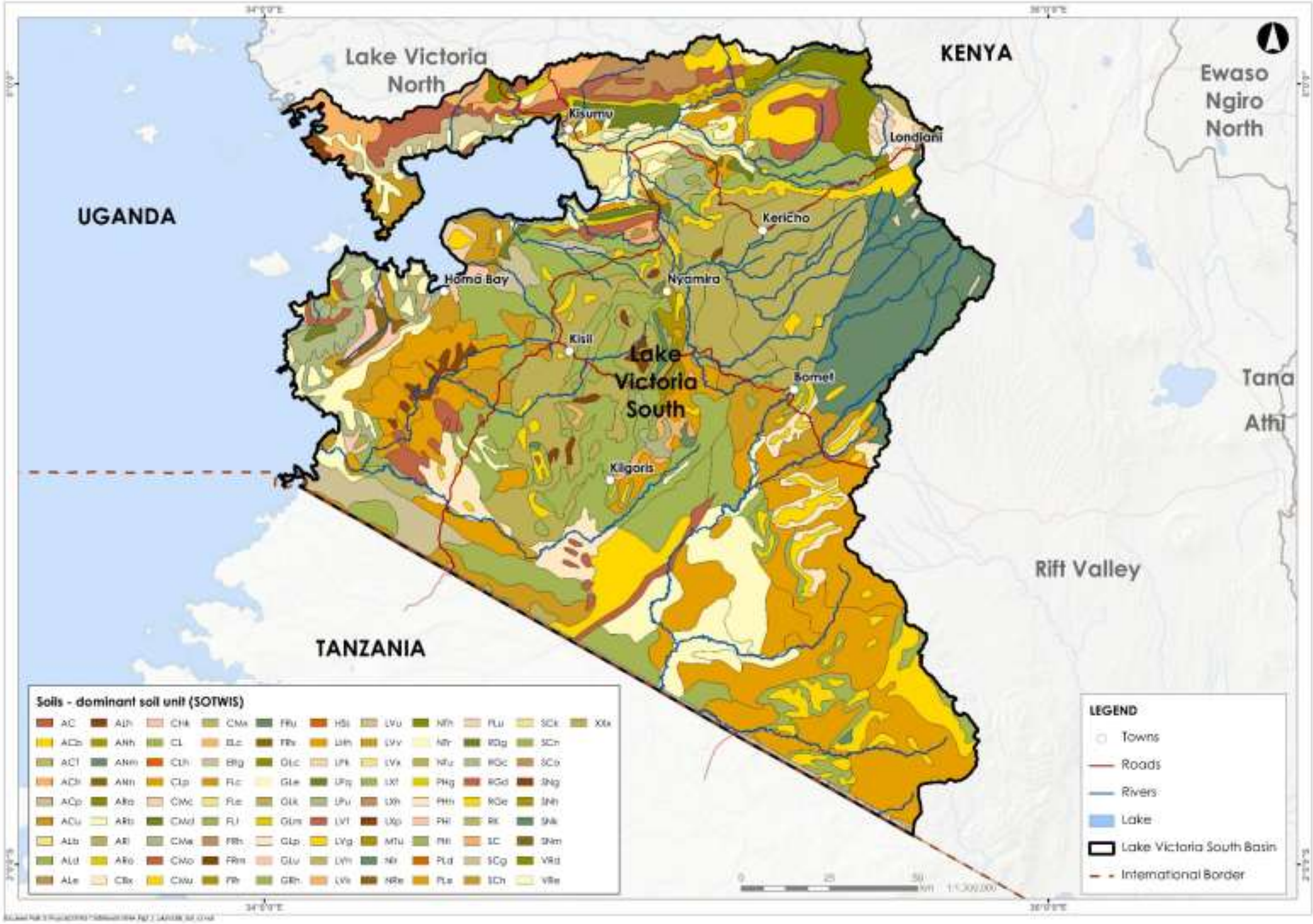


Figure 2-6: Soils in the LVS Basin

Table 2-2: Soil Classifications for LVS Basin

Soil Index	Description	Soil Index	Description	Soil Index	Description
AC	Acrisols	**FLe**	Eutric Fluvisols	**NRe**	Nitisols
ACb	Cambic Acrisols	**FLt**	Thionic Fluvisols	**NTh**	Haplic Nitisols
ACf	Ferric Acrisols	**FRh**	Haplic Ferralsols	**NTr**	Rhodic Nitisols
ACh	Haplic Acrisols	**FRm**	Mollic Ferralsols	**NTu**	Humic Nitisols
ACp	Plinthis Acrisols	**FRr**	Rhodic Ferralsols	**PHg**	Gleyic Phaeozems
ACu	Humic Acrisols	**FRu**	Humic Ferralsols	**PHh**	Haplic Phaeozems
ALb	Cambic Alisols	**FRx**	Xanthic Ferralsols	**PHi**	Lithic Phaeozems
ALd	Dystric Alisols	**GLc**	Calcaric Gleysols	**PHl**	Luvic Phaeozems
ALe	Eutric Alisols	**GLe**	Eutic Gleysols	**PLd**	Dystric Planosols
ALh	Haplic Alisols	**GLk**	Calcic Gleysols	**PLe**	Eutric Planosols
ANh	Haplic Andosols	**GLm**	Mollic Gleysols	**PLu**	Umbric Planosols
ANm	Mollic Andosols	**GLp**	Plinthic Gleysols	**RDg**	Dystric Regosol
ANn	Melanic Andosols	**Glu**	Umbric Gleysols	**RGc**	Calcaric Regosols
ARa	Albic Arenosols	**GRh**	Haplic Greyzems	**RGd**	Dystric Regosols
ARb	Cambic Arenosols	**HSs**	Terric Histosols	**RGe**	Eutric Regosols
ARl	Luvic Arenosols	**LHh**	Haplic Luvisol	**RK**	Calcic Regosol
ARo	Ferralic Arenosols	**LPk**	Rendzic Leptosols	**SC**	Solonchaks
CBx	Carbic	**LPq**	Lithic Leptosols	**SCg**	Gleyic Solonchaks
CHk	Calcic Chernozem	**LPu**	Umbric Leptosols	**SCh**	Haplic Solonchaks
CL	Calcisols	**LVf**	Ferric Luvisols	**SCk**	Calcic Solonchaks
CLh	Haplic Calcisols	**LVg**	Gleyic Luvisols	**SCn**	Sodic Solonchaks
CLp	Petric Calcisols	**LVh**	Haplic Luvisols	**SCo**	Ferralic Solonchaks
CMc	Calcaric Cambisols	**LVk**	Calcic Luvisols	**SNg**	Gleyic Solonetz
CMd	Dystric Cambisols	**LVu**	Humic Luvisols	**SNh**	Haplic Solonetz
CMe	Eutric Cambisols	**LVv**	Vertic Luvisols	**SNk**	Calcic Solonetz
CMo	Ferralic Cambisols	**LVx**	Chromic Luvisols	**SNm**	Mollic Solonetz
CMu	Humic Cambisols	**LXf**	Ferric Lixisols	**VRd**	Dystric Vertisol
CMx	Chromic Cambisols	**LXh**	Haplic Lixisols	**VRe**	Eutric Vertisol
ELc	Rendzinas	**LXp**	Plinthic Lixisols	**XXx**	Xanthic Xerosols
ERg	Rendzinas	**MTu**	Greyzems		
FLc	Calcaric Fluvisols	**NIr**	Nitisols		

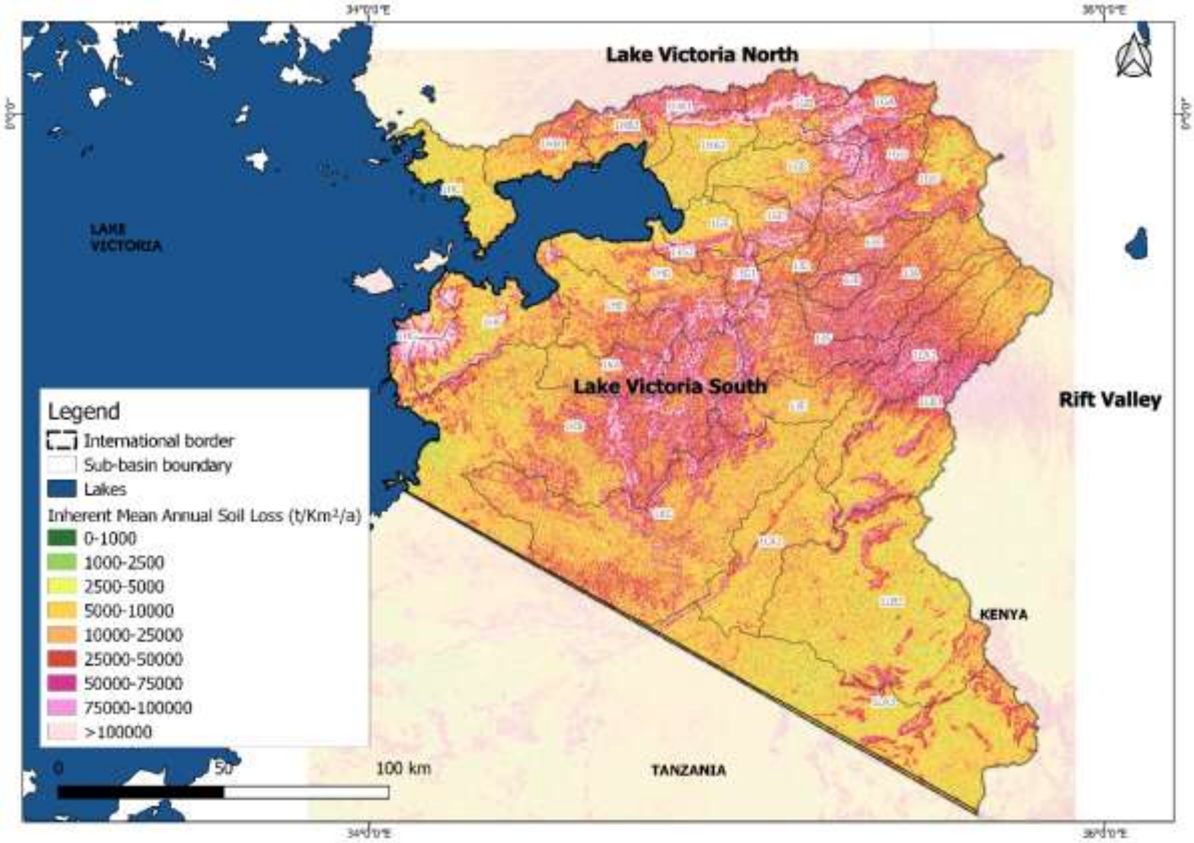


Figure 2-7: LVS Basin Inherent Soil Erosion Risk (C and P factors not included)

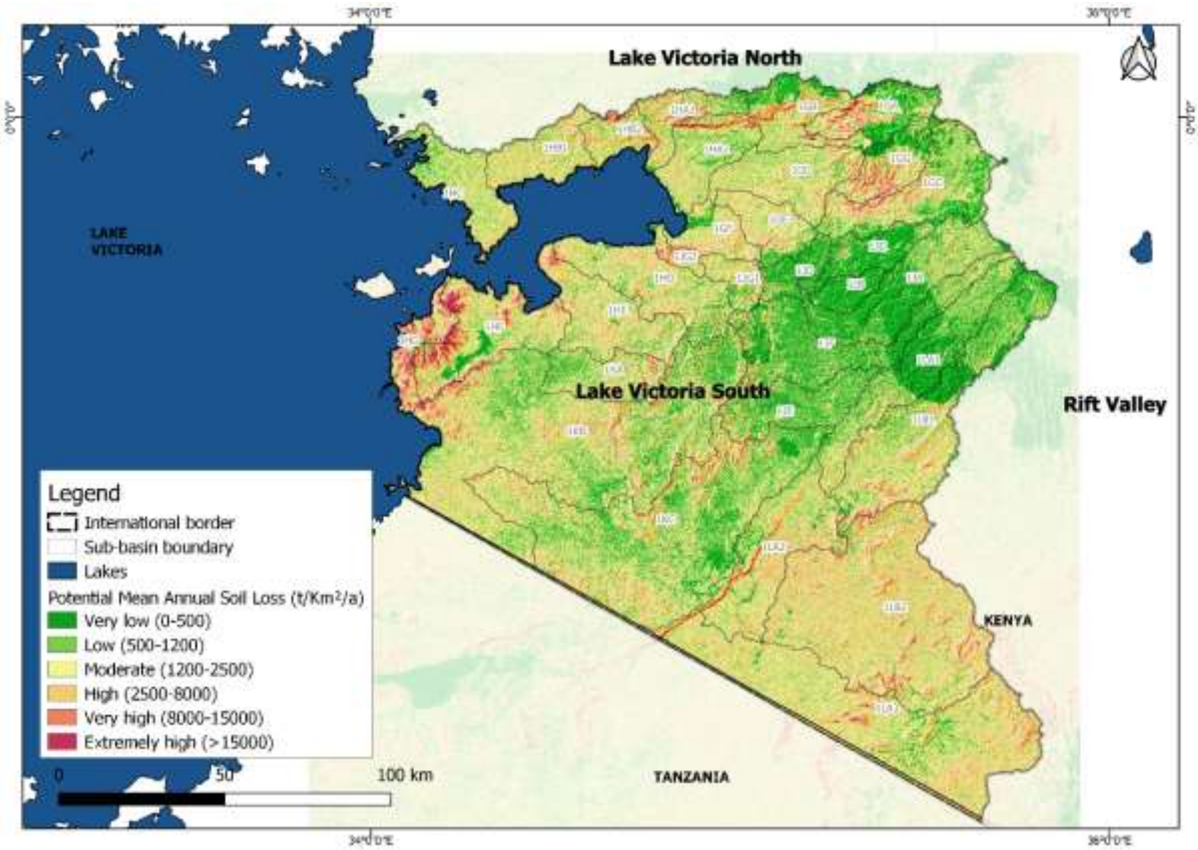


Figure 2-8: LVS Basin Potential Soil Erosion Risk

2.2.1.3 Geology and hydrogeology

2.2.1.3.1 Geology and groundwater characteristics

One of the major rock types constituting the geology of the LVS Basin is the Archaean-Palaeoproterozoic granite-greenstone terrane, which is found in western Kenya around Lake Victoria (Figure 2-9). The Nyanzian rock group includes basalts, endesites, dacites, rhyolites, pyroclastics and ashes, and the structural geology is characterised by a series of east-west orientated folds, and faults and shear zones are common. The Kisii Group (or Bukoban) occurs in the Kisii area of the LVS Basin and includes sandstones, quartzites, basalts and rhyolites. The Kissii Group includes a series of folds and weak foliation surfaces.

The main geological and groundwater characteristics of the LVS basin are summarised below, with the numbering corresponding to Figure 2-9.

1. The lower parts of the Basin are underlain by metamorphic Basement and by metasediments of the Nyanzian (basalts, endesites, dacites, rhyolites, pyroclastics and ashes) and Kavirondan (conglomerates, greywackes, sandstones, shales and mudstones) groups. Where these are weathered they constitute useful localised aquifer systems that provide water to numerous springs and shallow wells, and a smaller number of boreholes.
2. Groundwater availability in the Mara sub-basin is of poor quality (EC>3,000µS/cm), although in the upper reaches (the south western Mau) groundwater conditions are likely to be similar to those in the Kericho area (Oligocene-Miocene volcanics). In the lower parts of the basin the groundwater often contains excessive fluoride concentrations (Mosonik, 2015). On the western flank of the Loita Hills, and within the Mara ecosystem, there are several perennial springs: Sianna, Morijo Loita, Entasekera, Onyoke, Kipleleo, Bardamat and Aitong to name a few (Saggerson, 1966; Williams, 1964). They achieve prominence in these geological reports principally because they occur in an arid area otherwise characterised by very few perennial water sources.
3. A 2006 listing covering the lower part of the catchment (excluding the highlands and the Mara sub-basin) includes 592 boreholes. Across 310 of these (ignoring dry sites), yields range from less than 0.1 to 9.6 m3/hr (with a mean of 3.3 m3/hr). This is broadly representative of the groundwater potential of the lower part of the Basin, and particularly the Basement and metasedimentary geologies, although local, higher borehole test yields are possible.
4. Homa Bay County in the west hosts a complex geological sequence. Plateau volcanics are downthrown to the NW by the SW to NE trending Kaniamwana Fault, creating the Lambwe Valley. West of this is the Kisingiri central volcanic complex, including the Rangwe carbonatite (McCall, 1958). The Lambwe Valley area hosts good groundwater resources. Boreholes have previously yielded 48,000 to 55,200 gallons per day (9.1 to 10.5 m^3/hr) from boreholes up to 174 m deep (McCall, 1958).
5. Groundwater south of the Kendu Fault on the Nyambondo Plateau is shallow and abundant, occurring in weathered phonolites overlying Basement geology. Shallow wells rarely exceed 8 meters in depth and produce water of very low EC (<150 µS/cm). However, these shallow groundwaters are of bacteriologically-poor quality (DHV Consultants, 1988a).
6. The lower parts of the Nyando River east and south of Kisumu (the Kano Plain) are underlain by recent sediments draped over thick lake sediments and occasional phonolite lava flows (Olago, 2018). Borehole yields range from 2 to 18 m^3/hr (DHV Consultants, 1988a), while transmissivity values range from 2 to 60 m^2/d. Water quality is variable and typically poor in shallow aquifers (>2,000 µS/cm near the Lake shore, falling to 500 µS/cm inland to the east). In deeper aquifers, near-shore ECs exceed 1,500 µS/cm, falling to <500 µS/cm 15 km east of the shoreline (DHV Consultants, 1988a).

7. Groundwater along the Northern Shoreline of the Winam Gulf (Water Resources Management Authority, 2015a), is found in Basement rocks (in the weathered regolith/saprock, and in faults and fractures at greater depth) and in local overlying sediments. Groundwater in shallow (12 to 25 mbgl) and medium (25 to 60 mbgl) depth aquifers is abundant and generally of good quality (EC >1,000 µS/cm) (DHV Consultants, 1988a). Locally (particularly in the colluvium along the base of the Nyando Escarpment in the Kibos-Miwani area), yields can approach 10 m^3/hr. Similar maximum yields have been reported in the Muhoroni area (<0.1 to 9.1 m^3/hr). This area is at the boundary of upland volcanics and Basement, with localised alluvium blanketing the older material.
8. The highlands to the east are underlain by Oligocene-Miocene-Pliocene volcanics. These form locally useful aquifers in Kericho and Bomet Counties (and in the small fragments in the Basin in Nandi, Uasin Gishu, Baringo and Nakuru Counties). Boreholes drilled in the humid Londiani area (Kericho County) have yields ranging from 0.54 to 36.4 m^3/hr, with a mean of 9.2 m^3/hr. Transmissivities in four of these boreholes ranged from 2 to 30 m^2/d. This constitutes useful groundwater, with water quality being generally good (EC <3,000 µS/cm).

2.2.1.3.2 WRMA aquifer classification

The WRMA aquifer classification system (Water Resources Management Authority, 2007a) is partly demand-oriented and partly geo-political. As part of this consultancy, a new aquifer classification system is proposed in section 6.4.4, and uses the same classes and status as is described below.

There are five classes in the WRMA aquifer classification system (Water Resources Management Authority, 2007a) as follows:

- STRATEGIC aquifers: aquifers used to supply significant amounts/proportions of water to an area where there are no alternatives, or where alternatives would take time and money to develop;
- MAJOR aquifers; high-yielding aquifers with good quality water;
- MINOR aquifers; moderate-yielding aquifers with variable water quality;
- POOR aquifers; low-yielding aquifers with poor to reasonable quality water;
- SPECIAL aquifers; aquifers or parts of aquifers designated ‘special aquifers' by the Authority.

Each is further defined in terms of its status, described as follows:

- **Satisfactory**; no immediate stress, pressure or threat;
- **Alert**; stress, pressure or threat identified or anticipated;
- **Alarm**; water levels declining, water quality declining (stress, pressure or threat identified).

The Lake Victoria South Basin’s aquifers under the WRMA aquifer classification system are summarised in Table 2-3.

Table 2-3: Current classification of aquifers in the Lake Victoria South Basin

Name	Dominant lithology	Status
Strategic		
Winam (30 km^2)	Granites, Tertiary volcanics & Nyanzian volcanics (fissure & intergranular).	Satisfactory (WQ)
Pap Alego (20 km^2)	Granites, Tertiary volcanics & Nyanzian volcanics (fissure & intergranular).	Satisfactory (WQ)
Londiani Basin	Lavas & associated material, & sediments (fissure & intergranular).	Satisfactory
Winam Plain (alluvial shoreline)	Alluvial gravels & sands (intergranular).	Satisfactory
Migori Town	Lavas & associated material (fissure & intergranular).	Satisfactory
Lambwe Valley	Volcanics & sediments (intergranular & fissure).	Satisfactory
Lemotit	Lavas & associated material, & sediments (fissure & intergranular).	Satisfactory
Major		
Suneka	Bukoban (metamorphosed volcanics & quartzites) (fissure, some intergranular).	Satisfactory (WQ)
Nyagusu		Satisfactory (WQ)
Nyamusi		Satisfactory (WQ)
Homa Bay	Nyanzanian (andesites, basalts, greywackes & rhyolites) (fissure).	Satisfactory (WQ)
Oyugis/Kendu Bay	Bukoban (metamorphosed volcanics & quartzites) (fissure, some intergranular).	Alert (WQ)
Kuria/Kehancha/Isebania	Granites	Satisfactory (WQ)
Minor		
Kisii	Bukoban (metamorphosed volcanics & quartzites) (fissure, some intergranular).	Satisfactory (WQ)
Kericho Town	Weathered phonolite & associated material (intergranular).	Alert (QTY)
Kipkelion Town	Pliocene trachytes, phonolites & basalts (fissure, some intergranular).	Alert (WQ)
Poor		
Bomet volcanics	Tertiary volcanics (fissured & intergranular).	Alert (WQ)
Homa Hill	Alluvium (intergranular) & Nyanzian (fissure).	Alert (WQ)
Mara River	Metamorphic Basement (fissure, some intergranular).	Alert (WQ, QTY)
Yao Kadongo SW and Seme shallow aquifer	Granites	Alarm (WQ)
Special		
None designated		

Source: Water Resources Management Authority, 2007a
Note: "WQ" indicates that water quality is questionable; "QTY" indicates that water quantity is a concern

2.2.1.4 Drainage

The LVS Basin is one of two basins in Kenya which drains to Lake Victoria. The Basin is divided into 32 sub-basins, 1GA to 1LB (Figure 2-10). The basin is characterised by the Mau Forest Complex along its north-eastern border with the Rift Valley Basin from where its major rivers originate, including the Nyando, Sondu, Mara and Gucha-Migori rivers. The Mara River crosses the border into Tanzania in the Masai Mara National Reserve. Collectively, these 4 rivers drain almost 80% of the Lake Victoria South Basin. The remainder of the basin is drained by smaller catchments discharging into the Winum Gulf of Lake Victoria.

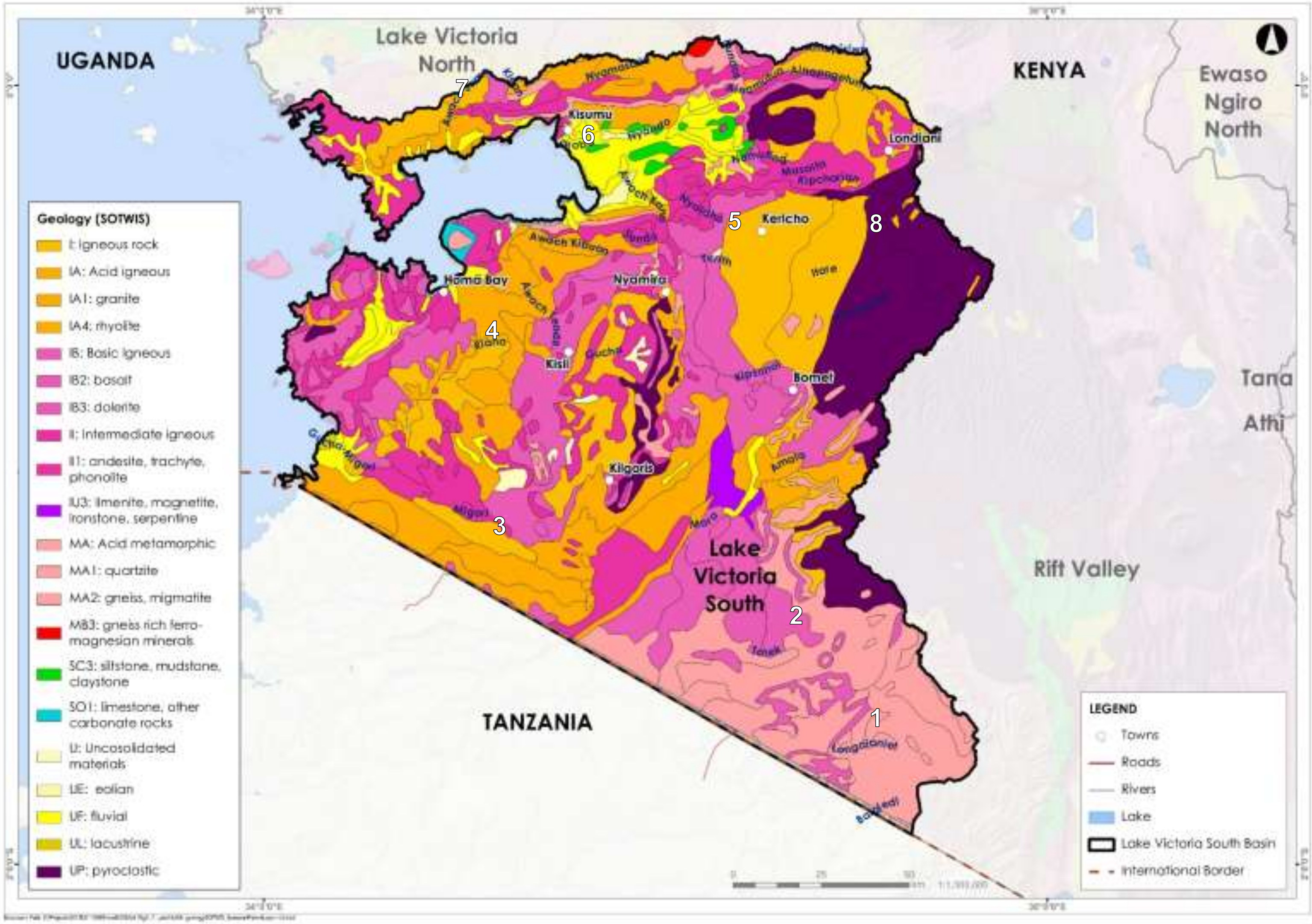


Figure 2-9: The geology of the Lake Victoria South Basin

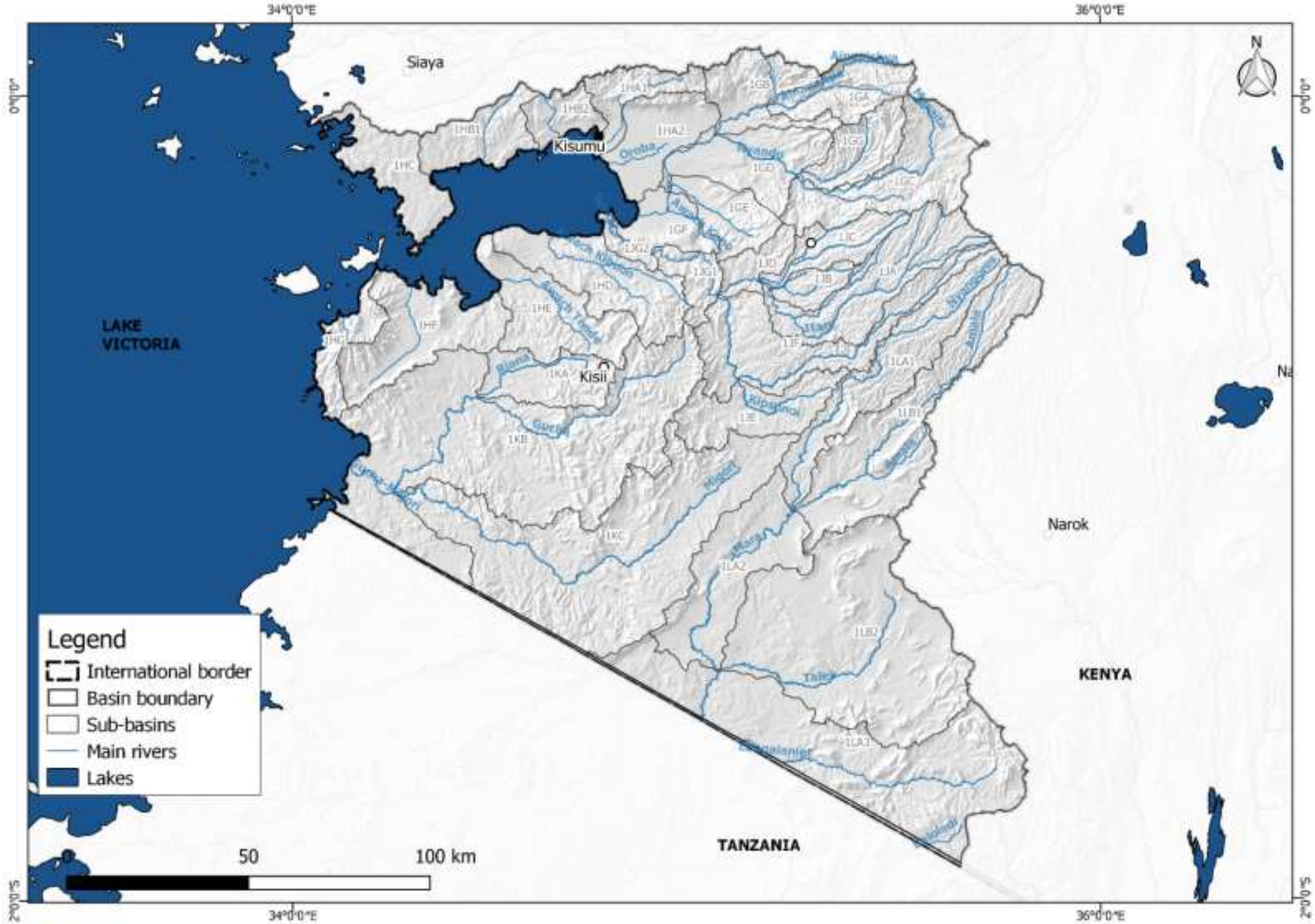


Figure 2-10: The drainage network and sub-basins of the LVS Basin

2.2.1.5 Lakes and wetlands

The LVS Basin faces the north-eastern side of Lake Victoria, which is the largest freshwater lake in Africa. The Lake is a shared water resource between Kenya, Tanzania and Uganda. The main wetlands in the LVS Basin are associated with the Gucha-Migori, Nyando and Sondu rivers originating in the Mau Forest Complex (Figure 2-11). The Nyando (Kusa) Swamp, located at the mouth of the Nyando River, is covered with dense papyrus beds and is home to many rare bird species. The Swamp provides filtration to sediments and pollutants which are carried down the rivers towards Lake Victoria, and the papyrus is the source of livelihood for the local communities.

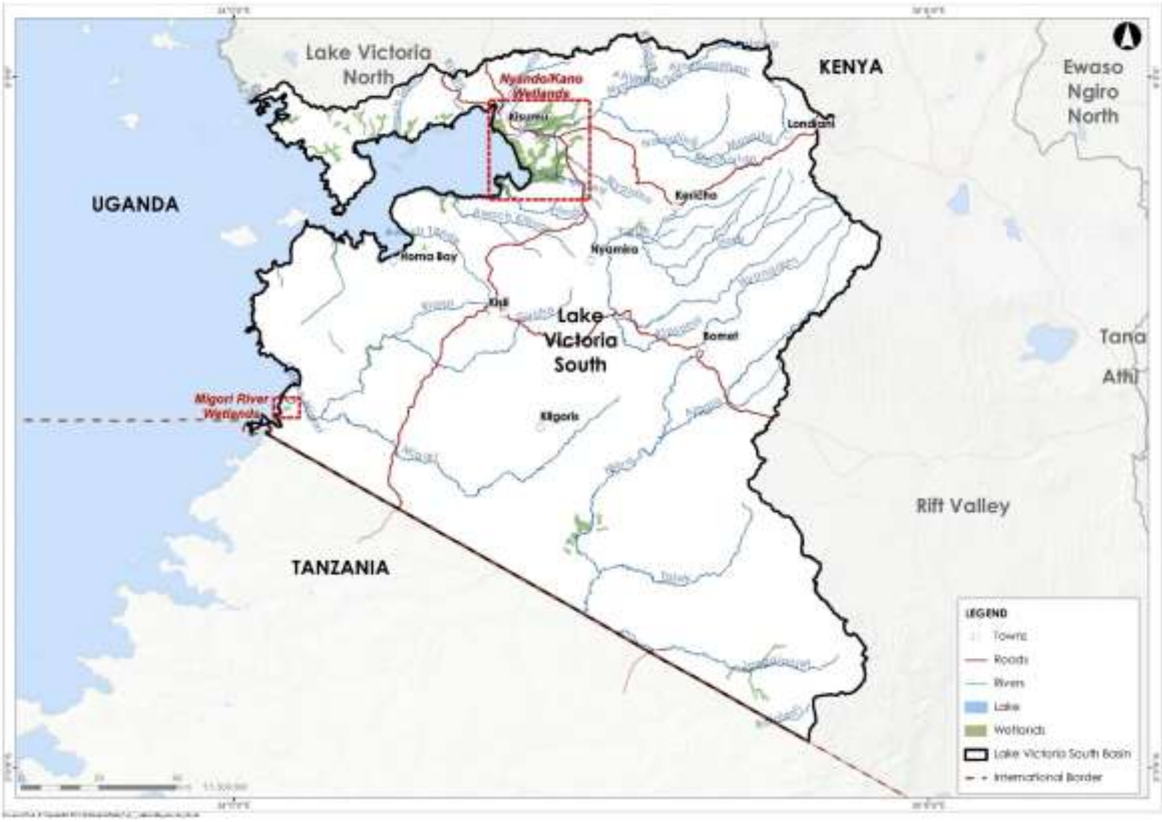


Figure 2-11: Major wetlands in the LVS Basin

2.2.2 Climate

2.2.2.1 Current climate

The LVS Basin falls under the equatorial hot and humid climate with a bi-modal rainfall pattern. Figure 2-12 displays the mean annual precipitation and average temperatures across the basin. The changes are presented spatially, and the extent of change is shown by the contour lines of the maps. Average annual maximum day temperatures vary from 15°C to 37°C across the basin, while the average annual minimum night temperatures vary from 3°C to 23°C. The central and northern parts of the basin receive higher rainfall, with some areas receiving a MAP as high as approximately 1900 mm, while the MAP reduces to less than 1000 mm in the southern parts of the basin. The MAP across the basin equals 1 316 mm.

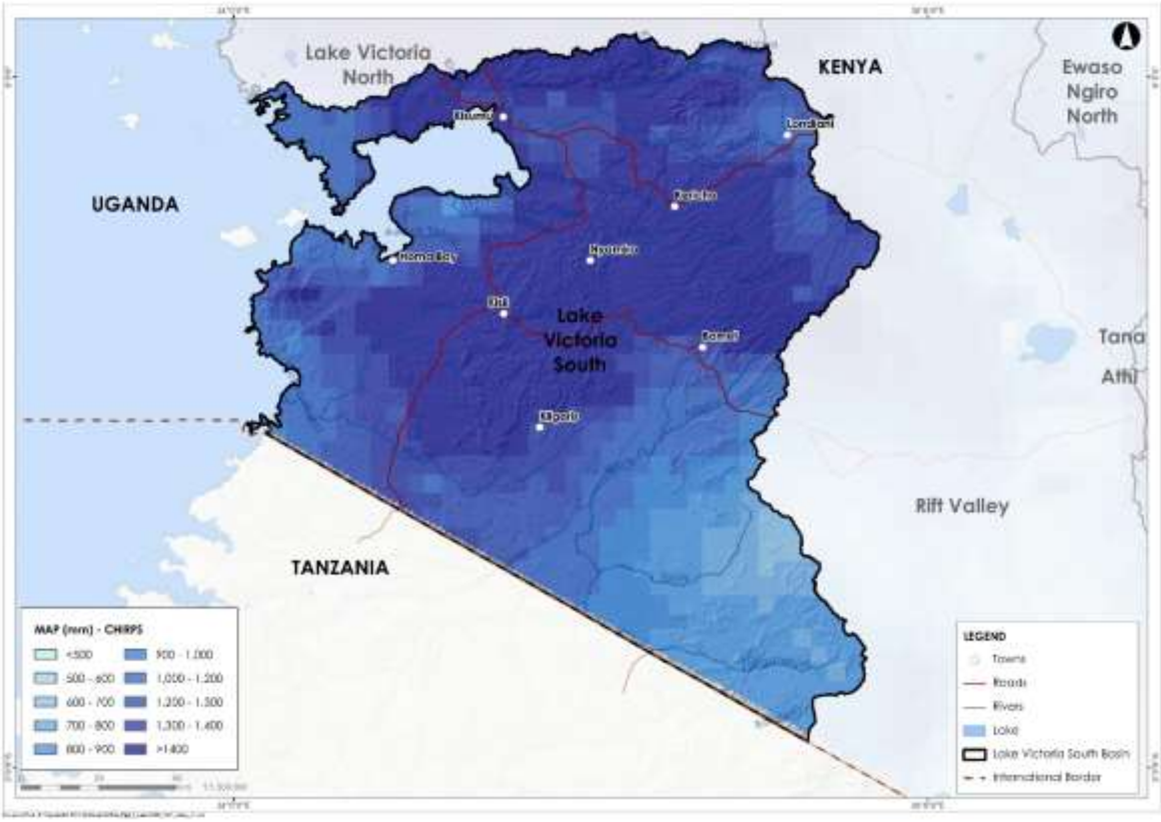


Figure 2-12: Mean annual precipitation across the LVS Basin

Two periods of rainfall occur during the year, namely the long rains between March and May, and the short rains from October to November. The variation of temperature and precipitation at Migori (south) and Kisumu (north) in the Basin is shown in Figure 2-13.

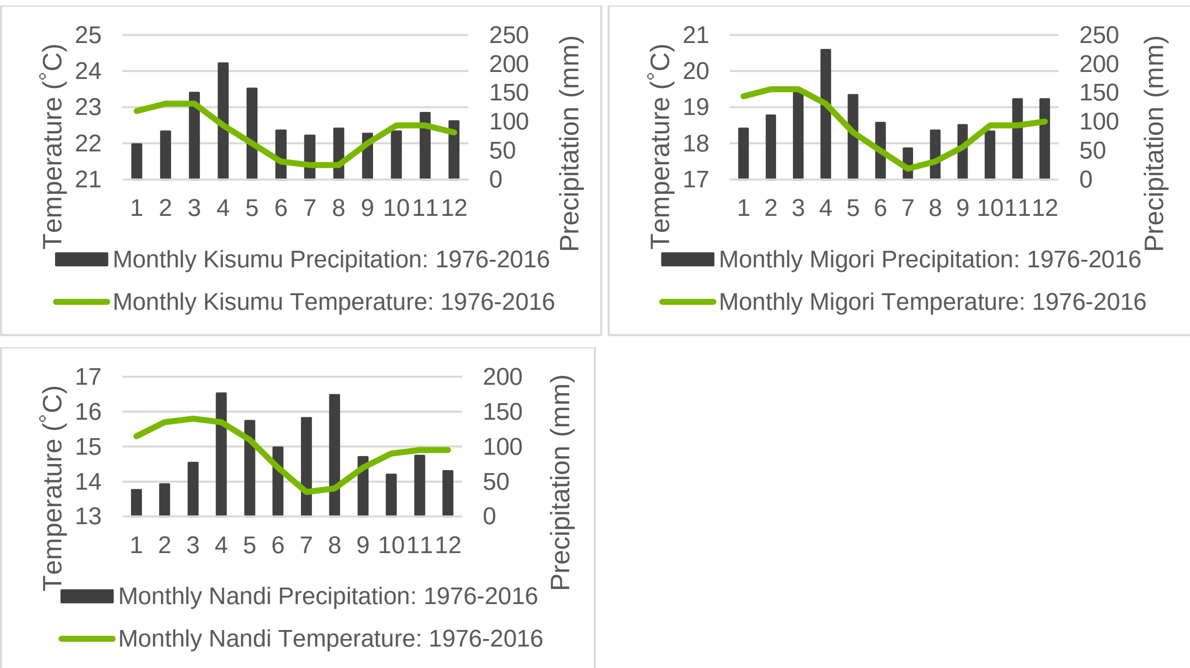
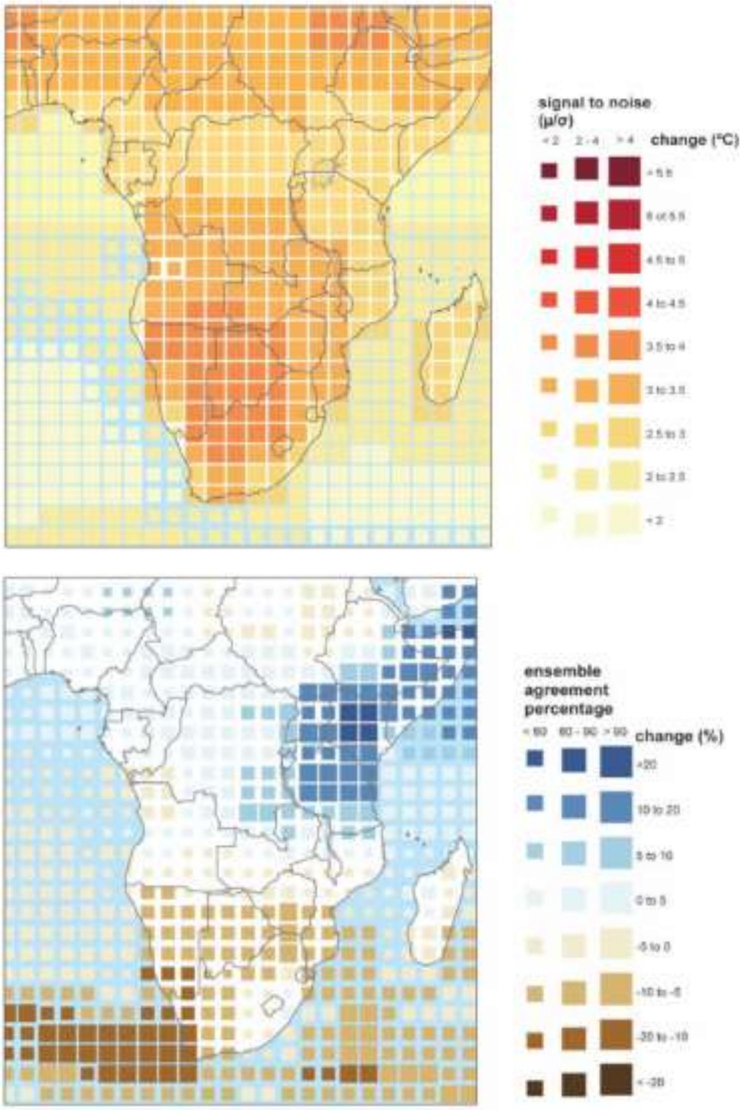


Figure 2-13: Baseline temperature and precipitation in the Lake Victoria South Basin

2.2.2.2 Future climate

It is recognised that climate change is a serious global challenge and that climate-related impacts may impede economic and social well-being, development efforts, and ultimately catchment sustainability. It is therefore essential to assess the relevant risks associated with a changing climate and the adaptation opportunities at the catchment scale in order to ensure long term water security in Kenya. An effective response to climate change, combining both mitigation and adaptation strategies, will be imperative in achieving sustainable development and enhancing resilience.

Figure 2-14: Visualisation of GCM predictions of temp (top) and rainfall (bottom) for Africa by 2100. shows the expected changes in precipitation and temperature across parts of Africa by 2100 and indicates that rainfall and temperature over Kenya are expected to increase. This is likely to change the risk and vulnerability profiles of Kenya and its basins.



* From 1960-1990 baseline climate, percentage change in average annual precipitation, averaged over 21 CMIP3 models. Source: Met Office (2011). *Climate: Observations, projections and impacts. Kenya. Exeter, UK: Met Office.*

Figure 2-14: Visualisation of GCM predictions of temp (top) and rainfall (bottom) for Africa by 2100.

Factors such as the topography, proximity to the equator, and air masses contribute to the range and variability in precipitation and temperature regimes. The climate analysis which was undertaken as part of the LVS Basin, focused on projected climate trends and analysed multiple spatial and temporal source datasets with the intention of better conveying the interactions between and impact on communities, water security and the environment as a result of projected climate change. Temporal analysis, of varying resolutions, informed likely anomalous climatic characteristics such as shifts in seasonality, extreme events occurrence, precipitation intensity and volumes.

The climate change analysis which was undertaken as part of this Consultancy (refer to **Annexure A2**), showed a general increase (between 4% and 6%) in mean annual rainfall across the basin, while extreme temperatures are also expected to increase by up to 1.35°C.

The climate analysis on precipitation, indicates a consistent increase in future precipitation in the sub-basins during the ‘short’ rainy season and during the months of January to April. During the ‘long’ rainy season the increase in precipitation is less pronounced and decreases during May. During the dry season from June to October, an overall decreasing precipitation trend is observed.

Projected sub-basin precipitation and temperature changes under climate change scenario RCP 4.5 were superimposed on the hydrological model of the LVS Basin to assess the potential impacts on runoff. The flow increases slightly during the short rainy season and during January and February and decreases during the long rainy season as well as during the dry season from June to September. The total surface water runoff from the LVS Basin is projected to decrease by 1.4% by 2050. Furthermore, it is expected that both high-flows and low-flows in the river will decrease in magnitude. This suggests that even though the precipitation increases by a small percentage, the temperature rise would increase the evapotranspiration from the densely vegetated catchment, thereby causing flows to decrease especially during the long rains and the dry season.

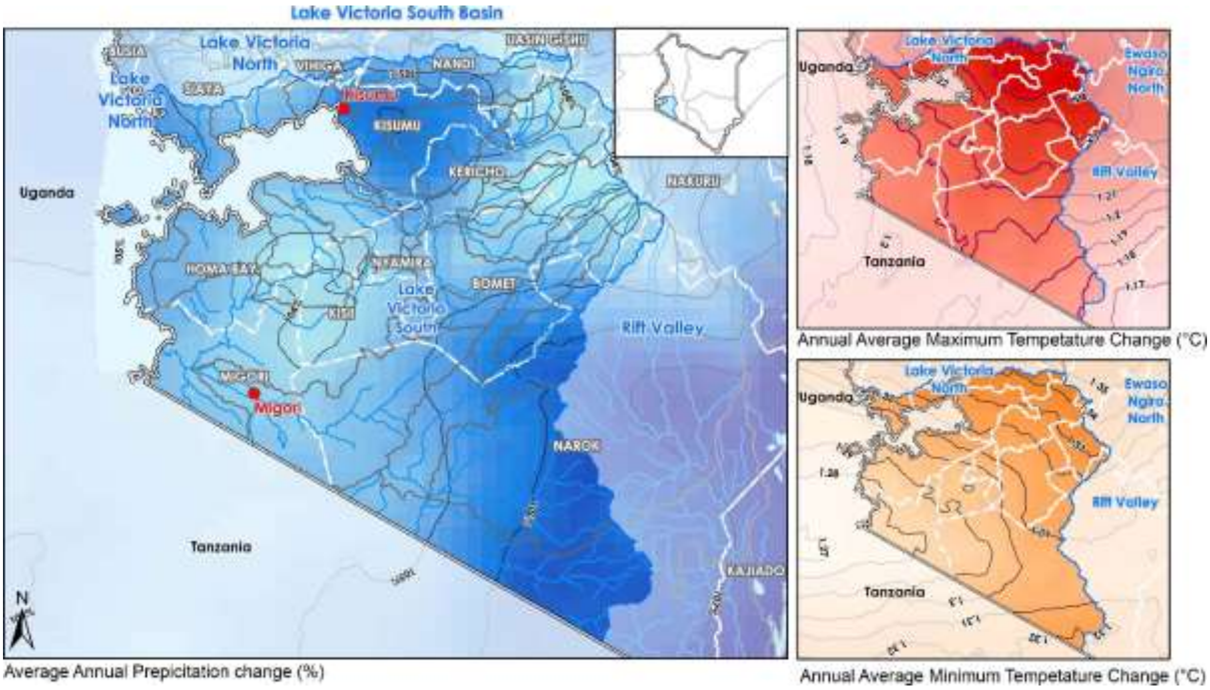


Figure 2-15: Change in Annual Precipitation, Maximum and Minimum Temperature by 2050 (RCP 4.5)

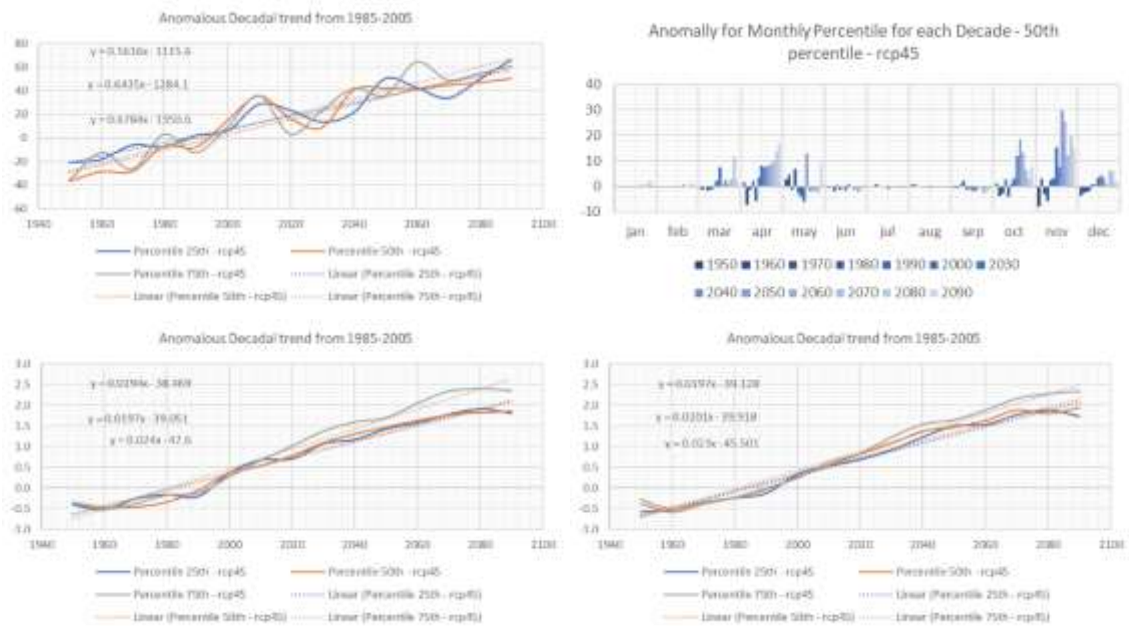


Figure 2-16: Project Tmax anomalies in the LVS Basin by 2050 (RCP 4.5)

2.2.3 Environment

2.2.3.1 Vegetation cover

Vegetation cover is important, as dense vegetation cover will act to protect the land from erosion and increase infiltration rates, whilst overgrazed and cleared land is more exposed. The density of vegetation cover reflects the influence of cropping practices, vegetation canopy and general ground cover. Maintaining a dense and diverse vegetation cover is important for catchment management as it reduces erosion.

Figure 2-17 shows the spatial variation of vegetation cover in the LVS Basin. (A high cover management factor indicates poor vegetation cover and vice versa).

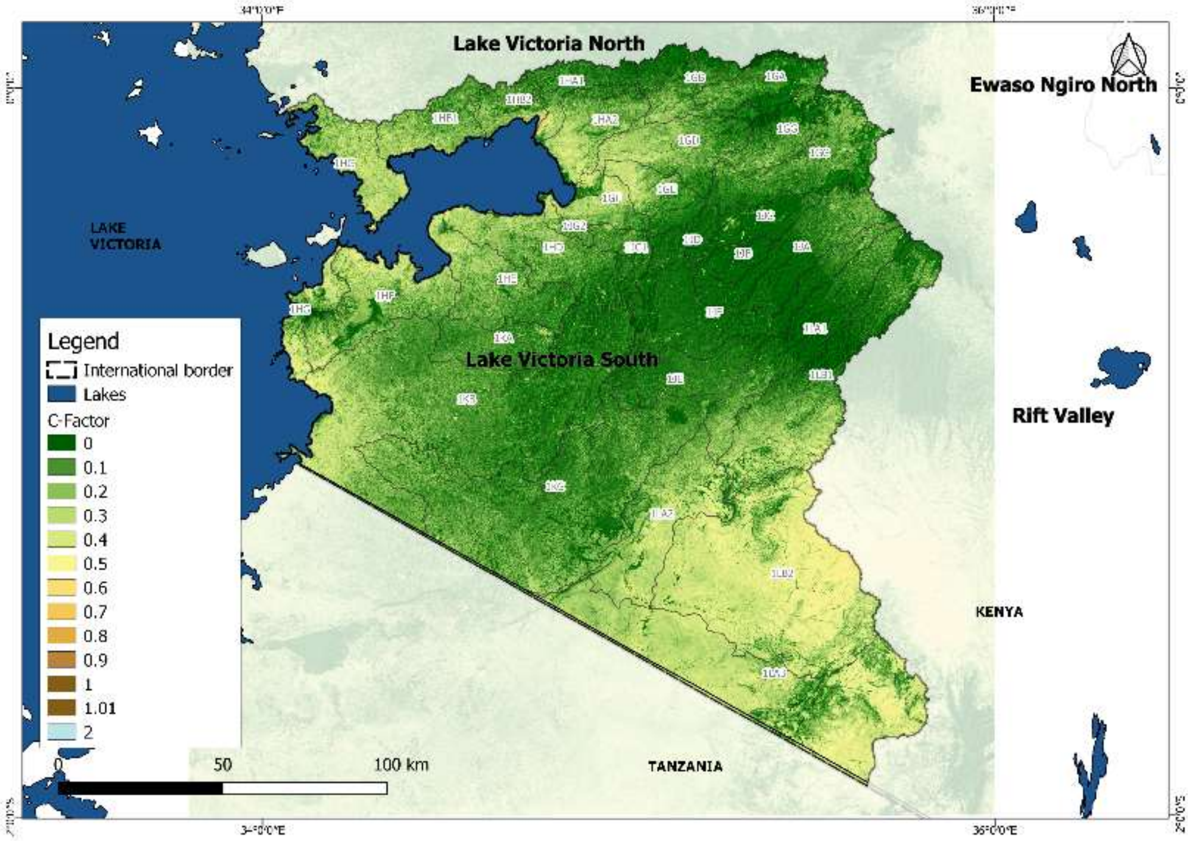


Figure 2-17: Vegetation cover in the LVS Basin

The LVS Basin forms part of the highest rainfall region in the country. The vegetation cover is mainly mosaics of forest and evergreen vegetation, with mountain forest vegetation in the highlands. Table 2-4 lists some of the main forested hills in the LVS Basin.

Table 2-4: Major forested hills in the LVS Basin

Forest Mountain /Hill	Catchment	County
Northern Tinderet	1GA	Nandi
Tinderet,	1GG, 1GA, 1GC	Kericho
Londiani	1GC	Kericho
Western Mau	1GC,1JC	Kericho, Nakuru
South West Mau	1JA, 1JF	Bomet, Nakuru
Eastern Mau	1JA, 1JF, 1LA1, 1LB1	Nakuru, Narok
Transmara	1LA1	Narok
Chepalungu (A & B)	1KC	Bomet
Gwasi, Rangwe, Gembe Hills	1HG, 1HF	Homa Bay
Lambwe	1HF	Homa Bay

2.2.3.2 Biodiversity

Biodiversity in LVS Basin is linked to water resources and forest reserves or protected areas. An important forest reserve is the Mau Forest Complex. The forest occurs on the Mau Escarpment, a block of raised land that forms the western wall of the Rift Valley. There are four main Forest Reserves in LVS Basin: Eastern, Western and South-western Mau and Trans-Mara. The forest is a water tower for streams such as the Sondu and Mara river systems, which flow into Lake Victoria. The areas surrounding the forest are intensively farmed, with human population densities about twice as high on the western side of the forest as on the east (Birdlife International, 2019a). Vegetation patterns are complex, but there is a broad altitudinal zonation from west to east, lower montane forest below 2,300 m giving way to thickets of bamboo *Arundinaria alpina* mixed with forest and grassland, and finally to montane sclerophyllous forest near the escarpment crest (Birdlife International, 2019a). The forest has a rich highland bird community and rare mammals, insects and other plant life.

The Maasai Mara is home to approximately 25% of Kenya's wildlife (East Africa Natural History Society, 2017) and is well known for the annual migration of wildebeest. The Reserve has a varied habitat ranging from grassland to forests. Grasslands host the migratory corn crake and the Jackson's widow bird and the woodlands host the grey-crested helmet shrike.

The deltaic Nyando wetlands perform important ecosystem services due to its location fringing Lake Victoria. Kusa Swamp has dense stands of *Cyperus papyrus, Vossia cuspidate* and *Phragmites spp.* with associated rare animals and birds (Birdlife International, 2019a).

2.2.3.3 Protected areas

The LVS Basin contains several environmentally protected areas. The Mau Forest Complex, located in the northern part of the catchment, is one of the country's main water towers. It is important to conserve the Mau Forest Complex as it is the main water source of the major rivers in the LVS Basin.

Other protected areas include the Ndere Island and Ruma National Parks, the Masai Mara National Reserve and several National Sanctuaries. Figure 2-18 shows the location of the main protected areas in the basin. The KWTA is responsible for the management of areas considered to be water towers for downstream water supply. The LVS Basin has 1 gazetted Water Tower and 10 non-gazetted Water Towers.

Table 2-5: The important and protected areas in the LVS Basin

County	Water Tower	Forest	Protected area	Wetland
Siaya				Wetlands
Kisumu				Nyando/Kano wetlands
Nandi	Nandi Hills (N)	Northern Tinderet, Tinderet		
Kericho	Mau Forest Complex	Tinderet, Londiani, Western Mau		Wetlands
Nakuru	Mau Forest Complex	Western Mau, South West Mau, Eastern Mau		
Narok	Mau Forest Complex	Transmara	Masai Mara National Reserve	
Bomet	Mau Forest Complex	South West Mau, Chepalungu (A & B)		
Nyamira	Sironga (N)			
Kisii	Nyangweta Hills(N) Nyacheki Hill (N) Sameta Hill (N) Taracha Hill (N) Manga Hill (N)			
Migori	Maeta Hills (N) Taragwiti Hills (N)			Migori River wetlands

County	Water Tower	Forest	Protected area	Wetland
Homa Bay	Gwassi Hills (N)	Gwasi, Rangwe, Gembe Hills, Lambwe	Ruma National Park	Wetlands

N: Non-gazetted

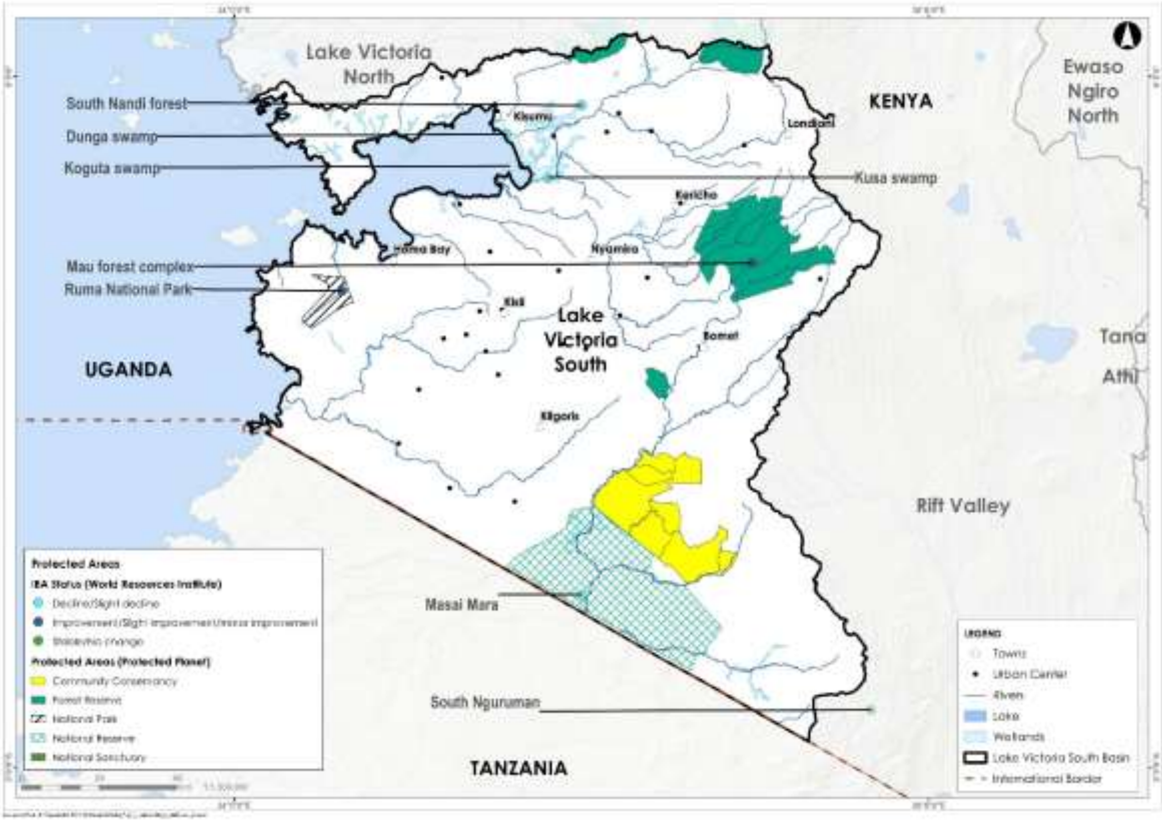


Figure 2-18: Protected areas across the LVS Basin

2.2.3.4 Land use

Land use in the LVS Basin includes forest, grassland/rangeland, agricultural use, and several major towns and the city of Kisumu. The Basin has a high population density and scattered urban and built-up areas. The dominant land use in the Basin is rain-fed agriculture and rangeland. The productivity is often low due to land fragmentation and rainfall variability. Figure 2-19 shows the major land use and land cover types in the LVS Basin.

To assist with the assessment of land capability and sustainable land use in the Basin, a GIS-based land capability tool was developed based on the USDA Land Capability Classification (refer to **Annexure A1**). Placing soils into these classes allows for an understanding of the crop and management constraints. It is evident that the tops of hills and mountains have a soil capability of 8 and steep slopes have a soil capability of 5-7 (i.e. non-arable land). Most of the Basin has a soil capability of 1-3 (i.e. arable land).

Overlaying the Land Capability map with the current land use in the Basin, provides an indication of the level of sustainable land use in the LVS Basin under current conditions. From Figure 2-20, it is evident that existing land under crops includes "sustainable" and "unsustainable" crops. The land use is considered to be "unsustainable" when crops occur on non-arable land. While large parts of the basin have sustainable cropland use, areas in the upper Nyando and Sondu river catchments, areas in the Mau Forest Complex, as well as areas in the central part of the basin in Kisii and Nyamira Counties have unsustainable land use.

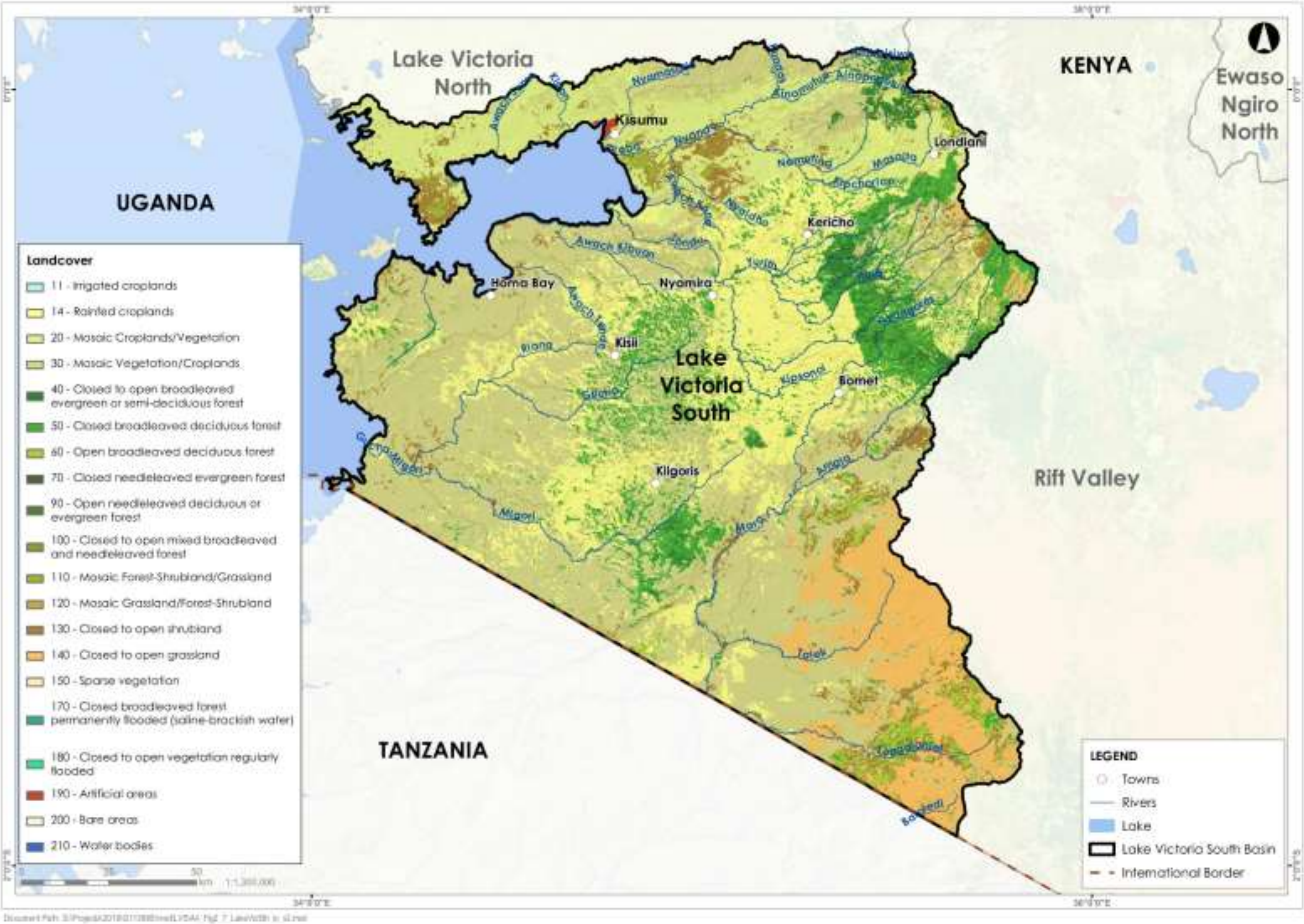


Figure 2-19: LVS Basin land cover and use map

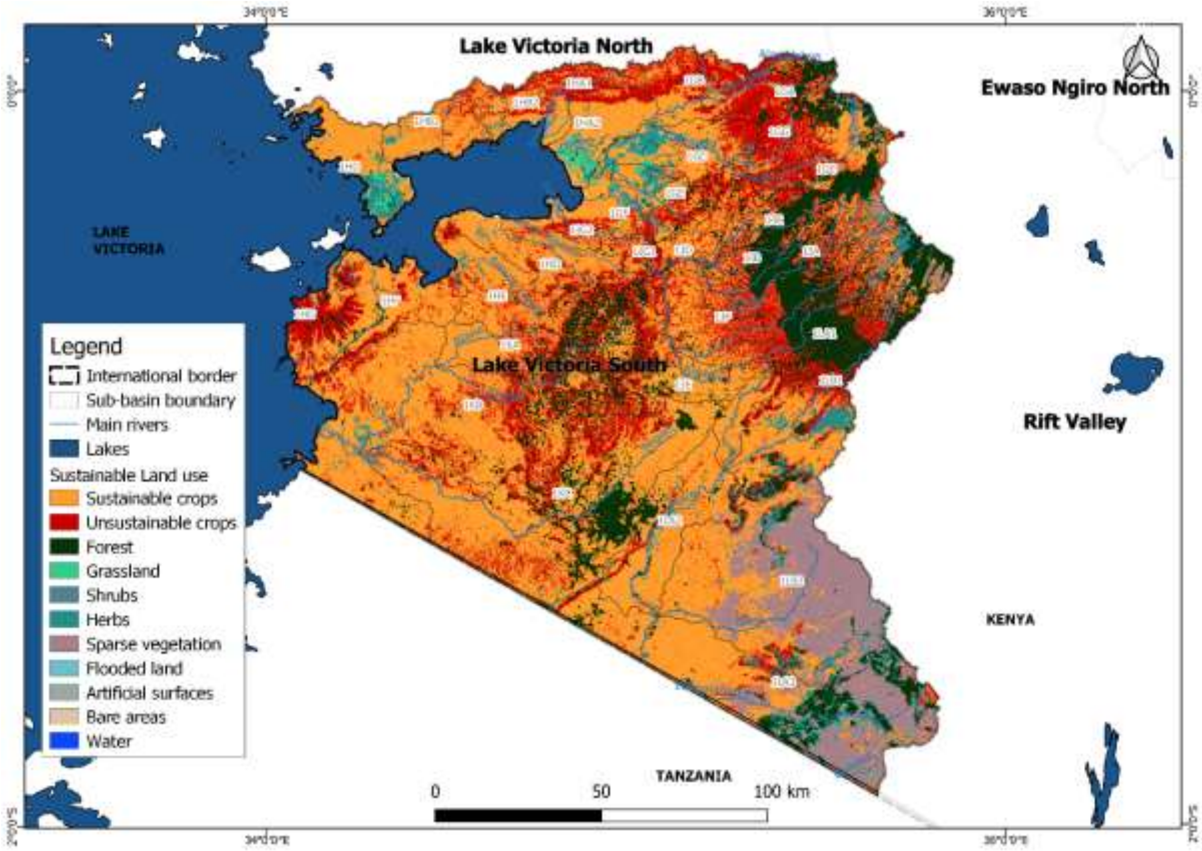


Figure 2-20: Sustainability of current land use in the LVS Basin

2.3 Socio-economics

Water plays a key role in the socio-economic environment in the LVS Basin. It is of critical importance for the agricultural sector, which is the mainstay of Kenya's economy, for industries, health, tourism and for improving the standard of living. The Economic Recovery Strategy for Wealth and Employment Creation (Government of Kenya, 2003) emphasised economic growth and creation of wealth and employment as a means of eradicating poverty and achieving food security and water is central to this growth strategy.

2.3.1 Demographics

The main demographics was sourced from the 2019 Census (Kenya National Bureau of Statistics, 2019), Socio-economic Atlas of Kenya (Wiesmann, Kiteme & Mwangi, 2016), as well as County Fact Sheets (Commission on Revenue Allocation, 2013). The total population of the LVS Basin in 2019 was estimated as 8.57 million, which is equivalent to a very high population density of 319 persons/km^2. Most of the population in the LVS Basin currently reside in rural settlements, with only a relatively small percentage of the population residing in urban areas. However, the population of the LVS Basin is expected to increase due to high projected growth rates, particularly for the urban sector.

Projections based on Census 2019 Census (Kenya National Bureau of Statistics, 2019) population data and United Nations population growth rates as estimated in the Kenya Vision 2030. The total population is projected to be 12.72 million in 2030. The rural population is projected to reduce from 5.52 million in 2010 to 4.73 million in 2030. The urban population is projected to increase from 1.85 million to 7.99 million by 2030 (Water Resources Management Authority, 2013).

The education level index measures the average level of formal education reached by adults in a given area. It is calculated by averaging together the highest education level reached by each individual in a specific area. When calculating the index ranges from 0 (no formal education), 1.0 (completed primary school), 2.0 (completed secondary school) and 3.0 (completed university degree). The education level index in the LVS Basin is 1.0, which indicates that, on average, all adults have completed primary school education and very few completed secondary school education. This is an average value, individuals in a given area will differ.

2.3.2 Economy

2.3.2.1 Economic activity

There is limited economic activity in the LVS Basin and the average poverty rate in the Basin is at 46%. The LVS Basin includes 14 counties, some of them only partly, as shown in Figure 2-2. Key economic activities in the main 11 counties within the LVS Basin are described below:

Table 2-6: Economic activity of each county

County	Economic Activities	Reference
Siaya	Settlement in Siaya county follow the agro-ecological zones and fish landing bays, with high potential areas having the higher population density. Agriculture and fishing are the main economic activities, and cattle and poultry are also kept. There are a number of fisheries in the county that process fish from Lake Victoria. Main food crops include maize, sorghum, millet, beans, cowpeas, cassava, sweet potatoes, groundnuts and finger millets, and cover 150 300 ha. Cash crops include cotton, rice, sugar cane and groundnuts, and cover an area of 2 500 ha. Vegetables and fruit are also grown. There is little industry in the county, limited mining and some tourist activity. Unemployment rates are high and 48% of the population are estimated to be living below the poverty line.	County Government of Siaya, 2018
Kisumu	Kisumu county has a strategic position on the banks of Lake Victoria, and acts as a gateway for Kenya into the rest of the African Great Lakes Region. The Kano-Plains, which is a flat expanse lying on the floor of the Rift Valley, and the Nyabondo Plateau make up the topography of the county. It serves as the main commercial and transport hub for Western Kenya and the East African Region. The main economic activities are trade, farming and fishing.	County Government of Kisumu, 2018
Nandi	A large percentage of Nandi county is rural, with only a limited population in urban centres. Agriculture is the main economic activity in Nandi County, and many households keep cattle for both the production of beef and dairy products. Food crops (maize, beans, finger millet, sorghum, sweet potatoes and cassava) cover approximately 105 087 ha, while cash crops (tea, coffee and sugar cane) account of 28 294 ha. Nandi County. The main manufacturing industries are tea factories, with smaller activities such as timber lumbering, coffee, milk, honey value addition and other agro processing cottage enterprises. A textile apparel unit is being set up through the department of Trade, Investment and Industrialisation.	County Government of Nandi, 2018
Nakuru	The main economic activity in the county is agriculture, tourism and financial services, although most of these activities occur in the Rift Valley Basin. Settlement in the county has been shaped by the major transport infrastructure (i.e. rail and A104). The county has an important agricultural sector, with the main crops produced being maize, beans, irish potatoes, sweet potatoes, vegetables, herbs, spices, fruits and cut flowers. Livestock production is also a major economic activity in the county.	County Government of Nakuru, 2018
Kericho	The economy of Kericho County predominantly depends on agriculture and is well known for its tea processing industry. The topography in the county slopes down from the North-East at the Mau Escarpment towards the South-West lowlands.	County Government of Kericho, 2018
Bomet	Agriculture is the main economic activity of Bomet County. This includes tea, coffee, maize, pyrethrum and dairy farming. Bomet County includes a portion of the indigenous Mau Forest, which is home to various species of animals and plants. The topography in the county slopes down from the North-East at the Mau Escarpment towards the South-West lowlands.	County Government of Bomet, 2018

County	Economic Activities	Reference
Nyamira	Most of Nyamira county is dependent on agricultural production and marketing directly and indirectly. The county forms part of the Lake Basin Economic Bloc. There are tea zones that has promoted employment among tea factories. The Kiabonyoru, Nyabisimba, Nkoora, Kemasare Hills and the Manga Ridge are the most predominant topographical features in Nyamira County. The county's economy relies greatly on agriculture. Tea, which is the major cash crop, is grown at high altitudes within the county.	County Government of Nyamira, 2018
Kisii	The economy of Kisii County largely depends on agriculture. The topography in Kisii County is characterised by hills with several ridges and valleys.	County Government of Kisii, 2018
Homa Bay	The main economy in Homa Bay County is agriculture. Homa Bay County is divided into two main relief regions, namely the lakeshore lowlands and the upland plateau.	County Government of Homa Bay, 2018
Migori	Agriculture is practiced throughout the county and is the main land use type and economic activity. Migori County is mostly covered by undulating hills, with a few stretches of flat land.	County Government of Migori, 2018
Narok	The Narok county is a member of the South Rift Economic Bloc intending to improve the agricultural sector to increase exports to African countries and abroad, livestock production, wildlife and cultural tourism, minerals and the environment. The main crops grown in the county are wheat, barley, maize, beans, Irish potatoes and horticulture crops. Mining activities include gold mining and sand mining.	County Government of Narok, 2018

2.3.2.2 Employment and livelihoods

The formal sector is made up of both public and private enterprises which have been legally established or are listed with the registrar of companies. Most formal employment is in the urban centres although there is also formal employment in rural areas. The informal sector, also known as *jua kali*, employs 31% of the labour force in LVS Basin and covers all small-scale activities that are semi-organised, unregulated and use basic technologies. This sector provides employment for both rural and urban dwellers. Small-scale irrigation and pastoralism make up a large portion of the employment in the LVS Basin.

Livelihoods refers to a person's means of securing the basic necessities of life (i.e. food, water, shelter and clothing). Engaging in livelihood activities involves acquiring knowledge, skills, social network, raw materials, and other resources to meet individual or collective needs on a sustainable basis. Investing in livelihood activities reduces the costs associated with the provision of aid and protection; and builds self-reliance. The sources of livelihood vary across the basin, from formal employment in the urban areas to subsistence agriculture and crop and livestock production in the pastoral and farming areas. The main livelihoods in the various counties are described below.

Table 2-7: Livelihood activity of each county

County	Economic Activities
Siaya	The population is largely rural and over 70% is engaged in agriculture, which is the main source of income in the county. The poverty rate of the County was estimated to be 38% (Wiesmann et al., 2016).
Kisumu	24% work in the formal sector, while 55% are self-employed, in the informal sector, and agricultural activities including small-scale agriculture and pastoralism. The poverty rate of the County was estimated to be 40% (Wiesmann et al., 2016).
Nandi	Approximately 54% of the population are wage earning. A small portion of these people work in the formal sector, while the majority are self-employed, in the informal sector, and agricultural activities including small-scale agriculture and pastoralism. Average farm size is reducing because of the rapid increase in population and the demand for land. This fragmentation of land is likely to have an adverse effect on overall food production and land productivity. The poverty rate of the County was estimated to be 40% (Wiesmann et al., 2016).
Nakuru	33% work in the formal sector, while 41% are self-employed, in the informal sector, and agricultural activities including small-scale agriculture and pastoralism. The poverty rate of the County was estimated to be 34% (Wiesmann et al., 2016).
Kericho	23% work in the formal sector, while 39% are self-employed, in the informal sector, and agricultural activities including small-scale agriculture and pastoralism. The poverty rate of the County was estimated to be 39% (Wiesmann et al., 2016).
Bomet	17% work in the formal sector, while 41% are self-employed, in the informal sector, and agricultural activities including small-scale agriculture and pastoralism. The poverty rate of the County was estimated to be 51% (Wiesmann et al., 2016).
Nyamira	13% work in the formal sector, while 30% are self-employed, in the informal sector, and agricultural activities including small-scale agriculture and pastoralism. The poverty rate of the County was estimated to be 51% (Wiesmann et al., 2016).
Kisii	13% work in the formal sector, while 36% are self-employed, in the informal sector, and agricultural activities including small-scale agriculture and pastoralism. The poverty rate of the County was estimated to be 51% (Wiesmann et al., 2016).
Homa Bay	11% work in the formal sector, while 43% are self-employed, in the informal sector, and agricultural activities including small-scale agriculture and pastoralism. The poverty rate of the County was estimated to be 48% (Wiesmann et al., 2016).
Migori	38% work in the formal sector, while 12% are self-employed, in the informal sector, and agricultural activities including small-scale agriculture and pastoralism. The poverty rate of the County was estimated to be 50% (Wiesmann et al., 2016).
Narok	12% work in the formal sector, while 46% are self-employed, in the informal sector, and agricultural activities including small-scale agriculture and pastoralism. The poverty rate of the County was estimated to be 41% (Wiesmann et al., 2016).

2.3.3 Standard of living

2.3.3.1 Water supply and sanitation

The total storage volume of the existing dams in the LVS Basin is about 6.3 MCM, of which more than 80% is stored in small dams and pans (Water Resources Management Authority, 2013). There are a large number of boreholes in the basin, with a total estimated current abstraction volume of 69 MCM per annum.

Almost 50% of the total population in the Basin is supplied directly from unimproved drinking water sources. Only 12% of the population receive piped water from a WSP, while about 40% receive water from boreholes and springs (Water Resources Management Authority, 2013).

The majority of the urban and rural populations make use of septic tanks and pit latrines for sanitation. There are currently no sewerage systems in place in the rural areas, and only 4% of the urban population has access to formal sewerage systems (Water Resources Management Authority, 2013).

The Water Act 2016 devolves water and sanitation services to the county governments, who provides these services through WSPs. The Lake Victoria South Water Works Development Agency contracts WSPs to provide potable water to the population. There are eight urban WSPs and one rural WSP.

2.3.3.2 Land tenure

Four different entities can own land in Kenya, namely, the government, individuals and groups. Any Kenyan individual can own land if they have been granted citizenship, which includes natural citizens as well. Companies which are fully owned by Kenyan citizens or any trust whose beneficiaries are Kenyan citizens can own land.

The land tenure systems within Kenya can be characterised as private/modern and communal/customary. There are five types of land tenures**:**

- **Freehold:** allows the owner to hold the land for an indefinite term.
- **Leasehold:** a leasehold agreement confers upon the owner a limited term on the property, which can be extended upon expiry. The Kenyan constitution limited the tenure for non-citizens to no more than 99 years.
- **Customary:** rights are based on communal ownership, where the land is assigned to a defined group of users or individuals. Users may belong to a clan or ethnic community.
- **Public/State land:** this is when the government is a private land owner. This system dates from the Crown lands Ordinance of 1902 which declared that all waste and unoccupied land in the protectorate was crown land.
- **Foreign access to land in Kenya:** a person who is not a citizen of Kenya may hold the land as part of a leasehold tenure and this lease should not extend before 99 years.

In many parts of the LVS Basin, the land is private land, with the remainder being public or communal land. Many farmers have been issued with title deeds, although many of these title deeds need to be updated with the current occupiers of the land. There is little landlessness in the Basin, but the trend of leasing or selling land for commercial endeavours has the potential to cause this. High population densities in some areas and limited land for agriculture make these areas vulnerable.

2.4 Water resources management

2.4.1 Surface water resources

2.4.1.1 Conceptual approach to surface water resources assessment

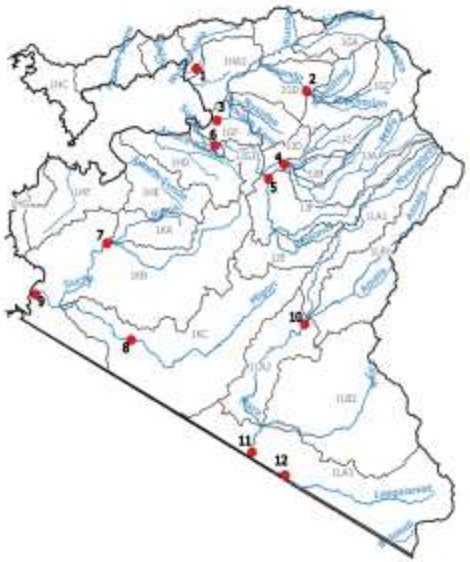
A surface water resources analysis for the Lake Victoria South Basin was undertaken to quantify the available surface water within the basin under natural conditions in both space and time (refer to **Annexure A3**). This involved the development of a water resources systems model of the basin, including a rainfall-runoff model. Based on the availability of historical rainfall data, a simulation period from 1960 to 2017 was used for the model simulations, conducted at a daily time-step. MIKE HYDRO Basin, which incorporates the NAM rainfall-runoff model, was used as the water resources systems model. The water resources modelling task involved a number of sequential steps including the collection, review and quality control of hydrometeorological data, model sub-catchment delineation, model calibration and validation, the configuration of a system model, and hydrological assessment through water resources simulation.

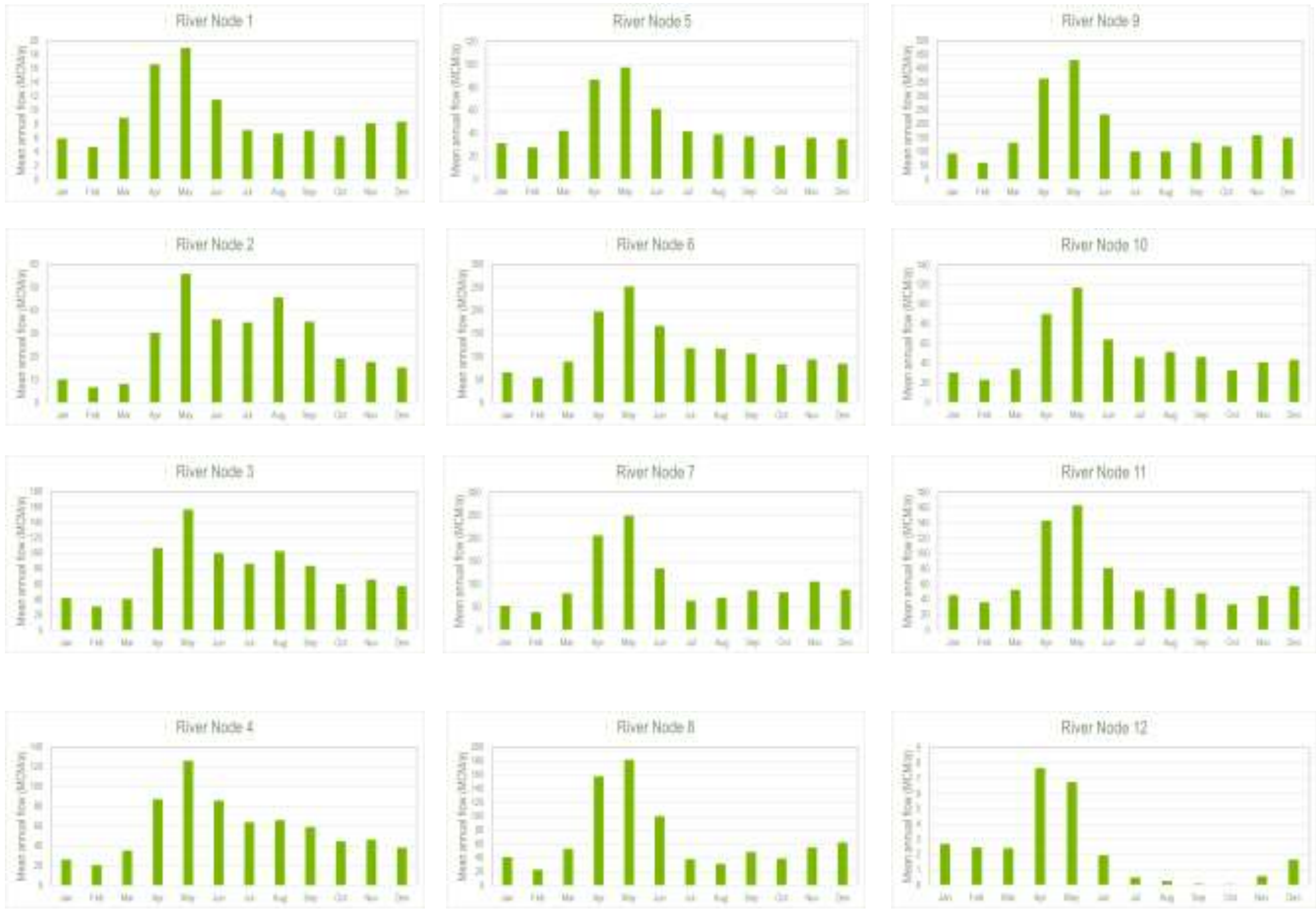
Note: More details regarding the surface water resources assessment for the Lake Victoria South Basin are provided in "ISC Report C1-4: Lake Victoria South Surface Water Resources Assessment".

2.4.1.2 Surface water resources potential

Figure 2-21 displays the simulated natural Mean Annual Runoff (MAR) at key locations across the Lake Victoria South Basin. From the Figure, the following observations can be made:

- The total Lake Victoria South Basin natural runoff equals 6 770 MCM/a, as calculated during this consultancy.
- Almost 80% of the total basin runoff originates from the Nyando, Sondu, Mara and Gucha-Migori rivers, i.e. 14% from the Nyando (932 MCM/a), 21% from the Sondu (1 431 MCM/a), 12% from the Mara (810 MCM/a) and 31% from the Gucha-Migori (2 085 MCM/a).
- All of the above rivers drain into Lake Victoria, including the Mara River which flows into Tanzania and finally into Lake Victoria.





River Node	River Name	Mean Annual Runoff (MCM)
1	Nyamasaria R	110
2	Nyando R @ Muhoroni	316
3	Nyando @ Lake Vic	932
4	Yurith R	699
5	Kipsonoi R	565
6	Sondu R @ Lake Vic	1431
7	Gucha R	1256
8	Migori R	830
9	Gucha-Migori R @ Lake Vic	2085
10	Upper Mara R	620
11	Mara R @ Intl. Border	810
12	Longaianiet R @ Intl. Border	27

Figure 2-21: Natural mean annual runoff and seasonal flow patterns at key nodes in the Lake Victoria South Basin

2.4.1.3 Seasonal flow variability

All the rivers show a pronounced high runoff season during April to June. The rivers in the central and northern parts of the basin have more or less constant elevated flows during July to December and low flows during January to March. The rivers in the southern part of the basin are also characterised by low flows during July to November, with higher flows during December.

To assess the extent to which the seasonal flows in the rivers vary, a Seasonal Index Map was developed (Figure 2-22), which expresses the average cumulative natural flow volume during the three driest consecutive months at each sub-basin outlet as a proportion of the total annual cumulative natural flow volume at the same location.

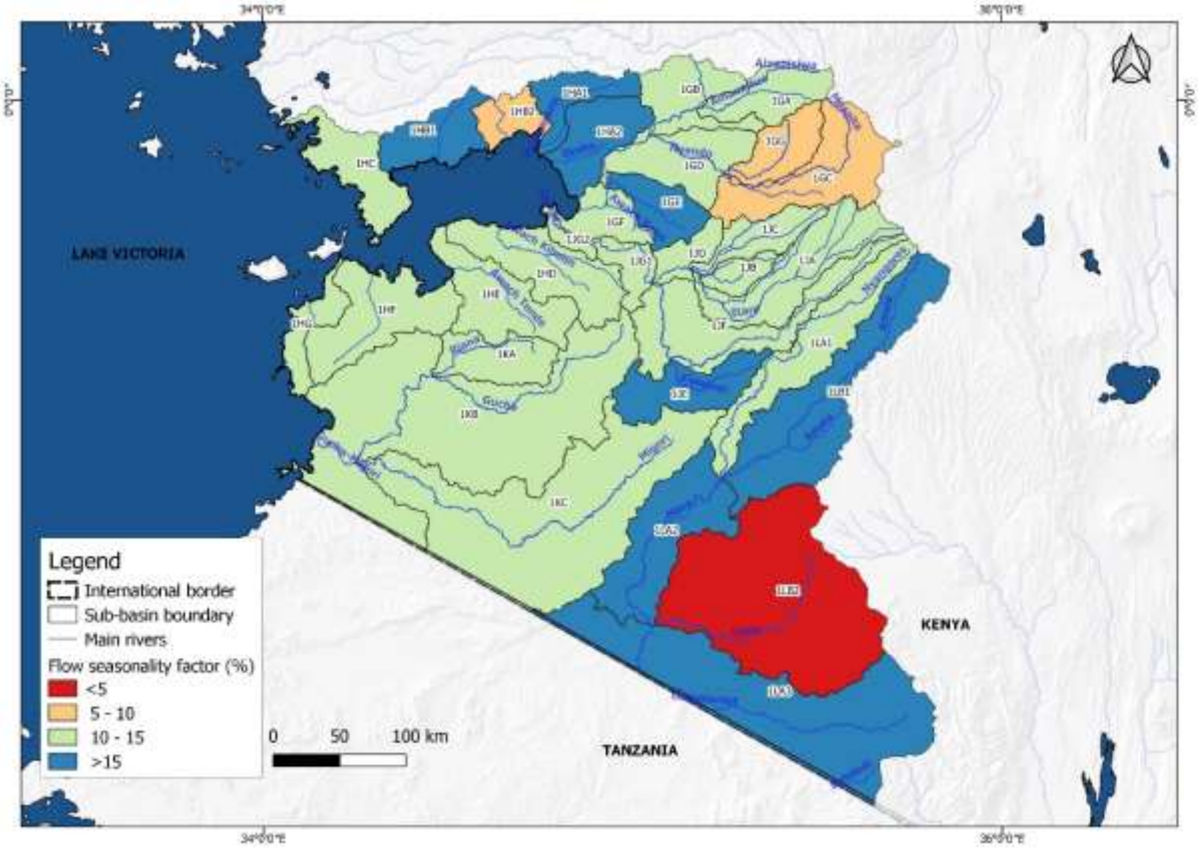


Figure 2-22: Flow seasonality Index per sub-basin

2.4.1.4 Annual flow variability

A key objective of water resources development, concerns mitigation of inter-annual flow variability through the provision of carry-over storage. As an example, Figure 2-23 displays the annual variability of natural flow in the Mara River where it crosses the border into Tanzania for the period 1960 to 2017. It is evident that there is significant flow variability and cyclicity in the basin due to hydrometeorological drivers as well as a possible trend. This highlights the need for the provision of more storage within the basin to improve resilience.

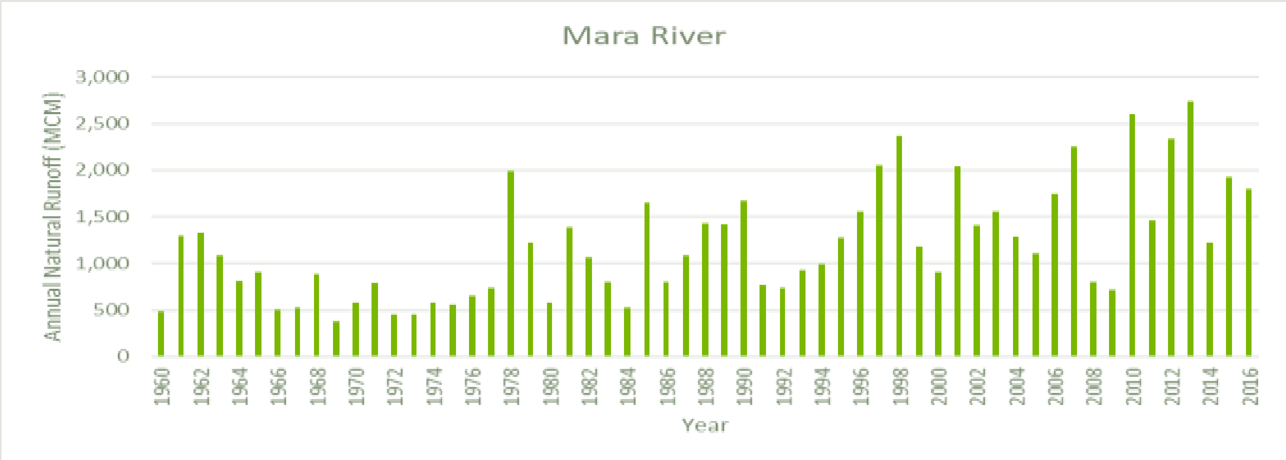


Figure 2-23: Annual flow variability in the Mara River where it crosses the border into Tanzania

2.4.1.5 Unit runoff

Unit runoff is defined as the depth of runoff (mm) from a catchment area and as such allows for direct comparison between geographically distinct areas.
Figure 2-24 shows calculated natural unit runoff values at sub-basin scale and highlights the relatively high and constant absolute unit runoff in most of the basin. It also highlights the low unit runoff values in the lower Mara catchment.

2.4.1.6 Runoff coefficient

The runoff coefficient is a dimensionless coefficient relating the amount of runoff from a catchment to the amount of precipitation received. It is typically a function of soils, topography, vegetation and rainfall intensity. A high runoff coefficient indicates lower interception, lower infiltration and higher runoff associated with steeper areas, while a lower runoff coefficient is associated with higher permeability, denser vegetation and more gentle topography.

As shown in Figure 2-25, runoff coefficients in the central and northern parts of the Lake Victoria South Basin are generally high and above 15%. Runoff coefficients towards the south-eastern part of the basin reduce to less than 5%. The average basin-wide runoff coefficient was calculated as 16.2%.

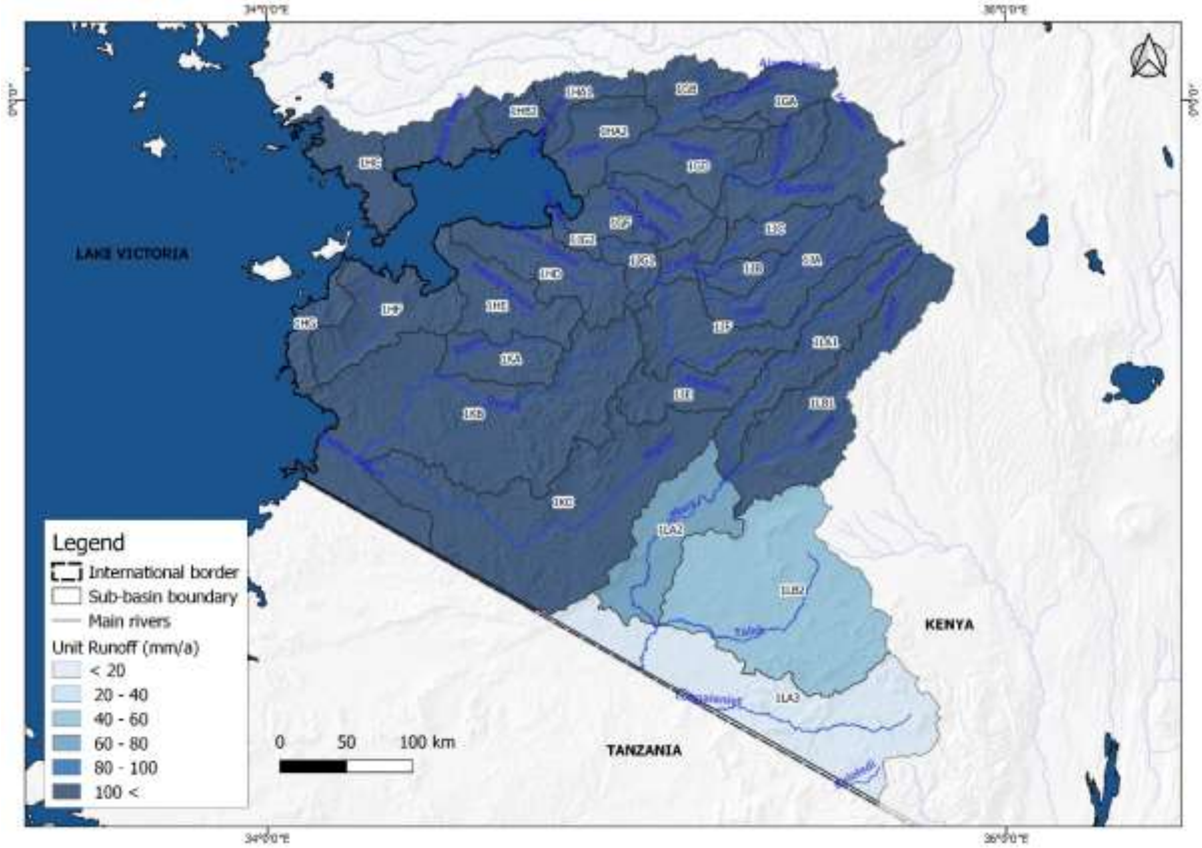


Figure 2-24: Unit runoff per sub-basin

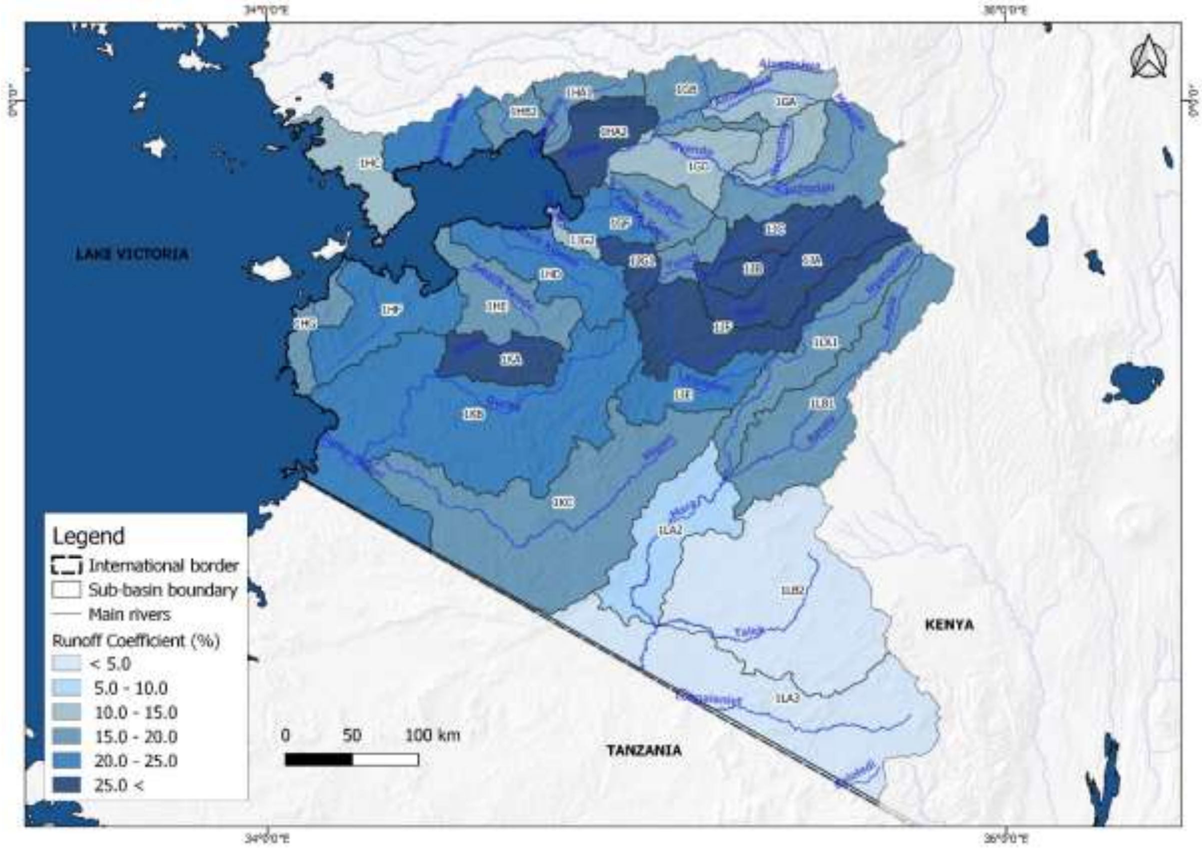


Figure 2-25: Runoff coefficient per sub-basin

2.4.1.7 Impacts of climate change on surface water resources

The climate change analysis which was undertaken as part of this Consultancy (refer to **Annexure A2**), showed that projected future precipitation totals are varied across the Lake Victoria South Basin. The RCP 4.5 analysis predicted that the Mean Annual Precipitation across the Lake Victoria South Basin would increase by 35 mm, from 1 316 mm to 1 349 mm by 2050, while day and night temperatures in the basin are expected to increase by up to 1.25°C and 1.35°C respectively by 2050.

Projected sub-basin precipitation and temperature changes under climate change scenario RCP 4.5 were superimposed on the hydrological model of the Lake Victoria South Basin to assess the potential impacts on runoff. Figure 2-26 shows that the natural runoff in the basin is expected to decrease in most sub-basins by between 1% and 3%, with some sub-basins staying unchanged or slightly lower or higher. The total surface water runoff from the Lake Victoria South Basin is projected to decrease with 1.4% to 6 674 MCM/a under RCP 4.5. Even though rainfall is projected to increase, the expected increase in temperature and associated evapotranspiration, will thus result in a net reduction in surface water runoff from the basin.

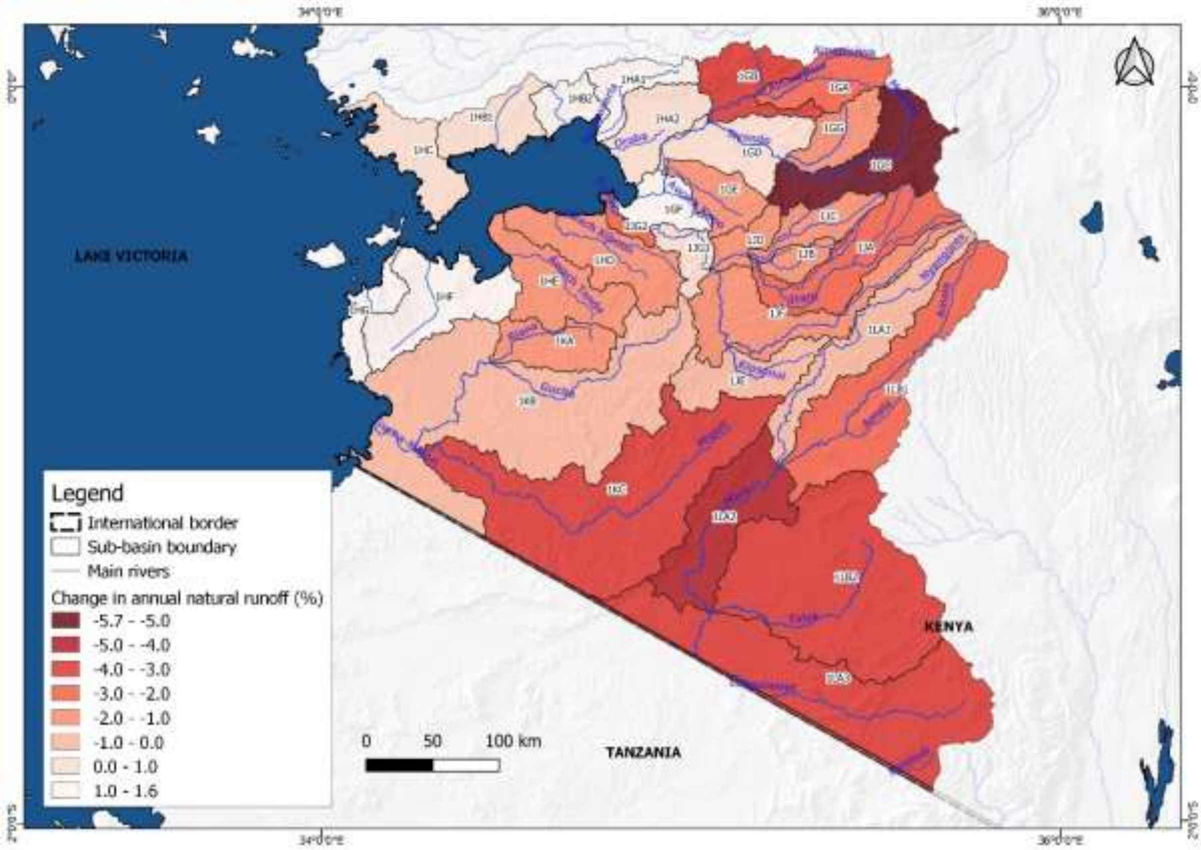


Figure 2-26: Climate change impacts on natural runoff in the Lake Victoria South Basin 2050 (RCP 4.5)

2.4.2 Groundwater resources

2.4.2.1 Conceptual approach to groundwater resources assessment

A high-level groundwater assessment to quantify the groundwater resources of the LVS Basin was undertaken as part of this Consultancy (**Annexure A4**). This entailed a GIS-based approach that used existing data at a national scale. Datasets were derived from macro and secondary geology, topography, rainfall and estimates of recharge, which were categorised and weighted to quantify groundwater availability / potential. While this approach allows for assessments at any scale, it provides generic data sets best suited for rapid and regional-scale groundwater resource assessments and does not replace the need for detailed resource assessments for areas with high groundwater competition or water quality concerns like saline aquifer intrusion, for example. The adopted approach takes local rainfall-groundwater recharge relationships and local lithological and structural permeabilities into account, and therefore is not applicable for deep-seated aquifers located far from their recharge source. It aims to capture the vast majority of the country where the availability of groundwater is a function of local recharge and permeability.

For the approach to be practical, the following principles were incorporated in the methodology:

- The data sets are spatially (GIS) based
- The data sets can easily be replaced once new data becomes available
- The approach is applicable at various scales (e.g. for aquifer, minor and major catchment studies)
- The approach is easy to use

The approach is considered scientifically sound and the assumptions, data sources and mathematics used to determine the answers are documented so that the calculations can be re-evaluated, checked and improved as new data becomes available. The main deliverables are data sets and maps on groundwater potential in a format that is accessible and useable for development planning and for providing guidance on how much water can be allocated for use.

Note: A detailed description of the groundwater assessment approach and methodology is provided in "ISC Report C2-1: National Groundwater Potential Assessment".

2.4.2.2 Groundwater resources potential

The annual groundwater recharge for the LVS Basin was estimated at 2,095 MCM/a, with a sustainable annual groundwater yield of 292 MCM/a. This is higher than the Kenya National Water Master Plan (NWMP) 2030 sustainable groundwater yield estimate of 203 MCM/a for the LVS Basin (Water Resources Management Authority, 2013). However, whereas the NWMP 2030 assumed sustainable yield as a percentage of recharge (10%), the groundwater assessment which was conducted as part of this Consultancy estimated sustainable yield based on regional and secondary permeability and topography.

Figure 2-27 and Figure 2-28 display the recharge and potential groundwater availability in the LVS Basin. High groundwater Potential is found throughout the basin.

Annexure B lists the groundwater potential per sub-basin.

2.4.2.3 Impacts of climate change on groundwater resources

In the longer term, the effects of climate change are expected to increase recharge and available groundwater in the LVS Basin. Projected sub-basin precipitation and temperature changes under climate change scenario RCP 4.5 (refer to **Annexure A**) were superimposed on the groundwater model of the LVS Basin to assess the potential impacts on recharge and groundwater potential. It was found that the recharge in the basin will increase by 3% to 2 154 MCM/a, while the potential groundwater yield is expected to increase by 4% to 303 MCM/a under RCP 4.5. This is different to the NWMP 2030 sustainable yield that shows a 7% decrease in sustainable groundwater yield for 2030.

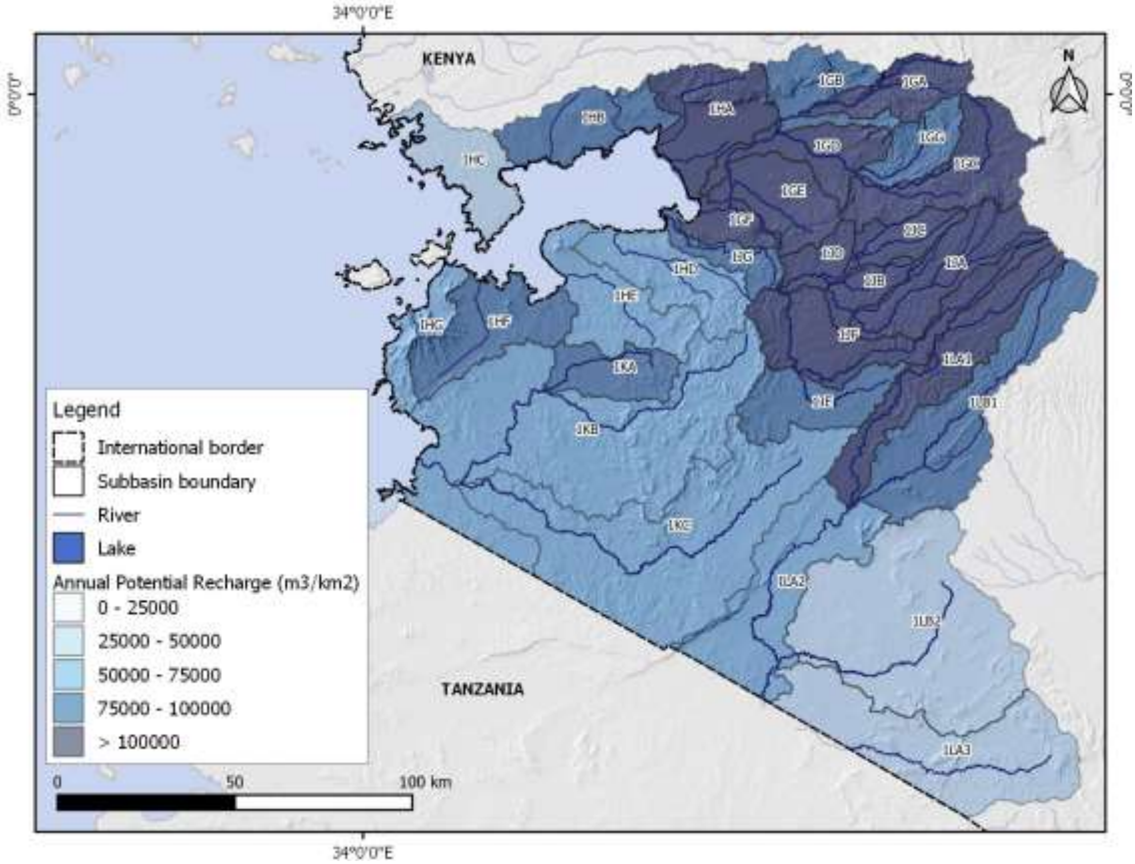


Figure 2-27: Estimated annual potential groundwater recharge in the LVS Basin

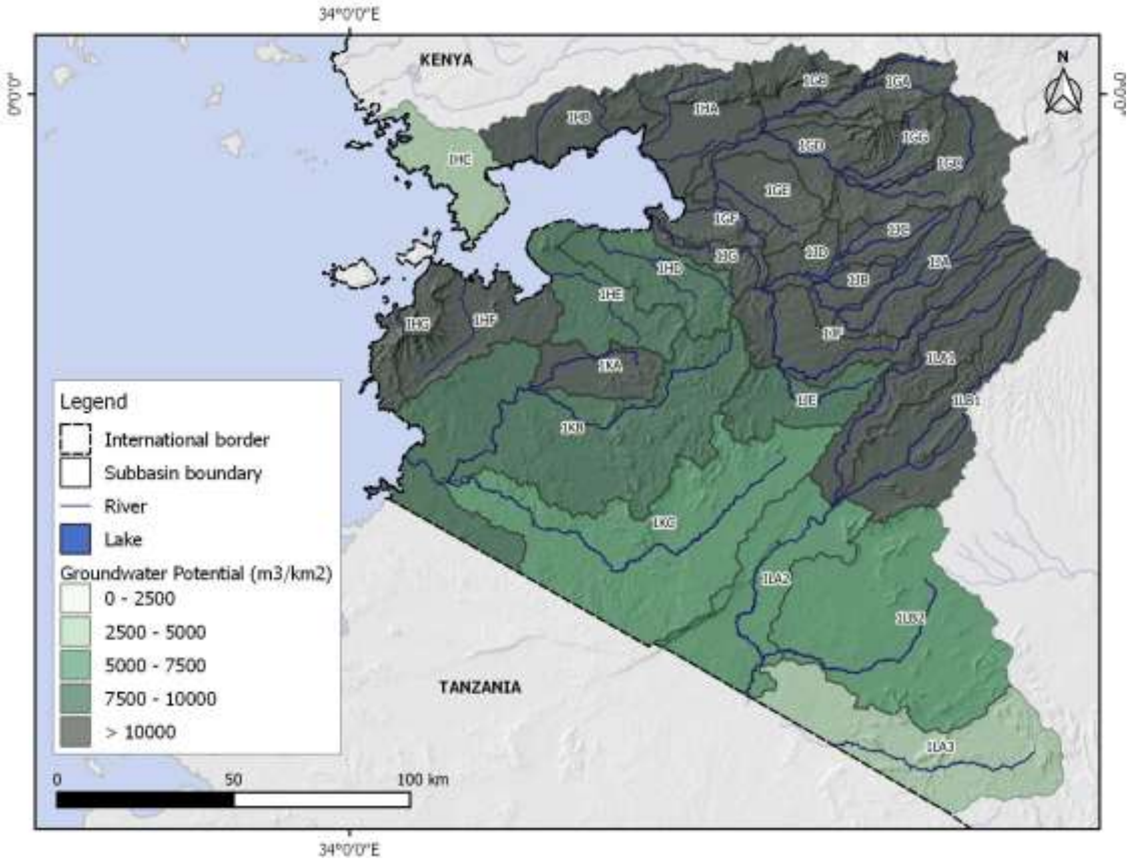


Figure 2-28: Estimated annual groundwater potential in the LVS Basin

2.4.3 Current water requirements

Currently, the main demand for water in the Lake Victoria South Basin consists of domestic, livestock, industrial, and irrigation water requirements.

2.4.3.1 Irrigation water requirements

To estimate irrigation water requirements in the Lake Victoria South Basin, information on the location and spatial extent of irrigated areas is needed as well as information on crop types, cropping patterns and cropping intensities. For this analysis, several sources were consulted. Information was obtained from the NWMP 2030, the 2015 UNECA Regional Centre for Mapping of Resources for Development crop mask for Kenya (Regional Centre for Mapping of Resources for Development, 2018), the 2015 Global Food Security-Support Analysis dataset (Xiong, Thenkabail, Tilton, *et al.*, 2017), a FAO Irrigation inventory compiled as part of the NWMP 2030, and the IWMI Irrigated Area Map of Africa (2010).

- NWMP 2030

  The NWMP 2030 differentiated between large-scale, small-scale and private schemes for the estimation of irrigation areas in Kenya. Information on large-scale irrigated areas were based on data as reported by the Kenya National Irrigation Authority (NIA) as well as on data extracted from the Water Permit Database. Information related to small-scale irrigation were sourced from Provincial and District Irrigation Field Offices, while areas under private irrigation were estimated with the assistance of regional WRA offices and based on data available in the Water Permit Database.

- Regional Centre for Mapping of Resources for Development (RCMRD)
  http://opendata.rcmrd.org/datasets/kenya-crop-mask-2015)

  The RCMRD Kenya Crop Land layer provides information on the extent of cropland, area specific major crops and other crops being grown in the same location. The layer was generated from Landsat 8, 30 meters resolution imagery data for Sep/Oct 2015 and validated using location points collected from subsequent field visits.

- Global Food Security Analysis-Support Data at 30 Meters (GFSAD30) Project
  https://lpdaac.usgs.gov/products/gfsad30afcev001/

  The GFSAD30 is a NASA funded project to provide high resolution global cropland and water use data that contribute towards global food security in the twenty-first century. The GFSAD30 products are derived through multi-sensor remote sensing data (e.g., Landsat, MODIS, AVHRR), secondary data, and field-plot data and aims to produce consistent and unbiased estimates of global agricultural cropland products such as cropland extent\area, crop types, irrigated versus rainfed, and cropping intensities. It is produced at a resolution of 30 m for the entire continent of Africa for the nominal year 2015 using Sentinel-2 and Landsat-8 time-series data (Xiong *et al.*, 2017).

- IWMI Irrigated Area Map of Africa (2010)
  http://waterdata.iwmi.org/applications/irri_area/

  The IWMI Irrigated Area Map of Africa aimed to map the irrigated and rainfed areas of Africa using freely available, remotely sensed, MODIS satellite data. High resolution images and the seasonal variations captured in multi-seasonal satellite images were used to classify the landscape and identify irrigated croplands using classification methods based on the seasonal profile of vegetation. The mapping was done using 16-day MODIS 250m NDVI composites images (MOD13Q1). A hierarchical classification procedure involving classification techniques and time-series analysis of the NDVI data was followed. The agricultural areas were categorised into irrigated and rainfed by analysing the seasonal vegetation trends.

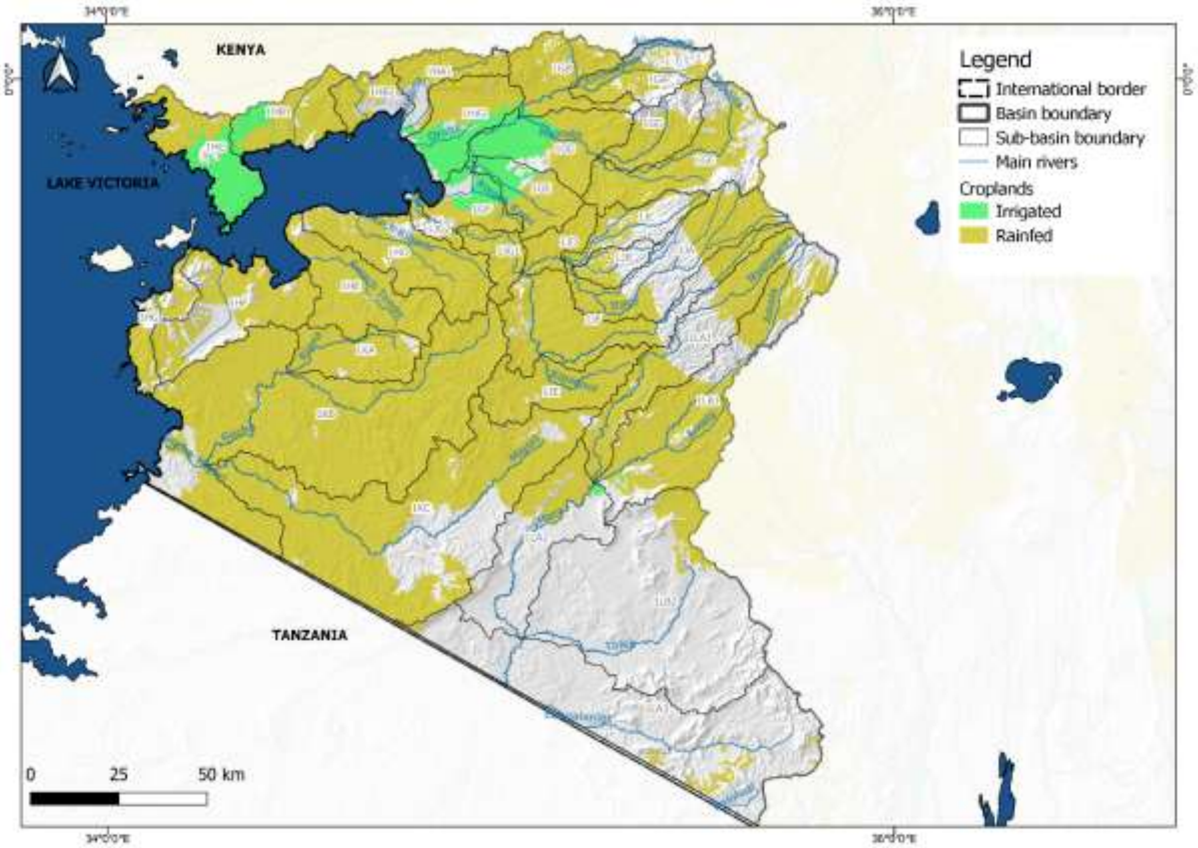


Figure 2-29: Irrigated crops in the LVS Basin (RCMRD Kenya Crop Mask, 2015)

The above data sources were supplemented with information provided by the NIA, and information provided by the Department of Irrigation at the Ministry of Agriculture, Livestock and Fisheries on dominant crop types, cropping intensities, irrigation efficiencies and a FAO Irrigation inventory. An analysis and synthesis of the data and trends allowed present-day (2018) large-scale, small-scale and private irrigated areas to be determined per sub-basin as summarised in Table 2-8. The total current (2018) irrigated area in the Lake Victoria South Basin is estimated as 16 616 ha. Of this, about 5 500 ha is large scale irrigation. This represents an increase of about 26 % compared to the 2010 irrigation area of 13 220 ha as determined in the NWMP 2030 and confirms the increase in irrigation in the basin.

Table 2-8: Irrigated areas per sub-basin (2018)

Sub-basin	Irrigated Area (ha)	Sub-basin	Irrigated Area (ha)	Sub-basin	Irrigated Area (ha)
1GA	90	1HC	223	1JG1	270
1GB	480	1HD	1,531	1JG2	321
1GC	200	1HE	1,365	1KA	310
1GD	320	1HF	2,225	1KB	1,834
1GE	577	1HG	843	1KC	123
1GF	985	1JA	154	1LA1	144
1GG	198	1JB	34	1LA2	34
1HA1	364	1JC	45	1LA3	88
1HA2	1,177	1JD	20	1LB1	136
1HB1	1,079	1JE	116	1LB2	82
1HB2	1,068	1JF	181	**Total**	**16 616**

The standard crop coefficient (Kc) approach was used to estimate irrigation water requirements per sub-basin. Kc values were obtained from the FAO Irrigation and Drainage Paper 56 (Allen et al, 1998), using regional data where available. An effective rainfall factor of 0.6 was assumed, and an average irrigation efficiency factor of 0.5 (Ministry of Agriculture, Livestock and Fisheries, personal communication, February 2019). 200% cropping intensities were assumed for small-scale horticulture, maize, rice and sorghum, while a 60% cropping intensity was used for vegetables, beans, green grams and cow peas (Ministry of Agriculture, Livestock and Fisheries, personal communication, February 2019). The current (2018) irrigation demand in the Lake Victoria South Basin was calculated as 256 MCM/a.

2.4.3.2 Domestic and Industrial water requirements

For the main urban centres in the Lake Victoria South Basin, the latest water demand figures for domestic and industrial use were obtained from recent master plans or similar studies and projected to 2018 based on historical population growth factors. The total 2018 urban demand was estimated as 92 MCM/a of which 12 MCM/a is supplied from groundwater.

For the remainder of the Lake Victoria South Basin, water demands for urban domestic and industrial as well as rural domestic use were extracted per sub-basin from the NWMP 2030 and from the WRA Permit Database and compared. Where the Permit Database values were higher than the NWMP 2030 estimates extrapolated to 2018, the permit Database values were used as representative of the current demand and vice versa. The estimate of the total basin-wide domestic and industrial water demand in the Lake Victoria South Basin, excluding urban centres, came to 208 MCM/a. Surface water supply towards this demand was estimated at 164 MCM/a, with groundwater contributing 44 MCM/a.

The total current (2018) domestic and industrial water demand in the LVS Basin therefore comes to 300 MCM/a, which is more than the NWMP 2030 estimate (2010) of 175 MCM/a.

2.4.3.3 Livestock water requirements

The livestock water demands in the Lake Victoria South Basin as per the WRA Permit Database, were compared to that of the NWMP 2030 and found to be significantly less. A conservative approach was therefore adopted by using the NWMP 2030 demand and extrapolating it to 62 MCM/a as the demand for 2018. Most of the livestock water demand is supplied from surface water.

2.4.3.4 Wildlife and fisheries

Water demands for wildlife and fisheries in the Lake Victoria South Basin is negligible. Consequently, the water demand figures as stated in the NWMP 2030 were accepted as correct and extrapolated to a 2018 demand of 15 MCM/a based on historical growth trends.

2.4.3.5 Total water requirements

The total current estimated water demand (2018) in the Lake Victoria South Basin equates to 633 MCM/a as shown in

Table 2-9. Most of the water is needed for domestic/industrial use and irrigation. Figure 2-30 shows the distribution of current water demands across the Lake Victoria South Basin.

Table 2-9: Current (2018) water requirements in the Lake Victoria South Basin per main sector

Sector	Total (MCM/a)
Irrigation	**256**
- Small scale / Private	183
- Large-scale	73
Domestic and Industrial	**300**
– Urban centres	92
– Basin-wide	208
Livestock	**62**
Other	**15**
Total	**633**

2.4.4 Current large-scale water resources infrastructure

The existing water resources developments in the Lake Victoria South Basin include a dam and large-scale irrigation schemes.

2.4.4.1 Storage

Only dams with a storage capacity equal to or greater than 1 MCM were explicitly modelled in this Consultancy. There is only one existing dam that is equal to or greater than 1 MCM in the Lake Victoria South Basin, viz. the Sondu Miriu Dam on the lower Sondu River. The dam, with a storage capacity of about 1 MCM, is used for hydropower production. The installed hydropower capacity is 60 MW. Key information on the dam is presented in Table 2-10.

Table 2-10: Key information for the Sondu Miriu Dam

Dam Name	Location		Purpose	Storage Capacity (MCM)	Dead storage volume (MCM)	Bottom Level (masl)	Full Supply Level (masl)	Minimum Operating Level (masl)
	Lat	Long						
Sondu Miriu	-0.4005 S	34.8897 E	Hydropower	1.0	-	1 400	1 418	1 406

2.4.4.2 Hydropower

There are two existing hydropower installations in the Lake Victoria South Basin:

- Sondu Miriu Dam on the lower Sondu River with an installed capacity of 60 MW. Further downstream, the Sangoro Hydropower Scheme has an additional capacity of 21 MW using the tailwater of the Sondu Scheme.
- Gogo Falls hydropower station, which is essentially a run-of-river installation, on the lower Gucha River with an installed capacity of 2 MW.

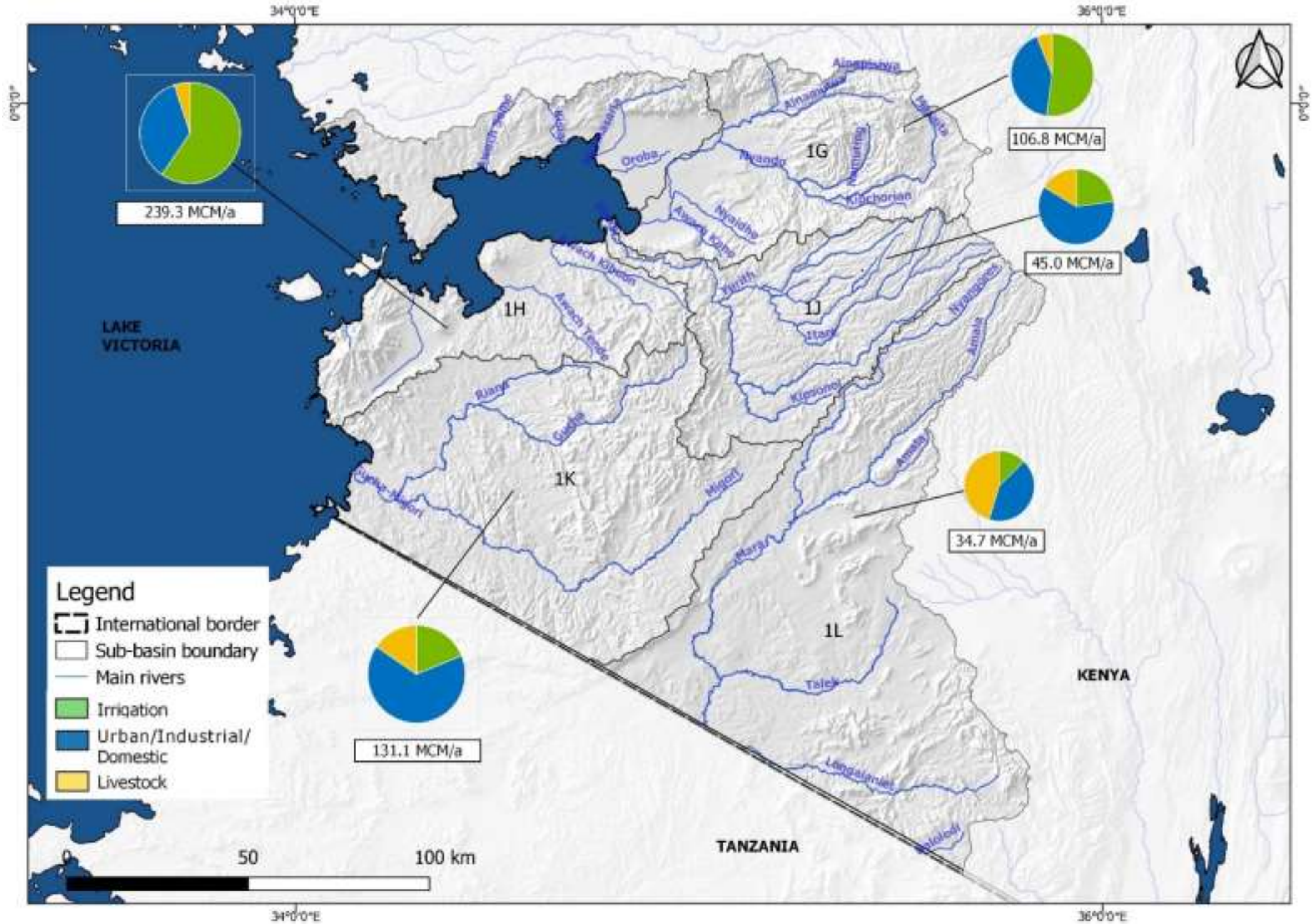


Figure 2-30: Present-day (2018) water requirements across the Lake Victoria South Basin

2.4.4.3 Water transfers

There are currently no inter- or intra-basin transfers in the Lake Victoria South Basin.

2.4.4.4 Large-scale irrigation schemes

Information on existing large-scale irrigation schemes in the basin was obtained from the NWMP 2030, the NIA and the Department of Irrigation at the Ministry of Agriculture, Livestock and Fisheries. In addition, a recent paper on paddy development schemes in the Lake Victoria Basin (Sumita & Mamoru Watanabe, 2017) was consulted. Only schemes equal to or larger than 2 000 ha were classified as large-scale for this Consultancy. Other irrigation was lumped together in each sub-basin and modelled as small-scale irrigation. Information on existing large-scale irrigation schemes in the Lake Victoria South Basin is summarised in Table 2-11.

Table 2-11: Existing large-scale irrigation schemes

Large-scale Irrigation Scheme	Irrigation area (ha)	Main crop type
West Kano*	910	Rice
Ahero	1 050	Rice
Lower Kuja	88	Rice
South West Kano	1 200	Rice
North West Kano	800	Rice
Kimira	1 460	Maize
Total	**5 508**	

**West Kano Irrigation Scheme abstracts water for irrigation from Lake Victoria*

2.4.4.5 Groundwater development and use

The use of groundwater in public water service providers (WSPs) in the LVS Basin is very limited, partly due to an abundance of perennial surface water resources, and partly because aquifer yields are relatively small. However, small-scale groundwater sources (community boreholes and protected and unprotected shallow wells and springs) are widely utilised for rural water supply and in some municipal areas. Large-scale water users (categories B, C and D) are normally captured in the PDB system, while shallow wells or springs that utilise pumps from point water sources (with smaller abstraction volumes) are usually overlooked.

Current groundwater use in the LVS Basin is estimated at 67 MCM/a. The percentage of the total water demand in each sector that is supplied from groundwater is shown in Table 2-12. Groundwater supply for each sector was determined from information in the Permit Database and the NWMP 2030.

Table 2-12: Groundwater contribution to meeting water demand in the LVS Basin (%) per sector

Use	Domestic (basin-wide)	Domestic (urban centres)	Livestock	Large-scale Irrigation	Small-scale Irrigation	Industrial	Other
% met by groundwater	22%	21%	9%	0%	3%	5%	0%

2.4.4.6 Ongoing major water projects

The Ministry of Agriculture, Livestock and Fisheries recently completed the feasibility study for the Lower Kuja Irrigation Project in Migori County. This scheme, which will eventually comprise 10 0000 ha, will be close to the shores of Lake Victoria, downstream of the confluence of the Gucha and Migori Rivers, and will be supplied from the new Gogio Falls Dam – a multipurpose dam at the location of the existing Gogo Falls hydropower plant. The dam will have an installed capacity of 15 MW. Kengen plans to increase the hydropower capacity even further in future.

The Lake Basin Development Authority has gone out to tender for construction of Magwagwa Multipurpose Dam on the Sondu-Miriu River in Nyamira County to generate hydropower, to supply domestic and industrial demands in Nyamira, Homa Bay and Kisii counties, to supply water for large scale irrigation development on the Kano Plains and for flood control along the lower Sondu River.

The Lake Victoria South Water Works Development Agency is moving ahead with the Implementation of the Bunyunyu Dam Project on the upper Gucha River in Kisii County to supply water to Kisii Town and other surrounding towns in Kisii and Nyamira counties.

In order to improve the reliability of supply to Kisumu Town, and to ensure that the expected growth in water demand is met, Kibos Dam on the Kibos River in Nandi County, upstream of Kisumu, has been identified for imminent construction by Kisumu Water and Sanitation Company.

The Rift Valley Water Works Development Agency has started with implementation of Itare Dam on the Itare River, an upper tributary of the Sondu River, in Nakuru County. This dam will supply water to towns in Kericho, Bomet and Nakuru counties in the LVS Basin as well as to Nakuru Town and other smaller towns in the adjacent Rift Valley Basin via an inter-basin transfer (tunnel). Contractual disputes have halted implementation of this dam.

The planned Bosto Dam in Bomet County will have a capacity of 30 MCM and serve a population of 550 000 people in the county. This is currently a priority for the Government of Kenya. However, environmental activist groups are strongly opposing the construction of the dam on the Kipsonoi River inside the South West Mau Forest, which is a biodiversity hotspot and Kenya’s most significant catchment.

2.4.5 Water balance

The 2018 water balance in the Lake Victoria South Basin in terms of natural surface water runoff and sustainable groundwater yield, the ecological reserve and current (2018) water demands is summarised in Table 2-13. The current water demand constitutes about 9% of the total water resources available for use.

Table 2-13: Current (2018) Lake Victoria South Basin water balance (MCM/a)

Water Source	Surface water	Groundwater	Total
Natural / Available water	6 770	292	7 062
Ecological reserve	(316)	-	(316)
	Total		6 746
	Water demand (2018)		(633)
	Balance		**6 113**

Due to climate change impacts, the natural surface water runoff is expected to decrease to 6 674 MCM/a, while the groundwater yield is projected to increase to 303 MCM/a by 2050, which will result in the volume of available water in the LVS Basin to decrease slightly to 6 977 MCM/a.

Note: Future water balance scenarios which assess climate change impacts on future water availability and requirements are addressed in Section 6 of this Plan.

The water resources model, which was developed under this Consultancy, was used to assess surface water availability under current (2018) development and water requirement conditions at sub-basin level. To determine current water balances at sub-basin scale, the total annual water demand per sub-basin was expressed as a proportion of the surface water (less the ecological reserve) and sustainable groundwater available in that sub-basin. Water balances were then calculated as a surplus or shortfall, i.e. where the sub-basin demands constitute 60% of the sub-basin MAR, the water balance is calculated as 40%. Conversely, if the total demand in a sub-basin exceeds annual runoff in the sub-basin by 20%, the water balance is expressed as -20%. Figure 2-31 displays the current surface, sub-basin water balances and shows that all of the sub-basins still have surface water available. In fact, for the major part of the basin, water availability is above 80%, which means that less than 20% of the available annual surface water runoff is being used.

It is important to realise that although the total annual demand in many sub-basins, where demands are met by local runoff, is less than the total annual average runoff being generated in the sub-basin, supply deficits often occur during dry years and/or the dry season, when the demand exceeds availability of water in the rivers. Supply reliability and water deficits are evaluated as part of the scenario analysis (refer to Section 6).

The current estimated groundwater use in the Lake Victoria South Basin equates to 67 MCM/a, which is about 22% of the estimated sustainable groundwater yield of 292 MCM/a. This leaves 227 MCM/a of groundwater available for potential use in the Lake Victoria South Basin.

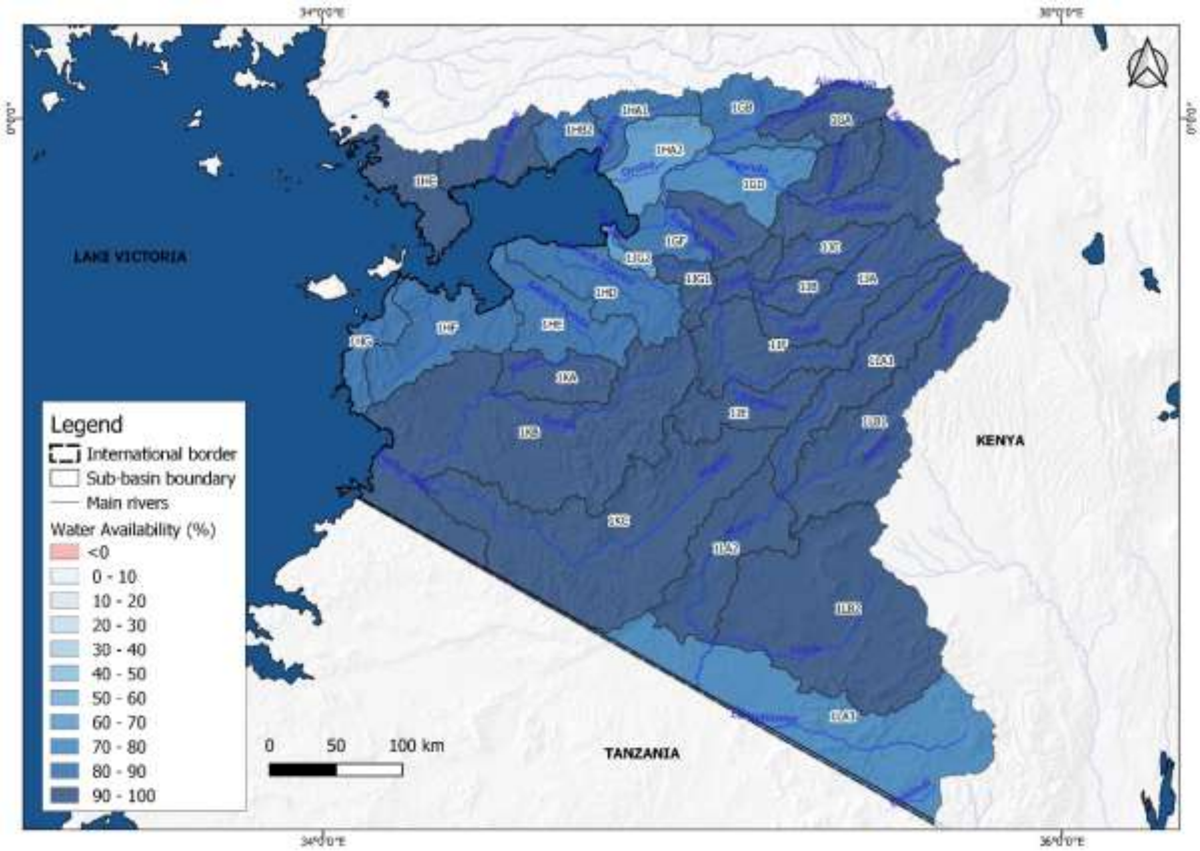


Figure 2-31: Surface water balance per sub-basin

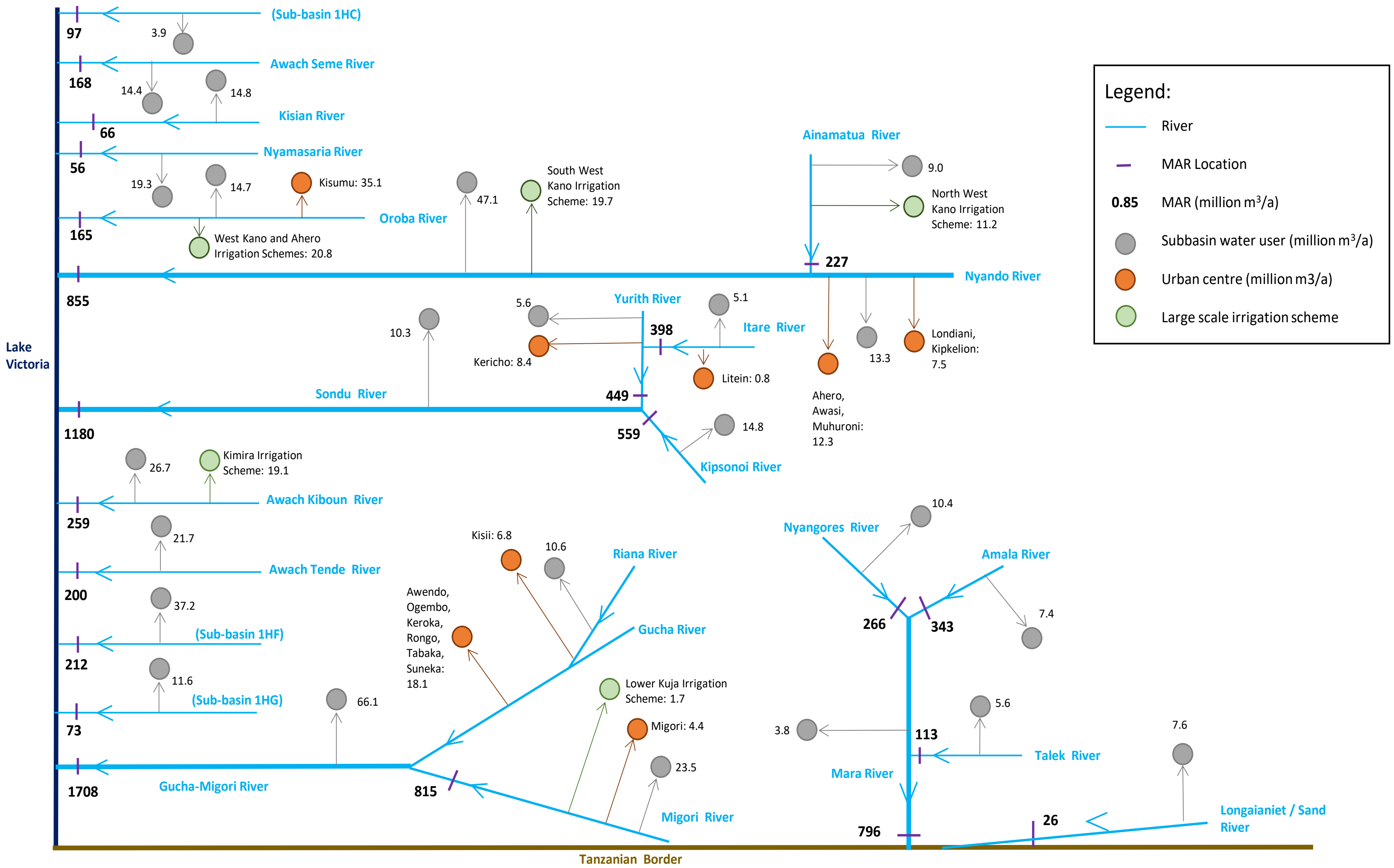


Figure 2-32: Current-day water availability and use in the LVS Basin

2.4.6 Surface water allocations

The WRA uses the permitting system as a tool to regulate the use of water resources in Kenya, and enhance equitable use of water resources. This water allocation is based on order of priority; reserve, domestic, agricultural, and finally industrial. Water permits have a five-year validity period, with renewal subject to the conditions attached for compliance. These permits, as captured in the Permit Database, reflect the current allocation of water to different user categories. The volume of water which is available for allocation in any catchment, is determined in accordance with the Guidelines for Water Allocation (Water Resources Management Authority, 2010) superseded by Draft 2018 Water Allocation Guideline (Water Resources Authority, 2019a). Essentially, the Guideline prescribes a flow/reliability approach based on natural flow exceedance values, to estimate the volumes (Q) of water which are available for allocation to domestic and irrigation users. It also specifies how the Reserve should be quantified:

$Q < Q95$: Ecological reserve

$Q95 < Q < Q80$: Normal flow (available for domestic and industrial use)

$Q80 < Q$: Flood flow (available for irrigation use)

This water allocation framework which is reflected in the water regulations aims to:

- safeguard at least a minimum ecological reserve (Q95) throughout the year
- safeguard dry season resource availability for domestic use by restricting allocation to the dry season resource availability. The dry season flows (called normal flow) are typically less than the Q80 flow
- allocate water for irrigation from flood flows (i.e. when flow exceeds Q80) which implies the need for storage as irrigation demand occurs during the dry season when abstraction for irrigation is restricted

In accordance with the guidelines, a high-level analysis was conducted, using the above daily flow exceedance thresholds (m^3/day), to assess the surface water allocation status in the LVS Basin - based on sub-basin hydrology developed as part of this Consultancy and current allocation volumes extracted from the Permit Database. It is important to note that this calculation approach did not consider the availability of storage.

Figure 2-33 provides a comparison, per sub-basin, of the current permit allocations per user category vs the water available for allocation in the Lake Victoria South Basin. Sub-basins shown as “under-allocated”, mean that either the Normal Flow component (available for domestic and industrial use) and/or the Flood Flow component (available for irrigation use) has not been exceeded by the current allocation volumes in these respective categories as reflected in the Permit Database and vice versa. Sub-basins indicated with “no data” represent sub-basins with no permit-based allocation records in the Permit Database.

Note: It is important to note that the above water allocation balance calculations only consider the incremental surface water runoff generated in each sub-basin and do not accommodate excess water (river flow) from upstream sub-basins.

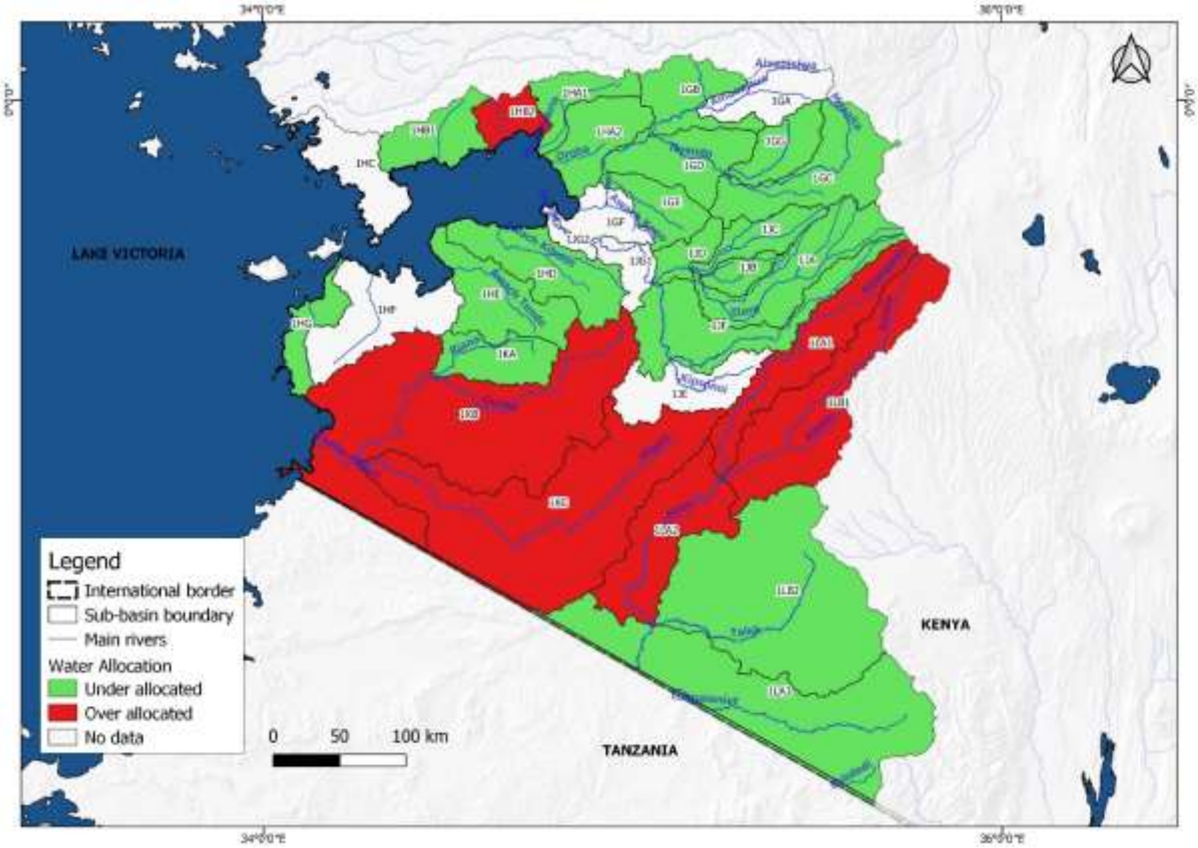


Figure 2-33: Surface water allocation status per sub-basin (2018)

2.4.7 Water quality

Water quality in Lake Victoria adjacent to the LVS Basin has declined due to undesirable activities happening upstream in the LVS Basin. The result is water hyacinth infestation which blocks major navigation routes, interferes with fishing, hampers dam operations and threatens the lake ecology. Rangelands are also increasingly being converted to agro-pastoralism, which leads to a loss of natural protective vegetation cover, and to increased erosion during rainy seasons. Unsustainable farming practices and poor management of croplands is evident in the catchment. The major water pollution threats are municipal waste, industrial waste, sedimentation, mining waste and agro-chemicals. Water quality issues also stem from inadequate monitoring and compliance control, poor waste disposal management and sedimentation of water bodies.

The most common pollutants in the runoff from the LVS Basin are:

- Industrial effluents from major towns as well as municipal/domestic sewage from urban settlements
- Solid wastes from dump sites
- Nutrients and Pesticide Residues from Agro-based industries
- Mercury and cyanide pollution from artisanal small-scale gold mining operations
- Sediment loads from degraded farmlands and from soil erosion in overgrazed lands and un-tarmacked roads at steep slopes
- Pollutants in storm runoff from roads and urban centres, as well as oil and grease from oils spills, garages and petrol stations
- Leachates from pit latrines, septic tanks and feedlots as well as acaricides from cattle dips

2.4.8 Existing hydrometeorological monitoring network

As part of this consultancy, the current hydrometeorological network was reviewed, and a proposed hydrometeorological monitoring design network is discussed in section 6.8.3. The chapters below present the existing situation of hydrometeorological stations in the basin, as it was in 2018. It is important to note that the number of operational hydrometeorological stations may have changed since the study was completed in 2018. For stream, lake and dam monitoring, only WRA stations were reviewed.

2.4.8.1 Stream flow measurement

In 2018, The Lake Victoria South Basin had 50 recorded stream flow monitoring stations (both operational and non-operational), although it is highly likely that this number was much higher in the past. Of these, only 38 are known to be currently operational. Table 2-14 provides details on the operational stream flow monitoring network in the LVS Basin. From Table 2-14 it is evident that the majority of currently operational stations are manually operated.

Table 2-14: Current stream flow monitoring stations in LVS Basin

SRO	Operational			
	Telemetric	Automatic	Manual	Total
Kericho	3	2	9	14
Kisii	1	0	8	9
Kisumu	2	0	13	15
Total	**6**	**2**	**30**	**38**

The majority of the operational river gauging stations are rated sections. Most are read manually by gauge readers, with 8 automatic stations (2 of which are fitted with telemetry). Rating curves are updated yearly at the National office and distributed to the regional and subregional offices for use. However, challenges remain because many of the stations are also inaccessible during high flow conditions. Figure 2-34 displays the locations of operational stream flow gauging stations in the LVS Basin.

2.4.8.2 Monitoring of dam and lake levels

There is currently one operational lake monitoring station in the LVS Basin at Kisumu (Lake Victoria). Historical data for this stations is available in the MIKE database, with varying continuity and period of records.

2.4.8.3 Meteorological monitoring

Many different organisations including the WRA, Kenya Meteorological Department (KMD), regional police stations, primary and secondary schools, National Parks, private enterprises, research institutions and agricultural offices operate meteorological stations throughout the LVS basin.

Figure 2-35 displays the spatial distribution of the operational meteorological stations in the LVS Basin for which information is available.

2.4.8.4 Water quality monitoring

Kenya's existing surface water quality monitoring network was designed to collect water quality data in key river systems to support the assessment and management of water quality in the country. The current practice in WRA is to monitor certain water quality parameters at most operational river gauging stations. This is done by sub-regional WRA staff at unknown intervals. In addition, effluent samples are supposed to be taken at potential point source pollution locations across the basin. In 2018, as part of this project, the number of existing water quality monitoring stations (for surface water, effluent and groundwater) were assessed across the basin (Table 2-15).

Table 2-15: Number of water quality monitoring stations in the LVS Basin (2018)

LVS Basin water quality stations	No. of current stations (2018)
Surface water quality	73
Effluent quality	26
Groundwater quality	29
Total	**128**

Currently, the water quality monitoring programme operated by WRA faces the challenges of inadequately qualified and trained staff and inadequate operational resources to facilitate regular sampling and laboratory analysis. In addition, because of inadequate equipment currently, the laboratories are only able to carry out analysis on a handful of parameters as listed in Table 2-16.

Table 2-16: Surface water quality parameters currently analysed

Type of Water quality monitoring station	Parameters tested
Effluent discharge points	Flow, pH, DO, Temperature, BOD, COD, Conductivity, TDS, Nutrients- NO2-, NO3-, PO43-, TSS
Surface water quality monitoring stations	Flow, pH, DO, Temperature, TSS Conductivity, TDS, Nutrients- NO2-, NO3-, PO43-.

2.4.8.5 Groundwater monitoring

There are a total of 18 groundwater monitoring points across the Basin (Water Resources Authority, 2018a). This is apparently unchanged from the 2014-15 reporting period when 18 sites were reported. The Water Resources Management Authority (2015b) lists and names 14 monitoring sites, though an accompanying map shows 22 sites. Data quality is patchy; most groundwater level data are collected from boreholes that are used as production boreholes, so all too often the data show dynamic as well as static water levels. This restricts the utility of water level data to determine long-term trends.

Of the existing monitored wells, most are manually dipped. Maintenance of monitoring wells is a serious concern. Similarly, to the surface water quality monitoring, inadequate equipment limits the parameters that are tested for groundwater. These parameters are listed in Table 2-17 It is not clear when the groundwater monitoring network was initiated in the LVS Basin or how far back the records go. However, the WRA started monitoring with mainly production boreholes where arrangements were made with the borehole owners to have them monitored. The monitoring is for static water level and periodic water quality testing on some wells. Water levels for these sites are measured manually by dip-meter inserted in a dipper tube. Further to these, WRA has installed a few automatic level-loggers on dedicated solitary monitoring wells.

Table 2-17: Groundwater quality parameters currently analysed

Type of Water quality monitoring station	Parameters tested
Ground water quality monitoring stations	pH, DO, Temperature, TSS Conductivity, TDS, Nutients-NO^{2-}, NO^{3-}, PO_4^{3-}.

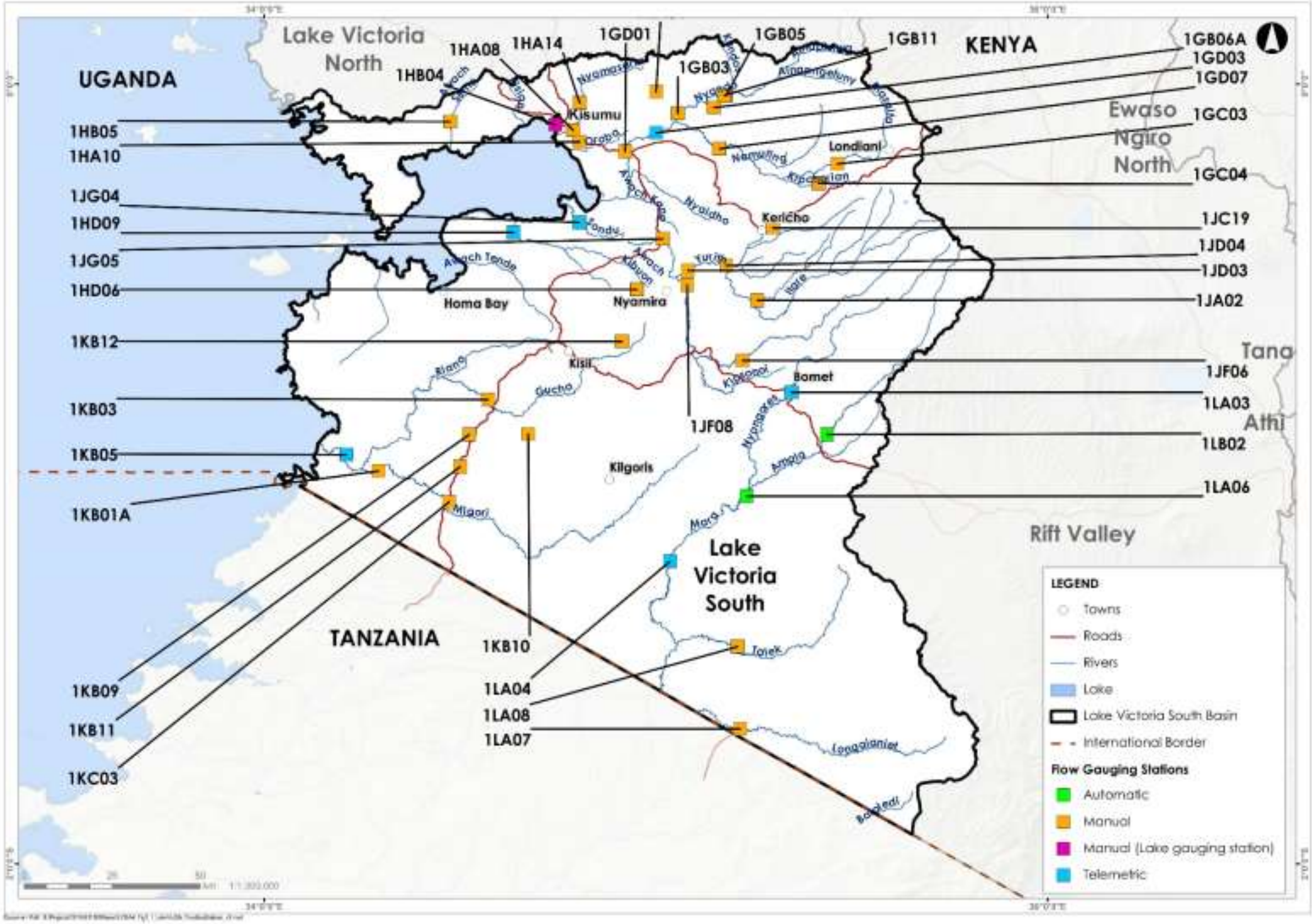


Figure 2-34: Locations of operational stream flow gauging stations in the LVS Basin

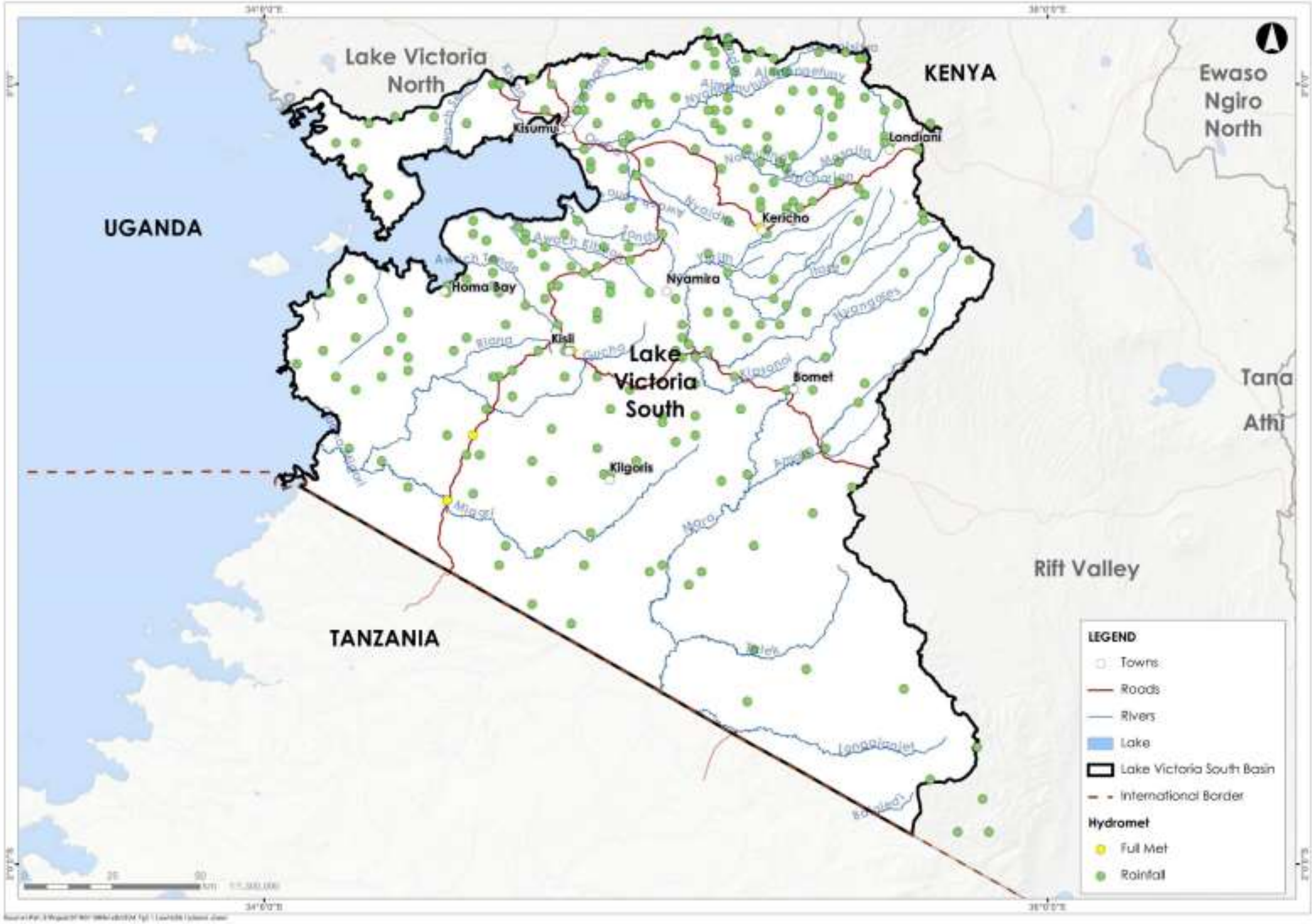


Figure 2-35: Locations of operational meteorological stations in the LVS Basin

Image source: Kisumuinsyder 2019 'Kisumu-City'. Available online at https://kisumuinsyder.co.ke/wp-content/uploads/2019/02/Kisumu-City-1068x600.jpg

03

Institutional Overview

3 Institutional Overview

3.1 Legislative, Policy and Institutional Framework

The Constitution of Kenya (2010) provides the basis for water resources management in the country and recognises this through the right to a clean and healthy environment, through the management and sustainable development of natural resources (which includes both surface and ground water), as well as through the economic and social right "*to clean and safe water of adequate quantities*". Importantly, the State has the obligation to ensure that water is conserved, that development is managed to be sustainable and to ensure that the benefits accrued are shared equitably. Whilst, it is noted that the utilisation of natural resources should be for the benefit of the people of Kenya, there is important emphasis placed upon the needs of marginalised communities. Also of importance is the recognition of the link between water and land. As such, this recognition provides the basis for improved integration in the planning, management and sustainable development of natural resources. In this regard, institutional arrangements from national to county level are imperative for leading efforts in socio-economic development at national scale and for implementing national government policies on natural resource and environmental conservation at a local scale.

To ensure that the implementation of the sub-plans, strategies, and actions emanating from this Basin Plan is guided by relevant legislative, policy and institutional principles, **Annexure C** provides an overview of the legal, institutional and policy framework relating to environmental and integrated water resources management. This framework needs to be understood if the LVS Basin Plan is to attain the goals of social acceptability, economic viability and technical sustainability in line with internationally accepted standards for good practice.

3.1.1 National policies

3.1.1.1 Water

Worldwide, there is increased recognition of the importance of water in terms of socio-economic development. This is increasingly emerging through the nexus discussions which acknowledge the interfaces between water, food and energy, and, more recently the findings of the World Economic Forum through their Global Risks Reports which repeatedly reflect water and climate related risks as being the most significant to economic growth.

At national level in Kenya, this sentiment has been mirrored in the development of various forms of national development plans. The Kenya Vision 2030, published in 2007, provides the national development blueprint. It is structured around economic, social and political dimensions and notes the important role of water in catalysing growth. National targets outlined in the Vision 2030 that have implications for the water sector include:

- Water and sanitation - to ensure that improved water and sanitation are available and accessible to all by 2030
- Agriculture - to increase the area under irrigation to 1.2 million ha by 2030 for increase of agricultural production
- Environment - to be a nation that has a clean, secure and sustainable environment by 2030
- Energy - to generate more energy and increase efficiency in the energy sector

In addition to these strategic targets outlined above, many flagship projects were identified for unlocking development related to water resources. These projects include rehabilitation and protection of Kenya's five major water towers (the Aberdares, Cherengany, Mau, Mt. Kenya and Mt. Elgon), and waste management and pollution control.

The Kenya National Water Resources Management Strategy provides the overarching policy framework for water resource management and development in Kenya, despite several successive adjustments in the core water legislation. This consistency in policy intent has been critical in guiding the water sector, with legislative amendments being progressively utilised to improve and strengthen the way that policy is affected. At the time of its introduction, the 'Sessional paper no. 1 of 1999 on national policy on water resources management policy and development' introduced key shifts in policy such as the separation of functions (including water resource management, water service delivery, policy, regulation, financing), the devolution of decision making to regional and local levels, the commercialisation of water (i.e. water to be treated as an economic and social good) and stakeholder participation through community and private sector participation.

The 'Sessional paper no. 1 of 1999 on national policy on water resources management policy and development' provides specific policy objectives covering the core focus of water resources management, water supply and sewerage development, institutional arrangement and financing of the water sector, which include:

- Preserve, conserve and protect all available water resources and allocate it in a sustainable, rational and economical way
- Supply of water of good quality and in enough quantities to meet the various water needs including poverty alleviation, while ensuring safe disposal of wastewater and environmental protection
- Establish an efficient and effective institutional framework to achieve systematic development and management of the water sector
- Develop a sound and sustainable financing system for effective water resources management, water supply and sanitation development

3.1.1.2 Environment and natural resources

In conjunction with the 'Sessional paper no. 1 of 1999 on national policy on water resources management policy and development' (Government of Kenya, 1999a), the National Environment Policy (NEP) (Government of Kenya, 2013a) provides an important framework in terms of improved river basin management in that the NEP has the goal of ensuring a "b*etter quality of life for present and future generations through sustainable management and use of the environment and natural resources*". As such, this framework policy has relevance to several differing sectors that are engaged in the management of natural resources, including water resources. The objectives of this policy that have relevance to the management of the LVS Basin include, amongst others:

- Provide a framework for an integrated approach to planning and sustainable management of Kenya's environment and natural resources
- Strengthen the legal and institutional framework for good governance, effective coordination and management of the environment and natural resources
- Ensure sustainable management of the environment and natural resources, such as unique terrestrial and aquatic ecosystems, for national economic growth and improved livelihoods
- Promote and support research and capacity development as well as use of innovative environmental management tools such as incentives, disincentives, total economic valuation, indicators of sustainable development
- Promote and enhance cooperation, collaboration, synergy, partnerships and participation in the protection, conservation, sustainable management of the environment and natural resources
- Ensure inclusion of cross-cutting and emerging issues such as poverty reduction, gender, disability, HIV&AIDS and other diseases in the management of the environment and natural resources.

Incorporated in the NEP are several important principles to take into consideration in undertaking planning in the LVS Basin and these are presented in Table 3-1.

Table 3-1: Guiding National Environmental Policy principles for basin planning

Environmental Right	Every person in Kenya has a right to a clean and healthy environment and a duty to safeguard and enhance the environment
Right to Development	The right to development will be exercised taking into consideration sustainability, resource efficiency and economic, social and environmental needs
Ecosystem Approach	An integrated ecosystem approach to conserving environmental resources will be adopted and enhanced to ensure that all ecosystems are managed in an integrated manner while also providing a range of benefits to the citizenry
Sustainable Resource Use	Environmental resources will be utilised in a manner that does not compromise the quality and value of the resource or decrease the carrying capacity of supporting ecosystems
Equity	The management of the environment and natural resources will ensure equitable access to resources for present and future generations
Public Participation	A coordinated and participatory approach to environmental protection and management will be enhanced to ensure that the relevant government agencies, County Governments, private sector, civil society and communities are involved in planning, implementation and decision-making processes
Subsidiarity	The management of the environment and natural resources will be through decentralisation and devolution of authority and responsibilities to the lowest level possible
Precautionary Principle	Where there are credible threats of serious or irreversible damage to key environmental resources, lack of full scientific certainty will not be used as a reason for postponing cost-effective measures to prevent environmental degradation
Polluter Pays Principle	The polluter and users of environmental and natural resources shall bear the full environmental and social costs of their activities
Good Governance	Rule of law, effective institutions, transparency and accountability, respect for human rights and the meaningful participation of citizens will be integrated in environmental management
Benefit sharing	Where benefits will accrue from utilisation of biodiversity, these will be shared in order to promote conservation and sustainable use of biodiversity; and
Community Empowerment	Communities will be involved in decision making and empowered in the implementation of such decisions

There is significant alignment in the objectives and principles laid down in NEP with the current approaches utilised within the Kenyan water sector, and this is aligned with best practice.

A key issue to distil from the ‘Sessional paper no. 1 of 1999 on national policy on water resources management policy and development’ and NEP concerns the recognition of the value and benefits that are accrued from ecological infrastructure. This refers to the naturally functioning ecosystems that deliver valuable services to people, such as water and climate regulation, soil formation and disaster risk reduction (South African National Biodiversity Institute, 2013). Our ability to ensure that ecological infrastructure is managed and maintained will be an essential dimension of our resilience against climate variability and climate change.

3.1.1.3 Agriculture

The Kenya Vision 2030 identified agriculture as one of the key sectors to deliver the desired economic growth rate of 10% per annum and resulted in the development of various policies and strategies for the agricultural and irrigation sectors to guide the development, transformation and strengthening of these sectors. The transformation of smallholder agriculture from that of subsistence to an innovative, commercially oriented and modern agricultural sector has been identified as a fundamental component for achieving agricultural growth. It is realised that this transformation will be achieved through transforming key institutions in agriculture, livestock, forestry and wildlife to promote agricultural growth; increasing productivity of crops, livestock and tree cover; introducing land-use policies for better use of high- and medium-potential lands; developing more irrigable areas in ASALs for both crops and livestock; improving market access for smallholders through better supply chain management; and adding value to farm, livestock and forestry products before they reach local, regional and international markets.

Increasing the productivity of agricultural water use in Kenya is a national priority given the country's low water endowment, growing population, and changing climate. Increasing productivity will also help contribute to achieving one of the primary targets of the Big Four Agenda; food security. Expanding the use of modern irrigation technology, such as drip and sprinkler systems, will be fundamental to achieving water productivity because of the potential for such systems to increase yields relative to water withdrawals. One of the key outputs of the NWMP 2030 was the identification of potential areas for future irrigation expansion. All the proposed schemes will be supplied from surface water - either by means of irrigation dams, multi-purpose dams or weirs. An Irrigation and Drainage Master Plan for Kenya was prepared in 2009 (Government of Kenya, 2009), which identified the following interventions to increase agricultural production: finalising and implementing the national irrigation policy and legal framework; intensifying and expanding irrigation; improving rainwater harvesting and storage for agriculture; rehabilitation and protecting water catchments; and implementing the irrigation flagship projects.

3.1.1.4 Energy

The enactment of the 2010 Constitution generated transformative processes in the energy sector. National government is tasked with the formulation of energy policy under the auspices of the Ministry of Energy and Petroleum. The draft National Petroleum and Energy Policy (Government of Kenya, 2015), indicates that government will transform the Rural Electrification Agency (REA) into the National Electrification and Renewable Energy Authority (NERA) to be the lead agency for development of energy resources that includes both geothermal energy and hydropower. Hydropower provides a significant portion of the energy mix, with the intention to further improve current systems whist developing new opportunities.

3.1.2 Legislation

The water and environmental legislation in Kenya has developed over time and this has enabled successive adjustments to improve the manner in which water (and other natural resources) are managed and sustainably developed.

The GoK *2002 Water Act (Act No. 8 of 2002)* came into effect in March 2003. It provided the legal framework to support the 'Sessional paper no. 1 of 1999 on national policy on water resources management policy and development'. Importantly, the Act provided for the establishment of new institutions with clearly determined functions, with decentralised decision-making reflected in several autonomous regional water management institutions and Water Resource User Associations (WRUAs). This provided a key step forward to enable more effective implementation of national policy.

The promulgation of the GoK *2016 Water Act (Act No. 12 of 2016)* was required to align with the 2010 Constitution as well as enabling amendments that were required to support the improved management of water resources. The GoK 2016 Water Act revises the institutional mandates of key water sector institutions and sets out the role of counties in the water sector. It also defines a clear role for the WRA in the regulation of water resources, which provides a potential strengthening in the way that water resource development is regulated. However, there are some ambiguities in the GoK 2016 Water Act that require resolution to clarify institutional matters. The ambiguity is regarding the dual and conflicting mandate of the BWRCs as an advisor to WRA on one hand and with executive powers for basin level water resources management on the other hand. In reality, operationalisation of the BWRCs is impossible if this ambiguity is not removed as it affects establishment of the committees and should be addressed urgently. The MoWSI is leading a water sector transition process which will address such challenges and assist institutions to give effect to policy and law.

The *Environmental Management and Co-ordination Act (EMCA) (Act No. 8 of 1999)* was promulgated in 1999 and provided Kenya's first framework for environmental legislation. The EMCA recognises the importance of improving the legal alignment and administration across the various sectors that are engaged in the management and development of environmental resources. As it stands there is a range of legislative instruments, across these various sectors, that face challenges in alignment towards the aim of sustainable development as outlined in Vision 2030. The EMCA has undergone a number of revisions over time to strengthen various elements of the law and in a sense, these have also been largely focused upon improving the regulatory environment.

There are a range of legislative instruments that underpin the development of agriculture in Kenya. Amongst these is the *Agriculture, Fisheries and Food Authority Act (Act No. 13 of 2013)* which provides for the regulation and promotion of agriculture. This is supported through the establishment of the Agriculture, Fisheries and Food Authority that is charged with, in consultation with County Governments, administering the *Crops Act (Act No. 16 of 2013)* and the *Fisheries Act (Chapter 378 of 1989)*. The drive to increase agricultural development will require ongoing development in irrigation capacity. As such, a draft Irrigation Bill was developed in 2015 intended to repeal the *Irrigation Act (Chapter 347 of 2013).* This amendment bill has been enacted to the *Irrigation Act (Act No 14 of 2019)* for the strengthening of irrigation regulations.

In terms of energy, the current legal framework is still informed by *Sessional Paper No. 4 on Energy of 2004 (Ministry of Energy, 2004)* and the *Energy Act (Act No. 6 of 2006)*. Sessional Paper 4 identified the need to integrate energy and petroleum planning with national economic, social and environmental policies, as energy and petroleum are critical inputs in the social economic progress of the economy. The 2006 Energy Act assigns the responsibility for development of indicative national energy plans to the Energy Regulatory Commission. In 2009, the Energy Regulatory Commission established a committee with responsibility for preparation of the Least Cost Power Development Plan in the electricity sub sector. The development of plans for the petroleum, coal and renewable energy subsectors, as well as for integrated energy and petroleum are yet to be developed and are a critical part of supporting the socio-economic development of Kenya.

3.1.3 National institutions

The GoK 2010 Constitution provides for two tiers of Government with national government being broadly responsible for policy development and regulation to ensure that policies are effectively implemented. Some of the key functions, articulated in detail within the fourth schedule of the Constitution, relate to socio-economic development and natural resources management and are critically important from a basin planning perspective. These include, for example: the use of international waters and water resources; national economic policy and planning; national statistics and data on population, the economy and society generally; education; national public works; general principles of land planning and the coordination of planning by the counties; protection of the environment and natural resources with a view to establishing a durable and sustainable system of development, including, in particular - fishing, hunting and gathering; protection of animals and wildlife; water protection, securing sufficient residual water, hydraulic engineering and the safety of dams; and energy policy; disaster management; agricultural policy; energy policy including electricity and gas reticulation and energy regulation; capacity building and technical assistance to the counties; public investment; and tourism policy and development.

In the aftermath of the 2017 national elections, the national government in Kenya has undergone some changes in configuration to support a more effective and efficient Government. Whilst there are several Ministries that can be seen as enablers (e.g. Education, Justice etc), the key sector ministries from a basin planning perspective include:

- Ministry of Water, Sanitation and Irrigation
- Ministry of Environment and Forestry
- Ministry of Agriculture, Livestock and Fisheries
- Ministry of Energy and Petroleum
- Ministry of Devolution and ASAL.

This list is by no means exhaustive but rather indicative. Whilst these Ministries have the broad ambit to develop policy, under legislation they have established various national level public entities that have the mandate to perform regulatory and developmental functions. These public entities that function at a national level are tabulated, in Table 3-2.

Table 3-2: National level public entities that have relevance to basin plans

Institution	Roles and responsibilities*
Water Resources Authority (WRA)	- Formulate and enforce standards, procedures and regulations for the management and use of water resources and flood mitigation. - Regulate the management and use of water resources. - Receive water permit applications for water abstraction, water use and recharge and determine, issue, vary water permits; and enforce the conditions of those permits. - Determine and set permit and water use fees as well as collect water permit fees and water use charges. - Provide information and advice to the Cabinet Secretary for formulation of policy on national water resources management, water storage and flood control strategies.
Water Services Regulatory Board (WASREB)	- Protect the interests and rights of consumers in the provision of water services. - Determine and prescribe national standards for the provision of water services and asset development for water service providers. - Evaluate and recommend water and sewerage tariffs to the county water service providers and approve the imposition of such tariffs in line with consumer protection standards. - Set licence conditions and accredit water service providers. - Monitor and regulate licensees and enforce licence conditions.
National Environmental Management Authority (NEMA)	- Co-ordinate environmental management activities being undertaken by lead agencies and promote the integration of environmental considerations into development policies, plans, programmes and projects to ensure the proper management and rational utilisation of environmental resources. - Take stock of natural resources in Kenya and their utilisation and conservation. - Establish and review in consultation with the relevant lead agencies, land use guidelines. - Monitor and assess activities, including activities being carried out by relevant lead agencies, to ensure that the environment is not degraded by such activities and environmental management objectives are adhered to.
Energy Regulatory Commission (ERC)	- Issue, renew, modify, suspend or revoke licences and permits for all undertakings and activities in the energy sector. - Develop regulations which may be necessary or expedient for the regulation of the energy. - Formulate, enforce and review environmental, health, safety and quality standards for the energy sector, in coordination with other statutory authorities.

Institution	Roles and responsibilities*
Water Sector Trust Fund (WSTF)	- Finance the provision of water and sanitation services to disadvantaged groups and includes: ▪ Community level initiatives for the sustainable management of water resources. ▪ Development of water services in rural areas considered not to be commercially viable for provision of water services by licensees. ▪ Development of water services in the under-served poor urban areas. - Research activities regarding water resources management and water services, sewerage and sanitation.
Water Tribunal (WT)	- Arbitrate water related disputes and conflicts.
National Water Harvesting and Storage Authority (NWHSA)	- Development of national public water works for water resources storage and flood control. - Maintain and manage national public water works infrastructure for water resources storage. Develop a water harvesting policy and enforce water harvesting strategies.
Water Works Development Agencies (WWDAs)	- Undertake the development, maintenance and management of the national public water works within its area of jurisdiction. - Operate water works and provide water services as a water service provider, as a transitional arrangement or as instructed by the WASREB. - Provide technical services and capacity building to County Governments and water service providers within its area as may be requested.
Kenya Water Towers Agency (KWTA)	- Coordinate and oversee the protection, rehabilitation, conservation, and sustainable management of Kenya's water towers. - Co-ordinate and oversee the recovery and restoration of forest lands, wetlands and biodiversity hot spots. - Promote the implementation of sustainable livelihood programmes in the water towers in accordance with natural resource conservation.
Kenya Water Institute (KEWI)	- Provide training, research and consultancy services in the wider water sector. - Provide a forum for effective collaboration between the public and private sectors and other interested parties for the development of the water and sanitation sectors.
National Irrigation Authority (NIA)	- Conduct research and investigation into the establishment of national irrigation schemes. - Formulate and be responsible in conjunction with the WRA for the execution of policy in relation to national irrigation schemes. - Raise funds for the development of national irrigation schemes. - Design, construct, supervise and administer national irrigation schemes.

* The roles and responsibilities provided are not comprehensive but provides some of the key functions.

To achieve effective integrated planning and management, there is a need for integrated approaches between different departments and agencies at the national level. However, there are significant challenges in terms of ensuring the alignment in policy and legislation, which requires capacity in the respective institutions, to be able to work in an integrated manner and have the necessary systems to support this integration.

3.1.4 Basin and sub-basin institutions

Noting the requirements of Integrated Water Resources Management, institutions have been established at basin and sub-basin levels to improve the day-to-day management of water resources as well as to improve the regulation and oversight required to ensure that water is efficiently used in accordance with water use permits.

Under the auspices of the 2016 Water Act, this is achieved through the Regional and Sub-Regional Offices of the Water Resources Authority (WRA) and the Water Resource Users Associations (WRUAs).

The LVS Basin is managed by three WRA Sub-Regional Offices (SROs) with the WRA Regional Office (RO) located in Kisumu. The Basin has been delineated into nine Catchment Management Units (CMUs) based on hydrological and water resource considerations. Table 3-3 lists the sub-regions, the locations of the SROs and the CMUs managed by each SRO, while Figure 3-1 displays the locations of the WRA offices and the geographical extent of each sub-region.

Table 3-3: WRA sub-regions, offices and CMUs in the LVS Basin

Sub-Region	WRA SRO	CMUs
Northern Shorelines / Nyando	Kisumu	Northern Shorelines, Upper and Lower Nyando
Southern Shorelines / Gucha-Migori	Kisii	Southern Shorelines, Gucha and Migori
Mara / Sondu	Kericho	Sondu, Upper and Lower Mara

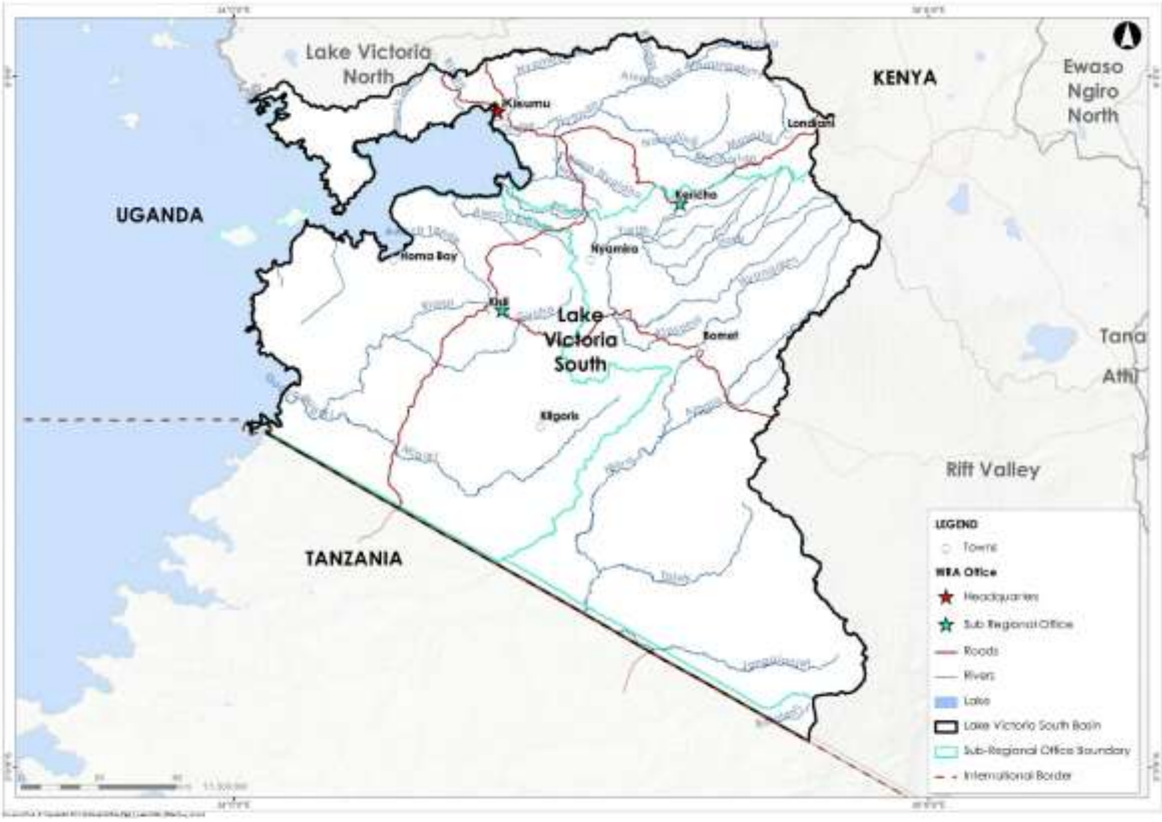


Figure 3-1: WRA Offices and sub-regions in the LVS Basin

Water users apply for water permits through the relevant WRA SRO, and the application is then sent to the RO for processing. Class A to C permits are handled at RO level, while Class D permits are handled at Head Office. A hydrological or hydrogeological assessment report conducted by a qualified professional must be submitted by the water user with the application. The water permits are recorded in the Water Permit Database at the RO.

The 2016 Water Act in effect strives to strengthen the management of water resources at the basin and sub-basin level, whilst strengthening the regulatory role of WRA both at national and basin scales. This not only removes the dichotomy that WRA faced as being manager and regulator, but also attempts to create a stronger management regime within the basins and sub-basins, noting that counties have a key role to play in water service delivery as well as ensuring that water is used efficiently within their jurisdictions. To this end, the 2016 Water Act introduced Basin Water Resource Committees (BWRCs) as a replacement for the previous Catchment Area Advisory Committees (CAACs), with a more managerial intent than the purely advisory role that was played by the CAACs. At this juncture, during what is effectively a period of transition, the BWRCs function will be as per Water Act 2016, however, it will be critically important to learn from the challenges that were experienced with the CAACs so that the BWRCs become more effective in supporting water resource management. The regulatory function of the WRA will continue to be strengthened and, in the transition period, ring-fencing of staff within the Regional and Sub-Regional Offices will be essential to separate staff and functions that are managerial in nature, and as such, supportive of the BWRCs. The BWRCs fall under the WRA, and their responsibilities (which must be delegated by WRA) include the formulation of Basin Water Resources Strategies, management of basins, advice to WRA and the facilitation of WRUA establishment.

At a more localised level, the establishment of the Water Resource User Associations (WRUAs) has been essential in ensuring a focus on the operational management functions within a sub-basin. The WRUAs are community-based, voluntary associations made up of water users and riparian owners interested in proper management of their water resources and were established to enable the collaborative management of water resources and to provide essential support in the resolution of conflicts concerning the use of water resources. As provided for in the Water Act 2016 Section 29 (4), BWRCs may contract WRUAs as agents to perform certain duties in water resource management. To date, WRUAs have performed important local functions, but have faced an array of challenges that have served to hinder their effectiveness. Many of these are enabling factors such as capacity in terms of having sufficient skills and training, but also include such issues as insufficient financial resources. These challenges will require redress in order to support the implementation of this Basin Plan and realise the local level capacitation that can unlock the localised socio-economic development required to support Vision 2030. This is supported by the 2016 Water Act that provides in Section 29 (3) that "*basin area water resources management strategy shall facilitate the establishment and operation of water resources user associations*".

3.1.5 County governments

The 2010 Constitution introduced a decentralised system, with 47 county governments and one national government with specific functions accorded to the two levels. Guided by the overarching objectives and principles of the county governments as set out in the Constitution, specific functions of counties are provided in Schedule Four of the Constitution. County functions which are closely related to basin planning include:

- **Agriculture:** Crop and animal husbandry; plant and animal disease control; and fisheries
- **Health:** Refuse removal, refuse dumps and solid waste disposal
- **County planning and development:** statistics; land survey and mapping; boundaries and fencing; housing; and electricity and gas reticulation and energy regulation
- **Natural resources and conservation:** Implementation of specific national government policies on natural resources and environmental conservation: soil and water conservation; and forestry
- **County public works and services:** Storm water management systems in built-up areas; and water and sanitation services
- Firefighting services and disaster management
- **Community participation:** Ensuring and coordinating the participation of communities in governance at the local level and assisting communities to develop the administrative capacity for the effective exercise of the functions and powers and participation in governance at the local level

There are thirteen counties within the LVS Basin, seven of which are fully enclosed within the basin (refer to Figure 2-2). Some counties cross hydrological boundaries and as such have to engage with multiple BWRCs and WRA offices. The counties within the Basin include Siaya, Vihiga, Kisumu, Nandi, Uasin Gishu, Kericho, Nakuru, Bomet, Nyamira, Kisii, Homa Bay, Migori and Narok.

The county governments face considerable challenges as a relatively new level of government and these include capacity and financial resources. The latter is being assisted through the Division of

Revenue Act (No 1 of 2018) which will provide an "equitable share" of national revenue to the counties. In addition, the Equalisation Fund, which targets specific counties and areas, typically in the arid areas, where socio-economic indicators lag significantly behind the national average, will also support in reducing the financial shortfalls. Recognising that the county governments will be required to give effect to policy that is provided by national government across an array of sectors, they will face considerable institutional challenges in working horizontally across these various sectors endeavouring to ensure effective integration whilst trying to ensure that there is effective vertical interaction with the various Ministries and national public entities. The effective alignment in various planning instruments across spatial scales and differing sectors will be critical for county governments to ensure the service delivery mandate that they have been given.

3.1.6 Partnerships and engagement

3.1.6.1 Partnerships

Internationally there has been a growing recognition of the important role that the private sector and civil society must play in the management of water resources. The importance of collective action is being realised in that the available capacity and resources within Government are not sufficient to ensure that common-pool resources such as water are sustainably managed.

In addition, partnerships and civil society engagement becomes more important as water resources become increasingly utilised (through increasing abstractive water use and waste discharges) and exposed to the associated risks. Therefore, whilst there is a need for the private sector and civil society to engage in water resources management to manage their own risks, in so doing they provide critical support to the wider water sector.

The nature of these partnerships will vary depending on their relationship with the water sector and the various interfaces that these actors have. For example, the partnership between WRA and the Kenya Meteorological Department (KMD) at national level is seen as critical in that KMD provide meteorological and climatological services to the water sector. This is not only essential for the hydrological modelling that assists in understanding the status of water resources, but also provides important information in terms of flood and drought warnings. Another example is that with international Non-Governmental Organisations (NGOs) such as World Wildlife Fund (WWF) and International Union for Conservation of Nature (IUCN), amongst others. These provide useful capacity as well as enable (and often fund) studies and research that sometimes serve to unlock challenges.

As the implementation of the LVS Basin Plan progresses, partnerships will be further developed to realise the implementation of the basin plan. It will be important to map and bring together all the partners into one big picture that is centrally monitored for the good of the entire basin. The Lake Victoria Environmental Management Project (LVEMP) is one such partnership in the basin that is a multi-stakeholder initiative that brings together the Government of Kenya, development partners, the private sector and civil society.

3.1.6.2 Engagement

Legislation across the sectors emphasises the importance of stakeholder engagement. This provides a means of not only bringing in diverse views and opinions that enrich solution development, but also creates the sense of ownership for processes and products that can help to ensure better implementation.

There is always room for improvement regarding stakeholder engagement and there is a sense that in Kenya this is the case. The benefits that can be realised through catchment forum processes have not always been maximised and ongoing work is needed to find more appropriate forum structures and functional modalities that ensure that the maximum benefits from stakeholder engagement is ensured. To date the forums have met annually and have not truly enabled the discussion required. The basin planning process has not only in itself been a vehicle to improve engagement, but also provides a cogent and pragmatic stakeholder engagement framework.

It emerged from consultations with the various levels of government at national, county and local levels that one of the major challenges on effective engagement is overlap of mandates of the various national and county government agencies working in water resources management. The BWRCs will provide a better engagement plan with county governments and will allow for better representation of basin area stakeholders in matters relating to IWRM. This Consultancy has developed tools to better equip the BWRCs to ensure they deliver on their mandate and to provide a systematic way of enhancing their effectiveness. This process however must involve adequate stakeholder consultations including county governments and various actors in the basin who need to be included in the planning for such engagement to work (refer to Annexure C).

3.2 Existing Development Plans and Sectoral Perspectives

3.2.1 Introduction

To ensure that this Basin Plan is representative and aligned with current plans and strategies related to water resources planning and management in the LVS Basin, relevant current plans and strategies were reviewed and are briefly described below. In addition, high level sectoral perspectives in relation to water resources planning and management in the LVS Basin are also presented in this Section.

3.2.2 National Water Master Plan 2030

The NWMP 2030 was completed in 2013 and covers all six river basins in Kenya. For each basin, the NWMP 2030 provides information related to water resources, water demands, high level water allocations, economic evaluations of proposed interventions and implementation programmes. In addition, the NWMP 2030 presents development plans related to water supply, sanitation, irrigation, hydropower and water resources.

NWMP 2030 information on surface water and groundwater resources availability and use in the LVS Basin have been compared with the water resources assessment results undertaken in this Consultancy (refer to Section 2.4). Furthermore, the NWMP 2030 was used extensively to inform the development of the LVS Basin Plan.

3.2.3 Catchment management strategy

The LVS Catchment Management Strategy (CMS) (Water Resources Management Authority, 2015b) was completed in 2015 for the period 2015-2022 and provided a vision and framework for the management of water resources and related land resources in the basin. It outlines how the concept of integrated water resources management (IWRM) should be implemented at catchment level. The strategy provides an opportunity for water resources management institutions and stakeholders to formulate a coherent approach and focus for managing the water resources in a catchment. As such, the CMS is both a process and a framework for management, binding the Authority, the water users, other stakeholders and their representative structures in a social and/or legal union. The CMS timeframe was developed to harmonise with the NWMP 2030.

Table 3-4: Objectives of the LVS CMS

Strategy	Theme	Objective
Water resource protection	Water resource protection	- To ensure all effluent dischargers comply with permitting requirements - To maintain the RQOs - To improve water quality assessments - To collaborate with County Governments and other stakeholders on water quality management
	Catchment protection and conservation	- Restore degraded catchment areas - Protect water catchment - Enhance collaboration with county governments and other stakeholders - To enhance capacity in catchment protection and conservation
Resource augmentation adaptation and development	Flood and drought management	- To develop and implement a framework for collaboration with County Governments (CGs) and other Stakeholders on IFDM - To enhance capacity on IFDM including monitoring skills, use of Information Systems and Flood Control centres
	Climate change adaptation	- To strengthen monitoring systems for enhanced data collection - To enhance capacity and create awareness on climate change effects - To develop climate change scenarios to support decision making
	Water resources infrastructure development	- To regulate water resources infrastructure development. - To regulate the operations of the infrastructure - To identify potential sites for water resources infrastructure development
	Rights based approach	- Maintain reserve for all water bodies - Enhance access to water resources to vulnerable groups
	Livelihoods enhancement	- To build capacity of WRMA and other stakeholders to promote livelihood activities - Implement livelihood management projects
Implementation, information management and financing	Institutional strengthening	- To enhance the capacity of WRMA and CAAC to effectively undertake IWRM - To enhance collaboration with stakeholders on IWRM issues in the region - To build capacity for County Governments to effectively participate in water resources management - To enhance capacity of WRUAs to undertake WRM activities - To enhance collaboration with stakeholders on WRM
Monitoring and management		- To optimize water resources monitoring network - To upgrade water resource data and information management system - To establish an effective monitoring and evaluation system

3.2.4 Sub-catchment management plans

WRA has delineated Kenya into 1 237 sub-catchment areas with the intention of forming Water Resources User Associations (WRUAs) for each. At present, only 106 WRUAs out of a potential 137 WRUAs have been formed in the LVS Basin. The sub catchment management plan (SCMP) is a planning tool that is developed by the Water User Associations (WRUA) under regulation by the Water Resources Authority (WRA). Its main objective is to guide the implementation of water resources management and regulation activities within a defined period of time in any given sub catchment. The activities, in most cases, relate to catchment protection, pollution control and water infrastructure development. Being the lowest planning tool developed to implement the National Water Master Plan and the basin area plan, it is directly held in the custody of the WRUAs who are in charge of its implementation. The plan is a resource mobilization tool that the WRUA uses to source for implementation funds and other resources.

The constitution 2010, Fourth Schedule Part 2, section 10, outlines water resource management as a function of the county government. This devolvement of the conservation role to the counties creates a direct linkage between the SCMP and the County Integrated Development Plan (CIDP). The county sets aside funds for the management of catchments that are absorbed through the implementation of SCMP or directly through CIDP identified activities. The regulation of the process to ensure the catchments are well protected and the harmony of the two planning perspectives rests with the Authority.

The Basin Plan is used as a reference document in the preparation of the SCMPs. To date, only 46 SCMPs have been developed in the SCMPs Basin.

3.2.5 County integrated development plans

County Integrated Development Plans (CIDPs) are prepared every five years by counties as a road map for development. The plan touches on all sectors devolved to county governments, providing a plan towards improvement. Catchment protection and water and sanitation services are devolved functions and as such feature in all CIDPs. A review of the CIDPs showed that planned activities related to water resources mainly revolve around rehabilitation of old pipe networks, extension of distribution network, development of new water sources including boreholes and small dams/pans, extension of sewer networks and expansion of sewer treatment plants.

The following paragraphs briefly describe key aspects of each CIDP for the main counties located in the LVS Basin. (Refer to Figure 2-2 for a map of the counties).

Table 3-5: Key aspects of the CIDP

County	Water and Sanitation	Natural Resources	Agriculture
Kisumu	Programmes include urban and rural water supply and sanitation improvements, water conservation, protection and governance. Flagship programmes include the construction of Koru-Soin Dam.	Programmes include solid waste management, afforestation initiatives, conservation and rehabilitation of degraded landscapes, noise and air pollution control, strengthening environmental governance, climate change mitigation and adaptation, promoting renewable energy.	Programmes include irrigation schemes infrastructure development, livestock development and management, fisheries development and management. Flagship programmes include rice production development, expansion of the Mboha, Nyamthose and Kano irrigation schemes.
Kericho	Programmes include water and sanitation infrastructure development (i.e. construction of water supply line and sewerage facilities, rainwater harvesting). Flagship projects include drilling boreholes, the Kusumek Water and Sewerage Project and the Kabianga Water and Sewerage Project.	Programmes include solid waste management, environmental management and protection (i.e. safe removal and disposal of asbestos, waste water management, sustainable forest management.	Programmes include livestock development and management, crop development and management, fisheries development and management.
Vihiga	Programmes include the completion of the hydrogeneration plant at Kaimosi Dam, drilling boreholes, water and sanitation infrastructure development, promotion of rainwater harvesting, procurement of water boozers, waste water management.	Programmes include protection and restoration of indigenous trees, soil management, climate change adaptation and mitigation and the reclamation of degraded land.	Programmes include crop and land development, apiculture (bee keeping) initiatives, veterinary services, livestock production and management, agricultural extension services, promotion of fish farming, promotion of smallholder irrigation and greenhouse farming, crop diseases and pest control.

County	Water and Sanitation	Natural Resources	Agriculture
Siaya	The water supply in the county is inadequate, supplying only 42% of the population. The CIDP intended to expand the water supply system, introduce campaigns to educate people about safe water and sanitation practices, and to intensify environmental conservation. Climate change mitigation and adaption measures would be adopted, guided by the National Climate Response Strategy. Sanitation is also a problem in the county, with only 6% of households having access to piped water, and only 75% having latrines. No sewage systems existed in the urban centres at the start of the CIDP planning period. A major project to construct a water and sewer system in Bondo Town was planned for the CIDP. Waste management in urban centres needs to be improved with the introduction of a proper solid waste disposal system.	Considerable environmental degradation has taken place in the county, particularly in Lake Victoria. Water levels have reduced, and soil erosion is taking place, resulting in the silting up of wetlands, dams and water pans. Additionally, river banks, arable farmland and forests have been destroyed. This has resulted in the decline in agricultural and fisheries production in the county. The CIDP aims to promote environmental conservation and embrace measures to green the economy.	Programmes to improve and grow agriculture include expanding the extension services, increasing the land under irrigation, increasing the quality and quantity of farm produce, improving storage of farm produce, enhancing livestock disease control, improving access to markets, making fish stocks more sustainable, improving storage of harvested fish, making credit more available to farmers. Flagship projects applying to the whole county include subsidising farm inputs and implementing the multi strategic food reserve. Flagship projects located in Siaya are: a mechanisation project, and the modernisation of the Siaya Agricultural Training College.
Kisii	Programmes include water and sanitation services (i.e. developing water schemes, rain water harvesting, sanitation services), Flagship projects include expanding water supply in Bobaracho Ward, Kisii.	Programmes include spring protection, energy services (i.e. biogas promotion, energy savings Jikos), environmental management (i.e. rehabilitation services, recreational services, river cleaning services, afforestation services, land reclamation, solid waste management, climate change mitigation, natural resources management).	Programmes include crop and livestock development, (i.e. extension and training services, pest and disease control, crop marketing services, dairy production, value addition/agro-processing), fisheries development, veterinary services and agricultural training services.
Nyamira	Programmes include improving water supply and storage services and developing sanitation services and management. (i.e. borehole development, rehabilitation and development of dams, waste water treatment).	Programmes include land use management and soil fertility, spring protection, environmental protection (i.e. solid waste management and afforestation).	Programmes include crop development, agribusiness development and value addition, livestock development and management, fisheries development and management. Flagship programmes include establishing the Nyamira Fish Multiplication Training Centre and the Agricultural Resource Centre in Kitaru, Borabu Sub-county.

County	Water and Sanitation	Natural Resources	Agriculture
Homa Bay	Programmes include water supply and sanitation services, irrigation, drainage and land reclamation services. Flagship projects include the Miriu-Wang'chieng' Gravity Water Scheme and Kaswanga Water Project.	Programmes include environmental protection and natural resources management services (i.e. waste management services, afforestation, climate change adaption services).	Programmes include crop development services, livestock development, fisheries development, agribusiness development services, food security enhancement (i.e. climate smart agriculture) and veterinary services.
Migori	Programmes include expansion of water supply services, maintenance and operation of water supplies. Flagship projects include the Migori County Urban and Rural Water Supply Project.	Programmes include solid waste management, disaster management (i.e. drought and flood management, fire response services), afforestation, climate change adaption and mitigation and energy services (i.e. the expansion of Gogo Dam for hydropower). Flagship projects include the County Afforestation Programme.	Programmes include crop development and management (i.e. improving agricultural productivity and value addition), livestock production services, veterinary services and fisheries development. Flagship projects include the County Agriculture Integrated Input Access Project.
Nandi	Programmes to achieve these goals are described as follows: All water projects that have become dysfunctional will be revived and rehabilitated, and existing dams will be rehabilitated. The County Government will collaborate with communities and NGOs to drill boreholes to be managed by community groups. The Kapsabet wastewater treatment plant will be rehabilitated and expanded, and a new treatment works will be constructed in Nandi Hills at Mokong river. Existing community-based water projects will be rehabilitated, revived and expanded. Flagship programmes include: the Keben water project, which will provide water to Nandi Hills and Kapsebet town and their environs. Nandi County Spatial Plan will apply to the whole county to provide a basis for investment and the provision of infrastructure EU Water Tower Programme applies to the whole county to restore degrades landscapes Nandi Hills water project will provide water to Nandi Hills town and its surrounds.	The county intends to create policies to protect the environment. Environmentally sensitive areas will be mapped, and development of these areas will be prohibited. Degraded wetlands and river banks will be restored. Communities will be sensitised and made aware of these areas. Public open spaces that have been 'land grabbed' will be repossessed and developed. Sustainable liquid and solid waste disposal systems will be promoted. All buildings will meet energy efficient criteria (solar heating systems and roof water harvesting), and other forms of green energy will be encouraged. Climate change considerations will be included in all county policies and plans.	Agriculture is a vital source of income for households and the county; and is a priority for economic empowerment in the county. The goal for the sector is to increase food and nutritional security, commercialisation of agriculture, and effective and efficient marketing systems in the sector. This will be achieved through crop and livestock development, increased access to irrigation, soil and water conservation, and increased agricultural extension and training. Flagship projects planned for implementation throughout the county include the installation of a milk processing plant, a maize milling plant, a coffee milling plant, soil fertility management, poultry hatcheries and artificial insemination services and milk coolers.

County	Water and Sanitation	Natural Resources	Agriculture
Bomet	Programmes include infrastructure development (i.e. water supply, irrigation and sanitation infrastructure development). Flagship projects include the Bosto Water Project, the Bomet-Mulot Water Project, the Kibusto Water Project, the Sotik Sewerage System Project and the Mulot Sewerage System. The planned Bosto Dam in Bomet County will be implemented by the NWHSA and will have a capacity of 30 MCM.	Programmes include environmental conservation and natural resources management (i.e. soil and water conservation, riparian protection, forestry management, solid waste management, environmental education and awareness). Flagship projects include the rehabilitation of Chepalungu Forest.	Programmes include improving administration and support services, crop development and management, livestock, fisheries and veterinary services, establishing agricultural training centres and the Bomet Tea Agency.
Narok	Programmes include urban water supply, drought mitigation and sewerage development and rural water supply improvement. Flagship projects include the construction of Mega dam at Nitiyaya.	Programmes include afforestation and climate change mitigation and adaptation.	Programmes include training and extension services, sustainable environmental management and inclusion, crop development and management, fisheries development and management and veterinary services development.
Nakuru	Programmes include increased provision of portable water and improved sanitation. Flagship projects include the inter-basin transfer from Itare Dam in the Lake Victoria South Basin to Nakuru in the Rift Valley Basin.	Programmes include pollution control, solid waste management, climate change management, regulation and protection of riparian land, environmental resource management and promotion of renewable energy sources.	Programmes include training and extension services, livestock resource management and development, crop development and fisheries development.

3.2.6 Regional development plans

District development plans were once a tool for implementing development at the district level in Kenya. Currently, under the new dispensation, local development is done under county governments. The regional body within the LVS Basin who is responsible for development activities within the basin is the Lake Basin Development Authority (LBDA).

The LBDA area of jurisdiction covers approximately 39,000 km^2, comprising the counties in the LVS Basin. The mandate of LBDA is to formulate and implement twenty-five sustainable integrated basin-based development programmes, enhance sustainability in all areas of operations, increase market share of LBDA’s products and services by 10%, and enhance institutional and human capacity for improved performance by 25%.

The Lake Basin Development Authority has gone out to tender for construction of Magwagwa Multipurpose Dam on the Sondu-Miriu River in Nyamira County to generate hydropower, to supply domestic and industrial demands in Nyamira, Homa Bay and Kisii counties, to supply water for large scale irrigation development on the Kano Plains and for flood control along the lower Sondu River.

3.2.7 Projects planned by Water Works Development Agencies

The Lake Victoria South Water World Development Agency (LVSWWDA) is operational in the LVS Basin. The WWDA has ongoing and proposed projects that vary from rehabilitation of water supply schemes to major dam and water resource projects.

The LVSWWDA is establishing water supply in Kisumu, Kericho, Kisii, Nyamira, Bomet, Siaya, Homa-Bay, Nandi and Migori counties and is moving ahead with the Implementation of the Bunyunyu Dam

Project on the upper Gucha River in Kisii County to supply water to Kisii Town and other surrounding towns in Kisii and Nyamira counties.

In order to improve the reliability of supply to Kisumu Town, and to ensure that the expected growth in water demand is met, Kibos Dam on the Kibos River in Nandi County, upstream of Kisumu, has been identified for imminent construction by Kisumu Water and Sanitation Company.

The Rift Valley Water Works Development Agency has started with implementation of Itare Dam on the Itare River, an upper tributary of the Sondu River, in Nakuru County. This dam will supply water to towns in Kericho, Bomet and Nakuru counties in the LVS Basin as well as to Nakuru Town and other smaller towns in the adjacent Rift Valley Basin via an inter-basin transfer (tunnel). Contractual disputes have halted implementation of this dam.

Note: *Following the enactment of the Water Act 2016, Water Services Boards (WSBs) have transformed into Water Works Development Agencies (WWDAs).*

3.2.8 Sectoral perspectives

3.2.8.1 Water supply and sanitation

There is currently one large dam in the LVS Basin, and the total storage volume in the Basin is made up of small dams and pans, with a combined storage volume of approximately 5.3 MCM (Water Resources Management Authority, 2013). Further water resources development is essential to satisfy the growing future water demands.

According to the NWMP 2030, about 48% of the population in the LVS Basin receives drinking water from unimproved sources (unregistered water vendors and water taken from lakes and streams without proper treatment), while about 41% of the population get drinking water from springs, wells and boreholes. The total population that receives piped water from WSPs is 12%. There are eight urban WSPs and one rural WSP, and together these WSPs provide a capacity of 89,438 m^3/day. Out of the eight urban WSPs, three have records of more than 50 % of non-revenue water (NRW).

The LVS Basin has a limited sewerage system coverage ratio of just 1%. About 82% of the population use on-site sanitation facilities such as septic tanks and about 17% do not have any treatment facilities, and resort to unsanitary waste disposal (Water Resources Management Authority, 2013).

Development in the water supply and sanitation sector in the Basin is hampered by insufficient institutional, human resources, financial and technological capacity. Some of the specific aspects relate to poor performance of many utilities, high levels of non-revenue water (NRW) in many utilities (above 50%), poor governance practices, non-viable utilities, inadequate enforcement of water resources regulations, a lack of clear mandates for actors in the storage sub-sector. Challenges under the water supply sector include water scarcity, assurance of supply, population growth, urbanisation, financial constraints, water quality, low reliability of supply, and various institutional challenges. To overcome these challenges, innovative solutions, such as public private partnerships, water demand management and payment recovery mechanisms should be considered.

3.2.8.2 Energy, hydropower and mining

The energy sector in Kenya relies on three main sources of energy, namely biomass, petroleum and electricity at 68%, 21% and 9% of total energy consumption (Institute of Economic Affairs, 2015). The remaining 1% consisting of solar and other forms of energy. Hydroelectric power in Kenya currently accounts for about 49% of installed capacity, which is about 761 MW. However, the Government of Kenya is strongly pushing for a shift to other alternative resources of electricity generation and by 2030 it is expected that hydro power will only account for 5% of total capacity at 1,039 MW.

The National Water Resource Management Strategy (Government of Kenya, 2006b) acknowledges the need to identify and prioritise energy-based needs as part of the planning and management aspects of water resources management. Due to the increasing power demand in Kenya, there is a need to expand the existing hydropower system, but also a need to diversify into other alternative but sustainable energy forms based on life cycle least cost criteria to minimise stress on the water resources. The lack of access to modern energy services for cooking and lighting is leading to the destruction of trees and resultant catchment degradation in many parts of Kenya. This in turn impacts base flows along rivers that provide the driving force for hydropower.

Only about 8% of the population in the LVS Basin has access to electricity. Paraffin is commonly used for lighting in households without access to electricity, and about 95% of the population use biomass (burning of fire wood and charcoal), as a source of energy for cooking. There are three existing hydropower schemes in the Basin. The Gogo Falls Hydropower Station is in the lower Gucha River, with an installed capacity of 2 MW. The Sondu and Sangoro Hydropower Stations are located on the lower Sondu River. The run-of-river Sondu Hydropower Scheme has an installed capacity of 60 MW, while the Sangoro Hydropower Scheme has an additional capacity of 21 MW using the tailwater of the Sondu Scheme.

The geology of an area is of critical relevance to the occurrence of different minerals. The LVS Basin is connected with the Rift Valley volcanic geology. There are gold deposits located in Homa Bay, Migori and Narok counties. Other mineral deposits in the Basin include iron ore in Homa Bay County and soap-stone in Kisii County.

3.2.8.3 Agriculture

The Kenya Vision 2030 identified agriculture as one of the key sectors to deliver the annual economic growth rate of 10% envisaged under the economic pillar. However, there are many issues and challenges related to agriculture in Kenya linked to crop production, climate, water security, markets, finance, trade, institutional setups, land management, soil management and environmental sustainability. To achieve agricultural sector growth, transforming smallholder agriculture from subsistence to an innovative, commercially oriented and modern agricultural sector is critical. This will be supported by appropriate institutional reform in the agricultural sector. Agriculture is the most important sector of the Kenyan economy and agricultural sector growth and development is therefore crucial to Kenya’s overall economic and social development.

Only 17% of Kenya’s land area is suitable for rain-fed agriculture, with 83% of Kenya being ASAL. While most of Kenya’s arable land is cultivated for crop production, a very small proportion is irrigated. However, as the cropping and livestock production systems follow the annual rainfall patterns which are highly variable and unreliable, it is well recognised that the country must embrace irrigation development to remain competitive in the global and regional arena. Kenya has not fully developed her irrigation potential. In 2010, about 142,000 ha was under irrigation, with a corresponding total irrigation water demand of 1.6 BCM/a. Most of this is used for private and smallholder irrigation and mostly in the Athi and Tana catchments. Most of the growth in irrigation in recent years is contributed by smallholder and private sector schemes, while no substantial development was achieved in public schemes over the last number of years. Although Kenya has ample land resources available, water resources for irrigation are limited in most basins. Based on high-level water balance calculations undertaken for the NWMP 2030, it was anticipated that water for future irrigation will have to be supplied mainly from surface water, supplemented from groundwater and water harvesting sources and it is evident that significant investments in large dams would be required for storage purposes. Increasing the productivity of agricultural water use in Kenya is a national priority, given the country’s low water endowment, growing population, and changing climate. Expanding the use of modern irrigation technology, such as drip and sprinkler systems, will be fundamental to achieving water productivity because of the potential for such systems to increase yields relative to water withdrawals.

The total livestock water requirement in Kenya in 2010 was estimated at 255 MCM/a in the NWMP 2030 and is mainly supplied from surface water. However, this is expected to almost double by 2030. Water harvesting measures such as small dams and/or pans have been identified as the most feasible for supplying this growth in demand, a large portion of which is expected to occur in the ASAL parts of Kenya. In high-rainfall areas there is potential to develop the dairy, poultry and pig industries, whilst in ASALs the availability of natural resources is linked to emerging industries although rangelands are chronically short of pasture and water (Government of Kenya, 2010b).

Aquaculture is an important contributor to Kenya's fisheries sector. Freshwater aquaculture development has grown remarkably, making Kenya one of the fastest-growing major producers in Sub-Saharan Africa (Saunders, Menezes, Aguilar-Manjarrez, *et al.*, 2017). Aquaculture production has risen since the late 1990s, with a focus on private, large-scale aquaculture development. However, the aquaculture sector suffers basic challenges such as a minimal knowledge and skills and inadequate supplies of quality feed and seed fish. Small-scale rural enterprises produce mainly Tilapia at a subsistence level.

Water demands for agriculture in the LVS Basin include irrigation, wildlife, livestock and fisheries. These demands are projected to increase due to population and economic activities.

Various Directorates under the Agriculture, Fisheries and Food Authority (AFFA) provide technical input and advice to county governments. The Authority also conducts farmers' training programs aimed at increasing their knowledge on production technologies and prospects for various types of crops, through farmer training institutions. Conservation agriculture has been promoted as a sustainable alternative for farmers to address the problem of declining soil fertility and provide the dual benefit of enhanced food production and adaptation/resilience to changing climatic conditions (Agriculture and Food Authority, 2017). Aquaculture has been promoted as a food security intervention at the household level. Counties are being encouraged to increase aquaculture in both marine and inland systems. Improved livestock productivity has been promoted through improving animal breeds, improving feeds regulation, developing pastures and forage and enhancing extension services. Cooperatives have not performed adequately since State withdrawal from their day-to-day operations (Agriculture and Food Authority, 2017), therefore counties are encouraged to revitalise cooperatives and strengthen their capacities to make them competitive. Aquaculture in the LVS Basin occurs in Lake Victoria next to Homa Bay.

3.2.8.4 Forestry, Land use and Catchment management

In 2010, the total forest area in the LVS Basin was about 159,000 ha. Forest reserves in the basin largely cover the areas surrounding the major water towers of the Basin. These reserves include Northern Tinderet, Tinderet, Londiani, Western Mau, South West Mau, Eastern Mau, Transmara, Chepalungu (A & B), Gwasi, Rangwe, Gembe Hills and Lambwe. These reserves are located mainly in Nandi, Kericho, Nakuru, Bomet, Narok and Homa Bay counties. The valuation of the forests in the basin and its contribution to the national economy is largely undocumented.

In recognition of the importance of forests for sustainable development, the 2010 Constitution in Article 69 provides for the state to work towards increasing the country's forest cover to 10% of the land area of Kenya (Government of Kenya, 2010a). A total area of 410,000 ha of forestation is proposed in the NWMP 2030 for LVS Basin up to 2030.

The National Environmental Management Authority (NEMA) has Environmental Committees who provide technical support for environmental management and provide input to county integrated development plans. The Kenya Water Towers Agency (KWTA) looks after Kenya's water towers. The Forest Management and Conservation division under the Kenya Forest Service (KFS) is charged with the management and conservation of the natural forests in Kenya, of which most form water towers. Strategic outputs involve increasing percentage cover through tree planting and gazetting new forests; as well as improving livelihoods. The KFS Forest Farm and Dryland Forestry program provides technical support to the Counties, advisory services for forest management, promoting biomass energy development and utilization, promote dryland forest conservation and promote participatory forest extension methodologies including farmer field schools.

Poor land use planning and management have detrimental effects on the water resources of a basin. Human encroachment of riparian land and forest areas, as well as unsustainable agricultural are some of the major land use issues in the LVS Basin.

The Mau Forest Complex and other water source forests in the middle to upper reaches of the Migori River have seen significant vegetation loss between 2001 and 2013 in areas. Deforestation and forest degradation are known to cause soil erosion, thus impacting inflows into rivers and causing floods. Cultivated areas have also been known to cause soil erosion. The forest and land use management schemes being promoted by different counties are discussed in **Section 4.4.** above.

3.2.8.5 Biodiversity, protected areas and tourism

As noted in Section 2.2.4., biodiversity in the LVS Basin is linked to water resources and forest reserves or protected areas.

An important forest reserve is the Mau Forest Complex. The areas surrounding the forest are intensively farmed, with human population densities about twice as high on the western side of the forest as on the east (Birdlife International, 2019a). Vegetation patterns are complex, but there is a broad altitudinal zonation from west to east, lower montane forest below 2,300 m giving way to thickets of bamboo *Arundinaria alpina* mixed with forest and grassland, and finally to montane sclerophyllous forest near the escarpment crest (Birdlife International, 2019a). Although the lower montane forest is in best condition in the South-western Mau Nature Reserve, elsewhere, the zone has been heavily and destructively logged (Birdlife International, 2019a). Substantial parts of the high *Juniperus–Podocarpus–Olea* forest have been encroached and cleared, although some sections remain in good condition (Birdlife International, 2019a). Large areas of both the Eastern and Western Mau have been converted to plantation forest (Birdlife International, 2019a). The forest has a rich highland bird community and rare mammals, insects and other plant life.

The Maasai Mara is home to approximately 25% of Kenya’s wildlife (East Africa Natural History Society, 2017) and is well known for the annual migration of wildebeest. Rainfall is the principal driver of population dynamics of savanna herbivores due to food chain links with biomass production and plant nutrients therefore climate change impacts to will have a large impact to the biodiversity of Massai Mara. As the Masaai Mara is Kenya’s most visited protected areas this would also have an impact on the country’s economy and tourism industry.

Wetlands such as the deltaic Nyando wetlands perform important ecosystem services due to its location fringing Lake Victoria. Kusa Swamp has dense stands of *Cyperus papyrus, Vossia cuspidate* and *Phragmites spp.* with associated rare animals and birds (Birdlife International, 2019b). Wetlands in LVS Basin have been under threat by farming activities and encroachment. The invasion of water hyacinth in Lake Victoria has also influenced fishermen to seek livelihood alternatives elsewhere, often hunting in these wetlands. The National Environment Management Authority (NEMA) raised great concern for the degradation of wetlands in Kenya, and in 2011, NEMA enforced regulations to improve and conserve these ecologically sensitive areas.

Aside from the Water Towers and gazetted forests, which are managed by KWTA and KFS respectively, the Parks and Reserves Division of the KWS manages the National Parks, National Reserves, National Sanctuaries, Marine National Parks and Marine National Reserves in the country. KWS is also involved in forest conservation and water towers conservation, as well as ratifying the RAMSAR convention. KWS exercises mandates over the LVS Basin, not just in areas within parks and reserves, but also as the custodians of Kenya’s biodiversity, a role they are committed to through the Nagoya Protocol of the Convention of Biological Diversity. Kenya ratified the Protocol in May 2014, which obliges states to develop appropriate domestic measures for effective management of biodiversity in relation to access to genetic resources, benefit-sharing and compliance. Biodiversity in wetlands and sections of the river flowing through protected areas also receive protection by KWS.

The main threats to protected areas in the LVS Basin are increased deforestation and loss of biodiversity. This has been caused by both direct and indirect drivers. The main direct drivers to increased forest degradation and deforestation leading to high biodiversity losses are illegal and legal excision arising mainly from pressure for expansion of agricultural land, urban development and settlements, unsustainable utilisation of forest resources, increasing dependence on wood energy for lighting and domestic consumption especially firewood and charcoal, forest fires, overgrazing and institutional failures. The weak institutions arise from weak governance structures and inadequate capacity for law enforcement, and weak stakeholder participation in forest management and governance. This is exacerbated by inadequate funding of the forestry sector from the exchequer, civil and public sectors. The LVS Basin ecosystems, as with most river basins in Kenya, do not have specific plans or strategies that target biodiversity and ecosystem conservation. However, efforts made for natural resource management, basin rehabilitation and integrated water resource management in the basin result in biodiversity conservation.

Tourism is a sensitive industry, which is adversely affected by insecurity and even the actions taken to restore security. To preserve this important industry, it is imperative that all stakeholders come together to develop a new approach that ensures its resilience and sustainability vis a vis current reality. To remain competitive, tourism can no longer revolve exclusively around wildlife populations, unless they are endemic species. The current tourist is a sophisticated individual who will be attracted by human factors, such as resilient and functioning ecosystems, rather than exclusion zones, which are anachronisms from the past. An unexploited townsman attraction in Kenya is the interface between wildlife habitats and livestock production. This calls for government policy action to manage rather than eliminate that interface with fences and barriers, which also fragment wildlife habitat. This policy action would be geared towards practicing conservation that is based on an equilibrium between human and wildlife, rather than mutual exclusion.

04

Image source: Silje Forbes 2017. 'Masai Mara National Reserve'. Available online at https://www.basecampexplorer.com/kenya/safari-dictionary/masai-mara-national-reserve/

Key Issues, Challenges and Trends

Water Resources Authority

4 Key Issues, Challenges and Trends

4.1 Introduction

The water resources of Kenya are currently threatened by many issues. These include catchment degradation, pollution, inadequate monitoring networks, inadequate integrated basin planning and management, water availability and supply issues, inadequate capacity (number of staff, skills, equipment and finances), uneven spatial and temporal distribution of water resources, anthropogenic encroachment on environmentally sensitive areas, inadequate flood and drought management and various other issues. In addition to the above issues, the LVS Basin has location-specific challenges and issues which, coupled with its unique basin characteristics, are an important consideration for effective water resources management and planning at basin and sub-basin level.

Main concerns are detailed in this Section and substantiated with further research. The information presented in this Section also informed the evaluation of scenarios (Section 5) and the development of plans for key strategic areas (Section 6).

4.2 Stakeholder engagement

The specific issues for the LVS Basin were identified and prioritised during a two-day workshop with key stakeholders. Figure 4-1 illustrates the key issues and associated frequency of occurrence within the LVS Basin as identified during the workshop sessions). The colours on the map relate to types of issues, while the numbers relate to sub-issues raised during the workshops and recorded in feedback tables.

Figure 4-1: Example of outputs from the workshop for the LVS Basin

Issues were identified under the following main categories:

- Biophysical issues;
- Socio-economic issues;
- Water resources issues;
- Institutional issues

Figure 4-2 shows the relative frequency of the identified issues in the LVS Basin under the above categories.

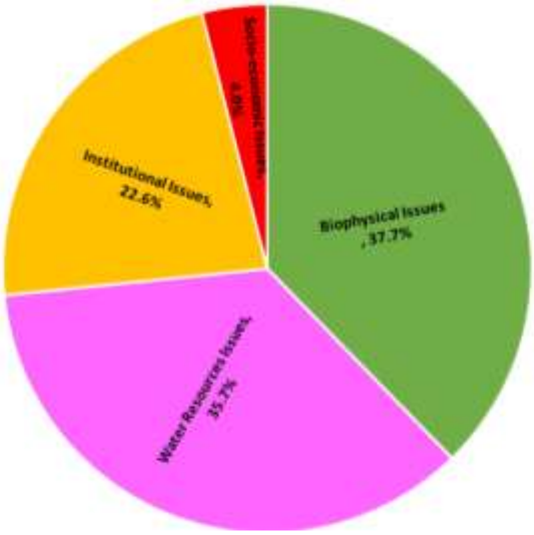


Figure 4-2: Frequency of identified key issues in the LVS Basin

The remainder of this Section presents and addresses the issues identified during the workshops based on the categories and sub-categories framework as depicted in Figure 4-3.

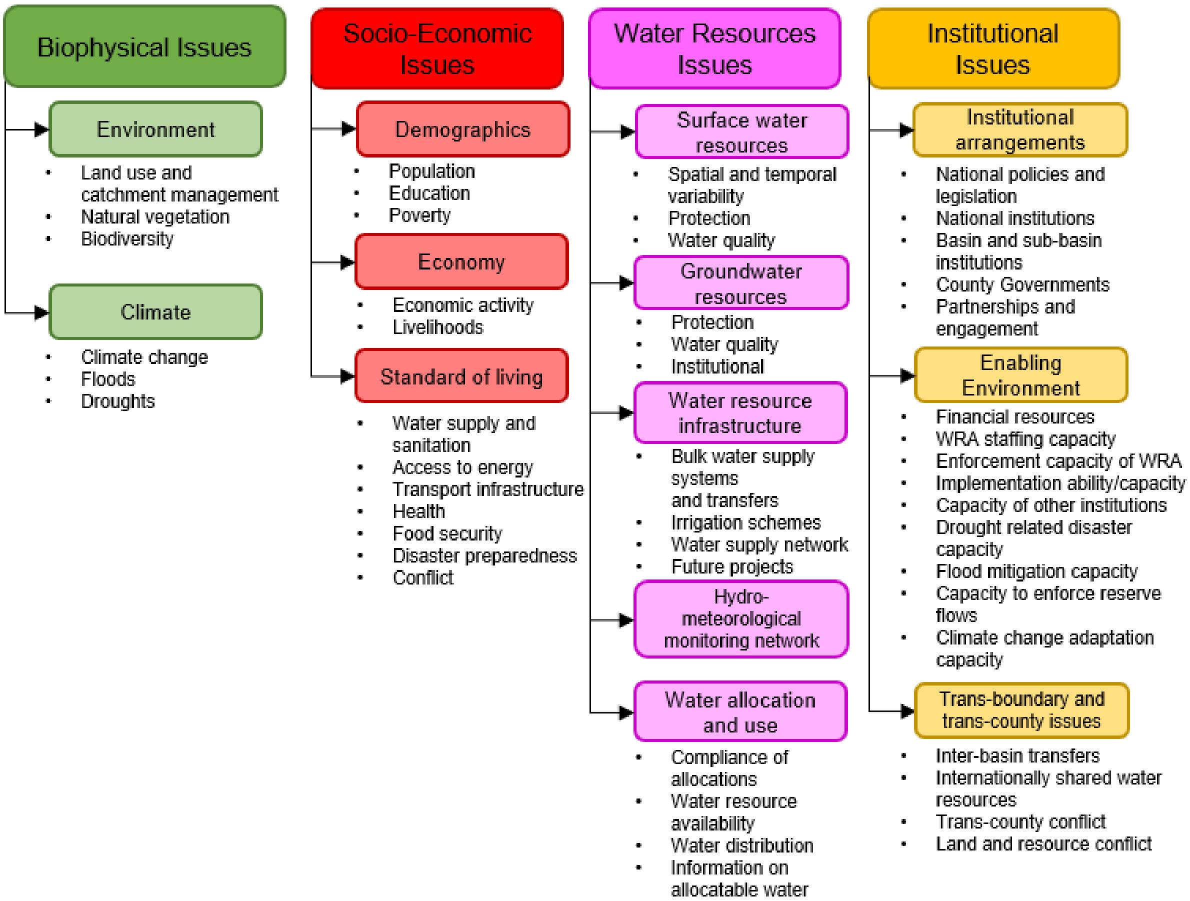


Figure 4-3: Key issues framework

4.3 Biophysical issues

Out of the four categories of issues identified, biophysical issues ranked highest in the LVS Basin along with water resources issues. Poor land use and catchment management issues were considered the most important to address, followed by environmental issues (loss of natural vegetation and biodiversity loss), and climate issues (droughts and floods).

4.3.1 Environment

The environment encompasses the land, vegetation and biodiversity of LVS Basin. Sustainable management of the land is necessary to maintain healthy vegetation and biodiversity. Issues arise through poor land use management and vegetation or biodiversity loss.


Water hyacinth in Lake Victoria, Homa Bay County:
mobile.nation.co.ke/news/The-weed-that-refuses-to-go-away/1950946-4920298-qq0c7r/index

4.3.1.1 Land use and catchment management

Land is the most important resource in agricultural production, but limited availability of productive land is a major constraint to the Vision 2030 strategy of a 10% annual economic growth rate. The current strategy is to expand agriculture through increasing productivity, changing land-use, improving access to markets and value addition. About 16% of Kenya's land is potentially arable. This is dominated by commercial agriculture (cropland 31%, grazing land 30% and forests 22%), urban centres, game parks, markets, homesteads and infrastructure (Government of Kenya, 2010b). The remaining 84% of Kenya's land that is non-arable is arid or semi-arid land (ASAL), which are mainly used as rangelands by ranchers, agropastoralists and pastoralists.

Land management is critical to the social and economic pillars of national development, but land degradation can erode these pillars and lead to chronic poverty for those that are closely linked to natural resource use. Poor land use planning and management can also have detrimental effects on the water resources of a basin. Unsustainable agricultural, pastoral and livelihood activities that are incompatible with the capacity of the land are some of the major land use issues in the LVS Basin.

Agricultural systems can either be rainfed or irrigated agriculture. Most of Kenya is dependent on rainfed agriculture, with the performance being dependent on the agro-climatic zones. The ASAL areas have frequent droughts and the land is most suitable to pastoralism and ranching. While there is ample land, farmers tend to grow crops that are unsuitable for the rainfall regime or soils (Government of Kenya, 2010b).

4.3.1.1.1 Unsustainable agricultural practices and expansion

The LVS Basin has both small-scale rain-fed farming as well as large-scale irrigated farming, particularly along the Lake Victoria and rivers. With an increased population in these areas there has been an expansion of agriculture into sensitive ecosystems such as riparian areas and wetlands. Unsustainable agricultural practises have resulted in land degradation including soil erosion, soil infertility, increased water losses and thus poor crop yields. Catchment degradation in the basin is also fuelled by illegal logging and bush clearing in farmlands, accompanied by poor soil husbandry (Water Resources Management Authority, 2015a)

Examples of unsustainable agricultural/pastoral practices and expansion:

- The Mara ecosystem is showing the impacts of unsustainable land use and degradation, that are linked to poor land use practices and other socio-economic drivers. High population growth and settlement in ecologically sensitive hotspots has led to the unsustainable exploitation of natural resources (County Government of Bomet, 2018).
- The Mau forest is being encroached on in the counties of Narok, Bomet, Kericho and Nakuru. Large areas of Nakuru county have little tree cover due to planned excision of land for settlement and excessive harvesting of trees without replanting (County Government of Nakuru, 2018).

4.3.1.1.2 Poor rangeland management

Croplands and rangelands constitute the largest land use areas in the LVS Basin. Rangelands are areas outside of towns and cultivate fields where animals graze. Rangeland management is the practice of deciding where to graze animals, how many animals to graze at one time, when to burn, how to harvest firewood and thatch grass and other issues relevant to natural resource management.

The rangelands in the LVS Basin, which are supposed to support pastoralism, have been increasingly converted to agro-pastoralism with consequent loss of the protective vegetation cover. Their fragile soil once disturbed by cultivation becomes easily eroded during rainy season. Limited resources have meant that pastoralists move into sensitive areas such as riparian areas, seasonal rivers and forests for forage and water. Land degradation is also influenced by overgrazing as livestock may be forced to graze areas to a point where soil is exposed and vulnerable to wind and water erosion.

Examples of poor rangeland management:

- The two dominant vegetation types in the Narok county include forest land in the Mau area and grasslands and shrubs in the lowland areas of Suswa, in Narok North, Osupuko and Loita divisions in Narok South, as well as the Mara sections in Transmara. These grasslands are regularly exploited for livestock rearing, resulting in overgrazing and land degradation. In addition, rangelands are also necessary for wildlife survival in the Masai Mara (County Government of Narok, 2018).
- Overgrazing and farming, in combination with wetland encroachment, is threating the Kuje wetland in Chemamul area (County Government of Kericho, 2018).

4.3.1.1.3 Unsustainable sand harvesting

Sand is harvested mainly for commercial purposes and is a major source of income and livelihood. Sand harvesting is considered detrimental when operated without environmental considerations. Sand harvesting sites require an environmental management plan (EMP) to guide the rehabilitation of the site (National Environment and Management Authority, 2007). Sand harvesting can take the form of on-farm harvesting, seashore/lakeshore harvesting and river bed harvesting. Sand harvesting may not be conducted on river banks due to the significant soil erosion risks, and catchment degradation risks associated.

Example of unsustainable sand harvesting:

- Sand harvesting in the Suswa area and sections of the Greater Mara region has resulted in overexploitation, leaving the land bare and further exacerbating soil erosion. This results in low water retention and incidences of flash floods (County Government of Narok, 2018)
- Migori County has adequate deposits of good quality sand along Lake Victoria and major rivers like Migori, Kuja and Kuria. Sand is currently mainly mined in Sori and Isebania (County Government of Migori, 2018).
- Sand harvesting is common along most rivers and a few beaches in Homa-Bay County, especially around Kochia and Sindo (County Government of Homa Bay, 2018).
- Quarrying activities in Kisii County, mainly for extraction of sand, clay, ballast and soapstone, is not well coordinated leading to environmental degradation (County Government of Kisii, 2018).
- Nakuru County has 13 sand harvesting operations on most major rivers (County Government of Nakuru, 2018).
- Sand harvesting in Kericho County is predominant in Ainamoi, Belgut and Bureti. (County Government of Kericho, 2018)

4.3.1.1.4 Unsustainable mining

Mining and collection of stones and other minerals is carried out and sold for commercial value and as building materials. Quarry sites require an environmental management plan (EMP) to guide the rehabilitation of the site, although small scale mines have not been adhering to this legislation. Small scale mining has adverse environmental impacts due to the limited rehabilitation and planning conducted. Quarrying involves the destruction of vegetation and fauna habitats, soil erosion, dust and noise impacts. Many quarry sites are uncontrolled and have been located haphazardly without proper planning. When quarry sites are located near a river, they may lead to water pollution through oil or petroleum spills, sedimentation and other waste products.

Example of unsustainable mining:

- Quarrying activities for sand, ballast and building stones is also a rapidly growing industry across the Narok county, but there is no county policy on mining and extraction, resulting in the land being left dilapidated after mining (County Government of Narok, 2018).
- Nakuru County has 15 stone quarries that are mainly found in Bahati, Gilgil and Naivasha sub-counties. Major land degradation has occurred in the quarry mining areas in Nakuru Town East and West, Gilgil, Naivasha and Bahati, Njoro and Kuresoi North (County Government of Nakuru, 2018).
- Gold and iron ore mining take place in Kendu Bay, and this area was found to be a major erosion hotspot in Homa Bay county.

4.3.1.1.5 Land use change

Land use is changing drastically across the LVS Basin, and natural land and vegetation (including grasslands, forests and wetlands) are being converted to agricultural areas. Most of these land types have naturally high water resource potential, making them ideal for agricultural activity. The change in land use can have several effects, depending on the type of change that occurs. Farmers turning rangeland to farmland may result in increased soil erosion once the land is cultivated as well as the introduction of fertilisers and pesticides into the soil, which may seep into nearby water sources. Rangeland may also be turned to settlements, which may increase surface runoff due to the change in land cover. Urban areas will produce waste, which may increase pollution if not handled properly.

4.3.1.1.6 Urban sprawl

Urban sprawl is defined as the fast spread of a city or its suburbs and often involves construction of residential and commercial buildings on undeveloped land on the outskirts. Urban sprawl is driven by urbanisation, which increases the demand for housing in the urban and peri-urban areas of Kisumu and other major cities.

4.3.1.2 Natural vegetation

The major contributors to the loss of natural vegetation in the LVS Basin are encroachment and deforestation due to high population growth rates and agriculture expansion. The livelihoods of the people are becoming reliant on these acts of encroachment and deforestation, which raises a big concern for the lifespan of the Basin’s natural fauna and flora, including the famous Masai Mara and Mau forest.

According to the Global Forest Watch dataset there has been significant tree loss (tree cover considered to be vegetation above 5m) over the period 2001-2019 (Figure 4-4). The areas surrounding Nandi Hills and Kericho have also had tree gain over the period 2001-2012.

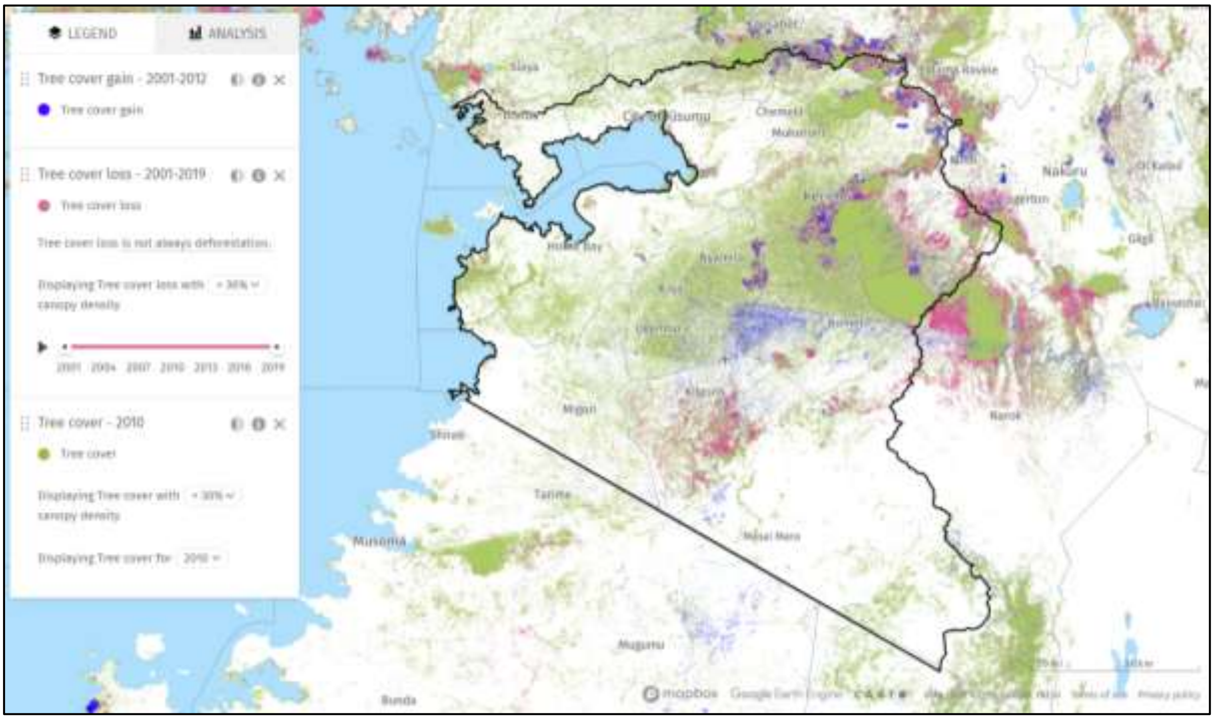


Figure 4-4: **Tree loss and tree gain for LVS Basin according to Global Forest Watch**

4.3.1.2.1 Vegetation loss

The density of vegetation cover on the land is important, as dense vegetation cover will protect the land from erosion and less dense cover will expose the land to erosion. The occurrence of flooding is also more likely when the natural vegetation is removed. The density of vegetation cover reflects the influence of cropping practices, vegetation canopy and general ground cover. The key drivers of vegetation loss are deforestation for agriculture, charcoal fuel and construction.

4.3.1.2.2 Deforestation

The LVS Basin has seen a loss of decrease in forests of 40% from 1990 to 2010, the third worst deforestation rate in the county after Athi and Rift Basins (Water Resources Management Authority, 2013). Forest currently covers 5% of the catchment. Deforestation and forest degradation are rampant in the water source forests such as the Mau Forest Complex and private forests in the middle to upper reaches of the Migori River. It has also resulted in high soil erosion.

Increasing demand from urban markets drives deforestation for commercial purposes. New and expanding settlements have also led to encroachment as communities use wood for firewood and charcoal. Some communities fell the trees and use the logs and sticks to build their houses. Charcoal burning has become a major economic activity and source of income and livelihood for the local communities.

Examples of deforestation:

- Deforestation is reported across every county in the LVS Basin
- In Homa-Bay County, deforestation is the main contributor to the environmental degradation, resulting to reduction in vegetation cover that has left the land bare and vulnerable to soil erosion, low rainfall and flash floods (County Government of Homa Bay, 2018).
- The Mau forest complex is one of the few remaining indigenous forest blocks in Kenya and is experiencing an alarmingly high deforestation rate. The expansion of group ranches is a major factor for the high deforestation rate (Duguma, Atela, Minang, *et al.*, 2019).

4.3.1.2.3 Encroachment of aquatic land

Wetlands, rivers and Lake Victoria in the LVS Basin are being encroached for farming and grazing. This causes an issue for downstream water resources as upstream wetlands are an important part of the hydrological system. NEMA raised great concern for the degradation of wetlands in Kenya and in 2011 enforced regulations to improve and conserve these ecologically sensitive areas.

Examples of encroachment of aquatic land (wetlands):

- The wetlands in Kericho County have problems of ownership and uncertainty, thus causing encroachment and sub segment destruction. Tionosoyiet wetland along Kericho town-Nyagacho road and Daraja sita wetland in Kapkatet are the most affected wetlands by car-washing activities. Kuje wetland in Chemamul area has been degraded by overgrazing and farming within the wetland due to encroachment (County Government of Kericho, 2018).
- Brick making occurs in the Mochenwa Wetlands (County Government of Nyamira, 2018).
- King'wal, Kiprong, Kimondi and Birei swamps are some of the most important wetlands in the Nandi county and are protected areas due to their rich biodiversity. However, demand for more land for settlement and agriculture due to population pressure and decline in land productivity has contributed to land encroachment. King'wal Swamp is the most affected, with rampant vegetable farming and brick making shrinking it (County Government of Nandi, 2018).

4.3.1.2.4 Invasive alien species

From the feedback during stakeholder workshops it has been demised that the main threat from alien invasive plants is the growing of eucalyptus trees in the riparian zones along rivers and lakes. Eucalyptus is used as a source of energy by the tea factories and electric poles, and the market demand for the tree products is high and this has motivated farmers to engage in the growing of them.

4.3.1.2.5 Eutrophication and water hyacinth

Eutrophication occurs when excessive nutrients enter a lake, resulting in an algal bloom. This causes oxygen depletion of the water body, and the death of other aquatic flora and fauna. In addition to nutrients from agricultural activities, stakeholders raised the issue of the use of feeds for cage fishing in the Lake Victoria, that can result in eutrophication.

Water hyacinth is another issue that plagues the Lake Victoria, and one which was regularly raised in stakeholder consultations. Water hyacinth grows at a rapid speed and is extremely difficult to remove. It blocks major navigation routes, interferes with fishing, hampers dam operations and threatens the lake ecology (water quality). Water hyacinth has resulted in a reduction of quality and quantity of fish production in Kisumu and Mara.

4.3.1.3 Biodiversity

Along with the loss of natural vegetation, human encroachment is resulting in the loss of biodiversity due to habitat loss. Pollution is also contributing to water quality issues. The management of environmental flows in also inadequate. The issues of biodiversity loss are addressed below.

4.3.1.3.1 Threatened ecosystems

The LVS Basin has many important ecosystems which are being threatened by human encroachment and pollution. The KFS and KWS are responsible for the protected areas in the Basin, but there are various sensitive ecosystems outside of protected areas.

Examples of threatened ecosystems:

- The Mau Forests Complex forms the largest closed-canopy forest ecosystem in Kenya, the largest indigenous montane forest in East Africa, and is the most important water catchment in the Kenyan Rift Valley. It is threatened by deforestation and expansion of agricultural land.

- The world famous Masai Mara ecosystem, with its life force being the Mara River, is one of the most important habitat areas for a variety of African animals, making it a top tourism site for the country as well. Over-exploitation of the Mara River and other water sources, as well as habitat encroachment from population pressures, are threatening this precious ecosystem.
- Lake Victoria is the second largest freshwater lake in Africa. It is not only an important ecosystem, but a key economic driver and water source for the countries of Kenya, Tanzania and Uganda. It faces numerous threats including pollution, biodiversity loss, habitat destruction and soil erosion.

4.3.1.3.2 Inadequate reserve flow requirements

Reserve flows are currently determined using the 95th percentile of the naturalised present daily flow duration curve. This method, which is known as a hydrological index method, has many shortcomings and should ideally be replaced with more comprehensive reserve determination methods which promote variable environmental flow regimes. Although WRA are putting in efforts to monitor and enforce the reserve, there are serious challenges in this regard. Although the Mara River has had environmental flow assessments, the rest of the basin has not. Environmental monitoring may be taking place, but this monitoring is not part of a larger ecological Reserve study therefore not all ecological requirements are considered.

4.3.1.3.3 Wildlife impacts

Infrastructure and irrigation schemes which impact wildlife migration routes or water supply will increase human-wildlife conflict.

Examples of wildlife impacts:

- The Maasai Mara is regarded as the jewel of Kenya’s wildlife viewing areas. Nowhere in Africa is wildlife more abundant than in Maasai Mara Game Reserve, where the annual wildebeest’s migration alone involves over 1.5 million animals arriving in July and departing in November. The wildlife in the Masai-Mara reserve tends to be most concentrated on the reserve’s western escarpment. There are six registered wildlife conservancies in the county of Narok, namely LVSonkishu, Mara, Naboisho, Mara North, Olare Motoroki, Olkinyei and Pardamat. Among the key challenges are Human-Wildlife Conflicts (as a result of increased competition for pastural land and loss of biodiversity), deforestation, and rampant land subdivision and fencing of wildlife corridors, thus restricting the free movement of wildlife (County Government of Narok, 2018).

4.3.2 Climate

The LVS Basin has a tropical humid climate, with two rainy season from March to May (long rains) and October to November (short rains). The Basin has a mean annual precipitation (MAP) of 1 316 mm, while the highlands receive about 2 400 mm annually. The average annual daily temperatures vary from 18°C to 35°C across the Basin, while the average annual night temperatures vary from 8°C to 16°C. Climate change is recognised as a serious global challenge, with impacts extending to the economy/society, development and ultimately catchment sustainability. This has significant impacts in the Basin due to it emphasising water scarcity and droughts.

4.3.2.1 Climate change

Under the influence of climate change there has been an increase in extreme climatic events in the LVS Basin. Rainfall events have become more unpredictable and intense, droughts are more likely, and temperatures are swinging to extremes on either end of the spectrum. Changing rainfall seasonality is already having an impact on farm crop selection and planting regimes. With more rain falling as heavy storm events, rainfall is less effective, there is increased erosion, increased streamflow, and an increased risk of flooding and greater environmental degradation. Higher evaporative demand offsets any benefits should rainfall possibly increase, also resulting in less effective rainfall. These changes also have societal impacts through crop yields, as well as on the forestry industry which make proper sustained catchment management implementation ever more essential. Most of the economic activities in Kenya are largely dependent on the climate. The sections below provide examples of the issues caused by the inadequate preparedness for floods, and droughts in the Basin. They specifically discuss the effects on people, the economy, infrastructure, and the rise of conflict. The climatic issues in the LVS Basin include the inadequate preparedness for floods and droughts, which impacts communities, the economy and infrastructure among other things.

4.3.2.2 Floods

The inadequate preparedness for floods that occur in the Basin has affected many of the Basin's communities, the economy, and infrastructure which has led to conflict on several occasions. Flood prone areas within the Basin include Kano Plains, Budalangi Area, Nyando River, and the Bondo District (WMO, 2004). The inadequate preparedness for floods has caused land degradation, loss of soil fertility (WMO, 2004), and increased the probability of landslides in some areas. The following sections provide examples of the issues caused by the inadequate preparedness for floods in the Basin.

4.3.2.2.1 People affected by floods

Floods have social consequences for people due to the disruption they cause on everyday activities. People are affected by floods in the event of displaced households. Pit latrines are easily destroyed or washed away in floods due to them being in the ground, resulting in sanitation issues as well as waterborne diseases, such as cholera and typhoid. Floods cause erosion and sedimentation, which reduces the water quality, causing health issues. Due to some farmlands located in floodplains, crops are destroyed, which increases food insecurity.

It must be noted that similar to the farmlands, numerous communities reside in floodplain areas, which is why they are affected by seasonal floods. This is a major issue as these communities have been established in areas which are not safe to inhabit, and relocating communities has many issues and is often not regarded as an option.

Examples of people affected by floods:

- Kenya and the Lake Victoria basin are prone to recurring floods especially river flooding (Gichere, Olado, Anyona, *et al.*, 2013), as a result of changes in weather patterns, temperature and precipitation. The loss of livelihoods, and displacements due to flood events in the Lake Victoria South Basin have been reported.

4.3.2.2.2 Economic impacts of floods

The agricultural sector, along with individual farmers, can experience major setbacks due to floods. Crops can be destroyed, or the growth stunted through inundation or leaching. Irrigation equipment can also be damaged in a flood. As a result, the farmers and agricultural sector experiences a loss of income with reduced crop yields, additional expenses to repair equipment and possible re-cultivation of the land. Floods can cause livestock diseases and deaths, which result in livestock farmers incurring profit losses (WMO, 2004). In the urban centres, flooding not only causes physical damage to businesses, but losses may be incurred due to loss of manpower and reduced efficiency when employees are unable to commute to work as well as the inability to perform certain activities.

Examples of economic impacts of floods:

- Frequent and ongoing floods make people in the Basin more vulnerable to poverty due to low income levels (i.e. farmers do not get remunerative prices for their produce). As a result, household level provision and long-term planning becomes challenging (Mutua, 2001).
- Floods have negatively affected the prices of commodities within the LVS Basin.
- Furthermore, critical infrastructure is destroyed during floods in the LVS Basin (Government of Kenya, 2010c).

4.3.2.2.3 Damage to infrastructure

Depending on the magnitude and frequency, floods have the potential to deteriorate, and cause major damage to infrastructure, and property.

Examples of damage to infrastructure caused by floods:

- Flash floods put strain on infrastructure causing more deterioration and maintenance of critical existing infrastructure (Mutua, 2001).
- Floods also cause the damage, and loss of property as well as critical communication infrastructure in the basin in extreme cases (Government of Kenya, 2010c).

4.3.2.3 Droughts

Drought events in the Lake Victoria South Basin are of concern. They impact livelihoods, the environment and public health issues in the basin. Drought events in recent years in the basin are known to have increased in frequency but also in severity because of the changes in weather patterns, which includes rainfall and temperature. Water use restriction levels are not clearly defined for the existing dams in the Basin, which cause operational issues during times of drought. These needs to be reframed. In addition, dam operating rules should be adhered to, and new ones should be developed to mitigate the impacts of droughts and floods

4.3.2.3.1 People affected by droughts

People, in both rural and urban areas, are affected by droughts due to water scarcity and food insecurity as well as the livelihoods of those earning an income from the agricultural sector. Droughts increase food insecurity due to poor crop growth or lower crop yields and a decrease in milk production. As a result of lower crop yields, crop prices increase, which reduces the household purchasing power. Water scarcity increases, which decreases water supply and the communities who collect water from a water source may need to travel further. Water quality issues increase during droughts, which increases the number of health issues of the population. The environment and living standards during a drought increase people's susceptibility to diseases. With an increase in droughts, leading to food insecurity and water scarcity, the percentage of the population suffering from malnutrition is likely to increase.

Examples of people affected by droughts:

- People in the LVS Basin are affected by droughts and put under additional water stress due to irregular seasonal and annual rainfall.
- People in the LVS Basin rely on sources of surface water, and groundwater, but during long drought spells people have to rely on water tankers that are filled by non-governmental organisations because Kenya as a country is known as a water-scarce country (Government of Kenya, 2010c).
- Droughts have also caused food insecurity and as a result the vulnerable face food insecurity in the LVS Basin.
- People living in areas that are characterised by acute poverty, high population density, lack of education, and poor planning and management of agricultural lands are more vulnerable to droughts.

4.3.2.3.2 Economic impacts of droughts

The agricultural sectors of all the Counties in the Basin experience major losses due to droughts. Due to a large amount of the farmlands in the Basin being rain-fed agriculture, droughts result in low crop yields, poor quality of produce, and a change in varieties. Although crop prices increase to counter the lower crop yields, the agricultural sector usually experiences a reduction in sales, and therefore a reduction in income (Water Resources Management Authority, 2015a). Various areas in the Basin have been susceptible to losses in the agricultural sector due to droughts. The livestock sector experiences several issues as a result of droughts. The lack of water for cattle results in decreased milk production. Water scarcity also contributes to livestock diseases and deaths. Pastoralists are often forced to migrate in search of water for their livestock.

Examples of economic impacts of droughts:

- Generally, drought events in any country have negative effects to its economy. Kenya and Lake Victoria are no exception to this difficult situation. Due to the droughts it experiences there is a decrease in production of major crops, often crops used for exporting. This makes it difficult to export the crops and in turn weakens the county's balance payments (Government of Kenya, 2010c).
- The tourism sector is negatively affected as tourists might be turned away who had already booked venues in Kenya (Government of Kenya, 2010c).
- With climate change worsening the drought situations, causing dams to dry up, ultimately impacts hydropower potential (Government of Kenya, 2010c).

4.3.2.3.3 Conflict due to droughts

Droughts result in scarcity of water, so wildlife and livestock travel in search of water. This gives rise to conflicts between various groups for reasons such as resource-based conflict, human-wildlife conflict, predation of livestock by wild animals, and transboundary conflict. Conflict arises between locals and pastoralists when the migration of the pastoralists' livestock increases competition for available resources (i.e. resource-based conflict). Crop farmers do not like livestock travelling across their land. The probability of humans encountering wildlife increases during droughts as both humans and animals are in search of food and water (i.e. human-wildlife conflict). Livestock are preyed upon by wild animals, especially during a drought when food is scarce (i.e. conflict due to predation of livestock).

4.4 Socio-economic issues

Socio-economic issues were deemed least important relative to other issue categories in the LVS Basin.

4.4.1 Demographics

The demographic challenges in the LVS Basin include an increasing population in certain areas, the inadequate education and the level of poverty.

4.4.1.1 Population

4.4.1.1.1 Increased population growth

The LVS Basin is expected to experience population growth in the future, although water resources are limited and affected by climate change. This poses a challenge in terms of managing and servicing the growing population, especially in the growing urban centres.

4.4.1.1.2 Urbanisation

With water challenges in the Basin it is likely that there will be migration to urban centres. Currently most of the population is in the rural areas therefore this increase in urban population will put pressure on existing resources. This means that there will be an increased need for water supply and sanitation systems in urban areas. With an increase in paved areas, the amount of stormwater runoff will increase. Industrial areas increase along with the growth of an urban area, which will result in increased industrial effluent.

4.4.1.2 Education

Inadequate education can affect water resources management in terms of information sharing with the public as well as general understanding of water resources and the relevant laws and regulations put in place to protect water resources. The education challenges are discussed further below.

4.4.1.2.1 Information sharing

Education and literacy levels impact the ability to share information with the community. This creates challenges when the authorities are required to share information with the public, such as any changes in regulations, water restrictions that are being implemented or even alternative methods of water harvesting.

4.4.1.2.2 Minimal understanding and awareness

There is minimal understanding of catchment management and the protection of land and water resources as people think it is normal to live or farm within riparian areas or floodplains. This has resulted in catchment degradation. Improved education will give the opportunity for better understanding of laws and regulations, and implementation and enforcement will also improve. There is minimal awareness and knowledge within communities on the impacts of climate change as well as adaptation strategies, which can be implemented at household and community level, such as reforestation and rainwater harvesting.

4.4.1.2.3 Inadequate education of water resources from a young age

Understanding brings awareness, which raises the concern of the inadequate of exposure of school children to water resources and its protection. It will be very beneficial to incorporate water resources management information into the school curriculum.

Examples of education issues:

- Adoption of sustainable agricultural activities, such as conservation agriculture and agroforestry, by small-holder farmers is reliant on extension services supplied by the AFFA and KFS. These extension services need to be strengthened.
- There is a high dropout rate in primary schools during the drought seasons.
- Technical and Vocational Training Centres (TVETs) are aimed at equipping trainees with practical skills and entrepreneurial skills to enable opportunities and improve livelihoods. These facilities need to have sustainable water and land management strategies integrated into them.

4.4.1.3 Poverty

The Constitution of Kenya (2010) is based on the identification of sustainable access to safe water and basic sanitation as a human right and an economic good. Although there are multiple poverty eradication strategies being implemented in the Basin there are still challenges with reaching a large and increasing population, particularly in the urban centres. The challenges with poverty are that it creates a financial handicap, which restricts an individual's financial capacity. This affects the individual's ability to pay for services, making them reliant on incentivised programmes. The challenges faced in the LVS Basin due to poverty are described below.

4.4.1.3.1 Subsistence farming

Subsistence farming and natural resource use are the livelihoods of the rural poor. It is often subsistence farmers who encroach on riparian and wetland areas as these areas receive a good amount of water for crops. Encroachment is usually driven by droughts.

4.4.1.3.2 Lack of finances

Poverty affects the financial capacity of individuals to pay for services. This means that certain areas of the Basin require free basic water supply and sanitation. This is costly, due to the increasing population in urban areas. The Water Sector Trust Fund provides financial assistance towards capital investment costs in areas lacking adequate services, which are usually inhabited by the poor. The Fund works with WASREB in partnership to encourage utilities to improve services for low-income customers.

4.4.1.3.3 Access to water supply

The poor, particularly women and children, spend a significant amount of time fetching water in both urban and rural areas.

4.4.2 Economy

Economic development has a major influence on the development of water resources. With an increase in population expected there is a need to invest in infrastructure development. Furthermore, as discussed above, agriculture is the mainstay of Kenya's economy. Water scarcity has a direct impact on rain-fed and irrigated agriculture as well as livestock and an indirect impact on food processing industries. The economic activity occurring in the LVS Basin, discussed below, will influence the planning for water resources.

4.4.2.1 Economic activity

4.4.2.1.1 Plans for new infrastructure

With the projected increase in urbanisation in LVS Basin it is important to provide for a growing population in certain areas.

4.4.2.1.2 Agriculture

4.4.2.1.2.1 Access to water for livestock

Livestock plays an important economic and socio-cultural role in Kenya. Both crop farmers and pastoralists keep livestock for food and income generation. Livestock production is constrained by access to water and limitations thereof has influenced conflict amongst pastoralists.

4.4.2.1.2.2 Aquaculture impacts

Aquaculture has been promoted in Kenya as a subsector which can significantly contribute to the national economy by creating employment, earning foreign exchange, reducing poverty and supporting food security (Government of Kenya, 2010b). Through this promotion areas that are unsuitable for crop production such as rivers, wetlands, lakes and swamps are being promoted as areas for aquaculture, which may have a detrimental effect on water resources.

4.4.2.2 Livelihoods

Those engaging in livelihood activities are usually reliant on natural resource supply in a catchment. With increasing population and demand, natural resources are being degraded therefore livelihood activities are not sustainable. This is an issue as it impacts people's self-reliance, and thus puts pressure on the economy. Sources of livelihoods in the LVS Basin vary from fishing to subsistence agriculture and crop/livestock farming. Threats to these activities include the following:

4.4.2.2.1 Crop and livestock disease

Pests and disease cause heavy loss through deaths, reduced productivity and loss of markets for products (Government of Kenya, 2010b). Managing livestock disease requires heavy investment in preparedness, surveillance and controls at entry ports. Lack of appropriate storage and poor handling have resulted in high post-harvest losses. Pesticides and pest control equipment is also expensive for small-scale farmers. County governments have proposed strategies for improved post-harvest storage and handling and improved livestock disease control.

4.4.3 Standard of living

The Constitution of Kenya (2010) is based on the identification of sustainable access to safe water and basic sanitation, as well as a healthy environment as a human right. The people in the LVS Basin face various challenges in terms of their standard of living, which have been categorised into water supply and sanitation challenges, access to energy, transport infrastructure, food security and disaster preparedness. These are discussed further below.

4.4.3.1 Water supply and sanitation

The greatest water security needs in Kenya are for household and agricultural use. A first step in increasing access to potable water is recognising equal rights to water, regardless of ability to pay (UNDP, 2011). The Water Act (2016) devolves water and sanitation services to county governments, who provide services through WSPs. About 34% of the population get drinking water from unimproved water sources and 40% of the population get water from springs, wells and boreholes (Water Resources Management Authority, 2013). Achieving the goal of increasing access to potable water across the Basin has the following challenges:

About 26% of the urban population receives piped water from a WSP, whilst 7% of the rural population receives piped water from a WSP (Water Resources Management Authority, 2013). The majority of the urban and rural populations make use of septic tanks and pit latrines for sanitation. There are currently no sewerage systems in place in the rural areas, and only 4% of the urban population has access to formal sewerage systems. 20% of the rural population do not have any treatment facilities and resort to unsanitary waste disposal (Water Resources Management Authority, 2013).

4.4.3.2 Access to energy

Access to electricity is an important factor in raising living standards. Electrification can reduce poverty by increasing productivity, employment and time spent in school and reducing environmental degradation (UNDP, 2011). Areas without access to electricity use inefficient fossil fuels as a substitute. Over-exploitation of biomass can cause catchment degradation and requires a large amount of time for fuel gathering. Green technologies are being promoted by Counties and the government has also implemented tariff changes for green energy, but at the local scale communities are still engaging in charcoal and wood burning.

4.4.3.3 Transport infrastructure

Inadequate transport infrastructure contributes to food insecurity and limits future opportunities for development. Access roads above seasonal rivers (laghas) in the LVS Basin become unusable during the rainy seasons as they become muddy or submerged. Sectors or industries which rely on transport, are therefore limited in their ability to travel to various parts of the basin during the year.

4.4.3.4 Health

Approximately 80% of communicable diseases are water, sanitation and hygiene related (Wiesmann *et al.*, 2016). More than 90% of the water and sanitation related disease outbreaks occur in rural households. Water quality issues are caused by industrial effluent, solid waste dumping, sanitation issues, salinisation of groundwater, among others. Health issues are encountered when a person is malnourished, which is a result of food insecurity. Floods often result in the contamination of boreholes, raising concern for waterborne diseases. It is anticipated that the increase in temperatures due to climate change would provide an environment conducive for malaria vectors to thrive. Siaya, Nandi, Kericho, Bomet, Nyamira, Kisii, Homa Bay, Migori and Narok counties all have experienced Malaria as a top disease, causing morbidity.

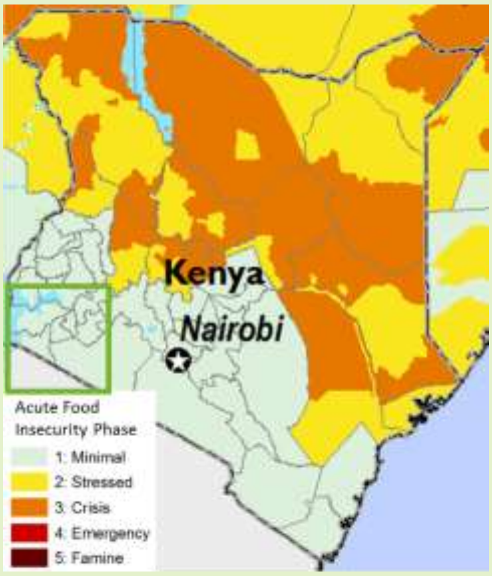
4.4.3.5 Food security

High population growth and low agricultural productivity in Kenya have led to agricultural production not meeting consumption. Low production is linked to the reliance on rain-fed agriculture, limited access to farming inputs, low uptake of new technology and influence of climate change. Populations in semi-arid counties are already facing food crises due to chronic drought. The country's most food insecure areas do not fall within the LVS Basin; however, parts of the catchment do suffer from food insecurity. Food shortages are experienced in some of the area alongside Lake Victoria, such as Homa Bay, as the households cannot afford to purchase adequate food supplies. The households in these areas tend to have small plots for planting, and a large percentage of the heads of the households work on other agricultural plots without time to tend to their own plots. The percentage of households with poor/borderline food consumption is 5 to 10% in Narok, Bomet and Kericho County, 10 to 15% in Migori, Kisii and Kisumu County, and 15 to 20% in Homa Bay and Nyamira County.

Short term food security outlook

Although large areas of the country recently experienced food shortages due to below-average rainfall in the long rainy season from March to May 2017, the LVS Basin is a relatively food-secure catchment due to its high rainfall and agricultural production. According to the Famine Early Warning Systems Network (FEWSNET), although crop production activities are currently at below-average levels, the catchment is in a minimal food-insecurity phase. The reduced crop production has led to other issues such as an increase in casual wholesale maize prices in urban markets and a reduction in casual labour opportunities.

The short-term food security outlook for the LVS Basin was in a minimal food-insecurity phase during 2018.



Short-term food security outlook in LVS Basin

4.4.3.5.1 Prolonged droughts

Changing rainfall patterns and prolonged droughts are an issue in most of the Basin where pastoralism is the main livelihood activity. Droughts reduce pasture land and limit water resources, creating significant food security issues.

4.4.3.5.2 Rain-fed agriculture

There are a few existing large irrigation schemes in the LVS Basin. Most of the agricultural land in the basin is rain-fed agriculture.

4.4.3.5.3 Food price fluctuations

With the crops being vulnerable to the weather conditions, price fluctuations occur depending on the crop yield for the season. When the crop production is low the price rises, while the price falls when the crop yield is high.

4.4.3.6 Disaster preparedness

In areas where natural resources are degraded or where no disaster planning has taken place, communities are more vulnerable to the effects of the disasters. Fires can damage and destroy houses, forests, crops and grazing land. Floods can cause personal danger to communities and can also wash away good farming soil if there is no village-level emergency planning in place. Floods can cut off access to clean water supply and contribute to the spread of illnesses such as cholera. In the LVS Basin there is inadequate disaster response and disaster management protocols in place for communities. With the effects of a disaster often being devastating, the inadequate of preparedness for these disasters increases and prolongs these effects as the relief work may be delayed in response to the disaster. As a result, the people and the economy are affected more when there is an inadequate of preparedness to a disaster event. The issues and challenges involved are discussed further below.

4.4.3.6.1 Susceptibility to impacts of disasters

There is currently inadequate capacity for community-based disaster management in the scarcely-populated areas. This is a major concern as certain communities are affected by seasonal floods and droughts. The susceptibility of communities to a disaster affects the residents' standard of living as their houses could get destroyed and the community's economy will dip. There is also an element of fear involved when a community is aware that it is susceptible to the effects of a disaster, but there is no plan in place for them to protect themselves or their community.

4.4.3.6.2 Dependence on charities/NGO's

The Government does not have the funds for disaster relief and rehabilitation to the damages occurred. The Government, and therefore the affected communities, are dependent on funds and aid from charities and organisations.

4.4.3.7 Conflict

Water-related conflicts within the LVS Basin fall into one of the following categories:

- Human-wildlife conflicts, principally among communities that live in proximity to wildlife areas such as the national parks.
- Conflicts related to trans-boundary issues with Tanzania in the Mara River catchment.
- Illegal encroachment into the water towers and wetlands.
- Water use conflicts in which excessive upstream abstraction denies downstream users access to the water resource.
- Resource use conflicts from pastoralist communities.
- Over-abstraction from rivers during the dry season.
- Water pollution by industries who do not comply with their license agreements.

4.5 Water resources availability, management and development issues

Water resources availability, management and development issues were a key issue in terms of frequency in the LVS Basin. The main sub-issue was water quality, this was in relation to water quality in rivers as well as in Lake Victoria.

4.5.1 Surface water resources


Masai Mara River:
www.exploring-africa.com/en/kenya/great-masai-mara-ecosystem-and-human-conflict/excessive-exploitation-mara-river-basin-threat

The LVS Basin has many water resources challenges, with insufficient water to meet demand in certain locations and during certain times of the year. Domestic and industrial are the greatest demand in the basin, followed by irrigation, which are both expected to increase in the future. Sedimentation of seasonal rivers and pans is an issue as it limits already scarce water resources. The main surface water issues are described below:

4.5.1.1 Spatial and temporal variability

The spatial variability of water resources in LVS Basin influences the availability of water supply. The level of population pressure and water demand is also varied across the Basin.

4.5.1.1.1 Water security

The LVS Basin has few perennial streams, and the availability of surface water is highly variable over different seasons. Although the water resources in the catchment area are abundant, there was scarcity in some sub-catchments due to their unique characteristics. As a result, conflicts were reported in Northern and southern Shoreline and lower Sondu sub-catchment areas (Water Resources Management Authority, 2015a).

4.5.1.1.2 Water supply access

Access to clean and safe water is the foundation of a community and due to the spatial variability of water resources in the Basin, this varies greatly.

Example of water access issues:

- Despite Homa Bay county being situated on the shores of Lake Victoria, the average distance to the nearest water point is 5 km (County Government of Homa Bay, 2018). More than 80% of the county’s waste water is discharged into rivers and the lake without treatment, further limiting the availability of potable water.
- Bomet county is endowed with surface water resources, with numerous permanent rivers originating from the Mau forest. Most of the population draws its water from these rivers as well as springs and water pans. Despite the abundance of surface water, access to potable water in the county is still low, with only 25% of the population having access to piped water (County Government of Bomet, 2018). The bulk of the county has water access within 1 km. However, during the dry season in the lower parts of the county (Chepalungu and Bomet East sub-counties), water is mainly derived from dams and pans, and travelling distance is around 5 km (County Government of Bomet, 2018).

4.5.1.2 Protection

Poor management of Kenya's limited water resources breaches the constitution and urgent measures are required to reverse the trend. Water resource protection issues in the LVS Basin are discussed below:

4.5.1.2.1 Over abstraction

There is concern that surface water in the high lying headwater regions is being over abstracted, leaving limited water resources for downstream users. Warnings were raised in stakeholder meetings that the construction of the Itare Dam along the Mau forest, Kenya's largest watershed, could threaten water availability. There is already conflict around the Mau forest, where over abstraction is already occurring in the headwaters and affecting availability downstream. It was raised in workshop dialogues that unplanned dams in the Basin, that are not factored into water allocations, can also result in over-abstraction of surface water upstream.

4.5.1.2.2 Inadequate RQOs

There is currently inadequate Resource Quality Objectives (RQOs) for the water resources in the LVS Basin. The RQOs represent the desired status of the water resource, covering all aspects of quantity, quality, timing and aquatic biota. Management decisions should be made such that the condition of the resource is targeting the RQO. The degradation of the water resources in the LVS Basin due to pollution emanates, among many other things, from the lack of RQOs. However, there are urgent plans to develop guidelines for the establishment of RQOs and River Classification for all the Catchment areas.

4.5.1.3 Water quality

Water quality issues in the LVS Basin are mainly centred around urban quality issues, as a result of high population growth. These, and other issues affecting surface water quality in the basin, are discussed below.

Macalder gold mine, Migori county:
www.enca.com/africa/pictures-kenyas-gold-rush

4.5.1.3.1 Sedimentation

Sedimentation negatively affects the water quality of the rivers and limits surface water storage. Unsustainable land husbandry, overstocking, overgrazing and deforestation of the Mau escarpment have led to soil erosion and sedimentation of the rivers. Sedimentation studies in the LVS Basin show the massive levels of nutrients and sediments that transported annually into Lake Victoria, resulting in the proliferation of hyacinth and other weeds. The lower reaches of the Nyando River experiences collapsing river banks which increases the sediment load. Sediment is also contributed by encroachment on riparian reserves

The most common sedimentation issues in the Basin are:

- Sediment loads from degraded farmlands
- Soil erosion from overgrazed lands and deforestation

4.5.1.3.2 Dumping of solid waste

The dumping of solid waste contributes to surface water pollution. Issues are usually linked with informal settlements. In urban centres such as Kisumu and Kisii there are established solid waste management systems, but other areas in the Basin do not have the same level of service. This solid waste lands up in the stormwater, which ends up in rivers and dams.

4.5.1.3.3 Sanitation

In most counties, sanitation falls behind water supply in terms of population reach. Many urban centres usually have unplanned informal settlements, often with high population densities. These areas lack sewer systems and on-site sanitation (such as pit latrines) is used to dispose of faecal matter. These wastes often find their way into nearby water courses and can contaminate shallow groundwater. In the LVS Basin, inadequate sanitation also occurs in the tourist establishments in the Masai Mara game camps on the Mara River.

4.5.1.3.4 Inadequate sewerage treatment

Similar to the inadequate connections to proper sewerage systems, there is inadequate wastewater treatment facilities, which makes efforts to alleviate water quality deterioration difficult to implement.

4.5.1.3.5 Non-point sources

Non-point sources of pollution include agricultural chemicals (fertilisers and pesticides), unmanaged storm water, soil erosion, overgrazing and infrastructural developments.

Stakeholder workshops indicate that fertiliser and pesticides used in tea plantations in Kericho are resulting in surface water contamination. One of the main pollution sources in the Nyando, Gucha-Migori and Sondu-Miriu Rivers, as a result of discharge of non-point sources, is agrochemicals emanating from sugarcane, maize, tea and coffee plantations (Water Resources Management Authority, 2015a). Water pollution is also noted in the Migori County from the use of agro-chemicals in tobacco mining.

4.5.1.3.6 Industrial effluents

River pollution from effluents from factories was raised regularly during stakeholder workshops as a part of this consultancy. This is no surprise as Kisumu has various industries (including cement, construction materials, brewing and beverages, food processing, timber and timber products, textiles, printing and light engineering), and the tea processing industry is famous in Kericho and its surrounding areas (Water Resources Management Authority, 2013). Water quality issues from industrial pollution are seen in the counties of Kisumu, Homa Bay and Bomet. Tea and sugar factories are a major source of pollution in the Nyando River,

4.5.1.3.7 Small-scale gold mining operations

Gold mining activities have led to the pollution of surface waters in the LVS Basin, particularly in the Migori area sub-catchment 1KC (Migori-Gucha), largely polluting the Gucha-Migori River. The Migori-Kihancha Regional Master Plan recognised that surface water drainage from the Macalder Mine contained elevated concentrations of copper and zinc (Government of Kenya, 1975). There is relatively widespread artisanal mining in the southern part of the Basin, particularly in the Migori Gold Belt. This has led to mercury contamination in surface waters, and likely groundwater too (Ogola, Mitullah & Omulo, 2002).

4.5.1.3.8 Cage fishing

The issue of the use of feeds for cage fishing in the Lake Victoria, resulting in eutrophication, was raised in stakeholder workshops.

Example of water quality issues:

- Kisumu County generates about 5,720 tons of solid waste per day out of which only about 25 % is collected for open disposal at Kachok dumpsite (County Government of Kisumu, 2018). In addition, Kisumu currently has two existing sewage treatment plants that can only manage 16% of the connected households (Raballa, 2018). Solid waste and sewage can enter water ways and percolate into shallow groundwater, resulting in contamination.
- Ogola et al. (2002) described Acid Mine Drainage (AMD) in the Macalder Mine area and showed that surface waters and stream sediments in the area were significantly polluted. Ngure et al.

(2017) showed elevated lead and mercury levels in surface water in Macalder, Gucha and Karunga, which are likely to pollute adjacent alluvial and bankside aquifers.

4.5.2 Groundwater resources

Only 22% of the LVS population is reliant on groundwater, and over-abstraction (and consequent salinization) are currently not a serious cause for concern in the basin. However, as surface water sources diminish or become more polluted, groundwater is becoming an increasingly important source for many communities. The main issues regarding groundwater quality and quantity are described below. A more extensive discussion around groundwater issues is presented in section 6.4.5.

4.5.2.1 Protection

The Water Act (2016) defines protection of groundwater under Section 22/23 and groundwater use is managed through Section 47 and 104. The unsustainable use of groundwater is not a big concern for the LVS Basin, but some groundwater issues have resulted from inadequate protection of groundwater, which is discussed further below.

4.5.2.1.1 Groundwater protection programs

Discussions about a policy for groundwater protection were initiated within the WRMA in 2006 (Water Resources Management Authority, 2006); these were considered during the development of the National Groundwater Policy (Ministry of Water and Irrigation, 2013).

- The National Water Quality Management Strategy (Ministry of Water and Irrigation, 2012): in S. 2.7 (Ground Water Protection), the NWQMS lays out the following “strategic responses”:
- Extraction of groundwater at sustainable rates to avoid seawater intrusion.
- Intensifying groundwater quality monitoring by sinking observation boreholes.
- Establishing a monitoring program for selected production wells to capture any changing trends.
- Requiring all borehole owners to have their water tested periodically as part of the water quality monitoring programme.
- Maintain updated database of borehole data.
- It recommended the “Development of Ground Water Protection programs” without defining or describing them. This needs to be refined.

4.5.2.1.2 Groundwater recharge areas

Prasad & Obiero (2014) outline the risks that high population densities, conversion of land to intensive subsistence farming, and the planting of Eucalyptus trees in recharge areas, could have on spring flow in a part of Migori County (698 people per km2). The 2015 CMS (Water Resources Management Authority, 2015a), makes mention of Eucalyptus as “unfriendly-water use plants” in the context of catchment degradation. Eucalyptus trees have long been known to jeopardise near-surface groundwater resources (Oballa, Konuche, Muchiri, *et al.*, 2010; Regional Land Management Unit, 2003). NEMA published a Vacation Order prohibiting the planting of Eucalyptus in wetlands and riparian areas in 2011 (National Environment and Management Authority, 2011). However, there remains resistance to the NEMA Order from farmers.

4.5.2.1.3 Unsustainable groundwater use

There is little evidence of over-abstraction in the LVS Basin, although inadequate enforcement could be placing groundwater resources under stress. Over-abstraction across the LVS Basin is patchy and restricted to ‘hotspots’:

- The WRA identified two aquifers that are at risk of over-abstraction (Water Resources Management Authority, 2007b). These are the Kericho aquifer (a minor aquifer); and the Mara River aquifer (a poor aquifer in the Mara basin). Given the relatively high density of boreholes in the Migori area (Onyango, 2014), this aquifer should be studied to determine whether over-abstraction is taking place. Migori hosts one of the WRA monitoring boreholes (Water Resources Management Authority, 2015c).

- Aquifers that have water quality concerns (either natural water quality or pollution) are relatively numerous (Water Resources Management Authority, 2007b), see Table 2-3 in section 2.4.2.2. Assessing whether these require management interventions must await the completion of groundwater abstraction and water quality surveys.
- A Mara River Basin Monograph (WREM International Inc, 2008) makes mention of depleting groundwater and deteriorating groundwater quality in that area, but provides no evidence of either.
- Over-abstraction from other aquifers in the LVS Basin is uncertain, though there are some concerns about aquifers beneath Kericho and Bomet. More recent data suggest that the Kisii and Migori aquifers in the vicinity of these Towns may be under stress. It is possible that some Basement and metasedimentary aquifers have suffered localised depletion.


Make-shift pit latrine in Kericho County: www.nation.co.ke/counties/Mau-evictees-in-Kericho-protest/1107872-3379476-pgfqhc/index

4.5.2.2 Water quality

Natural contaminants in the LVS are relatively low. Shallow aquifer contamination from sanitation systems and mining activities are the main contributors to poor groundwater quality in the LVS Basin. There are currently no Groundwater Quality Management Plans for areas with a high level of risk to groundwater quality issues.

Shallow aquifers face the greatest threat of pollution by human wastes, especially in areas of high population density and in informal peri-urban settlements. Shallow aquifer and well pollution is associated with pit latrines and is a serious cause for concern. Nyabayo et al. (2016) found that the concentrations of *faecal* coliforms in shallow well waters correlated with distance between well and pit latrine – the closer the pit latrine to the shallow well, the higher the *faecal* coliform count.

Polluted surface water from gold mining activities in the LVS Basin is likely to result in pollution of adjacent alluvial and bankside aquifers, and shallow groundwater. Okoth (2011) measured groundwater contamination by lead and iron in the area of Macalder gold mine.

Fluoride is not a significant natural constituent of LVS groundwaters except in the drier parts of Bomet County and probably in the part of Narok County that lies in the LVS Basin. In Bomet, elevated natural fluoride was reported in deep groundwaters and water pans.

Example of groundwater quality issues:

- The Migori-Kihancha Regional Master Plan described bacteriological contamination in unprotected and protected springs (Government of Kenya, 1975); 75% of unprotected springs showed faecal contamination, whereas only 33% of protected springs did.
- Kimani-Murage & Ngindu (2007) found bacterial prevalence patterns in an informal settlement in Kisumu, confirming earlier work in the Migosi and Manyatta residential areas carried out by Orwa (2001). All are associated with high densities of pit latrines and shallow wells. Wright et al. (2013) found that nitrate and bacterial contamination in shallow groundwaters beneath Kisumu were linked. Again, pit latrine concentrations correlated strongly with excessive nitrate.

4.5.2.3 Institutional

4.5.2.3.1 Regulations

There is poor planning and water allocation when it comes to considering surface water and groundwater allocation. The two remain divided, and effectively treated as different water resources. The recent Water Allocation Plan Guideline (Water Resources Authority, 2019a) should help to resolve this, as it treats both resources in a given area in its approach to WAPs. There is confused NEMA and WRA mandates with regards to wastewater management and licensing (both bodies seek ‘polluter payments’ from water users/polluters). NEMA legislation (Act in 1999 and effluent regulations in the Environmental Management and Co-ordination (Water Quality) Regulations, 2006) pre-date water legislation (Water Act in 2002, and effluent regulations in the Water Resources Management (Amendment) Rules, 2012). Communication of mandates between counties and the WRA are also uncertain, with counties drilling boreholes without the benefit of WRA Authorisations and sometimes of poor technical quality (installing mild steel casing/screen in low pH GW environments, for example). Further potential conflict between national and county governments is likely, regarding the sharing of natural resources benefits (cf. the Natural Resources (Benefit Sharing) Bill, 2014 and the Natural Resources (Benefit Sharing) Bill, 2018). The 2014 Bill was shelved, and the 2018 Bill has yet to be debated; both Bills specifically include water resources. Mandates between different state actors are trans-sectoral.

4.5.2.3.2 Inadequate monitoring

Groundwater data quality is patchy, and most groundwater level data is collected from boreholes that are used as production boreholes. All too often, the data shows dynamic as well as static water levels. This restricts the utility of water level data to determine long-term trends. Abstraction monitoring is also done on an ad hoc basis at best; groundwater users are required to submit abstraction data monthly or quarterly as evidence to support their water charge payments, but these are rarely checked in the field by the WRA. Private sector or NGO players may operate their own monitoring networks, such as that operated by Base Titanium Ltd in the South Coast (covering both water levels and water chemistry).

4.5.2.3.3 Unclassified groundwater applications in the PDB

The PDB of the WRA has had challenges, including numerous duplicate or out-of-date entries. When it comes to water permit classification, a decision must be made whether dedicated monitoring boreholes (or piezometers) require a Water Permit. Prior to 2014, applications to construct monitoring boreholes were issued with Authorisations but not Water Permits; since 2014 there has apparently been no requirement for either Authorisations or Permits for monitoring boreholes (diameters <4”/102mm). Furthermore, clarity is also required whether true exploratory boreholes require a Water Permit after completion, if they are not to be commissioned as production boreholes. Finally, the function and application of the Form WRMA 0A3 (Notification Approval for Construction of Work and Use of Water) needs clarification.

4.5.2.3.4 Under representation of small-scale groundwater use

Based on recorded values from the Permit Data Base, only 6% of the domestic water demand appears to be met by groundwater. It is however known that this value is too low. Research in the late 80s from DHV Consultants (1988a) showed that 35% of Kisumu’s rural population rely on groundwater. NWMP 2030 indicates that boreholes in the LVS Basin contribute to 22% of the domestic water demand. The 2015/16 Kenya Integrated Household Budget Survey (Kenya National Bureau of Statistics & Ministry of Devolution and Planning, 2018) shows that 49% of the households in the LVS Basin are reliant on groundwater to meet their needs. Although the percentage for the last case cannot be translated to absolute groundwater volumes, they do all show the growing importance of groundwater for domestic supply in the basin.

Most of the rural groundwater demand is met by shallow wells, hand pumps, community springs small-scale groundwater use. However, the PDB over-looks smaller abstraction volumes from point water sources and focuses on large-scale water users. This is not a fault of the permit process, but the need to drive revenue generation and capture large-scale water users (categories B, C and D) that have the greatest effects on water resources availability, inevitably meaning that category A water users (typically less than 10 m3/d) are more likely to evade capture. This is even more likely in an environment where water sources are exploited without the use of powered mechanical pumps. Furthermore, the public perception of having to pay for water emerging naturally from a spring (protected or otherwise) is likely to encounter push-back. For these reasons and many others, small-scale groundwater use is under represented in the PDB, resulting in a groundwater supply percentage that is far smaller than the actual value.

4.5.3 Water resources infrastructure

Although the LVS Basin has an abundance of surface water resources in comparison to other basins, the absence of large dams and transfer schemes mean that the available water cannot be distributed evenly across the catchment. The key issues regarding water resources infrastructure are described below.

4.5.3.1 Bulk water supply systems and transfers

There is limited infrastructure development for surface and ground water abstraction in the LVS Basin. As a result, there is overdependence on water drawn directly from the rivers, springs and small pans (Water Resources Management Authority, 2015a). The design of large-scale dams is an important part of the basin’s development plan.

4.5.3.2 Irrigation schemes

The LVS Basin has shown a significant increase in irrigation since 2010, however, the total area under irrigation is still less than 1% of the basin. Six large-scale irrigation schemes exist in the basin, relying on water from the major rivers and Lake Victoria, while most of the small-scale irrigation is rain-fed. Given the high agricultural output of the basin, further irrigation schemes are proposed to boost economic development and ensure food security.

4.5.3.3 Water supply network

The water supply and sanitation systems suffer from various issues including losses due to leakages, bursts and blockages, illegal connections, inefficient and wasteful water use and overflow of sewers.

4.5.3.4 Future projects

4.5.3.4.1 Inadequate capacity for infrastructure development

The WRA and the Water Works Department do not have sufficient capabilities and financial resources for the regulatory, monitoring and technical aspects of water resource infrastructure development. The high cost of assessment of potential dam sites inhibits the Water Works Department’s ability to support the development of new reservoirs. There is also inadequate capacity at WRUA level to initiate the development of storage infrastructure.

4.5.3.4.2 Lack of investments into infrastructure development

An article by Business Daily (Wafula, 2010), highlights the issue that potential investors in the water sector are put off by Kenya’s regulatory framework. Investors are hesitant to invest in the high-risk water sector of Kenya where there are no guaranteed payments from consumers.

4.5.3.4.3 Priority areas for groundwater resource development

There is currently inadequate information regarding the groundwater potential across the LVS Basin, and priority areas have not been identified for groundwater resource development.

4.5.4 Hydro-meteorological monitoring network

The current monitoring network in the LVS Basin is inadequate, and the network is not being effectively operated. Inconsistent collection, recording and analysis of data, and as well as vandalism of monitoring stations, are a serious problem in the basin (Water Resources Management Authority, 2015a).

Data management and sharing platforms are not well established, and there is inadequate technical capacity coupled with an oversupply of work that requires data processing, analysis and reporting, beyond the available time of the staff. There is also inadequate maintenance of the gauging stations. Although the WRA continuously rehabilitates and expands the hydromet monitoring network, issues such as ageing, vandalism and flood damage limit progress.

4.5.5 Water allocation and use

A challenge across the LVS Basin is limited water resource availability, particularly in the drier parts where surface water is not as readably available or is contaminated. Managing and enforcing water allocations and use is one of the major challenges in the basin, as described below.

4.5.5.1 Compliance of allocations

Managing and enforcing water allocations and use is one of the major challenges in the Basin, and there is currently inadequate capacity and time in WRA to enforce compliance and to physically collect, record and analyse water resource monitoring data. There is also inadequate monitoring of actual water use for large water users and illegal abstractions taking place which are not monitored and removed.

4.5.5.2 Water distribution

The water supplied in the LVS Basin is distributed unevenly in terms of both spatial and temporal contexts. The areas beyond the jurisdiction of the eight WSPs either have no water infrastructure or receive water through community water projects. These areas rely on a variety of unimproved water sources ranging from rock catchments, springs and wells. Most of these are unprotected and are at risk of contamination. Another issue is the drying of springs, streams and rivers at certain times of the year attributed to unpredictable and unreliable rainfall and increased human activity.

4.5.5.3 Information on allocable water

There is currently inadequate information on surface and groundwater availability for the purpose of water allocation management. Only limited estimates of allocable water are available.

4.6 Institutional issues

4.6.1 Institutional arrangements

Institutional issues ranked third in terms of frequency in the LVS Basin, with resource conflict as the priority sub-issue.

The LVS Basin has an intricate water resources management institutional framework that comprises of public and private sector players who operate at the national or local level. The vibrancy of the stakeholders allows for progress in water resource management on various fronts. However, the disconnect between institutions and operating in silos during policy formulation and implementation amongst other challenges is a huge setback. The following sections expound on institutional challenges being faced in the basin at the national, local and community level.

4.6.1.1 National policies and legislation

4.6.1.1.1 Promulgation of the Constitution (2010)

Kenya's new Constitution (2010) introduced the County Governments structure that was aimed at decentralising some of the national functions to the 47 counties. The Water Act (2016) provides policy direction and relegates catchment management and water supply services to County Governments.

4.6.1.1.2 Conflicting policies, regulations and mandates

The management of natural resources, water included, requires collaboration and alignment between multiple institutions with differing institutional mandates. This complex and multi-stakeholder environment can result in conflicting mandates, policies and regulations. The main underlying cause of the conflicts is siloed planning between the institutions resulting in inadequate alignment of policies and regulations when they are being developed. For example, organisations such as NEMA and Kenya Wildlife Service (KWS) have acts in place which conflict with WRA regulations. Furthermore, NEMA's Physical Planning Act, is not aligned with the WRA regulations. A major issue is the mandates on wetlands and riparian lands. The Physical Planning Act, and Agricultural/Land Acts, hold different definitions to the Water Act regulations as to what constitutes riparian land. This has created mandate conflict on a national level and has also made it easy for people to encroach on riparian land or for developers to bypass the law. Much of the siloed planning has occurred due to lack of platforms at national, regional, and local level aimed at ensuring an integrated approach to governance.

Going forward, there is a need to increase collaboration between government institutions and ensure alignment of government policies, regulations and mandates through the establishment of government wide consultative platforms. These platforms will be essential for facilitating interactions between various institutions and streamlining government priorities and activities in order to avert conflict. Therefore, there is need to carry out a mapping and analysis of key institutions in the national and County Governments, civil and private sectors and their overlapping mandates while identifying opportunities of synergy. A detailed stakeholder analysis should be undertaken at the beginning of the SEA process and should include a governance and institutional assessment of the various institutions and assessment of how these are envisaged to change in the proposed basin plan.

4.6.1.1.3 Revenue collection and resource mobilisation challenges

The LVS basin is struggling to collect revenue from water use charges. In 2014 the WRA had a revenue collection efficiency of 60%. This low revenue collection efficiency can be attributed to a number of factors such as limited metering of users, inadequate capacity to undertake meter readings, incorrect metering and billing of user, a culture of non-payment from users, inefficient billing of users, decline in water permit application and inadequate capacity to enforce punitive measures for non-payment and non-compliance. Therefore, the capacity of the WRA to improve revenue collection efficiency is critical for the effective management of water resources and undertaking of regulatory activities, as well as ensuring that the revenue collected gets ploughed back to improve services and enhance availability of water resources such as through investment in catchment conservation/protection activities.

Currently, WRA is mostly dependent on revenue accrued from collection of water use charges and permit application fees, allocations from the national fiscus and development partner support. These three funding streams have been ineffective in supporting the WRA to comprehensively undertake its mandate. Therefore, there is need to explore innovative additional revenue streams to increase the revenue base such as: (a) Further developing a policy directive/caveat on all future development projects to include a 10-15 % budget to be set aside for conservation of water resources management activities. Such a policy caveat has been developed, and the percentages are the only remaining bit under discussion with the MWSI; (b) Commercialise water testing labs through accreditation; and (c) Establish a Water Payment for Ecosystem Services Scheme anchored on ‘beneficiary pays principle’.

4.6.1.1.4 Non-compliance to effluent discharge regulations

The water quality challenges affecting the basin are a testament of poor compliance to effluent discharge regulations. The main effluent discharge sources are industries and factories (sugar) particularly in Kisumu, Homa Bay and Bomet areas. Dysfunctional sewerage works which discharge raw effluent into water bodies negatively affect river ecosystems. In 2014, 30 major effluent dischargers were registered in the basin of which only 3 complied with the Effluent Discharge Control Plan (EDCP) and were issued with effluent discharge (ED) permits (Water Resources Management Authority, 2015a). The low number of ED permits issued indicates an inadequate capacity to control pollution by enforcing compliance measures with regards effluent discharge regulation as well as low awareness of industries on the regulations for effluent discharge management. Given the widespread water quality challenges affecting the basin, strengthening the capacity of the WRA to enforce effluent discharge regulations, conduct water quality testing and compliance checks is pertinent for reversing the trend of non-compliance amongst effluent dischargers.

4.6.1.2 National institutions

4.6.1.2.1 Uncoordinated institutional roles

The national institutions undertaking natural resource management are not aligned, this has resulted in inefficiencies, confusions over roles and responsibility and the eventual conflict between the organisations. WRA, KFS and KWS all have a catchment protection mandate, which creates conflict when all three organisations have their set roles to fulfil. Similarly, there is conflict between CFAs and WRUAs in terms of forest and water resources management, where the river sources are in the forest which falls under the jurisdiction of the CFAs, while the WRA usually manages the sub catchment outside the jurisdiction of CFAs.

At a local level, there is inadequate coordination between CGs and WRA. This makes it difficult for the WRUAs, whose responsibility lies between that of the CGs and WRA. Also, water and soil conservation are functions that have been devolved to the CGs, while WRA performs regulation of the CG’s management of water resources.

Given the shortage of human resources and financial deficit affecting government institutions, there is a need to improve coordination and create horizonal and vertical coherence across government. The establishment of platforms of engagement at national, regional and local level is pertinent for improving coordination, clarifying roles and responsibilities as well as improving efficiencies amongst government institutions.

4.6.1.3 Basin and sub-basin institutions

4.6.1.3.1 Dormant or potential WRUAs

There are currently 106 existing Water Resource User Associations (WRUAs) in the LVS Basin in 2017, as well as a further 31 WRUAs which have been proposed by the WRA. Given the expanse of the LVS basin, there is a positive WRUA coverage notwithstanding, the remaining WRUAs that need to be urgently established.

Although LVS basin has been impressive in establishing WRUAs, some of these institutions have a myriad of challenges affecting their operational efficiency and ability to perform their mandate. The less developed WRUAs lack human and financial resources. Given the important role WRUAs play in water use conflict resolution, catchment management and the rehabilitation of catchments WRUAs need to be adequately financed through sustainable revenue streams. In addition, they need to be adequately staffed with legal, technical, professional and para technical human resources.

4.6.1.3.2 The unclear role of the BWRCs

There are conflicting mandates for the BWRCs in the Water Act (2016) where they have both advisory and management functions. In reality, both scenarios cannot be implemented at the same time without conflicts and thus only one scenario can work. This implies that there is urgent need to remove this ambiguity. WRA's transition committee is currently addressing this issue and the outcome of this process will inform what function will be adopted by the BWRCs. Additionally, the Act stipulates that BWRCs can delegate some of their functions to the WRAUs, the BWRCs are not independent legal entities which poses a set back on their ability to enter into contracts with the WRUAs. This issue needs to be resolved.

4.6.1.3.3 Expansive area of jurisdiction

The LVS Basin is divided into nine Catchment Management Units (CMUs) based on common characteristics, managed by three SROs and with the WRA RO located in Kisumu. Admittedly the LVS has a small land area in relation to the Tana or Ewaso Ng'iro North Basins however, this does not take away from the reality that the whole basin is served by only three offices. Issues of understaffing, inadequate vehicles, insufficient monitoring infrastructure and limited financial resources affect these offices thus making it difficult for the WRA to effectively manage the entire basin.

4.6.1.3.4 Inadequate institutions in forestry sector

The inadequate institutions arise from weak governance structures and inadequate capacity for law enforcement and weak stakeholder participation in forest management and governance. This is exacerbated by inadequate funding of the forestry sector from the exchequer, civil and public sectors. Since the enactment of the new Constitution in 2010, nationally and within the basin, the level of public support to the conservation of forests has increased significantly but has not been matched by an equal measure of resource allocation in all sectors. For example, the Forest Management and Conservation Fund (FMCF) established in the Forests Act 2005 and the Forest Conservation and Management Act No.34 2016 to promote the development of forests, maintenance and conservation of indigenous forests, the promotion of commercial forest plantation, provision of forest extension services, the establishment of arboreta and botanical gardens, and a variety of other purposes outlined in Forest Act is yet to be fully operationalised.

Furthermore, there are conflicting institutional mandates as is evident from the overlapping mandates, programmes, projects, and conflicting policies and legislation. Overall, forest conservation has witnessed increased cases of political interference in the management of forests, poor governance as well as inadequate and/or weak structural/institutional capacity for forest law enforcement and governance.

4.6.1.4 County Governments

4.6.1.4.1 Governance issues

Water resources management decisions in Kenya are often influenced by political agendas, which are not always aligned with scientific, engineering and resource realities. This creates unrealistic expectations and often leads to frustration. Furthermore, there is sometimes a misconception that WRA acts as a barrier to people's desire to get access to water resources. This in return occasionally creates animosity amongst community members towards WRA, which can negatively impact WRA's activities on the ground. Another instance of political opportunism involves politicians announcing unrestricted access to water, which for example results in people drilling illegal boreholes.

4.6.1.4.2 Inadequate coordination

Since 2013, Kenya has had a devolved system of government and one of the components of this is counties planning their own land independently of each other. This has contributed to improved allocation of resources however; it has led to siloed and fragmented planning between county government with regards to the management and development of natural resources such as land and water. There is need for policy action to ensure integration of planning and decision making at all levels in order to reduce inefficiencies for cross-cutting activities between county governments.

Inadequate coordination also exists between county governments and national departments as well as national agencies responsible for natural resource management. Inadequate coordination has been perpetuated by the limited priority placed on intergovernmental relations and cooperative governance between the different spheres of government. County Executive Committees draw membership from Government platforms, and these current platforms that aim at improving intergovernmental relations should be strengthened, to ensure horizontal and vertical coherence across spheres of government.

4.6.1.5 Partnerships and engagement

4.6.1.5.1 Inadequate partnerships

There are relatively few partnerships operating in the basin, the existing partnerships are externally driven and are formed between national government and respective agencies with international donors. Due to the nature of these partnerships, they often have a specific aim which at times does not effectively address local needs. For example, the internationally driven partnership between KIWASCO and NAWASSCO (water utilities serving Kisumu and Nakuru towns) with the European Union (EU) (funder), Vitens Evides International; Hoogheemraadschap de Stichtse Rijnlanden, SNV Netherlands Development Organisation and Sustainable Aid in Africa International was aimed at improving asset management practices for (waste) water treatment facilities and (collection) distribution networks. Although the partnership gained successes it was more top down rather than bottom up. Localised bottom up partnerships are lacking in the basin as a result, more efforts need to be made in supporting the establishment of partnerships and the mobilisation of resources to support partnership activities.

4.6.1.5.2 Inadequate coordination between stakeholders

There is currently inadequate coordination between catchment stakeholders and as a result it is challenging to establish strong partnerships and undertake meaningful engagements. There is inadequate coordination between national and local government, inadequate coordination amongst government institutions operating at a local level, inadequate coordination between government institutions with the private sector and civil society organisations.

The inadequate coordination between the WRA, WRUAs and the County Governments leads to siloed planning, inefficiencies, poor urban planning and uncontrolled development. In addition, it affects the way development and environmental trade-offs from developments are managed. Improved coordination between stakeholders is much needed to create alignment in the protection of natural resources and socio-economic development.

4.6.1.5.3 Low public awareness of WRA’s mandate

There is generally a low public awareness of the WRA’s mandate in the basin. Inadvertently the inadequate awareness has translated into minimal stakeholder participation in water resource management. In 2014 the basin had approximately 98 stakeholders participating in water resource management through WRUAs and CAACs (Water Resources Management Authority, 2015a). There is urgent need to create awareness and understanding of WRA mandate as a regulator through activism and engagement with other partners, articulate WRA’s functions well, demonstrate ways of measuring results achieved, package those results in ways attractive to different stakeholders in the basin.

4.6.2 Enabling environment

The CMS for the LVS basin (Water Resources Management Authority, 2015a) identifies inadequate capacity (number of staff, staff skills and equipment/funds) at the Regional and Sub-Regional levels of the WRA as the key enabling environment issue affecting effective water resource and catchment management. Therefore, strengthening the capacity of the WRA to deliver its core functions is pertinent for operational efficiency.

4.6.2.1 Financial resources

The WRA is sitting with a funding gap of KES 819 million as is not receiving sufficient money from national government to undertake operations and it is not collecting enough through water use charges and permit application fees to cover operational functions. The gap in financing affects the operational activities and consequently the quality and quantity of outputs by the Authority. The WRA therefore needs to broaden the financing pool and tap into alternative modes of financing. Opportunities that exist within the sector with regards to financing water and sewerage infrastructure include:

- Donor finance – there exist several international organisations that supports this sector. Projects like KIWASH, WSUP are opportunities that can be explored in bridging the financing gap.
- Market finance – Commercial banks are currently supporting water utilities in expansion activities. This initially happened under Output Based Aid and has supported several water utilities. The water utility must demonstrate that it is commercially viable to benefit from the loan facility.
- Water Sector Trust Fund – The Water Sector Trust Fund targets to improve service in pro-poor areas. The water utilities can take advantage of this facility to increase access to services in low income areas where the population is limited by the ability to pay for connection to services.
- Public Private Partnership – The sector in recognition of the financing gap and the need to achieve vision 2030 has embraced PPP arrangement.

In addition, there are programmes by international banks that target the sector under special conditions such as the Kenya Towns Sustainable Water and Sanitation Program being implemented by the African Development Bank Group.

4.6.2.1.1 Inadequate office space and equipment

Some of the issues facing the LVS Basin include limited office space coupled with a minimal office equipment (desks, computers, servers, printers) as well as limited water resource data collection and monitoring equipment. The new WRA laboratories in Kisumu RO are in the Lake Victoria South Water Works Development Agency building, indicating an inability for the WRA offices in Kisumu to accommodate such a facility. Data collection tools/equipment and infrastructure at gauging stations are often in need of maintenance, repair or upgrade, e.g. survey equipment, meter readers, water quality monitoring equipment and manual data collection tools. The short comings relating to monitoring equipment are further compounded by vandalism of monitoring stations and inadequate maintenance and calibration of instruments.

4.6.2.1.2 Inadequate vehicles and/or fuel

The LVS basin has as a cumulative total of 8 vehicles, with the RO and SRO all having two vehicles each. The current vehicle fleet doesn’t support effective delivery of services particularly water quality testing, collection of surface and groundwater data and for conducting compliance and enforcement activities. The lack of vehicles affects the ability of the WRA to conduct daily activities aimed at improving water resource management in the catchment. The lack of vehicles inadvertently contributes to lack of visibility of the WRA in the basin therefore, low public awareness.

4.6.2.1.3 Inadequate laboratory facilities

The basin’s newly constructed laboratory facilities are in the Kisumu RO which is far from the Kisii SRO and the Kericho SRO. Laboratory facilities should be constructed for the SRO in order to ensure that each regional office is able to conduct surface and groundwater assessments easily without having to travel far.

4.6.2.2 WRA staffing capacity

The WRA has a staff complement of 94 employees across the RO and the SRO in the LVS basin distributed as follows: Kisumu RO (30); Kisumu SRO (23) Kisii SRO (20) and Kericho SRO (21). Capacity gaps exists in senior management and administrative cadres, professional areas including technical i.e. water quality monitoring, lab technicians. Understaffing affects the operational efficiency of the WRA, therefore the capacity of the WRA needs to be improved by upskilling and reskilling existing staff, undertake training of staff and employment of new staff.

4.6.2.3 Enforcement capacity of WRA

Oversight and enforcement capacity of the WRA in the LVS basin is weak as the WRA is struggling to control pollution from effluent dischargers as well as reduce illegal abstractions. The inadequate enforcement capacity is likely due to a lack of a fully capacitated localised compliance and enforcement unit to immediately respond to unlawful activities. Currently, compliance and enforcement is a centralised function operating from HQ with the legal department taking the lead. The legal department has approximately trained 17 legal prosecutors drawn from various departments such as water rights. Subsequently, the number of trained legal prosecutors keeps reducing as some of the members have retired and others are going to retire soon. Therefore, greater importance should be placed on employing new staff to undertake compliance and enforcement activities at a localised level as well as upskilling existing staff’s skills to undertake compliance and enforcement activities. Having localised compliance and enforcement units is important for improving the footprint and efficiency in responding to unlawful activities.

4.6.2.4 Implementation ability/capacity

The basin’s CMS was developed shortly after the gazettement of the 2002 Water Act. Whilst, several years have lapsed since the development of the catchment strategy (Water Resources Management Authority, 2015a), progress in implementing strategic actions coming out of the strategy has been slow. The main constraints to implementing strategic actions has been inadequate human and financial resources. Strengthening the capacity of the WRA to improve implementation of strategies will require an assessment of the specific bottlenecks with regards to human and financial resources that are affecting the implementation of long-term plans and the development of corrective measures. In addition, proper monitoring and evaluation platforms for strategic actions of the CMS need to be developed in order to improve performance and achieve results.

4.6.2.5 Capacity of other institutions

There are a range of capacity challenges affecting other institutions operating in the basin. Capacity challenges include limited technical staff, inadequate facilities and infrastructure as well inadequate compliance and enforcement capacity. KFS, NEMA, KWS, KWTA and County Governments are just some of the institutions that are facing capacity constraints. The deterioration of wetlands indicates a capacity gap within NEMA regarding oversight on wetlands including inadequate capacity to enforce compliance measures. Some of the wetlands and riparian zones in the basin have suffered degradation through human encroachment for settlement, expansion of crop production, urbanization, livestock grazing, and commercial activities.

4.6.2.6 Capacity in WRA to deal with drought related disasters

The LVS basin has experienced periodic droughts which have resulted in death of livestock, drying of small rivers, shortage of water resources which in turn exacerbated human and wildlife conflicts. The regions that have been most affected by periodic droughts include Migori, Bomet, Narok, and parts of Kisumu. Currently the basin does not have capacity to deal with drought related disasters, this is largely due to the fact that a holistic drought management programme has not been developed, water use restriction during times of drought for water use sectors have been set, water use restrictions on major reservoirs have not been set and there are no early drought warning systems. In addition, some of the flood and drought management strategies detailed in the CMS (Water Resources Management Authority, 2015a) have not been implemented. Given that with climate change there will be an increase in prolonged periodic droughts there is a need to improve the capacity of the LVS basin to mitigate against drought related disasters.

4.6.2.7 Capacity in WRA with regards to flood mitigation

The LVS basin tends to be reactive and implements mitigation measures in the wake of flood related disasters, clearing indicating inadequate capacity to respond to flood related disasters before they occur. There is currently no systematic flood management taking place in the basin, a holistic mapping of flood prone areas in the basin has not been undertaken, existing flood control measures particularly structural measures are lacking and there is a need to construct multipurpose storage facilities. Furthermore, non-structural measures such as early warning systems have not been implemented in some areas. Although, Integrated Flood Management Plans have been developed for the Nyando River Basin (2009), Guchs-Migori (2014) and Awach-Kano (2016), there is limited human and financial resources in order operationalise these strategies.

4.6.2.8 Capacity to enforce reserve flows

The WRA offices in the LVS basin are understaffed, have limited compliance and enforcement capacity and struggle with over abstraction incidences. It therefore follows that the WRA struggles to enforce reserve flows. Moreover, WRA has undertaken only minimal reserve determination of all water resources of the basin in order to be able to monitor abstractions and ensure that the issuance of water use permits is in line with the reserve.

4.6.2.9 Capacity of WRA with regards to climate change adaptation strategies

The Government of Kenya has developed the NAP. The issue arises with inadequate knowledge and ability to implement these adaptation strategies at a local and basin level due to insufficient staff capacity. The current staff complement of the WRA does not include climate adaptation technical staff, and there is a lack of evidence suggesting that the current staff complement has been upskilled and trained in developing and implementing climate adaptation strategies. There is also a lack of funding and investments for implementing climate strategies in the basin.

4.6.3 Transboundary and trans-county issues

4.6.3.1 Inter-basin transfers

There are currently no inter-basin and intra-basin transfers in the LVS Basin. However, with the completion of Itare and Londiani there will be an inter-basin transfer of 41 MCM/year to Nakuru to support domestic use. There is also a planned inter-basin transfer of 82 MCM/year from Amala Dam to the Rift Valley Basin (Water Resources Management Authority, 2013). The transfer will support domestic use, irrigation and hydropower generation in the Rift Valley. The Itare dam is set for completion in 2021, however the construction of the dam has been met with some opposition. Elders from the Kipsigis, Luo, Kuria, Abagusii and Ogiek communities were opposed to the project in Nakuru County. The elders complained that the project would directly affect water supply to their counties and render their lands dry (Matheka, 2019). Furthermore, there is also the planned Nandi Forest Dam Project in LVN, which will transfer water into the LVS Basin for irrigation development, while generating hydropower.

4.6.3.2 Internationally shared water resources

Lake Victoria is a shared water resource between Kenya, Tanzania and Uganda, and all three countries depend on the lake as a source of water supply, hydropower and livelihood. The trans-boundary nature of the water resources in the LVS Basin presents a challenge for the protection of the resources and collaboration with trans-boundary stakeholders is essential to managing conflict. At present there are conflicts between Kenya and Uganda over the ownership of Migingo Island. The Island is abundant with fish stock which is the main drawcard for fishermen from the two nations. Whilst the countries are co-managing the Island, there are signs that the Ugandan government might have more political influence over the Island. Kenyan citizens wanting to fish on the Island need to apply for a permit from Uganda and the Ugandan flag is the only one hoisted on the Island.

There are transboundary conflicts between Kenya and Tanzania over the management and use of water in the Mara River Basin. The Mara river rises in the Mau forests of Kenya, flows through world-famous savannah rangelands; in Tanzania it forms a floodplain wetland – the Mara wetland – before discharging into Lake Victoria in Tanzania. Around 65% of the river basin is located in Kenya and 35% in Tanzania (WWF-UK, 2017).

There is increasing demand on the Mara's water resources, and more water is being abstracted from the river. Inadequate coordinated water resources management between Kenya and Tanzania, and the lack of an agreement for the transboundary flow of the Mara river, compounds this problem. Unless an agreement is negotiated soon there is a real danger that the cross-border dry season flow will be reduced to a trickle, potentially leading to an international dispute.

Water quality in the Winam Gulf area of Lake Victoria has declined due to water pollution and eutrophication and water hyacinth infestation blocks major navigation routes, interferes with fishing, hampers water abstractions and threatens the lake ecology. The decline in water quality in the lake could potentially lead to conflict between the countries utilising the Lake Victoria's water.

4.6.3.3 Trans-county conflict

There have been cross-county conflicts between the Nandi and Kisumu Counties over arable land and water resources. Similarly, conflicts over water have been noted between Bomet /Narok and Kericho. There are disputes between the upstream and downs stream users over the use of rivers from the Mau Forest. There is a belief that the upstream users are over abstracting and affecting the flow of water for the downstream users.

4.6.3.4 Land and resource conflict

Gaining access to arable land for grazing and farming within proximity of adequate water resources has resulted in conflicts between some communities in Bomet /Narok and Kericho.

Image source: Patrick Shepherd/CIFOR 2017 'A river running through the Mau Forest'. Available online at https://www.flickr.com/photos/cifor/36978973483nagarjun/42810877592/

Vision and Scenario Evaluation

5 Vision and Scenario Evaluation

5.1 Introduction

In light of an improved understanding of the current situation in the LVS Basin as described in Sections 2 to 4, this Section presents the Vision for the LVS Basin along with scenarios and evaluations towards identifying a sustainable development pathway for the basin which is aligned with the Vision.

5.2 Vision for LVS Basin

A Vision for the LVS Basin was developed in conjunction with stakeholders and reads as follows:

A sustainably conserved and climate resilient basin providing equitable ecosystem services through integrated water resources management by 2040

5.3 Conceptual approach towards the evaluation of water management interventions

Scenario analysis provides a structured method of thinking about possible future options, opportunities and risks, and how these might interact. The results are useful for consensus building and decision making. Furthermore, it augments the understanding about the future by highlighting issues and exposing underlying forces in a sector or geographic region that would otherwise not be considered.
Within a basin planning context, a scenario is defined as a contemplated future state of the basin, induced either through targeted human intervention (e.g. combinations of development and management interventions) or through externalities (e.g. climate change, economic policies etc.). Development interventions and/or management options form the basis of alternatives, which are expressed in the form of different scenarios.

Figure 5-1 presents a typical six step conceptual approach towards the evaluation of water management interventions.

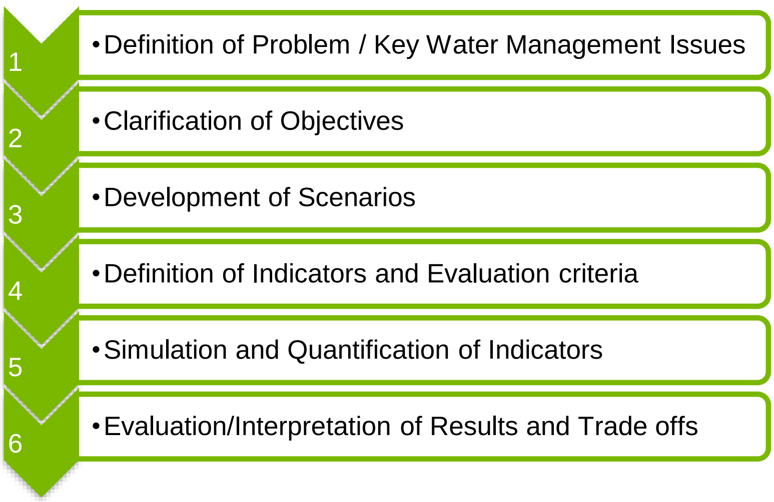


Figure 5-1: Scenario Evaluation (adapted from Kusek & Rist, 2004 and World Bank, 2008)

The key aim of the LVS Basin Plan was to provide a pathway towards a future which achieves a sustainable balance between utilisation and development of water resources and the protection of the natural environment, i.e. minimising negative environmental and social impacts and maximising socio-economic benefits, taking into consideration the availability of water.

The approach adopted by this Study is illustrated schematically in Figure 5-2 below. The interventions and drivers are the key variables which constitute scenarios. Each scenario produces a set of indicators and scenarios are then compared through their indicators using multi-criteria analysis. Through evaluation of the results, a sustainable development pathway was identified.

Evident from Figure 5-2 is the use of analytical tools at various key stages throughout the scenario development and evaluation process. These tools included erosion models, climate change analysis tools, surface water resources models, groundwater assessment tools, environmental flow assessment tools and multi-criteria analysis tools. Detailed descriptions of the analytical tools are provided in **Annexure A.**

5.4 Interventions and drivers

To build scenarios, several key interventions and drivers were identified and incorporated into the scenario analysis in different combinations, constituting the key "building blocks" or variables of the defined scenarios. These include climate change impacts on water availability and water use, land use management, the anticipated growth in future water requirements, potential local water supply and large-scale water resources developments, the degree of compliance with environmental flows and possible institutional interventions. To align with the issues discussed in Section 4, the "building blocks" for the scenarios were categorised into biophysical, socio-economic, water resources and institutional interventions and drivers.

5.4.1 Biophysical

5.4.1.1 Land management

The erosion risk tool which was developed as part of this Study was used to quantify erosion risk and potential sediment yields and loads in relation to changes in vegetation (forestry) under different scenarios.

5.4.1.2 Climate change impacts

The impacts of climate change on future precipitation and temperature within the LVS Basin were superimposed on the hydrological models of the basin representing different scenarios, to assess how the change in climate translates into changes in surface water runoff, groundwater availability and crop water requirements.

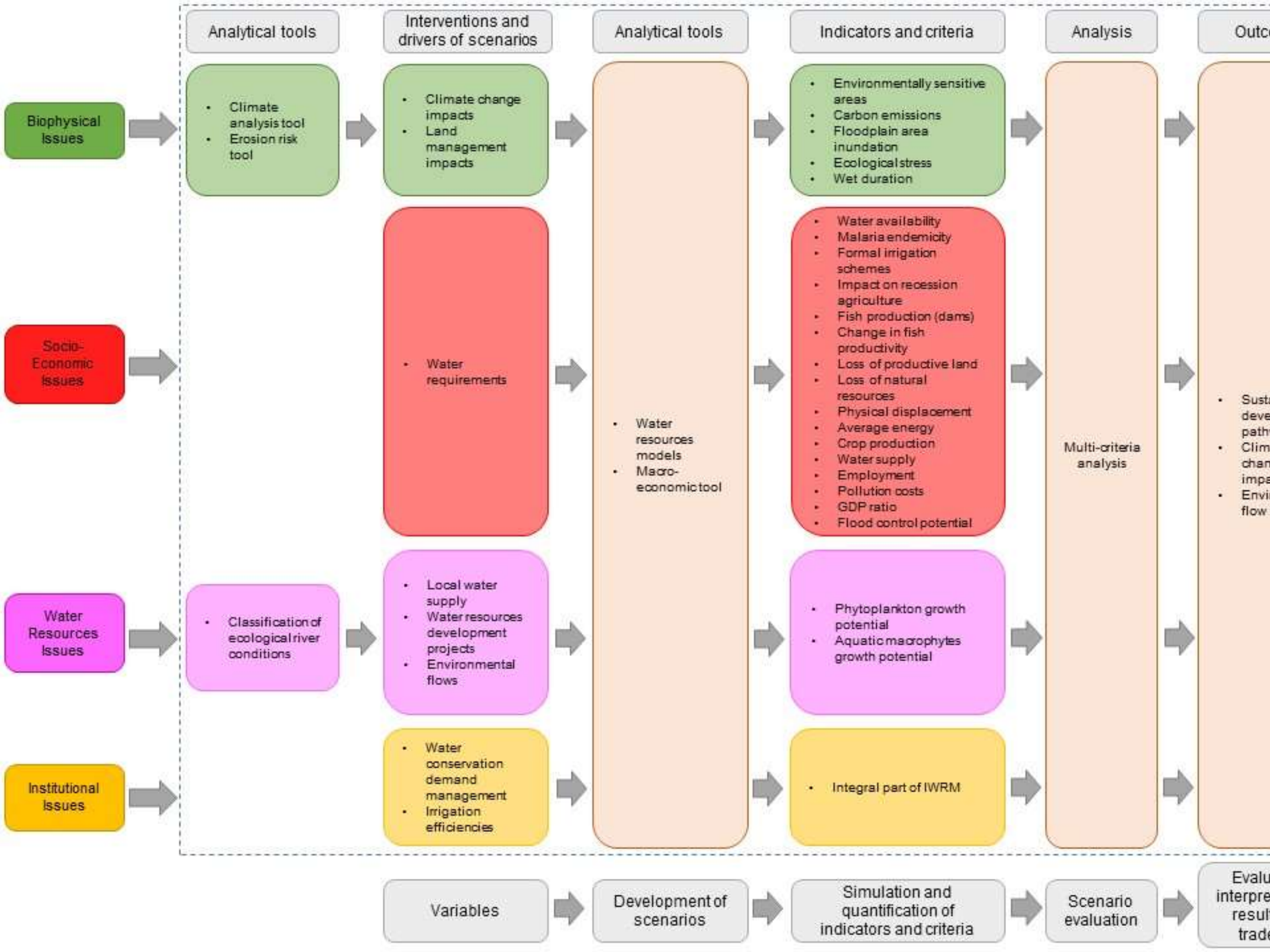


Figure 5-2: Approach to scenario development and evaluation

5.4.2 Socio-economic

5.4.2.1 Future water requirements

A key driver in the development of future scenarios in the LVS Basin relates to the expected growth in future water requirements. To estimate future (2040) water requirements in the LVS Basin, the following approach was used:

5.4.2.1.1 Irrigation water requirements

To estimate future (2040) small-scale irrigation areas in the LVS Basin, the baseline (2018) small-scale irrigation area in each sub-basin was extrapolated linearly to 2040 based on the projected growth factor in small-scale irrigation areas between 2010 and 2030 as presented in the NWMP.

The growth in large-scale irrigation area up to 2040 in the LVS Basin was based on the expected growth in large-scale irrigation as per Table 5-3 - validated with the Department of Irrigation at the Ministry of Agriculture, Livestock and Fisheries. Only schemes with proposed areas larger than 2000 ha were considered as large-scale. Planned schemes with areas below 2000 ha were included in the small-scale irrigation areas as determined per sub-basin.

To estimate future (2040) small-scale irrigation water requirements, crop types, crop patterns and cropping intensities were assumed to be similar to current conditions. For planned large-scale schemes, information on crop types was sourced from the NIA. Using the FAO 56 approach, future irrigation water requirements could be estimated per sub-basin for different growth and irrigation efficiency scenarios.

5.4.2.1.2 Domestic and Industrial water requirements

For estimates of future domestic and industrial water demands in the major urban centres as well as the smaller towns and rural areas in the LVS Basin, information per sub-basin was sourced from the NWMP and CIDPs as relevant.

The NWMP estimated 2030 water demands based on expected population growth in urban and rural areas, assumptions with regard to design water consumption rates, and future target levels of coverage in terms of different water supply systems. Baseline (2018) demands were therefore extrapolated to 2040 demands, based on projected growth factors between 2010 and 2030 as presented in the NWMP.

5.4.2.1.3 Livestock and wildlife water requirements

Current estimated livestock and wildlife water demands in the LVS Basin were extrapolated to 2040 based on observed trends. Growth factors were calculated per sub-basin using data from the NWMP.

5.4.3 Water resources

5.4.3.1 Local water supply

As evident from Section 2.4, there are still surface water resources available in some sub-basins which can be used to address current and future local supply deficits. However, utilising this water optimally will require storage in dams and pans. Similarly, based on the groundwater analysis conducted as part of this study, groundwater resources are still available for allocation in some sub-basins.

The provision of additional surface water storage in dams and pans in conjunction with local groundwater development to improve water availability to local domestic, industrial, small-scale irrigation and livestock demands at sub-basin scale, was considered as part of the scenario development. Required surface water storage and sustainable groundwater abstraction volumes were estimated with the use of the water resources system model and groundwater assessment tool.

5.4.3.2 Potential water resources development projects in the LVS Basin

Strategic and master plans at national, regional and local level by the Water Resources Authority, Regional Development Authorities, Water Works Development Agencies, Counties, the NIA, the National Water Harvesting and Storage Authority, relevant ministries and other national agencies and stakeholders identified several potential water resources projects in the LVS Basin. These include surface water storage for water supply and flood control, irrigation development, hydropower development, inter and intra-basin transfers, and groundwater development schemes. For the purpose of this Basin Plan, information on water resources development schemes in the LVS Basin, which represent potential projects for implementation within the next 20 years (i.e. by 2040), were extracted and used as input for the definition of scenarios. These projects include dams and hydropower, inter- and intra-basin transfers and large-scale irrigation schemes as listed in Table 5-1,

Table 5-2 and Table 5-3 respectively. Only dams greater than or equal to 1 MCM are considered large-scale, while irrigation schemes greater than or equal to 2 000 ha are considered large-scale.

Table 5-1: Potential water resources development projects - dams and hydropower

Dams and Hydropower				
Name	**Sub-basin**	**County**	**Proposed Storage (MCM)**	**Purpose**
Amala	1LB1	Narok, Bomet	175	Water Supply (Bomet and Narok Counties) Transfer to Rift Valley Basin Large scale irrigation (Amala Irrigation)
Sand River / Naikara	1LA3	Narok	1	Water supply (Narok County)
Magwagwa	1JG	Nyamira	445	Water supply (Nyamira, Homa Bay and Kisii counties) Large scale irrigation (Kano Plain Irrigation) Hydropower (115 MW) Flood control
Itare	1JA	Nakuru	20	Water Supply (Nakuru and Bomet Counties) Transfer to Rift Valley Basin
Londiani	1GC	Kericho	25	Water Supply (Londiani, Kipekerion) Transfer to Rift Valley Basin
Nyando / Soin-Koru	1GD1	Kericho, Kisumu	87	Water supply (Kisumu, Ahero, Awasi, Muhoroni, Chemelili) Large scale irrigation (Nyando Irrigation, Ahero and West Kano Irrigation) Flood control
Kibos	1HA	Nandi	26	Water supply (Kisumu) Flood control
Bunyunyu	1KB	Kisii	6.3	Water supply (Awendo, Kisii, Suneka, Tabaka, Rongo, Ogembo, Kereko, Nyansiongo)
Gogo Falls	1KB	Migori	464	Large scale irrigation (Lower Kuja Irrigation) Hydropower (15 MW)
Ilooiterre	1KC	Narok	14	Water Supply (Kehancha, Migori) Large scale irrigation (Ilooiterre Irrigation)
Nandi Forest	1FD	Nandi	220	Water supply and Flood Control (Kisumu); Large scale irrigation (LVS), Hydropower (50MW)
Bosto	1JE	Bomet	30	Water Supply (Bomet County)

Table 5-2: Potential water resources development projects - transfers

Scheme	Counties	Avg. Transfer Volume	Purpose
Londiani Dam to Itare Dam Itare Dam to Rift Valley	Nakuru	41 MCM/a	Water Supply (Rift Valley Basin)
Amala Dam to Rift Valley	Narok	82 MCM/a	Hydropower (Rift Valley Basin) Irrigation (Rift Valley Basin)

Scheme	Counties	Avg. Transfer Volume	Purpose
Nandi Forest Dam to LVS	Nandi	189 MCM/a	Hydropower (LVS) Water Supply (LVS) Irrigation (LVS)

Table 5-3: Potential water resources development projects - large-scale irrigation

Large-scale irrigation				
Scheme	**County**	**Proposed Area (ha)**	**Crop type**	**Source**
Nyando	Kericho	3 000	Maize, sorghum	Nayndo / Soin-Koru Dam
Nandi Forest	Kisumu	7 300	Horticulture, sugarcane	Nandi Forest Dam (Transfer from LVN)
Lower Kuja	Migori	10 000	Maize, rice, fruit trees, sorghum	Gogo Falls Dam
Amala	Bomet	5 000	Maize, sorghum	Amala Dam
Ilooiterre	Narok	3 000	Maize, sorghum	Ilooiterre Dam
Ahero / West Kano	Kisumu	5 150	Rice	Run-of-river (Nyando River)
Kano Plain	Nyamira/Kericho	15 000	Maize, sorghum	Magwagwa Dam
Kisumu Clusters	Kisumu	3 660	Maize, sorghum	Run-of-river (Nyamasaria River)
Nyabomite	Nyamira	2 020	Maize	Run-of-river (Charachani/Eaka River)

5.4.3.3 Environmental flows

Three alternatives regarding environmental flows were considered and incorporated into scenario development viz. no environmental flows, using Q95 as a constant minimum environmental flow and implementing variable “holding e-flows” as opposed to Q95 (refer to **Annexure A5**).

5.4.4 Institutional

5.4.4.1 Water conservation and demand management

Water conservation and demand management interventions were considered which reduced future water requirements.

5.4.4.2 Irrigation efficiencies

The inefficient water use by irrigation schemes was addressed in the scenario development by improving the irrigation efficiencies of both large scale and small-scale irrigation schemes.

5.5 Scenario definition

To evaluate the potential impacts and benefits of different development and management alternatives in the LVS Basin, towards identifying a sustainable development pathway, various scenarios representing a possible 2040 future were defined and analysed using the analytical tools. For each scenario, a separate MIKE HYDRO Basin model was configured reflecting the specific rainfall-runoff characteristics in relation to climate change, various degrees of infrastructure development, water demands under different development levels and climate impacts, and predefined environmental flow requirements. In addition, the erosion risk and sediment yield tool was used to estimate potential sediment yield and cumulative sediment loads under each scenario.

Table 5-4 summarises the main development and management interventions incorporated in each scenario.

5.5.1 Scenario 0: Baseline

The Baseline Scenario represents the current (2018) conditions in the LVS Basin and provides a baseline against which future scenarios are evaluated. The scenario reflects existing water resources development and infrastructure, current water demands, no climate change impacts and also assumes non-compliance with the Q95 Reserve due to lack of monitoring and enforcement.

5.5.2 Scenario 1: Lack of funding / Business as usual with irrigation development

This scenario represents the “do nothing” case - a possible worst-case scenario. It assumes that there is no further investment in water resources infrastructure and development including large-scale irrigation. Yet, growth in water demands up to 2040 across all sectors are assumed to be in line with projections (urban, domestic, industrial, livestock, small-scale irrigation). A continuation of the deteriorating trend in terms of vegetation loss in the catchment is also assumed (10% reduction by 2040 due to deforestation and overgrazing). Similar to Scenario 0, non-compliance with the Q95 Reserve due to inadequate monitoring and enforcement is assumed. Climate change impacts are incorporated in the water resources model.

5.5.3 Scenario 2: Full development

The full development scenario is the same as Scenario 1, except that funds are now available to implement all of the major dams and large-scale irrigation schemes as identified in various studies and plans and by stakeholders. In essence this scenario evaluates the availability of water and the ability of the identified storage and transfer schemes to reliably supply future demands, specifically the significant large-scale irrigation and the projected increase in urban and rural demands. It evaluates the trade-off between potential socio-economic benefits due to the water resources developments, and negative environmental and social impacts. As funds are now available, compliance with Q95 as the ecological reserve is assumed. However, similar to Scenario 1, vegetation loss at 10% across the catchment is still assumed due to the focus on large scale development in the basin.

Two sub-scenarios were defined under Scenario 2:

- Scenario 2A: With climate change impacts
- Scenario 2B: Without climate change impacts

5.5.4 Scenario 3: Sustainable development

This scenario represents a scaled-back version of Scenario 2 towards a sustainable development future, i.e. balanced water resources development which limits environmental and social impacts yet provides meaningful socio-economic benefits linked to the development of water resources with a reliable supply of water. This scenario aims for reduced sediment through reforestation, the successful implementation of a 20% reduction in future urban demands through water demand management, a reduction in large scale irrigation areas which are unproductive, and improved irrigation efficiencies.

The criteria which were adopted for the sustainable development of water resources in the LVS Basin include:

- Improving the assurance of supply to above 90% for urban, domestic and industrial users, taking into consideration the projected increase in water demand by 2040

- Improving and/or maintaining a high supply reliability for irrigation and livestock users, compared to the current (baseline) supply reliability, taking into consideration the projected increase in irrigation areas and livestock numbers by 2040
- A 10% improvement in forested area by 2040
- Successful implementation of a reduction in future urban demands through water demand management (-20%)
- Improved irrigation efficiencies: 60% for small scale and 80% for large-scale schemes

Three sub-scenarios were defined under Scenario 3:

- Scenario 3A: With Q95 as environmental flow requirement
- Scenario 3B: With EFlow holding flows as environmental flow requirement
- Scenario 3C: Same as 3A, except:

– Amala Dam and Sand River Dam releasing EFlows as minimum environmental flow releases to mitigate the environmental impact in the Mara River downstream

– Amala Irrigation Scheme no longer implemented to mitigate potential water quality and quantity impacts in the Mara River downstream

– Areas of proposed run-of-river irrigation schemes reduced:

  - Ahero / West Kano: New area 4 150 ha
  - Kisumu Clusters: New area 0 ha
  - Nyabomite: New area 1 000 ha

– Londiani Dam to Itare Dam transfer no longer implemented. Instead Londiani Dam will transfer water to sub-basin 1JC to meet future demands of Kericho.

– Bosto Dam no longer implemented due to environmental concerns.

– In addition, it assumes that smaller dams and pans as well as groundwater abstraction will be implemented at local/sub-basin level to alleviate domestic, livestock and small-scale irrigation water shortages during the dry season.

Table 5-4: Scenario definition

Category	Type	Scenario						
		0	1	2A	2B	3A	3B	3C
Water resources development	Large dams	Sondu-Miriu (1 MCM)	Sondu-Miriu (1 MCM)	Sondu-Miriu (1 MCM)	Sondu-Miriu (1 MCM)	Sondu-Miriu (1 MCM)	Sondu-Miriu (1 MCM)	Sondu-Miriu (1 MCM)
				Amala (175 MCM)	Amala (175 MCM)	Amala (175 MCM)	Amala (175 MCM)	Amala (175 MCM)
				Sand R/Naikara (1 MCM)	Sand R/Naikara (1 MCM)	Sand R/Naikara (1 MCM)	Sand R/Naikara (1 MCM)	Sand R/Naikara (1 MCM)
				Magwagwa (445 MCM)	Magwagwa (445 MCM)	Magwagwa (445 MCM)	Magwagwa (445 MCM)	Magwagwa (445 MCM)
				Itare (20 MCM)	Itare (20 MCM)	Itare (20 MCM)	Itare (20 MCM)	Itare (20 MCM)
				Londiani (25 MCM)	Londiani (25 MCM)	Londiani (25 MCM)	Londiani (25 MCM)	Londiani (25 MCM)
				Nyando/S Koru (87 MCM)	Nyando/S Koru (87 MCM)	Nyando/S Koru (87 MCM)	Nyando/S Koru (87 MCM)	Nyando/S Koru (87 MCM)
				Kibos (26 MCM)	Kibos (26 MCM)	Kibos (26 MCM)	Kibos (26 MCM)	Kibos (26 MCM)
				Bunyunyu (6 MCM)	Bunyunyu (6 MCM)	Bunyunyu (6 MCM)	Bunyunyu (6 MCM)	Bunyunyu (6 MCM)
				Bosto (30 MCM)	Bosto (30 MCM)	Bosto (30 MCM)	Bosto (30 MCM)	
				Gogo Falls (464 MCM)	Gogo Falls (464 MCM)	Gogo Falls (464 MCM)	Gogo Falls (464 MCM)	Gogo Falls (464 MCM)
	Hydropower	Sondu Miriu (60 MW)	Sondu Miriu (60 MW)	Sondu Miriu (60 MW)	Sondu Miriu (60 MW)	Sondu Miriu (60 MW)	Sondu Miriu (60 MW)	Sondu Miriu (60 MW)
		Sangoro (21 MW)	Sangoro (21 MW)	Sangoro (21 MW)	Sangoro (21 MW)	Sangoro (21 MW)	Sangoro (21 MW)	Sangoro (21 MW)
		Gogo Falls (2 MW)	Gogo Falls (2 MW)	Gogo Falls (15 MW)	Gogo Falls (15 MW)	Gogo Falls (15 MW)	Gogo Falls (15 MW)	Gogo Falls (15 MW)
				Magwagwa (115 MW)	Magwagwa (115 MW)	Magwagwa (115 MW)	Magwagwa (115 MW)	Magwagwa (115 MW)
	Intra-basin transfers			Londiani to Itare (8 MCM/a)	Londiani to Itare (8 MCM/a)	Londiani to Itare (8 MCM/a)	Londiani to Itare (8 MCM/a)	Londiani to Itare (8 MCM/a)
	Inter-basin transfers			Itare to RV basin (41 MCM/a)	Itare to RV basin (41 MCM/a)	Itare to RV basin (41 MCM/a)	Itare to RV basin (41 MCM/a)	Itare to RV basin (41 MCM/a)
				Amala to RV basin (82 MCM/a)	Amala to RV basin (82 MCM/a)	Amala to RV basin (82 MCM/a)	Amala to RV basin (82 MCM/a)	Amala to RV basin (82 MCM/a)
				Nandi Forest to LVS basin (189 MCM/a)	Nandi Forest to LVS basin (189 MCM/a)	Nandi Forest to LVS basin (189 MCM/a)	Nandi Forest to LVS basin (189 MCM/a)	Nandi Forest to LVS basin (189 MCM/a)

Category	Type	Scenario						
		0	1	2A	2B	3A	3B	3C
Water resources development	Small-scale irrigation	11 116 ha	47 611 ha	47 611 ha	47 611 ha	47 611 ha	47 611 ha	47 611 ha
	Large scale irrigation (ha)	Ahero and West Kano (2 000)	Ahero and West Kano (2 000)	Ahero and West Kano (4 150)	Ahero and West Kano (4 150)	Ahero and West Kano (4 150)	Ahero and West Kano (4 150)	Ahero and West Kano (4 150)
		Lower Kuja (88)	Lower Kuja (88)	Lower Kuja (10 000)	Lower Kuja (10 000)	Lower Kuja (10 000)	Lower Kuja (10 000)	Lower Kuja (10 000)
		South West Kano (1 200)	South West Kano (1 200)	South West Kano (1 200)	South West Kano (1 200)	South West Kano (1 200)	South West Kano (1 200)	South West Kano (1 200)
		North West Kano (800)	North West Kano (800)	North West Kano (800)	North West Kano (800)	North West Kano (800)	North West Kano (800)	North West Kano (800)
		Kimira (1 460)	Kimira (1 460)	Kimira (1 460)	Kimira (1 460)	Kimira (1 460)	Kimira (1 460)	Kimira (1 460)
				Kano Plain (15 000)	Kano Plain (15 000)	Kano Plain (15 000)	Kano Plain (15 000)	Kano Plain (15 000)
				Nandi Forest (7 272)	Nandi Forest (7 272)	Nandi Forest (7 272)	Nandi Forest (7 272)	Nandi Forest (7 272)
				Nyabomite (1 000)	Nyabomite (1 000)	Nyabomite (1 000)	Nyabomite (1 000)	Nyabomite (1 000)
				Nyando (3 000)	Nyando (3 000)	Nyando (3 000)	Nyando (3 000)	Nyando (3 000)
				Ilooiterre (3 000)	Ilooiterre (3 000)	Ilooiterre (3 000)	Ilooiterre (3 000)	Ilooiterre (3 000)
				Amala (5 000)	Amala (5 000)			
				Kisumu Clusters (3 660)	Kisumu Clusters (3 660)			
	Small dams/pans (MCM)	5.3	5.3	5.3	5.3	186.0	186.0	186.0
	Groundwater use (MCM/a)	67	67	67	67	270	270	270
Environment	Ecological reserve	No	No	Q95	Q95	Q95	EFlows	Q95, Amala and Sand R Dams (EFlows)
Catchment	Forests	Current	10% reduction	10% reduction	10% reduction	10% improvement	10% improvement	10% improvement
	Erosion risk - sediment (Mt/a)	9.03	9.53	9.53	9.53	8.51	8.51	8.51

Category	Type	Scenario						
		0	1	2A	2B	3A	3B	3C
Climate	Climate change	No	Yes	Yes	No	Yes	Yes	Yes
Water demand (MCM/a)	Irrigation	256	919	1 207	1 199	939	939	850
	Domestic/ Industrial	300	1 235	1 235	1 235	834	834	834
	Other	77	182	182	182	182	182	182
	Export	0	0	123	123	123	123	123
	Total	633	2 336	2 747	2 738	2 078	2 078	1 989

5.6 Scenario analysis

5.6.1 Definition and quantification of indicators

Within the context of water resources management scenario evaluation, indicators are required to quantify and simplify information in a manner that facilitates an understanding of impacts related to water resource interventions. Typically, their aim is to assess how interventions affect the direction of change in environmental, social and economic performance, and to measure the magnitude of that change. Evaluation criteria are then defined through a single or combined set of indicators, which have been identified and quantified during scenario planning and appraisal and which forms the basis of scenario evaluation. The selection and specification of indicators is a core activity during the evaluation of water management interventions as it drives all subsequent data collection, analysis and reporting tasks.

Table 5-5 provides a categorisation of indicators based on the typical structure of the results-based approach to project design and management, where indicators are used to quantify or measure results of project interventions or actions. Impact and Outcome indicators, which are used for ‘results’ monitoring and evaluation, are typically most relevant for water resources planning. The indicators which were defined for the multi-criteria analysis, which was done as part of the development of the basin plans, can be classified as Impact, Outcome and Output indicators.

Table 5-5: Structured indicators for evaluation of water management interventions

<table>
<tr><th>Category</th><th colspan="3">Type of Measurement</th></tr>
<tr><td>Impact indicators:
measures of medium or long-term physical, financial, institutional, social, environmental or other developmental change that the project is expected to contribute to.</td><td rowspan="2">Leading indicators:
advance measures of whether an expected change will occur for outcomes and impacts.</td><td rowspan="5">Cross-cutting indicators:
measures of crosscutting concerns at all levels.</td><td rowspan="5">Exogenous or external indicators:
measures of necessary external conditions that support achievement at each level.</td></tr>
<tr><td>Outcome indicators:
measures of short-term change in performance, behaviour or status of resources for target beneficiaries and other affected groups.</td></tr>
<tr><td>Output indicators:
measures of the goods and services produced and delivered by the project.</td><td rowspan="3"></td></tr>
<tr><td>Process indicators:
measures of the progress and completion of project activities within planned work schedules.</td></tr>
<tr><td>Input indicators:
measures of the resources used by the project.</td></tr>
</table>

Table 5-6 lists the indicators used for the evaluation of scenarios in this analysis. The indicators are categorised as environmental, social or economic indicators and are quantified based on response functions. These functions quantify how interventions affect the direction of change in environmental, social and economic performance, and measure the magnitude of that change through defined relationships or linkages between water resource driven processes (i.e. model outputs) and impacts or benefits. Typically, these response functions are based on empirical relationships derived from observed data, physically based conceptual models which describe indicator responses in relation to physical parameters or statistical indices or relevant values extracted from output time series.

Table 5-6: Indicators used for scenario evaluation

Type	Category		Indicator	
Environment (EN)	1	Footprint	1	Environmentally sensitive area
			2	Carbon emissions
	2	Downstream	1	Floodplain inundation
			2	Ecological stress
			3	Wet season duration
	3	Water quality	1	Phytoplankton growth potential
			2	Aquatic macrophytes growth potential
Social (SL)	1	Water availability	1	Riparian users
	2	Community health and safety	1	Malaria susceptibility
	3	Food security / livelihoods	1	Commercial irrigation
			2	Recession agriculture
			3	Fish production – dams
			4	Fish production – river
			5	Productive land use
			6	Access to natural resources
	4	Displacement	1	Physical displacement
Economic (EC)	1	Energy	1	Energy generated (hydropower)
	2	Food production	1	Crop production
			2	Fish production – dams
	3	Water supply ratio	1	Urban supply
			2	Rural supply
			3	Large-scale irrigation supply
			4	Small-scale irrigation supply
	4	Flood damage	1	Flood reduction benefit
	5	Macro-economic	1	Employment: Commercial irrigation
			2	Employment: Hydropower
			3	Health costs: Water quality
			4	Contribution to GDP
	6	Sediment	1	Sediment load

More detail regarding the categorisation and quantification of individual indicators are provided in **Annexure A6** and **Annexure A7**.

5.6.2 Multi-criteria analysis

To assess relative impacts and benefits related to the defined water resources development scenarios, the indicator values at pre-determined locations within the basin for each scenario, were combined into three criteria groups representing the three dimensions of sustainability viz. Environmental, Social and Economic.

Table 5-7 describes how the criteria were determined from the indicators, which were then used to compare and evaluate different combinations of scenarios using multi-criteria analysis.

Table 5-8 indicates the evaluation criteria as calculated for each scenario of the LVS Basin, with each criterion ranked with a green (best) to orange (worst) colour scale.

By assigning weights to criteria categorised under the three dimensions of sustainability, it was possible to assess the relative impacts and benefits of scenarios in relation to these three dimensions. Table 5-9 indicates the weightings used per sustainability dimension. The multi-criteria analysis was based on the unit vector normalisation method, while ordinal ranking was used for weighting. In ordinal ranking, the order of ranking assigned to criteria is important, while the absolute differences between criteria values is not, due to it being disproportionate and/or difficult to quantify. The indicator analysis provides a wide array of indicators, which cannot be assessed against each other; thus, ordinal ranking was the suitable option.

Table 5-7: Criteria used for scenario evaluation

Type	Criteria				
	Category	Name	Units	Description	Indicator ID
ENVIRONMENT	Footprint Areas	Environmentally Sensitive Area	km^2	Summed Environmentally Sensitive Area for all schemes in scenario	1.1
		Carbon emissions (dams / large scale irrigation schemes)	Million tons	Summed Carbon emissions for all schemes (dams / large scale irrigation) in scenario	1.2
	Downstream Areas	Floodplain Area Inundated	% change from Baseline	Average Floodplain Area Inundated downstream all schemes in scenario	2.1
		Ecological Stress	Index (-5 to 0)	Average Ecological Stress downstream all schemes in scenario	2.2
		Wet Duration	% change from Baseline	Average Wet Duration downstream all schemes in scenario	2.3
	Water Quality	Phytoplankton growth potential	%	Average Phytoplankton growth potential of all dams in scenario	3.1
		Aquatic macrophytes growth potential	Index (-5 to 5)	Average Aquatic macrophytes growth potential of all large scale irrigation schemes in scenario	3.2
SOCIAL	Water Availability	Change in availability of water for riparian users: domestic consumption, subsistence agriculture and livestock	% change from Baseline	Average Change in water availability for riparian users downstream all schemes in scenario	1.1
	Community Health and Safety	Susceptibility of development scheme areas in basin to malaria	km^2	Summed Susceptible malaria area of all schemes in scenario	2.1
	Food security and Livelihoods	Establishment of formal, commercial irrigation schemes in basin	km^2	Summed Irrigation scheme footprint areas in scenario	3.1
		Impact on recession agriculture due to changes in flow regime - floodplain inundation	% change from Baseline	Average Impact on recession agriculture downstream all schemes in scenario	3.2
		Fish production in all dams	ton/annum	Summed Fish production in all dams in scenario	3.3
		Change in fish productivity along river reaches in basin	% change from Baseline	Average Change in fish productivity along river reach downstream all schemes in scenario	3.4
		Productive land use for crops, grazing inundated by dam or lost due to development of schemes in basin	km^2	Summed Productive land use lost due to establishment of all dams and irrigation schemes in scenario	3.5
		Loss of access to natural resources due to development of schemes in basin	km^2	Summed Loss of natural resources due to establishment of all dams and irrigation schemes in scenario	3.6
	Displacement	Physical displacement of population due to development schemes in basin	Population	Summed Physical displacement due to estabishment of all dams and irrigation schemes in scenario	4.1
ECONOMIC	Energy	Average Energy generated by hydropower in basin	GWh/annum	Summed Average energy for scenario	1.1
	Food production	Crop production in basin	million ton/annum	Summed Crop production for scenario	2.1
		Fish production - dams	ton/annum	Summed Fish production in all dams in scenario	2.2
	Water supply	Percentage of urban demand supplied	%	Average Percentage urban demand supplied in scenario	3.1
		Percentage of rural demand supplied	%	Average Percentage domestic demand supplied in scenario	3.2
		Percentage of large scale irrigation demand supplied	%	Average Percentage large scale irrigation demand supplied in scenario	3.3
		Percentage of small scale irrigation demand supplied	%	Average Percentage small scale irrigation demand supplied in scenario	3.4
	Flood control	Flood control potential	Ratio	Basin wide flood reduction benefit	4.1
	Employment	Jobs created through establishment of formal, commercial irrigation schemes	No. jobs	Summed Jobs created through establishment of formal, commercial irrigation schemes in scenario	5.1
		Jobs created through energy generation of hydropower plants	No. jobs	Summed Jobs created through energy generation of hydropower plants in scenario	5.2
	Pollution cost	Health related costs of phytoplankton growth, aquatic macrophyte growth and urban pollution	Ratio of baseline	Equal to Pollution cost indicator	5.3
	Macro-economic	Impact on GDP	Ratio of baseline	Equal to Macro-economic indicator	5.4
	Sediment	Sediment potential index	Ratio of baseline	Equal to Sediment indicator	6.1

Table 5-8: Scenario evaluation criteria

Dimension	Category	Criteria	Unit	SC0	SC1	SC2A	SC2B	SC3A	SC3B	SC3C
ENVIRONMENT	Footprint areas	Environmentally sensitive areas	Area (km^2)	n/a	0.0	39	39	39	39	25
		Carbon emissions dams	tons	n/a	0	321994	321994	321994	321994	319656
		Carbon emissions LIR	tons	n/a	0	934921	934921	934921	934921	788352
	Downstream areas	Floodplain area inundated	% change from baseline	n/a	-11.4	-37.8	-32.7	-37.2	-18.1	-35.4
		Ecological stress	Index (-5 to 0)	n/a	-1.4	-2.8	-2.4	-2.6	-2.1	-2.6
		Wet duration	% change from baseline	n/a	-14.0	-35.0	-30.0	-31.9	-30.3	-30.7
	Water quality	Phytoplankton growth potential	Average growth potential %	0.00	0.0	92.8	92.0	90.5	92.0	89.7
		Aquatic macrophytes growth potential	Index (-5 to 0)	-0.20	-0.8	-1.3	-1.5	-1.3	-1.1	-1.0
SOCIAL	Water availability	Change in availability of water for riparian users	% change from baseline	n/a	-23.9	-6.7	-20.3	-10.4	-11.3	-9.8
	Community health and safety	Malaria endemicity	Malaria endemicity (km^2)	21	21	168	168	168	168	149
	Food security and livelihoods	Formal irrigation schemes	Area (km^2)	46	46	587	587	587	587	479
		Impact on recession agriculture	% change from baseline	n/a	-11.4	-37.8	-32.7	-37.2	-18.1	-35.4
		Fish production (dams/lakes)	tons/annum	74	74	570	589	593	475	551
		Change in fish productivity	% change from baseline	n/a	-14.0	-35.0	-30.0	-31.9	-30.3	-30.7
		Loss of productive land	Area (km^2)	n/a	0	265	265	265	265	222
		Loss of natural resources	Area (km^2)	n/a	0.0	39	39	39	39	25
	Displacement	Physical displacement	Number people	n/a	0	184326	184326	184326	184326	142816
ECONOMIC	Energy	Avg energy	GWh/annum	33	29	331	340	335	340	199
	Food production	Crop production (formal irrigation)	Million ton/annum	0.02	0.0	1.40	1.50	1.50	1.40	1.40
		Fish production (dams/lakes)	tons/annum	74	74	570	589	593	475	551
	Water supply	Urban water supply	Ratio	0.89	0.67	0.85	0.85	0.88	0.78	0.90
		Domestic water supply	Ratio	0.95	0.89	0.86	0.86	0.86	0.85	0.86
		Formal irrigation water supply	Ratio	0.84	0.73	0.62	0.63	0.67	0.58	0.80
		Small-scale irrigation water supply	Ratio	0.85	0.69	0.62	0.61	0.63	0.58	0.80
	Employment	Employment formal irrigation	Jobs/annum	9188	9188	117302	117302	146628	146628	119825
		Employment hydropower	Jobs/annum	66	59	661	680	838	849	498
	Pollution costs	Pollution cost index related to dams and formal irrigation scheme	Ratio of baseline	1.00	1.2	3.7	4.1	3.7	3.4	3.3
	Sediment	Sediment potential index	Ratio of baseline	1.00	1.00	0.95	0.95	0.94	0.94	0.94
	Primary GDP	GDP index	Ratio of baseline	1.00	3.3	15.6	15.6	15.7	15.7	15.3
	Flood control	Flood control potential	Ratio	0.00	0.00	0.19	0.19	0.19	0.19	0.19

Table 5-9: Criteria weightings

Dimension	Category	Criteria	ECON	ENV	SOC
ENVIRONMENT	Footprint areas	Environmentally sensitive areas	28	1	30
		Carbon emissions dams	29	2	29
		Carbon emissions LIR	30	3	28
	Downstream areas	Floodplain area inundated	24	4	27
		Ecological stress	26	5	25
		Wet duration	25	7	26
	Water quality	Phytoplankton growth potential	27	6	24
		Aquatic macrophytes growth potential	23	8	23
SOCIAL	Water availability	Change in availability of water for riparian users	22	11	18
	Community health and safety	Malaria endemicity	21	17	11
	Food security and livelihoods	Formal irrigation schemes	18	13	1
		Impact on recession agriculture	20	12	10
		Fish production (dams/lakes)	14	15	2
		Change in fish productivity	19	14	4
		Loss of productive land	16	10	14
		Loss of natural resources	17	9	15
	Displacement	Physical displacement	15	16	16
ECONOMIC	Energy	Avg energy	10	28	12
	Food production	Crop production (formal irrigation)	8	26	13
		Fish production (dams/lakes)	9	23	9
	Water supply	Urban water supply	2	19	6
		Domestic water supply	3	20	8
		Formal irrigation water supply	4	21	20
		Small-scale irrigation water supply	12	22	19
	Employment	Employment formal irrigation	5	24	5
		Employment hydropower	6	25	3
	Pollution costs	Pollution cost index related to dams and formal irrigation schemes	7	18	21
	Sediment	Sediment potential index	13	30	22
	Primary GDP	GDP index	1	27	7
	Flood control	Flood control potential	11	29	17

5.7 Scenario evaluation

5.7.1 Sustainable development pathway

The objective of this evaluation was to compare the benefits and impacts under four future development scenarios: Scenario 1, where there is no future investment in water resources infrastructure vs. Scenario 2A, which involves full development of the basin as per existing plans vs Scenarios 3A and 3C, both of which represent sustainable development scenarios.

The results of the analysis are summarised in Table 5-10:

- Scenario 3C ranks above Scenarios 1, 2A and 3A from an Economic and Social perspective, while ranking second from an Environmental perspective, confirming Scenario 3C as the sustainable development pathway, i.e. maximum economic benefit, without unsustainable social / environmental footprints due to infrastructure development. Both Scenarios 3A and 3C include reduced water demands, which highlights the importance of improved water demand management in the LVS Basin.
- Scenario 3C ranks highest overall mainly due to high supply reliability to water users as well as sufficient water being available for the large-scale irrigation areas and good water productivity by the crops; thus, increasing crop production. Furthermore, Scenario 3C aims to reduce environmental impacts in footprint areas and downstream river reaches.
- Scenario 1 scores the highest from an Environmental perspective due to no large-scale infrastructure development and no environmental impacts from footprint areas. Although the implementation of Q95 as a minimum release under Scenarios 2A and 3A should lead to a slight improvement to the aquatic environment, this is not enough to outscore Scenario 1 Environmentally – also because application of Q95 as a constant minimum flow does not significantly improve the aquatic habitat.
- Scenario 2A scores lowest from an Environmental perspective, which confirms the significant environmental impacts of the very large areas of commercial irrigation and dams for flow regulation proposed under this scenario.
- The business as usual scenario (Scenario 1) scores lowest from an Economic and Social perspective, mainly due to the impacts of increased water demands without corresponding investment in infrastructure.

Table 5-10: Scenario scores and ranking for the full and sustainable development comparison

	ECON	ENV	SOC
SC1	0.647	0.837	0.712
SC2A	0.738	0.566	0.715
SC3A	0.829	0.617	0.782
SC3C	0.843	0.636	0.782
SC1	4	1	4
SC2A	3	4	3
SC3A	2	3	2
SC3C	1	2	1

The evaluation of development and management scenarios provided useful information towards informing the strategy for the sustainable development of water resources in the LVS Basin. The main outcomes of the sustainable development scenario evaluation with relevance to water resources development in the basin are summarised below:

- The supply deficits for current urban and rural domestic demands as well as small scale irrigation demands typically go up to as high as 40%, mainly due to shortfalls during the dry season.

- The significant expected growth in urban and rural domestic water demands by 2040 will result in a reduction in supply reliability to these users. A priority for the development of water resources in the LVS Basin should therefore concern improved water supply to meet existing and especially future urban and rural demands through interventions towards improving water availability and assurance of supply. This demands a combination of new storage dams, importing water for Kisumu via an inter-basin transfer from LVN, water demand management measures, conjunctive use depending on groundwater availability and quality, as well as consideration of measures for rainwater harvesting.
- Itare Dam on the Itare River, an upper tributary of the Sondu River, will be able to supply towns in Bomet and Nakuru counties in the LVS Basin, while a significant volume of water will be available for transfer to Nakuru Town and other smaller towns in the adjacent Rift Valley Basin via an inter-basin transfer in line with the current planned average transfer volume of 41 MCM/a.
- Amala Dam on the Amala River, an upper tributary of the Mara River will be able to divert a significant volume of water to the Ewaso Ng'iro South River in the Rift Valley Basin for the generation of hydropower in line with the current planned average transfer volume of 82 MCM/a.
- In order to reduce the predicted loss in storage in the proposed large dams in the basin due to sedimentation, catchment management measures and programmes should be implemented in the upstream catchments where erosion risk has been identified as high.
- To improve current and future reliability of supply to towns and rural settlements outside of the major urban centres, for livestock as well as for supply of small-scale irrigation, new or additional storage (dams and pans), as well as local groundwater development need to be promoted.
- Except for a reduction in the areas of some of the proposed run-of-river irrigation schemes, the full extent of planned large-scale irrigation development in the LVS Basin should be feasible. This will, however, require the construction of large dams to ensure a high reliability of supply viz. Magwagwa, Nayndo/Soin-Koru, Gogo Falls and Ilooiterre dams.
- It is proposed that the Amala Irrigation Scheme not be implemented due to concerns about water quantity and quality impacts on the downstream Masai Mara National Reserve and the Serengeti National Park in Tanzania
- Climate change is expected to result in increased rainfall and temperatures; however, the net impact will be less water availability and increased irrigation demands. This highlights the importance of providing storage and the need for water demand management.
- It is recommended that water demand management is implemented in all urban areas, while irrigation efficiencies should also be improved.
- The availability of water for use within the basin will be severely impacted by the introduction of variable minimum environmental flows as opposed to the current Q95 minimum constant flow. Careful consideration should be given to resource classification and how this will impact water resources availability.
- Significant and variable environmental releases (in excess of Q95) have to be implemented at Amala Dam and Sand River Dam to ensure the health of the downstream Mara River as it passes through the Masai Mara National Reserve and into the Serengeti national Park in Tanzania.

5.7.2 Climate change impact analysis

The objective of this evaluation was to assess the impacts of climate change under the two full development scenarios: Scenario 2A, which includes climate change vs Scenario 2B, which excludes climate change.

The results of the analysis are summarised in Table 5-11.

- Scenario 2B (without climate change), ranks above Scenario 2A (with climate change) from an Economic, Social and Environmental perspective. This is expected – although the rainfall increased under the climate change scenario, the increased evapotranspiration due to climate change results in increased evaporation loss, higher crop water requirements, increased health costs, and shifts in flow seasonality and a net reduction in water availability. Climate change is thus anticipated to have a negative impact on the LVS Basin and highlights the importance of development and management interventions to mitigate climate risks and improve resilience.

Table 5-11: Scenario scores and ranking for the climate change comparison

	ECON	ENV	SOC
SC2A	0.969	0.944	0.965
SC2B	0.991	0.992	0.988
SC2A	2	2	2
SC2B	1	1	1

5.7.3 Environmental flow impact analysis

The objective of this evaluation was to compare the benefits and impacts on water availability of imposing the first order EFlows as determined during this Consultancy as opposed to the Q95 environmental flows under the sustainable development scenario: Scenario 3A with Q95 as minimum environmental flow vs. Scenario 3B with EFlow holding flows.

The results of the analysis are summarised in Table 5-12.

- The impact of the EFlows from an Economic and Social perspective is evident as Scenario 3B scores lower than Scenario 3A for these categories. Under Scenario 3B, the minimum flows in the rivers are significantly greater; however, this results in lower storage volumes in the dams, reducing the supply reliability of the urban and irrigation demands. As a result, crop production and assurance of supply to users reduce.

- Scenario 3A scores lower than Scenario 3B from an environmental perspective. This is expected as the Q95 constant environmental flow is not sufficient to mimic the natural flow in the rivers, which leads to a deterioration of river health with associated environmental impacts.

Table 5-12: Scenario scores and ranking for the environmental flow comparison

	ECON	ENV	SOC
SC3A	0.971	0.937	0.964
SC3B	0.925	0.958	0.926
SC3A	1	2	1
SC3B	2	1	2

Although the EFlow scenario ranked higher than the Q95 scenario in two dimensions, careful consideration should be taken for the implementation of environmental flows. The current Water Act (No. 43 of 2016) stipulates the implementation of Q95 as the minimum flow. The availability of water for use within the basin will be severely impacted by the introduction of variable minimum environmental flows as opposed to the current Q95 minimum constant flow. Careful consideration should be given to resource classification and how this will impact the availability of water resources. Furthermore, environmental flood releases should be incorporated in the operating rules of dams.

Image source: Aurecon 2019. 'Lake Victoria South Basin'.

Key Strategies and Themes

6 Key Strategies and Themes

6.1 Introduction

The key aim of the LVS Basin Plan is to provide a clear way forward for the integrated management and development of the water resources of the LVS Basin as a pathway towards a future which achieves a sustainable balance between utilisation and development of water resources and the protection of the natural environment, i.e. minimising environmental and social impacts and maximising socio-economic benefits, taking into consideration the availability of water. To comprehensively and systematically address the range of water resources related issues and challenges in the LVS Basin and to unlock the value of water as it relates to socio-economic development, ten Key Strategic Areas (KSAs) were formulated for the LVS Basin as presented in Table 6-1.

Table 6-1: Key Strategic Areas and Objectives

Key Strategic Area		Strategic Objective
1	Catchment Management	To ensure integrated and sustainable water, land and natural resources management practices
2	Water Resources Protection	To protect and restore the quality and quantity of water resources of the basin using structural and non-structural measures
3	Groundwater Management	The integrated and rational management and development of groundwater resources
4	Water Quality Management	Efficient and effective management of water quality to ensure that water user requirements are protected in order to promote sustainable socio-economic development in the basin
5	Climate Change Adaptation	To implement climate change mitigation measures in the water resources sector and to ensure water resource development and management are adapted and resilient to the effects of climate change.
6	Flood and Drought Management	To establish and guide a structured programme of actions aimed at ensuring the prevention of, mitigation of, timeous response to, and recovery from, the harmful impacts of floods and droughts across the Basin or specific catchment area.
7	Hydromet Monitoring	An operational and well-maintained hydromet network supported by effective and functional data management and information management systems
8	Water Resources Development	To develop water resources as a key driver for sustainable economic and social development
9	Strengthened Institutional frameworks	To achieve an appropriate balance between operational functionality and the need for effective oversight and governance.
10	Enabling environment to support effective institutions	Improved regulatory responses to strengthen catchment-based water resources management

The 10 KSAs are discussed in detail in the following sections in terms of the current status, context, challenges and constraints, and current best practice as applicable, with themes and strategies specific to each KSA being presented. Implementation Plans for the KSAs (refer to **Annexure E**) constitute the next step towards implementation of the strategies and themes under each KSA and are discussed in Section 7.

6.2 Catchment Management

6.2.1 Introduction

Water resources degradation is intimately linked to land degradation and influenced by various catchment management and land use factors. Implementing effective catchment management therefore requires a bigger picture perspective and an understanding of the role of natural resource use within a water resources context. People, animals and plants constitute those components of a catchment that make use of the physical resources of land and water. Misuse of these resource elements will therefore lead to unstable natural and social systems, often resulting in further land and water degradation. Integrated catchment management acknowledges the relationships between households, villages, communities and the broader catchment and envisages that individuals take ownership of their role in catchment management - as opposed to a top-down approach lead by legislation and regulations. This is the cornerstone of Integrated Water Resources Management. A key issue in many catchments in Kenya relates to the influence of population pressures on the existing landscape-biodiversity dynamics. With an increasing demand for natural resources and under the influence of historic-political and socio-economic drivers, the human footprint has pushed many natural systems beyond a stable threshold. Any disruption to the natural system impacts the human population, more so in rural areas where communities still live and work very closely to the natural environment.

The objective of Catchment Management is to enable communities, county governments and other relevant governing bodies and institutions to implement integrated catchment management interventions through increased knowledge. As water is the common link among resource users in a catchment, it is appropriate that the catchment is used as a planning unit for resource management. Integrated catchment management is aimed at deriving the greatest possible mix of sustainable benefits for future generations and the communities in a catchment, whilst protecting the natural resources upon which these communities rely. This approach seeks to maintain a balance between the competing pressures exerted by the need to maintain natural resources in the long-term, against the need for continuous economic growth and use of these resources.

6.2.2 The key principles of Catchment Management

Land and water degradation, together with the subsequent impacts on users, cannot easily be separated or managed independently of one another. The utilisation and management of land and water resources should thus be done in an integrated manner in order to ensure the sustainability of both.

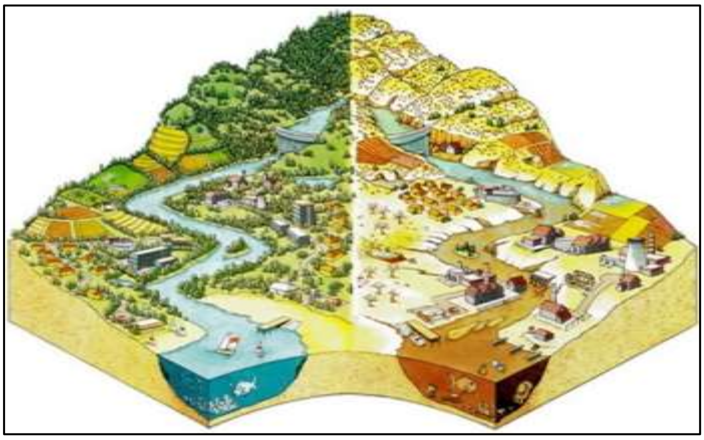


Figure 6-1: Illustration of good (left) and poor (right) state of both land and water resources in a catchment

Land degradation is not just the physical degradation of the soil, but the disturbance of the biophysical environment through human activity. This occurs through activities such as overgrazing, deforestation, alien invasive infestation, poor solid waste management and other similar disruptive actions, and leads to a disturbance of the natural system, which in some cases pushes a system beyond a critical threshold. The impacts of land degradation are long-term and damaging to not only the biophysical environment, but also the socio-economic environment of communities. A loss of soil fertility will lead to low crop yields, which in turn lead to food shortages and reduced income generation, whilst increased runoff due to exposed soil and soil erosion leads to gully erosion and sedimentation of water bodies, leading to biodiversity threats and water resources depletion and degradation, and a reduced capacity to use the water resource e.g. for irrigation or hydropower. In general, the impact that is readily felt in rural communities is a reduced standard of living, which leads to chronic poverty.

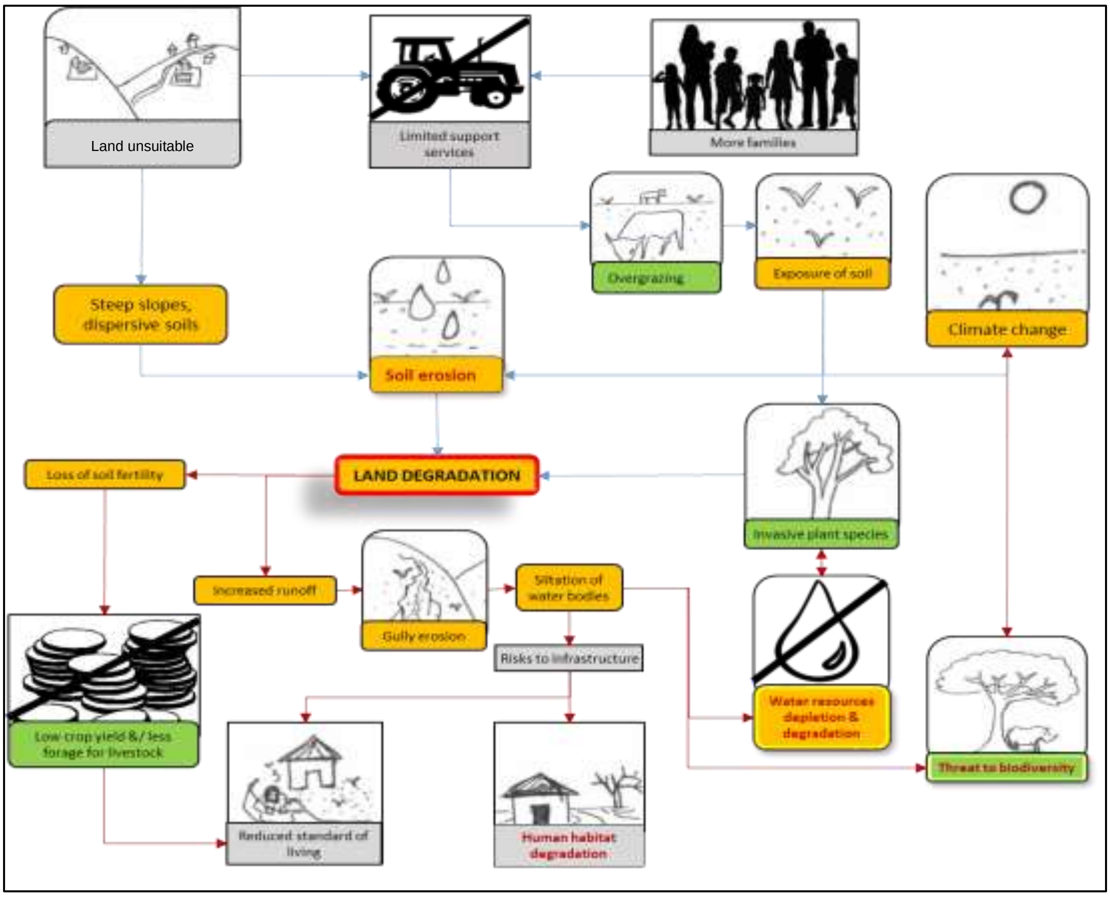


Figure 6-2: An example of the interconnected links of land degradation

Soil degradation (the long-term decline on soil productivity) is exacerbated through the physical decline in soil structure or through accelerated erosion via water and wind. Soil, termed sediment once eroded, also becomes a significant non-point pollution source for water resources. Soil erosion and sedimentation is one of the biggest problems facing mankind globally due to the serious environmental, economic and social consequences, including loss of productive land, siltation of reservoirs, reduction of water quality for human use and impacts on aquatic ecosystems.

The above implies that a co-ordinated and integrated approach and actions are required across all scales of a catchment and through all levels of catchment management - from individual land users, through local and regional structures to national level. Integrated Catchment Management addresses soil, water, biodiversity and people issues at a catchment scale as shown in Figure 6-3.

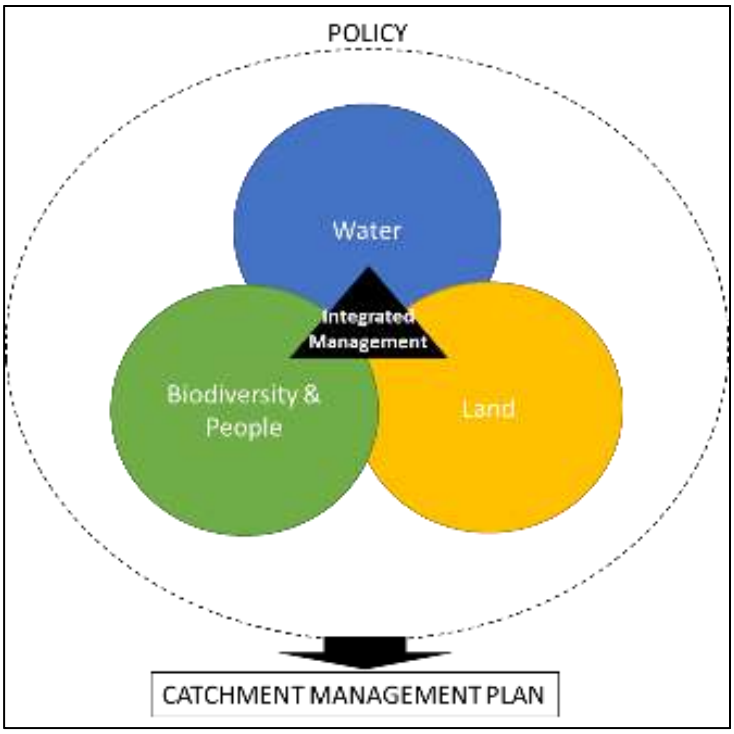


Figure 6-3: The interaction of different management strategies for Catchment Management

In its widest possible sense, Integrated Catchment Management recognises the need to integrate all environmental, economic and social issues within a catchment (at any scale) into an overall management philosophy, process and strategy or plan. It is thus aimed at deriving the greatest possible outcome of sustainable benefits for future generations and the communities in the area of concern whilst protecting the natural resources upon which these communities rely. Often, water resource management paradigms have assumed that sustainability of water resources can be achieved merely through focused efforts to control water use and protect the integrity of water resources within a catchment context. However, in more recent times it has been acknowledged that this approach ignores the complex issues of land use patterns and the varied roles played by stakeholders, which impact on the water use and water resources. In order to achieve integrated catchment management and derive the best outcome of benefits while protecting resources, requires careful planning, the physical implementation of activities in day to day practices and livelihoods, and a strong legislative, regulatory and institutional framework to support the planning process and implementation.

There are several concepts and principles that are important to integrated catchment management. These are discussed below:

6.2.2.1 Catchment and River Basin Scale

A water resource at a particular location is the product of runoff or groundwater recharge that originates in, and reflects conditions and events throughout, a geographically defined drainage area known as a catchment (“local scale”) or basin (large scale, multiple catchments). The way humans use and abuse land inside the catchment has a decisive impact on the quantity and quality of the water resource and on the health of the aquatic ecosystems reliant on that resource. In this way the hydrological cycle, land-use and aquatic ecosystem functioning form a continuum bounded by the extremities of the catchment. This calls for recognition that naturally occurring water can usually be effectively and efficiently management only within river basin (regional scale management) or catchment (local scale management) boundaries, because of the need to technically account for all aspects of the hydrological cycle, including the way humans change aspects of the cycle by land use. Figure 6-4 illustrates how water and land use activities overlap in an example catchment.

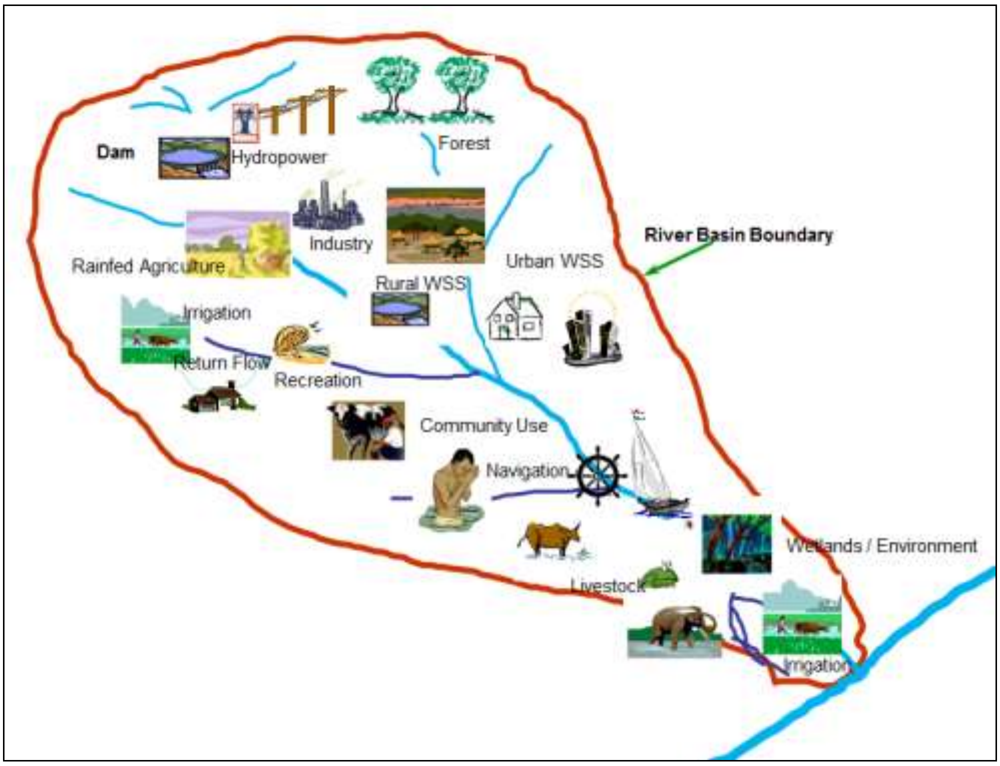


Figure 6-4: Illustration of water and land use activities within a catchment

Several difficulties arise in this concept. Firstly, people are not settled according to catchment boundaries. Secondly more than one Tribal Authority or District Council may fall into catchment, and conversely one Tribal Authority or District Council's administrative area may cover more than one catchment area.

6.2.2.2 Integrated management

Catchment management is a philosophy, a process and an implementation strategy, to achieve a sustainable balance between utilisation and protection of water resources in a catchment. Catchment management recognises the interdependence of land-use, water and the environment, and aims to manage these components in an integrated manner in order ensure the sustainable utilisation of environmental resources and the protection of such resources.

6.2.2.3 Sustainability

Sustainability in the use and development of natural resources systems means that the system can cope with and recover from stresses and shocks and maintain or enhance its capability and assets both now and in the future, while not undermining the natural resource base. Sustainable use of resources therefore must deliver basic environmental, social and economic services to all residents of a community without threatening the viability of the natural built and social systems upon which the delivery of these systems depends. The key to achieving sustainability is adopting a long-term and forward-looking approach to improving quality of life. This ensures that future and cumulative impacts of current development activities are anticipated and managed for continued productivity. It is generally accepted that sustainable development requires a process and ultimately consensus-building among all stakeholders. This must be inclusive of all role-players, government institutions, stakeholders, clients, non-governmental organisations and community-based organisations as partners who together define the problems, design possible solutions, collaborate to implement them, obtain specific products, and monitor and evaluate the outcome. In some cases, this has been incorporated into "water stewardship" whereby water use is evaluated across the entire value chain and water users are willing to be accountable to a larger group that is operating in a service and working to achieve a fundamental change.

6.2.2.4 Reasonable utilisation

In order to ensure that natural resources are not depleted or ruined, development must be balanced between economic and social benefits whilst also protecting the resource base that supports these. People want access to more reliable domestic water supply, better sanitation, water for livestock and irrigation, timber and fuel from forests and good soils for productive agriculture. Many of these activities, singly and in combination, can result in adverse impacts on the catchment itself and on the natural resource base of the catchment such as impacts on groundwater recharge, streamflow, flood flows and soil erosion. Water for environmental services especially in wetlands and securing the biodiversity in the plants and wildlife, are all very important to protect and improve the present access to water and land resources. Reasonable utilisation of natural resources must be encouraged so that that development and resource use do not waste or diminish the resource, as for example, discharge of wastewater and pollutants into the catchment.

6.2.3 Key catchment management issues in the LVS Basin

There are always rules, formal/informal, which determine how people access resources and opportunities (Levine & Pavanello, 2012). These rules, and the ways in which they are enforced, constitute 'institutions'. Institutions could relate to the institutions of the state or organised committees following written constitutions, to informal rules of culture and locally accepted figures of authority. Local-level catchment management strategies address issues that are locally relevant, but depending on the mandate, also legislatively relevant.

Who is responsible for catchment management?

Integrated catchment management requires management of both land and water resources, inclusive of different role players and institutions. Some of the institutions involved are as follows:

- Water resource-based: WRA/BWRC/WRUA
- **Land/Agricultural based:** AFFA/Extension officers/Pastoralists
- Environmental/Biodiversity based: NEMA/KWTA/KFS/KWS
- Governance based: County government

It is critical that these institutions work together to achieve sustainable management of the Basin.

6.2.3.1 Water resource-based issues

The LVS Basin is managed by three WRA Sub-regional offices, which manage nine Catchment Management Units (CMUs) based on hydrological, water resources and land use considerations.

Basin Water Resource Committees (BWRCs) are responsible for management of the six main basins in Kenya. However, conflicting mandates for the BWRCs have been identified in the Water Act (2016), where BWRCs are assigned both advisory and management functions. Both scenarios cannot be implemented at the same time without conflicts and thus only one scenario can work. This implies that there is urgent need to remove this ambiguity. WRA's transition committee is currently addressing this issue and the outcome of this process will inform what function will be adopted by the BWRCs.

A CMS was developed for the LVS Basin for the period 2015-2022 (Water Resources Management Authority, 2015a). Chapter 8 of the strategy focused on catchment protection and conservation for sustainable availability of good quality water. Reducing catchment degradation through soil and water conservation activities and appropriate land use practices was considered an important step. Key issues were identified as soil erosion and sedimentation, loss of vegetation cover, loss of wetlands, pollution from solid waste disposal and invasive plant species in water bodies and wetlands. It was noted that identification of hotspot areas is an important initial step and that there needs to be periodic monitoring and livelihood support in order to ensure sustainability.

Water Resource User Associations (WRUAs) have been established at a more local level to focus on the operational management within a catchment. These are community based, voluntary associations made up of water users and riparian owners. The WRUAs are formed around Sub-Catchment Areas. These areas require Sub-Catchment Management Plans (SCMPs), developed through access to a grant from the Water Sector Trust Fund. The SCMP is an IWRM tool for water resource management to support sub-catchment management. The LVS Basin has 106 existing WRUAs out of a potential 137 WRUAs needed to cover the whole basin. The 31 gap of dormant or potential WRUAs needs to be addressed to ensure basin coverage of WRUAs is increased. Even among the existing WRUAs, there are capacity concerns and disparities in levels of development and maturity of the WRUAs. This denotes the need for continued capacity building for the existing WRUAs in addition to continued technical support. SCMPs mainly focus on the management of water and land resources.

Table 6-2: Catchment management institutions operating at a local level in the LVS Basin

LVS		
	WRA SR / SRO / CMUs	Northern Shorelines and Nyando / Kisumu / Northern Shorelines, Upper and Lower Nyando Southern Shorelines, Gucha and Migori / Kisii / Southern Shorelines, Gucha and Migori Mara and Sondu / Kericho / Sondu, Upper and Lower Mara
	Issues	- Soil erosion: loss of topsoil, gully erosion, riverbank erosion - Loss of vegetation cover: encroachment into protected areas, tree-cutting for timber and fuel wood - Loss of wetlands due to encroachment for brick making, cultivation/settlement, planting of unfriendly-water-use plants, siltation due to upstream soil erosion - Sedimentation - Pollution from solid waste disposal - Invasive plant species in water bodies and in wetlands(hyacinth) - Collaboration and consultation with the County Governments - Inadequate mapping of land use types prone to degradation - Low development and implementation of SCMPs - Inadequate capacity in catchment management

6.2.3.2 Land/Agriculture-based issues

Various Directorates under the Agriculture, Fisheries and Food Authority (AFFA) provide technical input and advice to County Governments. The Authority also conducts farmers' training programs aimed at increasing their knowledge on production technologies and prospects for various types of crops, through farmer training institutions. Extension officers are involved in on the ground catchment management activities, particularly for smallholder farmers. These smallholder farmers are most at risk to the impacts of climate change and infertile soils. Conservation agriculture has been promoted as a sustainable alternative for farmers to address the problem of declining soil fertility and provide the dual benefit of enhanced food production and adaptation/resilience to changing climatic conditions (Agriculture and Food Authority, 2017).

Agricultural extension services in Kenya date back to the early 1900s. Agricultural extension services refer to a systematic process of working with producers or communities to help them acquire relevant and useful agriculture or related knowledge and skills to increase farm productivity, competitiveness and sustainability (Agriculture and Food Authority, 2017). Catchment management approaches are promoted through various methods, with a focus on soil and water conservation and conservation agriculture.

Land and water is also important to pastoralists, although the importance of the resource is linked to treating it as common property freely available for all with livestock (Levine & Pavanello, 2012). The management of natural resources is thus inseparable from the management of relationships between the pastoralist clans and ethnic groups. Pastoralists move their herds in seasonal patterns, according to the conditions of each year. This movement is managed to maintain the right balance of species in the best possible condition over the long term through careful control of grazing (Levine & Pavanello, 2012). Management requires a set of rules and requires the right institutional framework. This is mainly set by groups of elders, who constitute customary authorities.

The Agricultural Sector Development Strategy (ASDS) intends to provide a guide for overcoming challenges facing the agricultural sector in Kenya (Government of Kenya, 2010b). The ASDS 2010-2020 (Government of Kenya, 2010b) proposes integrated development and management of rangeland due to the climatic changes, coupled with overstocking and degraded environment, having a devastating effect on pasture regeneration and pastoralists livelihoods. Rangelands are chronically short of pasture and water (Government of Kenya, 2010b), restoring this will require reseeding and range pitting, bush control, soil conservation and water rehabilitation and development. The ASDS 2010-2020 also emphasises the need to rehabilitate and protect water catchments due to issues such as increased runoff, flash floods, reduced infiltration, erosion and siltation, and limited water resource base.

Table 6-3: Land institutions operating at local level in the LVS Basin and relevant issues

LVS		
	AFFA/extension services	Siaya, Kisumu, Nandi, Kericho, Bomet, Nyamira, Kisii, Homa Bay, Migori and Narok counties
	Pastoralists	Narok county
	Issues	- Yala Swamp is being promoted for agricultural use. - Declining fish landing sites in Lake Victoria is impacting aquaculture. - Overgrazing of croplands - Mono-cropping

6.2.3.3 Environmental/biodiversity-based issues

The National Environmental Management Authority (NEMA) has Environmental Committees who provide technical support for environmental management and provide input to county integrated development plans. The Kenya Water Towers Agency (KWTA) looks after Kenya's water towers – defined as "montane forests", i.e. mountainous regions that are the sources of water. A water tower collects and filters natural water including rain, dew and snow. It is the zone through which the rainwater and snow seeps, to eventually provide base flow to rivers, lakes and spring water and provides for groundwater recharge. There are 18 gazetted, 24 non-gazetted, water towers in Kenya. In the LVS Basin the gazetted water towers include Mau Forest Complex.

The Forest Management and Conservation division under the Kenya Forest Service (KFS) is charged with the management and conservation of the natural forests in Kenya, of which most form water towers. Strategic outputs involve increasing percentage cover through tree planting and gazetting new forests; as well as improving livelihoods. The Division includes forest biodiversity conservation, participatory forest management and fire management, natural forest management, licencing and eco-tourism.

The KFS Forest Farm and Dryland Forestry program provides technical support to the counties, advisory services for forest management, promoting biomass energy development and utilization, promote dryland forest conservation and promote participatory forest extension methodologies including farmer field schools. Issues in the Forestry sector are weak institutions arising from weak governance structures and inadequate capacity for law enforcement and weak stakeholder participation in forest management and governance. This is exacerbated by inadequate funding of the forestry sector from the exchequer, civil and public sectors. Since the enactment of the new Constitution in 2010, nationally and within the basin, the level of public support to the conservation of forests has increased significantly but has not been matched by an equal measure of resource allocation in all sectors. For example, the Forest Management and Conservation Fund (FMCF) established in the Forests Act 2005 and the Forest Management and Conservation Act No.34 2016 to promote the development of forests, maintenance and conservation of indigenous forests, the promotion of commercial forest plantation, provision of forest extension services, the establishment of arboreta and botanical gardens, and a variety of other purposes outlined in Forest Act is yet to be fully operationalised. Furthermore, there are conflicting institutional mandates as is evident from the overlapping mandates, programmes, projects, and conflicting policies and legislation. Overall, forest conservation has witnessed increased cases of political interference in the management of forests, poor governance as well as inadequate and/or weak structural/institutional capacity for forest law enforcement and governance.

The Parks and Reserves division of the Kenya Wildlife Service (KWS) manages the National Parks, National Reserves, National Sanctuaries, Marine National Parks and Marine National Reserves in the country. KWS is also involved in forest conservation and water towers conservation as well as ratifying the RAMSAR convention. KWS exercises mandates over the rivers in the LVS Basin, not just in areas within parks and reserves, but also as the custodians of Kenya's biodiversity, a role they are committed to through the Nagoya Protocol of the Convention of Biological Diversity. Kenya ratified the Protocol in May 2014, which obliges states to develop appropriate domestic measures for effective management of biodiversity in relation to access to genetic resources, benefit-sharing and compliance. Biodiversity in wetlands and sections of the river flowing through protected areas also receive protection by KWS.

Table 6-4: Biodiversity institutions operating at local level in the LVS Basin and relevant issues

LVS		
	Water Towers (KWTA)	Mau Forest Complex
	National Parks (KWS)	Masai Mara National Reserve, Ruma National Park
	Issues	- Mau Forest Complex - The Mau forest is an important water tower for rivers in LVS but it is under threat of human encroachment, particularly in counties aligned to the forest (i,e, Bomet and Nakuru county) - Maasai Mara National Reserve - Fire hazards frequent during dry spells. Causes habitat destruction. - Ruma National Park - Yala swamp is under threat of degradation from agriculture.

6.2.3.4 Governance-based issues

County Integrated Development Plans (CIDPs) are meant to provide an overall framework for development in each county. The plans aim to coordinate the work of both levels of government in a coherent plan to improve the quality of life for all the people and contribute towards devolution. The first plans cover the period 2013 to 2017. The County governments rely on technical input and advice from the different agencies with a mandate to govern natural resources. A major issue is the mandates related to wetlands and riparian lands. There are about nine laws with contradicting recommendation on riparian distance. There is need for all the relevant laws to be harmonized in order to give directions on the riparian distance. This will enable people and developers be aware and be compliant. There is also an issue of a limited coordination and poor resource use due to the independent nature of County planning.

The portion of Siaya county that occurs in LVS Basin are Yala Swamp areas and moderate lowlands (County Government of Siaya, 2018). Although the Yala Swamp has been promoted for agricultural development the wetland is a vital habitat for many birds and several fish species. The swamp also filters sediments, nutrients and pollutants from the waters entering Lake Victoria from LVS Basin.

Kisumu county is characterised by the Kano-Plains, Nyabondo Plateau and over-hanging granite rocks at Riat hills, Maseno and Seme areas (County Government of Kisumu, 2018). The Nyando River and Sondu-Miriu River traverse the county, depositing alluvial soils which favour agricultural production. Lake Victoria and the wetlands associated with the main rivers in the county are threatened and water sources are also under threat from pollution.

The portion of Nandi county that occurs in LVS Basin are from the Nandi Hills to Kisumu county (County Government of Nandi, 2018). The physiography of this region includes the dissected Nyando Escarpment and part of the Tinderet Volcanic mass. Nyamasaria, Kundus, Ainamutua Rivers traverse the county from the headwaters within the LVS Basin. These rivers are controlled by volcanic rock and agglomerates. The rugged topography and steep slopes impact transport access, which is exacerbated during the rainy season. Deforestation is a major contributor to environmental degradation in the county as wood fuel is used as a major source of energy and demand for agricultural land is increasing.

Kericho county is characterised by undulating topography (County Government of Kericho, 2018). The county is surrounded by the Mau Escarpment, Kipkelion and Kericho plateau. Although the undulating nature of the topography is prone to erosion, the dense vegetation cover provides protection. There are parts of the county with limited vegetation cover and exposed soils. Environmental degradation along river banks, drying up of springs and poor harvests are some of the issues faced by the county.

A large part of Bomet county is characterised by undulating topography that gives way to flatter terrain (County Government of Bomet, 2018). The Kipsoni River flows through Sotik to Lake Victoria, Chemosit River flows through Kimulot, Nyongores flows from the Mau Forest southwards, Amalo River originates in the Transmara Forest, Tebenik/Kiptiget Rivers flow along the north of the county. The county borders the Mau forest, which is threatened by human encroachment.

Most of Nyamira county is hilly (County Government of Nyamira, 2018). Various permanent rivers and streams originate in the hilly headwaters and drain towards Lake Victoria. The water levels have declined due to environmental degradation and the planting of eucalyptus trees along the banks.

Gucha River extends across Kisii county from Nyamira county. Kisii county is characterised by hilly topography with several ridges and valleys (County Government of Kisii, 2018).

Homa Bay is divided into the lakeshore lowlands and the upland plateau (County Government of Homa Bay, 2018). Most of the permanent rivers originate in Kisii and Nyamira counties, with seasonal rivers originating from headwaters within the county. Bush clearing and poor farming practices have led to environmental degradation in the county, which in turn has led to water pollution and habitat degradation in Lake Victoria.

In Migori county undulating hills cover most of the county, with few stretches of flat lands (County Government of Migori, 2018). The main rivers originate from Kisii and Narok counties. Environmental issues in the county include deforestation, soil erosion, flooding and pollution.

Narok county extends within LVS Basin and Rift Valley Basin (County Government of Narok, 2018). Within the LVS Basin Amala River extends from Mau Forest to become Mara River after its confluence with Nyangores River from Bomet county. Talek, Longaianiet and Baloledi Rivers also extend across the east of the county. The Mara River extends through the Masai Mara National Reserve, which is considered an important wildlife habitat and tourism destination. Environmental degradation in the county is mainly the result of unsuitable farming methods, poor solid waste management, soil erosion, deforestation, mining and alien invasive species.

Table 6-5: Governance operating at local level in the LVS Basin and relevant issues

County	Issue
Siaya county	- Degradation of Yala Swamp - Declining fish landing sites - Sand harvesting - Water pollution
Kisumu county	- Lake Victoria and wetlands threatened by murram/sand mining and habitat removal and well as pollution. - Nandi county - Deforestation for wood fuel exposes land to soil erosion. - Poor waste management. - Slums. - Tea factories using wood fuel.
Kericho county	- Reforestation and agroforestry programs to increase forest cover under LVEMP II, KFS, CDF and county. - Degradation increasing due to coffee and tea factories increasing and population increasing. - Degraded hilltops - Wetlands degraded and encroached
Bomet county	- Wetlands and river banks erosion caused by planting eucalyptus trees - Quarries cause surface runoff channels - Sand and stone mining - Chepalugu forest is degraded - Mono cropping degrading crop lands - Overgrazing degrading pasture lands.
Nyamira county	- Cultivation up to river banks has resulted in soil erosion. - Quarrying led to blocked up waterways. - Reduced water levels in springs and rivers.
Kisii county	- Cultivation on steep slopes, wetlands, riparian areas led to degradation. - Quarrying for hard core and ballast caused degradation. - Planting eucalyptus along rivers has led to soil erosion and declining water levels.
Homa Bay county	- Deforestation has left the land bare and vulnerable to soil erosion and flash floods. - Lake Victoria pollution. - Poor waste management
Migori county	- Charcoal burning soil erosion, overgrazing and poor farming practices on hilltops. - Disused mines causing pollution. - Sand harvesting, brick making and farming on river banks. - Cutting of trees and poor farming practices in flood prone areas.
Narok county	- Drought and famine. - Increased flooding. - Windstorms. - Fire outbreaks in Masai Mara.

6.2.4 Strategy

In previous Section of this Report, many critical issues related to catchment management have been identified including the need for sustainable land use, improved management and protection of natural resources, and land restoration and rehabilitation. In addition, erosion risk scenarios have demonstrated the impacts and potential benefits of improved land management (Figure 6-5).

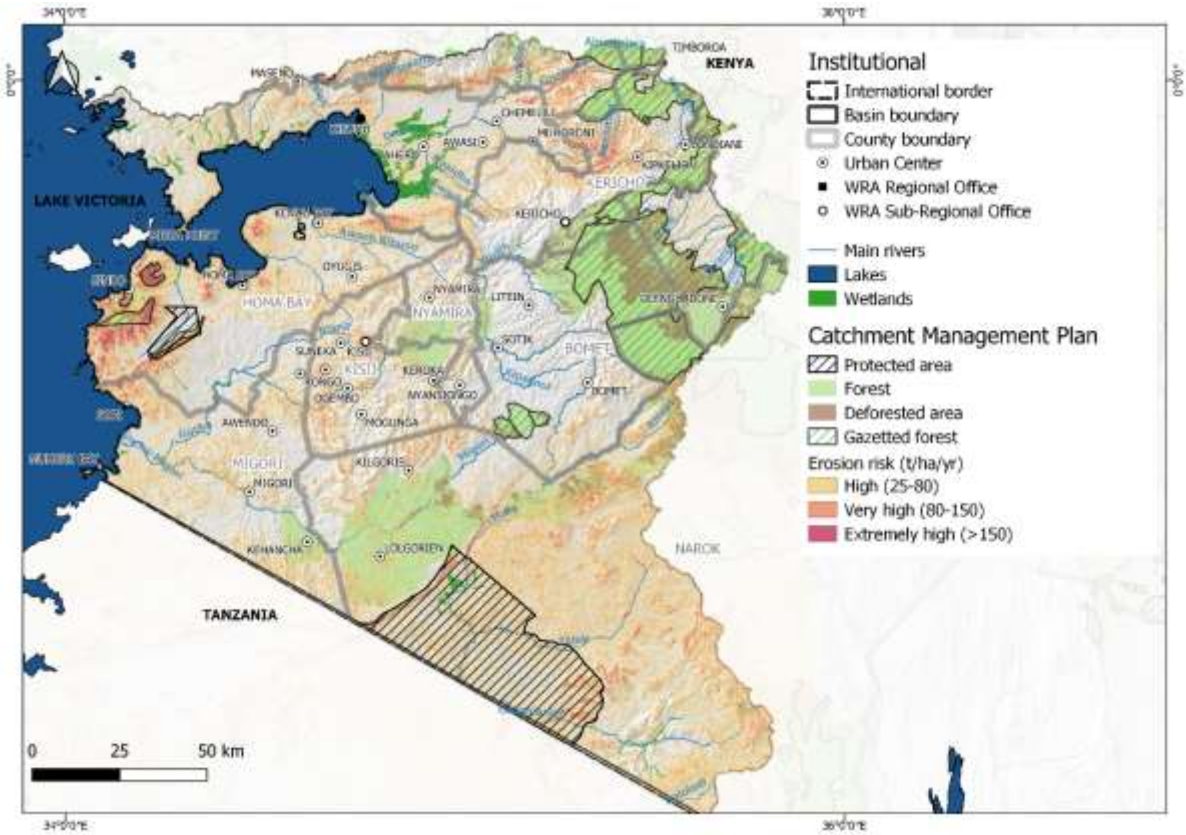


Figure 6-5: Catchment management considerations in LVS Basin

In order to comprehensively and systematically address the range of catchment management issues identified in the LVS Basin, Table 6-6 sets out 4 Strategic Themes and specific Strategies under each Theme. The Themes address Improved and Sustainable Catchment Management, Sustainable Water and Land Use Practices, Natural Resources Management, and Rehabilitation of Degraded Environments.

Table 6-6: Strategic Framework - Catchment Management

1	**Key Strategic Area:**	**Catchment Management**
1.1	**Theme:**	**Promote improved and sustainable catchment management**
1.1.1	Promote sustainable land development and planning	
NEMA Environmental Sustainability Guidelines for Ministries, Departments and Agencies (MDAs) defines sustainability as meaning “meeting the needs of the present without compromising the ability of future generations to meet their own needs”. Sustainability is defined as not being an end goal, but rather a journey that MDAs should take to improve the social equity, environmental, and economic conditions in their jurisdiction. In order to reduce the degradation of land and water resources, a sustainable management approach must be implemented in the LVS Basin. It is important that resource management activities not only apply to new activities, but rehabilitation of degraded resources is critical in order to ensure sustainable management of ecosystem functions and availability of resources for future generations. Degradation of resources will continue if no action is implemented and resources will be further depleted. MDAs should explore the environmental issues within their operations, develop appropriate interventions and document the same in the form of an environmental sustainability policy.		

1	Key Strategic Area:	Catchment Management
1.1.2	Strengthen participatory approaches	

The National Environment Policy (Government of Kenya, 2013a) guiding principles emphasises the inclusion of communities in decision making. These participatory approaches need to be strengthened for sustainable catchment management as communities are closely connected with resources in a catchment. Communities need to take ownership of catchment management activities, and this can be achieved through participatory processes through SCMPs, agricultural extension services and CIDPs.

The aim of SCMPs is to plan the activities of the sub-catchment in an efficient and sustainable manner to achieve optimum benefits for all in the sub-catchment, through making use of available resources in a sustainable and efficient manner. The process and purpose of a SCMP is to empower the people of the sub-catchment to make decisions and take responsibility for and promote the collective action for the rehabilitation, sustainable management and utilisation of their natural resources. The Plan is developed by the community of the sub-catchment, for the community of the sub-catchment. The plan accommodates the resources available to the sub-catchment community and their needs.

Agricultural extension officers and Farmers Field Schools from the AFFA need to be aware of the SCMPs and ensure that catchment management activities fit in with this plan.

County governments are also required to consider the SCMPs in the CIDPs.

Appropriate catchment management activities should be considered from theme 1.2. to 1.4.

1.2	Theme:	Sustainable water and land use and management practices
1.2.1	Promote water conservation and management at catchment level	

Water conservation and management is considered a priority in the LVS Basin due to water scarcity. Water is important in the Basin both for urban use as well as for agricultural/rangeland use therefore water management and access to water are important. Access can be improved through community or household storage of water and through resource protection. Access to water is also improved through water efficiency and through recycling water. The timeframe of access to water is also important as the seasonality of water resources in the semi-arid parts of the basin has meant that pastoralists move further into National Parks to find water, which increases human/wildlife conflict.

Water resource management has been identified as a strategic objective in most CIDPs, with strategies involving water harvesting, storage and treatment. Catchment management activities that can be also be implemented to promote water conservation and management are as follows (Braid & Lodenkemper, 2019):

1. **Water use efficiency and recycling**

By improving water efficiency through suitable crop selection, proper irrigation scheduling, effective irrigation techniques, and using alternative sources of water for irrigation, it will be possible to increase water availability and make the water last longer. These also address point source protection of water collection points. These activities should be implemented by smallholder farmers.

- **Water use efficiency,** i.e. through installation of drip irrigation systems.
- **Wastewater recycling**, i.e. treating wastewater to remove solids and impurities, greywater can be separated from blackwater.
- **Excess water reuse**, i.e. channel water spills at hand pumps to a ‘fertility pit’.

2. **Water harvesting and storage**

By providing access to additional water by harvesting water (collecting runoff) and storing water. By harvesting water, farmers can increase the area they irrigate, grow crops in the dry season, and support livestock. Water storage at the household or village level improves access to water, and reduces the labour burden, by reducing the number of trips to boreholes. These activities should be implemented in the ASAL regions of the LVS Basin. Ridging and swales should be implemented on steep hillslopes where small scale farming is being practiced.

- **Roof runoff and storage**, installation of rainwater harvesting tanks for households.
- **Below ground storage**, installation of large below ground storage of potable water for larger populations.
- **Road runoff**, diversion of runoff from roads into channels/canals and then distributed into ditches/basins or farmland.
- **Ridging**, erosion and runoff control located in drainage lines or near culvert outlets, which are put in place to prevent or reduce sedimentation and erosion of the landscape.
- **Swales**, erosion from rainfall on steep slopes can be reduced by creating swales. A swale is a long, shallow depression in the ground designed to collect or redirect water.

1	Key Strategic Area:	Catchment Management

3. **Groundwater protection and Infiltration**

By providing information to improve groundwater resources, particularly the infiltration of rainwater into the soil, thereby increasing availability of water stored in the rooting zone and groundwater. Increased water availability in the rooting zone reduces dependence on surface water irrigation and provides increased potential for cultivation during dry seasons. Increased groundwater feeds the spring and improves surface water flow lower down the catchment as well as the level of water in wells close-by. These activities should be implemented as a priority in groundwater recharge zones in the LVS Basin.

- **Contour bunds**, construct stone or earth bunds to harvest water on crop lands, or degraded rangeland. Stone bunds act as semi-permeable barrier along contour to retain runoff for water harvesting. Earth bunds retain all runoff from slope for water harvesting.
- **Zai planting pits**, act as micro-catchments within fields to retain runoff from the slope for water harvesting. Suitable for range and degraded land.
- **Infiltration trenches**, shallow excavations with rubble or stone that create temporary subsurface storage of stormwater runoff, thereby enhancing the natural capacity of the ground to store and drain water. Infiltration trenches allow water to exfiltrate into the surrounding soils from the bottom and sides of the trench.
- **Spring protection and management,** designate set-back distances for springs and monitor for contamination.

1.2.2	Promote soil conservation and management at catchment level

Soil erosion, deforestation, poor agricultural practices, loss of soil fertility, inadequate runoff management and gully formation each contribute to the degradation of land resources with resultant impacts on the Basin both up and downstream. To reduce land degradation, mitigate degradation and implement sustainable land use practices, various aspects of sustainable land management are required. Implementing these techniques and practices will minimise the loss of topsoil (through erosion) and reduce the erodibility of a catchment.

The steeper regions of upper LVS Basin which do not have a dense vegetation cover are more prone to high levels of erosion than the lower plains. Although forest cover provides protection from soil erosion, these areas are increasingly being encroached by communities. Improved erosion and runoff control measures and sediment trapping will also improve resilience to flash floods and erosion. In the lower plains of LVS Basin rangeland management should be implemented to prevent overgrazing. The movement of livestock up slopes and over rivers also needs to be managed as this can lead to eroded paths.

Although there are many different parties involved in providing soil conservation and management advice, it is recommended that consensus is built, and a consistent message is given by the SCMPs, CIDPs and Extension Officers.

Most of the CIDPs promote soil and water conservation as a key programme, with the objective to promote sustainable land use and environmental conservation. Activities that are promoted are on farm water harvesting structures (i.e. terraces), tree planting during rainy season, use of organic manure, river bank protection, rehabilitation of degraded land and gully control, excavation of water pans, construction of check dams/sand dams and desilting of water pans. Catchment management activities that can be implemented to promote soil conservation and management are as follows (Braid & Lodenkemper, 2019):

1. **Rangeland management**

In Kenya rangelands are managed by pastoralist communities, and much of the knowledge related to its management is based on an inherited knowledge of the landscape. Climate changes, coupled with overgrazing and degraded environments, have a devastating effect on pasture regeneration and pastoralists livelihoods. The ASDS (2010) emphasizes the need to restore rangelands through reseeding and range pitting, bush control, soil conservation and water resource development and management. The CIDPs also promote the development of range and ranch resource management through training of herders, developing ranch plans, constructing water pans and developing firebreaks. Access roads. Rangeland management is the practice of deciding where to graze animals, how many animals to graze at one time, when to burn, how to harvest firewood and thatch-grass, and other issues relevant to managing natural resources.

- **Rotational resting of rangeland**, overgrazed land leads to increased soil erosion and loss of soil nutrients. Grazing lands should be rested to allow vegetation to recover and protect the soils while other areas are being grazed in rotation. Pastoralism practices which allow for grazing areas to be rested should be promoted.
- **Prevention and rehabilitating overgrazing**, where land has been overgrazed, it needs to be rehabilitated to improve ecosystem function and goods and services provision.
- **Grazing movement**, moving animals around allows livestock owners to control where and when animals

1	Key Strategic Area:	Catchment Management

graze. This allows much greater control over the feeding of the animals and the resting of different areas. This is applicable to livestock owners who do not move over large areas, and who can practice block grazing.

- **Cattle paths up a slope**, cattle paths on slopes can be a major source of erosion and can quickly become large gullies. Reducing cattle paths up slopes requires a combination of rehabilitating existing paths and using strategies to prevent future paths from forming.

2. Erosion and runoff control measures

Erosion and runoff control tools are structures or measures, located in drainage lines or near culvert outlets, which are put in place to prevent or reduce sedimentation and erosion of the landscape caused by intensive rainfall and direct runoff.

- **Contour ridging**, construct during dry season to allow time for re-aligning ridges. Height is usually 30-40cm and interval between ridges varies according to slope gradient.
- **Contour vegetation rows**, vegetation barrier slows down and retains runoff and reduces erosion. Roots increase resistance to rills and gullies.

3. Gully management and sediment trapping

Gullies may not be actively eroding in some cases but provide a channel for increased runoff and sediment delivery. Prevention is better than rehabilitation.

- **Gully prevention**, prevent gully development through sound land use, runoff control and reduction in flow concentration. Raised footbaths and field boundaries should also be implemented.
- **Gully reclamation (small),** gullies can be reclaimed either to cultivate, or simply to prevent further loss of soil and land.
- **Stone check dams**, large gully rehabilitation requires more complex interventions to prevent continued erosion. Check dams can be implemented in a stepped-approach for larger gullies to gradually trap sediment and be reclaimed.
- **Brushwood check dams**, where stones are not available brushwood check dams may be used in some cases.
- **Vegetation barriers**, silt traps reduce the loss of soil and the resulting sedimentation of rivers.
- **Erosion management along roadsides,** one of the areas most prone to erosion and gully formation is along the side of roads, especially dirt roads. This affects the usability of these roads during the wet season. Improved runoff management, such as mitre drains, along the roads will help mitigate this problem.

4. Stream/River bank management

A more manageable riverbank habitat is beneficial to wildlife and at the same time manages the riverine zone, ensuring adequate river function through sediment control and water quality improvement.

- **Riparian buffer zones**, some of the most productive farming areas are on stream/river banks because of the fertile silt and ease of access to water. However, this practice results in the loss of important riparian vegetation which amongst other things helps to clean the water, reduce flood flows, trap sediments, provide food and is also an important habitat for biodiversity.
- **River crossing for cattle**, cattle can cause a lot of damage to river banks where they cross rivers. They cause soil erosion, can drop dung and urine in rivers, which pollutes the water for people living downstream of the cattle crossing. Well-designed cattle crossings can substantially improve the water quality, as well as making it safer for animals and people to cross rivers.
- **Earth berm**, flooding is a natural phenomenon of rivers. For ease of access to water and highly fertile soils, many villages are established near rivers. However, these are affected by floods. A berm/dyke is a wall that runs parallel with the watercourse. Berms or dykes help reduce flood waters affecting villages –they do not stop floods or prevent damage. They require prioritised maintenance.
- **Gabion baskets**, bank collapse along rivers and gullies contribute to catchment degradation. Gabion baskets are rock filled structures to protect banks, reduce erosion and prevent bank collapse.

1.2.3	Conservation agriculture and improved farm management

One of the most important natural resources is the soil. Healthy and fertile soils produce good yields of crops; whereas poor or degraded soils produce low and unreliable yields. Soil health is a function of rooting depth, nutrient fertility, structure, organic matter content, below-ground biodiversity and water holding capacity – all of which are related. Ensuring soils remain healthy and fertile requires a variety of management techniques including climate-smart farming practices and nutrient management.

Most of the CIDPs promote soil fertility improvement and agroforestry but a more holistic approach would to consider conservation agriculture and improved farm management as follows (Braid & Lodenkemper, 2019):

1. Climate-smart agriculture

Climate-smart agriculture practices contribute to improving the health of the soil by enhancing its physical,

1	Key Strategic Area:	Catchment Management

chemical and biological properties. Good soil health will produce higher and more stable yields. These techniques contribute to avoiding erosion and controlling rainfall runoff, by increasing infiltration of rainwater and water holding properties and thereby improving soil moisture. Climate-smart agriculture covers the principles and practices of conservation agriculture and Permaculture (natural farming). Nutrient management focuses on soil fertility, which is of fundamental importance for agricultural production. These include compost techniques and natural fertilizers.

- **Conservation agriculture:** Conservation agriculture combines profitable agricultural production with environmental concerns and sustainability by conserving, improving, and using natural resources more efficiently through integrated management of soil, water and biological resources. Conservation agriculture contributes to food security and increases tolerance to changes in temperature and rainfall including incidences of drought and flooding. Conservation agriculture combines three basic principles or 'pillars': (i) minimum tillage, (ii) crop rotation and (iii) maintaining soil cover by crops or crop residues.
  - Conservation tillage: Minimum tillage is superficial loosening of the soil (5 cm), ripping of planting rows with a ripper tine (chisel plough), or making permanent planting basins by hand, without disturbing the soil between. Zero or no-tell is direct planting through a mulch layer using a special planter or hand tool. Conservation tillage is any form of reduced tillage technique.
  - Crop rotation and intercropping: Mixing crops by either planting a different crop in each field every season, or by planting a mixture of crops which complement each other can be beneficial. Rotating crops regularly reduces the ability of each crop's pests to become established in the soil through minimising the available food and habitat for each pest. The variety of crops also increases opportunities for a mixture of pest predators to survive.
  - Soil cover (mulching): Soil cover and mulches protect the soil from the heating and drying effects of direct sunlight and the physical damage caused by heavy rain. They also reduce evaporation, and moderate soil surface temperatures. Soil covers also slow surface runoff during rainstorms, reducing erosion and increasing infiltration.
- **Natural farming (small scale) :** Energy can be saved by laying out the farm and household cultivation/ farming beds and plots more efficiently.

2. Nutrient management

Soil fertility is of fundamental importance for agricultural production. Certain techniques maximize the efficiency of nutrients and water use for better agricultural productivity. This improves and sustains soil quality for the future. These include compost techniques and natural fertilizers.

- **Compost:** Compost helps return nutrients to the soil, reduces reliance on chemical fertilizers, increases soil organic matter, maintains moisture and provides soil cover. Compost can be made household level for cost-effective soil fertility improvement.
- **Natural fertilizer:** A balance of all essential soil nutrients is necessary for healthy plant growth. The application of any one nutrient in a soil with multiple nutrient deficiencies will have limited impact on crop growth.
- **Micro dosing:** Low-technology precision agriculture technique initially developed by ICRISAT. Small doses of fertilizer applied in the right place has been found to lead to large benefits in yields for the smallholder farmer.
- **Weeding:** A move from conventional farming (i.e. tilling the soil) to conservation farming can result in increased number of weeds. An appropriate weeding strategy is required for successful conservation farming. Weeds lower crops yields due to competition for water, nutrients, light and space.
- **Agroforestry:** Agroforestry is the intentional integration of trees within a cropping system for multiple benefits. It is increasingly recognised as one way of dealing with the lack of space and infertile soils.

1	Key Strategic Area:	Catchment Management
1.3	Theme:	Natural resources management for the protection and sustainable use of natural resources

1.3.1 Improved wetlands and lake management

According to the LVS Basin CMS (Water Resources Management Authority, 2015a), wetlands are under threat from human encroachment for settlement, expansion of crop production and livestock grazing. The Yala Swamp in Siaya county is under threat from agricultural encroachment (County Government of Siaya, 2018). Wetlands within Kisumu county are threatened by sand mining and encroachment (County Government of Kisumu, 2018). Water levels of springs and rivers in counties surrounding Lake Victoria have also been in decline with Eucalyptus being identified as one of the drivers for the decrease in water levels.

Although significant wetlands are protected from use (refer to KSA 2), in certain cases seasonal wetlands are utilized by surrounding communities. It is important to not only conserve what is existing, but also improve the farming practices and grazing in wetlands for more sustainable utilisation and reduced impacts (Braid & Lodenkemper, 2019).

1. Wetland conservation

Refer to KSA 2

2. Sustainable utilization of wetlands

WRUAs should facilitate the integrated sustainable management of wetlands that require communities to not only manage the wetlands through land use planning but also the surrounding catchments that sustain and impact the wetlands.

Wetlands must be clearly zoned with a 50m buffer of protected natural vegetation to act as an infiltration zone and blocker of sediments/runoff reaching the wetland and should have fire protection. Cultivation in the wetland should be limited to small plots or beds surrounded by natural vegetation closer to the edge of the wetland, with no development at the centre of the wetland. This will limit erosion and gully formation. Erosion and increased sedimentation can be further limited through managed grazing practices.

Correctly utilised drainage ditches will give crops space to grow, move water away to prevent waterlogging (wet season), be well placed to limit erosion, not be dug too deep/have excessive drainage which would lower the water table (dry season) and lead to gully development (flash flood event).

Organic compost improves water infiltration close to the roots of the crops. Water hungry plants such as sugar cane and Eucalyptus that reduce the water supply should not be planted in wetlands. In the catchment, agroforestry trees reduce sedimentation, improve infiltration, and stabilise and improve soil fertility. It also reduces the removal of natural vegetation for fuel wood and building materials which is a problem.

Wetlands must be clearly zoned to ensure communities manage it sustainably.

The wetland centre must be clearly demarcated and natural vegetation must be protected to prevent erosion

Community wells should not be located in the centre of the wetland because they can become focal point for gully formation. They should be placed closer to the edge of the wetlands.

1.3.2 Promote alternative/sustainable livelihoods

Communities rely on natural resources to live and earn an income. Over utilisation leads to the depletion of natural resources. Natural resources need to be managed and utilised in a sustainable manner, to maximise the goods and services received from them, while still maintaining their function and production capacity. Natural forests, grasslands and wetlands are finite resources that must be managed sustainably; similarly, alien vegetation can provide useful resources but needs to be managed to prevent uncontrollable spread. Programs that require management are as follows:

- Alien vegetation woodlots for personal and commercial use
- Promotion of alien vegetation for agroforestry use
- Agroforestry tree nurseries
- Beekeeping
- Inland aquaculture

1.3.3 Improved solid waste management

To ensure that catchment management activities and resource protection activities can be implemented, it is important that activities around the household, farm and village are also sustainable and of a high standard. These include activities such as waste management. Waste management involves the generation, collection, transportation, and disposal of garbage, sewage and other waste products. Responsible waste management is the process of treating solid wastes and offers a variety of solutions for waste with the ultimate aim of changing mind-sets to regard waste as a valuable resource rather than something that must be thrown away. The

1	Key Strategic Area:	Catchment Management

government is constitutionally bound to provide sanitation services to all of its citizens, this includes the removal and proper treatment of solid waste. In reality this is not being done in many parts of the country, particularly in remote rural areas. Water resources nearby urban areas are particularly at risk, as evident in the CIDPs. It is important to ensure that the mind-set of waste management extend to individuals and communities as it is important for a clean and safe environment.

3. Household waste management

Household waste management reduces the potential for underground contamination of water by preventing the infiltration of pollutants into the surrounding soil of illegal dump sites. Households should be encouraged to reduce the production of unnecessary waste and dispose of what cannot be reused, recycles or composted in a responsible way at a legal disposal site.

4. Village waste management

In communal rural areas, solid waste is left on open land or dumped on the roadside. Food scraps and plastic present in dumped waste creates unpleasant odours and can contribute to the spread of diseases. Waste often spreads from these sites into drains causing blockages leading to local flooding and results in various undesirable health and environmental impacts. A village waste management program involves the community in waste management.

5. Buy back centres

Many unemployed people earn some income collecting and selling recyclable goods on an informal basis. Waste picking is therefore an important alternative for those who cannot find employment in the formal labour market due to a lack of skills. Buy back centres play a crucial role in facilitating the recycling potential of these informal sector participants. Buy back centres are depots where waste collectors can sell their recyclable waste. The Buy back centres, in turn, sell these waste products to other larger Buy back centres or directly to recycling companies. Formal recycling companies process the recyclable waste into a form that is readily usable by a manufacturer or end-use market, where the recyclable waste is converted into materials or other consumption products. Buy back centres are the link between formal and informal sector activities.

1.3.4 Improved forestry management

Forests are important to return moisture to the air through evapotranspiration, which then generates rain, as well as to stabilise soils with their root systems; they can also be rich in terms of biodiversity as well as stores of carbon. Sustainable management of forests both natural and plantation, for reforesting of areas where forests have been removed including the selection of beneficial tree species.

The Vision 2030 requires the country to work towards achieving a forest cover of at least 10% of the land area to ensure sustainable resource use, growth and employment creation. The National Forest Policy (2014) indicates that the sustainable management of forests includes:

- Indigenous forests
- Plantation forests
- Dryland forests
- Urban forests and roadside tree planting
- Farm forestry

To achieve the national forest cover target of 10% of land area, the major afforestation effort will have to be in community and private lands. This is being conducted through various programs in the Basin, also linked with the reduction of sediment yield to Lake Victoria (i.e. LVEMP). Previous efforts for soil erosion mitigation (i.e. planting of eucalyptus on river banks) has caused degradation of water resources therefore proper planning is required for afforestation efforts. Consideration needs to be made to the objective of these programs as there could be significant long-term challenges associated with planting trees with high water requirements in counties with limited water supply.

1.3.5 Removal of alien invasive species

Community knowledge base on how to sustainably manage invasive and alien species should be strengthened. This is because there is knowledge but not strong understanding on the general approaches to sustainably manage invasive and alien plant species. The KFS and KWTA need to consider alien invasive vegetation management as invasive alien plant species are a threat to water resources and water availability. By managing them and preventing their further spread, these plants can also provide useful resources and alternatives to rapidly depleting indigenous vegetation.

1. Controlling alien invasive vegetation

Invading alien plants use much more water than indigenous trees and plants – and through doing so they grow faster. They prevent rainwater from reaching rivers and deprive people and ecosystems of much needed water. Invasive alien plants can displace indigenous species and thereby reduce biodiversity. Invading alien plants also

1	Key Strategic Area:	Catchment Management

increase fuel loads making the area vulnerable to devastating fires that destroy infrastructure and damage soils. By damaging the soils, important indigenous seed banks are destroyed and may be eliminated from the area.

Invasive alien plant control relies on four main methods - manual, mechanical, chemical and biological control. Long-term success of any programme is best achieved through a combination of these. This is called an integrated control approach.

Removal of larger hardwood invading alien vegetation such as: ring, barking, strip barking and hand pulling.

2. Utilising and controlling blue gum (eucalyptus) trees

Blue Gum trees, if left unmanaged, will invade and replace indigenous vegetation by monopolising the water resources. Application of invasive species management should be done throughout the catchment, but a particular focus should be given to areas closer to settlements, areas near smaller non-perennial rivers and areas known to have an elevated fire risk

3. Utilising and controlling pine trees

Invasive plants such as pine trees use much more water than indigenous species. As such they prevent rainwater from reaching rivers and deprive people and ecosystems of much needed water. Invasive alien plants can displace indigenous species and thereby reduce biodiversity. Invading alien plants also increase fuel loads enhancing the potential intensity of fires that destroy infrastructure and damage soils. However, as they are fast growing trees they are useful for afforestation projects, they must however be carefully managed in order to prevent uncontrollable spread through the catchment.

4. Utilising and controlling Bamboo

There are many types of bamboo but in general they can be divided into either clumpers or runners. The clumping species are non-invasive and can be used for building materials or stabilising soil erosion. Running bamboo species can be become very invasive and must be controlled.

5. Utilising and controlling Prosopis species

Prosopis spp. also known as mesquite, is a dominant groundwater dependent invasive alien species found in the arid and semi-arid areas. Hybridization between the dominant species, *Prosopis velutina* and *Prosopis glandulosa var. torreyana* are very invasive.

6. Utilising and controlling water weed/hyacinth

Water hyacinth, *Eichhornia crassipes* (Mart.) *Solms-Laubach* (Pontederiaceae) is a perennial, herbaceous, free-floating aquatic plant that is widely recognized as one of the world's worst invasive weeds. Anyone undertaking biological or chemical control methods should have proper training in the use of the chemical/biological agents. Additionally, they must have a strategic plan in place over several years to ensure that the process in successful and the system doesn't relapse into an infestation state.

1.3.6	Improved fisheries management

Promote the sustainable development and management of fisheries in lakes, dams, wetlands and rivers.

1.3.7	Improved energy management

To ensure that catchment management activities and resource protection activities can be implemented, it is important that activities around the household, farm and village are also sustainable and of a high standard. These include activities such as energy management. Renewable sources of energy should be promoted to generate electric power for use in the household, or community, as a replacement for the burning of wood or charcoal.

Most CIDPs promote "green energy" as an alternative fuel to wood and charcoal.

The following renewable sources could also be promoted for energy supply instead of burning wood or charcoal:

- Solar cooker; Solar electrification; Solar borehole pump; Wind pump; Micro hydropower; Biogas digester; Energy efficient stoves and ovens; Heat retention cooker; Solar turtle

1.3.8	Improved sand mine management

Develop policies for sand harvesting. Consider alternative sources of sand.

1.4	**Theme:**	**Rehabilitation of degraded environments**

1.4.1	Rehabilitation and Restoration Plan

Develop a restoration and rehabilitation programme. Refer to 1.2.2.

1.4.2	Land restoration and rehabilitation of specific priority areas

Implement restoration and rehabilitation programme.

1	Key Strategic Area:	Catchment Management
1.4.3	Site specific rehabilitation of degraded riparian areas	
Rehabilitation planning, implementation and associated management is a long-term commitment to a natural resource. The successful rehabilitation of freshwater ecosystems, and thus the overall resilience and sustainability of the system, can only be achieved through engagement of all the stakeholders reliant on the natural capital. Through the Reserve process studies should be conducted to delineate riparian areas of significant water resources. These studies are required to understand the riparian functioning so that an effective rehabilitation strategy can be developed. The level and type of rehabilitation adopted is case/site specific, as rehabilitation planning is largely dependent on the extent and duration of historical and current disturbances, the cultural landscape in which the ecosystem is located and the opportunities available for rehabilitation. Understanding the overall functioning of the system, particularly in a landscape where the community is dependent on the natural resource, is key for the success of any rehabilitation project. This is further supported by ensuring that an adaptive management approach is incorporated into the planning and aftercare of the system, thus ensuring the ecosystem is maintained at a desirable level and offering it resilience to stressors.		
1.4.4	Site specific rehabilitation of degraded wetlands	
Prioritize wetlands in need of rehabilitation. Once these have been prioritised, rehabilitation and restoration plans should be developed, that will result in increased natural vegetation cover. Local CBOs and NGOs should be involved in this process.		
1.4.5	Site specific rehabilitation of Gazetted forests or protected forests that have been degraded	
Gazetted forests or protected forests that have been degraded need to have new trees planted in order to meet the Kenya Vision 2030. When KFS engage in re-planting trees, it should be done considering appropriate soil and water conservation techniques and beneficial/natural trees as a part of an integrated catchment management approach. According to the LVS Basin CMS (Water Resources Management Authority, 2015a) forests in Narok, Bomet, Nakuru, Baringo, Uasin Gishu, Nandi, Kisumu and Homa Bay have had vegetation cover loss. The CIDPs have promoted tree planting for agroforestry, woodlots for alternative energy and provided education about the detrimental effects of deforestation for communities and the environment.		
1.4.6	Mining area rehabilitation	
Mining removes the protective covering from the land and exposes soils to soil erosion as well as pollution impacts. During mining activities exposed soils must be revegetated and soil conservation techniques implemented.		

6.3 Water Resources Protection

6.3.1 Introduction

Water is critical to social and economic development but also supports key ecological systems which underpin human wellbeing and provides essential ecosystem goods and services. According to the Kenya Water Act (2016), a water resource is defined as *"any lake, pond, swamp, marsh, stream, watercourse, estuary, aquifer, artesian basin or other body of flowing or standing water, whether above or below the ground, and includes sea water and transboundary waters within the territorial jurisdiction of Kenya*". It is important to differentiate between surface and groundwater resources as these are treated differently within the context of water resources protection: surface water resources include rivers (i.e. stream, watercourse), wetlands (i.e. lakes, ponds, swamp, marsh, spring) and estuaries, while groundwater resources refer to aquifers and artesian basins.

> In Kenya, wetlands are defined as areas of land that are permanently or occasionally water logged with fresh, saline, brackish, or marine waters, including both natural and man-made areas that support characteristic plants and animals. These include swamps, marshes, bogs, shallow lakes, ox-bow lakes, dams, riverbanks, floodplains, fishponds, lakeshores and seashores. They also include coastal and marine wetlands such as deltas, estuaries, mud flats, mangroves, salt marshes, seagrass beds and shallow reefs all of which at low tide should not exceed 6 meters.
> - Ministry of Environment Water and Natural Resources, 2013

The 2016 Water Act also outlines the designation of Basin areas, with functions of Basin Water Resource Committees (BWRCs) within each Basin clearly stated. Furthermore, the Act defines the establishment and functions of Water Resource Users Associations (WRUAs) i.e. associations of water resource users at the sub-basin level in accordance with Regulations prescribed by the Authority. These associations are community based for collaborative management of water resources and resolution of conflicts concerning the use of water resources.

Protection of water resources in Kenya therefore starts at the National level with the WRA developing policies and legislation for protection of water resources. BWRCs then enact these measures to fulfil the water resource quality objectives for each class of water resource in a basin and need to put in place measures for sustainable management of the water resources; whilst at the sub-basin level more local level community-based management occurs through WRUAs (see Figure 6-6).

Figure 6-6: The different levels of water resources protection in Kenya

6.3.2 Classification of water resources and resource quality objectives

To date, Kenya has not classified its water resources. Protection of water resources requires defining the Class, the Resource Quality Objectives and the Reserve of the resource. The Water Act (2016) states that the WRA shall classify each water resource, specify the resource quality objectives, and specify the requirements for achieving the objectives. The Act also prescribes criteria for classifying water resources for the purpose of determining water resources quality objectives for each class of water resource. These criteria include trans-boundary considerations, strategic functions, ecological functions and vulnerability and may be considered as Resource Directed Measures, which provide the descriptive and quantitative goals for the state of the resource. This is different to the local scale management of resources, which is directed through Source Directed Controls (i.e. specifying the criteria for controlling impacts such as waste discharge or abstraction).

Classifying water resources is a step-wise process. The classification and resource quality objectives approach forms part of the Water Resource Management cycle which is an adaptive management approach focused on goal-setting (Figure 6-7). The first step in the cycle is to determine a vision for the desired future state of water resources. Water resources are then categorised according to specific Water Resource Classes which represent a management vision of a particular catchment, take into account the current state of the water resource and defines the ecological, social and economic aspects that are dependent on the resource (Department of Water Affairs, 2007). The vision for the desired future state of water resources are typically expressed as a range of Ecological Categories e.g. from A to F, in order of decreasing levels of protection for, or increasing levels of risk to aquatic species and habitats (Department of Water Affairs, 2011). The resulting Ecological Categories and ultimately the determined Class of a resource will then dictate the Resource Quality Objectives (RQOs)and the associated Reserve that is set to achieve it. The RQOs are numerical and/or narrative descriptive statements of conditions which should be met in the receiving water resources in order to ensure that the water resource is protected. The purpose of determining the RQOs is to establish clear goals relating to the relevant water resources that can be monitored and thereby give effect to the desired water resource classes in the catchment.

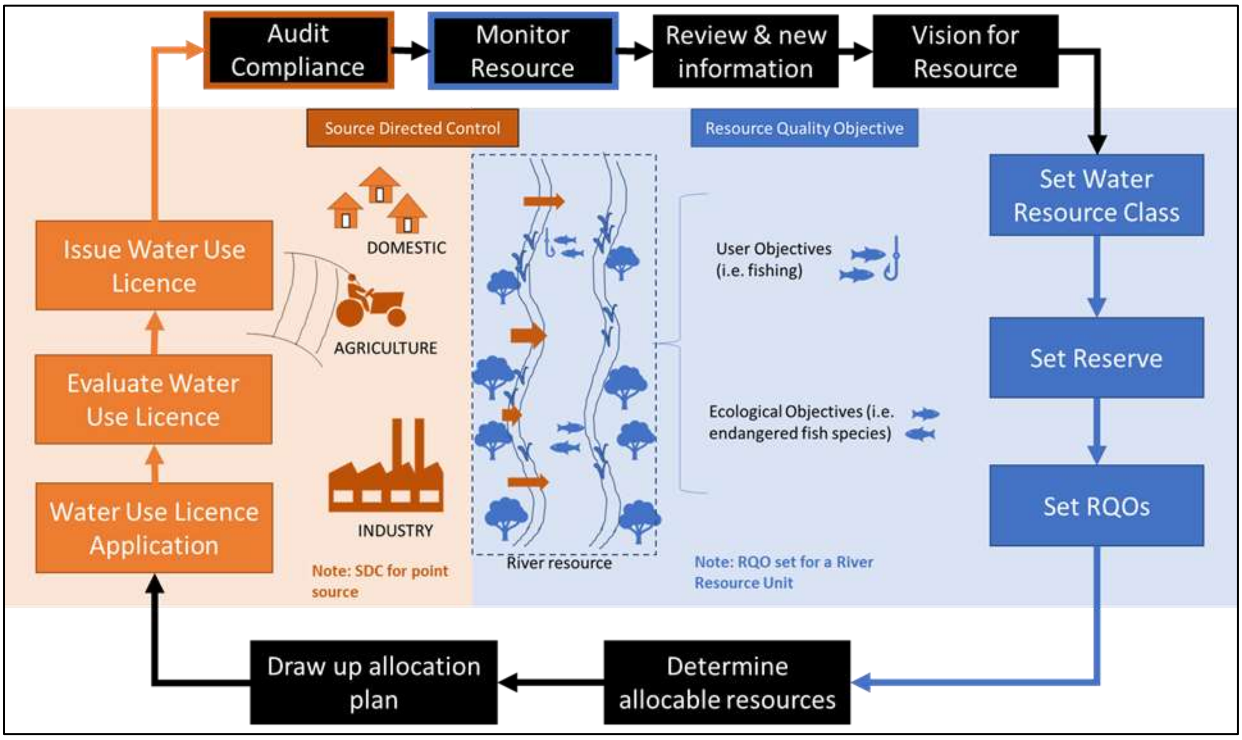


Figure 6-7: Water resources management cycle

Classifying water resources and determining Resource Quality Objectives follow aligned steps as shown in Figure 6-8. These involve delineating the water resources, establishing a vision for the Basin, linking the value and condition of water resources, quantifying the environmental water requirements (EWRs) (i.e. the EFlows), determining future scenarios and associated water resource classes, then prioritising and selecting resource units to take forward for development of Resource Quality Objectives.

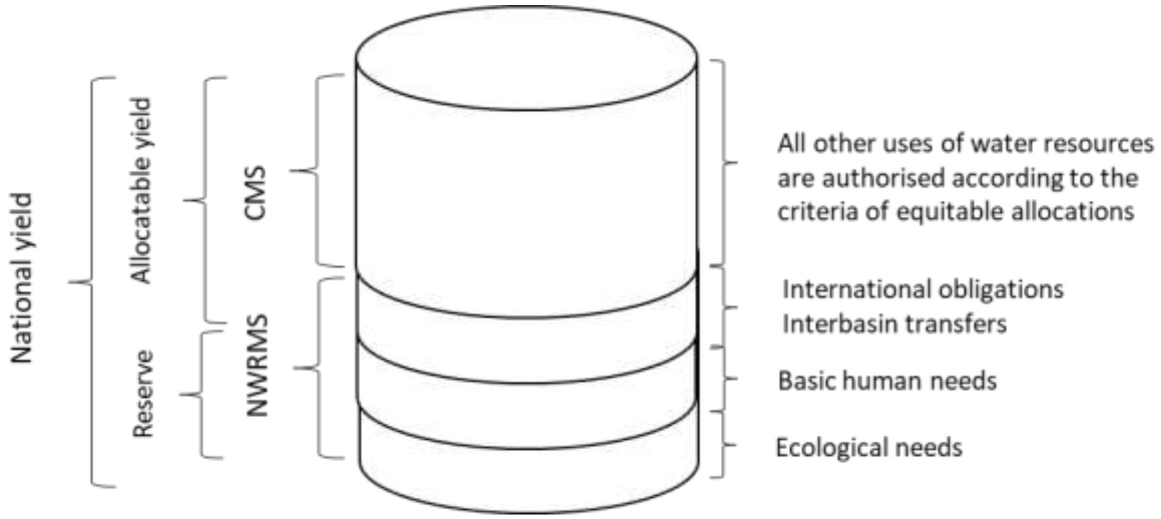
The Reserve (in terms of quantity and quality) refers to the volume of water needed to satisfy the basic human needs of people who are or may be supplied from the water resource (i.e. Basic Human Needs) and the volume of water needed to protect aquatic ecosystems in order to secure ecologically sustainable development and use of the water resource (i.e. Ecological Reserve). The Reserve must therefore be met before any allocation may be made.

The Kenya Guidelines for Water Allocation (Water Resources Management Authority, 2010) defines the Reserve quantity for streams and rivers as "*the flow value that is exceeded 95% of the time as measured by a naturalised flow duration curve*". Although this minimum flow value, which classifies as a rapid hydrological index method, allows the Reserve to be quantified, no consideration is given to the specific nature of rivers or its biota, the timing and duration of flows or the broader aquatic ecosystem.

(Department of Water Affairs, 2007, 2011)

Figure 6-8: The seven steps to determine water resource classes and resource quality objectives

The Reserve constitutes one of the four demand categories when allocating water resources in Kenya as shown in Figure 6-9. The total water resource is made up of what is available for allocation or use and the Reserve.



***Source**: Water Resources Management Authority, 2010*
Figure 6-9: The total water resource, comprised of the Reserve and allocatable resource

6.3.3 Water resources protection in the LVS Basin

6.3.3.1 Water resource protection under the Water Act

In accordance with the Kenya Water Act 2016, at the basin-level, BWRCs have to enact water resources protection and advise the WRA and county governments concerning conservation and protection of water resources. The BWRCs, in consultation with the WRA and the county governments whose jurisdiction lie within the basin area, are tasked with:

- putting in place measures to fulfil the water resource quality objectives for each class of water resource in the basin area
- describe the measures to be put in place for the sustainable management of water resources of the basin area
- contain a water allocation plan for the water resources of the basin area
- provide systems and guidelines to enable the users of water resources within the basin area to participate in managing the water resources of the basin area

As the water resource classes and water resource quality objectives in Kenya have not been defined yet, this puts strain on the BWRCs as in order to manage and protect the water resources, they need a Water Management Strategy which defines the Class, Reserve and RQOs. Management decisions should be made based on strategic targets for water resources. Without these targets there is no reference to manage towards.

Community based management of water resources is enacted through WRUAs. WRUAs are tasked with the development of Sub-Catchment Management Plans (SCMPs), which are local level action plans. The LVS Basin has 106 existing WRUAs out of a potential 137 WRUAs needed to cover the whole basin. The 31 gap of dormant or potential WRUAs needs to be addressed to ensure basin coverage of WRUAs is increased. Even among the existing WRUAs, there are capacity concerns and disparities in levels of development and maturity of the WRUAs. This denotes the need for continued capacity building for the existing WRUAs in addition to continued technical support.

Table 6-7: Key water resources protection areas in the LVS Basin

County	Water Tower	Forest	Wetland
Siaya			Wetlands occur
Kisumu			Nyando/Kano wetlands
Nandi	Nandi Hills (N)	Northern Tinderet, Tinderet	
Kericho	Mau Forest Complex	Tinderet, Londiani, Western Mau	Wetlands occur
Nakuru	Mau Forest Complex	Western Mau, South West Mau, Eastern Mau	
Narok	Mau Forest Complex	Transmara	
Bomet	Mau Forest Complex	South West Mau, Chepalungu (A & B)	
Nyamira	Sironga (N)		
Kisii	Nyangweta Hills(N) Nyacheki Hill (N) Sameta Hill (N) Taracha Hill (N) Manga Hill (N)		
Migori	Maeta Hills (N) Taragwiti Hills (N)		Migori River wetlands
Homa Bay	Gwassi Hills (N)	Gwasi, Rangwe, Gembe Hills, Lambwe	Wetlands occur

6.3.4 Strategy

In order to comprehensively and systematically address the hydrometeorological monitoring issues and challenges in the LVS Basin (Figure 6-10),

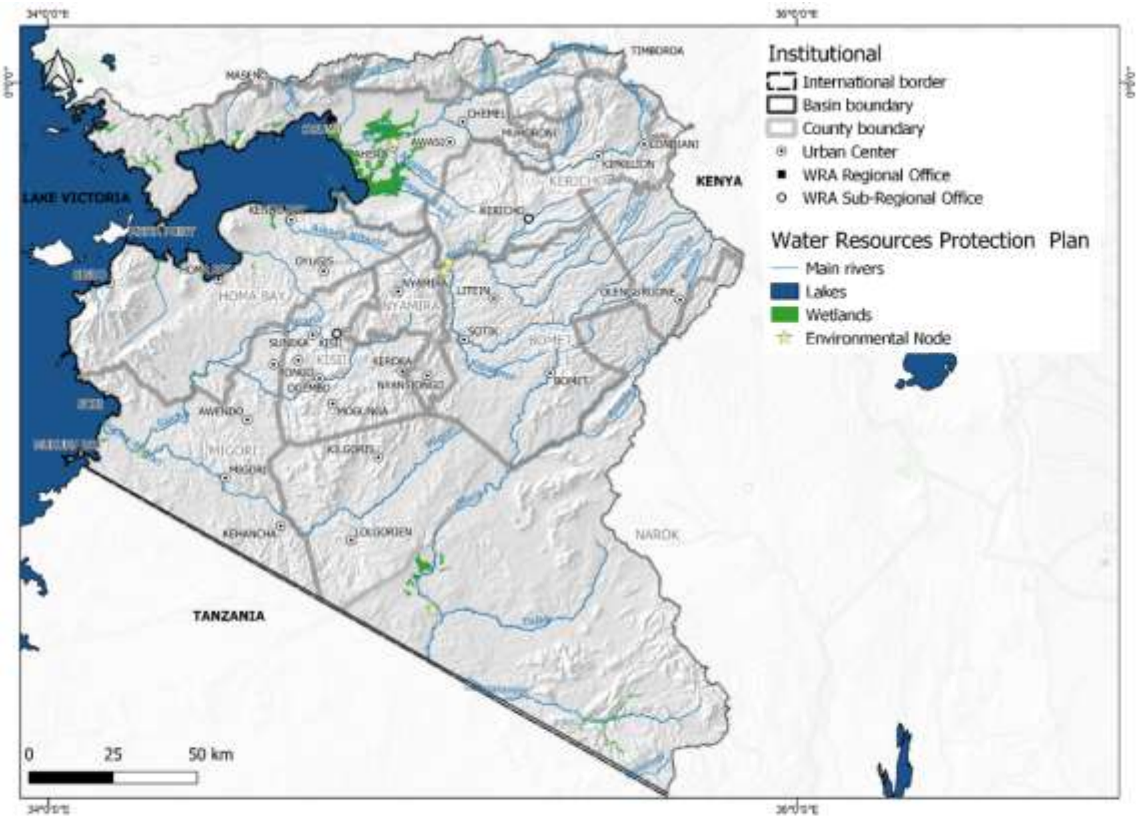


Figure 6-10: Water resource protection considerations for LVS Basin

Table 6-8 sets out 4 Strategic Themes with specific Strategies under each Theme. The Themes address Classification of water resources, Reserve determination, Resource quality objectives and the Conservation and Protection of ecological infrastructure.

Table 6-8: Strategic Framework - Water Resources Protection

2	**Key Strategic Area:**	**Water Resources Protection**
2.1	**Theme:**	**Classification of water resources**
2.1.1	Determine the baseline for Resource Directed Measures: Surface and groundwater assessments at appropriate scales to inform the classification of water resources in the basin.	
Water quality and quantity assessments are required in order to set a baseline for Resource Directed Measures. This baseline will inform the classification and resource quality objectives for the significant water resources in the LVS Basin.		
2.1.2	Determine Class of water resources	
Determining the Class of a water resource is the first step in the Water Resource Management cycle. A vision for the desired future state of water resources results in Ecological Categories for water resources based on the level of protection or increasing levels of risk. Ultimately the determined Class of a resource will determine the Reserve and associated Resource Quality Objectives that are set to achieve it.		
2.2	**Theme:**	**Ecological Reserve**
2.2.1	Reserve determination	
In order to protect the water resources of the LVS Basin the ecological Reserve needs to be determined. The total water resource (surface and groundwater) is made up of what is available for allocation or use and the Reserve. The Reserve (in terms of quantity and quality) is made up of what is needed to satisfy the basic human needs of people who are or may be supplied from the water resource (i.e. Basic Human Needs) and what is needed to protect aquatic ecosystems in order to secure ecologically sustainable development and use of the water resource (i.e. ecological Reserve). The water requirements of the ecosystem must therefore be met before any allocation may be made. This forms part of the Water Resource Management cycle which is an adaptive management approach focused on goal-setting. Once the ecological reserve is defined then the resource quality objectives can be determined for priority water		

2	Key Strategic Area:	Water Resources Protection
resources.		
2.2.2	Reserve compliance	
Water quantity is a key driver of water resources therefore its management is critical in the maintenance of ecosystems and for the provision of water for socio-economic purposes. Once the environmental reserve has been set then the flows required to maintain the reserve need to be managed. Implementing the operating rules to ensure that the releases from infrastructure required by users and the ecology are met in time and at Eflow site. This may consist of the operation of dams, abstractions and other infrastructure as well as management through licensing and implementation of restrictions. Compliance hydrological monitoring is required, based largely on the continuous monitoring at a network of flow and water level gauges. Compliance monitoring is also required, based on monitoring low flows and water levels at gauging weirs and boreholes.		
2.3	**Theme:**	**Determine Resource Quality Objectives**
2.3.1	Set Resource Quality Objectives	
Determine the Resource Quality Objectives for prioritised water resources in the LVS Basin.		
2.4	**Theme:**	**Conservation and protection of ecological infrastructure**
2.4.1	Integrate environmental considerations into basin development and planning	
Water is critical to social and economic development but is also a critical component in supporting key ecological systems which underpin human wellbeing as well as providing essential ecosystem goods and services. A strategic social and environmental assessment is therefore an important component of the Classification of LVS Basins water resources. The Classification of water resources a balance between social and environmental considerations.		
2.4.2	Groundwater protection	
Rehabilitate polluted aquifers, springs and wells as part of Catchment Management Plan. Groundwater source protection zones defined by WRA and gazetted under Water Act 2016.		
2.4.3	Riparian areas protection	
Riparian areas, as defined by WRA, gazetted under Water Act 2002 and WRM Regulations 2007, currently under amendment by Attorney General in accordance with revised definition agreed on at sixteenth meeting held on 2 June 2020 by the National Development Implementation and Communication Cabinet Committee.		
2.4.4	Ecosystem services protection	
Water is critical to social and economic development but is also a critical component in supporting key ecological systems which underpin human wellbeing as well as providing essential ecosystem goods and services. In particular, certain environmentally sensitive areas are reliant on the protection of water resources. Although environmentally sensitive areas are defined by NEMA, this information should be provided to WRA during the Classification of water resources in order for WRA to classify and protect according to the Water Act 2016.		

6.4 Groundwater Management

6.4.1 Introduction

Groundwater has provided and will continue to provide much of the water needed for livelihoods and development for many communities and industries in Kenya. Numerous rural communities and small towns across the Republic depend on groundwater from boreholes and shallow wells for their domestic and livestock needs, and to support other economic activities. Spring flow and baseflow contribute significantly to maintaining streamflow, particularly during dry seasons. Groundwater management is known to be one of the most important, least recognised and highly complex of natural resource challenges facing society (Foster, 2000).

Groundwater in Kenya is currently not managed in a coherent fashion (Mumma, Lane, Kairu, *et al.*, 2011). A final draft National Policy on Groundwater Resources Development and Management was published in 2013 (Ministry of Water and Irrigation, 2013), but despite the best of intentions, groundwater remains poorly understood and poorly managed. The policy document highlights a number of specific issues:

- Availability and vulnerability of groundwater resources in Kenya are poorly understood

- Institutional arrangements for groundwater management in Kenya, including management capacity and financing are weak
- Very limited integrated water resources management in Kenya, with groundwater and surface water typically being treated as separate water resources
- Very limited groundwater quality management in Kenya

In addition to the National Policy on Groundwater Resources Development and Management, the National Water Quality Management Strategy (Ministry of Water and Irrigation, 2012) addresses groundwater protection in S. 2.7. It recommended the “Development of Ground Water Protection programs” without defining or describing them. The NWQMS lays out the following “strategic responses”:

- Extraction of groundwater at sustainable rates to avoid seawater intrusion.
- Intensifying groundwater quality monitoring by sinking observation boreholes.
- Establishing a monitoring program for selected production wells to capture any changing trends.
- Requiring all borehole owners to have their water tested periodically as part of the water quality monitoring programme.
- Maintain updated database of borehole data.

A groundwater management strategy is influenced by hydrogeological, socio-economic and political factors and is informed by both policy and strategy. This Groundwater Management Plan is necessary for the integrated and rational management and development of groundwater resources in the LVS Basin. It aims to capture and integrate a basic groundwater understanding, describes sustainable management measures and presents an action plan with clear objectives and desired outcomes. It also estimates the financial requirements needed for implementation and the timeframe for its implementation. It is not a static instrument. As resources monitoring and data analysis takes place across the planning period, improvements and even whole new aspects may need to be incorporated.

The key objectives of the Plan include:

- Conserve the overall groundwater resource base and protect its quality
- Recognise and resolve local conflicts over resource allocation (abstraction or pollution)

Note: A Groundwater Management Plan needs to be differentiated from an Aquifer Management Plan: the former considers groundwater management from a Basin perspective, while an Aquifer Management Plan is applied to a single aquifer unit

6.4.2 Groundwater use

The use of groundwater in public water service providers (WSPs) in the LVS Basin is very limited. However, some WSPs supplement surface water supply with groundwater.

- The Bomet Water Company Limited (BOMWASCO) supplied an average of 11,270 m^3/d of water to 61 614 people in 2016/17 (Water Services Regulatory Board, 2018). BOMWASCO operates nine schemes, and there are also 10 community managed water supplies in the County. Three of these community-supplied projects utilise mainly boreholes, namely Tegat, Itembe and Kapkesosio (Water Services Regulatory Board, 2018). Groundwater potential is said to be poor in the northern part of the County, while boreholes in the south are generally high in fluoride (Mosonik, 2015).
- A 2006 listing shows five boreholes in the Kisii area, two described as ‘Town boreholes’ (yields 0.3 to 5 m^3/hr). Groundwater in this aquifer system is considered contaminated. While Kisumu City relies entirely on surface water (from Lake Victoria and the Kibos River), extensive use is made of shallow and deep groundwater by the private sector and domestic consumers. The shallow aquifer system has been studied in detail, particularly in Manyatta and Migosi Estates, and has been found to be contaminated by human wastewater from pit latrines and septic tanks.

- There is extensive groundwater use in and around Migori Town. The Lake Victoria South Water Works Development Agency has a groundwater application Completion Certificate for 20 m^3/d for 'Migori', and a 2006 listing shows that at least 17 boreholes existed at that time in the Migori locality. This included four boreholes explicitly used for Migori water supply, and a further five for 'MoWD/NORAD' that may be public use boreholes. Yields for these ranged from 0.5 to 4 m^3/hr. More recent data (Onyango, 2014) show borehole yields ranging from <0.5 to 15.1 m^3/hr (mean 5.6 m^3/hr). There is some evidence that shallow groundwater beneath Miigori Town is contaminated by human wastewater from pit latrines and septic tanks.
- The Nyasare Water and Sanitation Company was formerly the Nyasare Water Supply Association. In September 2013 it was taken up by the LVSWWDA, but is still run by the community (Onditi, 2015). According to the Water Services Regulatory Board (2018), it supplied an average of 395 m^3/d to 24,996 people in 2016/17. The water source is solely groundwater, with eight protected springs and one borehole serving an area under gravity, and a further five shallow wells with hand pumps for residents who do not fall within this area. The stated yield is 12,700 m^3/month: with 9,800 m^3/month from springs, 2,300 m^3/month from the borehole and an estimated 600 m^3/month from the shallow wells. This averages 416 m^3/d (Onditi, 2015). There is a single PDB Authorisation issued to the Nyasare Water Supply and Sanitation Company Ltd for 20 m^3/d from the Migori aquifer, presumably for the borehole. If the figures cited by Onditi (2015) are correct, then borehole abstraction at 75 m^3/d exceeds the Authorisation volume.
- In a 2006 borehole list there are a total of 110 boreholes drilled by government entities (including the Department of Water Development, the MoWD, and the LBDA/RDWSSP). The vast majority of these were drilled for rural communities under LBDA/RDWSSP, and likely to have been originally largely equipped with handpumps. It is uncertain the extent to which these have been captured by the water permit process. This indicates the significance of these rural development programmes in rural water supply.
- The LVNWWDA has PDB Authorisations for four groundwater sources, all for 20 m^3/d, in Kangeso (Migori aquifer), Nganaiyo (Nyangusu aquifer), Nyamila (Homa Bay aquifer) and Reru (Winam aquifer). The Lake Basin Development Authority (LBDA) has two Authorisations in the PDB, for a total of 28 m^3/hr (one of which is clearly for the new LBDA Headquarters building in Kisumu).

Limited public conjunctive use is in place at present. For the town of Kisii, surface water supply is supplemented by limited groundwater resources from boreholes. As with Kisii, Migori's surface water meets most of Migori's demand, but a few town boreholes supplement this. The Nyasare project north of Migori also helps meet some of the Town's water demand. The Nyasare supply is sourced entirely from groundwater. The extent to which the NIA's "Ahero Irrigation Project" uses groundwater is unknown, as no permit application paperwork exist for either surface or groundwater. Irrigation water comes from the Nyando River. There are also likely to be small-scale conjunctive water use projects, but if they exist they are unlikely to be significant in volumetric terms.

There is limited conjunctive use in the private sector, although there are a few examples below. There may be other conjunctive water uses in the LVS Basin.

- Homa Lime Ltd has two surface water Permits for a total of 200 m^3/d (domestic, irrigation and commercial) and Authorisations for three boreholes amounting to 19 m^3/d (domestic).
- Isinya Roses Ltd (Kericho County) derives 56 m^3/d from surface water (permitted) and three groundwater applications (permit or inspection report received) for a total of 85 m^3/d.
- James Finlay (K) Ltd, Lemotit Farm, Londiani (Kericho County). A flower farm harvests rainwater runoff from greenhouses and has constructed a small dam from which it has a permit to abstract 1,320 m^3/d and an application for a further 100 m3/d. The farm has three groundwater permits for a total of 420 m^3/d. Water is used for domestic, irrigation and pack house (commercial).
- Kibos Sugar and Allied Industries Ltd (Kisumu County). A sugar farm and factory have three groundwater applications (all Completion Certificates Received) for a total of 350 m^3/d; and surface water Authorisations, Permits or Completion Certificates Received for three sources for a total of 1,129 m^3/d. Water uses include domestic, irrigation and industrial/commercial.

- Transmara Sugar Company Ltd (Narok County). A sugar farm and factory that uses both surface water and groundwater: 400 m^3/d from the Keyian River (Permit, for industrial use) and 30 m^3/d from the Nyangusu aquifer (Authorisation, for domestic use).

6.4.3 Groundwater resource potential

The annual groundwater recharge for the LVS Basin was estimated at 2,095 MCM/a, with a sustainable annual groundwater yield of 292 MCM/a. This is higher than the Kenya National Water Master Plan (NWMP) 2030 sustainable groundwater yield estimate of 203 MCM/a for the LVS Basin (Water Resources Management Authority, 2013). However, whereas the NWMP 2030 assumed sustainable yield as a percentage of recharge (10%), the groundwater assessment which was conducted as part of this Consultancy estimated sustainable yield based on regional and secondary permeability and topography.

Projected sub-basin precipitation and temperature changes under climate change scenario RCP 4.5 were superimposed on the groundwater model of the LVS Basin to assess the potential impacts on recharge and groundwater potential. It was found that the recharge in the basin will increase by 3% to 2 154 MCM/a, while the potential groundwater yield is expected to increase by 4% to 303 MCM/a under RCP 4.5. This is different to the NWMP 2030 sustainable yield that shows a 7% decrease in sustainable groundwater yield for 2030.

Annexure B lists the groundwater potential per sub-basin.

6.4.4 Proposed aquifer classification

The current classification system of aquifers in the LVS Basin (refer to Section 2.2.1.3) has the advantage of simplicity. It relies primarily on aquifer use and use intensity to determine aquifer description and status, followed by the county or locality, and finally the geology/hydrogeology.

However, this classification system is not entirely appropriate as it may lead to the understanding that certain aquifers or aquifer types ‘belong’ to specific counties or locales. They do not; geology and hence groundwater does not respect geopolitical boundaries. A revised system is therefore proposed, which ignores geopolitical boundaries and relies wholly on the geology of the Basin’s aquifers, as shown in Figure 6-11 and Table 6-9.

It is acknowledged that this approach does not specifically capture those aquifer units or parts of aquifer units that are of key importance as water supply sources. However, these should ultimately be captured by Aquifer Management Plans and numerical models developed for them. They would be designated Priority Aquifers.

Note: The proposed aquifer classification system for the Lake Victoria South Basin is included in “ISC Report D2-2: Groundwater Monitoring and Management Guideline”.

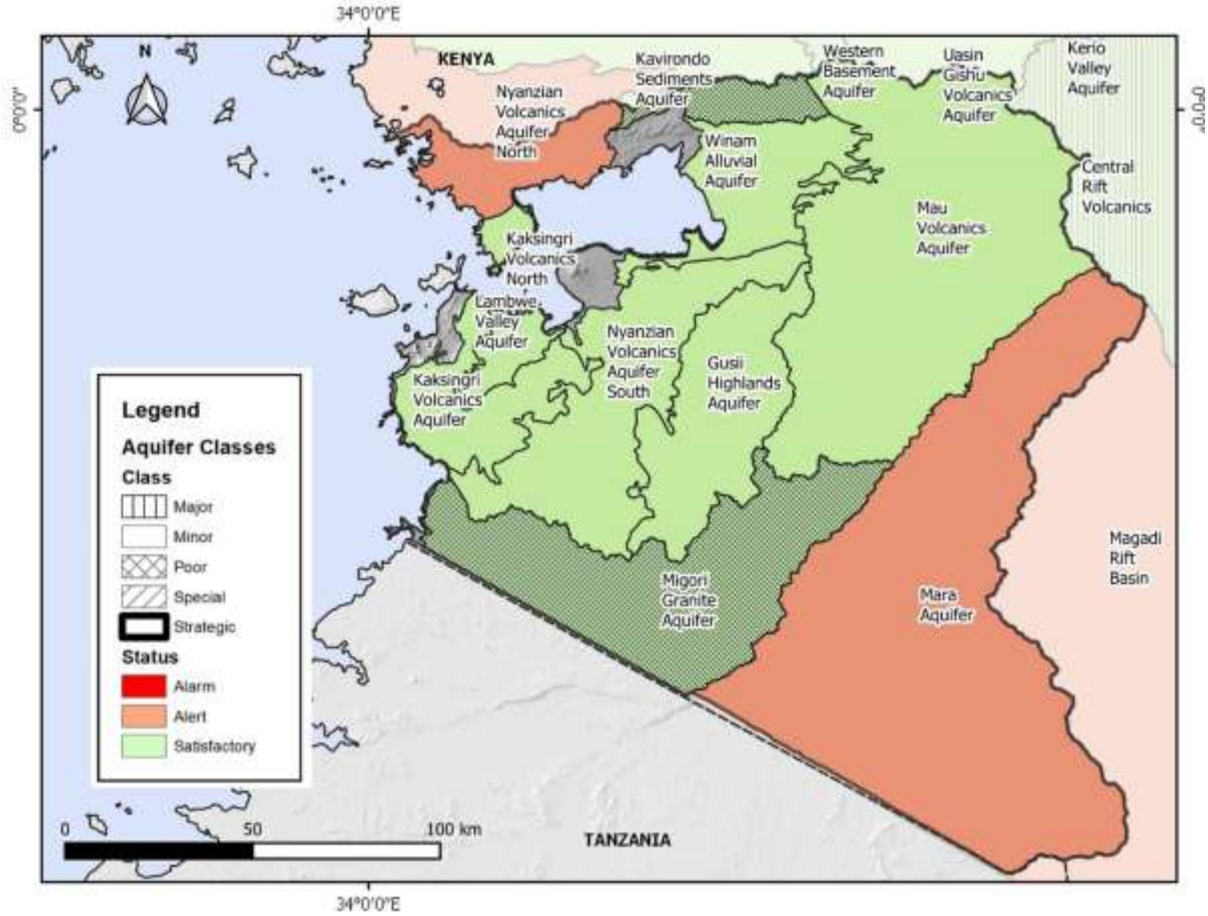


Figure 6-11: Proposed aquifer classification of the LVS Basin

Table 6-9: Proposed classification of aquifers in the LVS Basin

Name	Geology/lithology	Area (km^2)	Depth range (m)	Yield potential (m^3/day)	Dominant flow type(s)	Typical water quality	Status
MINOR							
Mara	The aquifer is a suite of volcanic and Basement rocks. The Basement rocks belong to the South-western Mozambican Belt System, which comprises gneisses, schists and amphiholites together with intercalated massive quartzites. The Tertiary volcanic rocks consist of phonolitic lava flows, being generally less than 60m thick and younger volcanic ashes and tuffs of Mau. Between the Mau Tuffs and the Mau Ashes, thin horizons of lapilli tuffs and agglomerates may be found.	8,422	Upper Mara - >200; Lower Mara -50-150	Upper Mara<240 Lower Mara>86	Fracture and intergranular	Upper Mara EC<1000 µS/cm Lower Mara EC<1500 µS/cm	Alert
Gusii Volcanics	Composed of rhyolitic tuffs with quartzites and cherts underneath; these rocks belong to the Bukoban System, which is characterised by a succession of basalts, quartzites and cherts. The latter tend to outcrop in valleys, while the higher areas are made up of rhyolites and rhyolitic tuffs.	1,928	<60	<240	Fracture and intergranular	EC<1500 µS/cm	Satisfactory
Nyanzian Volcanics South and North	The Nyanzian System is a suite comprising porphyritic andesites, andesitic tuffs, basalts, metabasalts with banded ironstones, rhyolites, greywackés and conglomerates. In the Nyanzian Volcanics North, the rhyolites and tuff are absent; porphyritic andesites are dominant, alongside basalts and dacite.	2,553	<50	<240	Intergranular and fracture	EC<1500µS/cm	Satisfactory; Alert in North

Name	Geology/lithology	Area (km^2)	Depth range (m)	Yield potential (m^3/day)	Dominant flow type(s)	Typical water quality	Status
Kaksingri Volcanics	Made up of the Kisingiri Volcanic Series that belongs to the Nyanzian System. They range from agglomerates and tuffaceous deposits to pyroclastics and reworked volcanic material. The reworked material and pyroclastics were deported as lake beds	1,121	<100	<240	Intergranular and fracture	EC<15000 µS/cm	Satisfactory
Lambwe Valley aquifer	Diatomitic lake beds, reworked volcanic sediments and alluvial deposited in the Lambwe Valley	359	<100	<240	Intergranular	EC<15000 µS/cm	Satisfactory
Winam Alluvial aquifer	Medium to coarse grained alluvium from clastic sediments derived from hillwash of the Nyando Escarpment, silt and fine clayey alluvium in the lowest zones. Recent alluvial materials here consist of lateritised lava soils and red and grey soils.	1.281	<100	<240	Intergranular	EC<1500 µS/cm	Satisfactory
Mau Volcanics	A volcanic succession of Kericho phonolites, phonolitic nephelinites and trachytic phonolites. The Kericho phonolites are the oldest member in the succession and make the main water-bearing unit in the Mau Volcanics. The series overlies undifferentiated Basement rocks and where a contact aquifer is encountered, it tends to be brackish.	6,000	Multi-layer; <100; <150; >200	<240	Fracture and intergranular	<1500 µS/cm	Satisfactory
POOR							
Migori Granite	As the names suggests, a granite bedrock aquifer; the unit belongs to the Kavirondo Series. There are several varieties of granite – a grey to pink generally fine non-porphyritic, a porphyritic type and the coarse tor-forming granite.	3,370	<60	<86	Intergranular	EC<1500 µS/cm	Satisfactory

Name	Geology/lithology	Area (km^2)	Depth range (m)	Yield potential (m^3/day)	Dominant flow type(s)	Typical water quality	Status
Kajulu Hills	The aquifer is distinguished by the Maragoli granites bedrock. It is coarse and well-jointed, forming large tors which dominate the Nyando Escarpment on top of which the Kajulu Hills is situated. The granite is heterogeneous, varying from syenite to granodiorite and typical granite. It is predominantly porphyritic	462	<50	<86	Intergranular	EC<1500 µS/cm	Satisfactory

6.4.5 Key groundwater issues and challenges in the LVS Basin

6.4.5.1 Vulnerability

A review of groundwater vulnerability assessment in Kenya as a whole is given by Rendilicha et al., (2018) and highlights how few vulnerability assessments have been carried out in Kenya. The risk of pollution to deep groundwater across Kenya is discussed in general terms in the draft National Groundwater Potential Report (Water Resources Authority, 2019b).

The vulnerability of LVS Basin aquifers is largely unknown, as few studies have been carried out at the appropriate level of detail. However, there is broad evidence showing that pollution has already occurred in shallow groundwater systems in the LVS. Shallow aquifers underlying densely-populated informal urban settlements have been found to be polluted by human wastewaters (see next section under Pollution). Practical management approaches that make meaningful improvement are likely to be difficult to implement; in such areas, the most obvious solution will be the installation of WSP water supplies to kiosks or individual connections (Wagah, Onyango & Kibwage, 2010).

Given the significance of spring waters in meeting water demand (especially in some of the most densely populated counties, namely Kisii and Nyamira), and the impact of land use changes on natural recharge, consideration should be given to catchment protection measures that protect spring recharge zones. Prasad & Obiero (2014) outline the risks that high population densities, conversion of land to intensive subsistence farming, and the planting of Eucalyptus trees in recharge areas, could have on spring flow in a part of Migori County (698 people per km). Eucalyptus trees have long been known to jeopardise near-surface groundwater resources (Oballa *et al.*, 2010; Regional Land Management Unit, 2003). NEMA published a Vacation Order prohibiting the planting of Eucalyptus in wetlands and riparian areas in 2011 (National Environment and Management Authority, 2011). However, there remains resistance to the NEMA Order from farmers[2]. The 2015 CMS (Water Resources Management Authority, 2015a), makes mention of Eucalyptus as “unfriendly-water use plants” in the context of catchment degradation.

6.4.5.2 Water quality

Natural contaminants include iron, manganese and chloride. Fluoride is not a significant natural constituent of LVS groundwaters except in the drier parts of Bomet County and probably in the part of Narok County that lies in the LVS Basin. In Boomet, elevated natural fluoride was reported in deep groundwaters and (surprisingly) water pans. Wet and dry season averages for fluoride in borehole waters were 4.37 and 4.51 mg/L respectively, and 2.74 and 2.46 mg/L in pans respectively. In contrast, other water sources has fluoride values of between 0.38 and 0.53 mg/L (rivers), 1.55 and 0.83 mg/L (springs) and 0.54 and 0.73 mg/L (shallow wells) (all after Mosonik, 2015).

6.4.5.2.1 Impacts of mining

Gold mining activities have led to the pollution of surface and groundwaters in the LVS Basin, particularly in the Migori area sub-catchment 1KC (Migori-Gucha). The Migori-Kihancha Regional Master Plan recognised that drainage from the Macalder Mine contained elevated concentrations of copper and zinc (Government of Kenya, 1975). Ogola et al. (2002) describe Acid Mine Drainage (AMD) in the Macalder Mine area and showed that surface waters and stream sediments in the area were significantly polluted. Ngure et al. (2017) sampled surface waters in the Migori river basin (at Macalder, Gucha and Karungu; Kisumu rural as a control). Significant concentrations of trace metals were measured, with values higher than KEBS (2007), shown in red in Table 6-10. The lead concentrations are very significant, and if present in surface waters, the recharge by polluted waters of adjacent alluvial and bankside aquifers is likely to occur.

Table 6-10: Surface water contamination from gold mining in the Migori area (µg/L) (Ngure *et al.*, 2017)

Site	Hg	As	Pb	Cd	Cr	Cu
Macalder	0.92	0.042	59.2	83.3	27.7	99.2
Gucha	18.1	0.029	69.6	91.1	26.3	69.1
Karungu	18.9	0.097	89.3	136.1	87.7	34.1
Control	0.6	0.001	13.1	32.3	14.1	41.7
(Kenya Bureau of Standards, 2007)	1	10	10	3	50	1,000

Okoth (2011) measured trace metals (Zn, Cu, Pb and Fe) in borehole waters within a 35 km radius of the Macalder Gold Mine (Table 6-12). Groundwaters from the inner zone (0 – 17.5 km) contained significantly higher concentrations of these species than those from the outer zone (17.5 – 35 km).

Table 6-11: Groundwater contamination in the Macalder Gold Mine area (mg/L) (Okoth, 2011)

Species	KEBS (2007)	Inner Zone (0 – 17.5 km)		Outer Zone (17.5 – 35 km)	
		Wet	Dry	Wet	Dry
Zn	5	0.1 - 0.37	0.08 - 0.19	0.03 - 0.12	0.04 - 0.07
Cu	1	0.07 - 0.12	0.02 - 0.04	0.01 - 0.06	0.01 - 0.03
Pb	0.01	3.67 - 4.05	1.97 - 2.48	0.51 - 2.93	0.62 - 2.00
Fe	0.3	1.10 - 1.33	1.36 - 1.63	0.40 - 1.12	0.44 - 1.51

Okoth (2011) showed that the concentrations of the trace metals decreased with increasing distance from Macalder. Despite this, even the lowest reported concentrations of lead (Pb) far exceed the Kenya Standard for Drinking Water (Kenya Bureau of Standards, 2007), and is a severe health concern. Iron (Fe) is an essential nutrient, but when present at excessive concentrations it can turn water a dirty brown colour and stain laundry and plumbing fittings. This study did not discuss the reasons for the trace metal distribution, but it is unlikely to be solely caused by mining or mine wastes, as excessive concentrations are also found upstream of the Macalder Mine and in other sub-catchments. It is more likely to be a distance-associated function of the mineralogy of the Migori Gold Belt, which hosts iron, gold, silver and lead in pyrite, arsenopyrite, pyrrhotite, chalcopyrite, electrum and galena, occurring in a narrow band extending from Lolgorien (Narok County) to Macalder (Shackleton, 1946).

Mining waste pollution is not an unusual phenomenon in mining environments. Mining is not widespread in the LVS Basin yet, but exploration is continuing, especially for gold. There is relatively widespread artisanal mining in the southern part of the Basin, particularly in the Migori Gold Belt. This has led to mercury contamination in surface waters (Ogola *et al.*, 2002).

6.4.5.2.2 Pollution

Onyango (2014) presented water chemistry data for 15 boreholes in and around Migori Town (across about 70 km^2. This did not show serious signs of pollution; fluoride ranged from 0.01 to 2.7 mg/L (two waters with F >1.5 mg/L); iron 0.05 to 4.8 mg/L (six > 0.5 mg/L); manganese 0.07 to 0.26 mg/L; chloride 4.0 to 230 mg/L; and nitrate 0.01 to 44.3 mg/L. In two waters nitrate approached the Standard (50 mg/L), suggesting that some pollution may be taking place. TDS in these waters ranged from 84 to 1,150 mg/L.

The Migori-Kihancha Regional Master Plan described bacteriological contamination in unprotected and protected springs (Government of Kenya, 1975); 75% of unprotected springs showed faecal contamination, whereas only 33% of protected springs did.

Kimani-Murage & Ngindu (2007) found bacterial prevalence patterns in an informal settlement in Kisumu, confirming earlier work in the Migosi and Manyatta residential areas carried out by Orwa (2001). All are associated with high densities of pit latrines and shallow wells. Wright et al. (2013) found that nitrate and bacterial contamination in shallow groundwaters beneath Kisumu were linked, but that a correlation with chloride was not as strong. Again, pit latrine concentrations correlated strongly with excessive nitrate, with the latter reaching a maximum concentration of 199 mg/L.

Most recently, Kanoti et al. (2019)sampled and analysed 22 waters (4 rivers, 1 lake, 5 springs, 8 shallow wells and 4 boreholes) over a period of one year within and around Kisumu City. The study found that all sources were polluted with thermotolerant bacteria (TTC), the most polluted being river waters (geometric mean TTC 952 cfu/mL), then shallow wells (304 cfu/100 mL), springs (124 cfu/100 mL) and the lake (78 cfu/100 mL). Borehole waters were the least contaminated. As with previous studies, proximity of pit latrines and shallow wells correlated well with TTC counts. River pollution was ascribed to untreated raw sewage releases. Recommendations were made regarding the correct relative distances between wells and pit latrines (*cf.* AGROSS, 2001).

Misati (2016) studied water source contamination in 345 households in Kisii Central Sub-county; 106 water sources were sampled, comprising 41 springs, 34 shallow wells and 31 rainwater collection tanks. Wells were 100% contaminated by faecal coliforms, springs 95% and rainwater tanks 61%.

Nyabayo et al. (2016) sampled 96 shallow wells in Bomachoge Borabu, Kisii County and measured the distance from each well to the nearest pit latrine, as well as the depth of each shallow well and pit latrine. The study found that the concentrations of *faecal* coliforms in shallow well waters correlated with distance between well and pit latrine – the closer the pit latrine to the shallow well, the higher the *faecal* coliform count.

Despite extensive research efforts in the Mara basin, little information is available regarding groundwater quality. Surface water quality is generally acceptable, except that pesticides (hexachlorobenzene and 4,4' DDE) were detected on the Amala River near Mulot (Mara River Basin Initiative, 2006); and PCBs were detected in six out of eight stations sampled, including sites in the Masai-Mara National Reserve and Serengeti National Park. Absolute concentrations were low, however, Gichana et al. (2014) confirmed the presence of significant bacterial contamination in the Nyangores River (mean total coliforms 500 to 4,628 cfu/100 mL; and mean *E. coli* 200 to 3,469 cfu/100 mL). Nyairo et al. (2015) confirmed the presence of copper, cadmium, zinc, chromium, manganese, lead and selenium in surface waters in the upper Mara (Amala and Nyangores Rivers), but not at concentrations of concern. As previously alluded to, polluted surface waters can pollute bankside aquifers through lateral recharge.

A Mara River Basin Monograph (WREM International Inc, 2008) makes mention of deteriorating groundwater quality, but provides no evidence for it.

Generally, the extent and significance of groundwater pollution in the Lake Victoria South Basin is uncertain. However, as the paragraphs above show, numerous studies confirm the extent and significance of shallow aquifer pollution by human wastes. It is very likely that the patterns described above occur elsewhere in the LVS Basin, especially in areas of high population density and in informal peri-urban settlements.

6.4.5.3 Other issues and challenges

6.4.5.3.1 Regulatory

Poor planning and integration when it comes to surface water and groundwater allocation are evident, with surface and groundwater effectively treated as different water resources. The recent Water Allocation Plan Guideline (Water Resources Authority, 2019a) should help resolve this, as it defines both surface water and groundwater as resources.

Unclear NEMA and WRA mandates re wastewater management and licensing (both bodies seek 'polluter payments' from water users/polluters) is an issue. NEMA legislation (Act of 1999 and effluent regulations in the Environmental Management and Co-ordination (Water Quality) Regulations, 2006), pre-dates water legislation (Water Act in 2002, and effluent regulations in the Water Resources Management (Amendment) Rules).

Mandates between Counties and the WRA are also uncertain, with Counties in particular drilling boreholes without the benefit of WRA Authorisations and sometimes of poor technical quality (installing mild steel casing/screen in low pH GW environments, for example). Furthermore, potential conflict between national and county governments is likely, regarding the sharing of natural resources benefits (cf. *the Natural Resources (Benefit Sharing) Bill*, 2014 and *the Natural Resources (Benefit Sharing) Bill*, 2018). Both Bills specifically include water resources.

6.4.5.3.2 Inadequate monitoring

The current state of groundwater monitoring in the LVS basin is presented in section 2.4.8.5.

Private sector or NGO players do operate their own monitoring networks, such as that operated by Base Titanium Ltd in the South Coast (covering both water levels and water chemistry). The water level monitoring network operated by UNICEF/CARE Kenya in the Dadaab part of the Merti aquifer has been terminated.

Field water quality data collection is improving, with a broader range of measurements planned in order that resource quality objectives can be determined. Parameters planned cover the following: electrical conductivity, turbidity, temperature, pH, total suspended solids, dissolved oxygen, total nitrogen and total phosphorus. This list given in the 2015 LVS CMS for surface water, it is assumed that the same instruments are available for GW quality monitoring (Water Resources Management Authority, 2015a).

Abstraction monitoring is done on an ad hoc basis at best - groundwater users are required to submit abstraction data monthly or quarterly as evidence to support their water charge payments, but these are rarely checked in the field by the WRA. The capacity to improve abstraction monitoring will be boosted by the adoption of formal guidelines for groundwater abstraction surveys, using electromagnetic flow meters (Water Resources Authority, 2018b).

6.4.5.3.3 Groundwater permit classifications

For water permit classification it is necessary to determine whether dedicated monitoring boreholes (or piezometers) require a Water Permit. In cases where a monitoring borehole may be periodically used to obtain small quantities of water for analysis (<<1m^3), a Category A Permit should potentially be issued. Prior to 2014, applications to construct monitoring boreholes were issued with Authorisations but not Water Permits. Since 2014 there has apparently been no requirement for either Authorisations or Permits for monitoring boreholes (diameters <4”/102mm). It is necessary to determine whether true exploratory boreholes require a Water Permit after completion if they are not to be commissioned as production boreholes. There is a need to clarify the role and application of the Form WRMA 0A3 (Notification Approval for Construction of Work and Use of Water).

For Class A, the applicant will get an Approval. For Class B, C and D, the applicant is issued with a Permit. For all Classes, the applicant is mandatorily required to obtain an Authorization.

6.4.5.3.4 Outdated borehole inventory

Borehole data have been and are stored in a number of separate systems:

- The 1992 NWMP (Water Resources Management Authority, 1992) initiated the National Water Resources Database (NAWARD), which remains a source of data - although it has not been updated since 2005. In the period 2005-2010, the data collection role was taken up by the WRA, and during the handover period, there was a measure of confusion as to which agency drilling contractors should submit drilling data to (Ministry of Water and Irrigation, 2012).
- The WRA currently collects and stores borehole data in a combination of paper and digital formats, with the long-term intention of digitising all records. The first attempt at digitising borehole data was

made in 2010 as part of the Nairobi Borehole Census. All borehole records that could be found across a wide range of sources were digitised and established in a Microsoft Access database system, protected by password access.

Completion of the digitisation exercise is essential. This should be digitally linked to/interfaced with the PDB.

6.4.5.3.5 Over-abstraction in the LVS Basin

There is little evidence of over-abstraction in the LVS Basin, although inadequate enforcement could be placing groundwater resources under stress. Over-abstraction across the LVS Basin is patchy and restricted to 'hotspots':

- The WRA identified two aquifers that are at risk of over-abstraction (Water Resources Management Authority, 2007c). These are the Kericho aquifer (a minor aquifer); and the Mara River aquifer (a poor aquifer in the Mara basin). Given the relatively high density of boreholes in the Migori area (Onyango, 2014), this aquifer should be studied to determine whether over-abstraction is taking place. Migori hosts one of the WRA monitoring boreholes (Water Resources Management Authority, 2015a).
- Aquifers that have water quality concerns (either natural water quality or pollution) are relatively numerous (Water Resources Management Authority, 2007c; see Table 2-3 in section 2.4.2.2). Assessing whether these require management interventions must await the completion of groundwater abstraction and water quality surveys.
- A Mara River Basin Monograph (WREM International Inc, 2008) makes mention of depleting groundwater and deteriorating groundwater quality in that area, but provides no evidence of either.
- Over-abstraction from other aquifers in the LVS Basin is uncertain, though there are some concerns about aquifers beneath Kericho and Bomet. More recent data suggest that the Kisii and Migori aquifers in the vicinity of these Towns may be under stress. It is possible that some Basement and metasedimentary aquifers have suffered localised depletion.

6.4.5.3.6 Insufficient information on groundwater recharge and groundwater potential

Updated high level estimates of groundwater recharge and potential have been completed as part of this Consultancy (see Section 2.4.2). No numerical models on groundwater in the LVS Basin have been developed (Blandenier, 2015). There is therefore a need to select Priority Aquifers for modelling. This will inevitably require the establishment of a water resources monitoring network in advance of generating a model, which would involve any or all the following: climate; surface water flows; groundwater levels, abstraction rates and water quality. A time series of several years is ideally required for the baseline dataset which the model will use for calibration. Given the natural climate variability of much of the Basin, it is desirable that both drier and wetter than 'normal' years are captured.

6.4.5.3.7 Transboundary aquifers

There are no 'official' transboundary aquifers in the Lake Victoria South Basin (Nijsten, Christelis, Villholth, *et al.*, 2018). However, there is likely to be some groundwater flow from those parts of the upper Migori catchment that lie in Tanzania into Kenya. Similarly, given the surface gradient (north to south), there is likely to be moderate groundwater flow into Tanzania from the Mara aquifer system. Neither are likely to be significant in volumetric terms. Further study will be required to determine whether either of these localised aquifers should be treated as a transboundary resource, but this is not seen as a priority.

6.4.5.3.8 Climate change

Groundwater is less affected by climate change than surface water, and as such it can contribute hugely to ameliorating the short-term effects of climate change. In the longer term, the effects of climate change on LVS Basin aquifers are uncertain, though an increase in mean annual recharge is likely.

6.4.5.3.9 Poor technical quality of drilling

The National Groundwater Policy (Ministry of Water and Irrigation, 2013) acknowledges that the quality of drilling in Kenya is poor - which is widely understood in the GW sector (S. 3.10 National and local level Capacity Needs, p. 36 – 37). Despite a drilling contractor registration and regulation process, the technical quality of borehole drilling in Kenya is poor and has declined perceptibly in the past two decades; This needs to be reversed by appropriate application of the existing Codes of Practice (for siting boreholes; for construction of boreholes; for supervision of borehole drilling and construction; and for the conduct of pumping tests – see (Water Resources Authority, 2018b,c,d). Regulation and registration is currently carried out by the parent Ministry, which does not monitor the quality of drilling works. This creates confusion between the WRA and the Ministry, as it is the WRA who observe the consequences of poor-quality drilling and are best positioned to report on and regulate it.

The technical capacity of the WRA in the supervision of borehole drilling needs to be improved, and the number of groundwater staff available to monitor or supervise drilling activities need to be increased. This is important not only to vet the private sector hydrogeologists who currently supervise drilling operations (if they are supervised at all), but also to support the development of this capacity.

Boreholes drilled by County water ministries often do not comply with the WRM Rules (Government of Kenya, 2007b) - either in drilling only after an Authorisation has been issued, failing to collect a water sample for analysis, or failing to conduct proper pumping tests

6.4.5.3.10 Enforcement of conditions of Authorisations to construct boreholes

Due to limited technical capacity and insufficient technical staff in the WRA, conditions attached to Authorisations are not always observed. This is associated with the discussion above on borehole drilling supervision capacity.

6.4.6 Strategy

In order to comprehensively and systematically address the groundwater issues and challenges in the LVS Basin, Table 6-12 sets out 4 Strategic Themes with specific Strategies under each Theme. The Themes address Groundwater Resources Assessment, Allocation and Regulation, Groundwater Development, Groundwater Asset Management, and Conservation and Protection of Groundwater.

Table 6-12: Strategic Framework – Groundwater management

3	**Key Strategic Area:**	**Groundwater management**
3.1	**Theme:**	**Groundwater resources assessment, allocation, regulation**
3.1.1	Groundwater assessment – assess groundwater availability in terms of quantity	
Assessing groundwater resource quantity is an essential pre-requisite for any water management process. Nationally, the Kenya Groundwater Mapping Project (47 Counties, 2017-2023; Government of Kenya, 2017b) should be implemented and supported as relevant to the LVS Basin. In parallel, more detailed estimates of sustainable groundwater yield in priority areas / aquifers should be undertaken.		
3.1.2	Groundwater assessment – groundwater quality and use	
Abstraction surveys (quantity and quality) for Priority Aquifers and other affected aquifers should be undertaken in order to assess current groundwater use and quality across the LVS Basin.		
3.1.3	Update and improve permit database	
The permit database (PDB) in relation to groundwater requires considerable improvement if it is to be the vital planning tool it must become. The fully functional PDB should allow the following types of data to be extracted from it: a) Permitted groundwater abstraction by aquifer unit or sub-catchment (or both) b) Calculate unallocated GW for each aquifer unit OR sub-catchment (or both). This requires that each groundwater Permit is ascribed to a named and geographically-defined aquifer unit. This aquifer classification process is a work in progress, relying as it does on the re-definition of aquifers. The PDB also needs to be broadened, to allow the capture of digitised borehole completion records (BCRs).		

3	Key Strategic Area:	Groundwater management
3.1.4	Groundwater allocation	

National Resource Quality Objectives (RQOs) should be developed. In relation to a groundwater resource, the RQO means the quality of all aspects of the resource and could include any or all of the following (Colvin, Cave & Saayman, 2004):

- Water levels, Groundwater gradients; storage volumes; a proportion of the sustainable yield of an aquifer and the quality parameters required to sustain the groundwater component of the Reserve for basic human needs and baseflow to springs, wetlands, rivers, lakes, and estuaries.
- Groundwater gradients and levels required to maintain the aquifer's broader functions.
- The presence or absence of dissolved and suspended substances (naturally occurring hydrogeochemicals and contaminants).
- Aquifer parameters (e.g. permeability, storage coefficient, recharge); landscape features characteristic of the aquifer type (springs, sinkholes, caverns); subsurface and surface ecosystems in which groundwater plays a vital function; bank storage for alluvial aquifers that support riparian vegetation.
- Aquatic biota in features dependent on groundwater baseflow, such as rivers, wetlands, and caves, or biota living in the aquifer itself or the hyporheic zone. Terrestrial plants and ecosystems dependent on groundwater.
- Land-use and water use which impact recharge quantity or quality. Subterranean activities, such as mining or waste disposal, that affect the aquifer directly. The control of land-based activities by aquifer protection zoning of land-use.
- Any other groundwater characteristic.

It is clear that RQOs can include any requirements or conditions that may need to be met to ensure that that the water resource is maintained in a desired and sustainable state or condition.

The Guidelines for the Development of Water Allocation Plans in Kenya (WRA, 2018d) discusses the determination of water balances and accommodates both surface water and groundwater. Current groundwater potential by sub-basin in the LVS Basin should be determined from the assessment of available groundwater and the current use (from the abstraction survey). Groundwater allocation plans should be developed. Groundwater allocation varies according to the importance of, and knowledge base for, a given aquifer:

- Poor and Minor aquifers: 25% of test discharge in an individual borehole is the safe allocable volume. Where an aquifer is reasonably well described (i.e. representative transmissivity values are available, as is the width, length and hydraulic gradient across the aquifer), then Darcy’s Law (Darcy, 1856) may be used to determine mean through-flow (Q = -k.i.A). In this case, total allocable water should be 25% of average through-flow.
- For Major aquifers, the approach proposed in the NWMP 2030 is proposed. The NWMP 2030 adopts a cautious approach to determining sustainable groundwater abstraction; this is defined as 10% of recharge, but specifically excludes the riparian zone, which it determines as total river length x 1km. Recharge was defined as annual renewable resource minus annual surface water runoff, with ‘annual renewable resource’ defined as precipitation minus evapotranspiration.
- For Strategic and Special aquifers that are not (or not yet) designated Priority Aquifers and subjected to modelling, the NWMP 2030 approach should be used.
- For Priority Aquifers that have been modelled, allocable GW is 10% of mean annual recharge. Mean annual recharge should, wherever possible, take into account both wet and dry years in order to recognise natural recharge variability.
- The allocation of Groundwater from aquifers that experience episodic recharge or are fossil aquifers remains unresolved, e.g. the Merti aquifer (Blandenier, 2015). How they should be treated in Kenya requires further debate and ultimately, a policy decision.

All the above require the completion of the aquifer classification exercise.

3.2	Theme:	Groundwater development
3.2.1	Aquifer recharge	

Estimates of recharge per sub-basin in the LVS Basin were undertaken as part of this Consultancy. These are not based on ground studies, geophysics, drilling or modelling; therefore, it is necessary to conduct a preliminary assessment of recharge areas from existing data.

Definition of Recharge Areas: At present, the accurate definition of the recharge areas for almost all aquifers remains unclear. This makes it difficult to protect such areas. Recharge areas for Priority Aquifers should therefore be defined.

3	Key Strategic Area:	Groundwater management

Augmenting/preserving natural recharge: The Sponge City Kajiado concept (Oord, 2017), aims to manage and improve natural recharge by protecting land where significant recharge occurs. There is probably scope to enhance natural recharge in the LVS Basin, particularly in Oda wellfield (Northern Basement aquifer) (National Water Conservation & Pipeline Corporation, 2006). Other aquifers have not been assessed.

Managed aquifer recharge (MAR): First mentioned in the 1999 Policy document (Government of Kenya, 1999a) and the Water Design Manual (Ministry of Water and Irrigation, 2005), Managed Aquifer Recharge is covered in the WRM Rules (Government of Kenya, 2007b). Efforts were made to encourage managed aquifer recharge by developing a Code of Practice that discussed methods and management approaches, and considered a few instances of MAR potential in Kenya (Water Resources Authority, 2018b). It has been developed further since (Water Resources Management Authority, 2015b; A Njuguna, personal communication, December 2018), but has yet to be published. A study of the potential for Managed Aquifer Recharge in Kenya, commissioned by the National Water Conservation & Pipeline Corporation in 2006, provides a useful introduction to MAR and describes a number of possible MAR schemes across the country.

At a practical level, sand dams (masonry or concrete weirs across sand rivers which accumulate coarse sands that act as a storage reservoir) also act as MAR structures (Borst & de Haas, 2006; Mutiso, 2003). These are in widespread use in ASALs underlain by siliceous metamorphic Basement and have been in use for decades. It is unlikely, but there may be scope for sand dams in those parts of the LVS Basin underlain by siliceous Basement or metasediments.

Ad hoc Managed Aquifer Recharge: Ad hoc Managed Aquifer Recharge may occur in the LVS Basin but has yet to be described.

Managed Aquifer Recharge potential in the LVS Basin: The scope of, and potential for, managed aquifer recharge is the LVS Basin is described below:

There is scope for MAR in the Ngunga catchment, Kitui County (seasonal surface water flow and sand dams) (National Water Conservation & Pipeline Corporation, 2006)

Recharge via sand dams in seasonal streams in areas underlain by siliceous metamorphic Basement or metasediments, such as Ngunga (National Water Conservation & Pipeline Corporation, 2006) may be possible in the lower parts of the LVS Basin.

3.2.2	Local groundwater development: Reconciliation of water demands and groundwater availability and implementation of groundwater schemes

Areas of unexploited groundwater resources should be identified and linked to small centre water demand estimates to determine if groundwater resources could meet these demands. Local groundwater development in the LVS Basin is largely ad hoc at present, heavily under-written at the WWDA and County level for rural water supply (single or a few boreholes to meet demands of small rural centres, schools and other institutions).

3.2.3	Large scale groundwater development: Reconciliation of water demands and groundwater availability and implementation of groundwater schemes

The potential for groundwater development at a large scale should be assessed as part of integrated planning for bulk water resources development (Refer to Strategy 8.2.1), specifically as part of regional water supply schemes.

The abundance of readily available surface water resources in the LVS Basin has probably limited concerted attempts to find high-capacity aquifers across it. Most boreholes constructed to date have been for small-scale abstraction, in part because of small demands but also because of the limited groundwater potential across the Basin. There are numerous springs across the Basin, but none of very high yield (such as Mzima or Njoro Kubwa in the LVS Basin).

However, the following areas/aquifers may have some scope for large-scale groundwater development, if surface water resources are impractical or expensive:

- The groundwater resources in the Londiani basin appear to be better than the average in LVS aquifers (range 0.54 to 36.4 m^3/hr; n = 37, mean 9.2 m^3/hr, median 8.6 m^3/hr). There may be scope for developing these groundwater resources for local water supply in the area east of Lemotit (6.5 km NW of Londiani), although a gravity project based on surface water impoundments to the north is probably a cheaper alternative in the long term.
- One area that may be promising for groundwater is the colluvium and sediments immediately south of the Nyando Escarpment in the axis Kibos – Miwani – Kibigori. Not only is there a significant buried fault in this zone, but yields in older boreholes drilled at Miwani suggest a reasonably significant groundwater resource may be present. This would require a significant exploratory geophysical and a potentially difficult drilling programme (very coarse unconsolidated material may require percussion drilling with temporary casing, a casing driver rig, or a dual-rotary rig).
- There may be a similar aquifer system at the base of the Nyakatch Escarpment, where the Kendu Fault occurs. We have reviewed no data that explicitly support the existence of such an aquifer, but a desk study may reveal that further exploration would be worthwhile.

3	Key Strategic Area:	Groundwater management

- The Lambwe Valley aquifer system appears to be an under-exploited resource. Again, we have seen only limited data that indicate that a significant groundwater resource exists in this area. Once again, a desk study may reveal that further exploration would be worthwhile

3.2.4	Conjunctive use: Reconciliation of water demands and groundwater availability

Areas of unexploited groundwater resources should be identified and linked to water demand estimates to determine if groundwater resources could meet these demands as part of conjunctive use schemes.

3.3	Theme:	Groundwater asset management

3.3.1	Develop asset inventory

An asset inventory should itemise all dedicated groundwater equipment in a readily accessible database. The asset inventory shall be available to those staff that may need it, and particularly to staff who will plan and coordinate activities or studies that require specific assets to support them. The inventory should include a list of assets determined during a formal inspection and verification process, complete with supporting paperwork:

- Vehicles/heavy plant; at present, WRA GW does not own or operate its own vehicles or GW plant. There may come a time when it will operate its own drilling rigs (to construct monitoring boreholes) or other dedicated equipment
- Office infrastructure (dedicated GW computers and printers, laptops/notebooks, PDAs, licensed software, storage facilities etc.)
- Laboratory infrastructure: it is not expected that GW sections would have laboratories tied exclusively to GW, but laboratory facilities must be expanded to include the capacity to measure GW-specific parameters, e.g. bromide, strontium and boron to determine extent/degree of seawater intrusion (to low ppm Limits of Detection, better than 0.01mg/L)
- Field equipment (geophysics equipment [surface and down-hole], GPS instruments, water chemistry meters and associated equipment, dipmeters and sonic dippers, GW sampling equipment, electro-magnetic flowmeters etc.)
- Static field equipment (monitoring boreholes, loggers/barometric loggers and telemetry [covering both pressure/water level and field chemistry parameters such as temperature and electrical conductivity], monitoring flowmeters owned by the WRA etc.)
- Mobile equipment that will be left in the field for the duration of a study (Automatic Weather Stations and associated meteorological equipment, rainfall samplers, evaporation pans, portable weirs, time-series water quality probes etc.)

An Asset Inventory database system should be developed:

- Each asset should be tagged with a unique number
- Each item and its tag number should be entered into the inventory database, together with all relevant details (year purchased/acquired, office allocated to, office lent to, last service or maintenance period, next recommended service/maintenance etc.). The database system must allow that major components (such as a multi-parameter water quality probe), are linked to related spare parts (such as individual parameter probes or calibration reagents).
- Where an item is available for rent to the public (such as geophysics equipment), the relevant details should be included in the inventory database; this will include, but not necessarily limited to, the following:
    - Rental cost (per day or per week, as relevant)
    - Rental requirements (items rented must be insured by the renter and proof of insurance provided to the WRA)
    - Any other condition of rental
    - Name, address and relevant details of the renter, and the anticipated duration of the rental period

3.3.2	Develop asset management plan

Asset management is necessary to ensure that assets are used for the correct purpose and contribute to meeting the objectives of the WRA at National, basin and sub-basin levels. The asset management plan should ensure that the location and status of all assets are known to relevant staff. An asset management plan should be developed which must list all equipment and facilities that require refurbishing, along with a corresponding programme and budget. This should involve appropriate consultation with basin and sub-basin offices:

- For each item, determine what refurbishment is required
- Draw up a priority list of the items to be refurbished, together with a deadline for its refurbishment
- Determine the cost and duration of the refurbishment process
- Draw up a Refurbishment Plan, containing the deadlines, costs and duration of refurbishment, and feed this into the annual procurement planning process

3	Key Strategic Area:	Groundwater management

- When refurbishment commences, ensure that the process is monitored and funds spent on it are tracked
- After refurbishment, update the Asset Inventory to reflect change of status
- Amend Asset Management Plan as necessary

The asset management plan will ensure that all equipment is fit for purpose at all times, and that equipment requiring servicing, maintenance or calibration is serviced, maintained or calibrated when it is required.

The Plan should also indicate:

- The value of each asset
- The need for spare parts, and what a practical spare parts/consumable inventory would be
- Maintenance frequency for all assets and the typical life cycle of the asset
- The frequencies of planned maintenance
- A calendar showing when each item must be released for maintenance;
- The type of maintenance required (some may be maintained in-house within the WRA; other items may require maintenance by a dedicated supplier, or even sent overseas for maintenance).
- The maintenance cost, or anticipated cost

The asset management plan will feed into the annual procurement planning process.

3.4	Theme:	Conservation and protection of groundwater
3.4.1	Groundwater source protection	

Groundwater vulnerability assessment: Once a National Policy for the Protection of Groundwater has been formulated and put into place (see KSA 9), Vulnerability Assessments should be conducted for the LVS Basin groundwater.

Groundwater conservation areas (GCAs): As above for GCAs; assess which LVS Basin aquifers or parts of aquifers require formal protection. Draw up Plans for the protection of Priority Aquifers or parts of Priority Aquifers.

Groundwater dependent ecosystems (GDEs): As above for GDEs; assess which LVS Basin aquifers contain important GDEs. Draw up Plans to protect important GDEs.

3.4.2	Rehabilitation of polluted aquifers, springs and wells

Where groundwater protections have failed, measures need to be taken to address polluted aquifers. Here aquifers, springs and wells are lumped together as 'aquifers'.

Define LVS Basin's polluted aquifers: Use the Guidelines for Groundwater Quality Surveys in Kenya (Water Resources Authority, 2018e) to define the extent of polluted aquifers, and determine what pollutants are present. Follow guidance presented in the NWQMS (Ministry of Water and Irrigation, 2012).

For each polluted aquifer, determine the optimum and most cost-effective way to rehabilitate it. The approach to be adopted will depend on the following:

- Whether the aquifer is confined or unconfined;
- The nature of the pollutant; e.g. dense non-aqueous phase liquids (DNAPLs) require a different treatment approach – pump, treat, return - compared with an aquifer polluted with human wastewater – eliminate the pollution source(s) followed by natural attenuation and remediation;
- Whether the source of the pollution is diffuse or from a point source;
- The affected aquifer area.
- Prioritise aquifers for rehabilitation and implement rehabilitation programmes.

6.5 Water Quality Management

6.5.1 Introduction

Water quality is the physical, chemical, biological and aesthetic properties of water that determine its fitness for its intended use, and that are necessary for protecting the health of aquatic ecosystems.

Water quality management is the maintenance of the fitness for use of surface and groundwater resources, on a sustainable basis, by achieving a balance between socio-economic development and water resources protection. Fitness for use is an evaluation of how suitable water is for its intended purpose (e.g. domestic, agricultural or industrial water supply) or for protecting the health of aquatic ecosystems. The fitness for use evaluation is based on scientific evidence in the form of water quality guidelines or standards for different water uses (e.g. drinking water standards). The business of water quality management is the ongoing process of planning, development, implementation and administration of Kenyan water quality management policies, the authorisation of water uses that impact on water quality, and monitoring and auditing all these activities.

This section provides an introduction of the key water pollutants responsible for the deterioration of water quality in the basin, the point and non-point sources associated with the pollutants, and overview of the water quality status and threats in the basin, and a strategic framework for water quality management in the basin.

6.5.2 Water quality standards and guidelines

Kenya has standards for drinking water quality (Table 6-13) and for effluent discharge limits for discharges into sewers and water bodies (Table 6-14) which WRA has adopted for use. National guidelines and standards for the different water uses, such as for Irrigation, Fisheries and Livestock watering still need to be formulated.

Table 6-13: Kenya and WHO Standards for drinking water quality

Parameters	Unit	WHO Standards	(Kenya Bureau of Standards, 2007)
pH	pH Scale	6.5-8.5	6.5-8.5
Colour	mgPt/l	Max 15	Max 15
Turbidity	N.T.U	Max 5	Max 5
Conductivity (25^0 C)	µS/cm	Max 2500	-
Iron	mg/l	Max 0.3	Max 0.3
Manganese	mg/l	Max 0.1	Max 0.5
Calcium	mg/l	Max 100	Max 150
Magnesium	mg/l	Max 100	Max 100
Sodium	mg/l	Max 200	Max 200
Potassium	mg/l	Max 50	-
Total Hardness	$mgCaCO_3/l$	Max 500	Max 300
Total Alkalinity	$mgCaCO_3/l$	Max 500	-
Chloride	mg/l	Max 250	Max 250
Fluoride	mg/l	Max 1.5	Max 1.5
Nitrate	mgN/l	Max 10	-
Nitrite	mgN/l	Max 0.1	Max 0.003
Sulphate	mg/l	Max 450	Max 400
Free Carbon Dioxide	mg/l	-	-
Total Dissolved Solids	mg/l	Max 1500	Max 1000
Arsenic	µg/l	Max 10	Max 10
Total Suspended Solids	mg/l	-	-

Table 6-14: Kenya Effluent Discharge Standards into water bodies and sewers

Parameters	Unit	Effluent Discharge Standards	
		Discharge into environment	Discharge into public sewer
Temperature	^oC	±3 ambient temp.	20-30
pH	pH Scale	6.5-8.5	6-9
Conductivity	µ S/cm	-	-
BOD5 days at 20 ^0C	mgO_2/l	30	500
COD	mgO_2/l	50	1000
Total Alkalinity	$mgCaCO_3/l$	-	-

Parameters	Unit	Effluent Discharge Standards	
		Discharge into environment	Discharge into public sewer
Total Suspended Solids	mg/l	30	250
Total Dissolved Solids	mg/l	1200	2000
Sulphides as S^{2-}	mg/l	0.1	2
Oil + Grease	mg/l	Nil	5 or 10
4 Hr Permanganate Value	mgO_2/l	-	-
Salinity	ppt	-	20
Nitrate	mgn/l	-	-
Turbidity	N.T.U	-	-
Dissolved Oxygen	MgO_2/l	-	30
Detergents (MBAS)	mg/l	Nil	15
Heavy Metals – Chromium, Cr	mg/l	0.05	0.05
- Lead, Pb	mg/l	0.01	1.0
`	mg/l	-	0.05
- Copper, Cu	mg/l	1.0	1.0
- Cadmium, Cd	mg/l	0.01	0.5
- Zinc, Zn	mg/l	0.5	5.0
- Arsenic, As	µg/l	0.02	0.02

6.5.3 Key water pollutants and pollution sources

To develop and successfully implement a Water Quality Management Plan for the LVS Basin, it is important to understand which key pollutants are typically present in river basins where urbanisation, agriculture and human settlements occur. These pollutants are listed and briefly described below.

Suspended sediments and erosion Sedimentation refers to the erosion; wash-off and silt load carried by streams and rivers and typically reflects the natural geophysical and hydrological characteristics of a catchment. Sedimentation studies under the LVEMP 1, showed that massive levels of nutrients and sediment are transported annually into Lake Victoria and hence the presence of water hyacinth and other weeds on the shores of the Lake Victoria.

Microbiological pollution and pathogens Microbial pollution refers to the presence of micro-organisms and parasites which cause diseases in humans, animals and plants. The microbial content of water represents one of the primary determinants of fitness for use. Human settlements, inadequate sanitation and waste removal practices, stormwater wash-off, and sewage spills are the major sources of deteriorating microbiological water quality in LVS basin rivers.

Organic material and dissolved oxygen Organic pollution refers to the discharge of organic or bio-degradable material to surface water that consumes oxygen when they decay, leading to low dissolved oxygen concentrations in the water. The decomposition of biogenic litter (vegetation, paper, raw sewage, etc.) in urban streams can contribute to low oxygen concentrations in receiving streams. Low dissolved oxygen concentrations are detrimental to aquatic organisms and it affects the solubility of, inter alia, metals. Metals adhered onto bottom sediment particles in streams, lakes and reservoirs can dissociate under low or anoxic conditions, dissolving back into the water where it can affect aquatic biota.

Nutrients Nutrient enrichment refers to the accumulation of plant nutrients in rivers and lakes in excess of natural requirements resulting in nutrient enrichment or eutrophication which may impact on the composition and functioning of the natural aquatic biota. The most essential nutrients required by plants are nitrogen and phosphorus in various forms (NO2, NO3, NH4, PO4). The direct impact is the excessive growth of algae and macrophyte (rooted and free-floating water plants) leading to impacts on the attractiveness for recreation and sporting activities; the presence of toxic metabolites in cyanobacteria; the presence of taste- and odour-causing compounds in treated drinking water, and difficulty in treating the water for potable and/or industrial use.

Hydrocarbons Petroleum and petroleum-derived products are complex mixtures, mainly of hydrocarbons (compounds of only carbon and hydrogen) plus some other compounds of sulphur, nitrogen and oxygen, and a few additives. Common petroleum products include petrol, naphtha and solvents, aviation gasoline, jet fuels, paraffin, diesel fuel, fuel oils and lubricating oils. Hydrocarbon pollution are associated with wash off from road surfaces and parking lots, especially during the early season rains, and the dumping of used motor or cooking oil into stormwater drains.

Metals Metals include sodium (Na), potassium (K), magnesium (Mg), titanium (Ti), iron (Fe) and aluminium (Al). Trace metals can be divided into two groups: (i) those that occur naturally in trace amounts in most waters (and most of which are plant nutrients in small amounts) such as cobalt (Co), copper (Cu), manganese (Mn), molybdenum (Mo) and zinc (Zn), and (ii) those that do not usually occur in measurable amounts in natural waters, are potentially toxic in low concentrations, and have become widely distributed as a result of human activities, such as cadmium (Cd), lead (Pb) and mercury (Hg).

Solid waste and litter Urban stormwater runoff can be polluted by, inter alia, nutrients, low pH (acidity), micro-organisms, toxic organics, heavy metals, litter/debris, oils, surfactants and increased water temperature. While the impact of litter may appear to be mainly visual and of aesthetic importance, litter can have serious impacts on the aquatic ecosystem of urban streams and rivers.

Agrochemicals Agrochemicals refers to the pesticides and herbicides residues in surface waters that are harmful to aquatic ecosystems and/or users of the water. It includes pesticides or their residues such as chlorpyriphos, endosulfan, atrazine, deltamethrin, DDT & penconazole. These compounds can have chronic or acute impacts on aquatic biota and/or it can cause respiratory diseases in humans and animals. Sources include spray drift of pesticides/herbicides into surface water courses, the wash off pesticides into surface and groundwater during rainfall events or irrigation of crops, or accidental spillages at storage facilities or during loading operations.

Emerging pollutants There are a number of emerging pollutants that could be a cause for concern but very little is known about their status in Kenya. These often occur in low concentrations, are difficult and expensive to detect, and requires sophisticated analytical equipment for sample analysis. They include partially metabolised pharmaceuticals, endocrine disrupting chemicals (EDCs), persistent organic pollutants (POPs), Unintentionally Produced Persistent Organic Pollutants (UPOPS) and Nanoparticles. UPOPS are products listed under Annex C of the Stockholm Convention on POPS. Some of these UPOPS include: Hexachlorobenzene, Hexachlorobutadiene, Pentachlorobenzene, Polychlorobiphenyls, Polychlorinated dibenzo-p- dioxins and dibenzofurans, and Polychlorinated napthalenes. UPOPS are produced due to incomplete combustion, during the manufacture of pesticides and some chlorinated compounds. Common sources are; burning of hospital wastes, municipal and hazardous wastes, vehicle emissions, peat, coal and wood burning. UPOPS have been linked to many human ailments including enzymatic and immune disorders and cancer. To reduce levels of UPOPS in the environment, best available technologies and practices should be used. As is the case in many developing countries, monitoring is required to develop a better understanding of the severity and extent of emerging pollutants in Kenya before strategies can be developed for its management.

Cyanide Poisoning in Cassava Local cases of cassava poisoning have been reported in Siaya in the Lake Victoria North Basin, although cassava is grown and consumed in many parts of Kenya including Lake Victoria South Basin. Cassava is a hardy plant that thrives during drought and is used as a staple source of carbohydrates, especially during famine. Cassava is the third-most important food source in tropical countries, but it has one major problem: The roots and leaves of poorly processed cassava plants contain Linamarin, a cyanogen - a substance that, can trigger the production of cyanide. Cyanide occurs naturally in many plants. Many edible plants contain cyanogenic glycosides. Other plants that contain high levels of cyanogen are Sorghum (whole immature plant), bamboo shoots and Lima seeds (Nartey (1980); Honig et al. (1983). Cassava roots however contain less linamarin level s than that found in leaves. Linamarin is converted to cyanide when cassava is eaten raw or when poorly cooked or processed. Long-term exposure of low doses of cyanide over time can lead to health problems, hence the danger posed by cyanide poisoning for those who use cassava as a staple carbohydrate source. Levels of cyanide in water sources are generally low but depend on releases from upstream sources and discharges. Cyanide is highly acute and toxic and should not be present in drinking water. The East African Standard for Discharges of Effluent into water bodies gives the maximum permissible level for cyanide as 0.05 mg/l.

Mitigation against cassava poisoning. To avoid cassava poisoning, cassava roots, peels and leaves should not be eaten raw as they contain two cyanogenic glucosides, linamarin and lotaustralin. These are decomposed by linamarase, a naturally occurring enzyme in cassava, liberating hydrogen cyanide (HCN), which is toxic. An effective way of removing cyanogen from cassava leaves is by pounding or crushing and then boiling them in water. Most of the cyanogenic glucosides are removed and cyanohydrins and free cyanide are completely removed in this way. (Nambisan 1994). Other proven methods of cyanide removal but with varying degrees of success include: Drying in the sun; Drying in an oven; Steaming, baking and frying; Fermentation of crushed cassava roots; Steam distillation of cassava pulp.

Sources of pollution are generally divided into two categories, namely point sources and nonpoint sources.

- **Point sources** of pollution is one whose initial impact on a water resource is at a well-defined local point (such as a pipe or canal). The US Environmental Protection Agency describes point sources of pollution as any discernible, confined and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, or vessel or other floating craft, from which pollutants are or may be discharged. Typical point sources of pollution are listed below:

Industrial point sources	Effluent discharges from industries can have a significant impact on receiving water bodies. These can include high concentrations of BOD/COD, nutrients, heavy metals, acids, dyes, suspended solids, oils and grease, bacterial pathogens, chemicals, phenols, etc.
Wastewater treatment works (WWTWs)	Wastewater treatment works (WWTWs) that discharge treated effluent into surface water streams are important point sources of pollution if they do not meet effluent standards. Domestic WWTWs are regarded as important sources of nutrients, organic matter (BOD/COD), suspended solids, human pathogens, and depending on the demographics, a source of partially metabolised pharmaceuticals and endocrine disrupting chemicals.
Mining and quarrying operations	Mines can be significant source of pollution and pollutants such as heavy metals, suspended solids, salinity, sulphates, and acidification are associated with mining activities. High suspended sediment loads, and increased turbidity are associated with sand mining and washing operations.
Agricultural processing plants	Agricultural processing plants such as coffee washing stations contribute significantly to the organic loads in receiving rivers and streams. The same applied to dairies and milking operations. Tea factories also produce wastewater that are rich in organic material. Fish farms can also have a major impact on water quality as the outflow from ponds can be high in BOD/COD, ammonium and nitrates from fish wastes and food residues.
Solid waste dumps and landfills	Solid waste dumps and landfills can also be regarded as point sources of pollution. Pollutants in seepage/leachate from landfills include organic wastes from decomposing organic wastes, heavy metals from corroding metallic objects and old batteries, waterborne pathogens from discarded diapers and sewage sludge, acidic waters, hydro-carbons and oils from used motor and cooking oils, etc.

– **Mitigation measures:** the following are some remedial measures to forestall pollution from point sources:
  - Treatment of industrial waste discharges at source, before discharge into receiving water bodies
  - Ensuring that industrial waste discharges meet the stipulated Effluent Discharge Standards before being discharged
  - Regularly reviewing the performance and waste removal efficiency of WWT plants as well as carrying out effective operation and maintenance procedures
  - Preparing and implementing safe and sound mining and quarrying operation guidelines
  - Ensuring that solid waste is sorted at source and safely transported to the dumpsites for final sorting out and safe disposal

- Ensuring that the dumping site is selected after an EIA has been carried out on the site, and that all urban centres have a dumping site for solid wastes
- Enhancing capacity to carry out timely water quality monitoring to identify polluters and take legal action against them.

- **Nonpoint sources** (also called diffuse sources) of pollution whose initial impact on a water resource occurs over a wide area or long river reach (such as un-channelled surface runoff from agricultural land or stormwater and dry-weather runoff from a dense settlement). The US EPA describes nonpoint source pollution resulting from land runoff, precipitation, atmospheric deposition, drainage, seepage or hydrologic modification. Nonpoint source (NPS) pollution, unlike pollution from industrial and sewage treatment plants, comes from many diffuse sources. NPS pollution is caused by rainfall moving over and through the ground. As the runoff moves, it picks up and carries away natural and human-made pollutants, finally depositing them into lakes, rivers, wetlands, and ground waters.

Agricultural nonpoint sources Agriculture is a major nonpoint source of pollution. The following generic land use categories can contribute to nonpoint source pollution, particularly sediments, nutrients, and agrochemicals:

Livestock grazing can contribute to sediment yield through removal of the natural vegetative cover (overgrazing), while nutrients and pathogens are associated with livestock faecal matter. These impacts are aggravated and significant bank destabilisation (habitat destruction) can occur where livestock are allowed direct access to wetlands and rivers.

Croplands, vegetable gardens and flower growing tunnels are often a major rural source of sediment, particularly if good land management practices are not adhered to. Wash-off of nutrients from fertilizers and of agrochemicals (pesticides and herbicides) can also have a significant impact, where these are applied. Croplands are particularly vulnerable during the preparation of plots for planting and harvesting when the soil is disturbed.

Irrigation of crops can be a further source of nutrient (inorganic fertilizer), pesticides, and pathogens if manure is used as fertilizer.

Confined animal facilities, such as livestock enclosures (zero grazing), piggeries, and chicken farms, can contribute significant nutrient, organic matter (BOD) and pathogen loads from faecal waste, especially during storm runoff directly to a stream or river. This is the main concentrated agricultural source and may include dairies and piggeries.

Urban nonpoint sources High levels of non-point sources of contamination, particularly organic material (BOD/COD), hydrocarbons, pathogens, and sediments are associated with formal urban areas and industrial activities with the urban boundaries. Their general character and impacts in Kenya are similar to those other developing countries, and are as follows:

Formal residential areas range from sparse small holdings on the outskirts of cities, through suburban and high density multi-stories apartments in the urban centre (informal settlements are dealt with below). They generally have some levels of waste management services (onsite sanitation, solid waste removal, and storm water drains). Residential areas cause increase storm runoff from impervious surfaces, with an associated wash-off of sediment, nutrients, pathogens, organic matter, litter, heavy metals, hydrocarbons and toxic substances. These impacts tend to increase with population density and are aggravated in areas where the waste management services are inappropriately used, overloaded or inadequately maintained. Increased streamflow and encroachment into the riparian zone causes habitat destruction.

Commercial and light industrial areas are generally located near the urban core and have similar water quality impacts to formal residential areas. Storm runoff increases with impervious area and heavy metal loading tends to be higher, associated with greater pedestrian and vehicle traffic. Pathogen and sediment wash-off can be similar or even higher than in formal residential areas due to the higher density of people. Garages and workshops are often a source of significant hydrocarbon pollution because there is no used oil recycling in Kenya. Fresh produce markets are a significant source of organic waste as peels and leaves from cleaning vegetables and fruit and vegetable cleaning often end up in stormwater drains.

Heavier industrial areas are located both within and on the edge of urban centres, and include the metal, food and beverage manufacturing, and agricultural product processing industries. They are generally associated with increased storm runoff and wash-off of heavy metals, toxic organics and nutrients, depending upon the processes and management practices at the site. Other water quality impacts are similar to light commercial areas.

Roads within and between urban centres are a major non-point source of heavy metals and hydrocarbons. Sediment, nutrient, litter, pathogens and organic matter loads from these roads are comparable to commercial and industrial areas. Unpaved and gravel roads in urban areas can cause severe soil erosion, sediment wash-off, and dust pollution.

Construction and urban development sites represent a significant source of sediment loads in urban areas; often an order of magnitude higher than other urban land uses. This also results in an increase in adsorbed contaminants, such as nutrients and heavy metals. Concrete wash water generally has a high pH due to the cement in the wash water.

Informal waste disposal sites represent a major concentrated source associated with formal residential and industrial areas. Pollutants include solid waste and litter, nutrients, organic matter, heavy metals, and toxic substances in surface wash-off or leachates form the sites.

Informal settlements Informal settlements are a feature of many developing countries and include settlements in and around the formal urban areas, but which consist of informal shack dwellings, usually with no or limited waste management services. They include the low to medium density (5 to 30 dwellings per hectare) informal areas on the periphery of urban centres, as well as the very dense shack areas on marginal land within the urban centre. Water quality impacts increase with density, and are largely associated with inadequate services, namely pathogens and nutrients from the disposal of grey and black wastewater, litter from solid waste disposal, organic matter and sediment from storm water. These impacts are exacerbated, because these settlements are usually on the most marginal urban land (e.g. poor stormwater drainage) or within the riparian zone of urban rivers.

Artisanal & small-scale mining It is estimated artisanal and small scale mining (ASM) operations such gold and gemstone mining provides employment to some 146 000 people compared to the large scale mining that employs about 9 000 workers (PACT and Alliance for Responsible Mining, 2018). A significant impact of ASM gold mining operations is the misuse of mercury and the discharge of mercury-cyanide complexes used in the extraction of gold, into aquatic systems. There are also substantial concerns related to deforestation. For gemstone mining, unsanitary mining camp conditions and bacterial pollution of scarce water sources is a major concern. All activities, including sand mining activities, would increase the sediment loads to rivers during rainfall events.

Gravel roads and erosion Roads, and gravel roads can be a significant source of erosion and fine sediments. When roads are constructed, they create an interference with the natural drainage systems and collect water, channel it through culverts, increasing its volume and velocity, resulting in accelerated erosion downstream of a bridge or culvert. One of the areas most prone to erosion and gully formation is along the side of roads, especially gravel roads. Roads also act as a source of oil pollution due to vehicle maintenance often conducted next to a road.

- **Mitigation measures:** The following are some mitigation measures to forestall pollution form non-point sources:
  - Encourage the adoption and use of effective and sustainable crop and animal husbandry practices
  - Collection and treatment of storm water discharges from roads and farmlands, before discharge into receiving water bodies
  - Ensuring that storm water and farmland discharges meet the stipulated Effluent Discharge Standards before being discharged into a receiving water body
  - Encouraging the use of approved on-site sanitation facilities to contain faecal human wastes in informal settlements
  - Erecting sediment traps such as grass strips to trap sediment and eroded soil from gravel roads
  - Controlling the amounts of chemicals used in artisanal mining and ensuring that the chemicals do not find their way back into the river.
  - Preparing and implementing safe and sound mining and quarrying operation guidelines
  - Selection and designation of specific solid waste dump sites for every urban centre
  - Ensuring that solid waste is sorted at source and safely transported to the dumpsites for final sorting out and safe disposal
  - Ensuring that the dumping sites are selected after an EIA has been carried out on the sites, and that all urban centres have a dumping site for solid wastes

- Enhancing capacity to carry out timely water quality monitoring to characterize pollution levels in water bodies.

6.5.3.1 Overview of heavy metals use and heavy metals pollution

The term “heavy metal’ refers to any metallic chemical element that has a relatively high density and is toxic to humans at low concentrations. Examples of heavy metals include mercury (Hg), cadmium (Cd), arsenic (As), chromium (Cr), Lead (Pb), Zinc (Zn), Nickel (Ni), Cobalt (Co), and Copper (Cu).

The heavy metals most commonly associated with poisoning of humans are lead, mercury, arsenic and cadmium. Heavy metal poisoning may occur from industrial exposure, air or water pollution, foods, medicines, improperly coated food containers, or the ingestion of lead-based paints. High levels of heavy metals are toxic to soil, plants, aquatic life and humans.

Some of the common toxic heavy metals include arsenic, cadmium, lead, and mercury. Other than polluted water, some foods, l may also contain heavy metals.

Anthropogenic sources contributing heavy metal contamination include automobile exhaust which releases lead; smelting (arsenic, copper and zinc); insecticide (arsenic); and burning of fossil fuels which release nickel, vanadium, mercury.

The most common heavy metal pollutants in water and soil are arsenic, cadmium, chromium, copper, nickel, lead and mercury. Most common heavy metal pollution in freshwater comes from mining companies, as they use acids to release heavy metals from ores.

Metalloids are elements (e.g. arsenic, antimony, or tin) whose properties are intermediate between those of metals and solid non-metals or semiconductors.

Major sources of heavy metals in contaminated soils and water are:

- Fertilizers
- Pesticides
- Bio-solids/Sludge and Manures
- Waste water
- Metal Mining and Milling Processes and Industrial Wastes
- Air-Borne Sources

It is therefore evident that heavy metals can easily be found as pollutants in industrial effluents being discharged from many of Kenya’s major towns and urban centres. The main threats to human health from heavy metals are associated with exposure to lead, cadmium, mercury and arsenic.

Heavy metals in water are determined in the Laboratory using Atomic Absorption Spectrophotometer (AAS). Heavy metals are not routinely determined in water samples by most laboratories, as only few Laboratories have installed and operate functional AASs. This means that in most cases there is no regular assay for heavy metals in water and waste water samples. This therefore makes it difficult to describe how serious the problem of heavy metal pollution is in the country, because of lack of data. However, in regions such as along Gucha- Migori River in LVS and River Yala in LVN, where it is known that mercury is being used in artisanal mining, regular heavy metals monitoring should be initiated. This will establish the levels of contamination in water, soil and fish, so that remedial action can be taken to safeguard both humans and the environment from the effects of heavy metal pollution.

Since heavy metals are likely to find their way into water courses from the major sources listed above, it is recommended that all Regional Laboratories procure AASs to be used for the analysis of heavy metals in water samples in all the six drainage basins.

6.5.3.2 Measures to undertake for accidental oil product spillages (pipeline leakages, trucks, petrol stations) and other pollutants to the Lake Victoria Basin waters

Under the LVEMP 1 – (1997-2003) a “Study on Toxic Chemicals and Oil Products Spill Contingency Plan for Lake Victoria” was undertaken. Before that there was no such a plan. The plan was to be adopted and implemented by the three EA countries that share Lake Victoria. The main purpose of such a plan was to ensure that countries prepared a timely response in case there was any oil spillage or any toxic pollutant spilled into the lake. The response could involve, local, national and regional actions including industry, and other agencies in order to minimize the impact and damage that would be caused by such a spillage. It appears that the provisions and recommendations of such a plan were never fully adopted or implemented and there are now plans to prepare a new plan under the coordination of the LVBC.

Although a draft Oil Spills Contingency Plan *(The National Contingency Plan for Marine Spills from Shipping and Offshore Installations, 2014)* has been prepared for the port of Mombasa by the Kenya Maritime Authority, it does not cover Lake Victoria waters.

In the event of an accidental oil spillage, the following is a summary of the measures to undertaken in sequence, if such an oil spillage and other pollutants occurs in the Lake Victoria basin waters:

- Notification/Reporting of spillage (where, when, size)
- Assessing/Establishing nature and type of spillage (chemical/oil; properties)
- Establishing level of response required (availability and location of equipment such as booms, pumps, boats and personnel)
- Setting up national response units/teams
- Activating national and regional response units
- Responses (local, national, regional, international)
- Sampling and analysis of samples (Environmental monitoring)
- Clean up of spillage
- Salvage/Termination of clean-up
- Protection of sensitive ecosystems
- Restoration of ecosystems
- Legal and economic aspects (Liability and compensation for pollution damages)
- Prosecution and reparation

It should be recalled that the sinking of the ship, MV Nyerere, off the Tanzania coast near Mwanza in 2018, was a wake-up call to the EA countries to put in place, locate and rescue plans and oil spill contingency plans to deal with such emergencies. However, it is noted that the LVBC also has one container of Oil Spill response equipment to handle small to medium oil and chemical spills that can be safely handled by local oil terminal personnel - equipment stationed at Kisumu Port which can be used in the event of oil pollution in the Lake. A major component in dealing with all the stages of reporting spillage and the responses is effective communication, which should be coordinated preferably from a central emergency response centre.

A toxic chemicals and oil spill contingency plan will need to be reviewed and revised preferably every two years.

6.5.4 Water quality status in the LVS Basin

Water resources in the LVS basin exhibits symptoms of deterioration due to rapid urbanisation, inadequate sewerage infrastructure and wastewater treatment, increasing use of agro-chemicals in the horticulture and agricultural sectors, indiscriminate disposal of solid and liquid wastes, and destruction of natural infrastructure. This deterioration in water quality has grave economic impacts because it increases the cost of doing business as many enterprises are forced to treat water before being able to use it in their industrial processes, the increased cost to municipalities and cities to treat water to drinking water standards, reduced economic productivity and an increased number of days that are lost due to water-related illnesses and/or poor crop yields, threats to human health and livelihoods where people are exposed to poor water quality for domestic use, and it reduces the amount of water available for use as more water must be retained in rivers to dilute pollution to acceptable standards.

The typical point and non-point sources of pollution in the LVS Basin are as follows:

- Point Sources:
- – Industrial wastes sources: Kericho, Homa Bay, Kisii, Nyamira, Kendu Bay. Migori, Kisumu
- – Sugar Industries: Miwani, Chemilil, Muhoroni, Sony.
- – Fish Industries: Migori/Homa Bay.
- – Municipal sewage works and related sources in Kericho, Homa Bay, Kisii, Nyamira, Kendu Bay. Migori, Kisumu
- – Oils and lubricants from workshops, garages and fuelling stations, such as Kenya Railways locomotive shed and marine workshops, petrol stations and Jua kali garages.
- – Human wastes and refuse from market and urban centres and fish landing villages

The major point pollution sources into the rivers Nyando, Sondu Miriu and Gucha-Migori are listed in Table 6-15 below.

Table 6-15: Major Point Sources of Pollution in LVS main rivers

River	Source	Type of waste	Receiving River System
River Nyando	Agro-Chemicals and Food Company factory effluent	Alcohol distillery and Yeast manufacture	Nyando
	Muhoroni Sugar Factory effluent	White Sugar processing	Nyando
	Chemelil Sugar Factory effluent	White Sugar processing	Mbogo
	Chemelil Sugar Company sewage ponds	Domestic sewage	Osengeteti
River Sondu Miriu	Kericho Municipal sewage plant	Domestic sewage	Dionsoyet
	Kericho Teachers College sewage ponds	Domestic sewage	Kimugu
	Premier Dairies factory effluent	Milk processing	Ainapkoi
	KCC –Sotik factory effluent	Milk processing	Kipsonoi
River Gucha-Migori	Kisii Municipal sewage treatment works	Domestic sewage	Riana
	St. Joseph's Mission Hospital, Ombo	Domestic sewage	Migori
	Prinsals Limited	Fish processing	Migori
	Sony Sugar wastewater treatment works	White sugar processing	Sare

- Non-Point Sources:
- – Environmental degradation especially catchment and wetlands destruction.
- – Release of high nitrate and phosphate quantities into the environment due to poor application of agricultural chemicals on farms
- – Soil erosion due to poor agricultural practices resulting in soil cover destruction or overgrazing.
- – Mercury and cyanide pollution from artisanal small-scale gold mining operations in the Migori River catchment.

6.5.4.1 Surface water

This section describes the water quality status in the main rivers of LVS Basin. Many rivers in the LVS Basin in their middle and upper reaches are polluted with:

- Sediments from soil erosion
- Acaricides used on Livestock
- Pesticide residues from Herbicides and insecticides used on farms
- Nutrients (N, P) from excessive fertilizers used on farms
- Nitrates from animal feedlots
- Pathogenic coliform and other bacteria from human settlements

It is imperative that sampling points and water analysis seeks to determine the extent and the levels of these pollutants in the water, and eventually calculate the loads that drains into Lake Victoria.

6.5.4.1.1 Nyando River

The Nyando River drains a catchment area of approximately 3,652 km². The river originates in the Nandi Hills and discharges its water directly into Lake Victoria from its Kenyan catchment area. While its transboundary importance lies on its volumetric water contribution into Lake Victoria, it also acts as conduit of pollutant transfer into the lake. Nationally, the river system supports major agro-based industrial development activities as well as being a source for domestic and livestock water supplies. The river receives pollutions from municipal and industrial effluents from the urban settlements along it. It also receives pollution from non- point sources of pollution from tea and sugarcane farms within the sub-catchment. Another problem experienced in the lower reaches is collapsing river banks, which increases the sediment load. Because of its polluted status, the water in this river need to be treated before using it for domestic purposes.

6.5.4.1.2 Sondu-Miriu River

The Sondu-Miriu River system with a catchment area of 3,508 km² discharges into Lake Victoria directly from its Kenyan catchment area. It is an important transboundary river partly due to its volumetric water contribution into Lake Victoria and partly as a conduit for carrying pollutants into the Lake system.

Nationally, the river is economically of significance as it contributes to both domestic and industrial water supplies. The river originates in the Nandi Hills. The river drains the manly agricultural areas where tea and coffee are grown as cash crops and maize and beans and sweet potatoes as subsistence crops. Main pollutants are non-point sources from the farmlands. However, there are also point sources of pollution that pollute the river. The water from Sondu rivers should be treated before being used for domestic purposes.

6.5.4.1.3 Gucha-Migori River

The Gucha-Migori River system has a catchment area which spans over 6,600 km². The river originates in the Kisii Highlands and discharges into Lake Victoria from its Kenyan catchment area. Its transboundary importance lies on its volumetric water contribution into Lake Victoria and as an agent for carrying pollutants into the lake.

Nationally, the river system supports major farming activities as well as being important as a source of water for domestic and industrial water use.

Pollutants include agro-chemicals used on the tea and coffee farms. Sediment is contributed by encroachment on riparian reserves. On the lower reaches after being joined by Migori at Macalder, pollution from heavy metals has been documented. The water from this river can be used for domestic purposes only after some form of treatment.

A major concern is the impacts of artisanal and small-scale mining gold operations around Migori and Osiri. The environmental and health risks associated with the misuse of mercury and cyanide are significant. It was reported that about ten cyanide plants, processing amalgamated tailings, were operating in the Migori region. Although the long-term health and environmental effects of artisanal mining are being documented (mainly as thesis studies by students and lecturers in the local universities) other concerns of these operations relate to deforestation around the mining areas and the impacts that has on soil erosion and suspended sediment loads into the Migori River.

Figure 6-12 displays a photo of Mogusi River at Nyakoe market downstream of old bridge on Kisii – Kisumu road. The photo shows that the river water is turbid and coloured soupy brown as a result of soil erosion from catchment degradation and encroachment on river riparian land. It depicts the physical state of many rivers in LVS during the rainy seasons.

Figure 6-12: Mogusi river at Nyakoe market, downstream of old bridge on Kisii – Kisumu road

6.5.4.1.4 Mara River

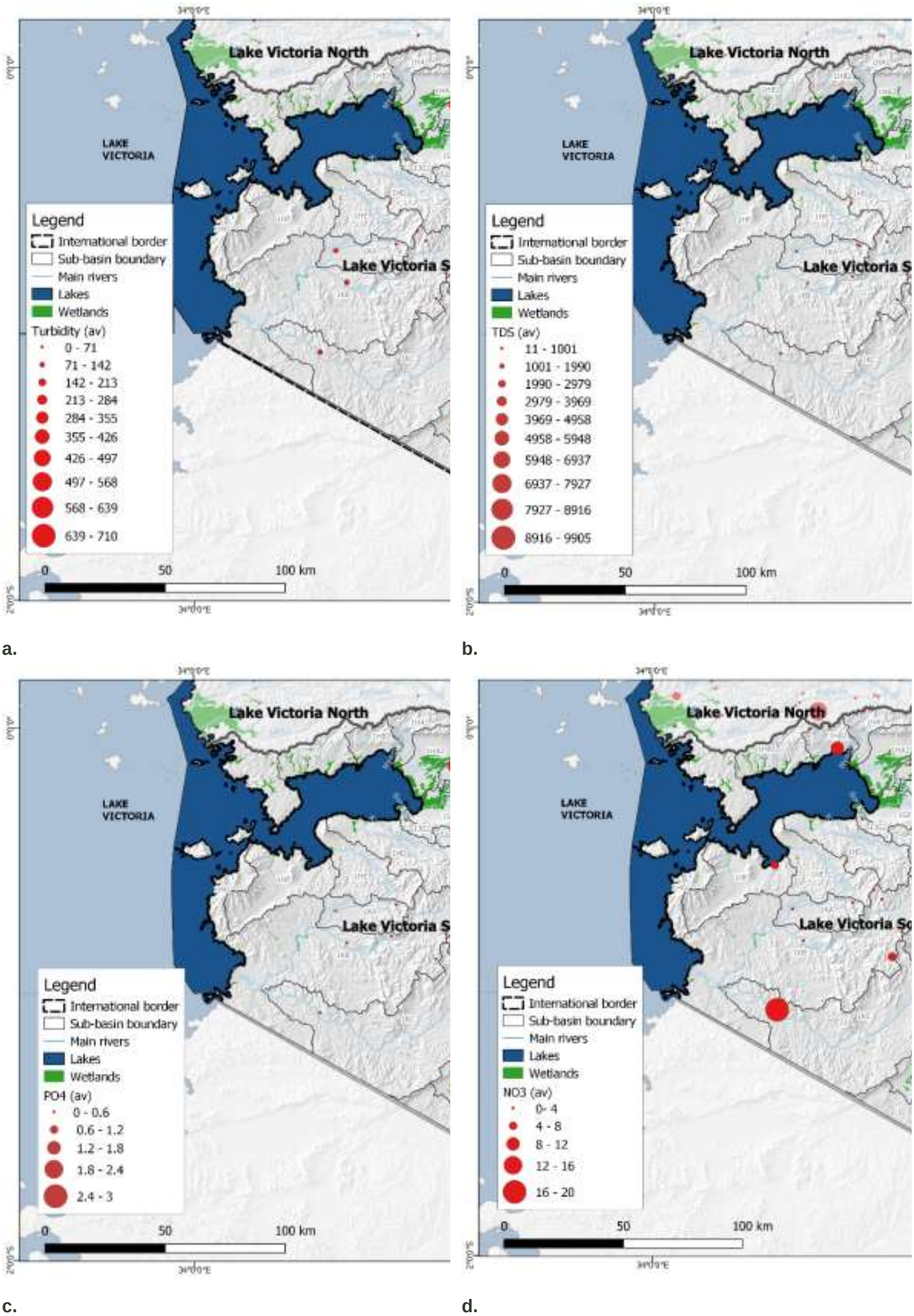
The Mara River with a catchment area of 9,000 km² flows from Kenya through Tanzania and discharges into Lake Victoria at Mwanza. This river receives its waters through its two main tributaries namely; Amala and Nyangores. The Mara River is characterized by major pollution problems occasioned by extensive land degradation and inappropriate agricultural activities in the upper catchments and inadequate sanitation within the tourist establishments based in the Masai Mara Game Camps. This river originates from the Mau escarpment. It is a transboundary river as it flows across into Tanzania. It is also world famous for its yearly wildebeest migration crossing. The river drains mostly the pastoralist region and there is minimal pollution from agro-based activities. Considerable deforestation of the upper region of the Mara River and other forms of land degradation have increased soil compaction, resulting in elevated runoff and soil erosion. Can be used for domestic purposes with caution.

6.5.4.1.5 Lake Victoria (Winam Gulf)

The lake receives polluted water from the 7 main rivers that discharge into it. The main pollutants into the lake are Sediment, industrial and domestic wastes, agro-chemicals and pathogenic bacteria.

Despite the daily loadings of pollutants into the lake, the lake still appears to be fairly in good state because it has a high dilution and waste assimilative capacity.

Lake Victoria is a shared water resource between Kenya, Tanzania and Uganda, and all three countries depend on the lake as a source of water supply, hydropower and livelihood. Water quality in the Winam Gulf area of the lake has declined due to water pollution and eutrophication and water hyacinth infestation blocks major navigation routes, interferes with fishing, hampers water abstractions and threatens the lake ecology. The trans-boundary nature of the water resources in the LVS Basin presents a challenge for the protection of the resources and collaboration with trans-boundary stakeholders is essential to manage conflict.



** Note data limitations meant that water quality maps for other parameters could not be developed*

Figure 6-13: The water quality monitoring stations in LVS Basin with turbidity (a), TDS (b), PO_4 (c) and NO_3 (d)

6.5.4.2 Groundwater

A comprehensive overview of groundwater quality is provided in section 6.4.5.2.

6.5.5 Strategy

In addition to the main objective of this Water Quality Management Plan, other objectives include:

- That the need for socio-economic development is balanced appropriately with the need to protect water quality for clean and safe water, and to enhance the quality of life of citizens and aquatic ecosystems,
- That a coherent approach to managing water quality are followed by government ministries and local authorities to ensure good governance of water quality,
- That there is an effective monitoring chain of data acquisition, information generation, and knowledge application so that water quality managers can make informed decisions about the management of water quality in the basin, and
- That water resource management institutions have the capacity and systems in place to efficiently manage water quality.

The water quality vision for the LVS Basin is to protect and restore the quality of water resources in the basin using structural and non-structural measures. Structural measures refer to the interception and removal of pollutants by means of installed structures such as traps, diversion, or treatment systems. Non-structural measures refer to pollution controls such as monitoring and enforcement of standards and by-laws, public awareness and anti-litter campaigns, pollution levies, street sweeping, etc.

Water quality management in the LVS Basin should be focused on managing the pollution problems in urban centres and maintaining the fitness for use.

In order to comprehensively and systematically address the water quality issues and challenges in the LVS Basin, Table 6-16 sets out 3 Strategic Themes with specific Strategies under each Theme. The Themes address Effective Water Quality Data Collection, Information and Knowledge Management, Governance, and Pollution Control.

Table 6-16: Strategic Framework - Water Quality Management

4	**Key Strategic Area:**	**Water Quality Management (SW and GW)**
4.1	**Theme:**	**Effective water quality data collection, information generation and dissemination, and knowledge management**
It is not possible to manage what you don't measure. A good water quality monitoring system is essential to support effective management, enforcement and compliance assessment. Added to this, the timely sharing of the right data and information, in the required format, enables the development of relevant and applicable water quality management interventions. Continuous improvement of monitoring networks and laboratory services enables effective enforcement and compliance of laws and regulation and supports an adaptive management approach to water quality management. Targets and activities to support this goal relate to the implementation of the monitoring system designed for Kenya but focused on monitoring of the LVS Basin. This entails implementation of routine water quality monitoring of rivers and lakes, reservoirs, effluent discharges, urban rivers, and dams/lakes. It also refers to initiation of limited duration water quality surveys to investigate specific problems in collaboration with, for example, academic institutions and selected specialists. It includes the upgrading central and regional laboratories. Lastly, it is essential that all the data gathered by means of routine programs and surveys, be stored and managed in Mike Info to maintain the integrity of the data, and to generate information and routine reports that meet the needs of water resource managers. Several strategies have been identified to support water quality monitoring.		

4	Key Strategic Area:	Water Quality Management (SW and GW)
4.1.1	Implement routine surface and groundwater quality monitoring	
A national water quality monitoring programme was designed as part of the ISC project. This programme should be implemented in the LVS Basin by ensuring that capacitated technical staff have the resources to collect water samples and conduct in-field measurements on schedule, the water testing laboratories can analyse the water samples accurately and on-time, submit the analysis results to the Mike Info WQ database, and the data are reviewed, analysed, reported on, and acted on by catchment staff.		
4.1.2	Biological Water Quality Monitoring	
Develop the required capacity to undertake biomonitoring in Kenya to assess aquatic ecosystem health. Identify streams in the LVS Basin for piloting biomonitoring and undertake pilot studies. Integrate the results with the water quality monitoring network to assess the overall fitness for use and ecosystem health of water resources.		
4.1.3	Undertake survey of pollution sources	
There is a need to compile an inventory of surface water pollution sources (point sources) across the LVS Basin and reconcile these against the discharge licences at NEMA and permits at WRA. This data should be used to assess compliance to effluent discharge standards and used in waste load allocation studies to assess the cumulative impact of sources concentrated in a specific river reach or sub-catchment. Effluent compliance monitoring should be undertaken at regular intervals.		
4.1.4	Upgrade water quality testing laboratories	
There is a need to upgrade the central and regional laboratories in the LVS Basin to support the national water quality monitoring programme that was designed as part of the ISC project. These include, inter alia, the recruitment of more technical staff, equipping the laboratory and stocking it with reagents, procuring Field Testing Kits, operationalising the LIMS in the central and regional laboratories and participating in proficiency tests to acquire the necessary accreditation and ISO certification to enhance data credibility.		
4.1.5	Institutionalise water quality data storage and management	
A centralised national water quality database was designed with Mike Info. The storage of all historical and new water quality data collected by WRA in the LVS Basin should be enforced. This database should also serve as the approved database for all reporting and assessment of water quality data in the LVS Basin.		
4.1.6	Design and implement routine water quality status reporting	
Routine water quality status reports should be designed and implemented to report on the water quality status in the LVS Basin, identify key water quality concerns, their causes and consequences, and recommend management actions to mitigate negative impacts.		
4.2	**Theme:**	**Promote sound water quality management governance in the LVS Basin**
With so many institutions involved in different aspects of water quality management in the LVS Basin, it is inevitable that there may be uncertainty about the mandate of each institution with respect to water quality management. This objective can be met by clarifying the mandates, the and roles and responsibilities of the different institutions involved in the LVS Basin. This can be achieved by reviewing the mandates, and roles and responsibilities of institutions. It is also important that there be effective arrangements between role players regarding water quality management to ensure that cooperative governance of water quality is achieved. This can be accomplished by establishing mechanisms for cooperation between government institutions on water quality management and pollution control issues. Two strategies have been identified to help alignment, collaboration, and institutional efficiency.		
4.2.1	Harmonise policies and strategies to improved water quality management	
There are several institutions involved in different aspects of water quality and pollution management (e.g. WRA, NEMA, MoA, NIA, counties, basin authority, PCPB, etc.). Their policies, strategies and plans are not always aligned because they are responsible for different aspects of water resources management in the LVS Basin. WRA should advocate alignment of strategies to serve a common purpose of rehabilitating urban rivers and streams in the LVS Basin.		
4.2.2	Coordination and cooperation mechanism on water quality issues established at a catchment level	
WRA should establish a coordination and cooperation mechanism to ensure there is alignment of actions to address water pollution management in the LVS Basin. Participate in river clean-up campaigns of rivers. This can be achieved by using the inter-agency task-force to mobilize resources, carry out clean-ups, creating awareness, and where appropriate, demolishing structures in riparian buffers.		

4	Key Strategic Area:	Water Quality Management (SW and GW)
4.3	Theme:	Efficient and effective management of point and nonpoint sources of water pollution

The water quality challenges in the LVS Basin will require efficient and effective management of pollution sources, as well as mitigating the symptoms of pollution in rivers, reservoirs, and lakes.

Point sources – Monitoring of compliance with Kenyan domestic and industrial effluent standards should be strengthened. All effluent monitoring data should be stored in a central database (Mike Info in this case). Protocols should be implemented for enforcing standards, and for dealing with non-compliant dischargers. To meet this goal, producers of wastewater should be encouraged to treat wastewater at source. This can be achieved by identifying industrial polluters with no wastewater treatment and not meeting effluent standards and directing them to implement onsite wastewater treatment. It can also be achieved by requiring onsite wastewater treatment at all new industries being established. Consideration should also be given to the design and construction of centralised WWTWs and sludge treatment facilities for large urban centres, and to progressively connect households and large wastewater producers to the sewerage network. Lastly, the focal areas of the Kenya National Cleaner Production Centre (KNCPC) should be supported, and industries should be encouraged to participate in this initiative.

Nonpoint sources – Nonpoint sources of pollution probably have the greatest impacts on water quality in the LVS Basin.

Erosion and sedimentation from agricultural lands is probably a major concern and interventions to manage its impacts should be implemented. It has also been the focus of may soil conservation initiative undertaken in Kenya over many years. Reducing erosion and sedimentation also has a large positive impact on water pollution as many pollutants adhere onto sediment particles, and intercepting the particles before they enter water courses, also prevents these pollutants from entering streams, rivers, and lakes. To meet this objective, several target sources have been identified dealing with urban stormwater, riparian buffer strips, hydrocarbon pollution, runoff from informal settlements, other agricultural impacts, and runoff from unpaved roads.

The management of stormwater in urban areas is important because it is the conduit for transporting pollutants into urban streams, and eventually nearby rivers and lakes. This requires promoting the use of structural stormwater control and treatment facilities (e.g. instream detention ponds) in urban areas, as well as reducing stormwater runoff by improved rainfall infiltration systems, efficient drainage network, and improved rainwater harvesting by households, complexes, and commercial buildings. Riparian buffer strips is an important measure to intercepting and filter polluted runoff. The installation and maintenance of riparian buffer zones and vegetated buffer strips should be promoted and enforced. Hydrocarbon pollution from the dumping of used oil into stormwater drains can contaminate large volumes of water rendering it unfit for use. The installation of oil separators at all garages and vehicle workshops should be enforced, and illegal dumping of used oil at informal workshops should be policed and culprits be prosecuted.

Informal settlements have a huge negative impact on urban water quality due to indiscriminate disposal of liquid and solid household wastes. Agricultural also has impacts on nutrient enrichment and pollution from the use of agrochemical to control pests. To deal with these impacts, authorities should promote climate smart agriculture, encourage farmers to use a combination of organic and inorganic fertilisers on their fields, and promote integrated pest management and the use of biodegradable pesticides where possible. Roads, particularly unpaved roads have a large impact on erosion and sediment production. It is recommended that gravel road drainage infrastructure be maintained to reduce erosion, and to implement dust suppression measures on unpaved urban roads to manage wash-off of fine sediments into the stormwater drainage system during rainfall events.

Several strategies have been identified to focus management of water pollution.

4.3.1	Improve sewerage systems and treatment

Promote wastewater treatment at source, especially at industrial sites, housing estates, hospitals, etc. This could be in the form of septic tanks for households or package plants for larger housing or industrial estates. The objective is to improve the quality of effluent discharges before it enters the environment or sewerage network.

4.3.2	Cleaner production methods

Support initiatives by the Kenya National Cleaner Production Centre (KNCPC) to promote excellence in Resource Efficient and Cleaner Production in industries in the LVS Basin in order to reduce water usage and effluents, as well as their impacts on water quality in receiving water bodies.

4	Key Strategic Area:	Water Quality Management (SW and GW)
4.3.3	Urban stormwater, sanitation, and solid waste management, and protection of upper reaches of rivers.	
Control sediment pollution from construction sites and unpaved urban roads in urban areas by adopting best urban stormwater management practices such as erecting sediment traps or screens, sediment detention ponds, etc. Compel county governments to maintain sewerage infrastructure and fix leaks or blockages as a matter of urgency to minimise sewage leaks into stormwater drains. Promote solid waste removal in urban centres and disposal at solid waste disposal sites that meet best national or international design standards. Rehabilitate existing solid waste dumps to intercept and treat poor quality drainage water and prevent it from running into water courses. Compel county governments to delineate and maintain riverine buffer zones to prevent encroachment. Stop encroachment of wetlands.		
4.3.4	Sanitation management in informal settlements	
Protect receiving streams from pollution, especially urban rivers by installing sewers or septic tanks to contain domestic wastes, by managing urban solid wastes, and monitoring receiving streams for BOD and COD. Create sewerage infrastructure to intercept and convey grey and black wastewater to wastewater treatment works. Control of organic pollution from unplanned and un-sewered settlements/slums in all the major urban centres by planning to install sewers or septic tanks and promoting solid waste collection and removal from these settlements. Support international aid projects that are designed to upgrade informal settlements and slums.		
4.3.5	Management of hydrocarbon pollution	
Control of oil and grease pollution from petrol stations and oil storage facilities by ensuring that all are equipped with functional oil & grease traps and monitoring nearby surface and groundwater for hydrocarbons. Control dumping of used motor oil at informal workshops by promoting recycling of used oil, and monitoring stormwater drains for hydrocarbon pollution. Protect groundwater against hydrocarbon contamination near petrol stations and dump sites by drilling observation wells at high risk areas and monitoring boreholes for hydrocarbons.		
4.3.6	Sedimentation from unpaved roads	
Control sediment pollution from unpaved roads by erecting sediment traps or vegetated buffer strips next to dirt and paved roads. Maintain stormwater drainage to prevent erosion next to roads and rehabilitate dongas near roads.		
4.3.7	Management of agricultural impacts on sediments, nutrients, and agrochemicals	
Control nutrients pollution from agricultural activities (N & P) in all farmed areas within the Basin by compiling & maintaining inventories of fertilizer use, and monitoring nutrients in receiving water bodies (rivers, reservoirs and lakes). Control agrochemical (pesticides and herbicides) residue pollution from farmlands by compiling an inventory of pesticide usage in the basin, and monitoring affected water bodies for residues. Promote efficient use agrochemicals in the agricultural sector. Promote best irrigation management practices and encourage irrigators to retain, treat and recycle irrigation return flows before discharging it to the environment. Encourage adoption of good land management practices such as avoiding overstocking and overgrazing, avoiding cultivation on steep slopes or use terracing, minimum tillage, etc.		
4.3.8	Enforcement of effluent standards	
Use the results of compliance monitoring of effluent discharge licence or permit conditions to prosecute offenders that consistently violate their licence/permit conditions and demonstrate no intention of meeting them.		
4.3.9	Control discharges from sand mining operations.	
Control sediment pollution from sand harvesting operations by enacting by-laws for its control, delineating sand harvest areas away from river riparian, and implementing good sand mining guidelines to mitigate their impacts. See for example the River Sand Mining Management Guidelines of Malaysia for good management practices to consider.		
4.3.10	Rehabilitation of polluted aquifers, springs and wells	
See Strategy 3.4.2		

4	Key Strategic Area:	Water Quality Management (SW and GW)
4.3.11	Promote wastewater re-use and wastewater recycling	
Kenya is a water scarce country and this strategy would ensure a saving in water usage. Water can be used severally either for irrigation, cooling or cleaning, before it is eventually discharged. This will be carried out bearing in mind the water quality requirements for these various uses. If necessary, use of economic and other incentives may be used to promote water re-use and water re-cycling technologies		
4.3.12	Evaluate the waste removal efficiency of existing Wastewater Treatment (WWT) and Sewage treatment works	
Many of the sewage treatment facilities in use in many major towns are old and have been in use for many years with poor maintenance being carried out on them. Some need urgent rehabilitation or a complete overhaul of the systems. In order to know whether to rehabilitate or completely overhaul the systems, an evaluation of the waste removal efficiency of the existing WWT and Sewage treatment works will need to be carried out.		

6.6 Climate Change Adaptation

6.6.1 Introduction

In the face of a changing climate, adaptation and resilience are Africa's and indeed Kenya's priority responses to address vulnerabilities and risks. The 15th African Ministerial Conference on the Environment (2015) strongly promoted investment in building resilience as a top funding priority and an integral part of national development funding. This aligns very well with Kenya's approach of mainstreaming climate adaptation in national and sub-national development planning.

The Kenya National Climate Change Response Strategy (NCCRS) (Government of Kenya, 2010c) acknowledged that the impacts of observed and projected climatic change pose serious threats to sustainable development. These predominantly relate to severe weather and changes in the climate extremes which will reduce the resilience in many sectors of the economy.

The Climate and Development Knowledge Network in their Government of Kenya Adaptation Technical Analysis Risk Report (Government of Kenya, 2012b) identified various sectors in Kenya which are at-risk, either directly or indirectly, from climate change. These sectors include agriculture, livestock and fisheries, manufacturing, retail and trade, water, health, financial services, tourism, urban and housing sectors, infrastructure, energy, transport, natural resources and environment, political and social sectors.

The Climate Change Act 2016 aims to strengthen climate change governance coordination structures and outlines the key climate change duties of public and non-state actors. It establishes a high-level National Climate Change Council chaired by the President, a Climate Change Directorate as the lead technical agency on climate change affairs, and a Climate Change Fund as a financing mechanism for priority climate change actions/interventions. Climate desks/units have subsequently been established in certain line ministries staffed by relevant climate change desk officers. The Act is to be applied across all sectors of the economy, and by both the national and county governments. Mainstreaming of climate change has to some extent been undertaken at the county government level, where some counties have taken measures to include climate change in their County Integrated Development Plans (CIDPs) and to develop relevant county legislation.

The National Climate Change Action Plan (NCCAP) 2013 to 2017 (Government of Kenya, 2013e) sets out a vision for a low carbon development pathway for Kenya and lists specific adaptation and mitigation actions for each national planning sector to support this vision. One of the "big wins" identified in the draft NCCAP 2018-2022 relates to "improved water resources management".

The draft NCCAP 2018-2022 (Government of Kenya, 2018c) builds on the first Action Plan (2013-2017) and provides a framework for Kenya to deliver on its Nationally Determined Contribution (NDC) under the Paris Agreement of the United Nations Framework Convention on Climate Change. The draft NCCAP 2018-2022 guides the climate actions of the national and county governments, the private sector, civil society and other actors as Kenya transitions to a low carbon climate resilient development pathway. It identifies strategic areas where climate action over the next five years is linked to Kenya's Big Four Agenda, recognising that climate change is likely to limit the achievement of these pillars. Of particular relevance to water resources management and planning is "Food and Nutrition Security" where food security may be threatened through climate change-driven declines in agricultural productivity. The draft NCCAP 2018-2022 also prioritises seven climate change actions, three of which (nos. 1 to 3) align very strongly with the planning and management of water resources.

Table 6-17: Priority climate change actions (Government of Kenya, 2018c)

Disaster Risk (Floods and Drought) Management	Reduce risks to communities and infrastructure resulting from climate-related disasters such as droughts and floods.
Food and Nutrition Security	Increase food and nutrition security through enhanced productivity and resilience of the agricultural sector in as low-carbon a manner as possible.
Water and the Blue Economy	Enhance resilience of the water sector by ensuring access to and efficient use of water for agriculture, manufacturing, domestic, wildlife and other uses.
Forestry, Wildlife and Tourism	Increase forest cover to 10% of total land area; rehabilitate degraded lands, including rangelands; increase resilience of the wildlife and tourism sector.
Health, Sanitation and Human Settlements	Reduce incidence of malaria and other diseases expected to increase because of climate change; promote climate resilient buildings and settlements, including urban centres, ASALs and coastal areas; and encourage climate-resilient solid waste management.
6. Manufacturing	Improve energy and resource efficiency in the manufacturing sector.
7. Energy and Transport	Climate-proof energy and transport infrastructure; promote renewable energy development; increase uptake of clean cooking solutions; and develop sustainable transport systems.

The Kenya National Adaptation Plan (NAP) 2015 to 2030 (Government of Kenya, 2016c) builds on the NCCRS and NCCAP and promotes adaptation as the main priority for Kenya, while also proposing that adaptation and development goals complement each other. Some of the key objectives of the NAP which are applicable to the LVS Basin Plan include understanding the importance of adaptation and resilience building actions in development; integrating climate change adaptation into national and county level development planning and budgeting processes; and enhancing the resilience of vulnerable populations to climate shocks through adaptation and disaster risk reduction strategies.

Within the context of the LVS Basin Plan, the objective of this component of the Plan is to understand the degree to which climate change will compromise the water resources sector and how those impacts will in turn alter the exposure to food security and to flood and drought risk potential. This component will also explore opportunities presented by climate change such as climate financing.

6.6.2 The changing climate in Kenya

Kenya's climate is already changing. The Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) presents strong evidence that surface temperatures across Africa have increased by 0.5-2°C over the past 100 years, and from 1950 onward climate change has changed the magnitude and frequency of extreme weather events.

The frequency of cold days, cold nights and frost has decreased; while the frequency of hot days, hot nights and heat waves has increased. Temperature increase has been observed across all seasons but particularly from March to May. Variation between locations has occurred, with a lower rate of warming along the coast. Surface temperature trends of Nairobi and its environs show warming of more than 2.5°C in the past 50 years.

Rainfall patterns have also changed. The long rainy season has become shorter and drier, and the short rainy season has become longer and wetter, while overall annual rainfall remains low. The long rains have been declining continuously in recent decades, and droughts have become longer and more intense and tend to continue across rainy seasons. The frequency of rainfall events causing floods has increased in East Africa from an average of less than three events per year in the 1980s to over seven events per year in the 1990s and 10 events per year from 2000 to 2006, with a particular increase in floods. Droughts and heavy rainfall have become more frequent in eastern Africa in the last 30-60 years.

The current trend of rising annual temperatures is expected to continue in Kenya in all seasons. The IPCC Fifth Assessment Report (IPPC, 2014) noted that during this century, temperatures in the African continent are likely to rise more quickly than other land areas, particularly in more arid regions. Climate modelling for the East Africa region using a high-emissions scenario suggests that mean annual temperatures will increase by 0.9°C by 2035, 2.2°C by 2065 and 4.0°C by 2100 (Government of Kenya, 2018c).

The IPCC reports that precipitation projections are more uncertain than temperature projections and suggest that by the end of the 21st century East Africa will have a wetter climate with more intense wet seasons and less severe droughts. The proportion of rainfall that occurs in heavy events is expected to increase. Regional climate model studies suggest drying over most parts of Kenya in August and September by the end of the 21st century.

6.6.3 Climate change impacts, hazards and vulnerabilities in Kenya

Climate change in Kenya is causing significant environmental and economic disruption. Heat, drought and floods are impacting Kenyans, and human health is increasingly at risk. Kenya's economy is very dependent on climate-sensitive sectors such as agriculture, water, energy, tourism, wildlife, and health, which under the future likely impacts of climate change will increase vulnerability. The increasing intensity and magnitude of weather-related disasters in Kenya aggravates conflicts, mostly over natural resources, and contributes to security threats. Expected social, environmental and economic impacts associated with climate change in Kenya are summarized in Table 6-18. Aspects which relate to water resources management and planning are highlighted.

Table 6-18: Potential climate change impacts in Kenya (adapted from Government of Kenya, 2018)

Social impacts	
Flooding	**Fluvial flooding** leads to the greatest loss of human lives in Kenya. In the aftermath of floods, there are often cholera outbreaks while people also experience an upsurge of mosquito-borne diseases such as malaria and dengue fever. The impacts of coastal flooding can also be severe due to sea level rise. The coastal area in Kenya has the largest seaport in East Africa and supports tourism and fishing industries.
Droughts	**Droughts** in Kenya destroy livelihoods, trigger local conflicts over scarce resources and erode the ability of communities to cope. Drought can cause changes in the migratory patterns of animals and increase conflicts between people and animals. Kenya's ASALs are particularly vulnerable to the impacts of climate change: The highest incidence of poverty is found in these areas and women and men experience greater competition over resources, growing populations and lower access to infrastructure. The ASAL economy is also typically highly dependent on climate sensitive activities e.g. livestock and wildlife tourism.
Human conflict	**Cross-border and cross-county conflict** is often exacerbated by climate change. As temperatures rise and rainfall patterns change, some areas become less conducive for livestock, particularly cattle, leading to a reduction in herd numbers. Counties with more favourable conditions often enter resource use conflicts as pastoralists from other counties move their animals to water and better pasture conditions.24 Cross border conflicts could also increase with neighbouring countries as pastoralists compete for food, water and grazing.
Migration	Migration linked to climate change does occur in Kenya - mainly as vulnerable groups are reliant on **resource-based livelihoods**. Reduced agricultural productivity and resource scarcity along with increased floods and droughts also contribute to movement of people.

Social impacts	
Vulnerable groups	Vulnerable groups include remote and pastoralist communities, hunters and gatherers, fisher communities and people who live in urban slums. All of these are affected by climate change because of environmental degradation and **growing competition for land and water.**
Ocean acidification	Ocean acidification is expected to impact many ocean species, leading to declines with negative impacts on fisher communities that rely on these species for food and livelihoods.
Women	Women in their roles as primary caregivers and providers of food and fuel makes them more vulnerable when flooding and drought occur. Drought compromises hygiene for girls and women and has a negative effect on time management as they must travel long distances to **search for water**.
Environmental impacts	
Droughts	The increased and abnormal frequency and severity of droughts in Kenya due to climate change, have serious environmental impacts.
Sea temperature	Rising sea temperatures in the Western Indian Ocean influence the coastal conditions associated with Kenya. It leads to coral bleaching and mortality on coral reef systems and is likely to affect the abundance and composition of fish species affecting the fisheries industry.
Rising sea levels	Rising sea levels are a concern for Kenya’s coastline consisting of mangroves, coral reefs, sea grass and rocky, sandy and muddy shores. The rate of sea level rise along Africa’s Indian Ocean coast is projected to be greater than the global average. This will lead to greater levels of and more frequent coastal flooding, changing patterns of shoreline erosion, **increased salinity of coastal aquifer**s, and modification of coastal ecosystems such as beaches, coral reefs and mangroves.
Ocean acidification	Ocean acidification is expected to impact many ocean species. Marine species that are dependent on calcium carbonate to build their shells and skeletons, such as corals, are also highly vulnerable.
Retreat of glaciers	The glaciers of Mount Kenya are declining and are expected to disappear in the next 30 years, largely because of climate change. Mount Kenya is one of the country’s **water towers** and the source of numerous rivers and streams.
Desertification	Desertification in the ASALs can be attributed to climate change impacts, in addition to human activities. It is intensifying and spreading, reducing the productivity of the land and negatively affecting communities.
Land degradation	Climate change is a major factor contributing to **land degradation**, which encompasses changes in the chemical, physical and biological properties of the soil.
Loss of biodiversity	Climate change is contributing to a loss of Kenya’s biodiversity including plant species, some animal species, and a decline in the productivity of fisheries in inland waters Climate change also has the potential to alter migratory routes and timings of species that use seasonal wetlands (such as migratory birds) and track seasonal changes in vegetation (such as herbivores). Furthermore, climate change also significantly affects marine ecosystems.
Deforestation and forest degradation	**Deforestation and forest degradation** in Kenya is largely a result of human activities, although climate change is likely to affect the growth, composition and regeneration capacity of forests resulting in reduced biodiversity and capacity to deliver important forest goods and services. Rising temperatures and long periods of drought will lead to more frequent and intense forest fires, rising temperatures will extend the ecosystem range of pests and pathogens with consequences on tree growth, survival, yield and quality of wood and non-wood products, and rising sea levels could submerge mangrove forests in low-lying coastal areas.42
Landslides	Landslides associated with heavy rainfall in regions with steep slopes could increase due to increased rainfall intensities associated with climate change.
Economic impacts	
GDP	The **economic cost of floods and droughts** is estimated to create a long-term fiscal liability equivalent to 2%-2.8% of GDP each year. Specifically, the estimated costs of floods are about 5.5% of GDP every seven years, while droughts account for 8% of GDP every five years.
Infrastructure and resources	Floods in Kenya regularly **destroy and damage infrastructure** such as roads, bridges, buildings, and telecommunication infrastructure as well as crops and livestock worth billions of shillings.

Social impacts	
Hydroelectricity	Droughts depress the **generation of hydroelectricity** leading to an increase in generation of electricity from thermal sources that are costlier and produce greenhouse gas emissions.
Livelihoods and income generation	The **impacts of drought** are felt at the household level and are particularly devastating for pastoralists in the ASALs where livestock production – and specifically, semi-nomadic pastoralism – is the key income source.
Coastal assets	Sea level rise will impact coastal towns and communities through increased coastal erosion and flooding

6.6.4 Strategy

The climate change strategy for the LVS Basin strives towards a well-managed river basin exhibiting enhanced climate resilience against annual variability, El Niño–Southern Oscillation (ENSO) cycles, flooding and extreme events and continuous drought years. Furthermore, it envisions a basin that applies climate mitigation and mainstreaming into development, while comprehending and promoting adaptation practices.

As suggested previously, the climate of Kenya has already started to experience the effects of a changing climate. This will be exacerbated into the future with expected impacts including increased temperature, increased intensity and frequency of extreme events as well as unpredictable weather patterns.

The Government of Kenya Adaptation Technical Analysis Report (Government of Kenya, 2012b) highlights the way forward as "*integrating climate change adaptation into the medium term planning and budgeting process at national level and ensuring that it is also captured during development of the County Development Profiles*" as well as considering and understanding the sectoral impacts of climate changes such that adaptation can "*address these impacts or maximise on the opportunities that some of the impacts provide*". The monitoring of the integration of climate change adaptation into long term developments is also required to ensure systems aren't compromised into the climate changed future.

In order to comprehensively and systematically address the range of climate change issues identified in the LVS Basin, **Table 6-19** sets out 3 Strategic Themes and provides specific strategies under each theme. These themes are focused on understanding and mitigating the impacts and cross sectoral ramifications of the changing climate in the LVS Basin.

Table 6-19: Strategic Framework - Climate Change Adaptation

5	Key Strategic Area:	Climate Change Adaptation and Preparedness
5.1	Theme:	Understand impacts of climate change on water resources at appropriate spatial scales
5.1.1	Quantify climate change impacts (rainfall & temperature) on surface water and groundwater resources and demands in the LVS Basin at appropriate scales for planning and management	
This is undertaken though research and public consultation processes, and where necessary, engaging with the private sectors for further insights. As the impacts will be felt in a practical sense, this process should focus more on the in-situ impacts, thresholds and exposer accounts rather than as a technical theoretical review.		
5.1.2	Assess relevance, and scale of potential social, environmental and economic climate change impacts as defined in NCCAP in LVS Basin and its relation to water resources planning and management; prioritise areas for interventions	

5	Key Strategic Area:	Climate Change Adaptation and Preparedness
This will assess climatic trends to evaluate frequency and magnitude of events resulting in flooding events. Furthermore, the highlighting of hotspot area will act as a pre-emptive measure building resilience. Assessment of meteorological data relative to the ENSO cycle may provide forewarning into future drought occurrence and severity. Furthermore, there should be analysis of rainfall onset and cessation, particularly in rainfed agricultural areas and areas highly reliant on surface water rather than reticulation. Assessment of meteorological data relative to the ENSO cycle may provide forewarning into future drought occurrence and severity. Furthermore, there should be analysis of rainfall onset and cessation, particularly in rainfed agricultural areas and areas highly reliant on surface water rather than reticulation. Engage local private sector, NGOs and knowledgeable individuals to facilitate wider experience transfer of adaptation practices. Engage local private sector, NGOs and knowledgeable individuals to facilitate wider experience transfer of adaptation practices		
5.2	Theme:	Climate change mitigation
5.2.2	Promote the generation and use of clean energy	
Propagate the usage of renewable energy source just as hydropower, wind power and solar geysers.		
5.3	Theme:	Climate change adaptation
5.3.1	Promote climate resilient infrastructure	
Promote the development in low risk areas and increase setback from rivers. Build to increased threshold specifications to address future climate impacts for both road and stormwater infrastructure		
5.3.2	Climate-related disaster risk management	
Reduce the risk of disasters linked to climate change e.g. floods, droughts, health-related risks, crop production etc. by understanding the potential threats and risks and by implementing structural and non-structural mitigation measures.		
5.3.3	Promote agroforestry	
Increase resilience through diversification of agroforestry’s varied land usage to increase biodiversity and minimise soil erosion and increase soil nutrients retention. Actively plant, living fences, medicinal and fruit trees		
5.3.4	Mainstream climate change adaptation in water resources strategy, planning and management at basin and catchment level	
Implementation and enforcement of practical mainstreaming practices and enhance the awareness of potential climate impacts on communities to promote uptake of adaptation.		
5.3.5	Enhance resilience of agriculture sector through climate smart agriculture	
Employ likely increased stress impact principles promoting soil quality, better drainage and weed/disease control in agricultural practices		

6.7 Flood and Drought Management

6.7.1 Introduction

Floods and droughts are caused by extreme climatic events and can have devastating consequences for the socio-economic welfare of rural and urban communities and regions.

Flooding of land surfaces occurs when heavy rainfall leads to runoff volumes that exceed the carrying and storage capacities of stream channels and urban drainage systems. In the process, crop and grazing lands, villages and urban neighbourhoods become inundated, transport infrastructure destroyed, and powerlines flattened. Floods can cause displacement of people, loss of life (human and livestock), increases in water related-diseases, severe soil erosion, land-slides, increased food insecurity and significant losses to the economy of a region.

Drought can be defined as an extended period (consecutive months or years) of unusually low rainfall, depleted soil moisture and groundwater levels and a severe reduction in availability of surface water resources in streams, reservoirs and lakes. Drought can be referred to as a “creeping disaster” since its effects accumulate slowly and may linger for years after the termination of the event. Droughts can decimate dryland crop production, severely curtail irrigated crop production, cause severe loss of life of livestock and game, diminish freshwater fish-stocks, result in severely restricted municipal and industrial water supplies and give rise to substantial losses to the economy of a region.

It follows from the above that systematic preparedness planning for floods and droughts is an imperative to ensure mitigation of and protection against the above negative consequences of extreme floods and droughts.

The purpose of a Flood and Drought Management Plan is to establish and guide a structured programme of actions aimed at ensuring the prevention of, mitigation of, timeous response to, and recovery from, the harmful impacts of floods and droughts across a specific Basin or catchment area.

6.7.2 Characteristics of floods and droughts in the LVS Basin

6.7.2.1 Frequency and extent of floods in the LVS Basin

The frequency and extent of significant floods in Kenya have increased during the past six decades from about one flood period every four years, on average, to a near-annual event, as is illustrated by the following details:

- Between 1961 and 1997/78, Kenya experienced 8 individual years with widespread flooding (Opere, 2013). The most devastating among these were the floods of 1997/98, the so-called El Nino Flood, with 1.5 million people affected, 770 000 displaced, 2000 flood-related human deaths and a further 5600 human deaths due to cholera, malaria and Rift Valley Fever, 2.3 million livestock lost, and 100 000 km roads and 13 major bridges destroyed (Gathura, 2015). The *Kisumu and Siaya* counties were particularly severely impacted.
- During the period 1998-2012, widespread flooding and landslides across Kenya were absent for only two of the years and during a number of these events *Kisumu and Siaya* counties were impacted to varying degrees. (Huho, Mashara & Musyimi, 2016). During April-May 2003 dykes along the Lower Nyando River were breached and bridges washed away.
- Widespread flooding and occasional landslides during March–May 2013 displaced 140 000 people and led to 96 deaths. *Kisumu, Migori, Kisii and Narok counties* in the LVS Basin were impacted (OCHA, 2013; Reliefweb, 2013).
- Widespread flooding and occasional landslides during October-December 2015 affected 240 000 people, displaced 104 000 and caused 112 deaths across the impacted areas. LVS Basin counties that were impacted were *Migori, Homa Bay, Kisii and Narok* (International Federation of Red Cross, 2016a).
- Widespread flooding and occasional landslides during April and May 2016 displaced 49 000 people and caused 100 deaths. LVS Basin counties that were severely impacted were *Kisumu and Homa Bay* (International Federation of Red Cross, 2016b).
- During 2017, two different periods of significant flooding occurred in separate parts of Kenya - during May in south-eastern Kenya and during November in northern Kenya. The LVS Basin was not severely impacted (Davies, 2017).
- Widespread flooding and various landslides during March-May 2018 impacted more than 800 000 people across Kenya, including in LVS Basin counties, *Kisumu and Narok*. About 300 000 people were displaced and 186 people lost their lives across the country. More than 8 500 hectares of crops were destroyed and some 20 000 livestock lost, while about 100 schools were flooded (OCHA, 2018).

6.7.2.2 Flood-prone areas in the LVS Basin

The chronic flood-prone areas in the LVS Basin are as follows (Government of Kenya, 2009; Water Resources Management Authority, 2015a):

- Long-duration flooding (up to a month) in the Lower Nyando River in the Kano Plains in Kisumu county, as well as in Migori county.

- Short-to-medium duration flooding (1 – 5 days) in the floodplains upstream of Sondu River mouth in Homa Bay county and Kuja River mouth in Migori county, respectively.
- Short-to-medium duration flooding (1 – 3 days) in Kisumu Town due to inadequate urban drainage infrastructure.
- Flash floods in the Awach Kano and Nyamasaria Rivers, originating in the Nandi and Mau Escarpments.

6.7.2.3 Frequency and extent of droughts in the LVS Basin

During the past two decades Kenya has experienced five widespread multi-year droughts with devastating socio-economic and environmental consequences. Table 6-20 provides an outline of these five droughts. The counties of the LVS Basin which were impacted by some of these droughts were Kericho, Nakuru and Homa Bay.

Table 6-20: Widespread Kenyan droughts during the past two decades

Years	Impacts
2016-17	3.4 million people severely food insecure, of which 1.1 million are children. About 0.5 million people without access to clean water.
2011-12	3.75 – 4.3 million people in dire need of food.
2008-09	4.4 million people affected; 2.6 million people at risk of starvation, 70% loss of pastoral livestock.
2004-06	3.5 million people affected; 2.5 million close to starvation; 40 human lives lost; 40% cattle, 27% sheep and 17% goats lost.
1999-2001	4.4 million people affected.

Source: *Huho et al., 2016; Reliefweb, 2018*

6.7.3 Drought-prone areas in the LVS Basin

The climate of the LVS Basin can be categorised as moderate to humid, with relatively high mean annual rainfall (1200 – 1800 mm/a). Under these favourable climate conditions, it follows that, should consecutive rainfall seasons produce below-average rainfall, emergency drought conditions would not generally develop in the LVS Basin, but three counties, *Kericho, Nakuru and Narok*, are vulnerable with respect to prolonged sub-normal rainfall.

6.7.4 Existing flood and drought management measures and response plans

The following sections outline the various flood and drought management strategies/plans, relevant to the LVS Basin, that have been compiled during the recent past.

6.7.4.1 Integrated Flood Management Plan (IFMP) for the Nyando River Basin (Water Resources Management Authority, 2009)

The proposed IFMP for the Nyando River Basin distinguishes between “structural” and “non-structural” measures.

The structural measures include the following:

- Lower Nyando River: a conventional dyke on both sides of the channel; retarding basins with groynes (19 km); dredging of a 20 m wide channel of length 16 km through the swamp at the river mouth.
- Lower Awach Kano and Lower Nyaidho Rivers: conventional dykes - respective lengths 7 km and 4 km; excavation and dredging of river channels – respective lengths 11 km and 6 km; two retarding basins for each river; 13 km river bank protection and three sediment retention structures for the Awach Kano; raising of 3 km of National Road A1 – including 9 sets of additional culverts - along the Awach Kano.
- Nyamasaria, Luando, Ombeyi, Miriu and Oroba Rivers: various structural improvements over lengths ranging from 5 km to 20 km; in each case these include some of the following – conventional dykes, de-siltation of river channels, river bank protection, retarding basins, sediment retention slit-type weirs, planting of riparian and upland trees.
- New flood control dams: Nyando Dam on the Nyando mainstem, Ainamotua Dam on a major Nyando tributary and Kibos Dam on a major Nyamasaria tributary.
- Raising 37 km of local roads.

The following non-structural measures were proposed for the catchments of the Nyando and Nyamasaria Rivers:

(i) Flood forecasting systems, (ii) flood early warning systems, (iii) information dissemination systems, (iv) education for disaster prevention, (v) flood hazard mapping, (vi) evacuation systems, and (vii) community driven flood management organisation.

6.7.4.2 National Water Master Plan 2030, Volume II Part C – Lake Victoria South Catchment Area

The Water Master Plan for the LVS Catchment Area consists of eight component plans, one of which is a flood and drought disaster management plan.

6.7.4.2.1 Flood disaster management plan

The proposed components of the flood disaster management plan for the LVS Catchment Area broadly followed the 2009 IFMP proposals (Water Resources Management Authority, 2009) outlined in Section 6.1 and distinguished between “structural” and “non-structural” measures, as follows:

- Implementation of Flood Control Measures in the Nyando River catchment: This includes various structural flood control measures such construction of new multi-purpose dams, construction of new dykes and rehabilitation of existing dykes, river channel/bank improvement works, retarding basins and catchment conservation.
- Operation of a Flood Forecasting and Warning System (FFWS) in the Nyando River catchment: The establishment of telemetric flood forecasting and warning systems in the Kano Plain and Nyando River catchment would be part of the medium-term plan. Flood forecasting analysis was to be performed by WRMA regional offices, in cooperation with KMD. Warning information would also be provided by WRMA regional offices.
- Preparation of a Flood Fighting Plan for the Nyando River: This Plan should cover the existing dykes for 15.1 km along both banks of the lower reaches of the Nyando River, to be prepared by the WRMA LVS Regional Office. The Flood Fighting Plan was aimed at preventing an expansion of inundation areas caused by dyke breaching and/or overtopping.
- Establishment of community-based disaster management (CBDM) systems in the Sondu River mouth and Kuja River mouth areas: It is proposed that the CBDM system includes various activities by community involvement, namely: systematisation of communities and establishment of a monitoring procedure; information dissemination; evacuation in cooperation with the WRMA LVSCA Regional Office, Kisii Subregional Office and local government offices; construction of evacuation centres and evacuation routes by community involvement; voluntary monitoring by the community

using simple rain and water level gauges; community involvement in flood fighting activities; and construction of small-scale structural measures such as a small revetments and culverts.

- Implementation of Urban Drainage Measures in Kisumu: These drainage works would involve new gravity drain systems as well as major associated works such as pumping stations, retarding basins, and improvement of receiving river channels.

6.7.4.2.2 Drought disaster management plan

The proposed components of a drought disaster management plan for the LVS Catchment Area were as follows:

- Preparation of drought operating rules for 2 existing (Sondu and Gogo Falls Dams) and 10 proposed reservoirs, as well as of restrictions placed on water supplies to the different water-user sectors.
- Establishment of a Basin Drought Conciliation Council for each of the Nyando, Kibos, Sondu, Kuja, and Amala River systems, with legal status to avoid water conflict during droughts. Each Council's membership would comprise WRMA regional staff, county staff and representatives of WRUAs.
- Establishment of a drought early warning system, based on existing KMD seasonal rainfall forecasts and utilised to commence with timely water restrictions.

6.7.4.3 Gucha Migori River Basin Integrated Flood Management Plan (IFMP) (Water Resources Management Authority, 2014)

The investigations leading up to the Gucha Migori IFMP identified the highest priority flood impacts as long-duration inundations at and downstream of the confluence of the Gucha and Migori Rivers caused by bank over-flow and backwater from Lake Victoria. The next highest priority flood impacts were flash floods in tributaries due to intense runoff from neighbouring hills in the upstream, midstream and downstream catchment areas.

The IFMP comprised 19 structural and 13 non-structural measures, divided into short-term (1 year), mid-year (2-3 years) and long-term (4+ years) horizons. The structural measures included various actions regarding evacuation centres, check-dams, retarding basins, dykes, river channel dredging, improvement of Gogo Falls Dam and construction of new upstream dams. The non-structural measures included various sensitisation and advocacy actions in communities and schools, evacuation drills, establishment of an IFM Forum, improved agricultural practices and community-based early warning systems.

6.7.4.4 LVS Catchment Area Catchment Management Strategy 2015 – 2022 (Water Resources Management Authority, 2015a)

In the LVS CMS, five levels of structural/non-structural flood and drought interventions are envisaged: regional, sub-regional, county governments, WRUAs and local communities. Table 6-21 presents a generic summary of the proposed interventions.

Table 6-21: Levels of flood and drought management envisaged for the LVS Catchment Area (Water Resources Management Authority, 2015a)

Focus at Regional Level		**Focus at Local Level**	
Structural	*Non-Structural*	*Structural*	*Non-Structural*
Development of large-scale infrastructure for flow regulation and storage.	Information gathering, analysis and dissemination.	Development of small scale infrastructure like river training, dykes, raised roads, evacuation centres, culverts, etc.	Flood and drought management activities mainstreamed in County Plans; e.g. early warning at local level, evacuation drills, flood hazard maps, public information on flood inundation.

Focus at Regional Level		Focus at Local Level	
	Development of analytical products such as inundation maps and drought hazard maps.	Development of rainwater harvesting structures such as water pans, small dams and roof-rainwater tanks.	Community flood and drought management committees formed to coordinate climate related issues.

The goal and objectives of the flood and drought management component of the CMS were as follows:

Goal: Effectively manage floods and droughts in collaboration with stakeholders.

Objectives:

- To develop and implement a framework for collaboration with County Governments and other Stakeholders on Integrated Flood and Drought Management.
- To enhance capacity on Integrated Flood and Drought Management, including monitoring skills, use of information systems and flood control centres.
- To mainstream Flood and Drought Management in Sub-Catchment Management Plans.

In pursuit of these objectives, the CMS proposed 23 individual Strategic Actions, some of which were to be completed between 2015 and 2020, while the rest were continuous and ongoing.

6.7.4.5 Awach Kano River Basin Integrated Flood Management Plan (IFMP) (Water Resources Management Authority, 2016)

The investigations leading up to the Awach Kano IFMP identified the highest priority flood impacts as long-duration inundations caused by Awach Kano River bank over-flow and backwater from Lake Victoria, particularly in the downstream reaches. The next highest priority flood impacts were flash floods in tributaries due to intense runoff from neighbouring hills in the upstream and midstream catchment areas.

The IFMP comprised 20 structural and 12 non-structural measures, divided into short-term (1 year), mid-year (2-3 years) and long-term (4+ years) horizons. The structural measures included various actions regarding evacuation centres, retention ponds, de-silting of water pans, dykes, check dams, river channel dredging, river bank rehabilitation, gully restoration and construction of new upstream dams. The non-structural measures included various sensitisation and advocacy actions in communities and schools, hazard maps, evacuation drills, improved agricultural practices, rainfall and streamflow gauging networks and community-based early warning systems.

6.7.5 Key achievements, challenges and constraints

In the documents discussed in Section 6, as well as in various relevant documents available on the GoK web-site, a range of achievements, challenges and constraints regarding flood and drought disaster management are identified. Although various of these items are aimed at the national level, they nevertheless have importance at the Basin, county and sub-county levels. These achievements, challenges and constraints are outlined in the following sub-Sections.

6.7.5.1 Achievements

- Multi-year Pilot Projects were successfully completed in five villages to “learn lessons” regarding the implementation of the Nyando River Basin IFMP (Water Resources Management Authority, 2009).
- Some 15 km of dykes have been built/rehabilitated along the Lower Nyando River, as well as some 14 km of river channel dredging and various river improvements to increase discharge capacity, have also been completed.
- Flood evacuation centres, flood evacuation routes, boreholes, raised toilets, culverts and bridges have been built in Nyando flood-prone areas.

- River revetments have been built along the Sondu River to strengthen river banks.
- By 2015 39 river gauging stations, 62 rainfall gauging stations and 24 groundwater monitoring stations had been established throughout the LVS Basin (Water Resources Management Authority, 2015a).
- A Flood Early Warning System has been established for the Lower Gucha Migori catchment.
- Community flood disaster management committees have been established in the Lower Nyando and Lower Gucha Migori catchments.
- The National Hydro-Meteorological Network Design Project for the Republic of Kenya, currently underway, has designed a provisional network of 56 meteorological and 52 river gauging stations (telemetric or automatic or manual) for the LVS Basin.
- The National Drought Management Authority (NDMA) has been established and it exercises its functions both at national level and Basin level, and, in collaboration with county governments, also at county and community level. The Ending Drought Emergencies Common Programme Framework (EDE-CPF) has been operationalised and is now in its 3rd Medium-Term Plan (Government of Kenya, 2017b).
- The Cabinet approved the National Drought Emergency Fund (NDEF) Regulations in May 2018. The Regulations guide the operations of the National Drought Emergency Fund which is to be established for improving the effectiveness and efficiency of drought risk management systems in Kenya as well as to provide a common basket of emergency funds for drought risk management. The establishment of the NDEF reflects a wider Government policy shift towards drought risk management rather than crisis management. NDMA has, since 2014, been piloting the use of a dedicated Fund in drought risk management through the European Union-funded Drought Contingency Fund (DCF). The DCF business process was successfully employed during the 2016-2017 drought, thereby mitigating losses both of lives and livelihoods.
- The Department of Agriculture has been rolling out a subsidised crop insurance policy to maize farmers in various counties. Campaigns are ongoing by the Department to advise farmers to construct water-harvesting structures on their farms in order to benefit from good rainfall periods.

6.7.5.2 Challenges

- Sourcing financing for completion of the implementation of the IFMP for the Awach Kano and Gucha Migori catchments: In 2016 the cost of this work for the Awach Kano catchment was estimated as USD 7 million (Water Resources Management Authority, 2016). Financing requirements for the IFMP for the Gucha Migori catchment can be expected to be of a similar order.
- Sourcing financing for implementation of the flood and drought management component of the LVS Basin CMS: In 2015 the cost of this work was estimated as USD 6 million.
- Ongoing urbanisation leading to increased urban populations.
- Ongoing encroachment of communities for crop and livestock farming in flood-prone zones.
- Increasing upland deforestation and soil degradation which compounds river siltation and subsequent flooding of riparian zones and floodplains.
- Expanding more widely the establishment of timely hydro-meteorological data collection and subsequent analysis necessary for setting up early warning systems.
- Adaptation required in the face of potential climate change impacts in the form of increased frequency of floods and droughts.

6.7.5.3 Constraints

- *Institutional complexity*: In terms of the Water Act of 2016, a Basin Water Resources Committee (BWRC) for the LVS Basin, ought to be in place to advise the WRA and county governments concerning flood mitigation activities, and, in collaboration with the NDMA, ought to be developing drought contingency plans and oversee their implementation as emergency response interventions. It has been a serious constraint that the LVS BWRC has not been established and operationalised. Without the BWRC being in place, the interfaces between the national roles of the NDMA and WRA and the local roles of county governments and WRUAs have remained fragmented and lacking an integrated Basin focus.

- However, because of ambiguities in the Water Act about whether BWRCs have advisory or executive functions, parliamentary processes are currently underway to amend the Water Act to limit the mandate of BWRCs to being purely advisory bodies. This change will likely leave a void that will have to be filled by much closer collaboration between counties (who have WRM functions), BWRCs, WRA's Regional and Sub-Regional Offices and the local structures of the NDMA.
- *Incoherent coordination of resource mobilisation:* A recent review of disaster preparedness in Kenya by the DFID (2017) found that coordination between national and local actors in humanitarian resource mobilisation was generally incoherent. Hence, this review concluded that international relief aid organisations and local NGOs have had to establish personal working relationships with institutional actors in each of the counties in which they operate to streamline collaboration by the county governments and other government agencies.
- *Institutional overlaps:* There is considerable overlap between the roles and functions of the NDOC and NDMU. Both institutions manage disaster response activities, the operations of both cut across both natural and man-made disasters, both collaborate closely with the National Police Service and Kenya Red Cross, amongst others. A further constraint is that the two entities are located in different Ministries.
- Furthermore, the mandate of NDMA also overlaps with the mandates of NDOC and NDMU. The Disaster Risk Management Bill, currently under consideration by Parliament, is aimed at bringing NDMA, NDOC and NDMU together as a new "Disaster Risk Management Authority."
- *Monitoring shortcomings*: WRA's surface water monitoring network is well-developed, but data quality is often poor due to inadequate operational and maintenance funding, vandalism of stations and, in some areas, flood damage of river gauging stations.
- Furthermore, protocols for sharing of streamflow and meteorological data between government institutions and professional services providers for flood and drought monitoring, planning and early warning are not satisfactory.
- *Weak community preparedness*: WRA has delineated about 1200 sub-catchment areas across Kenya for WRUA establishments. A process for capacity building of WRUAs has been established through the WRUA Development Cycle, but much work still needs to be done.

6.7.6 Strategy

In previous Sections of this Report, many critical issues related to flood and drought management have been identified including the need for IFMPs (Figure 6-14).

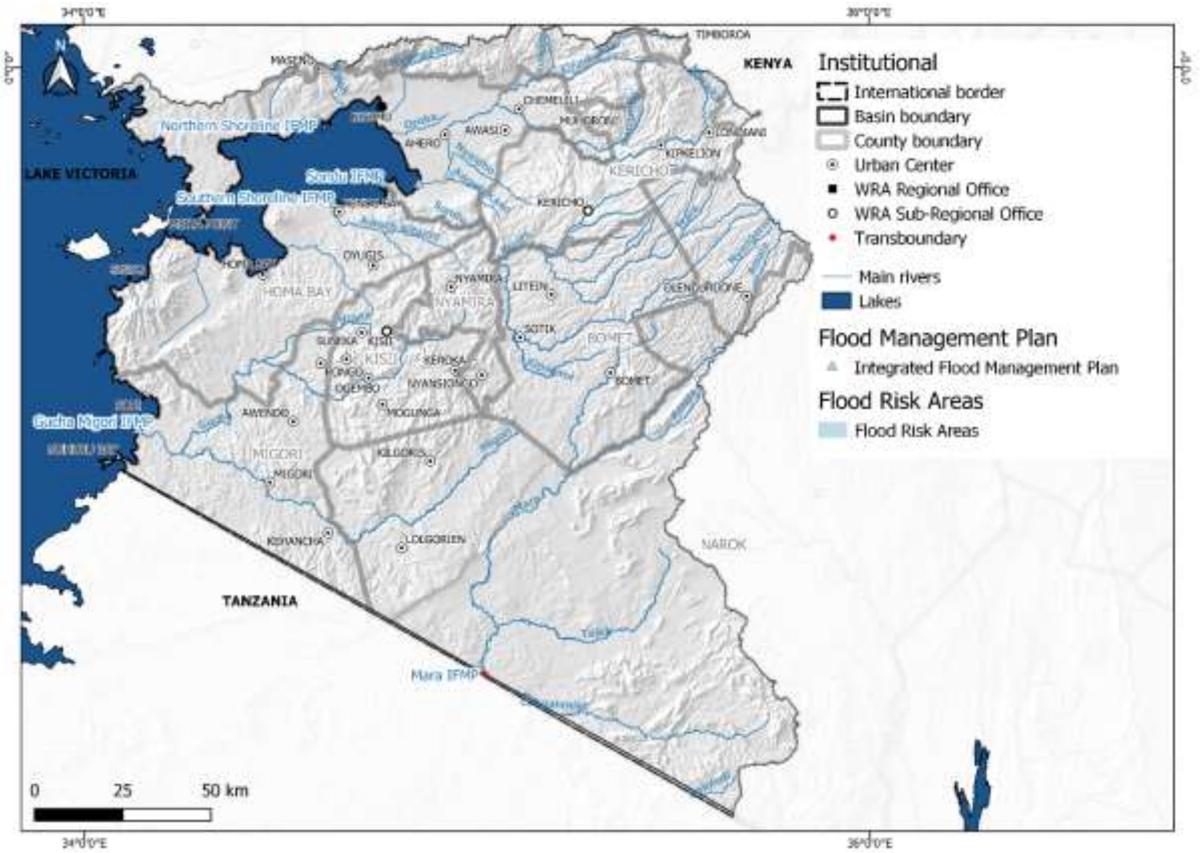


Figure 6-14: Flood management plan for LVS Basin

In order to comprehensively and systematically address the flood and drought issues and challenges in the LVS Basin Table **6-22** sets out two Strategic Themes with specific Strategies under each Theme. The Themes address Flood and Drought Management.

Table 6-22: Strategic Framework – Flood and drought management

Key Strategic Area 6		**Flood and drought management**
6.1	Theme:	Flood management
6.1.1	Undertake flood risk assessment	
The most flood-prone counties in the LVS Basin are Siaya, Kisumu, Homa Bay, Migori and Kerichu. High-level assessments will be made of the flood exposure of each village and town in these counties in terms of proximity to river channels, flood-plains and low-lying land, as well as vulnerable transport, access and escape routes and river crossings. Stormwater drainage in the larger urban areas will also be assessed. Both the characteristics of past floods and flooding and the existing flood protection structures and drainage systems will be noted, and the risk of flooding will be determined by reviewing historical information about the frequency of high water levels and long-duration inundations. The above information will be systematised in a *Flood Risk Register* for the LVS Basin, which will provide a starting point for the Integrated Flood Management Plans discussed below.		

Key Strategic Area 6	Flood and drought management
6.1.2	Formalise institutional roles and partnership collaborations.

The existing government institutions and agencies and other stakeholders with partnership roles in flood management are as follows[3]:

- KMD
- NDMU (including its County Coordinators)
- NDOC
- National WRA and Regional and Sub-Regional WRA Offices
- County Governments and County Disaster Risk Management Committees
- BWRCs
- WRUAs
- Village Disaster Risk Management Committees
- Various Ministries; particularly Departments dealing with Roads, Railways and Health
- Kenya Red Cross Service
- International Relief Aid Agencies
- NGOs

Formalising and aligning the roles of and proactive partnership collaborations among the above entities are crucial to ensuring that the above objectives of the flood response protocol are achieved. To this end, it is proposed that the *LVS Basin Flood Response Forum (FRF)* be established that integrates all flood-relevant resource mobilisations and related interventions in the LVS Basin by the various collaboration partnerships listed above. The *LVS Basin FRF* must operate under the auspices of the KMD and, to ensure continuity, it must be served by a Secretariat. The Secretariat can be physically housed in the WRA Regional Office or in one of the WRA Sub-Regional Offices. Furthermore, the activities of the *LVS Basin FRF* must be systematised through the development of appropriate standard operating procedures (SOPs)[4].

6.1.3	Develop flood response protocol

The flood response protocol: The flood response protocol follows a *multi-stakeholder* approach and comprises a structured set of inter-connected institutional and partnership roles, focus areas and mechanisms to prepare for, respond to and recover from a flood disaster. The components of the flood response protocol are as follows:

- Formalised institutional roles and partnership collaborations.
- A flood preparedness plan that is understood by both institutional actors and communities in flood-prone zones.
- A key principle of the plan is that it is better to protect more people from the frequent smaller floods, than fewer people from the rarer larger floods. Flood early warning systems should be used to warn communities when larger floods may occur.
- SOPs that comprise sequential response actions: monitoring ⇨ early warning alerts ⇨ severity trigger alerts ⇨ pro-active resource mobilisations ⇨ emergency interventions ⇨ post-flood recovery interventions.

Objectives of the flood response protocol:

- Minimise the impacts of flooding on the safety and quality of life of affected communities.
- Minimise environmental impacts.
- Accelerate recovery of prior homestead environments, livelihoods and transport routes of affected communities.

[3] There are currently three bills seeking to establish a National Disaster Management Authority and a National Disaster Management Fund. However, the three bills differ in content and structure e.g. proposed governance structure, membership and functions among other things. The mandates of NDMA, NDOC and NDMU overlap in various ways. The Disaster Risk Management Bill, currently under consideration by parliament, is aimed at bringing NDMA, NDOC and NDMU together as a new "Disaster Risk Management Authority." The sponsors of the bills will have to sit and agree on how to collapse the three bills into one or alternatively, the first bill to pass through all the stages of development will be adopted and the rest will be nullified.

[4] SOPs aim at: (1) Providing a list of major executive actions involved in responding to disasters and necessary measures needed for preparedness, response and relief. (2). Indicating various actions that should be taken and by which actors within their sphere of responsibilities – linking up with their contingency plans. (3) Ensuring that all concerned actors and agencies know the precise actions required of them at each stage of the response and that all actions are closely and continuously coordinated (Development Initiatives, 2017).

Key Strategic Area 6	Flood and drought management
6.1.4	Develop Integrated Flood Management Plans
The existing Integrated Flood Management Plans (IFMPs) for the Nyando, Awach Kano and Gucha Migori River Catchments will be updated. A new Integrated Flood Management Plan (IFMP) will be developed for each of the remaining individual drainage areas in the LVS Basin, namely the Sondu and Mara River catchments as well as the Northern Shoreline Streams and the Southern Shoreline Streams, respectively. The IFMPs will be structured around the following topics: Overview of the natural conditions (topography, climate, soils, land-use, land-cover, hydrology) and the socio-economic make-up of each catchment. Overview of the statutory, institutional and civil society stakeholder context of each catchment. Characteristics of floods and flooding in each catchment, namely identifying all flood-prone locations, flash floods, long-duration overbank inundations, sediment dumping floods, etc. Overview of existing flood management/counter measures – both structural and non-structural. Analysis and costing of required flood management/counter measures at all flood-prone locations, categorised as follows: *prevention measures; protection measures; preparedness measures; flood early warning systems; emergency response measures*. Stakeholder participation in prioritising required flood management/counter measures at all flood-prone locations. Proposed Implementation Schedules of flood management/counter measures at all flood-prone locations. Funding sources for the proposed flood management/counter measures.	
6.1.5	Implement flood management measures
The above proposed Implementation Schedules for the five catchment IFMPs that cover the LVS Basin, will be reviewed by the *LVS Basin FRF* and, through negotiation with representatives of each of the affected stakeholder sectors and villages/communities, be re-prioritised according to both non-structural and structural measures that cover all the short-term, medium-term and long-term flood management/counter measures that are required across the LVS Basin at all flood-prone locations. The above re-prioritised non-structural and structural flood management/counter measures will encompass the following: *prevention measures; protection measures; preparedness measures; flood early warning systems; emergency response measures*. These measures will be focused on flood-prone river reaches and flood-plains in each of the six catchments in the LVS River Basin. Wherever feasible, *community-based* flood early warning and flood preparedness approaches will be followed. The *LVS Basin FRF* will provide a platform for coordinating the resourcing and for supervision of the funding of the above re-prioritised non-structural and structural flood management/counter measures. In all instances, labour-intensive approaches will be followed.	
6.1.6	Capacity development
Capacity for flood management in the LVS Basin will be assessed according to three categories, namely, *organisational alignment/collaboration, technical skills and community preparedness.* The outcomes of these assessments will inform the strategy for development of capacity in each of the three categories. *Organisational alignment/collaboration*: The aim is to expand organisational capacity in the LVS Basin by aligning the flood response roles and responsibilities of the government institutions/agencies, International Relief Aid Agencies, Kenya Red Cross, NGOs and other stakeholders with partnership roles in flood management. The vehicle for this strategy will be the *LVS Basin Flood Response Forum (FRF)* introduced in Sub-Section 7.1.2. *Institutional technical skills*: The aim is to strategically expand institutional technical skills relevant to flood response activities across three different sets of competencies, namely, (i) competence at translating Flood Early Warning Bulletin information to support prioritisation of resource mobilisations for humanitarian interventions; (ii) competence at logistical planning of required interventions followed by subsequent operationalisation; (iii) competence at communicating technical and logistical information in multi-stakeholder environments. *Community preparedness*: Community-based flood early warning drills as well as emergency evacuation drills will be prioritised by the Secretariat of the LVS Basin FRF. The resources and experience of the NDMU/NDOC (or their successor institution) can make valuable contributions to developing community self-help awareness in terms of flood management.	

<table>
<tr><th colspan="2">Key Strategic Area 6</th><th>Flood and drought management</th></tr>
<tr><td>6.2</td><td>Theme:</td><td>Drought management</td></tr>
<tr><td>6.2.1</td><td colspan="2">Formalise institutional roles and partnership collaborations.</td></tr>
<tr><td colspan="3">The existing government institutions and agencies and other stakeholders with partnership roles in drought management are as follows[5]:
- NDMA
- NDMU (including its County Coordinators)
- NDOC
- KMD
- National WRA and Regional and Sub-Regional WRA Offices
- County Governments and County Disaster Risk Management Committees
- BWRCs
- WRUAs
- Village Disaster Risk Management Committees
- Ministry of Agriculture, Livestock and Fisheries as well as Ministry of Health
- Kenya Red Cross Service
- International Relief Aid Agencies
- NGOs
Formalising and aligning the roles of and proactive partnership collaborations among the above entities are crucial to ensuring that the above objectives of the drought response protocol are achieved.</td></tr>
<tr><td>6.2.2</td><td colspan="2">Develop drought response protocol.</td></tr>
<tr><td colspan="3">The drought response protocol: The drought response protocol follows a multi-stakeholder approach and comprises a structured set of inter-connected institutional and partnership roles, focus areas and mechanisms to prepare for, respond to and recover from a drought disaster. The components of the protocol are as follows:
- Formalised institutional roles and partnership collaborations.
- A drought preparedness plan that is understood by both institutional actors and communities in drought-prone zones.
- SOPs that comprise sequential response actions: monitoring → early warning alerts → severity trigger alerts → pro-active resource mobilisations → recovery interventions.
Objectives of the drought response protocol:
- Minimise the impact of water shortages on the quality of life of affected communities.
- Minimise environmental impacts.
- Ensure equitable allocation of water despite systematic restrictions of supply.
- Accelerate restoration of prior homestead environments and livelihoods of affected communities.</td></tr>
<tr><td>6.2.3</td><td colspan="2">Improve drought preparedness.</td></tr>
<tr><td colspan="3">The above LVS Basin Drought Response must address five primary drought response needs, i.e. drought monitoring, drought early warning, drought severity assessment, mitigation interventions and recovery interventions.
Currently, drought monitoring, drought early warning and severity assessment are conducted by the NDMA, who issues regular Drought Early Warning Bulletins, with inputs from KMD, the above two Ministries and WRA Offices. Regarding mitigation interventions and recovery interventions, NDMA oversees two coordinating bodies at the national level that bring together various stakeholders in drought preparedness. These are the Kenya Food Security Meeting and the Kenya Food Security Steering Group. At the county level, this is organised under County Steering Groups.
The drought severity assessments of the national and county-level coordinating structures of the NDMA relevant to the LVS Basin must be reviewed and deliberated by the collaboration partnership participants in the LVS Basin Drought Response. In the case of an adverse severity assessment, the LVS Basin Drought Response participants will have a common point of reference from which to launch and systematically</td></tr>
</table>

[5] There are currently three bills seeking to establish a National Disaster Management Authority and a National Disaster Management Fund. However, the three bills differ in content and structure e.g. proposed governance structure, membership and functions among other things. The mandates of NDMA, NDOC and NDMU overlap in various ways. The Disaster Risk Management Bill, currently under consideration by parliament, is aimed at bringing NDMA, NDOC and NDMU together as a new “Disaster Risk Management Authority.” The sponsors of the bills will have to sit and agree on how to collapse the three bills into one or alternatively, the first bill to pass through all the stages of development will be adopted and the rest will be nullified.

Key Strategic Area 6	Flood and drought management
coordinate their various drought-relevant resource mobilisations and related interventions in the LVS Basin.	
6.2.4	Strengthen existing drought early warning systems
The NDMA currently issues regular Drought Early Warning Bulletins for ASAL counties. Bulletins must in future also be issued for LVS counties that are more drought-prone than the rest, namely Kericho, Nakuru and Narok. SOP responses based on the Bulletins' early warning findings and alerts must be an integrating force in the above *LVS Basin Drought Response*. The sub-county scale of the Bulletins' reporting ensures that such responses can be spatially accurately focused. Furthermore, such informed responses will secure appropriate and timeous resource mobilisations and humanitarian interventions across all the collaborating partnerships at county, sub-county and local community scales across the above three drought-prone counties in the LVS Basin. The Famine Early Warning Systems Network (FEWS NET), which produces monthly reports and maps detailing current and projected food insecurity in a number of regions in the world, has a Regional Office in Kenya and FEWS NET outputs will support the deliberations by the participants in the *LVS Basin Drought Response*.	
6.2.5	Capacity development
Capacity for drought management in the LVS Basin will be assessed according to three categories, namely, *funding*, *organisational alignment* and *institutional technical skills.* The outcomes of these assessments will inform the strategy for development of capacity in each of the three categories. *Funding*: The funding strategy is to secure a standing allocation from the recently-established National Drought Emergency Fund (DEF) to the LVS Basin's two drought-prone counties to ensure that finance for early drought response will always be available when needed. This will avoid the hitherto time-consuming approach of emergency budgetary re-allocations, which is also counter-productive, because it takes resources away from the long-term development that should enhance resilience to drought. *Organisational alignment/collaboration*: The strategy is to expand organisational capacity in the LVS Basin by aligning the drought response roles and responsibilities of the government institutions/agencies, International Relief Aid Agencies, Kenya Red Cross, NGOs and other stakeholders with partnership roles in drought management. The vehicle for this strategy will be the *LVS Basin Drought Response* introduced in Sub-Section 7.2.1. *Institutional technical skills*: The strategy is to strategically expand institutional technical skills relevant to drought response activities across three different sets of competencies, namely, (i) competence at translating Drought Early Warning Bulletin information to support prioritisation of resource mobilisations for humanitarian interventions; (ii) competence at logistical planning of required interventions followed by subsequent operationalisation; (iii) competence at communicating technical and logistical information in multi-stakeholder environments.	

6.8 Hydrometeorological Monitoring

6.8.1 Introduction

An operational and well-maintained hydrometeorological network is critical to support the WRA with its key functions related to water resources planning, regulation and management in the LVS Basin. The WRA is responsible for all aspects related to the monitoring (quantity and quality) of surface and groundwater in Kenya, including the construction and maintenance of monitoring stations, related equipment, data collection, transmission, capturing and storage, and dissemination.

6.8.2 Issues related to hydrometeorological monitoring in the LVS Basin

A brief overview of the existing hydrometeorological monitoring network in the LVS Basin is provided in Section 2.4.8. The current network is inadequate, and the network is not being effectively operated. Data management and sharing platforms are not well established, and there is inadequate technical capacity for data processing, analysis and reporting. There is also inadequate maintenance of the monitoring stations. Although the WRA continuously rehabilitates and expands the hydromet monitoring network, issues such as ageing, vandalism and flood damage limit progress.

The majority of the operational river gauging stations in the LVS Basin are rated sections. Most are read manually by gauge readers. It has been reported that manual measurements are often difficult during high flow and flood events due to access challenges. Although procedures are in place to collect discharge data, compliance is often hampered due to logistical, financial and capacity constraints. Rating curves are updated yearly at the National office and distributed to the regional and subregional offices for use. Flow measurement for checking and updating rating curves are typically done manually with flow meters. However, local offices often lack the necessary equipment and even fuel to travel to remote stations to conduct measurements. There is also minimal updated bathymetry data in all sub-regions. Stage records that are collected manually are entered into a database at the subregional office then sent to the regional office for recording. Headquarters receives a backup copy from the regional office on a monthly basis. Little is known about the quality control process.

Many different organisations including the WRA, Kenya Meteorological Department (KMD), regional police stations, primary and secondary schools, national parks, private enterprises, research institutions and agricultural offices operate meteorological stations throughout the basin. Due to the expansive and diverse set of owners and operators of meteorological stations throughout the Basin, little accurate information is known about operational status, station types, parameters collected, operators, and even confirmed coordinates of meteorological stations.

Due to the high population density, the LVS is prone to numerous pollution threats, with most of the rivers being polluted. The LVS Basin's main water source, Lake Victoria, is also transboundary in nature and is shared with Uganda and Tanzania. Monitoring and protection of these water sources are therefore of utmost importance. To address this problem, intensified monitoring and enforcement of the water permit conditions and effluent discharge guidelines will be required as a start. Currently, the water quality monitoring programme operated by WRA faces challenges of limited qualified and trained staff and inadequate operational resources to facilitate regular sampling and laboratory analysis. There is a fairly well-equipped laboratory with AAS, and GLC, Water Quality Testing Laboratory at Kisumu. It is well equipped with other basic laboratory equipment and it is well staffed with 5 officers. Currently it is capable of analysing both physico-chemical parameters and heavy metals on samples. However, some Lamps are needed for the AAS and also more reagents and Biological media stocks are required.

Furthermore, the mandates and roles and responsibilities of the different institutions involved in water quality management in the LVS Basin need to be resolved to ensure that cooperative governance of water quality is achieved.

Groundwater monitoring in Kenya has improved significantly in the past decade. In the LVS Basin, there is currently a total of 18 operational groundwater monitoring points. Data quality is, however, patchy - most groundwater level data are collected from boreholes that are used as production boreholes. All too often, the data show dynamic as well as static water levels. This restricts the utility of water level data to determine long-term trends. Groundwater abstraction monitoring is done on an ad hoc basis at best - groundwater users are required to submit abstraction data monthly or quarterly as evidence to support their water charge payments, but these are rarely checked in the field by the WRA.

6.8.3 Hydromet monitoring network design

A key output from this Consultancy is the design of a hydrometeorological network for the LVS Basin. Details on the design approach as well as the proposed network are provided in "ISC Report D1-1: Hydromet Monitoring Network Design".

The following sections provide a brief overview of the proposed network.

6.8.3.1 Stream flow monitoring

The approach towards designing a stream flow monitoring network for the LVS Basin entailed an assessment of the existing and historical network in the LVS Basin against specific criteria. The result is a surface water network design for the LVS Basin consisting of 50 stations. The non-operational stations will be refurbished, with 3 non-operational automatic stations being downgraded to manual. In addition, 12 stations will be upgraded from manual to automatic, and 8 stations will be upgraded from manual to telemetric. No new stations will be constructed, and telemetric stations will remain the same.

Table 6-23: Proposed surface water monitoring network for the LVS Basin

Sub-Regional Office	Total Number of SW Stations			
	Telemetric	Automatic	Manual	TOTAL
Kericho	6	6	3	**15**
Kisii	3	7	6	**16**
Kisumu	5	4	10	**19**
TOTAL	**14**	**17**	**19**	**50**

The maps in Figure 6-15, Figure 6-16 and Figure 6-17 display the locations of the proposed surface water (flow) monitoring stations and meteorological stations per SRO area.

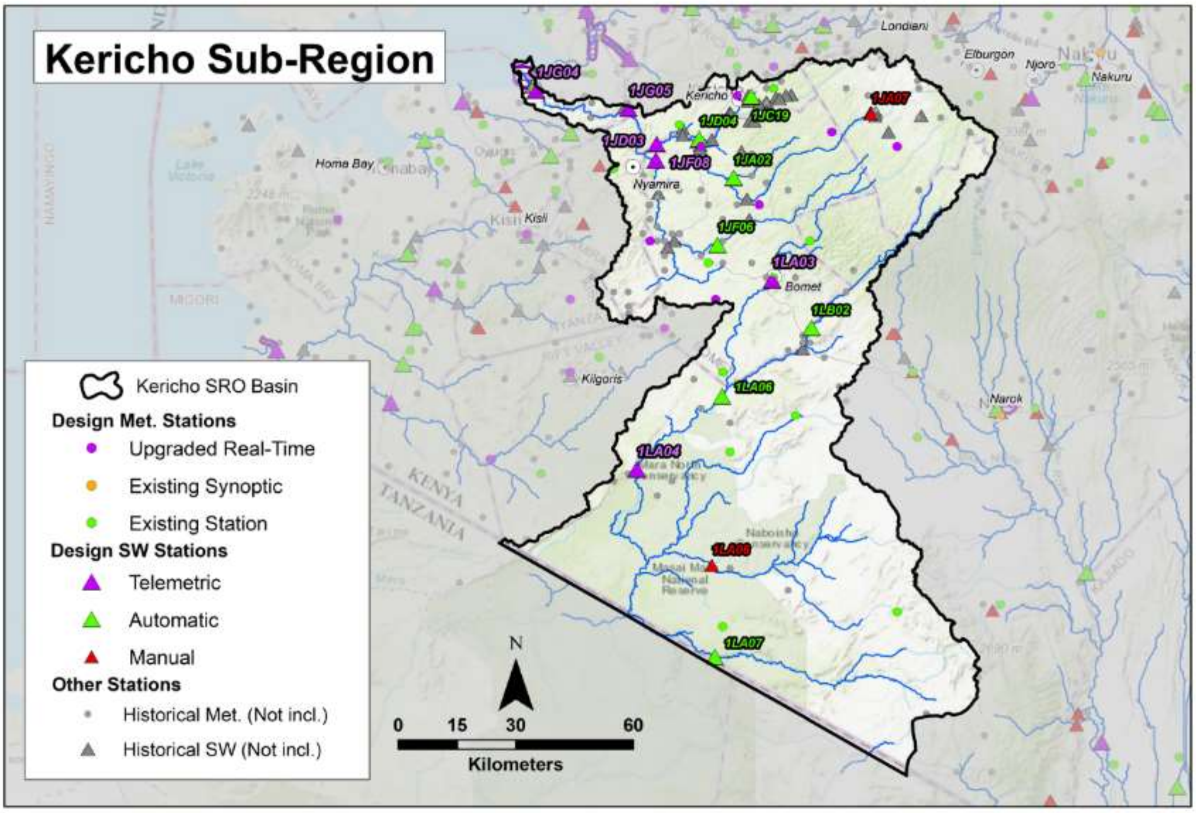


Figure 6-15: Kericho sub-region: Proposed flow and met monitoring network

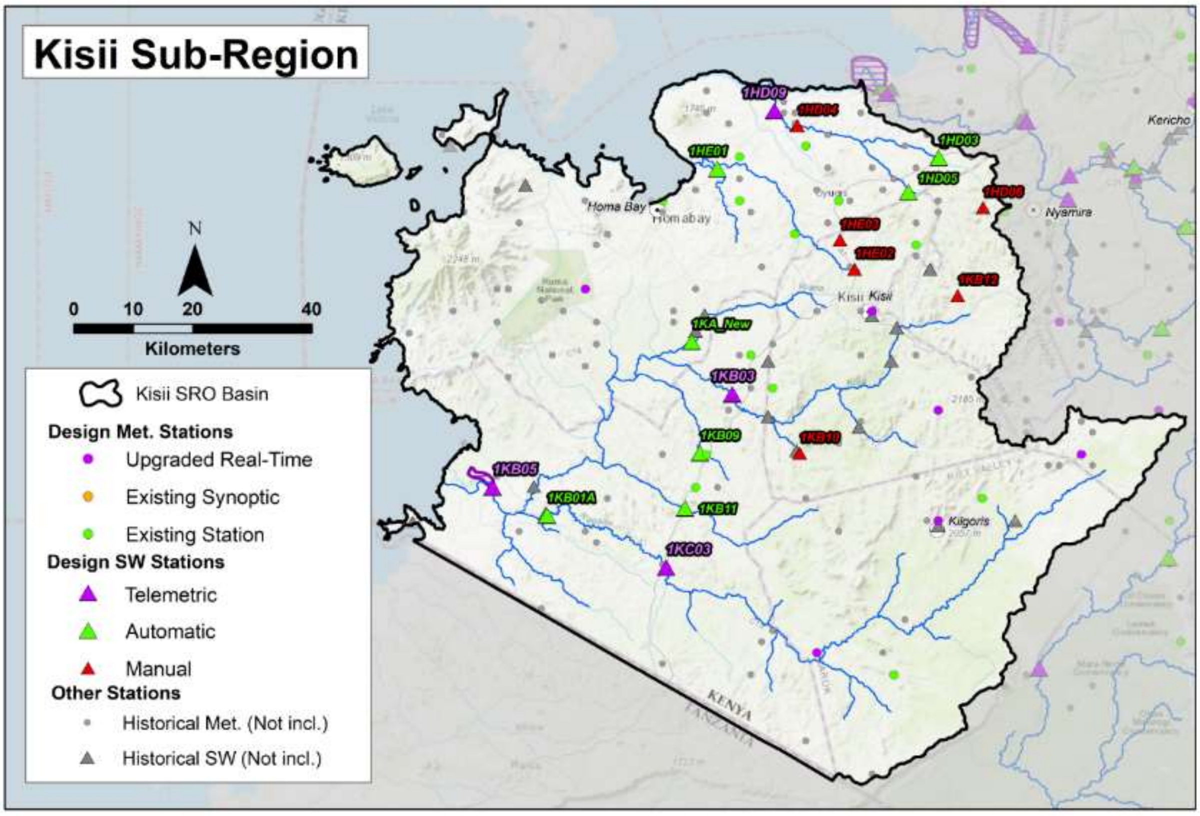


Figure 6-16: Kisii sub-region: Proposed flow and met monitoring network

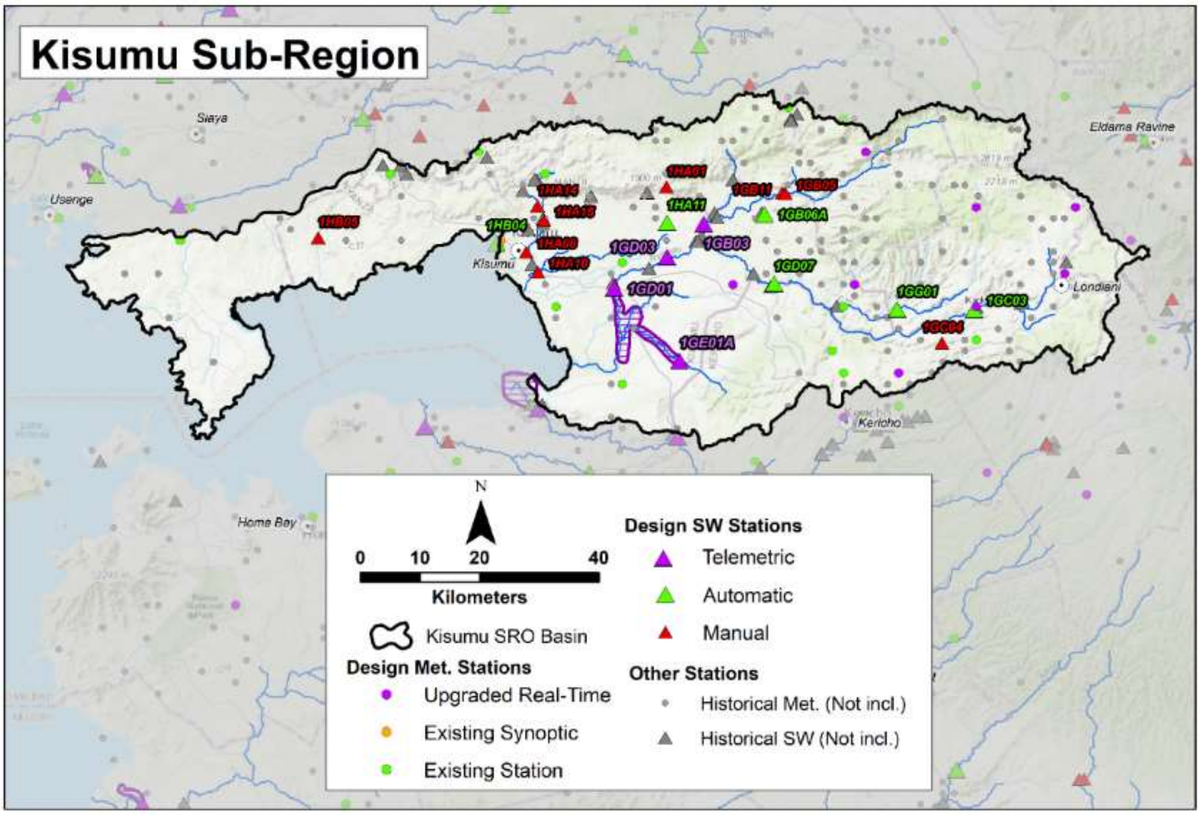


Figure 6-17: Kisumu sub-region: Proposed flow and met monitoring network

6.8.3.2 Monitoring of dam and lake levels

One existing, operational manual station on Lake Victoria at Kisumu is being updated to automatic (Figure 6-17). No new lake monitoring stations are proposed.

6.8.3.3 Meteorological monitoring

The approach towards the design of a meteorological network for the LVS Basin entailed an assessment of the historical meteorological network in the LVS Basin against specific criteria. The result is a meteorological network design for the LVS basin consisting of 56 stations: 18 in Kericho, 17 in Kisii, and 21 in Kisumu. All of these stations already exist and need to be upgraded or repaired. Figure 6-15, Figure 6-16 and Figure 6-17 also display the proposed meteorological network for the LVS Basin.

Note: The proposed meteorological network is awaiting input from KMD.

6.8.3.4 Water quality monitoring

The approach towards the design of a water quality monitoring network for the LVS Basin entailed a comprehensive review of the existing water quality monitoring network in the Basin, a needs assessment and a detailed evaluation of the proposed network design against identified evaluation criteria. The result is a water quality monitoring network design as detailed below. Note that most of the surface water stations coincide with stream flow gauging stations which are currently operational or have been identified for rehabilitation.

Table 6-24: Proposed water quality monitoring network for LVS Basin

LVS Basin	Current stations (2018)	Proposed stations to be retained	Proposed stations to be discontinued	Proposed new stations	Total
Surface water	73	67	6	10	**77**
Effluent stations	26	26	0	0	**26**
Ground water	29	29	0	0	**29**
Total	**128**	**122**	**6**	**10**	**132**

Out of the total proposed stations, a number of them were proposed to be first priority (Table 6-25). Most of the first priority stations will be telemetric stations. In addition, a number of surface water stations were proposed to be baseline monitoring stations.

Table 6-25: Proposed baseline and first priority stations for LVS basin

LVS Basin	Proposed baseline monitoring stations	Proposed first priority stations
Surface water	8	34
Effluent stations	-	13
Ground water	-	6
Total	**8**	**53**

6.8.3.4.1 Surface Water

The proposed surface water station water quality network for the LVS Basin differentiates between Baseline, Impact, Trends, Compliance or Surveillance type stations. In general Baseline stations are established towards the uppermost reaches of rivers while Impact and Trends stations are towards the lower reaches. Compliance stations will become active once the Resource Quality Objectives are established and the rivers have been classified.

The design further specifies the monitoring focus of each station as either: Nutrient and Sediment Loads, Organic matter from domestic sewage and agro-based industries, Heavy metals from industries, Pesticide residues from use of Pesticides on farms or suitability of the water for domestic use or for irrigation. Thus, the stations broadly fall under each of the following Types of Monitoring:

- Sediment Load Monitoring (TSS, Sediment Load)
- Nutrients Monitoring (Nitrogen compounds, Phosphates, Silica)
- Organic Loads monitoring (BOD, DO, pathogenic organisms)
- Industrial Loads monitoring (Heavy metals, COD)
- Agro-chemical Loads monitoring (Pesticide residues)
- General WQ &PC Monitoring (suitability for irrigation, other common uses, water supplies, wildlife and livestock watering)

Some stations have been categorised as 1st Priority Stations: Most of these stations coincide with flow gauging stations that currently are automated or have been prioritized for automation. These stations will be fitted with Water Testing Multi parameter Sondes, capable of testing a wide range of parameters to be specified. In the meantime, it is recommended that all ROs and SROs in the LVS Basin should have Portable Water Testing Kits to ensure regular water quality testing at these stations. 1st Priority stations comprise of all National stations, Special Stations, Global stations (In-lake stations, Lake Shore stations), River mouth stations, Pollution Hotspots, Upstream of Dams, intakes for Water supplies and Transboundary stations. Samples drawn from these stations as a priority will be able to give a fair description of the surface water quality in the basin. 2nd Priority Stations constitute the remainder of the water quality monitoring network stations, from which samples will be taken and tested in accredited laboratories as is the current practice. The maps below display the locations of the proposed surface water quality stations per WRA sub-region.

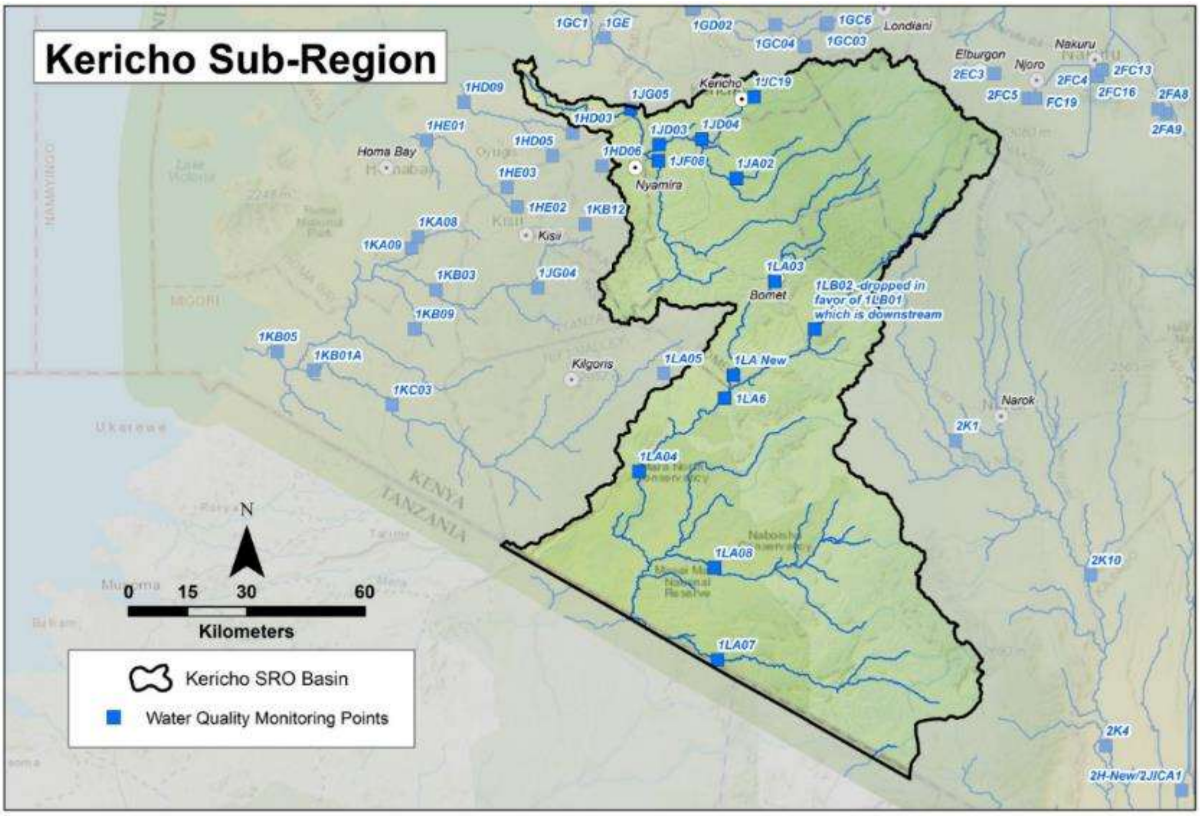


Figure 6-18: Kericho sub-region: Proposed surface water quality monitoring points

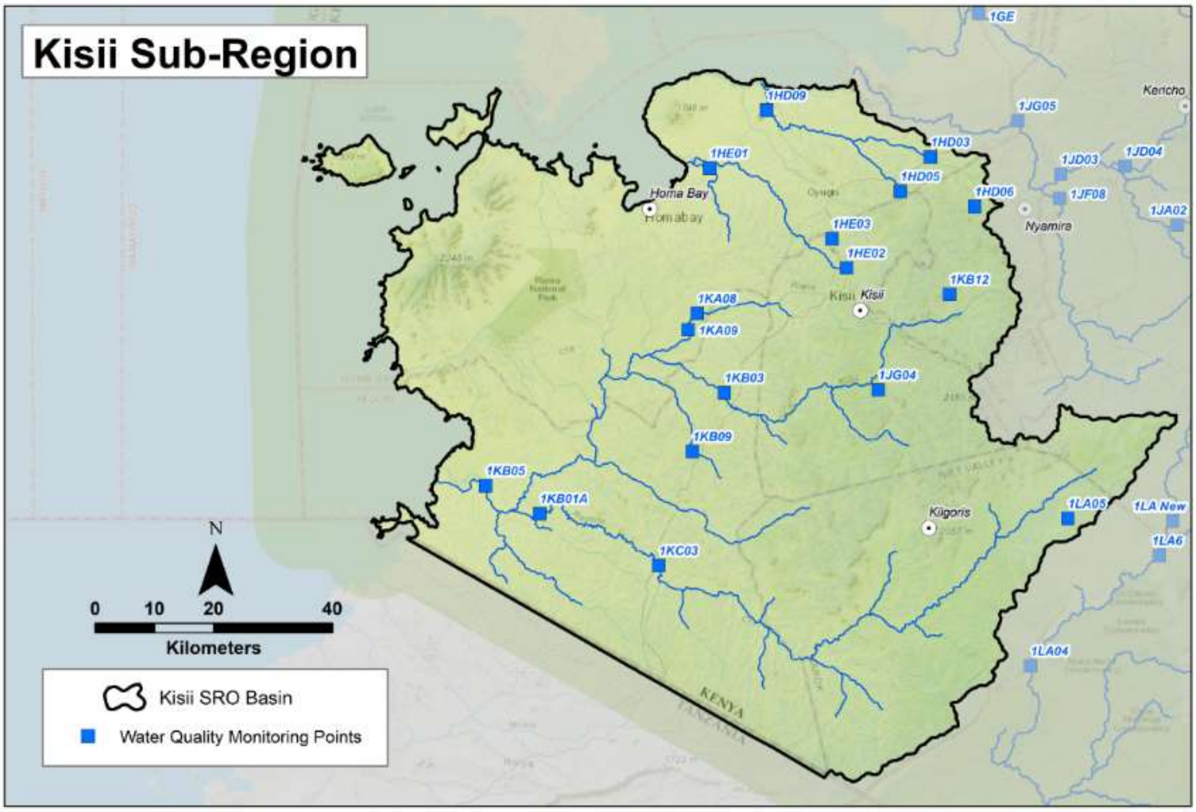


Figure 6-19: Kisii sub-region: Proposed surface water quality monitoring points

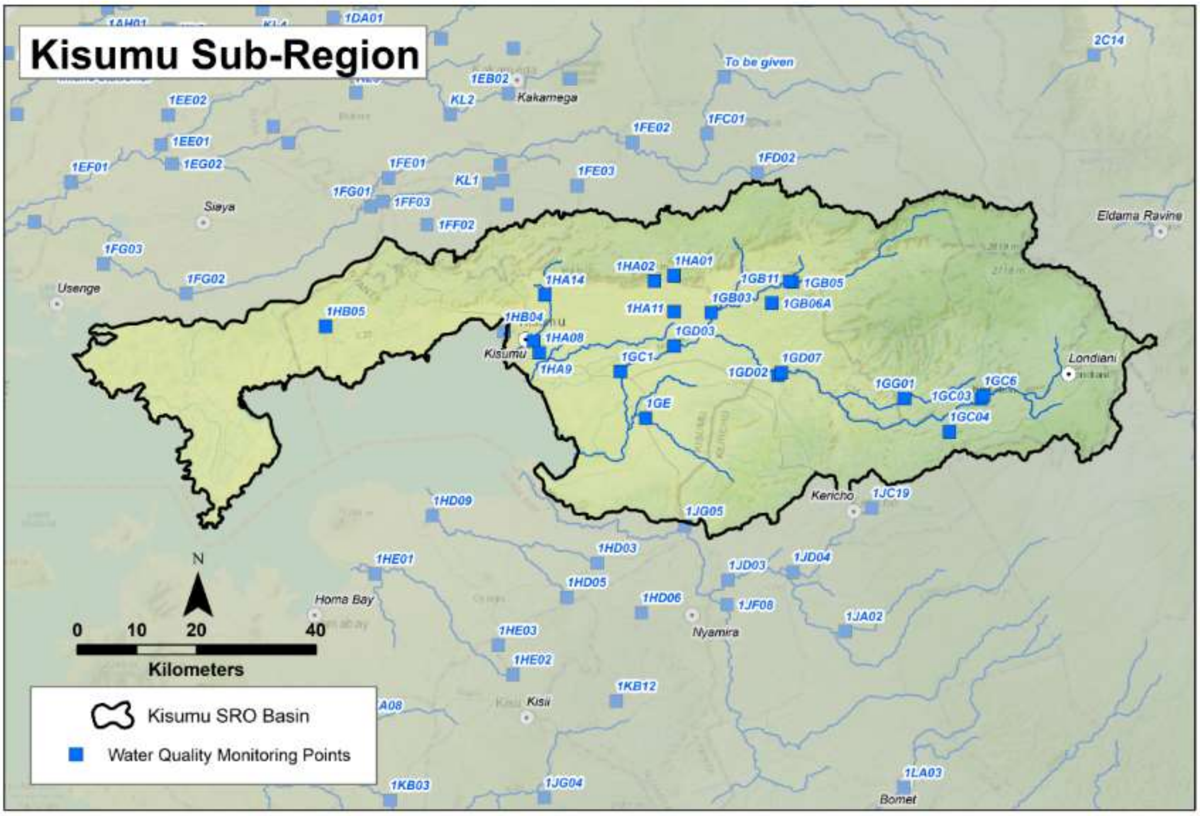


Figure 6-20: Kisumu sub-region: Proposed surface water quality monitoring points

6.8.3.4.2 Effluent monitoring stations

Effluent monitoring stations should be located as close to discharge points as possible and monitoring typically involves the sampling and analysis of samples collected from three related locations: the final effluent, upstream of the receiving stream and immediately downstream of the discharge outfall. Where these stations are known to be pollution hotspots, they have been designated as 1st Priority stations based on the pollution threat level, pollution loads and also based on past polluting history of the source. Most of the sources within the LVS Basin which have been identified in the selection of Effluent Monitoring stations are point sources of pollution. These may be broadly grouped into:

- Domestic Sewage outfalls from sewage works (from towns and cities)
- Industrial Effluent discharge from Factories (from towns and cities)
- Sugar Factories Effluent discharge
- Coffee Factories Effluent discharge
- Flower and Horticultural Farm discharges
- Sisal Waste discharges
- Dairies and Slaughter houses
- Hospital waste discharges

In many small towns, where no sewerage systems exist, human waste is still handled by Septic Tanks and Pit Latrines. When it rains and floods, many of the poorly constructed Septic tanks and Pit latrines fill up and overflow and pollute nearby streams. These locations should also be monitored. The critical parameters for domestic sewage are BOD and COD, while for Industrial effluent it is COD and Heavy metals, and oil and grease among others depending on the source.

Note: Coordinates of Effluent Quality Monitoring stations will need to be validated.

6.8.3.4.3 Groundwater quality monitoring stations

Historically, and under the Ministry of Water, all legally authorized Boreholes had Borehole Serial Nos. These were later changed, after the establishment of WRA, and each Region kept its own Borehole (BH) records. It is also a requirement that each BH shall have a BH Completion Report as well as a Water Quality (WQ) Analysis Report, hereby referred to as the Baseline Water Quality report. However, it has been observed that most BHs being monitored do not have BH IDs and neither are the BH completion reports available. It is recommended that this information be looked for and documented for all BHs. For BHs that do not have BH Completion Report or WQ Baseline Reports, it is proposed that the oldest WQ report on record be used as the BH WQ Baseline Report. If the BHs do not have any WQ test report, then a sample should be taken and analysed and its report preserved as the BH Baseline WQ report against which other subsequent future analyses can be compared. Most BH water samples can be easily analysed as for routine water quality analysis using Basic equipment.

Groundwater quality characteristics vary regionally. Ideally GW will show low concentrations of dissolved salts during the wet season and high concentrations during the dry season when recharge is minimal. Major WQ changes could occur as a consequence of over-abstraction. New groundwater monitoring boreholes are recommended in populous towns in the LVS basin.

The Prioritization of GWQ monitoring stations was based on Aquifer type and classification. All the aquifers within the basin are represented by at least one GWQ station and included in the 1st Priority list. Another factor considered is the population served by a BH. Most of the BHs proposed for WQ monitoring lack a complete set of coordinates. The few that had coordinates could also not be validated. It is suggested that during the launch of the revised WQM Network, with the aim of collecting the first set of samples for testing, the correct coordinates could be established as well as the validation of any other information.

6.8.3.4.4 Sampling/Monitoring frequency

The frequency of sampling or monitoring will be dependent on the nature and type of sampling stations. Generally, for groundwater sources, lakes and dams, which are not expected to undergo drastic WQ changes over time, the sampling frequency can be bi-annual. For river stations and effluent stations, whose water quality is constantly changing at short intervals, the recommended frequency of monitoring can vary from daily to quarterly. In general, and for most stations a sampling frequency of quarterly has been recommended, but this can be varied depending on the type of station and the circumstances prevailing.

6.8.3.4.5 Water Quality Design Parameters

The parameters to be tested for at each monitoring station have been identified and may be described as either Basic or Special parameters. Basic Parameters include pH, Colour, Turbidity, TSS, Conductivity, TDS, Chloride, Temperature, Coliforms, DO, Fluoride, Ammonia, Total Nitrogen, Nitrates, Nitrite, Total Phosphorus, Phosphates, Sulphates, Sodium, Potassium, Calcium, Manganese, Iron, Magnesium. Special Parameters refer to pesticide residues, heavy metals, hydrocarbons, oil and grease, sediment load, BOD and COD, and emerging special parameters such as organic micro-pollutants e.g. pharmaceuticals, hormones and chemical substances used in products and households.

At some stations, critical or important parameters have been identified, which should be given priority when testing. Such parameters would include Chromium downstream of a tannery; heavy metals downstream of a metallurgical industry; pesticide residues and nutrients downstream of an intensive farming area and BOD and COD downstream of a coffee de-pulping factory for example.

The selection of test parameters will typically be dictated by the data needs and issues in the river basin. Because of the current lack of adequate equipment, laboratories in Kenya are only able to carry out tests for a handful of parameters.

As a minimum requirement, all Regional Labs should be capable of analysing for all the basic parameters and where not possible, special parameters can be tested for at the CWTL. The CWTL in Nairobi should be elevated to a reference Laboratory to carry out advanced water quality analysis, and should be manned by qualified, trained and experienced staff.

6.8.3.4.6 Water Quality Design Equipment

Once the design parameters have been identified, equipment for the analysis of the parameters need to be selected for each station. These have been generally described as either Basic or Advanced Equipment. Basic Equipment is used for routine water quality testing. Such equipment would include a pH meter, Conductivity meter and UV-Vis Spectrophotometer among others. Advanced Equipment would include AAS and GLC and HPLC for the analysis of special parameters.

6.8.3.4.7 Laboratory Equipment

The current level of instrumentation in water quality laboratories is poor. The CWTL and all other labs need to be supported to procure basic water quality equipment and Field Water Test Kits, to be able to carry out their mandate. In general, Lab equipment can be categorized into 3 categories:

Field Water Test Kits: This mainly comprises of colorimeters and probes and versatile pocket meters such as pH meters, Turbidity and Conductivity meters, or the innovative Sondes/probes.

Basic Laboratory Equipment: UV/Vis Spectrophotometer, Flame Photometer, Analytical balance, Top-pan balance, pH meter, Conductivity Meter, DO Meter, Water still, Water Bath, Hot plate, Refrigerator, Flame photometer, Turbidimeter, Desiccators, Computers, Printers, Fuming Hood, Titrators, Ovens, water bath, Centrifuges, Incubators, rotary kilns, Muffles, Comparators, Multi-probes and many assorted items.

Advanced Water Testing Equipment: Atomic Absorption Spectrophotometer (AAS), Gas Liquid Chromatography (GLC), High Pressure Liquid Chromatography (HPLC), and Inductively Coupled Plasma Mass Spectrophotometer (ICP-MS).

6.8.3.5 Flood Early Warning System

One of the objectives of the design of the hydrometeorological network in Kenya relates to the strengthening of the network for flood early warning. Nineteen flood prone areas across Kenya were proposed for the installation of Flood Early Warning System (FEWS) (Table 6-26). FEWS priority regions are assessed based on populations impacted, types of flooding, required LiDAR and field surveys, and ground field visits. These were then graded and ranked through a consultative process to produce a list of the final seven flood-prone areas to be installed with FEWS (Table 6-26). The proposed flood-prone areas were discussed with stakeholders and selected on a national level, and not per basin, thus some basins do not have a proposed FEWS network.

Table 6-26: Flood prone areas across Kenya that have been proposed for the installation of FEWS

Flood Prone Areas proposed	River (if aplicable)	Final areas selected
Lake Victoria North Basin		
1. Lower Koitobos	Koitobos River	
2. Yala Swamp	Yala River	
3. Rambwa, Bunyala, Budalangi	Lower Nzoia River	
Lake Victoria South Basin		
4. Kisumu		
5. Kano Plains	Awach Kano	1
6. Sondu River	Sondu River	2
7. Lower Gucha Migori	Lower Gucha Migori	3
8. Ahero	Lower Nyando River	4
Rift Valley Basin		
9. Narok Town	Enkare Narok	
10. Marigat, Ilchamus	Perkerra River	5
11. Lodwar	Lower Turkwel River	
Ewaso Ng'iro North Basin		
12. Isiolo	Isiolo River	
13. Rumuruti	Ewaso Narok	
14. Habaweisen	Ewaso Ng'iro	
Tana Basin		
15. Garissa, Hola, Ichara	Lower Tana River	6
Athi Basin		
16. Lower Sabaki	Sabaki River	7
17. Nairobi		
18. Kilifi		
19. Mombasa		

Based on these discussions with the WRA and other key stakeholders, three Flood Early Warning System (FEWS) have been proposed in the following 3 flood prone areas in the LVS Basin: Lower Awach Kano and Nyando, Lower Gucha Migori Flood Proneand Lower Sondu Flood Prone Area. The proposed FEWS is shown in Table 6-27 and Table 6-28, and comprises 11 telemetric stream flow gauging stations and 21 full telemetric meteorological Automatic Weather Stations for the Lower Awach Kano and Nyando, Lower Gucha Migori and Lower Sondu. Details of the proposed stream flow and meteorological telemetric monitoring stations to inform the FEWS are shown in Figure 6-21, Figure 6-22 and Figure 6-23.

Table 6-27: LVS FEWS – Proposed telemetric stream flow gauging stations

ID	River	WRA SRO	Lat	Long	Operational status	Existing Station Type	ISC Design Station Type
Lower Awach Kano and Nyando							
1GB03	Ainamatua	Kisumu	-0.0753	35.0561	Operational	Manual	Telemetric
1GD01	Nyando	Kisumu	-0.1723	34.9209	Operational	Manual	Telemetric
1GD03	Nyando	Kisumu	-0.1254	35.0008	Operational	Telemetric	Telemetric
1GE01A	Cherongit	Kisumu	-0.2819	35.0194	Non-operational	Manual	Telemetric
Lower Gucha Migori							
1KB03	Gucha	Kisii	-0.8092	34.5721	Operational	Manual	Telemetric
1KB05	Gucha Migori	Kisii	-0.9503	34.2097	Operational	Telemetric	Telemetric
1KC03	Migori	Kisii	-1.0715	34.4721	Operational	Manual	Telemetric
Lower Sondu							
1JD03	Yurith	Kericho	-0.4778	35.0819	Operational	Manual	Telemetric
1JF08	Kipsonoi	Kericho	-0.5146	35.0799	Operational	Manual	Telemetric
1JG04	Miriu Sondu	Kericho	-0.3546	34.8050	Operational	Telemetric	Telemetric
1JG05	Sondu	Kericho	-0.3966	35.0170	Operational	Manual	Telemetric

Table 6-28: LVS FEWS – Proposed telemetric meteorological stations

ID	Station name	Lat	Long	Existing type	County
Lower Awach Kano and Nyando					
9035002	Londiani Forest Station	-0.1500	35.6000	Manual	Kericho
9035155	Makutano Forest Station - Londiani	-0.0500	35.6167	Manual	Kericho
9035186	Chebigen Secondary School - Kericho	-0.3000	35.3500	Manual	Kericho
9035256	Malagat Forest Station	-0.0500	35.4667	Manual	Kericho
9035258	Kipkelion Water Supply	-0.2000	35.4667	Manual	Kericho
9035220	Homa- Lime Co. Ltd - Koru	-0.1667	35.2833	Manual	Kisumu
9035290	Awasi School	-0.1667	35.1000	Manual	Kisumu
8935001	Kabagendui Kibet Farm	0.0333	35.3000	Manual	Nandi
Lower Gucha Migori					
9035236	Chepalungu Forest Station	-0.9000	35.1000	Manual	Bomet
9034087	Lambwe Forest Station	-0.6500	34.3500	Manual	Homa bay
9034072	Kiamokama Farmersco-Op Society.	-0.8333	34.8833	Manual	Kisii
9034088	Kisii Meteorological Station	-0.6833	34.7833	Synoptic	Kisii
9134011	Kilgoris Divisional Agricultural Office	-1.0000	34.8833	Manual	Narok
9134041	Masurura Dispensary	-1.2000	34.7000	Manual	Narok
Lower Sondu					
9035260	Koiwa Estate - Kericho	-0.6167	35.3167	Manual	Bomet
9035268	Kericho Manaret Settlement Schme	-0.7000	35.0667	Manual	Bomet
9035314	Makimeny Chief'S Centre	-0.8333	35.2167	Manual	Bomet
9035292	Ndoinet Forest Station	-0.4500	35.4833	Manual	Bomet
9035279	Kericho Meteorological Station	-0.3667	35.2667	Synoptic	Kericho
9035001	Jamji Estate (Kericho)	-0.4833	35.1833	Manual	Kericho
9035324	Karinget Forest Station	-0.4833	35.6333	Manual	Nakuru

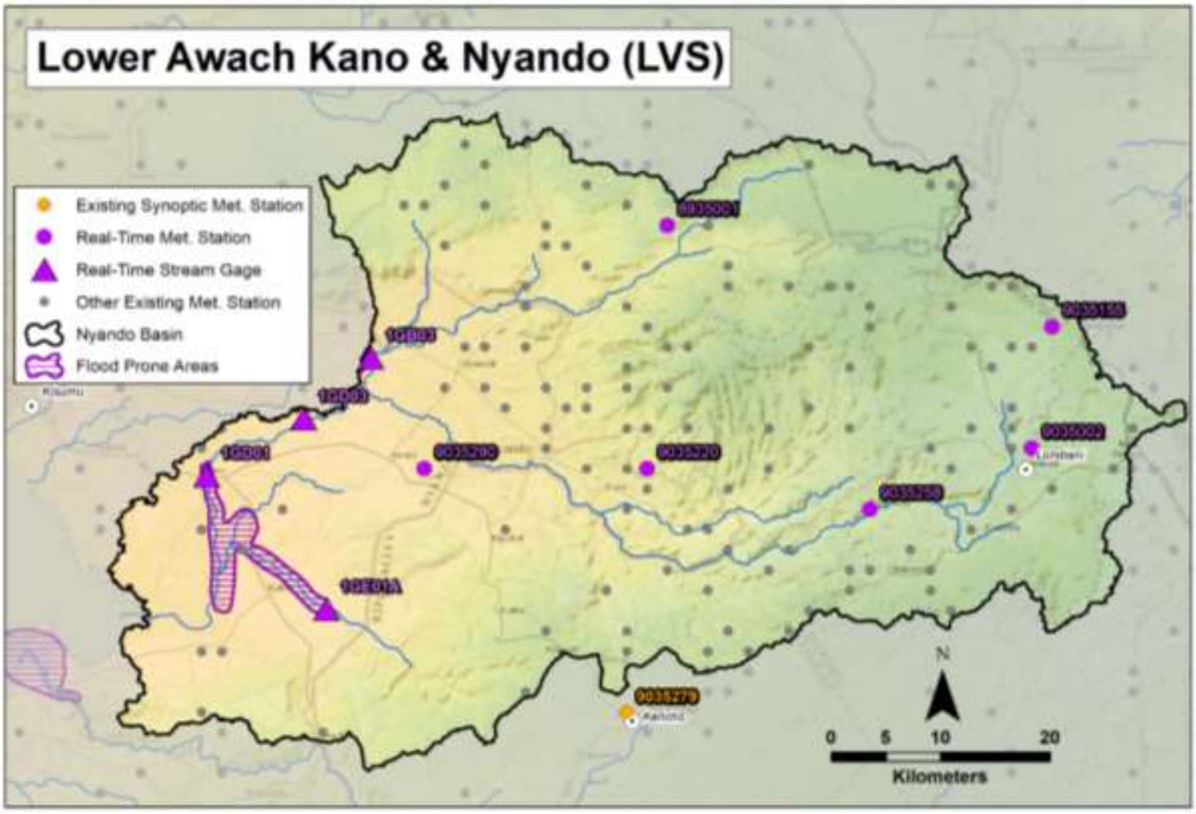


Figure 6-21: Proposed Lower Awach Kano and Nyando flood early warning hydromet network

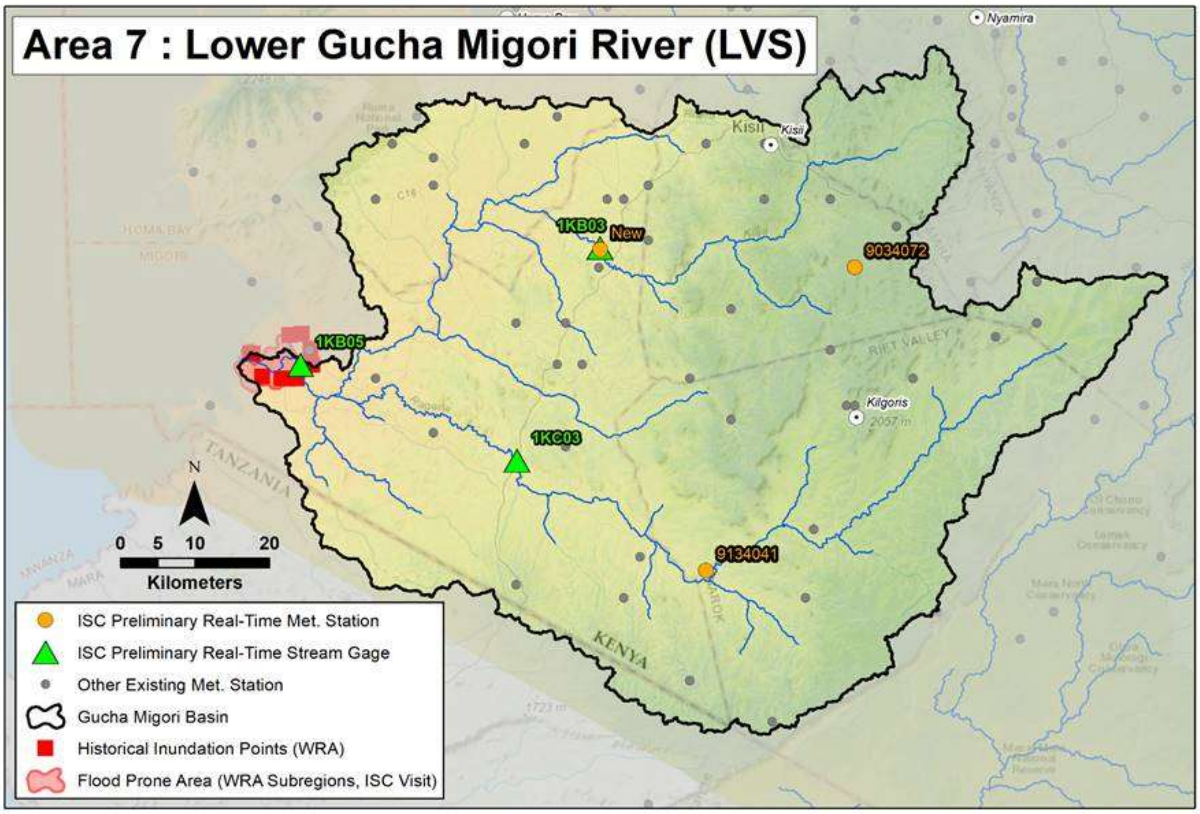


Figure 6-22: Proposed Lower Gucha Migori River flood early warning hydromet network

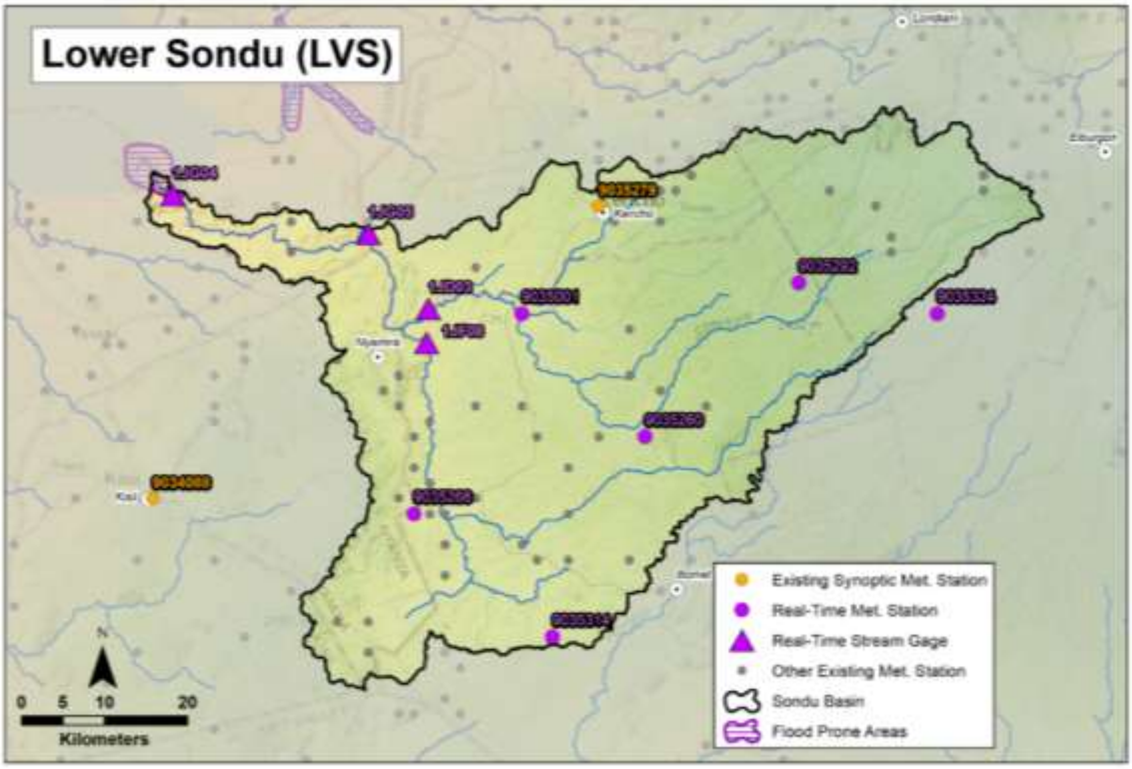


Figure 6-23: Proposed Lower Sondu flood early warning hydromet network

6.8.4 Strategy

In order to comprehensively and systematically address the hydrometeorological monitoring issues and challenges in the LVS Basin, Table 6-29 sets out 2 Strategic Themes with specific Strategies under each Theme. The Themes address Improvements to the Monitoring Network as well as Improved Data and Information Management.

Table 6-29: Strategic Framework - Hydrometeorological Monitoring

7	Key Strategic Area:	Hydrometeorological Monitoring
7.1	Theme:	Improved monitoring network
7.1.1	Surface water monitoring: River flow	
Under this Consultancy, the current flow gauging station network in the LVS Basin was assessed in terms of operational status, challenges, maintenance and equipment needs and data quality. Stations were prioritised for rehabilitation, for improvements and upgrades and for re-calibration. New station locations were identified based on pre-defined criteria and should be implemented according to the recommendations made in the Monitoring Network Design Report. A maintenance plan with budgets, timeframes and structured responsibilities should be prepared. The type of flow gauging stations to be installed should take into account that changes in river channel form due to floods often lead to changes in the rating curve, which requires re-calibration. Consideration should therefore also be given to fixed weirs (concrete structures) as opposed to rated sections.		
7.1.2	Monitoring: Dams and lakes	
The current instrumentation and level gauging network in dams and lakes in the LVS Basin should be assessed in terms of operational status, challenges, maintenance and equipment needs and data quality. Stations should be prioritised for rehabilitation where required, for improvements and upgrades and for re-calibration. New station locations should be identified based on pre-defined criteria and designed and implemented according to an implementation plan. A maintenance plan with budgets, timeframes and structured responsibilities should be prepared. Bathymetric surveys of dams and lakes should also be included in the plan.		
7.1.3	Groundwater monitoring	
Priority aquifers in the LVS Basin should be defined and monitoring requirements for each aquifer specified. A Groundwater Monitoring Network Design should be undertaken and necessary monitoring instrumentation procured and installed in accordance with an Implementation Plan.		

7	Key Strategic Area:	Hydrometeorological Monitoring
7.1.4	Water quality monitoring: Surface water and groundwater	
Under this Consultancy, the current water quality monitoring network in the LVS Basin was assessed in terms of operational status, challenges, maintenance and equipment needs and data quality. Stations were prioritised for rehabilitation where required, for improvements and for upgrades. New station locations were identified based on pre-defined criteria and should be implemented according to the recommendations made in the Monitoring Network Design Report. A maintenance plan with budgets, timeframes and structured responsibilities should be prepared.		
7.1.5	Meteorological monitoring	
Under this Consultancy, the current rainfall station network in the LVS Basin was assessed in terms of operational status, challenges, maintenance and equipment needs and data quality. WRA stations were prioritised for rehabilitation where required, for improvements and for upgrades. New station locations were identified based on pre-defined criteria and should be implemented according to the recommendations made in the Monitoring Network Design Report. A maintenance plan with budgets, timeframes and structured responsibilities should be prepared. WRA's requirements as far as meteorological data needs in relation to water resources planning and management are concerned should be discussed with KMD and roles and responsibilities regarding the design, upgrade and maintenance of the meteorological monitoring network should be clearly defined.		
7.1.6	Flood early warning monitoring network	
Under this Consultancy, the current flood early warning network in the LVS Basin was assessed in terms of operational status, challenges, maintenance and equipment needs and data quality. Stations were prioritised for rehabilitation where required, for improvements and for upgrades. New station locations were identified based on pre-defined criteria and should be implemented according to the recommendations made in the Monitoring Network Design Report. A maintenance plan with budgets, timeframes and structured responsibilities should be prepared WRA's requirements as far as meteorological data needs in relation to flood management are concerned should be discussed with KMD and roles and responsibilities regarding the design, upgrade and maintenance of the meteorological monitoring network should be clearly defined.		
7.1.7	Metering of water use and abstractions	
Abstractions from dams and rivers as well as groundwater abstractions should be identified, prioritised and flow meters installed. The prioritisation and selection of meter locations and types should be dictated by a needs assessment in relation to data requirements e.g. for operational, monitoring of compliance, water balance or other purposes.		
7.2	Theme:	Improved data and information management
7.2.1	Enhanced data management	
Data protocols and procedures regarding data collection, transfer, capture, storage, quality control and dissemination should be evaluated, standardised and improved where necessary in accordance with international best practice. Technical and computing capacity for processing, analysis and reporting of data should be addressed and enhanced. The MIKE Info database application which was developed for the WRA under this Consultancy should be employed by WRA SRO, RO and HQ staff to capture, store, quality control and manage hydromet data in accordance with training provided.		
7.2.2	Improved water resources information management systems	
The knowledge base tools which were developed under this Consultancy should be employed by WRA SRO, RO and HQ staff to manage and disseminate information related to water resources planning and management taking into consideration the specific needs and challenges across different organisations and institutions as stakeholders.		
7.2.3	Improved forecasting systems	
The real-time system developed under this Consultancy for accessing, visualizing and analysing hydromet observations in near real-time should be employed to inform decision making with regard to flood forecasting and water resources management. Shared mandates and responsibilities should be discussed and agreed with KMD.		

6.9 Water Resources Development

6.9.1 Introduction

The purpose of this Water Resources Development Plan relates to the planning and development of large-scale water resources and related infrastructure which will support socio-economic development in the LVS Basin, while improving water availability and assurance of supply to current and projected future water users in the basin, and while taking into consideration environmental sustainability. The rationale for the development of the plan was to assess whether the basin's water resources are sufficient to meet the expected growth in water requirements with 2040 as the planning horizon, and whether excess water would be available to transfer to the adjacent Rift Valley Basin. This included an evaluation of the need for and the capacity of large-scale water resources development interventions such as dams, some of which include multi-purpose projects. Most of the interventions which were considered were already identified as part of previous planning studies. Another important consideration in the development of the water resources development plan relates to an acknowledgement of the significant time that it takes to implement large infrastructure projects in Kenya. Proposed schemes and development interventions up to 2040 were therefore limited to what was considered reasonable from a financial and practical perspective and should be implemented in conjunction with management interventions i.e. water conservation and demand management initiatives. Such an approach, in combination with the phased development of new infrastructure, will allow an adaptive development strategy towards improving climate resilience.

6.9.2 Current water demands, resources development and supply reliability

The LVS Basin has some of the highest annual rainfall values of Kenya's six river basins. However, despite the high rainfall and abundance of surface water from Lake Victoria, water distribution in the basin varies greatly (both temporally and spatially) and many areas lack sufficient access to clean water. Some large-scale water resources development exists in the basin. There is only one existing dam in the Lake Victoria South Basin, the Sondu Miriu Dam on the lower Sondu River. The dam, with a storage capacity of about 1 MCM, is used for hydropower production, with an installed hydropower capacity of 60 MW. The discharge from the Sondu Miriu hydropower station is used to power the Sang'oro Hydroelectric Power Station further downstream, with an installed capacity of 21 MW. More hydropower production comes from Gogo Falls hydropower station on the lower Gucha River, with an installed capacity of 2 MW. Six large-scale irrigation schemes also exist in the basin: West Kano, Ahero, Lower Kuja, South West Kano, North West Kano and Kimira, with the main crop type as rice.

Imminent water resources development projects in the LVS Basin include the Sand River/Naikara, Magwagwa, Itare, Kibos and Bunyunyu dams, water transfer schemes from Itare Dam to the Rift Valley Basin as well as several large-scale irrigation projects. Most of the water currently consumed in the basin is for domestic and industrial use, followed by irrigation, with water being sourced directly from Lake Victoria, rivers, small dams and pans and from groundwater. Supply reliability in most parts of the basin is medium to high due to the generally good availability of surface and groundwater. However, frequent shortages are experienced during the dry season due to lack of storage, often exacerbated by the last start of the wet season. The total current water requirement (2018) in the basin equates to 633 MCM/a.

Table 6-30: Current (2018) water demands in the LVS Basin

Sector	Total (MCM/a)
Irrigation	**256**
- Small scale / Private	183
- Large-scale	73
Domestic and Industrial	**300**
– Urban centres	92
– Basin-wide	208
Livestock	**62**
Other	**15**
Total	**633**

6.9.3 Water resources development potential

The current (2018) total water demand in the Lake Victoria South Basin (633 MCM/a) constitutes about 10% of the total water resources available for use (6 746 MCM/a).

The results of the surface water resources analysis which was undertaken for this Consultancy, estimated the total natural surface runoff in the Lake Victoria South Basin as 6 770 MCM/a, equivalent to an average runoff coefficient of 19%. The current surface water demand in the LVS Basin was estimated at 568 MCM/a, which is about 9% of the surface water available - taking into consideration the ecological reserve (Q95), calculated as 316 MCM/a.

The current groundwater use in the LVS Basin was estimated at 67 MCM/a, which is about 23% of the estimated sustainable groundwater yield (292 MCM/a).

It is important to realise that although the water balances might indicate that the total annual demand is less than the water resources available, supply deficits often occur during dry years and/or the dry season, when the demand exceeds availability of water in the rivers.

6.9.4 Future water requirements

The scenario analyses undertaken as part of this Consultancy, highlighted the importance of demand management being implemented in all urban areas, while irrigation efficiencies should also be improved throughout the Basin. The future water requirements as presented below therefore incorporate a 20% reduction in major urban water requirements through water demand management, as well as improved irrigation efficiencies and a reduction in some of the proposed large-scale irrigation areas, i.e. a future that can be better supplied with water taking into account the proposed developments and projected (to 2040) growth in water demands across the basin. Future water demand for domestic and industrial use was based on a conservative, exponential population growth assumption based on recent trends in the basin, while also taking into consideration that less than 15% of the population in the basin is currently supplied by WSPs.

Under this scenario, the total future (2040) water requirement in the Lake Victoria South Basin was calculated at 1 989 MCM/a as detailed below. This represents a significant increase compared to the 2018 water demand in the basin, mainly as a result of new large-scale irrigation (an increase of 43 400 ha), an expansion of small scale irrigation (growth of 36 500 ha), and improving water supply to an 998increased number of urban and rural users. **Annexure B2** summarises future (2040) water demands per sub-basin and per main user category.

Table 6-31: Future (2040) water demands in the Lake Victoria South Basin

Sector	Total (MCM/a)
Irrigation	**850**
- Small scale / Private	426
- Large-scale	424
Domestic and Industrial	**834**
- Urban centres	374
- Basin-wide	460
Livestock	**161**
Exports	**123**
Other	**21**
Total	**1 989**

6.9.5 Proposed water resources development plan

6.9.5.1 Overview

The essence of the proposed water resources development plan for the LVS Basin, up to 2040, is to improve the reliability of supply to Kisumu and other urban centres; to provide storage for the expected growth in basin-wide urban water demands; to ensure a reliable water supply for the expansion of existing, and the proposed new, irrigation developments in the basin; to implement the identified schemes which will export water to the Rift Valley Basin; to improve existing and future water resources availability for smaller towns and basin-wide domestic, livestock and small-scale irrigation water demands; and to unlock socio-economic development through multi-purpose water resources development projects in the basin, including flood control schemes. This will necessitate the construction of small-scale and large-scale storage, transfer and regulation infrastructure and increased groundwater abstraction. In addition, water demand management will be required for both small and large-scale irrigation and for urban centres. The following specific interventions are proposed:

- Construction of Magwagwa Multipurpose Dam on the Sondu-Miriu River in Nyamira County to generate hydropower, to supply domestic and industrial demands in Nyamira, Homa Bay and Kisii counties, to supply water for large scale irrigation development on the Kano Plains and for flood control along the lower Sondu River.
- Implementation of the Bunyunyu Dam Project on the upper Gucha River in Kisii County to supply water to Kisii Town and other surrounding towns in Kisii and Nyamira counties.
- Construction of Soin-Koru (Nyando) Multipurpose Dam on the Nyando River close to Muhoroni on the border of Kisumu and Kericho Counties. The dam will meet the following purposes: supply water for a proposed large-scale irrigation scheme along the Nyando River; improve the reliability of supply to the existing West Kano and Ahero Irrigation Schemes; support flood control along the lower reaches of the Nyando River; and improve domestic water supply to roughly 1.71 million inhabitants in various towns in Kisumu and Kericho counties
- A Multipurpose Dam at the existing Gogo Falls Hydropower Station on the lower Gucha River in Migori County should be constructed to increase the existing installed hydropower capacity at Gogo Falls, while simultaneously making water available for large-scale irrigation expansion along the lower Gucha-Migori River.
- In order to improve the reliability of supply to Kisumu Town, in light of persistent water quality problems with the existing Lake Victoria abstraction, and to ensure that the expected growth in water demand is met, Kibos Dam on the Kibos River in Nandi County, upstream of Kisumu, should be constructed. In addition, some of the water of the planned inter-basin transfer from the Nandi Forest Dam in Lake Victoria North Basin to the Oroba River in LVS should be released into the Kibos River upstream of the planned Kibos Dam to augment the supply to Kisumu. However, it is important to note that the construction of Nandi Forest Dam is quite controversial due to its potential impact on the Yala Swamp and the South Nandi Forest.
- Construction of Londiani Dam on the Kipchorian River, an upper tributary of the Nyando River, in Kericho County to meet the urban demands of Londiani and Kipkelion towns. An intra-basin transfer from this dam to the adjacent Yurith River catchment to the south should also be constructed as a more reliable water source for Kericho Town.
- Itare Dam on the Itare River, an upper tributary of the Sondu River, in Nakuru County, will supply water to towns in Bomet and Nakuru counties in the LVS Basin as well as to Nakuru Town and other smaller towns in the adjacent Rift Valley Basin via an inter-basin transfer (tunnel).
- Amala Dam on the Amala River, an upper tributary of the Mara River, should be implemented to supply domestic and livestock demands in parts of Bomet and Narok counties. In addition, the dam will divert water through a tunnel to the Ewaso Ng'iro South River in the Rift Valley Basin for the generation of hydropower. Significant environmental releases would have to be made from this dam to ensure the health of the downstream river as it passes through the Masai Mara National Reserve and into the Serengeti national Park in Tanzania.

- Ilooiterre Dam on the middle Migori River should be constructed to meet domestic, small-scale and livestock water requirements in the surrounding areas of Narok County as well as to supply the towns of Kehancha and Migori further downstream. In parallel, the dam will ensure water availability for the proposed Ilooiterre Irrigation Project upstream of Kehancha Town.
- To meet the future domestic and industrial demands of other towns and rural areas as well as livestock and small-scale irrigation water demands within the remainder of the LVS Basin, additional storage should be provided through the construction of additional dams (e.g. Sand River/Naikara Dam in the lower Mara River catchment) and pans, and through the construction of more boreholes. (A cost-benefit analysis indicated that careful consideration needs to be given to Sand River Dam to ensure the financial viability of the scheme).

Implementation and enforcement of the Q95 flow downstream of proposed dams and large-scale irrigation schemes to maintain the ecological health of the rivers. For future dams in the Mara River catchment, environmental flows using advanced approaches should be determined and implemented.

The following dams have been planned but are very controversial. Further specialist studies are therefore required.

- The planned Bosto Dam in Bomet County is proposed to have a capacity of 30 MCM for supplying local county demands. However, environmental activist groups are strongly opposing the construction of the dam on the Kipsonoi River inside the South West Mau Forest, which is a biodiversity hotspot and Kenya's most significant catchment. Analyses undertaken as part of this Consultancy have shown that future water demands in Bomet County can be supplied from run-of-river abstractions, groundwater and by constructing additional small dams and pans, and Bomet Dam might therefore not be necessary.

Norera dam is proposed to be constructed on the Mara River, while Mungango and Silibwet dams are proposed to be constructed on the Nyangores River, a key tributary of the Mara River. All three dams will mainly be utilised for irrigation. The proposal of these dams on the Mara River, in addition to Amala transfer scheme and the Borenga dam in Tanzania, have spurred strong retaliation from environmentalist groups. The dams could drastically impact the Mara River during the dry season, thus threatening the Serengeti ecosystem further downstream, damaging habitation, and disrupting the migration routes of wildebeest, zebras and gazelles (Muchira, 2019). In addition, there has been several clashes between the Tanzanian and Kenyan government regarding the proposed three dams on Kenya's section of the Mara River. These dams would reduce flow to the proposed Borenga dam further downstream in Tanzania. Table 6-32 summarises the proposed water resources developments and interventions in the LVS Basin with a planning horizon of 2040, while Figure 6-24 displays the locations of the existing and proposed large-scale water resources developments.

Table 6-32: Water resources development plan for the LVS Basin

Item	2018	2040	Comment
Storage: Large dams (MCM)	1	1 263	1 existing dam, Sondu Miriu 5 new dams to supply growing urban centres in LVS and RV Basins 5 new multipurpose dams for large scale irrigation, urban water supply, hydropower and flood control
Storage: Small dams / pans (MCM)	5	159	To supply towns and local domestic and livestock demands and improve assurance of supply for small-scale and private irrigation
Groundwater use (MCM/a)	67	268	As conjunctive use with surface water storage, or as the only water source in areas where surface water is not available.
Irrigation area (ha)	9 000	96 530	The increase in irrigation area is due to new proposed large-scale schemes and expansion of small-scale irrigation
Hydropower (MW)	83	213	Existing hydropower at Sondu Miriu Dam (60 MW), Sangoro (21 MW) and Gogo Falls (2 MW) Hydropower to be installed at Magwagwa (115 MW) and Gogo Falls Dam (15 MW)

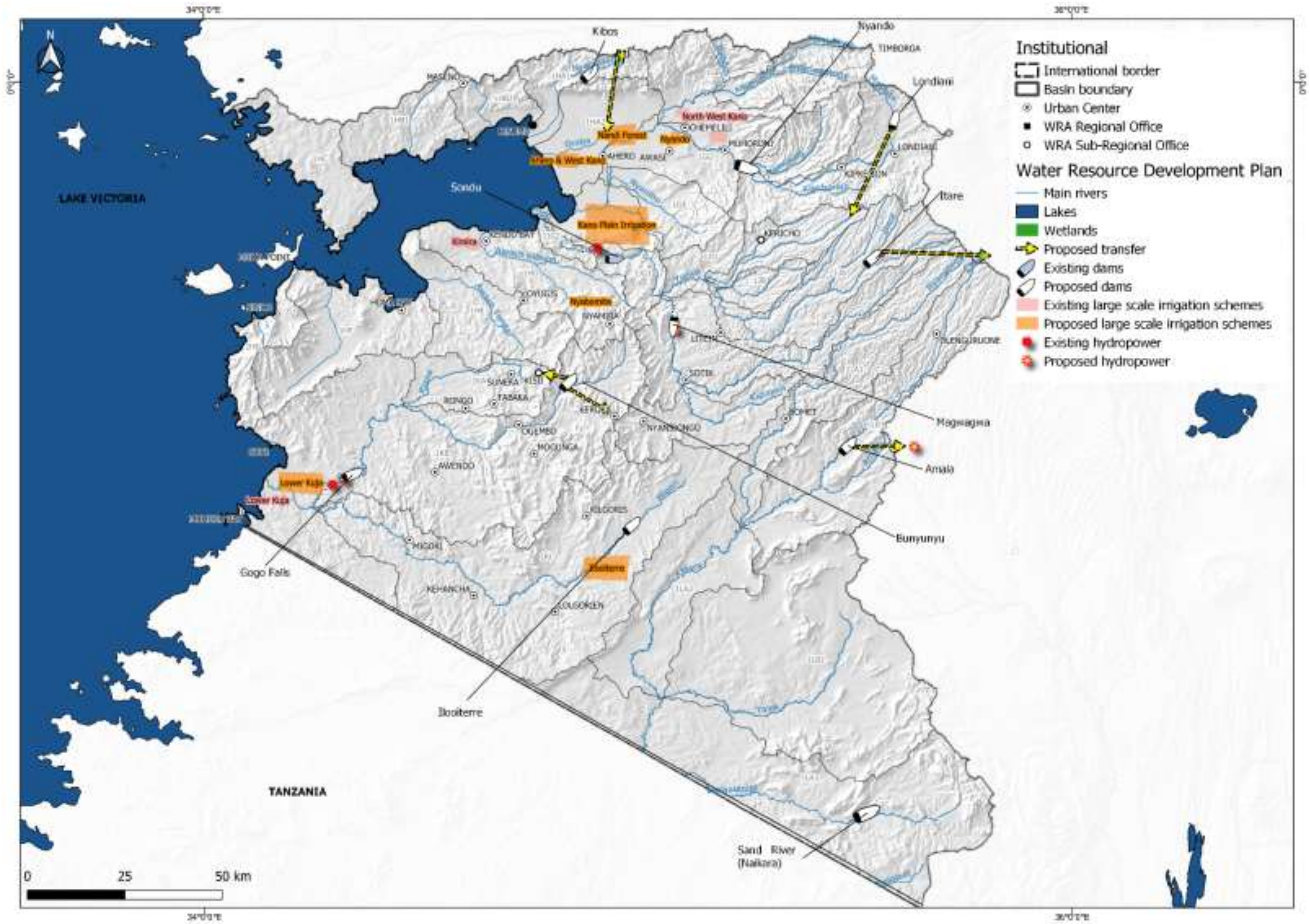


Figure 6-24:Proposed developments, dams and transfer schemes in the LVS Basin

6.9.5.2 Water supply to Kisumu

Kisumu is Kenya's third largest city and has about 600 000 residents. It is situated on the Winham Gulf of Lake Victoria and current water supply comes from Lake Victoria via the Dunga Water Treatment Works, as well as from the Kajulu River via the Kajulu Water Treatment Works. These works supply a number of reservoirs and in conjunction, the supply capacity exceeds the current water demand of Kisumu of about 40 000 m^3/day.

During drought and due to increasing water quality problems at the abstraction point in Lake Victoria, Kisumu often experiences disruptions to its water supply. Construction of the Kajulu weir, a mini-hydropower station, Water Treatment Works and gravity pipeline was completed 2014. The works has a capacity of about 36 000 m^3/day. During flood events, the works has to be shut down on account of the high silt content of the water. The construction of a dam (26 MCM) on the Kibos River upstream of the weir from which the Kajulu Water Treatment Works draws its water, and the upgrading of the Kajulu Water Treatment Works would considerably improve the reliability and dependability of the water supply from the Kajulu Water Treatment Works and would improve the reliability of supply in the short term. However, to ensure a reliable supply of water in line with the projected increase in demand at Kisumu up to 2040, some of the water of the planned inter-basin transfer from the Nandi Forest Dam in Lake Victoria North Basin to the Oroba River in LVS should be released into the Kibos River upstream of the planned Kibos Dam to augment the supply to Kisumu.

In addition, it is imperative that measures to address the problems caused by floating water weeds at the Dunga intake works on Lake Victoria are put in place. Decomposing vegetation results in increased treatment costs as well as smells and taste to the treated water. A floating might be effective in keeping floating weed and submerged weed debris away from the intakes to the Dunga pump stations, although some cleaning within the barrier would still be required.

Funding to improve the water supply to Kisumu is available under various initiatives e.g. the Long Term Action Plan for Water and Sanitation and the Lake Victoria Water and Sanitation Project (LVWATSAN), which aims to achieve the Millennium Development Goals linked to water supply and sanitation in urban areas surrounding Lake Victoria.

Figure 6-25: Diversion weir on Kajulu River

6.9.5.3 Magwagwa Multipurpose Dam Project

The Magwagwa Multipurpose Dam aims to provide many services to the three counties of Nyamira, Homa Bay and Kisii, including water supply for irrigation, domestic and industrial use, flood control, silt load reduction, hydropower production and fisheries development. The dam will be constructed near Magwagwa Town in Nyamira County, four kilometres downstream from where the Kipsonoi and Yurith tributaries of the River Sondu meet. At a storage capacity of 445 MCM, the dam will significantly improve water reliability for domestic supply in the region, will provide reliable water for large-scale irrigation on Kano Plain (15 000 ha), will generate electricity and will provide flood control.

6.9.5.4 Soin-Koru (Nyando) Multipurpose Dam Project

Construction of the Soin-Koru multipurpose dam were intended to commence at the beginning of 2019. The dam will control floods in the lower parts of Nyando River, provide domestic water supply to the counties of Kisumu, Ahero, Awasi, Muhoroni and Chemelili, and support two large-scale irrigation schemes (Nyando and Ahero/West Kano). Located on the Nyando River, the dam will have a storage of 87 MCM and cross the counties of Kisumu and Kericho.

6.9.5.5 Inter-basin transfers

Two inter-basin transfers to transfer surplus water from the LVS Basin to the Rift Valley Basin have been identified. These will involve the construction of large dams in the upper LVS Basin and transfer tunnels to Rift Valley Basin.

Water from Itare Dam, with a storage capacity of 20 MCM, on the Itare River an upper tributary of the Sondu River, will be transferred to augment water supply to Nakuru, Kuresoi, Molo, Njoro and Rongai in the Rift Valley Basin. This will involve a tunnel of almost 15 km with a design capacity of 41 MCM/a.

Similarly, water from Amala Dam (storage capacity of 175 MCM) on the Amala River, an upper tributary of the Mara River, will be transferred to the Rift Valley Basin via a 3.8 km tunnel with a design capacity of 82 MCM/a. This water will supply additional water to the proposed cascading hydropower scheme on the Lower Ewaso Ng'iro South River, which involves Oletukat, Oldorko and Leshota dams with an installed capacity of 180 MW. Amala dam will also be used to supply water for domestic demands in Nomet and Narok counties in the LVS Basin.

The total amount of water expected to be transferred out of the LVS basin is 123 MCM/a on average.

An additional inter-basin transfer will bring water from the Nandi Forest Dam in the LVN Basin, to the LVS Basin. This scheme entails a number of components, viz. a 220 MCM storage dam at the confluence of the Remonde (Kimondi) and Sirua (Mokong) Rivers in the Nandi Forest at an elevation of 1 800 masl, a 17.5 km tunnel which will divert about 6.6 m^3/s to Lake Victoria South Basin and a powerhouse at the foot of the Nayndo escarpment with an installed hydropower capacity of 50 MW. The flow will eventually be discharged into the Oroba River, from where the water will be abstracted for proposed irrigation of about 7 200 ha in Miwani and Chemelil. Other potential benefits include water supply to Kisumu in the Lake Victoria South Basin.

6.9.5.6 Water supply to Kisii Town and surrounding areas

Construction has begun on the Bunyunyu Dam on the Gucha River despite numerous set-backs. Once complete, the dam will benefit more than two million people in the counties of Nyamira and Kisii. For Kisii and its surrounding areas, there is no water available from Lake Victoria or the water towers, and the Gucha River is the only major water source in the area, apart from small-scale groundwater supply. The Bunyunyu Dam, with a storage capacity of 6.3 MCM, will have a significant impact on economic and livelihoods development in the area and analyses have shown that it will be able to meet water demands for domestic use in the surrounding towns up to 2040 at a relatively high supply reliability.

6.9.5.7 Gogo Falls Dam Project

Gogo Falls, located on the Guacha River in the Migori County, already hosts a 2 MW power station. It is the intention to replace the weir with a dam that can generate 15 MW of hydropower and support large-scale irrigation of 10 000 ha in the Lower Kuja Irrigation Scheme. The dam will have a storage capacity of 464 MCM.

6.9.5.8 Large-scale Irrigation development

There is significant irrigation potential in the Lake Victoria South Basin due to the abundance of water and the relatively limited water use at present. In some instances, the originally proposed irrigation areas to be developed as run-of-river schemes would have to be reduced to maintain a high assurance of supply, while dams would also be needed to support irrigation development and to ensure a reliable supply of water. Four storage dams would be required to ensure a high assurance of supply to these schemes, including Magwagwa, Nyando (Soin-Koru), Gogo Falls and Ilooiterre dams. Some of these proposed dams will act as multipurpose dams for water supply to urban centres, hydropower generation and flood control. There is also potential for significant irrigation development in Kisumu County linked to the expected water which will be transferred from the Nandi Forest Dam in the LVN Basin. The cost-benefit analysis indicated that careful consideration needs to be given to crop types on some of the schemes, notably Ahero / West Kano and Nyabomite to ensure the financial viability of the schemes.

Table 6-33: Proposed large scale irrigation areas

Scheme name	County	Area (ha)
Nyando	Kericho	3 000
Nandi Forest	Kisumu	7 300
Lower Kuja	Migori	10 000
Ilooiterre	Narok	3 000
Ahero / West Kano	Kisumu	4 150
Kano Plain	Nyamira/Kericho	15 000
Nyabomite	Nyamira	1 000

6.9.5.9 Groundwater development

The potential for groundwater development at a large scale should be assessed as part of integrated planning for bulk water resources development (Refer to Strategy 8.2.1), especially as part of regional water supply schemes. Numerous aquifers have good potential, particularly for localised, small-scale groundwater abstraction, but need to carefully managed as they are prone to contamination.

6.9.5.10 Water to supply basin-wide domestic, irrigation and livestock demands

In order to meet future domestic and industrial demands in towns and rural settlements outside of the major urban centres, and to improve reliability of supply to small-scale irrigation, new or additional storage dams as well as significant local groundwater development should be implemented to provide carry-over storage and to meet supply deficits during dry years and/or the dry season when the demand exceeds availability of water in the rivers. The water resources model, in conjunction with the groundwater availability assessment model, was used to determine surface water storage requirements and groundwater development per-sub-basin. The total additional surface water storage volume (as dams and pans) in the LVS Basin, which will be required to meet 2040 demands, amount to 154 MCM, while the total volume of additional groundwater development which will be required was estimated at 203 MCM/a. Table 6-34 provides estimates of additional surface water storage requirements, as well as estimates of groundwater development per sub-basin. The surface water storage should be provided in dams and pans.

Table 6-34: Additional storage and groundwater development to meet 2040 basin-wide demands

Subbasin	Groundwater (MCM/a)	Surface Water Storage (MCM)	Dams already identified
1GA	3.8	0.0	
1GB	6.8	0.0	
1GC	10.1	5.6	Londiani Dam
1GD	3.6	7.0	
1GE	7.6	0.0	
1GF	4.2	3.6	
1GG	4.7	0.3	
1HA1	4.8	-1.3	Kibos Dam
1HA2	8.1	0.9	
1HB1	3.0	4.0	
1HB2	3.1	1.0	
1HC	1.9	0.5	
1HD	3.3	2.2	
1HE	4.3	3.8	
1HF	10.9	19.5	
1HG	3.1	6.8	
1JA	5.4	0.0	Itare Dam
1JB	2.7	0.0	
1JC	3.9	1.1	Import water from Londiani Dam
1JD	2.9	0.0	
1JE	4.8	0.6	
1JF	9.8	0.4	
1JG1	0.9	0.7	
1JG2	1.3	0.6	
1KA	1.3	6.3	Bunyunyu Dam
1KB	18.9	27.9	Bunyunyu Dam
1KC	16.3	27.3	Ilooiterre Dam
1LA1	12.0	30.0	
1LA2	8.8	0.1	
1LA3	6.2	5.0	Sand River Dam
1LB1	11.9	0.0	
1LB2	12.1	0.0	

6.9.6 Project investment programme

The proposed water resources developments were grouped into schemes for implementation. Individual future schemes were evaluated using multi-criteria analysis. Most of the criteria which were employed in the evaluation correspond to the indicators which were used as part of the scenario analysis (refer to Section 5.6). However, additional indicators such as benefit-cost ratio and water productivity as well as qualitative indicators were introduced as part the scheme multi-criteria analysis. Scheme yields at 90% assurance of supply were incorporated in the benefit-cost analysis to estimate potential future water revenue streams.

Table 6-35 displays the decision matrix for the scheme multi-criteria analysis. The analysis used the unit vector normalisation method, while ordinal ranking was used for weighting. In ordinal ranking, the order of ranking assigned to criteria is important, while the absolute differences between criteria values is not, due to it being disproportionate and/or difficult to quantify. The indicator analysis provides a wide array of indicators, which cannot be assessed against each other; thus, ordinal ranking was the suitable option.

Table 6-35: Scheme multi-criteria analysis - Decision matrix

				Londiani Dam (25MCM) Kericho & Rural supply	*Nyando Dam (87MCM) Rural supply Nyando Irrigation (3,000ha) Flood control*	*Kibos Dam (26MCM) Kisumu & Rural supply Flood control*	*Bunyunyu Dam (6.3MCM) Kisii & Rural supply*	*Ilooiterre Dam (14MCM) Rural supply Ilooiterre Irrigation (3,000ha)*	*Sand River Dam (1MCM) Rural supply*	*Magwagwa Dam (445MCM) Rural Supply Kano Plain Irrigation (15,000ha) Hydropower (115MW) Flood control*	*Gogo Falls Dam (464MCM) Rural supply Lower Kuja Irrigation (10,000ha) Hydropower (15MW)*	*Ahero&West Kano Irrigation (4,150ha)*	*Nyabomite Irrigation (1,000ha)*	*Nandi Forest Dam (LVN) (220MCM) Kisumu, Yala (LVN) & Rural supply Nandi Forest Irrigation (7,272ha) Hydropower (50MW) Flood control*
ENVIRONMENT	Footprint areas	Environmentally sensitive areas	Area (km2)	0.53	5.82	0.02	0.00	0.00	6.07	0.00	0.00	7.04	0.00	3.83
		Carbon emissions dams	tons	11422	10766	4986	0	64434	198178	0	0	0	0	23999
		Carbon emissions LIR	tons	0.00	74081	0	0	142134	0	0	469610	102528	0	0
	Downstream areas	Floodplain area inundated	% change from baseline	-99	-99	-33	-7	-96	-21	-17	-15	-31	-15	-11
		Ecological stress	Index (-5 to 0)	-5	-5	-3	-1	-5	-2	-2	-2	-3	-2	-1
		Wet duration	% change from baseline	-24	-34	-41	-11	-47	-23	-30	-17	-33	-20	-10
	Water quality	Phytoplankton growth potential	Average growth potential %	96	84	53	7	43	5	85	97	0	0	88
		Aquatic macrophytes growth potential	Index (-5 to 0)	0	-2	0	0	-3	0	0	-1	-1	0	-2
SOCIAL	Water availability	Riparian users	% change from baseline	-89	25	-14	-84	100	-35	-18	-57	-46	-56	100
	Community health and safety	Malaria endemicity	Malaria endemicity (km2)	1	6	1	0	5	1	66	12	7	4	26
	Food security and livelihoods	Formal irrigation schemes	Area (km2)	0	30	0	0	30	0	150	100	42	10	73
		Impact on recession agriculture	% change from baseline	-99	-99	-33	-7	-96	-21	-17	-15	-31	-15	-11
		Fish production (dams/lakes)	Tons/annum	33	43	14	27	28	7	181	24	0	0	63
		Change in fish productivity	% change from baseline	-24	-34	-41	-11	-47	-23	-30	-17	-33	-20	-10
		Loss of productive land	Area (km2)	2	18	2	1	19	3	72	45	22	4	32
		Loss of natural resources	Area (km2)	1	6	0	0	0	6	0	0	7	0	4
	Displacement	Physical displacement	Number people	765	6452	2646	754	10168	245	62111	23805	7796	3536	23946
ECONOMIC	Energy	Avg energy	GWh/annum	0	0	0	0	0	0	507	62	0	0	223
	Food production	Crop production (formal irrigation)	Ton/annum	0	3405	0	0	3135	0	16119	45338	19699	782	38105
		Fish production (dams/lakes)	Ton/annum	33	43	14	27	28	7	181	24	0	0	63
	Employment	Employment formal irrigation	Number people	0	7500	0	0	7500	0	37500	25000	10380	2500	18180
		Employment hydropower	Number people	0	0	0	0	0	0	275	154	0	0	6
	Sediment	Volume of dam silted	Index (-5 to 0)	-5	-2	-4	-5	-5	-5	-1	-2	0	0	-1
	Financial	BCR	Ratio	1.6	2.6	2.2	4.9	1.6	0.6	1.4	2.7	0.6	0.1	3.5
	Flood control	Flood control potential	Ratio (Dam capacity/MAR)	0.8	0.9	1.1	0.1	0.3	0.1	0.8	0.5	0.0	0.0	0.5
	Water productivity	Water productivity formal irrigation	Million USD/MCM	0.000	0.058	0.000	0.000	0.056	0.000	0.069	0.281	0.267	0.060	0.345
		Water productivity hydropower	Million USD/MCM	0.000	0.000	0.000	0.000	0.000	0.000	0.026	0.014	0.000	0.000	0.010
QUALITATIVE	Preparedness for implementation		5 Ready for implementation, 0 Not started	1	2	3	4	0	0	3	2	3	2	2
	Public perception/buy-in		5 Full public support, -5 Very contentious	0	2	2	2	2	2	1	3	3	3	-3
	Scale of impact		5 Basin wide and beyond, 1 Very local	1	2	1	2	2	1	3	3	1	1	4
	Transboundary and trans-county implications		5 Beneficial, -5 Detrimental	0	0	0	0	0	-2	2	0	0	0	3
	Potential downstream / environmental impact		5 Beneficial, -5 Detrimental	0	-2	0	0	-1	-2	-2	-1	-1	-1	-3
	Fatal flaw		0 None, -5 Flawed	0	0	0	0	0	-2	0	0	0	0	-3

The outcome of the multi-criteria analysis provided a ranking of future schemes as shown in Table 6-36.

Table 6-36: Ranked water resources development schemes

1	**Magwagwa Scheme**	*Magwagwa Dam (445MCM)*
		Rural Supply
		Kano Plain Irrigation (15,000ha)
		Hydropower (115MW)
		Flood control
2	**Gogo Falls Scheme**	*Gogo Falls Dam (464MCM)*
		Rural supply
		Lower Kuja Irrigation (10,000ha)
		Hydropower (15MW)
3	**Bunyunyu Scheme**	*Bunyunyu Dam (6.3MCM)*
		Kisii & Rural supply
4	**Nandi Scheme (LVN)**	*Nandi Forest Dam (LVN) (220MCM)*
		Kisumu, Yala (LVN) & Rural supply
		Nandi Forest Irrigation (7,272ha)
		Hydropower (50MW)
		Flood control
5	**Nyabomite Scheme**	*Nyabomite Irrigation (1,000ha)*
6	**Kibos Scheme**	*Kibos Dam (26MCM)*
		Kisumu & Rural supply
		Flood control
7	**Ahero/West Kano Scheme**	*Ahero&West Kano Irrigation (4,150ha)*
8	**Londiani Scheme**	*Londiani Dam (25MCM)*
		Kericho & Rural supply
9	**Nyando Scheme**	*Nyando Dam (87MCM)*
		Rural supply
		Nyando Irrigation (3,000ha)
		Flood control
10	**Ilooiterre Scheme**	*Ilooiterre Dam (14MCM)*
		Rural supply
		Ilooiterre Irrigation (3,000ha)
11	**Sand River Scheme**	*Sand River Dam (1MCM)*
		Rural supply

Based on the above ranking and taking into consideration schemes where implementation is imminent, current and future levels of water supply deficits based on projected growth curves in water demand, an investment programme (Table 6-37) was developed which provides information on the timing / phasing of schemes and associated capital, operations and maintenance expenditure from 2020 to 2040.

Table 6-37: LVS Basin Water Resources Development Investment Plan

Proposed Infrastructure Development - Water Resources, Hydropower & Large-Scale Irrigation							Expenditure (USD Million)																						
Scheme	Storage / Transfer Volume	1:10 yield (MCM/a)	Purpose				Feasibility ESIA / Design	Capital	Phasing (Year) 2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
Multi-purpose Dam Projects	Capacity		Water Supply	Hydropower	Flood Control	LS Irrigation	**262**	**1747**																					
Magwagwa	445 MCM, 115 MW	284	●	●	●	●	107	710	53	53	237	237	237																
Soin Koru / Nyando	87 MCM	57	●		●	●	38	252												38	126	126							
Ilooiterre	14 MCM	8.5	●			●	8	55									8	28	28										
Gogo Falls	464 MCM, 15 MW	603		●		●	71	470							35	35	157	157	157										
Nandi Forest Dam	220 MCM, 50 MW	165	●	●	●	●	39	260													20	20	87	87	87				
Intra-basin Transfers							**6**	**40**																					
Londiani Dam to Sub-basin 1JC	8 MCM/a	-	●				6	40					6	20	20														
Inter-basin Transfers							**182**	**1215**																					
Nandi Forest Dam (LVN) to LVS	189 MCM/a	-	●	●		●	45	300													45	100	100	100					
Itare Dam (LVS) to RV	41 MCM/a	-	●				109	725	Cost included in Rift Valley Basin Plan																				
Amala Dam (LVS) to RV	82 MCM/a	-		●			29	190	Cost included in Rift Valley Basin Plan																				
Dams - urban centres / flood control / HP							**98**	**652**																					
Kibos	26 MCM	14.2	●		●		20	132		20	66	66																	
Bunyunyu	6.3 MCM	19.5	●				7	47			7	24	24																
Sand River / Naikara	1 MCM	0.42	●				2	12												2	12								
Londiani	25 MCM	16	●				13	89				13	45	45															
Amala	175 MCM	68		●			44	296	Cost included in Rift Valley Basin Plan																				
Itare	20 MCM	13.1	●				11	76	Cost included in Rift Valley Basin Plan																				
Small dams / pans & Boreholes							**68**	**453**																					
Dams and pans	154 MCM	-	●				53	355	27	27	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19
Groundwater (Boreholes)	203 MCM/a	-	●				15	98	7	7	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Large Scale Irrigation Schemes (cost excl. associated dams)							**128**	**854**																					
Nyando	3 000 ha	-				●	9	59														9	30	30					
Nandi Forest	7 300 ha	-				●	22	144														22	48	48	48				
Lower Kuja	10 000 ha	-				●	30	197									30	66	66	66									
Ilooiterre	3 000 ha	-				●	9	59												9	30	30							
Ahero / West Kano	4 150 ha	-				●	12	82																12	41	41			
Nyabomite	1 000 ha	-				●	3	18																			3	9	9
Kano Plain	15 000 ha	-				●	44	296		22	22	99	99	99															
								O&M Cost	0	0	8	19	30	35	36	36	41	48	55	57	62	69	76	83	88	90	90	91	92
								Total Annual Cost (USD Million)	**87**	**129**	**364**	**481**	**463**	**222**	**115**	**96**	**259**	**321**	**328**	**195**	**318**	**398**	**364**	**383**	**287**	**154**	**117**	**124**	**125**

6.9.7 Strategy

In order to comprehensively and systematically address the water resources development challenges in the Lake Victoria South Basin, Table 6-38 sets out 9 Strategic Themes with specific strategies under each theme. The Themes include Water resources assessment, allocation and regulation, Water resources planning, Water storage and conveyance, Groundwater development, Hydropower development, Water for agriculture, Water based tourism and recreation, Non-conventional water resources and System operation.

Table 6-38: Strategic Framework – Water resources development

8. Key Strategic Area		**Water resources development**
8.1	**Theme:**	**Water resources assessment, allocation and regulation**
8.1.1	Surface water resources assessment – surface water availability at relevant scales	
Before decisions are made regarding water resources developments, it is critical to have reliable information on availability of surface water at relevant spatial scales for planning, management and allocation. The existing hydrological and systems models which have been configured for each basin, need to be refined as appropriate for decision making.		
8.1.2	Groundwater resources assessment – groundwater availability	
Refer to Strategy 3.1.1		
8.1.3	Assess water use and fitness for use	
It is imperative that information regarding current water use is improved through abstraction surveys. This relates to both water quantity and quality.		
8.1.4	Update and improve permit database`	
The accuracy and completeness of the information in the PDB are questionable. The PDB should be checked and updated (based on the abstraction survey data) to ensure that it is a true reflection of the state of water allocation.		
8.1.5	Water allocation	
Water allocations should be re-assessed based on the improved understanding of water availability and current water use at relevant spatial scales. Allocation should be informed by updated water balances which should consider the reserve and RQOs.		
8.2	**Theme:**	**Water Resources Planning**
8.2.1	Updated planning for bulk water resources development	
Regional water supply schemes should be optimised and expanded in line with water demand projections. Enough lead time should be allowed for the implementation of the future phases. The conjunctive use of surface and groundwater to meet urban and rural demands should be investigated.		
8.3	**Theme:**	**Water storage and conveyance**
8.3.1	Implement large dams: complete relevant feasibility and impact studies and plans; design and construct	
To utilise the available water resources in the basin for hydropower, large-scale irrigation and to improve the reliability of supply for domestic and industrial use will require significant storage of water during the wet seasons. The proposed large dams should be investigated in more detail and implemented in line with the investment plan.		
8.3.2	Maintenance of existing dams	
There is a need to dredge existing dams to improve the capacity volume. Enhanced catchment management will decrease erosion and siltation of existing dams, and dredging will be required on a less frequent basis.		
8.3.3	Construct new water transfers	
8.3.4	Infrastructure development - small dams and pans	
At sub-basin scale, there is a need for storage of surface water on tributaries to improve the reliability of supply for local domestic, livestock and small-scale irrigation use. Studies should be initiated and an infrastructure development programme should be compiled to guide the phased implementation of storage at sub-basin scale		

8. Key Strategic Area		Water resources development
8.3.5	Provide other types of storage	
Sand dams, artificial recharge and water harvesting should be investigated and implemented where feasible to provide storage of water during the wet season for use during the dry season, especially in areas without reliable river flows.		
8.4	**Theme:**	**Groundwater development**
8.4.1	Develop groundwater resources	
Implement under Strategic Theme 3.2		
8.5	**Theme:**	**Hydropower development**
8.5.1	Large scale hydropower development	
The large dams which will supply large scale irrigation development in the basin should be constructed as multipurpose dams to include the generation of hydropower		
8.6	**Theme:**	**Water for agriculture**
8.6.1	Large scale irrigation development: Develop new / expand existing irrigation schemes. Limit to max sustainable areas	
Further large-scale irrigation development can be accommodated in the LVS Basin.		
8.6.2	Promote water conservation in irrigation	
As part of the sustainable scenario proposed in this basin plan, increased irrigation efficiency and reduced water demand for large-scale irrigation accounts largely for more sustainable water use. Water use efficiency can be increased through the rehabilitation or improvement of irrigation technologies and techniques, and through the use of smart metering.		
8.6.3	Compile infrastructure development program for small scale irrigation. Develop new / expand existing irrigation schemes	
Small scale irrigation in the basin should be encouraged due to the significant socio-economic benefits associated with this. However, water supply should be improved and/or expanded by means of storage (small dams), pans and boreholes.		
8.6.4	Aquaculture development	
The new large dams to be developed within the basin will provide opportunities for aquaculture and this should be promoted, while the development of aquaculture in Lake Victoria should be expanded.		
8.6.5	Improved water supply reliability at local scale through construction of small dams / pans and/or development of local groundwater resources to provide carry-over storage during the dry season	
Implement under Strategies 8.3.2 and 3.2.2		
8.7	**Theme:**	**Water based tourism and recreation**
8.7.1	Promote water-based tourism and recreation	
Adventure tourism, leisure activities, recreational activities and resorts should be promoted in the vicinity of large lakes and dams, especially Lake Victoria.		
8.8	**Theme:**	**Non-conventional water resources**
8.8.1	Rainwater harvesting	
Rainwater harvesting should be promoted in urban and rural areas. Especially in rural areas, harvested water can be used for some domestic purposes and gardening.		
8.8.3	Reuse	
Re-use is not considered to be an option for water supply in the basin at this stage.		
8.8.4	Water Conservation and Demand Management	
WCDM should be implemented as an immediate option to reduce water demand in urban areas.		
8.9	**Theme:**	**Water resources systems operation**
8.9.1	Optimise system operating rules	
The operation of the proposed large dams should be optimised, especially where these dams will serve multiple purposes.		

8. Key Strategic Area	Water resources development
8.9.2	Conduct Annual Operating Analyses (AOA) to decide need for and severity of restrictions for the coming year based on current storage levels and anticipated demands
Annual operating analyses, taking into consideration the current storage state, projected water demands and infrastructure constraints should be conducted for the bulk water supply systems in the LVS Basin to inform decision with regard to curtailment of water use and the need for/phasing of new augmentation schemes.	
8.9.3	Maintenance of piped network
Maintenance of piped network should be conducted to improve (reduce) NRW.	

6.10 Institutional Strengthening and Enabling Environment

6.10.1 Introduction

In effect, the key aspect of any institutional reform process is to find an appropriate balance between operational functionality and the need for effective oversight and governance. Despite the various efforts that have been targeted at improving the institutional framework in the LVS Basin, there still remain challenges that warrant dynamic and progressive approaches to address them. Thus, this Plan provides the opportunity to integrate institutional reforms with the various elements of water resources management and development, noting that these reforms are an important part of ensuring that this Plan is implemented. Whilst, the various technical dimensions of this Plan are of significant importance, it does need to be highlighted that the ability of institutions to implement, oversee and review approaches accordingly will determine the efficacy of the basin plan.

Noting the variability of the climate and the potential impacts of climate change, the ability of institutions to manage adaptively will become increasingly important. In addition, the importance of the LVS Basin in terms of Kenya's socio-economic development cannot be underestimated. This will require strengthened inter-governmental approaches and inter-sectoral partnerships. These will be imperative noting the importance of the water-food-energy nexus and will need to not only ensure improved levels of inter-sectoral planning, but equally improved effectiveness and efficiency from better implementation alignment as well as coordinated oversight. This is especially important when one notes the ongoing capacity constraints that face most sectors.

Whilst there will be ongoing pressures to develop and use water resources to enable socio-economic growth and development in the LVS Basin, the need to ensure that this takes place in a sustainable manner will become increasingly imperative. The shifts towards strengthening the regulatory role of the Water Resources Authority (WRA), aligned to the 2016 Water Act, are important and will have impact on the institutional roles and responsibilities within the LVS Basin. Hence, the drive to enable better coordinated resource development will be balanced by an improvement in the regulatory response by WRA. This will mirror and support the drive at a national level to strengthen catchment-based water resources management.

6.10.2 Institutional framework and challenges

The institutional framework in the LVS Basin is currently undergoing a transition in line with the water sector reforms. At the basin level, WRA operates through the Regional Offices (ROs) and Sub-Regional Offices (SROs) with respective offices spread across the Basin. These offices are facing various challenges including inadequate human resources, inadequate office space and equipment, inadequate vehicles and/or fuel, insufficient laboratory facilities, inefficient systems and tools, inadequate data and insufficient financing - which is partly due to inefficient revenue collection systems. These require an institution-wide approach to strengthen the regulatory role of WRA. In this regard, there is currently poor compliance with permit conditions and a range of unlawful activities that are enabled through inadequate enforcement.

At the same time, there is a need to improve the catchment-based management of water resources within the LVS Basin. This needs to take place through a range of approaches to address various challenges. There is a need to transition from the Catchment Area Advisory Committees (CAACs) to the Basin Water Resources Committees (BWRCs) as the representative basin area management entity. The BWRCs are yet to be established, but in terms of operational functionality, the BWRCs have an advisory role similar to their predecessor, the CAACs. The advisory nature of the CAACs was problematic in the sense that there was often limited consideration of their inputs, leaving the CAACs as effectively redundant. Noting the need to strengthen catchment-based management in the LVS Basin, there is a dire need to put in place dynamic measures to prevent the BWRCs from running into similar challenges as the CAACs and to ensure that the guidance provided by the BWRCs is considered and translated into implementable actions wherever possible. WRA is currently exploring options that will ensure better operational functionality of the BWRCs given the current setting.

Additionally, the Constitution of Kenya 2010 introduced the County Governments (CGs) into the water resources management space with a mandate on catchment conservation in their respective jurisdictions. There are teething challenges on how to better coordinate water resource management efforts cohesively between WRA and the Counties. These challenges include inadequate awareness of the CGs roles in catchment conservation and what this means for WRA in the overall regulation of management and use of the resource. It is anticipated that the BWRCs will provide a platform to ensure better coordination between WRA and the CGs, especially as the CGs are members of the BWRCs.

WRUAs are an important organ at the community level to ensure better water resources management. There have been a few successes with some WRUAs in the LVS Basin, but predominantly there are challenges with capacity of the WRUAs along with financing gaps for the WRUAs that affect their sustainability.

Lastly, noting the importance of inter-sectoral approaches to support improved water resources management and development, there is currently insufficient partnerships and stakeholder engagement to foster these integrated approaches.

6.10.3 Strategy

The Institutional Strengthening Plan for the LVS Basin is aligned with the overall vision for the Basin and focusses on *establishing an effective institutional framework in the Basin to ensure good governance and enhancing human and institutional capacities for sustainable management of the water, land, ecosystems and related resources.* The aim of the Plan is focused upon the incremental strengthening of the institutional frameworks to enable improved water resource governance within the LVS Basin. Noting the pressures upon the resource as well as the need to support ongoing socio-economic development within the basin, the need to have institutions that have clarity in roles and responsibilities, that have the capacity and systems to achieve their mandates, and that are supported by sustainable financing frameworks, is imperative. This Plan is therefore focused upon developing the institutional frameworks whilst supporting the enabling environment to underpin and sustain the operational implementation of this institutional framework.

The two tables below set out 2 Key Strategic Areas and Strategic Themes to achieve this objective and provides specific strategies under each theme.

Table 6-39: Strategic Framework – Institutional Strengthening

9	**Key Strategic Area:**	**Strengthen the Institutional Frameworks**
9.1	**Theme:**	**Promote improved and sustainable catchment management**
9.1.1	Strengthen WRA's regulatory role	
The 2016 Water Act, aligned to the Constitution of Kenya (2010), provides for the strengthening of the regulatory functioning of the WRA. Towards this end there is a need to separate out the regulatory and management functions of the Authority and provide different reporting lines for these differing functions. This will enable WRA to focus on its regulatory functions and in the longer-term work towards the delegation of management and operational functions to the BWRCs when they are established, the County Governments and WRUAs. Acknowledging that the process of establishing the BWRCs may be lengthy, and the need to strengthen the institutional capacity of the Counties and WRUAs will require time, there is need for WRA to establish interim modalities to bridge this gap and to ensure a smooth transition. This will require an optimisation of the ROs and the SROs supported by a capacity building drive. At the same time, there is a need for the ongoing improvement and strengthening of the regulatory approaches utilised by the WRA. This will include several enabling factors but also requires a clarification of roles and responsibilities across the entire institutional framework. This will include working with various sector stakeholders to support the improved harmonisation of legislation and regulatory instruments across a range of sectors. This will need to incorporate the development of operational modalities across institutions as well as across administrative and hydrological boundaries.		
9.1.2	Strengthen BWRCs	
The BWRCs have more representation from different stakeholders in the Basin and will thus enable improved engagement across a wider range of stakeholders as well as inter-sectoral issues. There are lessons to be learned from the CAACs and these need to be translated into improved operational modalities for the BWRCs. These lessons include ensuring adequate and sustainable financing, ensuring frequent and well-structured engagements of the members of the BWRCs, WRA providing secretariat and technical assistance services, clear communication and reporting channels between WRA and the BWRCs, modalities for WRA taking on board recommendations of BWRCs, detailed guidelines on appointing members to the committees including qualifications, operationalisation guidelines, prescribed remuneration for the committee members and continued training and capacity building for the members. In addition, strengthening the BWRCs will include WRA providing secretariat services through the ROs and SROs. There is need to provide appropriate channels for enabling recommendations made by the Committee to be taken on board by WRA for further action. This will need to be supported by designated line functions within WRA that do not dilute the WRAs regulatory authority. Training and capacity building will be an ongoing requirement for the BWRCs including a thorough on-boarding upon establishment. This would include not only the more technical dimensions of water resource management, but also a range of skills to enable sound governance.		
9.1.3	Strengthen county governments engagements in WRM in the basin	
The introduction of county governments into the management frameworks provides an opportunity for improved management at local levels. The key role of county governments to support localised socio-economic development is crucial and therefore there is a very important need to align planning instruments to ensure that the sustainable development of water resources does underpin this developmental agenda. To date, engagements with the county governments are unstructured, partly borne from a lack of clarity as to institutional mandates, roles and responsibilities. WRA needs to clarify these roles and responsibilities and to introduce more structured strategic planning and operational engagement. The BWRCs will provide a platform for structured engagements with the county governments, at a governance and strategic level, however, there is need to explore more ways of engaging with the Counties at the basin and sub-basin level for day to day issues that may arise. Training and capacity building is required for the county governments as well as awareness creation which can be achieved through a collaborative partnership approach with the counties. In addition, the ongoing development of protocols for the sharing of information and knowledge exchange need to be established to provide the necessary information required for decision making.		
9.1.4	Strengthen WRUAs	

9	Key Strategic Area:	Strengthen the Institutional Frameworks
WRUAs play an important role in sub-catchment management, but there are a range of institutional and capacity challenges that require resolution to enable WRUAs to be more effective. The institutional linkages between county governments and the WRUAs are important and ways to improve and strengthen these will be an important part of improving localised operational water resource management and development. WRUAs have had sustainability issues and exploring approaches that enhance their livelihoods while promoting catchment management will be an added advantage. More importantly, a more sustainable financing approach for WRUAs' activities is most needed to ensure financial sustainability of WRUAs. There is a need to provide training and capacity building to the members periodically on matters relating to WRM. Equally, improvements in information dissemination are needed to ensure community members can understand the message being passed across.		
9.2	**Theme: Guidelines, codes or practice and manuals**	
9.2.1	Develop policies	
Develop policies which are relevant to water resources planning and management need to be updated and/or developed based on international best practice and aligned with the policy and legal framework which dictates.		
9.2.2	Develop guidelines to support specific water resources management activities	
Develop technical guidelines which are relevant to water resources planning and management need to be updated and/or developed based on international best practice and aligned with the policy and legal framework which dictates.		
9.2.3	Develop Codes of Practice	
Develop codes of practice which are relevant to water resources planning and management need to be updated and/or developed based on international best practice and aligned with the policy and legal framework which dictates.		
9.2.4	Develop manuals	
Develop manuals which are relevant to water resources planning and management need to be updated and/or developed based on international best practice and aligned with the policy and legal framework which dictates.		

Table 6-40: Strategic Framework – Enabling environment to support effective water resources planning and management

10	Key Strategic Area:	Strengthen the enabling environment to support institutions
10.1	**Theme:**	**Development of institutional capacities to support improved water resource management and development.**
10.1.1	Strengthen policies and regulatory instruments	
Updating WRA's standards, policies and regulations in line with the WA2016 is needed. This should be followed by awareness creation and training and capacity building for the new standards, policies and regulations. Respective tools to support the new legislative instruments should also be developed to aid the implementation phases. Development of these tools should adopt a participatory approach in consultation with major stakeholders to ensure buy in and ownership of the new legislative instruments that will trickle down to implementation.		
10.1.2	Development of technical and management capacity	
Across the institutional framework there is a need to develop a range of technical and managerial skills to improve the institutional ability to deliver on mandate. This includes not only ensuring appropriate levels of staffing, but also the upskilling and training of staff to be able to perform functions to the required technical and managerial levels. This will need to take place in alignment with the ongoing work to clarify institutional roles and responsibilities and will look to introduce training opportunities across institutions supported by a basin level capacity building framework. Thus, training interventions will support the ongoing development of a community of practice within the basin and will enable more effective inter-institutional functionality.		
10.1.3	Strengthen partnerships	
The importance of inter-sectoral engagement in water resource management and development has increasingly been recognised. This will support the development of more aligned planning approaches to both management and development, as well as provide additional capacity support when and where appropriate. This could also introduce efficiencies that adjust institutional capacity requirements. To this end, there is a need for the development of a partnership framework that provides the basis for the approach towards partnerships. This will then be implemented through the ongoing development of partnership arrangements over time.		

10.1.4	Strengthen stakeholder engagement
The importance of stakeholder engagement cannot be over emphasised. The improvement in the development of water resource management and development solutions, the improvement in alignment of operational activities and the development of a sense of ownership of the management regime all provide the basis for more robust and sustainable management. There is a clear understanding that there is a need to improve upon the levels of stakeholder engagement and this cuts across the various institutions that play a role in water resource management and development. In this regard, the development of an agreed upon basin-wide framework for engagement is a key first step, supported then by the implementation of this framework. A key element of this, will include improving the functionality of the existing forum.	
10.1.5	Improved research
Noting the impacts that climate variability and climate change will have upon the water resources of the LVS Basin, together with the need to support ongoing development, there will be an ongoing need to develop innovative solutions to the ongoing challenges of water resource management and development. Research towards finding these innovative approaches and technologies will become increasingly important. Developing the network of supporting research institutions will be an important step together with providing the appropriate communication and engagement channels that enables exchange of information. A key challenge has always been ensuring that the research agenda is supportive of the challenges that the sector is experiencing, and so the need to ensure ongoing exchange is critical.	
10.1.6	Innovative financing
Ensuring adequate financial resources to support integrated water resources management at the basin level is a significant challenge evidenced by the financial hurdles for catchment-based institutions such as the WRA ROs and SROs, the former CAACs and forums. Embracing innovative internal and external resource mobilisation strategies is needed. This needs to factor in new entities in the sector such as the County Governments and other water sector institutions. The private sector provides opportunities for innovative financing for water resources management and should therefore be explored to complement the budget allocated for water resources management from the national fiscus. Internal and external resource mobilisation strategies will be implemented concurrently because of the very crucial role financing plays as a key enabler for IWRM implementation.	

Image source: Bushtops Camps 2015 'Masai Mara Wildebeest Migration'. Available online at https://bushtopscamps.com/wp-content/uploads/2015/11/Masai-Mara-Wildebeest-Migration.jpg

Way Forward

7 Way Forward

7.1 Introduction

This section establishes a link between the findings and outcomes of the basin planning process and the effective implementation of the recommended strategies within the framework of IWRM. It provides a high-level summary of the main outcomes of the basin planning process, contextualises the Basin Plan and recommends specific interventions for implementation of the Plan.

It is imperative to note that monitoring and evaluation of the Basin Plan be done to ensure that implementation is on track, to measure short and long-term impacts and to evaluate the impacts in order to modify the plan or its implementation (if necessary). Monitoring and evaluation needs to be guided by an efficient, effective and sustainable M&E system. Formal monitoring results should be shared with wider stakeholders and funders.

It is also important to remember that the Plan is a “living document”, which should accommodate adjustments and/or updates. Ideally the Basin Plan should be reviewed and updated every five years.

7.2 Key Outcomes

The main challenges associated with water resources development and management in the LVS Basin relate to the spatial and temporal availability of water and the expected growth in water demand linked to population growth and socio-economic and irrigation development, which are exacerbated by various management and institutional challenges. The rationale for the development of this Basin Plan was to assess whether the basin’s water resources are sufficient to meet the expected growth in water requirements with 2040 as the planning horizon.

This Basin Plan is a key deliverable towards the overall objective of the KWSCRP namely to strengthen WRA’s capacity in terms of tools, skills and infrastructure to deliver on its mandate for water resources regulation in the country. It constitutes an Integrated Water Resources Management and Development Plan for the LVS Basin, which considers the environmental, social and economic aspects of the river basin, addresses the key issues and challenges, and ensures that these aspects are integrated into an overall management strategy. It aims to achieve a sustainable balance between the utilisation, development and protection of water resources and provides a clear pathway for the sustainable utilisation and development of the water resources of the LVS Basin.

The essence of the proposed water resources development plan for the LVS Basin, up to 2040, is to improve the reliability of supply to Kisumu and other urban centres; to provide storage for the expected growth in basin-wide urban water demands; to ensure a reliable water supply for the expansion of existing, and the proposed new, irrigation developments in the basin; to implement the identified schemes which will export water to the Rift Valley Basin; to improve existing and future water resources availability for smaller towns and basin-wide domestic, livestock and small-scale irrigation water demands; and to unlock socio-economic development through multi-purpose water resources development projects in the basin, including flood control schemes. This will necessitate the construction of small-scale and large-scale storage, transfer and regulation infrastructure and increased groundwater abstraction. In addition, water demand management will be required for both small and large-scale irrigation and for urban centres.

In order to comprehensively and systematically address the range of water resources related issues and challenges in the LVS Basin and unlock the value of water as it relates to socio-economic development, ten key strategic areas were formulated for the LVS Basin. Strategic themes and strategies under each Key Strategic Area along with a prioritised implementation / action plan were prepared. It is important to ensure that the implementation of the sub-plans, strategies, and actions emanating from this Basin Plan are aligned with relevant legislative, policy and institutional principles and guided by internationally accepted standards for good practice to attain the goals of social acceptability, economic viability and technical sustainability.

7.3 Context

Within a global context, the adoption of the United Nations Sustainable Development Goals (SDGs) (UN, 2015) is an opportunity to enact an integrated approach to water resources management. Consequently, the Key Strategic Areas (KSAs) which lie at the heart of the LVS Basin Plan provide various synergies with the SDGs. Furthermore, it is important to note that the successful implementation of the LVS Basin Plan will depend on the degree to which concurrent and future planning in the basin, at various levels, is aligned with the proposed sub-plans, strategies, and actions within the LVS Basin Plan.

7.3.1 Linkages with the sustainable development goals

Since adoption of the UN 2030 Agenda for Sustainable Development, the Government of Kenya, as a member of the United Nations, has committed to the integration of the SDGs into national and county policy and planning frameworks. The UN 2030 Agenda is based on global sustainable development goals and covers the five critical pillars: people, planet, prosperity, peace and partnerships. It contains 17 goals and 169 targets that provide broad guidelines for sustainable development. The 17 Goals are all interconnected and the aim is that these should be achieved by 2030. Although SDG 6 is directly related to water, under IWRM all the SDGs are considered important. This Basin Plan includes actions that not only address specific issues associated with each KSA, but also integrate measures to achieve a number of SDGs. Figure 7-1 shows the Integration of the SDGs into the Basin Plan.

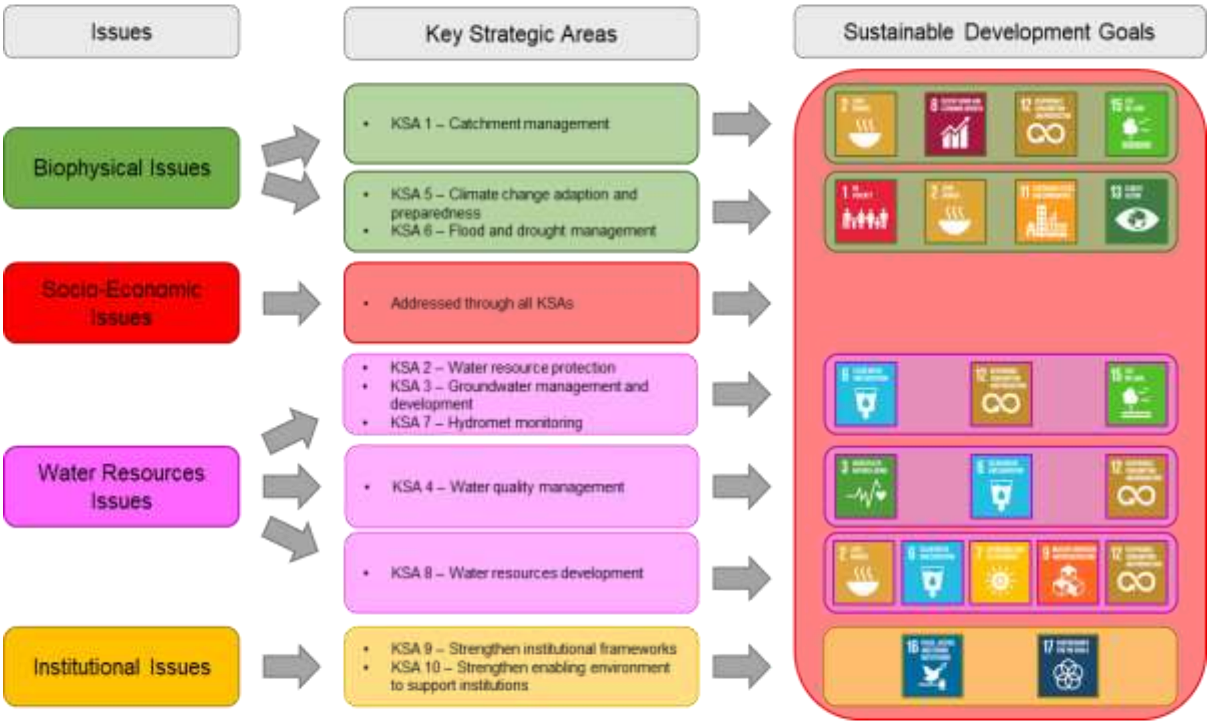


Figure 7-1: Integration of the SDGs into the LVS Basin Plan

7.3.2 Linkages with other plans

This LVS Basin Plan provides a vision and framework for the development and management of the water and related land resources of the LVS Basin. Essentially it reinforces the LVS CMS (2015-2022), supplements the NWMP 2030 and acts as a source of information for the development of Sub-catchment Management Plans (SCMPs), which Water User Associations (WRUAs) will implement. Whereas the Basin Plan contextualises the SCMPs, the SCMPs remain the resource mobilisation tools that WRUAs will use to source implementation funds and other resources. County governments are also involved in implementation activities, and as such will be required to review the Basin Plan and SCMPs to ensure that the County Integrated Development Plans (CIDPs) are linked and synchronised with the overall basin planning initiatives. Relevant Regional Development Authorities (LBDA) as well as the Water Works Development Agencies (LVSWWDA and RVWWDA) also need to review their proposed and existing projects to align with the investment plan as presented in the Basin Plan.

7.4 Roadmap for the Basin Plan

In order to ensure the successful implementation of the strategies and actions presented in the LVS Basin Plan as well as effective monitoring and evaluation thereof, institutional role players need to be coordinated, key institutions linked to implementation need to be strengthened, imminent infrastructure feasibility and impact assessments need to be started, the knowledge base presented in the basin plan needs to be expanded on, and financial resources need to be mobilised. In parallel, implementation of critical as well as longer-term activities must begin as soon as possible. These four steps are presented below and provide a roadmap to take the implementation of the basin plan forward. The following four sub chapters deal with each of these steps.

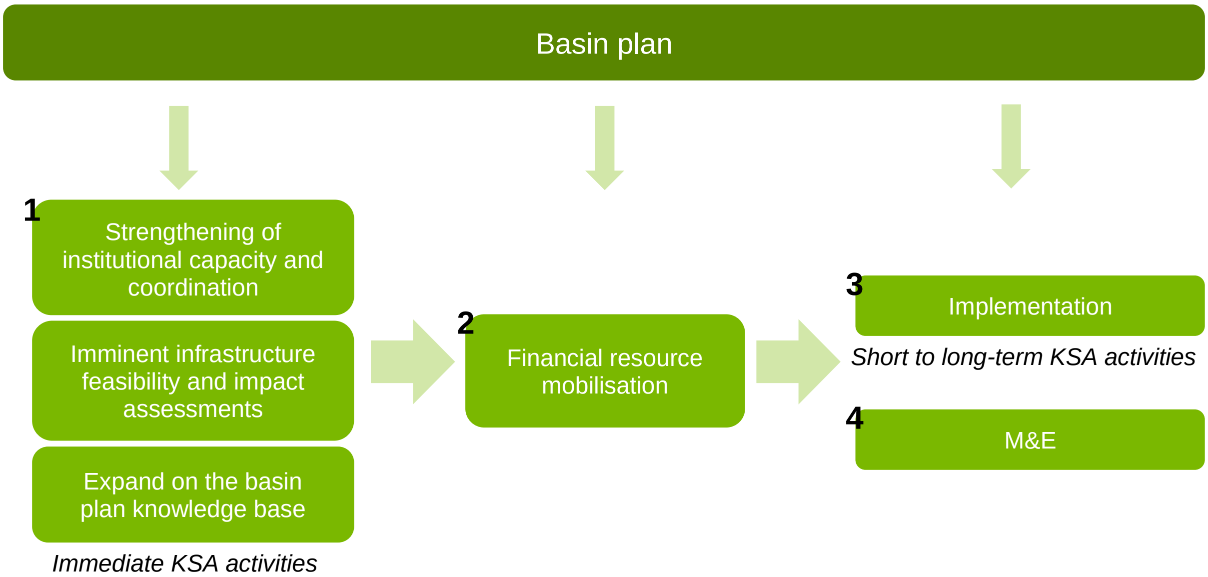


Figure 7-2: Roadmap for implementation of the Basin Plan

7.4.1 Immediate actions

7.4.1.1 Strengthening of institutional capacity and coordination

Strong institutions are necessary for effective governance. Not only must they be strong, but they must be well linked with partner institutions. On a national scale, there are many role players working in similar areas, and poor coordination can result in the duplication of efforts and failure of implementation. It is therefore not surprising that effective implementation must be rooted in strong institutions and partnerships.

Having strong institutions also provides invaluable benefits for securing external financing. When completing a risk assessment, strong institutions with good coordination mechanisms will have a much lower risk profile than their counterparts, making them an attractive investment opportunity for both development partners and the private sector.

IWRM requires the integration of various activities for the equitable and efficient management and sustainable use of water. There are many role players involved, at different scales (i.e. national to local scale), and before any activity is initiated it is critical to ensure that there are platforms in place for engagement.

The KSAs can also be used as a planning tool for key role players, without these institutions needing to sit in the same room. For example, should KFS want to implement a reforestation program, they can refer to the basin plan for information on which institutions and organisations they should collaborate with, and over what timelines implementation should take place.

Table 7-1:Implementation plan role players

		KSA1	KSA2	KSA3	KSA4	KSA5	KSA6	KSA7	KSA8	KSA9	KSA10
Ministries	MoWSI	☑	☐	☑	☑	☐	☑	☐	☑	☑	☑
	MoALF	☑	☐	☐	☑	☑	☑	☐	☑	☐	☐
	MoEF	☑	☐	☐	☑	☑	☐	☐	☐	☐	☐
	MoLPP	☑	☐	☐	☐	☑	☐	☐	☐	☐	☐
	MoICNG	☐	☐	☑	☐	☐	☐	☐	☐	☐	☐
	MoTIHUDPW	☐	☐	☐	☑	☑	☐	☐	☐	☐	☐
	MoH	☐	☐	☐	☑	☑	☑	☐	☐	☐	☐
	MoEn	☐	☐	☐	☐	☑	☐	☐	☑	☐	☐
	MoDASAL	☐	☐	☐	☐	☐	☑	☐	☐	☐	☐
National	WRA	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑
	AFA	☑	☐	☐	☑	☐	☐	☐	☐	☐	☐
	NEMA	☑	☑	☐	☑	☐	☐	☐	☑	☐	☐
	KWTA	☑	☐	☐	☐	☐	☐	☐	☐	☐	☐
	KFS	☑	☐	☐	☐	☑	☐	☐	☐	☐	☐
	NLC	☑	☐	☐	☐	☐	☐	☐	☐	☐	☐
	WASREB	☐	☐	☐	☑	☐	☐	☑	☑	☐	☐
	KNCPC	☐	☐	☐	☑	☐	☐	☐	☐	☐	☐
	KURA	☐	☐	☐	☑	☑	☐	☐	☐	☐	☐
	NECC	☐	☐	☐	☑	☐	☐	☐	☐	☐	☐
	EPRA	☐	☐	☐	☑	☐	☐	☐	☐	☐	☐
	KeRRA	☐	☐	☐	☑	☐	☐	☐	☐	☐	☐
	NIA	☐	☐	☐	☑	☐	☐	☐	☑	☐	☐
	PCPB	☐	☐	☐	☑	☐	☐	☐	☐	☐	☐
	KALRO	☐	☐	☐	☑	☐	☐	☐	☐	☐	☐
	NWHSA	☐	☐	☐	☐	☑	☐	☐	☑	☐	☐
	KenGen	☐	☐	☐	☐	☑	☐	☐	☑	☐	☐
	KMFRI	☐	☐	☐	☐	☐	☐	☐	☑	☐	☐
	KMD	☐	☐	☐	☐	☑	☑	☑	☐	☐	☐
	NDMA	☐	☐	☐	☐	☑	☑	☐	☐	☐	☐
	NDOC	☐	☐	☐	☐	☐	☑	☐	☐	☐	☐
	KPLCO	☐	☐	☐	☐	☑	☐	☐	☐	☐	☐
	CETRAD	☐	☐	☐	☐	☑	☐	☐	☐	☐	☐
Basin	BWRC	☑	☑	☑	☑	☐	☑	☐	☑	☑	☑
	WWDA	☑	☐	☐	☑	☐	☐	☑	☑	☑	☐
	DRMC	☐	☐	☐	☐	☑	☑	☐	☐	☐	☐
Local	CG	☑	☑	☑	☑	☑	☐	☐	☑	☑	☑
	WRUA	☑	☑	☑	☑	☑	☐	☑	☑	☑	☑

7.4.1.2 Imminent infrastructure feasibility and impact assessments

In addition to strengthening institutions and coordination, feasibility studies and impact assessments need to begin now for many large and important infrastructure projects, in order for construction to be completed timeously. In the LVS basin, feasibility studies should begin immediately with the large dams that scored the highest ranking in the scenario analysis. These include Magwagwa and Kibos dams. In addition, relevant studies and designs should immediately begin for the development of groundwater and small dams and pans. These are necessary for building the resilience of local communities and economies, including those that will eventually be supplied from large schemes.

7.4.1.3 Expand on the basin plan knowledge base

Several high-level studies were presented in this basin plan, such as those for determining groundwater availability, and climate change predictions. These are an important foundation but do require additional and more in-depth analysis. Strong scientific studies are a good tool to leverage external financial support and develop informed policies. Therefore, this should form the basis of all basin plan activities moving forward.

7.4.1.4 Immediate implementation activities

The timelines of the KSAs have been developed in such a way as to stagger the activity implementation across four planning horizons: immediate (2020 – 2022), short-term (2022 – 2025), medium-term (2025 – 2030) and long-term (2030 – 2040). The ‘immediate’ time-frame has specifically been developed to provide direction on which activities will be most beneficial to institutional strengthening.

These immediate activities will also require funding, and the key role players and other relevant partners should develop strategies for generating financing. However, it is likely that the financing may have to come from the institutions themselves. This can be considered as a long-term investment – by investing now in strengthening institutional capacity, finances will be more easily mobilised for future activities. These immediate activities are also relatively cheap in comparison to larger catchment size activities, or infrastructure activities.

Table 7-2: Immediate implementation activities linked to institutional strengthening

KSA	Priority activities (immediate)	% of total KSA budget
KSA 1 Catchment Management		7 %
- Increase awareness of sustainable catchment management with relevant ministries, WRUAs, CGs etc. through training, brochures, social media, internet, factsheets, forums and workshops. - Devolve ownership of catchment management activities to WRUAs through SCMP development. - Embed catchment-based water conservation and management activities related to crop and livestock production in SCMPs - Embed catchment-based soil conservation and management activities related to crop and livestock production in SCMPs - Embed conservation agriculture and improved farm management activities related to crop and livestock production in SCMPs - Coordinate approach to forestry management – roles, responsibilities and mandates		
KSA 2 Water resource protection		6 %
- Classify all significant water resources in the LVS Basin (conducted prior to Reserve and RQO determination) - Determine the Reserve for prioritised water resources in the LVS Basin (note Reserve required for RQOs) - Determine the Resource Quality Objectives for prioritised water resources in the LVS Basin		

KSA	Priority activities (immediate)	% of total KSA budget
KSA 3 Groundwater management		3 %
- Implement aquifer mapping and groundwater modelling across the LVS basin - Complete aquifer classification - Improve estimates of sustainable groundwater yield in priority areas using advanced techniques - Prepare groundwater abstraction plan and undertake groundwater abstraction and water quality survey - Undertake groundwater balance to determine sustainable yield available - For each aquifer in the basin, develop Allocation Plan and disaggregate to sub-basins		
KSA 4 Water quality management		2 %
- Implement national water quality monitoring programme in the LVS Basin by ensuring technical staff are capacitated and laboratories can analyse the samples accurately and on time - Ensure data submitted to Mike Info WQ database, and that the data are reviewed, analysed, reported on, and acted on by catchment staff - Develop capacity to undertake biomonitoring in Kenya to assess aquatic ecosystem health. - Identify streams in the Basin for piloting biomonitoring and undertake pilot studies - Compile an inventory of surface water pollution sources, especially in the upper LVS Basin - Upgrade central and regional laboratories in the Basin to support the national water quality monitoring programme - All historical and new water quality data collected by WRA in the basin stored in Mike Info - Advocate for alignment of strategies to serve a common purpose of rehabilitating urban rivers and streams in the Basin - Establish a coordination and cooperation mechanism to ensure there is alignment of actions to address water pollution management in the LVS Basin. - Embed water quality management activities related to domestic water use, crop and livestock production in SCMPs		
KSA 5 Climate change adaptation and preparedness		13 %
- Quantify climate change impacts (rainfall & temperature) on surface water and groundwater resources and demands in the LVS Basin at appropriate scales for planning and management - Assess potential social impacts: flooding; droughts; human conflict; migration; vulnerable groups; ocean acidification; agriculture; food production - Assess potential environmental impacts: droughts; sea temperature; rising sea levels; ocean acidification; desertification; lad degradation; loss of biodiversity; deforestation; forest degradation - Assess potential economic impacts: irrigation water requirements; crop type and yield; GDP; public Infrastructure; hydropower; coastal assets; livelihoods and income generation. - Incorporate flexible adaptation infrastructure principles in infrastructure planning and investment plans		
KSA 6 Flood and drought management		15 %
- Government institutions/agencies and other stakeholders with partnership roles in flood management will form the LVS Basin Flood Response Forum (FRF) under the auspices of the KMD to integrate all flood-relevant resource mobilisations and related interventions in the LVS Basin. - Establish a Secretariat for the LVS Basin FRF with accommodation in the WRA Regional Office. - Develop appropriate SOPs for the LVS Basin FRF. - Organisational alignment/ collaboration: The LVS Basin Flood Response Forum (FRF) will expand organisational capacity in the LVS Basin by aligning the flood response roles and responsibilities of the government institutions/agencies, International Relief Aid Agencies, Kenya Red Cross, NGOs and other stakeholders with partnership roles in flood management. - Establish a Secretariat for the LVS Basin DRF with accommodation in the Offices of one of the drought-prone counties. - Organisational alignment/ collaboration: Basin Drought Response Forum (DRF) will expand organisational capacity in the Basin by aligning the drought response roles and responsibilities of the government institutions/ agencies, International Relief Aid Agencies, Kenya Red Cross, NGOs and other stakeholders with partnership roles in drought management.		

KSA	Priority activities (immediate)	% of total KSA budget
KSA 7 Hydrometeorological Monitoring		3 %
- Develop implementation programme and implement metering of bulk water use and abstractions (surface and groundwater) - Use MIKE Info database developed under ISC for capturing, storing and managing all hydromet data. Data protocols and procedures with regard to data collection, transfer, capture, storage, quality control and dissemination should be evaluated, standardised and improved where necessary in accordance with international best practice. Technical and computing capacity for processing, analysis and reporting of data should be addressed and enhanced. - Use Knowledge base tools developed under ISC for dissemination of information products related to water resources management. - Use real-time system developed under ISC for accessing, visualizing and analysing hydromet observations in near real-time to inform decision making with regard to flood forecasting and water resources management.		
KSA 8 Water Resources Development		6 %
- Implement 4 large dams: complete relevant feasibility and impact studies and plans for schemes to be implemented soon - Develop programme for implementation of small dams & pans. Undertake relevant studies. Identify locations and types of dams to improve assurance of supply to local urban, domestic, small scale irrigation and livestock water users; complete relevant feasibility and impact studies and plans. - Phased design and construction of identified small dams / pans in accordance with proposed investment plan		
KSA 9 Strengthen the Institutional Frameworks		39 %
- Separate out regulatory and management functions of the Authority and provide different reporting lines for these. Parallel improvement and strengthening of the regulatory approaches utilised by the WRA. - Updating WRA's standards, policies and regulations in line with the WA2016 - Develop tools and systems to support implementation of the new legislative instruments - Hold stakeholder consultations for developing legislative instruments and implementation tools - Translate lessons learnt from CAACs into improved operational modalities. - Provision of secretariat services through Ros and SROs. - Appropriate channels formed for recommendations from BWRCs to be taken on board by WRA. - Clarify roles and responsibilities. - Introduce more structured strategic planning and operational engagement. - Develop a basin or sub-basin level platform for engagement with county government. - Strengthen linkages between county governments and WRUAs. - Develop a Policy on Transboundary Waters incorporating relevant elements of Treaty obligations - Updating WRA's standards, policies and regulations in line with the WA2016 - Complete the development of a National Policy for the Protection of Groundwater with all key stakeholders involved. - Review cross-sector policies, legislation and regulations relating to wastewater; streamline/clarify the roles of the Line Ministries, WRA, NEMA, the Counties and WSPs in relation to wastewater, to eliminate the dual mandates that the WRA and NEMA currently operate under in relation to 'polluter pays' and these agencies' revenue - Develop / Update Guidelines on: - Relevant Codes of Practice for Water Resources Planning and Management - Develop / Update National Manuals relevant to WRPM		

KSA	Priority activities (immediate)	% of total KSA budget
KSA 10 Strengthen the enabling environment to support institutions		21 %
- Development of technical and management capacity through focused training, continuous professional development, bursary schemes, audits, incentive schemes - Develop a partnerships framework - Identify potential partners - Strengthen existing partnerships, particularly on a local level - Undertake stakeholder consultations - Develop and strengthen guidelines for MOU drafting and development - Develop a basin-wide stakeholder engagement framework - Undertake stakeholder analysis - Implement the stakeholder engagement framework - Strengthen stakeholder engagement platforms i.e. forums - Strengthen links with tertiary education / research institutions - Incorporate R&D into WRM planning and decision making - Establish a network of supporting research institutions - Develop strategic partnerships for R&D - Promote innovative financing for basin level institutions (BWRCs, WRUAs, forums) - Develop internal resource mobilization strategies - Develop external resource mobilization strategies - Exploring private sector financing channels - Strategic partnerships for resource mobilization		

7.4.2 Financial Resource Mobilisation

Resource mobilisation refers to the various activities involved in making better use of existing resources to maximum benefit, whilst ensuring the ongoing acquisition of additional resources to ensure the achievement of organisational intent. These resources include financial resources, but also includes human resources and their organisational management, equipment, services, and technical cooperation. The range of these resources and their impact is outlined in the resource mobilisation position paper that is part of this consultancy.

Section 3 outlined the importance of developing strong institutions for financing. Part of this strengthening refers to developing the human and organisational resources. While this is a vital component, financial resources are needed to strengthen these other resources, as well as implement projects.

A review of successive WRA performance reports reflects the challenges that WRA has faced financially, and shows successive funding gaps (WRA, 2017). These have considerable institutional implications for the WRA that require consideration in developing an approach to not only strengthen the WRA, but to also underpin this with a sustained funding regime. Without this strategic intent to coherently develop the business model together with resource mobilization, the overall sustainability of the institution is at risk.

There are numerous forms of external financing, each with their own type of stakeholders and investment mechanisms.

- Innovative financing avenues can include philanthropic and public, water funds and facilitates, payment for ecosystem services, effluent charges, climate change funding schemes, carbon finance, corporate grants, impact investments and conservation finance.
- The key stakeholders and partners for these avenues can include development agencies, governments, multilateral development banks, public private partnerships, private or state banks, private sector, NGOs, asset managers and international councils and secretariats.
- The investment mechanisms can include grants, subsidies, guarantees, soft/hard loans, guaranteed philanthropy, result based payments, equity, loans, environmental impact bonds and microfinance.

It is important to note that different KSA activities will require different levels of partnership and will therefore have to tap into different financing avenue. Using the resource mobilization strategy as a base, it will be necessary for the WRA or the key implementing agency (as outlined in the KSA) to develop a resource mobilization and financier engagement strategy that is applicable to each specific activity.

7.4.3 Implementation

Having initiated the coordinated strengthening of institutional capacity as well as resource mobilisation as immediate critical actions (discussed in Section 7.4.2), other activities in each KSA should be considered for implementation. These activities are typically costlier and have a longer implementation horizon. They also often deal with more physical interventions, and therefore require a stronger local presence and engagement.

An Implementation Plan for each KSA for the LVS Basin is presented in **Annexure E**, which provides a clear intent and prioritised plan of action. The implementation plan is set up considering implementation:

- theme priority (i.e. critical, very important, important)
- activities (i.e. implementation actions)
- indicators to measure outcomes of activities (refer to Section 7.4.4)
- implementation horizon (i.e. immediate (1-2yr), short (2-5yr), medium (6-10yr) or long (11-20yr) term)
- responsibility for activity (i.e. at the basin scale, national scale, local scale and key stakeholders)
- estimated budgets for implementation of activities are provided (summarised in Table 7-3) with possible funding sources per activity identified
- Corresponding CMS Strategic Actions are linked to each activity.

7.4.4 Monitoring and Evaluation

Monitoring and evaluation (M&E) is essential to ensure that plan implementation is on track, to measure short and long-term impacts and to evaluate the impacts in order to modify the plan or its implementation (if necessary) (Global Water Partnership, 2006). M&E systems can be costly and often require significant human, data and financial resources. However, the cost of no M&E may be considerably higher when Basin Plan implementation is inefficient and ineffective. It is therefore necessary to develop an efficient, effective and sustainable M&E system, which can be implemented within existing or planned for resources and line functions. Interpreting and acting on the data is as important as data collection.

It is extremely important that the KSAs are monitored and evaluated on a regular basis. How often, and when, monitoring is carried out will be dictated by what is being measured (i.e. environmental improvements will have different timescales to budget expenditure). M&E will also provide an indication of where delays or diversions are being experienced. Monitoring also provides an evidence base to show funders that their money is being used effectively, to identify where more funding is required to tackle new issues or try new actions where stubborn problems remain. Formal monitoring results are often shared with wider stakeholders and funders, whilst informal monitoring will be restricted to those managing the process.

Lastly, and most importantly, the KSAs and Plans are “living documents” and should not stay static, as circumstances are not static. M&E allows for timely adjustments and/or updates. Ideally the Basin Plan should be reviewed and updated every five years – using the results of monitoring to identify what can and cannot be achieved when revising the plan.

7.4.4.1 Monitoring Framework

Key components of a M&E include the selection of M&E indicators and ensuring feedback of the results into the decision-making and implementation processes. A proper M&E system, whose results are shared among stakeholders, also fosters accountability and transparency, and is likely to generate broad-based support for Basin Plan implementation. M&E will aid the successful implementation of the Basin Plan by ensuring that targets and goals set out in the plan are achieved and that problems regarding implementation are detected early and addressed.

7.4.4.2 Targets and indicators

Monitoring of the LVS Basin Plan and achievements should be done on the basis of the Implementation Plan (refer to **Annexure E**) and should be guided by the specific result-based targets/indicators described in the Implementation Plan. This will include M&E of progress in terms of implementation programmes and actual against planned expenditure, among others. For individual projects/programmes, more detailed step-wise M&E indicators could be identified for each projects/programme so that progress can be adequately tracked and evaluated. The evaluation will be based on the monitoring results and possible additional data collected and will provide feedback into the decision-making process which could lead to adjustments in the plan and its implementation

Table 7-3: Summarised Basin plan budget under the 10 Key Strategic Areas

Key Strategic Areas and Themes		Budget (USD Million)				
		2020-2022	2022-2025	2025-2030	2030-2040	**Total**
KSA 1	Catchment management Promote improved and sustainable catchment management Sustainable water and land use and management practices Natural resources management for protection & sustainable use Rehabilitation of degraded environments	5.5	31.3	27.5	20.2	**85**
KSA 2	Water resources protection Classification of water resources Reserve determination Determine Resource Quality Objectives Conserve and protect ecological infrastructure	0.3	0.8	1.8	1.9	**5**
KSA 3	Groundwater management and development Groundwater resource assessment, allocation and regulation Groundwater development Groundwater asset management Conservation and protection of groundwater	5.0	45.1	37.4	50.8	**138**
KSA 4	Water quality management Effective data collection, information generation, dissemination, knowledge management Promote sound water quality management governance Efficient and effective management of point and nonpoint sources of water pollution	3.8	24.8	71.1	94.6	**194**
KSA 5	Climate change adaptation and preparedness Understand impacts of climate change on water resources at appropriate spatial scales Climate change mitigation Climate change adaptation	3.9	10.4	10.3	7.1	**32**
KSA 6	Flood and drought management Flood management	6.6	27.6	3.2	5.6	**43**

Key Strategic Areas and Themes		Budget (USD Million)				
		2020-2022	2022-2025	2025-2030	2030-2040	**Total**
	Drought management					
KSA 7	Hydromet monitoring Improved monitoring network Improved information management	1.0	13.6	10.0	6.0	31
KSA 8	Water resources development Surface water resource assessment, allocation and regulation Water resources planning Water storage and conveyance Groundwater development Hydropower development Water for agriculture Water based tourism and recreation Non-conventional water resources Water resources systems operation	204	1 507	902	1 559	4 173
KSA 9	Strengthen Institutional frameworks Promote improved and sustainable catchment management Guidelines, codes of practice and manuals	4.7	2.6	2.7	2.0	12
KSA 10	Strengthen enabling environment to support institutions Develop institutional capacities to support improved IWRM&D	5.3	9.0	4.4	6.0	25
	Total	**240**	**1 672**	**1 070**	**1 753**	**4 735**

7.4.4.3 Reporting and Dissemination

The reporting system, to be implemented by the responsible authority under each Activity, would have to be designed in such a way that progress is tracked, and that problems encountered, and the measures taken to address the problems, are reported on a quarterly and annual basis. In addition, systematic periodic evaluation and objective assessment of the progress made towards the achievement of the overall goal and vision will have to be done.

Reporting takes two forms. The first relates to reporting on progress on the Implementation Plan as a whole. This should be undertaken by a task team that meets bi-annually. The second relates to the reporting on the achievement of the specific actions and targets. It is important to report on progress of the activities and targets using the indicators. The timeframe for carrying out assessments must be realistic, i.e. it must provide time for projects to be implemented and take effect. A standard reporting timeframe is 2-3 years, depending on the targets and the longevity of the Implementation Plan. It is important to note that the institutions that were tasked specific activities are responsible for reporting on the activity specific indicators. This may result in several institutions reporting on the same target.

It is important to ensure the effective communication of progress against the targets, to all stakeholders involved, as well as the general public is carried out in order to build trust in the Basin Plan. Communication can take the form of newspaper articles, an updated progress chart on a webpage or regular newsletter. The overall responsibility for the development of the M&E component should sit with WRA and it would be outlined in the Institutional Organisation and Governance Strategy. Data and information needs would have to be coordinated with the Information Management Strategy, while WRA would be responsible for ensuring implementation and coordinating or carrying out the actual monitoring on a regular basis.

The format of a M&E Sheet would be similar to the implementation tables (**Annexure E**). This is then used as a scorecard and can be kept as records to follow progress. It useful to have the activities in time-order as well i.e. short, medium and long, so it is easy to follow what should be done immediately. A scoring matrix would be needed, so that the same rating can be used in the future which is not subjective. Possible scoring types could include:

- Measurement against set targets, e.g. expressed as % or numbers achieved
- Fixed measurement e.g. hectares or number of schemes
- Qualitative / subjective evaluation, which could e.g. be on a scale from 1 to 5

An M&E example from the implementation plan is shown in Table 7-4 below.

Table 7-4: Monitoring and Evaluation example

Key Strategic Area 1:		Catchment Management						
Strategic Objective:		To ensure integrated and sustainable water, land and natural resources management practices						
Strategic Theme 1.2:		Sustainable water and land use and management practices						
Theme priority:		Critical						
Strategy		**Activities**	**Indicators (M&E)**	**Timeframe**	**Responsibility**			
					National	Basin	Local	Other
1.2.1	Promote water conservation and management at catchment level	Embed catchment-based water conservation and management activities related to crop and livestock production in SCMPs: E.g. improved water use efficiency; water harvesting and storage; groundwater protection and infiltration	Improved understanding of water conservation and management; Reduction in water use; Increased water storage and water availability in the sub-catchment; Increased groundwater recharge	Immediate	WRA MoWSI KWTA MOALF	BWRC WWDA	WRUA CG	CBO
		Promote catchment-based water conservation and management principles with relevant MDAs through training, forums and conferences.	Level of awareness regarding water conservation and management; Number trainings/forums/conferences held	Short-term	WRA MoWSI MoALF KWTA	BWRC WWDA	CG WRUA	CBO KALRO

An example associated M&E sheet is shown in Table 7-5.

Table 7-5: Monitoring and Evaluation example sheet

Key Strategic Area 1:		Catchment Management				
Strategic Objective:		To ensure integrated and sustainable water, land and natural resources management practices				
Strategic Theme 1.1:		Rehabilitation of degraded environments				
Theme priority:		Important				
Strategy		**Activities**	**Indicators (M&E)**	**Scoring**	**Notes/Progress**	**Date**
1.2.1	Promote water conservation and management at catchment level.	Embed catchment-based water conservation and management activities related to crop and livestock production in SCMPs: E.g. improved water use efficiency; water harvesting and storage; groundwater protection and infiltration	Improved understanding of water conservation and management	No. of programs	Note on the improved understanding	Capture date
			Reduction in water use	Water use	Note on the water use reductions related to individual activities	Capture date
			Increased water storage and water availability in the sub-catchment	Water availability	Note on activities related to increased water storage and water availability	Capture date
			Increased groundwater recharge	Groundwater use	Notes on activities related to groundwater recharge	Capture date
		Promote catchment-based water conservation and management principles with relevant MDAs through training, forums and conferences.	Level of awareness regarding water conservation and management;	No. of programs	Note on the improved awareness	Capture date
			Number trainings/forums/conferences held	No. of training/forum/conference	Notes on improved awareness	Capture date

Image source: ICRAF (Nairobi) 'Nyando mouth at the inflow into Lake Victoria, Kenya'. Available online at https://commons.wikimedia.org/wiki/File:Nyando_mouth.JPG

08

Conclusion

8 Conclusion

Integrated Water Resources Management is based on the equitable and efficient management and sustainable use of water. It recognises that water is an integral part of the ecosystem, a natural resource, and a social and economic good, whose quantity and quality determine the nature of its utilisation (Global Water Partnership, 2006)(Global Water Partnership, 2006). This emphasises the importance of an integrated approach towards water resources planning, development and management - focusing on an enabling environment, institutional framework and setting up the management instruments required by institutions to understand mandates, roles and responsibilities to effectively and seamlessly do their job.

The LVS Basin Plan provides a status quo of the current water resources management situation and a plan for future management. There is no correct administrative model, but the principles of IWRM allow for selecting, adjusting and applying a mix of tools for a given situation and agreeing on milestones and timeframes critical for success.

This Basin Plan is a key deliverable towards the overall objective of the KWSCRP namely to strengthen WRA's capacity in terms of tools, skills and infrastructure to deliver on its mandate for water resources regulation in the country. It constitutes an Integrated Water Resources Management and Development Plan for the LVS Basin, which considers the environmental, social and economic aspects of the river basin, addresses the key issues and challenges, and ensures that these aspects are integrated into an overall management strategy. It aims to achieve a sustainable balance between the utilisation, development and protection of water resources and provides a clear pathway for the sustainable utilisation and development of the water resources of the LVS Basin.

9 References

Agriculture and Food Authority. 2017. *2017/18 – 2021/22 Strategic Plan*.

AGROSS. 2001. *Guidelines for Assessing the Risk to Groundwater from On-Site Sanitation - Commissioned Report CR/01/142*.

Birdlife International. 2019a. *Lake Victoria Data Fact Sheet*. [Online], Available: https://www.birdlife.org/datazone/sitefactsheet.php?id=6412.

Birdlife International. 2019b. *Important Bird Areas Factsheet: Kusa Swamp*. [Online], Available: https://www.birdlife.org/datazone/sitefactsheet.php?id=6412 [2020, March 04].

Blandenier, L. 2015. Recharge Quantification and Continental Freshwater Lens Dynamics in Arid Regions: Application to the Merti Aquifer (Eastern Kenya). University of Neuchâtel, Switzerland.

Borst, L. & de Haas, S.A. 2006. Hydrology of Sand Storage Dams: A case study in the Kiindu Catchment, Kitui District, Kenya. Vrije Universiteit Amsterdam.

Braid, S.G. & Lodenkemper, L.K. 2019. *Catchment Management Guidelines and Training Report No K5/2508*. Pretoria.

Colvin, C., Cave, L. & Saayman, I. 2004. *A Functional Approach to Setting Resource Quality Objectives for Groundwater Report No. 1235/1/04*. Pretoria.

Commission on Revenue Allocation. 2013.

County Government of Bomet. 2018. *County Integrated Development 2018-2022*.

County Government of Homa Bay. 2018. *Second County Integrated Development 2018-2022 (Draft)*.

County Government of Kericho. 2018. *Second Generation County Integrated Development 2018-2022*.

County Government of Kisii. 2018. *County Integrated Development 2018-2022*.

County Government of Kisumu. 2018. *County Integrated Development Plan 2018-2022*.

County Government of Migori. 2018. *County Integrated Development 2018-2022*.

County Government of Nakuru. 2018. *Nakuru County Integrated Development Plan 2018-2022*.

County Government of Nandi. 2018. *County Integrated Development Plan 2018-2023*.

County Government of Narok. 2018. *County Integrated Development 2018-2023*.

County Government of Nyamira. 2018. *County Integrated Development 2018-2023*.

County Government of Siaya. 2018. *County Integrated Development Plan 2018-2022*.

Darcy, H. 1856. *Les Fontaines Publiques de la Ville de Dijon (The Public Fountains of the City of Dijon)*. Dalmont, Paris.

Davies, R. 2017. *Kenya – Deadly Floods in Mombasa After 235mm of Rain, Thousands Displaced in Taveta*. [Online], Available: http://floodlist.com/africa/kenya-mombasa-may-2017 [2017, May 11].

Department of Water Affairs. 2007. *Development of the water resource classification system: overview and 7-step classification procedure*. Pretoria.

Department of Water Affairs. 2011. *Procedures to develop and implement Resource Quality Objectives*. Pretoria.

Development Initiatives. 2017. *Assessment of Kenya's preparedness to disasters caused by natural hazards: floods, drought and disease outbreak*. Bristol.

DHV Consultants. 1988a. *Rural Domestic Water Resources Assessment: Siaya District*.

DHV Consultants. 1988b. *Rural Domestic Water Resources Assessment: Kisumu District*. Kisumu.

Duguma, L., Atela, J., Minang, P., Ayana, A., Gizachew, B., Nzyoka, J. & Bernard, F. 2019. Deforestation and Forest Degradation as an Environmental Behavior: Unpacking Realities Shaping Community Actions. *Land*. 8(26):1–17.

East Africa Natural History Society. 2017. *Maasai Mara National Reserve: IBA IN FOCUS*. [Online], Available: https://naturekenya.org/2017/08/16/maasai-mara-national-reserve-iba-in-focus/.

Foster, S.S.D. 2000. *Sustainable Groundwater Exploitation for Agriculture: Current Issues and Recent Initiatives in the Developing World*. Madrid.

Gathura, G. 2015. Scientists warn El Nino to be worse than 1997/98. *The Standard* (Nairobi). 20 September. [Online], Available: https://www.standardmedia.co.ke/article/2000176966/scientists-warn-el-nino-to-be-worse-than-1997-98.

Gichana, Z.M., Nijru, M., Raburu, P.O. & Masese, F.O. 2014. Effects of Human Activities on Microbial Water Quality in Nyangores Stream, Mara River Basin. *International Journal of Scientific & Technology Research*. 3(2):153–157.

Gichere, S.K., Olado, G., Anyona, D.N., Matano, A.-S., Dida, G.O., Abuom, P.O., Amayi, J., Ofulla, A.V.O., et al. 2013. Effects of drought and floods on crop and animal losses and socio-economic status of households in the Lake Victoria Basin of Kenya. *Journal of Emerging Trends in Economics and Management Sciences*. 4(1):31–41. [Online], Available:

https://journals.co.za/content/sl_jetems/4/1/EJC132592 [2020, March 04].
Global Water Partnership. 2006. *Policy Brief 4: How IWRM Will Contribute to Achieving the MDGs*.
Government of Kenya. 1975. *Migori-Kihancha Regional Master Plan, Water and Land Utilisation - Supporting Report Volume 2*.
Government of Kenya. 1989. *The Fisheries Act*. Kenya.
Government of Kenya. 1999a. *Sessional Paper No. 1 of 1999 on National Policy on Water Resources Management and Development*. Nairobi.
Government of Kenya. 1999b. *The Environmental Management and Co-ordination Act*. Kenya.
Government of Kenya. 2002. *The Water Act*. Kenya.
Government of Kenya. 2003. *Economic Recovery Strategy for Wealth and Employment Creation 2003-2007*. Nairobi.
Government of Kenya. 2005. *The Forests Act*. Kenya.
Government of Kenya. 2006a. *The Energy Act*. Kenya.
Government of Kenya. 2006b. *The National Water Resources Management Strategy*. Nairobi.
Government of Kenya. 2006c. *Environmental Management and Co-ordination (Water Quality) Regulations*. Kenya.
Government of Kenya. 2007a. *Kenya Vision 2030*.
Government of Kenya. 2007b. *The Water Resources Management Rules*. Kenya.
Government of Kenya. 2009. *Interim Report on Irrigation and Drainage Master Plan, 2009*. Nairobi.
Government of Kenya. 2010a. *The Constitution of Kenya*. Kenya.
Government of Kenya. 2010b. *Agricultural Sector Development Strategy 2010-2020*. Nairobi.
Government of Kenya. 2010c. *The National Climate Change Response Strategy*. Nairobi.
Government of Kenya. 2012a. *The Water Resources Management (Amendment) Rules*. Kenya.
Government of Kenya. 2012b. *Government of Kenya Adaptation Technical Analysis Report*.
Government of Kenya. 2013a. *National Environment Policy*. Nairobi: Ministry of Environment, Water and Natural Resources. [Online], Available: www.environment.go.ke.
Government of Kenya. 2013b. *The Agriculture, Fisheries and Food Authority Act*. Kenya.
Government of Kenya. 2013c. *The Crops Act*. Kenya.
Government of Kenya. 2013d. *The Irrigation Act*. Kenya.
Government of Kenya. 2013e. *The National Climate Change Action Plan 2013-2017*. Nairobi.
Government of Kenya. 2014. *The Natural Resources (Benefit Sharing) Bill*. Nairobi.
Government of Kenya. 2015. *National Energy and Petroleum Policy - Final Draft*. Nairobi: Government of Kenya.
Government of Kenya. 2016a. *The Water Act*. Kenya.
Government of Kenya. 2016b. *The Forest Conservation and Management Act*. Kenya.
Government of Kenya. 2016c. *Kenya National Adaptation Plan 2015-2030*. Nairobi.
Government of Kenya. 2017a. *Sector Plan for Environment, Water and Sanitation 2018-2022 (Draft of 13th of June 2017)*. Nairobi.
Government of Kenya. 2017b. *Ending Drought Emergencies in Kenya - Progress Report*. Nairobi.
Government of Kenya. 2018a. *The Division of Revenue Act*. Kenya.
Government of Kenya. 2018b. *The Natural Resources (Benefit Sharing) Bill*. Nairobi.
Government of Kenya. 2018c. *The National Climate Change Action Plan 2018-2022*. Nairobi.
Government of Kenya. 2019a. *The Irrigation Act*. Kenya.
Government of Kenya. 2019b. *The National Disaster Management Authority Bill*. Nairobi.
Huho, J.M., Mashara, J.N. & Musyimi, P.K. 2016. Profiling Disaster in Kenya and their Causes. *Academic Research International*. 7(1):290–305.
Institute of Economic Affairs. 2015. *Situational Analysis of Energy Industry, Policy and Strategy for Kenya*. Nairobi.
International Federation of Red Cross. 2016a. *Emergency Plan of Action (EPoA) Kenya: Floods - 4 January 2016*.
International Federation of Red Cross. 2016b. *Emergency Plan of Action Final Report Kenya / Floods*.
IPPC. 2014.
Jones, A., Breuning-Madsen, H., Brossard, M., Dampha, A., Deckers, J., Dewitte, O., Gallali, T., Hallett, S., et al. 2013. *Soil Atlas of Africa*.
Kanoti, J., Olago, D., Opiyo, N., Nyamai, C., Dulo, S., Ayah, R. & Taylor, R. 2019. Microbial and Physical Chemical Indicators of Groundwater Contamination in Kenya: A Case Study of Kisumu Aquifer System, Kenya. *Journal of Water Resource and Protection*. 11:404–418.
Kenya Bureau of Standards. 2007. *Drinking Water – Specification, Part 1: The Requirements for Drinking Water (KS 459-1:2007)*. Nairobi.
Kenya National Bureau of Statistics. 2019. *2019 Kenya Population and Housing Census Volume I:*

Population by County and Sub-County. [Online], Available: https://www.knbs.or.ke/?wpdmpro=2019-kenya-population-and-housing-census-volume-i-population-by-county-and-sub-county [2020, March 03].

Kenya National Bureau of Statistics & Ministry of Devolution and Planning. 2018. *Kenya Integrated Household Budget Survey 2015-2016*.

Kimani-Murage, E.W. & Ngindu, A.M. 2007. Quality of water the slum dwellers use: the case of a Kenyan slum. *Journal of Urban Health: Bulletin of the New York Academy of Medicine*. 84(6):829–838.

Kusek, J.Z. & Rist, R.C. 2004. *A Handbook for Development Practitioners: Ten Steps to a Results-Based Monitoring and Evaluation System*. Washington, DC.

Levine, S. & Pavanello, S. 2012. *Rules of the Range - Natural resources management in Kenya-Ethiopia border areas: HPG Policy Brief 45*.

Matheka, B. 2019. Itare Dam scandal: Elders opposed construction. *Daily Nation*. 22 February. [Online], Available: https://www.nation.co.ke/news/Elders-opposed-construction-Itare-Dam/1056-4994344-y0iwetz/index.html.

McCall, G.J.H. 1958. *Geology of the Gwasi Area - Report No. 45*. Nairobi.

Ministry of Energy. 2004. *Sessional Paper No.4 on Energy*. Nairobi.

Ministry of Water and Irrigation. 2005.

Ministry of Water and Irrigation. 2012.

Ministry of Water and Irrigation. 2013.

Misati, A.G. 2016. Household safe water management in Kisii County, Kenya. *Environmental Health and Preventive Medicine*. 21(6):450–454.

Mosonik, C.B. 2015. Assessment of Fluoride Levels in Different Water Sources in Lower Region of Bomet County, Kenya and Remediation Using Moringa Oleifera Seed Cake. Jomo Kenyatta University of Agriculture and Technology.

Muchira, N. 2019. Kenya, Tanzania clash over planned dams on the Mara. *The East African*. 4 May. [Online], Available: https://www.theeastafrican.co.ke/news/ea/Kenya-Tanzania-clash-over-planned-dams-on-the-Mara-/4552908-5100248-6xophkz/index.

Mumma, A., Lane, M., Kairu, E., Tuinhof, A. & Hirji, R. 2011. *Kenya Groundwater Governance Case Study*. Washington, DC. [Online], Available: http://documents.worldbank.org/curated/en/2011/06/16583819/kenya-groundwater-governance-case-study.

Mutiso, S. 2003. The significance of sub-surface water storage in Kenya. in *Management of aquifer recharge and subsurface storage: making better use of our largest reservoir* Internatio ed. A. Tuinhof & J.P. Heederik (eds.). Utrecht: Netherlands National Committee for the IAH.

Mutua, F.M. 2001. *Report on the impacts of climate change on water resources in the Kenya*.

National Environment and Management Authority. 2007. *National Sand Harvesting Guidelines 2007*.

National Environment and Management Authority. 2011. *PRESS RELEASE: NEMA Orders Those Encroaching into Wetlands and Adjacent Riparian Land to Vacate*. [Online], Available: https://www.savelamu.org/nema-orders-those-encroaching-into-wetlands-and-adjacent-riparian-land-to-vacate/.

National Water Conservation & Pipeline Corporation. 2006. *Artificial Groundwater Recharge (AGWR) Draft Final Report*.

Ngure, V., Lelo, F. & Obwanga, B. 2017. Heavy Metal Pollution from Migori Gold Mining Area, Kenya: Health Implications for Consumers of Fish and Water. *Journal of Natural Sciences Research*. 7(6):46–53.

Nijsten, G.-J., Christelis, G., Villholth, K.G., Braune, E. & Gaye, C.B. 2018. Transboundary aquifers of Africa: Review of the current state of knowledge and progress towards sustainable development and management. *Journal of Hydrology: Regional Studies*. 20:21–34.

Nyabayo, C.J., Chemoiwa, E.J., Mwamburi, L., Jepkogei, R.M. & Kimutai, A. 2016. The effects of vertical and horizontal separations between pit latrine and hand dug well on contamination water by human fecal matter in Bomachoge Borabu, Kenya. *International Journal of Bioassays*. 5:4782–4790.

Nyairo, W., Philip, O. & Kengara, F. 2015. Effect of anthropogenic activities on the water quality of Amala and Nyangores tributaries of River Mara in Kenya. *Environmental Monitoring and Assessment*. 187:691.

Oballa, P.O., Konuche, P.K.A., Muchiri, M.N. & Kigomo, B.N. 2010. *Facts on Growth and Use of Eucalyptus in Kenya*. Nairobi.

OCHA. 2013. *Eastern Africa: Floods Update (as of 17 May 2013)*.

OCHA. 2018. *Flash Update #6 - Floods in Kenya*.

Ogola, J.S., Mitullah, W. V & Omulo, M.A. 2002. Impact of Gold mining on the Environment and Human Health: A Case Study in the Migori Gold Belt, Kenya. *Environmental Geochemistry and Health*. 24(2):141–157.

Okoth, M. 2011. Determination of Selected Heavy Metal levels in Underground Water and Soil and Analysis of Water Hardness Sources In Nyatike-Karungu Divisions. Egerton University.

Olago, D. 2018. Constraints and solutions for groundwater development, supply and governance in urban areas in Kenya. *Hydrogeology Journal*. (December, 1):1–20.

Onditi, C.O. 2015. Community Water Supply Management Case Study: Nyasare Water Supply Association In Migori County. University of Nairobi.

Onyango, O.R. 2014. Assessment of Groundwater Quality and Quantity in Migori Town, Migori County, Kenya. University of Nairobi.

Oord, A. 2017. *Hydrology and hydrogeology of Sponge City Kajiado, Kenya*.

Opere, A. 2013. Chapter 21 - Floods in Kenya. in *Kenya: A Natural Outlook* Vol. 16. P. Paron, D.O. Olago, & C.T. Omuto (eds.). Elsevier. 315–330.

Orwa, E.O. 2001. Groundwater Quality in Manyatta and Migosi Estates of Kisumu Town. Moi University.

PACT and Alliance for Responsible Mining. 2018. *Economic Contributions of Artisanal and Small-Scale Mining in Kenya: Gold and Gemstones*.

Prasad, H. & Obiero, K. 2014. Sustainable use of groundwater resources: A case study of spring and gravity water in River Gucha-Migori catchment, Western Kenya. *Hydrology: Current Research*. 5(4):149.

Raballa, V. 2018. Kisumu plans Sh800m sewage treatment plant. *Business Daily*. 10 April. [Online], Available: https://www.businessdailyafrica.com/news/counties/Kisumu-plans-Sh800m-sewage-treatment-plant/4003142-4381354-ityuc8/index.html.

Regional Centre for Mapping of Resources for Development. 2018. *Mapping for Sustainable Development*. [Online], Available: https://www.rcmrd.org/.

Regional Land Management Unit. 2003.

Reliefweb. 2013. *Kenya: Floods - March 2013*. [Online], Available: https://reliefweb.int/disaster/fl-2013-000038-ken.

Reliefweb. 2018. *Kenya: Drought - 2014-2018*. [Online], Available: https://reliefweb.int/disaster/dr-2014-000131-ken.

Rendilicha, H.G., Home, P.G. & Raude, J.M. 2018. A review of groundwater vulnerability assessment in Kenya. *Acque Sotterranee - Italian Journal of Groundwater*. 7:7–13.

Saggerson, E.P. 1966. *Geology of the Loita Hills Area - Report No. 71*. Nairobi.

Saunders, J., Menezes, A., Aguilar-Manjarrez, J. & Matere, J. 2017. *Atlas of aquaculture potential in coastal Kenya*. Rome.

Shackleton, R.M. 1946. *Geology of the Migori gold belt and adjoining areas (with coloured maps) Report No. 10*. Nairobi: Government of Kenya.

South African National Biodiversity Institute. 2013. *“Ecological Infrastructure: Nature Delivering Services”, Fact Sheet Produced by SANBI’s Grassland Programme and the CSIR’s ProEcoServ Project*. Pretoria.

Sumita, Y. & Mamoru Watanabe, S.S. 2017. Paddy Irrigation Development Considering the Rice Value Chain in the Lake Victoria Basin of Kenya.

The World Bank. 2008. *Toolkit for monitoring and evaluation of agricultural water management projects*. Washington, DC.

UN. 2015. *Sustainable Development Goals*. [Online], Available: https://sustainabledevelopment.un.org/sdgs [2020, March 09].

UNDP. 2011. *Human Development Report 2011 - Sustainability and Equity: A Better Future for All*. New York.

Wafula, P. 2010. Lack of investment in water sector leaves Kenyan towns parched. *Business Daily* (Nairobi). 16 July. [Online], Available: https://www.businessdailyafrica.com/news/539546-958756-pssc71/index.html.

Wagah, G., Onyango, G. & Kibwage, J. 2010. Accessibility of water services in Kisumu municipality, Kenya. *Journal of Geography and Regional Planning*. 3:114–125.

Water Resources Authority. 2018a. *Water Resources Situation Report, July 2017 to June 2018*. Nairobi.

Water Resources Authority. 2018b. *Code of Practice for the Siting of Boreholes*. Nairobi.

Water Resources Authority. 2018c. *Code of Practice for the Pumping Test of Boreholes*. Nairobi.

Water Resources Authority. 2018d. *Code of Practice for Supervision of Borehole Construction and Pumping Tests*. Nairobi.

Water Resources Authority. 2018e. *Draft Guidelines for Managed Aquifer Recharge*. Nairobi.
Water Resources Authority. 2019a. *Guidelines for the Development of Water Allocation Plans in Kenya (Draft)*. Nairobi.
Water Resources Authority. 2019b. *National Groundwater Potential Report IR2 VOLUME 4A*.
Water Resources Authority. 2019c. *Hydromet Monitoring Network Design IR2 VOLUME 7A*.
Water Resources Management Authority. 1992. *The Study on the National Water Master Plan*. Nairobi.
Water Resources Management Authority. 2006. *Groundwater Protection – Proposal for a National Policy*. Nairobi.
Water Resources Management Authority. 2007a. *Guidelines for Artificial Groundwater Recharge (Draft)*. Nairobi.
Water Resources Management Authority. 2007b. *Permit database - Database used in determining allocation thresholds for Athi catchment groundwater permit applications*. Machakos.
Water Resources Management Authority. 2007c. *Water Resources Allocation Thresholds for Classification of Permits - First Edition*. Nairobi.
Water Resources Management Authority. 2009. *The Study on Integrated Flood Management for Nyando River Basin in the Republic of Kenya - Final Report Volume II: Main Report*.
Water Resources Management Authority. 2010. *Preliminary Water Allocation Plan of the Nairobi Aquifer Suite, and Long Term Water Resources Management Strategy*. Nairobi.
Water Resources Management Authority. 2013. *The National Water Master Plan 2030*.
Water Resources Management Authority. 2014. *Gucha Migori Basin Integrated Flood Management Plan*.
Water Resources Management Authority. 2015a. *Lake Victoria South Catchment Area Catchment Management Strategy (CMS) (2015-2022)*.
Water Resources Management Authority. 2015b. *Tana Catchment Area Catchment Management Strategy (CMS) (2015-2022)*.
Water Resources Management Authority. 2015c. *Annual Water Resources Situation Report 2014-2015*. Nairobi.
Water Resources Management Authority. 2016. *Awach Kano River Basin Integrated Flood Management Plan*.
Water Services Regulatory Board. 2018. *Impact Report Issue No. 11/2019 - A Performance Review of Kenya's Water Services Sector - 2017/18*.
Wiesmann, U., Kiteme, B. & Mwangi, Z. 2016. *Socio-Economic Atlas of Kenya: Depicting the National Population Census by County and Sub-Location*. Nairobi.
Williams, L.A.J. 1964. *Geology of the Mara River-Sianna Area - Report No. 66*. Nairobi.
WMO. 2004. *Strategy for Flood Management for Lake Victoria Basin, Kenya*.
WREM International Inc. 2008. *Mara River Basin Transboundary Integrated Water Resources Management and Development Project Mara River Basin Monograph - Final Technical Report*. Atlanta.
Wright, J.A., Cronin, A., Okotto-Okotto, J., Yang, H., Pedley, S. & Gundry, S.W. 2013. A spatial analysis of pit latrine density and groundwater source contamination. *Environmental Monitoring and Assessment*. 185(5):4261–4272.
Xiong, J., Thenkabail, P.S., Tilton, J.C., Gumma, M.K., Teluguntla, P., Congalton, R.G., Yadav, K., Dungan, J., et al. 2017. [Online], Available: https://doi.org/10.5067/MEaSUREs/GFSAD/GFSAD30AFCE.001.

10 Annexures

Annexure A: Analytical tools

Annexure B: Data at sub-basin level

Annexure C: Basin Planning: Policies, legislation and institutions

Annexure D: Stakeholder information

Annexure E: Implementation Plans

Annexure F: Costing

Document prepared by

Aurecon AMEI Limited
Registration No: C087142-C1/GBL (MAU)
Ebéne House 3rd Floor
33 Cybercity
Ebéne
Mauritius

T +27 21 526 9400
F +27 21 526 9500
E capetown@aurecongroup.com
W aurecongroup.com

A1: Erosion risk and land use capability

Erosion risk in the LVS Basin was determined by using the Revised Universal Soil Loss Equation (RUSLE) model (Renard, Foster, Weesies, & Porter, 1991). The RUSLE model is used widely to predict long-term rates of inter-rill and rill erosion from field or farm size units subject to different management practices. RUSLE is a lumped model which assumes spatially homogeneous hillslopes. A raster-based GIS soil erosion risk assessment tool for the LVS Basin was developed, which calculates the mean annual gross soil erosion at a cell level as the product of six factors:

$$A = R_i \times K_i \times L_i \times S_i \times C_i \times P_i \quad (1)$$

where:

subscript $i = i^{th}$ cell

A_i = the average annual soil loss per unit area within the cell ($t \cdot ha^{-1} \cdot a^{-1}$)

R_i = rainfall-runoff erosivity factor ($MJ \cdot mm \cdot ha^{-1} \cdot h^{-1} \cdot a^{-1}$)

K_i = the soil erodibility factor ($t \cdot h \cdot MJ^{-1} \cdot mm^{-1}$)

L_i = the slope length factor

S_i = the slope steepness factor

C_i = the cover management factor

P_i = the conservation support practice factor

Input data for each erosion factor in the RUSLE model were collected from various sources as presented in Table A1-1.

Modelling the sediment production potential is based on the relatively constant factors associated with topography and soils. These factors are unlikely to change significantly over the short-term as they relate to the geomorphology of the Basin. Rainfall is dependent on climatic factors, therefore is inherently variable. The management factors (i.e. crop and practice) are more variable, as they are dependent on the conservation management measures and seasonal rainfall. A wider study in Kenya (Dunne, 1979) indicated that land use was a dominant control of sediment yield, although runoff and topography were also recognised as important. It was also determined that yield from agricultural land and grazed land was significantly greater than from forested basins, with variability in cultivated land.

Rainfall erosivity

One of the key drivers of erosion is rainfall erosivity. Although rainfall itself will not necessarily result in high levels of erosion, intense prolonged rainfall will act to increase soil erosion rates. Rainfall erosivity has a high impact on soil erosion as it provides the energy required to detach soil particles. As shown in Figure A1-1(a), the rainfall erosivity in the study areas ranged from approximately 1000 to 8000 MJ mm/ha.h.a. The rainfall erosivity follows the general topographical relief of the basin, with the rainfall erosivity being very high in the middle LVS Basin and lower values at the upper basin at Mau Forest complex and the basin outlet into Lake Victoria and Mara grassland. Most wetlands occur in these lower rainfall erosivity zones. This is indicative of a zone of deposition, where wetlands provide important flood attenuation services.

Table A1-1: Identified sources of input data for GIS based RUSLE model

	Factor	Input / Reference Data	Data type (Extent)	Resolution (arc-seconds)	Parameters used / derived
Output	**A**	-	Grid	1	-
Input	**R**	a) Global Rainfall Erosivity coverage based on the Global Rainfall Erosivity Database (GloREDa) b) CHIRPS precipitation dataset	a) Grid (Global) b) Grid (Global)	a) 30 b) 180	a) R Factor b) Mean Annual Precipitation (MAP)
	K	a) Soil and terrain database for Kenya (ver. 2.0) (KENSOTER) b) SOTER-based soil parameter estimates (SOTWIS) for Kenya c) ISRIC SoilGrids	a) Microsoft Access Database / Vector geometry (Kenya) b) Microsoft Access Database / Vector geometry (Kenya) c) Grid (Global)	a) n/a b) n/a c) 8	a) , b), c) sand, clay, silt and organic carbon fractions. Soil structure, soil permeability, surface stoniness
	LS	SRTM Digital Elevation Data 1-arc second	Grid (Global)	1	Derived surface slope, flow direction, flow accumulation, specific contributing area
	C	Cloud filtered Landsat Imagery	Grid (Global)	1	Normalized Difference Vegetation Index (NDVI)
	P	a) RCMRD Kenya Crop Mask 2015 b) RCMRD Kenya Sentinel2 LULC 2016 land cover c) Google Earth d) Limited field visits	a) Grid and Vector (Kenya) b) Grid (Kenya) c) Satellite imagery (Global) d) Local	a) 1 b) 1 c) n/a d) n/a	- Main Crop type - Crop extent - Visual inspection of practice type - Visual confirmation of practice type

Soil erodibility

A second key driver of erosion relates to soil characteristics. Figure A1-1(b) shows the soil erodibility factor in the LVS basin. The mountain, hillslope, floodplain and footslope landforms in the LVS Basin has high soil erodibility. The soils in Nyamira, Kisii, Tinderet, Western and South-West Mau complex Forest are Nitisols which are deep red soils with some organic matter characterised with high erodibility rate. The Eastern Mau soils are Andosols which are young soils formed from volcanic deposits. The floodplains in the lower LVS basin entry into Lake Victoria are Fluvisols which are young soils in alluvial deposits. The Mara plains are Planosols, which are soils with high clay content and low nutrient values. As an overview, the soils in the basin are mainly volcanic and alluvium deposits.

Topographic (LS-factor)

The LS-factor generally represents the effect of the topography on Soil erosion rates. The L-factor defines the impact of slope length and S-factor the slope steepness. As shown in Figure A1-1(c) the LS-factor is highest in regions of high elevation that is in the middle basin, Mau Forest complex, Gwasi and Gembe hills.

Vegetation cover

Vegetation cover is important when it comes to soil erosion, as dense vegetation cover will act to protect the land from erosion, whilst overgrazed land is more exposed. The density of vegetation cover reflects the influence of cropping practices, vegetation canopy and general ground cover. Maintaining a dense and diverse vegetation cover is important for catchment management as it reduces erosion. Water availability has important control over vegetation growth. This is shown in Figure A1-1(d) with low cover factor (i.e. high vegetation cover) located in the region of high rainfall in the upper, middle Basin and the protected forest. High cover factor (i.e. low vegetation cover) at the basin outlet into Lake Victoria

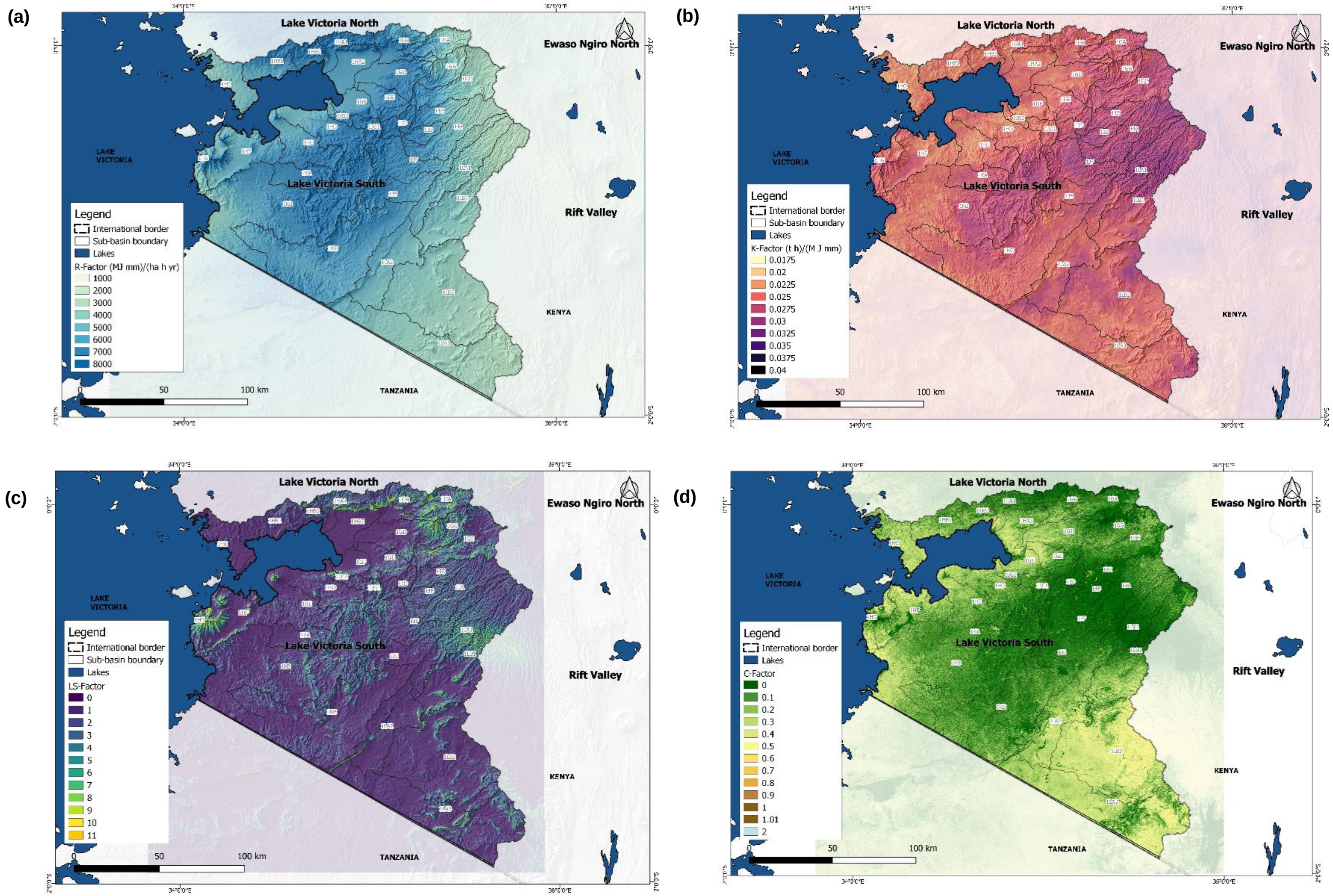


Figure A1-1: RUSLE factor maps for LVS Basin (a) rainfall-runoff erosivity, (b) soil erodibility, (c) slope length and slope steepness, (d) cover management factor

Estimated soil loss

Applying the RUSLE-based soil erosion risk assessment tool to the LVS Basin, using the flow chart as shown in Figure A1-2, resulted in estimates of soil erosion risk (expressed as long-term average soil loss per unit area) as displayed in Figures A1-3 and A1-4. It should be noted that Figure A1-4 is based on an assumed conservative conservation support practice (P) factor value of 1.

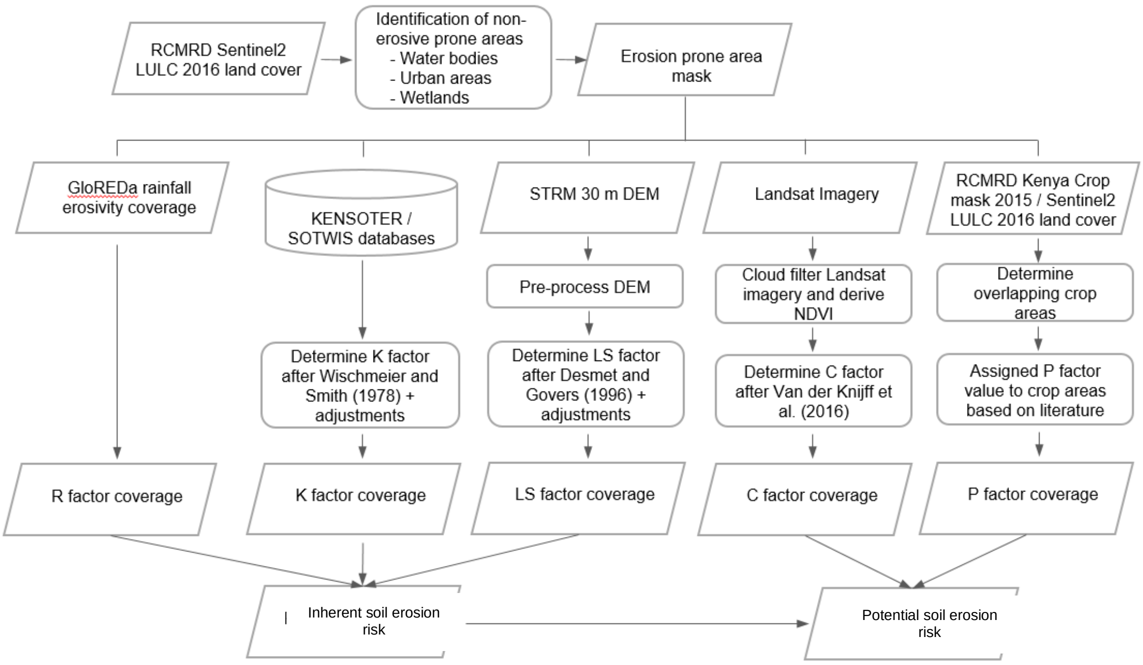


Figure A1-2: Modelling flow chart for soil erosion risk in Kenya

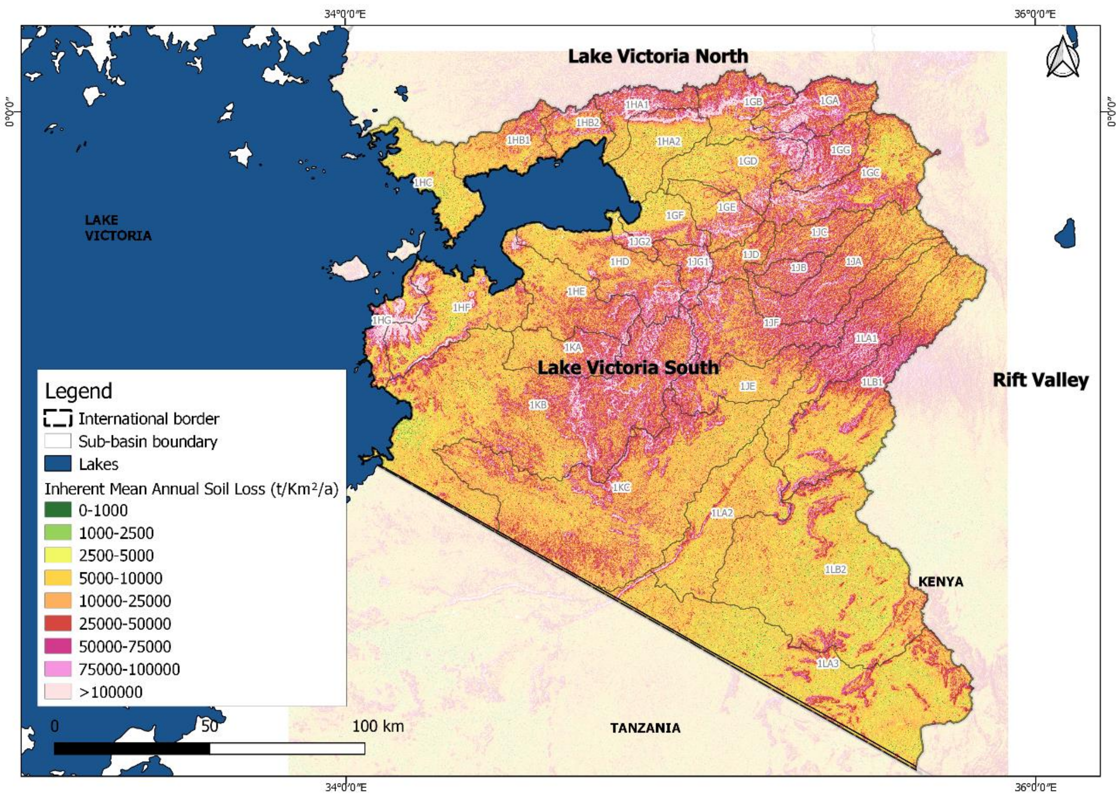


Figure A1-3: LVS Basin Inherent Soil Erosion Risk (C and P Factor not factored)

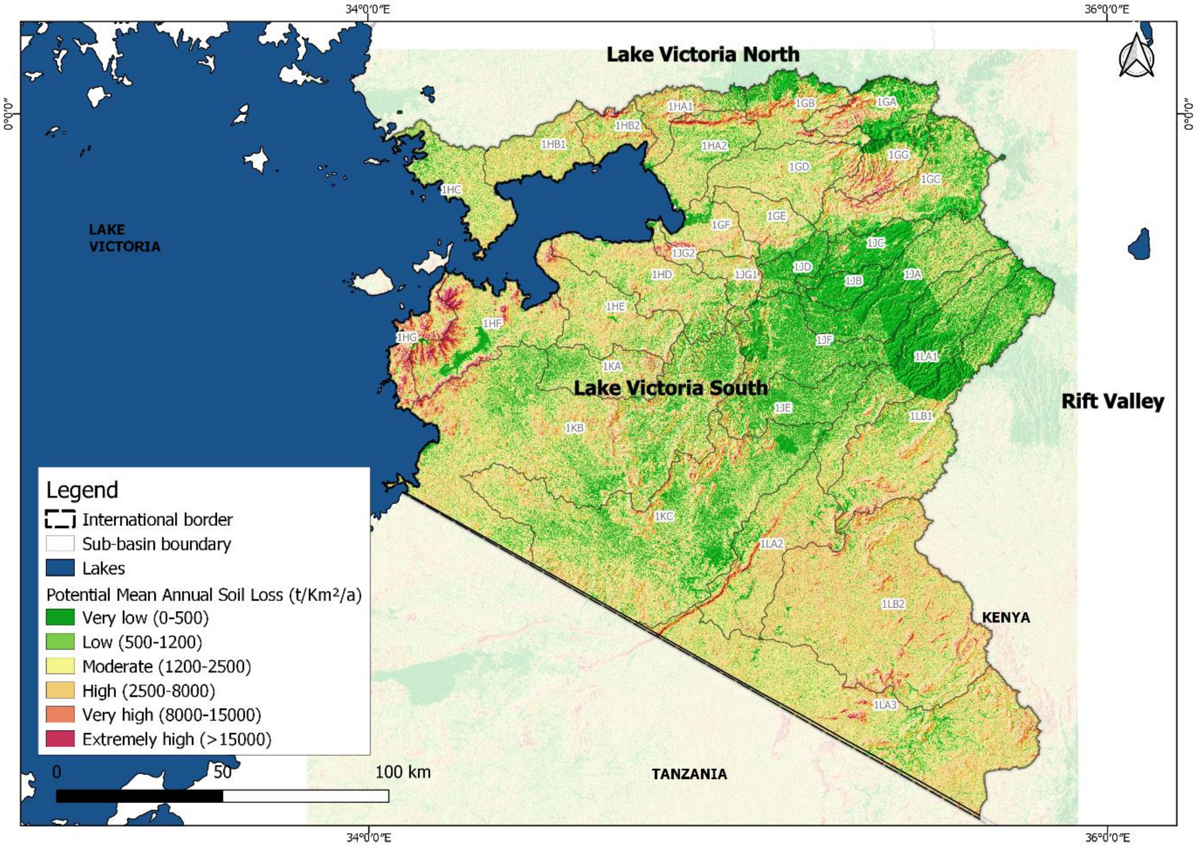


Figure A1-4: LVS Basin Potential Soil Erosion Risk

When comparing the inherent soil erosion risk to the potential soil erosion risk it is apparent that vegetation cover in protected areas and gazetted forests provide significant protection from soil erosion. Protected areas and gazetted forests have very low rates of erosion, although at the foot slopes of Gembe, Rangwe and Gwasi below the gazetted forest has less vegetation cover which influences the higher erosion rates.

Table A1-2: LVS Basin mean factors, inherent soil loss and potential soil loss

Sub-basin	Mean R	Mean K	Mean LS	Mean inherent soil loss (t/km²/yr)	Mean C	Mean potential soil loss (t/km²/yr)	Erosion risk
1HC	4744.46	0.02	0.68	7570	0.3	1968	Moderate
1JB	7186.2	0.03	2.31	46557	0.01	341	Very Low
1JC	6365.33	0.03	2.04	35409	0.02	699	Low
1HA2	6806.14	0.02	1.21	22846	0.19	2764	High
1GC	4679.32	0.03	2.45	32781	0.09	2338	Moderate
1GF	6819.12	0.02	1.29	23257	0.22	3550	High
1LA3	3776.74	0.03	1.41	12828	0.3	3166	High
1GE	7612.14	0.03	1.59	33065	0.15	2790	High
1KB	7046.94	0.03	1.43	28363	0.13	2501	High
1GD	7154.15	0.03	1.53	28579	0.16	2647	High
1GB	6986.82	0.03	2.88	51206	0.08	2990	High
1GA	5174.58	0.03	3.73	50327	0.06	2991	High
1GG	5164.36	0.03	3.6	49300	0.08	4026	High
1HG	5380.23	0.03	3.39	53827	0.28	8488	Very High

Sub-basin	Mean R	Mean K	Mean LS	Mean inherent soil loss (t/km²/yr)	Mean C	Mean potential soil loss (t/km²/yr)	Erosion risk
1HF	6147.43	0.02	1.85	31968	0.24	5470	High
1KA	8432.92	0.03	1.38	33013	0.09	2649	High
1JG2	6731.55	0.02	2.02	34661	0.26	5139	High
1HE	7470.12	0.02	1.36	26861	0.16	3072	High
1HA1	8388.39	0.02	2.31	49518	0.11	3488	High
1HD	7234.48	0.02	1.52	30554	0.18	2805	High
1HB2	8037.27	0.02	1.63	33254	0.15	4039	High
1JG1	8588.42	0.03	2.34	51103	0.07	3011	High
1JD	8227	0.03	1.4	31313	0.02	768	Low
1KC	6717.59	0.03	1.28	22117	0.1	2149	Moderate
1LA2	5328.7	0.03	1.06	14332	0.24	3202	High
1JE	6992.4	0.03	1.47	27827	0.05	1206	Moderate
1LB2	3915.93	0.03	1.26	12393	0.37	3910	High
1LB1	4004.26	0.03	2.21	24034	0.13	2132	Moderate
1JF	6499.88	0.03	2.19	39363	0.03	1011	Low
1LA1	4457.13	0.03	2.65	33678	0.06	1149	Low
1JA	4995.38	0.03	2.27	33746	0.05	951	Low
1HB1	6998.5	0.02	1.08	18803	0.18	2773	High

Sediment yield

Soil erosion involves the detachment, transport and eventual deposition of soil particles (Lal, 2001). Energy for these processes is provided for by physical (wind/water), gravity (landslides), chemical (weathering) or tillage sources. Sediment particles, once picked up by water, actually spend a relatively short time being transported and in fact more time in storage (Meade, 1982). This means that an understanding of the source (i.e. sediment potential areas) and sink (i.e. depositional areas) zones are needed in order to understand the impact of sedimentation. Erosion acts as the source of sediment, which travels downstream and has indirect impacts. These impacts can be seen when sediment travels in suspension, i.e. turbidity impacts to biodiversity, and when sediment stops moving and is deposited, i.e. sedimentation impacts to biodiversity and infrastructure. On the one hand deposited sediment renews soil fertility and lines channels of canal beds against seepage, but on the other hand it reduces capacity of reservoirs, inlet channel and irrigation canals (Ali, 2014). High sediment loads transported by the river during flood seasons has major influences on operation of reservoirs and in general reduces storage capacity. When in suspension sediment becomes a pollutant in its own right, as it limits light penetration and healthy plant growth. When sediment settles on the river bed it may smother aquatic habitats and impact fish spawning grounds. Nutrient rich sediments (especially sediments linked to agricultural lands) create turbid conditions which may result in eutrophication where fish species may be unable to survive.

Tracing the pathway of sediment from the upper LVS Basin, to Lake Victoria indicates that there are landforms which are linked to deposition zones, acting as sediment “traps” or buffer zones. These landforms such as alluvial plains, wetlands and delta plains are areas where sediment will likely be deposited. Infrastructure such as dams will also trap sediments, the scale of this relating to the dam storage capacity as well as location within a catchment.

Based on the characteristics in Table A1-3, sediment delivery ratios were estimated for each sub-basin and sediment yield values calculated as shown in Figure A1-5.

Table A1-3: Physiographic catchment characteristics contributing to sediment dynamics of LVS Basin

Factor	Basin
Basin area (m^2)	31,734
Annual Rainfall (mm)	1000 – 1900
Elevation (masl)	1,130 – 3,000
Topography	The upper Basin comprises one major water towers, while the middle Basin is covered by hilly topography extending into the flood plains up to Lake Victoria and Mara grasslands.
Vegetation	The vegetation cover is mainly a mosaic of forest and evergreen vegetation, with mountain forest vegetation in the highlands.
Land-use	Land use in the Basin is dominated by agricultural use and pastoralism, with small urban and industrial areas.
Connectivity (Sondu River)	Within the Sondu River sub-catchments, the landforms change from steep slopes to plateau and plain landforms. There is one existing dam and wetland as it discharges into Lake Victoria. The dam is mainly to provide the necessary head, therefore has limited storage and trapping capacity. The wetland has low sediment trapping capacity due to the steep gradient as Sondu River discharges into Lake Victoria.
Connectivity (Nyando River)	Within the Nyando River sub-catchments, the landforms change from steep slopes to depression landforms. The Nyando River wetlands are located downstream as it discharges into Lake Victoria which is indicative of a depositional feature.
Connectivity (Mara River)	Within the Mara River sub-catchments, the landforms change from steep slopes to the Mara plain. There are depositional wetlands in the Mara plains.
Connectivity (Gucha-Migori River)	Within the Gucha-Migori River sub-catchments, the landforms change from steep slopes to plateaux to plain. There are limited wetlands in the catchment plateau and as the River discharges into Lake Victoria which is indicative of low sediment trapping capacity.

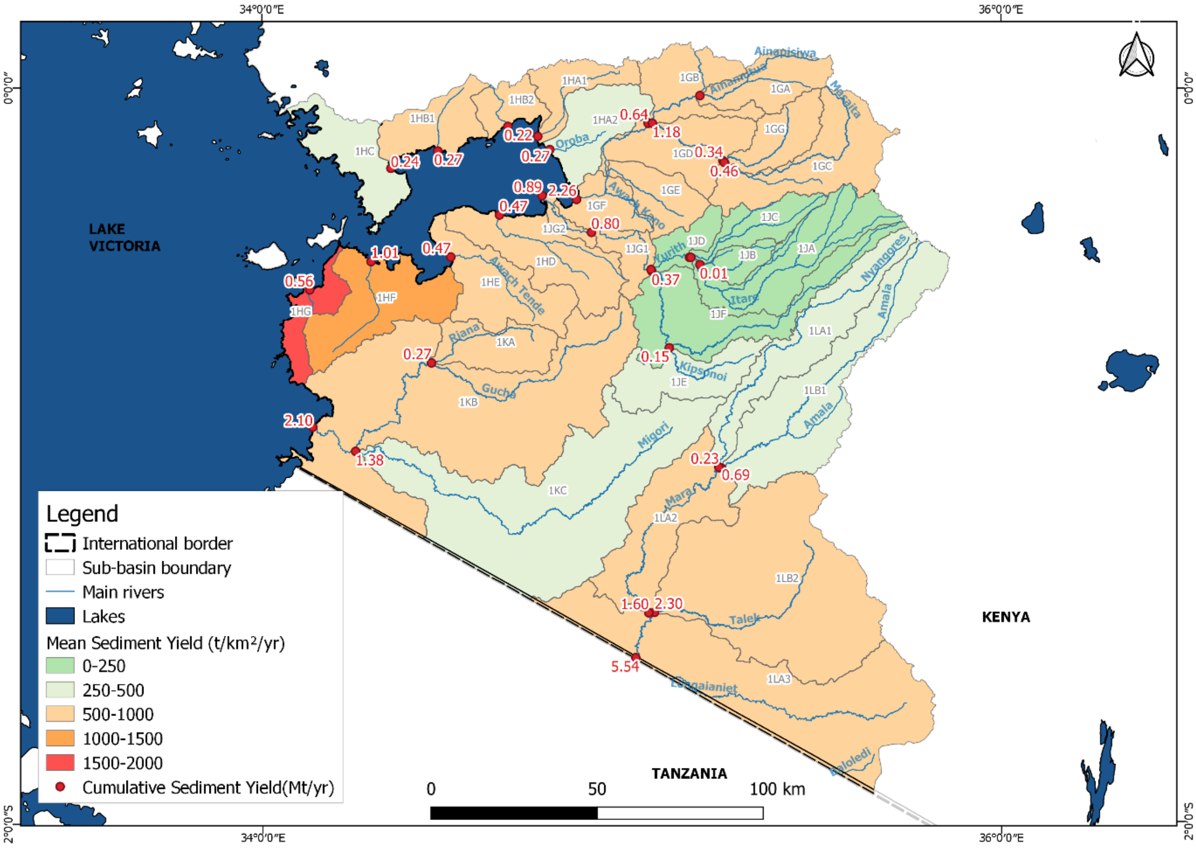


Figure A1-5: LVS Basin - Cumulative sediment loads

Table A1-4 summarises the erosion potential and sediment yield in the LVS Basin.

Table A1-4: Long term average soil loss estimates per sub-basin in the LVS Basin

Sub-Basin	Area (km²)	Potential soil loss (t/km²/yr)	Mean sediment yield (t/km²/yr)	Cumulative sediment load (Mt/yr)
1GA	454	2991	658	0.30
1GB	522	2990	658	0.64
1GC	902	2338	514	0.46
1GD	652	2647	582	1.18
1GE	371	2790	614	2.05
1GF	316	3550	639	2.26
1GG	385	4026	886	0.34
1HA1	349	3488	733	0.26
1HA2	537	2764	497	0.27
1HB1	471	2773	582	0.27
1HB2	257	4039	848	0.22
1HC	579	1968	413	0.24
1HD	800	2805	589	0.47
1HE	735	3072	645	0.47
1HF	882	5470	1149	1.01
1HG	301	8488	1867	0.56
1JA	849	951	209	0.18
1JB	178	341	75	0.01
1JC	340	699	154	0.05
1JD	217	768	161	0.28
1JE	581	1206	265	0.15
1JF	990	1011	222	0.37
1JG1	230	3011	662	0.80

1JG2	93	5139	925	0.89
1KA	469	2649	583	0.27
1KB	3486	2501	525	2.10
1KC	2922	2149	473	1.38
1LA1	924	1149	253	0.23
1LA2	1008	3202	672	1.60
1LA3	2455	3166	665	5.54
1LB1	1475	2132	469	0.69
1LB2	2677	3910	860	2.30

Land use capability

To assist with the assessment of land capability and sustainable land use in the Basin, a GIS-based land capability tool was developed based on the USDA Land Capability Classification System as defined in Table A1-5. The USDA Land Capability Classification relies on the following principles (Klingebiel & Montgomery, 1961):

- Areas of land are put into classes ranging from best (Class I) to worst (Class VIII),
- Land allocated to a particular capability class has the potential for the use specified for that class and for all classes below it.

Placing soils in these classes allows for an understanding of the crop and management constraints. The suitability of soils is as follows:

- Order A: Arable land – high potential land with few limitations (Class I and II)
- Order B: Arable land – moderate to severe limitations (Class III and IV)
- Order C: Grazing and forestry land (Class V, VI and VII)
- Order D: Land not suitable for agriculture (Class VIII)

Table A1-5: Relationship between USDA soil capability classification classes and intensity with which each class can be used safely (Davidson, 1992)

Soil Capability				GRAZING			CULTIVATION				Description	Soil/Terrain parameter			Soil/terrain parameter mix summary
Orders	Classes	WILDLIFE	FORESTRY	Limited	Moderate	Intense	Limited	Moderate	Intense	Very Intense		Slope	Erosion	Soil Depth	
Arable A	I	x	x	x	x	x	x	x	x	x	Soils have slight limitations that restrict their use.	S1	E1	D1	Gentle slope, very low erosion, deep soils
Arable A	II	x	x	x	x	x	x	x	x		Soils have moderate limitations that reduce the choice of plants or require moderate conservation practices.	S2	E1, E2	D1	Gentle to moderate slope, very low to low erosion, deep soils
Arable B	III	x	x	x	x	x	x	x			Soils have severe limitations that reduce the choice of plants or require special conservation practices.	S3	E1-E3	D1 - D2	Moderate slope, very low to moderate erosion, deep to medium deep soils
Arable B	IV	x	x	x	x	x	x				Soils have very severe limitations that reduce the choice of plants or require very careful management, or both.	S4	E1-E4	D1 - D2	Moderate slope, very low to high erosion, deep to medium deep soils
Non- arable C	V	x	x	x	x	x					Soils have little or no hazard of erosion but have other limitations, impractical to remove, that limit their use mainly to pasture, range, forestland, or wildlife food and cover.	S4	E1-E5	D1 - D2	Moderate slope, very low to very high erosion, deep to medium deep soils
Non- arable C	VI	x	x	x	x						Soils have severe limitations that make them generally unsuited to cultivation and that limit their use mainly to pasture, range, forestland, or wildlife food and cover.	S5	E1-E5	D1 - D2	Steep slope, very low to high erosion, deep to medium deep soils
Non- arable C	VII	x	x	x							Soils have very severe limitations that make them unsuited to cultivation and that restrict limit their use mainly to grazing, forestland, or wildlife.	S5	E1-E5	D2 - D3	Steep slope, very low to high erosion, medium to shallow soils
Non- arable D	VIII	x									Soils and miscellaneous areas have limitations that preclude their use for commercial plant production and limit their use to recreation, wildlife, or water supply or for aesthetic purposes.	S6	E1-E6	D2 - D3	Very steep slope, very low to high erosion, medium to shallow soils

Davidson (1992) categorised the USDA Classes in terms of the intensity of soil disturbance that is "safe" and introduced soil and terrain as useful physical parameters to define Classes, i.e. Slope Class (Table A1-6), Erosion Hazard Class (Table A1-7) and Soil Depth Class (Table A1-8**Error! Reference source not found.**).

Table A1-6: Slope Class for input to the Soil capability classification

Slope Class	Slope (%)
S1	0-5
S2	5-8
S3	8-12
S4	12-20
S5	20-40
S6	40-100

Table A1-7: Erosion Hazard Class for input to the Soil capability classification

Erosion Hazard Class	Erosion Hazard	Erosion (t/ha.yr)
E1	Very Low	0-5
E2	Low	5-12
E3	Medium	12-25
E4	High	25-80
E5	Very High	80-150
E6	Extremely High	>150

Table A1-8: Slope Depth Class for input to the Soil capability classification

Soil Depth Class	Soil Depth (mm)
D1	>300
D2	200
D3	<100

Using the USDA Land Capability Classification System in conjunction with Davidsons's land usability criteria, the LVS Basin was assessed in terms of land capability (excluding meteorological conditions). The resultant Land Capability map is shown in Figure A1-6 **Error! Reference source not found.** for the Basin. It is evident that the tops of hills and mountains have a soil capability of 8 and steep slopes have a soil capability of 5-7 (i.e. non-arable land). Most of the Basin has a soil capability of 1-3 (i.e. arable land).

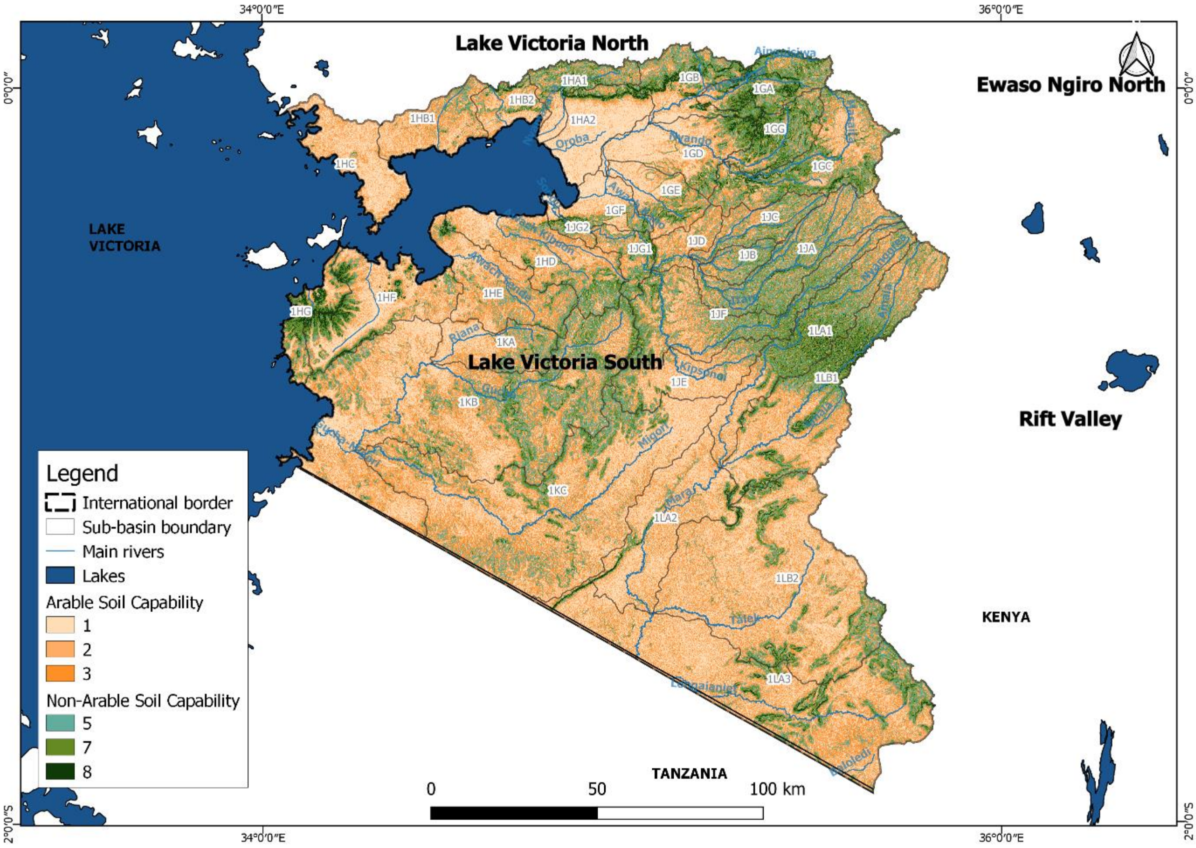


Figure A1-6: LVS Basin Soil Capability Map

Overlaying the Land Capability map with the current land use in the Basin, provides an indication of the level of sustainable land use in the basin under current conditions. Sustainable land use occurs where crops occur on arable land, and unsustainable land use occurs where crops occur on non-arable land. While large parts of the basin have sustainable cropland use, areas in the upper Nyando and Sondu river catchments, areas in the Mau Forest Complex, as well as areas in the central part of the basin in Kisii and Nyamira Counties have unsustainable land use.

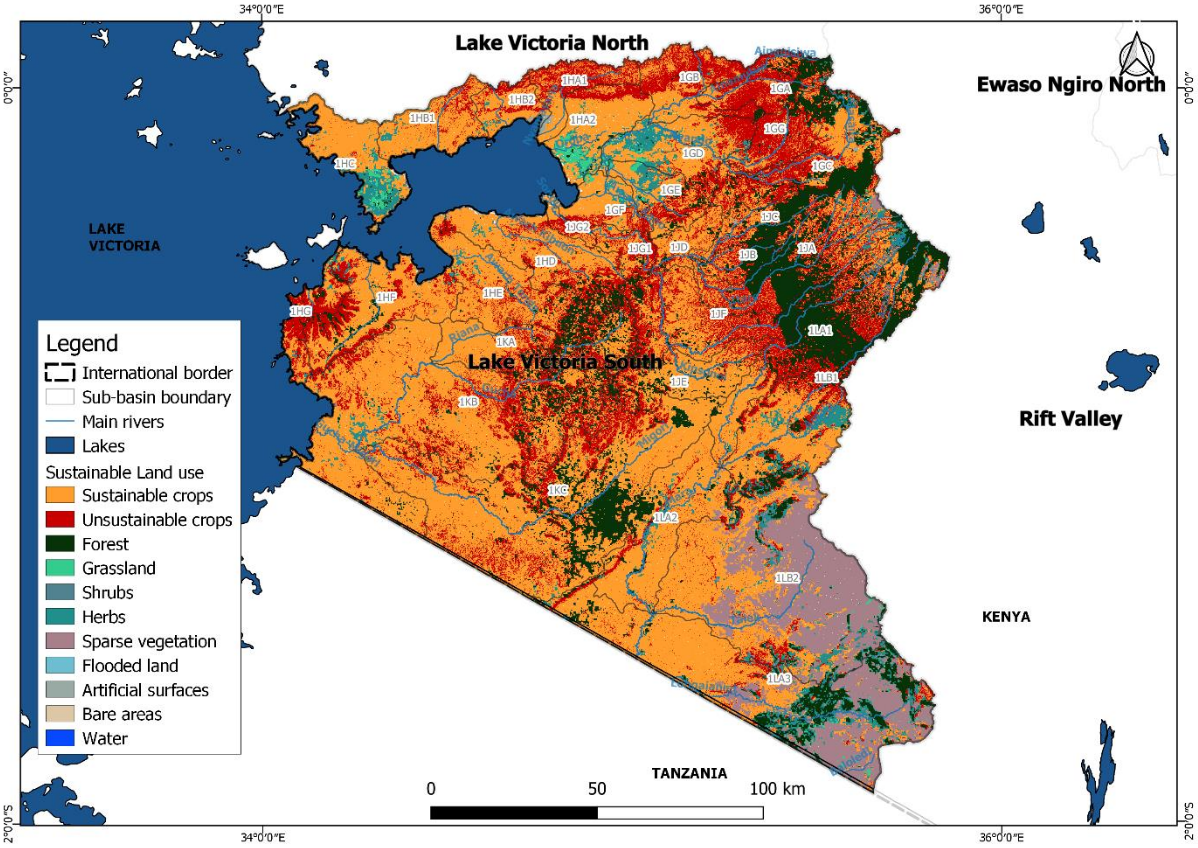


Figure A1-7: Sustainability of current land use in the LVS Basin

A2: Climate analysis

The scale of future climate impacts varies based on the anthropogenic mitigation of factors responsible for currently experienced changes. The mitigation scenarios account for several variances of potential global economic and environmental development and are quantified as the Representative Concentration Pathways (RCP).

In line with industry standards, the scenarios considered for this analysis were the RCP4.5 (likely) and RCP8.5 (worst case) scenarios. These RCPs show the change from pre-industrial insolation watts per m² resulting from the emissions. RCP 4.5 – likely best case – emissions stabilise from 2040 and decrease thereafter. RCP 8.5 represents the very high greenhouse gas emission scenario – emissions don't stabilise, worst case scenario with a focus on economic advancement at the expense of environmental sustainability. These emission scenarios give light to the varying potential climatic futures based on human development goals in the present and near future.

For these RCPs, Table A2-1 shows estimated concentrations of greenhouse gases viz. CO2, CH4 and N2O based on a combination of assessment models (MESSAGE (Riahi, Gruebler, & Nakicenovic , 2007), AIM (Hijioka , Matsuoka, Nishimoto, & Masui, 2008)), GCAM (Wise, et al., 2009), IMAGE (van Vuuren, et al., 2007)), global carbon cycle, and atmospheric chemistry and climate models. They also integrate assumed land use changes and sector-based emissions of greenhouse gasses from present day levels. The present greenhouse gasses include the sectoral assessment of energy supply, industry, transport, and buildings with contributions of 47%, 30%, 11% and 3% respectively (IPCC, Summary for Policymakers, 2014).

Table A2-1: Representative Concentration Pathways

	CO_2 (ppm)	CH_4 and N_2O (ppm)	Resulting radiative forcing ($W.m^{-2}$)	Scenario
RCP 4.5	538	92	4.5	Best case - Medium scenario
RCP 8.5	936	377	8.5	Worst case

The greenhouse gas concentrations under different RCPs are used as input for the coupled model ensembles of the IPCC Assessment Report Five (IPCC, Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects, 2014) (AR).

Using climate projection data requires the acknowledgement of various uncertainties. The IPCC projections rely on forty different GCMs with different accuracies forecasting to the varying RCP scenarios. These RCPs are themselves estimates of potential future thermal forcings, as informed by adherence to emission policies and potential future technologies. The downscaling of the IPCC data required robust constraining parameters to present a more accurate local projection. In areas where observational data is limited, these constraining parameters have increased uncertainty. Results obtained, and recommendations made based on these data should be used as a guideline to adapt/mitigate to a potential future climate rather than a definitive one. This is particularly prevalent when noting the significant disparity even in the current variability of rainfall regimes. This is influenced by things like topography, wind, vegetation and even ocean currents. Beyond that, a further layer of complexity is added with looking at rainfall intensity, diurnal and seasonal onsets before accounting for short and long-term influences such as the diurnal, seasonal, inter annual cycles, the ENSO cycles as well as decadal changes. When projecting precipitation changes into a semi unknown future these uncertainties are further exacerbated. The projection parameters are therefore presented in terms of a probability of changes highlighting the most likely range of precipitation experienced in the future. The probabilities also allow for the possibility of more extreme anomalous occurrence of events in both directions i.e. probability of more extreme rainfall days as well as less extreme rainfall days.

Factors such as the topography, proximity to the equator, and air masses contribute to the range and variability in precipitation and temperature regimes. The climate analysis which was undertaken as part of the Lake Victoria South Basin Plan, focused on projected climate trends and analysed multiple spatial and temporal source datasets with the intention of better conveying the interactions between and impact on communities, water security and the environment as a result of projected climate change. Temporal analysis, of varying resolutions, informed likely anomalous climatic characteristics such as shifts in seasonality, extreme events occurrence, precipitation intensity and volumes.

Data to be used in climate analysis need to be of sufficient duration and resolution to account for the cycles of natural meteorological variability as well as any climate change signal embedded in the data. While there is currently a dearth of climate change data of sufficient length and integrity for trend analysis available, SIMCLIM (CLIMSystems, 2005) and CORDEX (Gutowski et al, 2016) data were used to inform the analysis of climate change impacts as part of the development of this Basin Plan.

SimCLIM data is downscaled to 5km resolution from the IPCC AR5 climate models. It presents the monthly projection from 1996 to 2100 through selected models or a model ensemble, with different environmental sensitivities. SimCLIM is native to ESRI ArcGIS 10.3 and provides the basis for all spatial climate analysis and long-term trends.

CORDEX (A Coordinated Regional Climate Downscaling Experiment) data is downscaled to 45km resolution and has a daily temporal scale to 2100. The high temporal resolution of this data gives an indication of intra-seasonal meteorological characteristics. High resolution data has several advantages over the large scale GCMs, chief among them the increased spatial and temporal resolution. Having spatial higher resolution provides greater local context between areas of interest, while daily scale temporal scales allow for analysis such as extreme events or accumulation anomalies that is not possible in monthly data. The CORDEX experiments seeks to downscale the GCMs utilised in the IPCC AR5 analysis.

The GCM models listed in Table A2-2 were utilised for downscaling in this analysis.

Table A2-2: GCM model input

Model	Institute
CCCma-CanESM2	Canadian Centre for Climate Modelling and Analysis
CNRM-CERFACS-CNRM-CM5	Météo-France / Centre National de Recherches Météorologiques
CSIRO-QCCCE-CSIRO-Mk3-6-0	Commonwealth Scientific and Industrial Research Organization& Queensland Climate Change Centre of Excellence
ICHEC-EC-EARTH	Irish Centre for High-End Computing & -Earth consortium
IPSL-IPSL-CM5A-MR	Institut Pierre Simon Laplace
IROC-MIROC5	Model for Interdisciplinary Research on Climate
MOHC-HadGEM2-ES	Met Office Hadley Centre
MPI-M-MPI-ESM-LR	Max-Planck-Institut für Meteorologie
NCC-NorESM1-M	Norwegian Climate Centre & Norwegian Earth System Model 1
NOAA-GFDL-GFDL-ESM2M	National Oceanic and Atmospheric Administration & Earth System Model - Geophysical Fluid Dynamics Laboratory

Precipitation and Temperature

The climate analysis showed a general increase (between 4% and 6%) in mean annual precipitation (MAP) across the LVS Basin by 2050, with the average MAP across the basin increasing from 1385 mm to 1420 mm by 2050 under RCP 4.5.

Day and night temperatures in the basin are expected to increase by up to 1.25°C and 1.35°C respectively by 2050 (RCP 4.5).

To assess the expected impacts on more localised precipitation in the LVS Basin as result of climate change, four sub-basins were selected for detailed analyses namely: 1GC, 1KB, 1 LA1, and 1JF. The sub-basins and river nodes are illustrated in Figure A2-1.

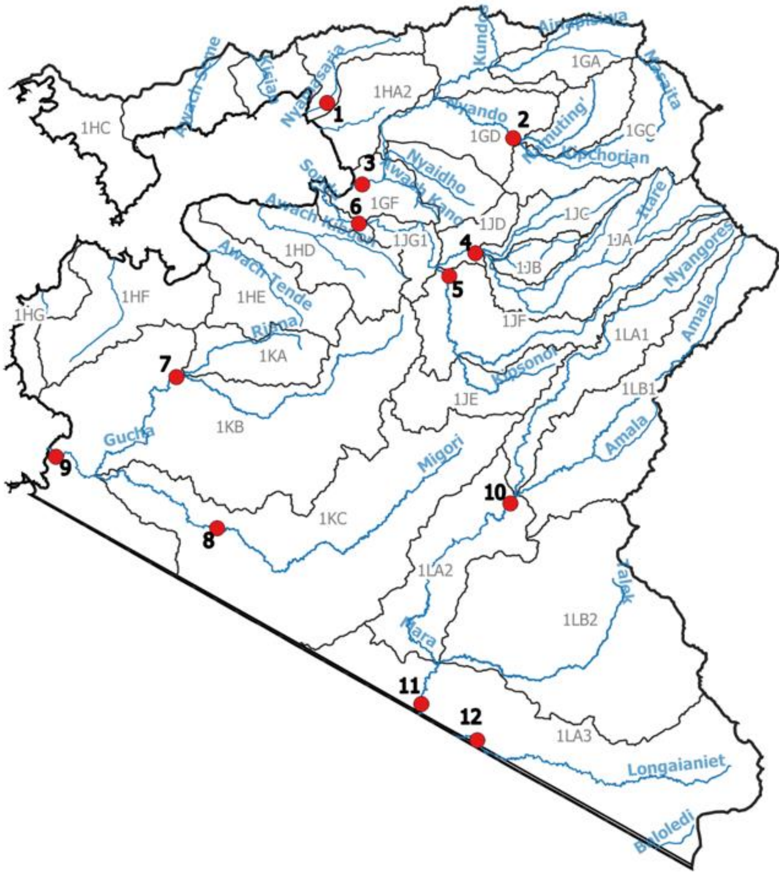


Figure A2-1: LVS Basin with sub-basins and river nodes

75th percentile precipitation values for the RCP4.5 scenario were used in the analysis. Figure A2-2 illustrates the anticipated changes in precipitation in the selected sub-basins. Changes were expressed as monthly percentage change from the average monthly historical precipitation (period between 1980-2000) to the average monthly future precipitation (period between 2040-2060).

Figure A2-2 indicates a consistent percentage increase in future precipitation in all four sub-basins during the 'short' rainy season from Oct to Dec and during the months of January and February. During the 'long' rainy season from March to May the increase in precipitation is less pronounced, except during May were a decrease in precipitation is experienced. During the dry season from June to October, an overall decreasing precipitation trend is observed from June to August. It is important to note that although the percentage change in precipitation is quite high during the dry months of January and February, actual rainfall depths are very low.

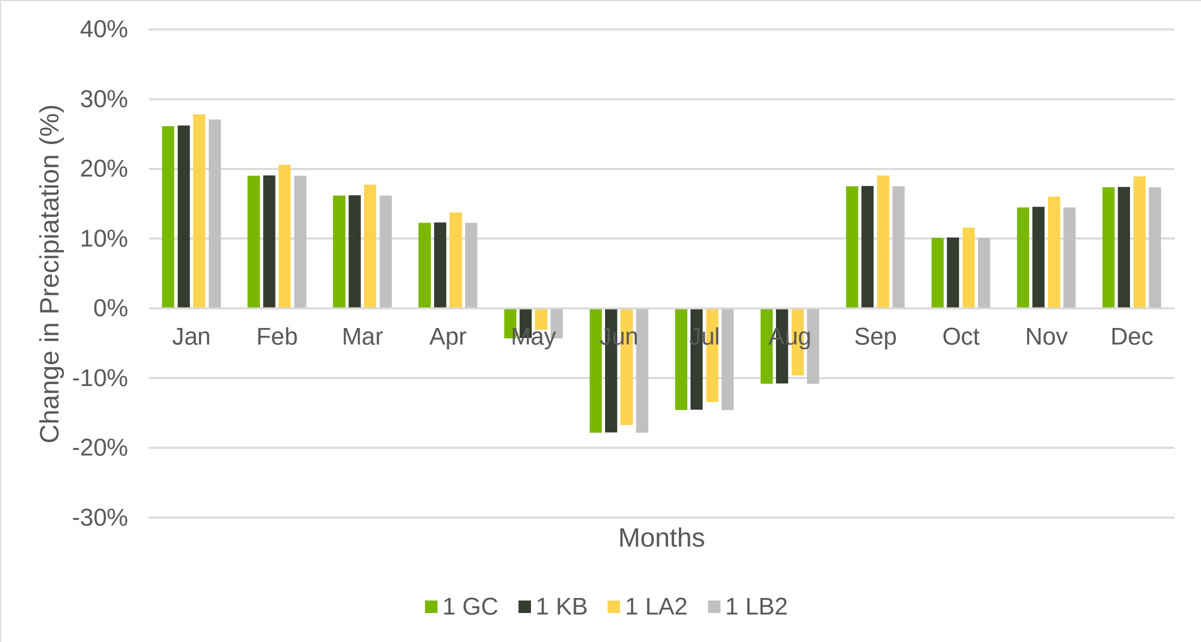


Figure A2-2: Percentage change in monthly precipitation for the period 2040 to 2060 compared to 1980 to 2000 in four sub-basins

Figure A2-3 to Figure A2-6 illustrate the historical monthly average precipitation (1980 to 2000), the monthly average future precipitation (2040 to 2060), as well as the associated percentage change in each of the four sub-basins. Evident from the figures is the significant increase in precipitation depth for October to December. The significant percentage increase in precipitation during the dry months of January to March, as illustrated in Figure A2-1, is also evident from Figure A2-2 to Figure A2-5. However, the precipitation depths remain relatively low. Although there is a decrease in precipitation during May associated with the long rainy season, the rainy seasons do not appear to shift.

Figure A2-7 to Figure A2-10 present the range of monthly precipitation as box and whisker plots for both historical (1980 to 2000) precipitation as well as future (2040 to 2060) expected precipitation.

The figures show a significant increase under climate change in mean precipitation for April accompanied by a significant increase in the range of precipitation depths, suggesting that April precipitation will become more variable (see Figure A2-6a) as an example). Similarly, the figures show an increase in mean precipitation for October, November and December under climate change. However, during these months, the future range (variability) of precipitation depths will increase. This suggests higher precipitation variability during the short rainy season, as well as more intense precipitation events

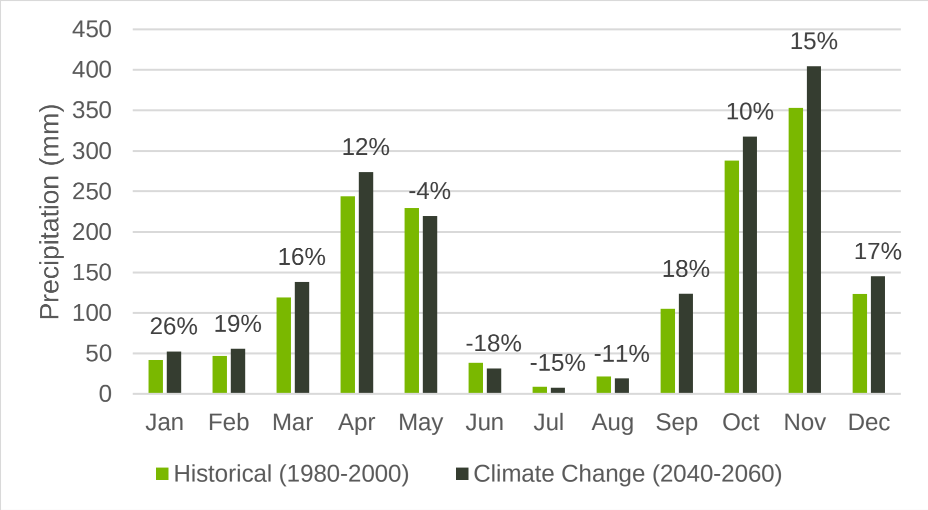


Figure A2-3: Percentage change - monthly avg. precipitation sub-basin 1KB

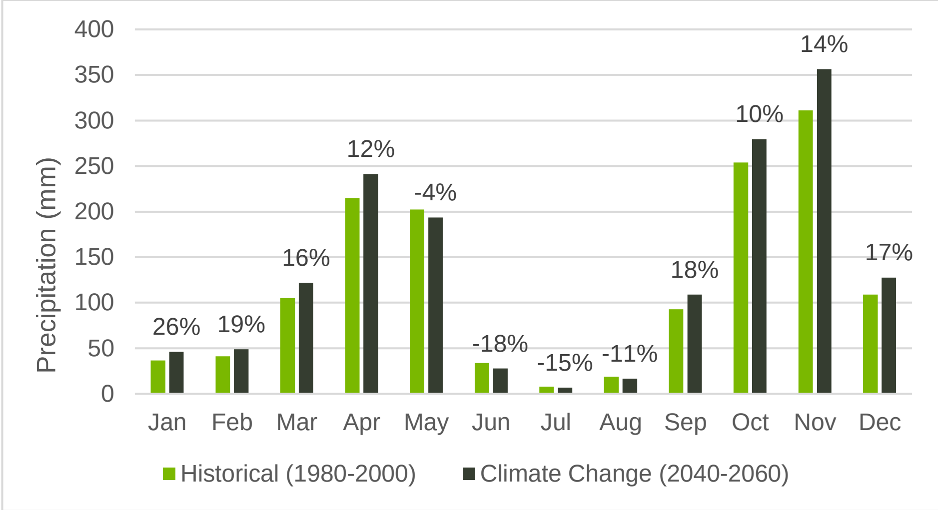


Figure A2-4: Percentage change - monthly avg. precipitation sub-basin 1 GC

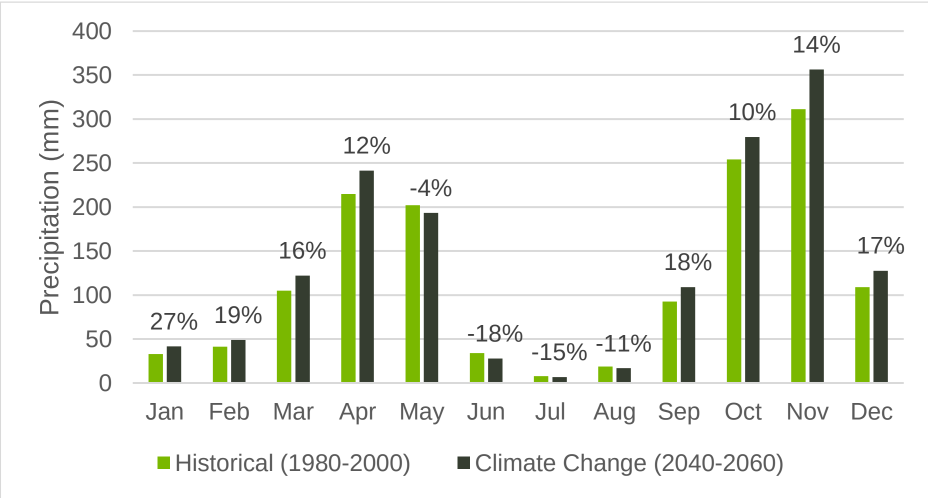


Figure A2-5: Percentage change - monthly avg. precipitation sub-basin 1 LA2

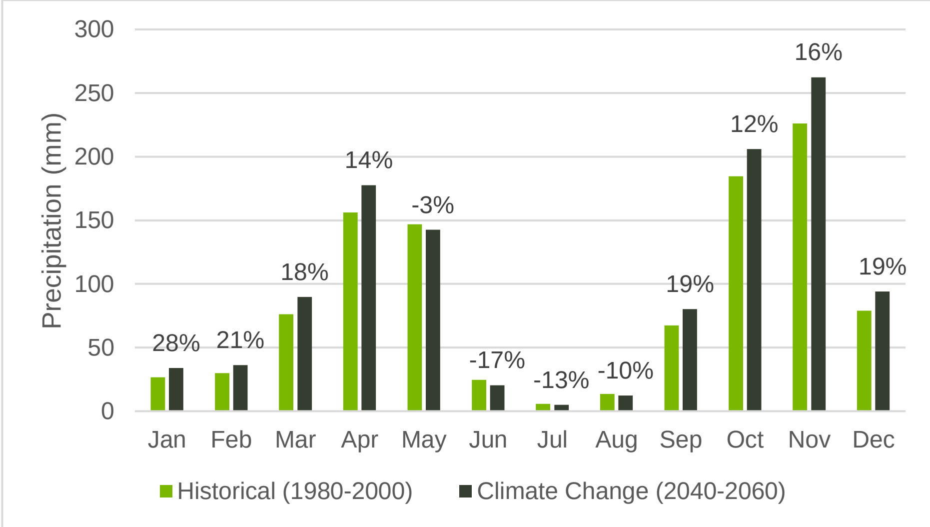


Figure A2-6: Percentage change - monthly avg. precipitation sub-basin 1 LB2

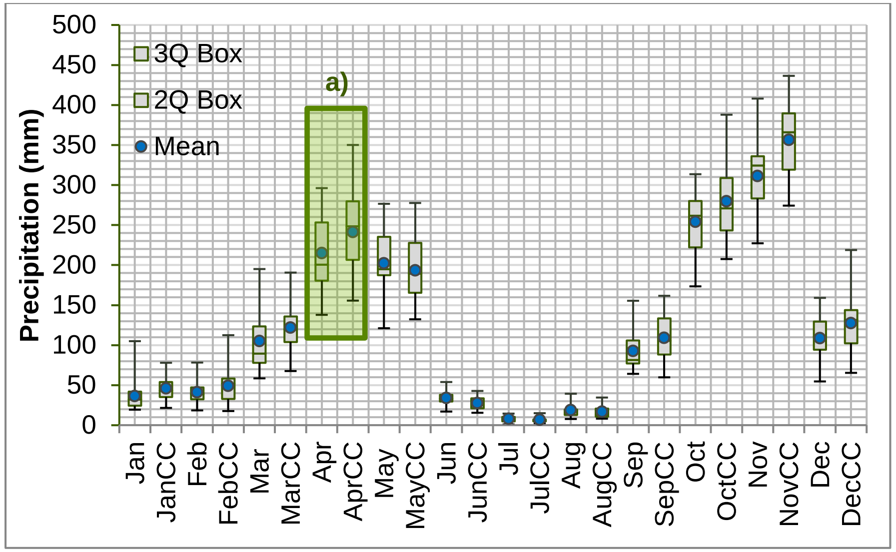


Figure A2-7: Precipitation box-plots for sub-basin 1 GC

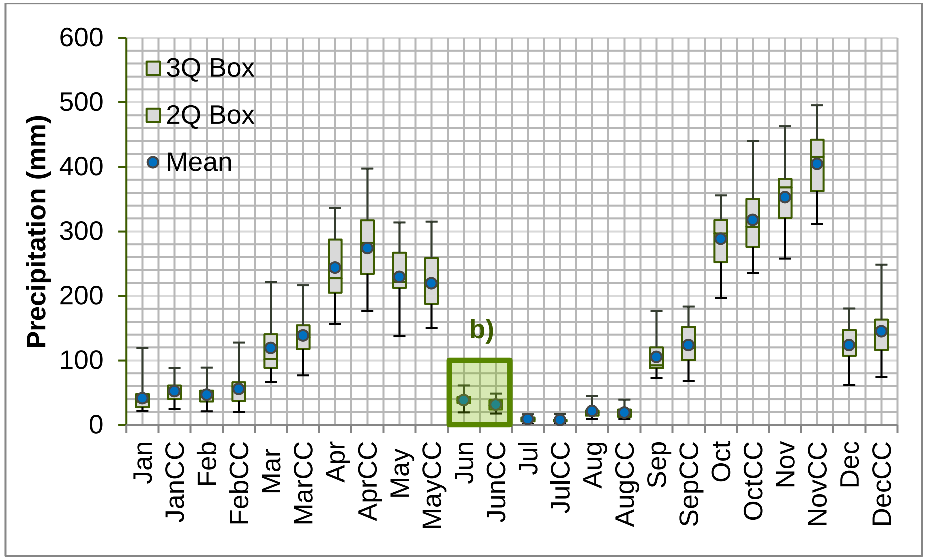


Figure A2-8: Precipitation box-plots for sub-basin 1 KB

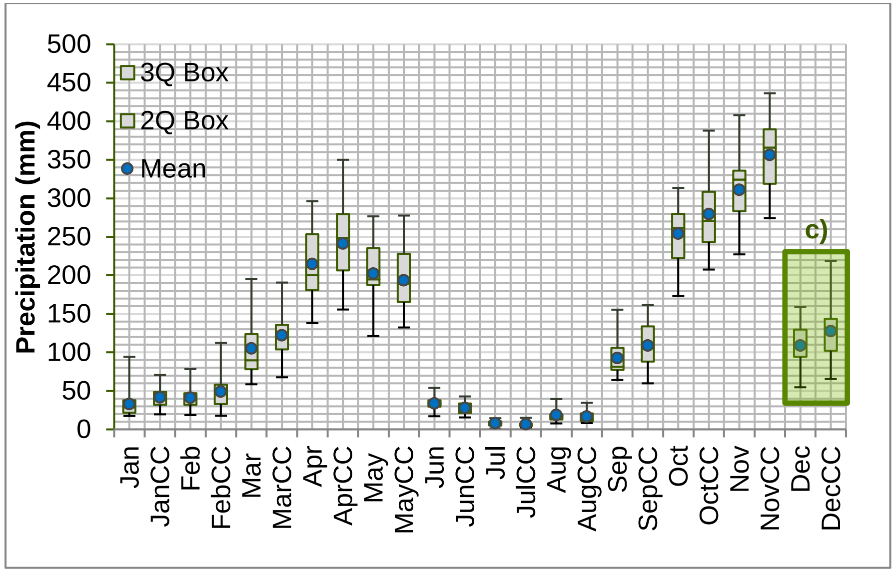


Figure A2-9: Precipitation box-plots for sub-basin 1 LA2

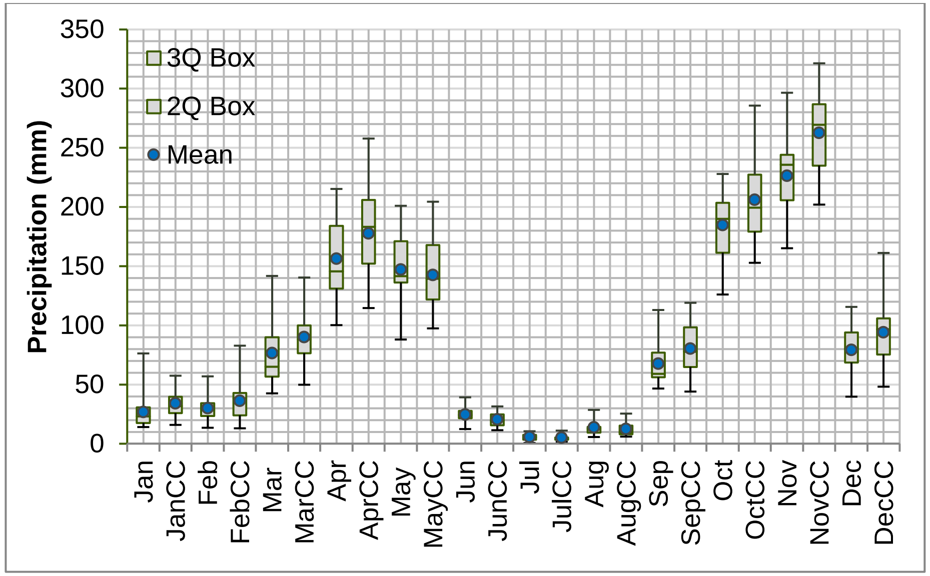


Figure A2-10: Precipitation box-plots for sub-basin 1 LB2

Steam Flow

Projected sub-basin precipitation and temperature changes under climate change scenario RCP 4.5 were superimposed on the hydrological model of the LVS Basin to assess the potential impacts on runoff. A simulation period of 1960 to 2017 was used. The analysis showed that natural runoff in the basin is expected to decrease in most sub-basins between 1% and 3%, with some sub-basins staying unchanged or slightly lower or higher. The total surface water runoff from the LVS Basin is projected to decrease with 1.4% by 2050 under RCP 4.5 climate conditions.

To assess the expected impacts on stream flow in the LVS Basin as result of climate change, four river nodes were selected: Node 2 and Node 5 in the northern parts of the catchment; and Node 9 and Node 11 in the southern parts of the catchment. The river nodes within the LVS Basin are indicated by red dots in Figure A2-1.

Figure A2-11 shows the percentage change in monthly average natural flow under climate change at each river node. The flow generally increases in October to December through to February, and decreases slightly from March to September; corresponding generally with the expected changes in precipitation. However, the significant magnitude increase in precipitation is not reflected in the increase in stream flow, this is due to the increased effects of temperature and evapotranspiration in the sub-basins (high vegetation). The average flow is thus expected to increase during the ‘short’ rainy season between late October to December extending through January and February, but decrease during the during the ‘long’ rainy season between April and May. Note that the high percentage increase in precipitation (Figure A2-2) during January to April, results in a smaller magnitude percentage increase in flow during January to February and decreases in flow during March and April (Figure A2-11).

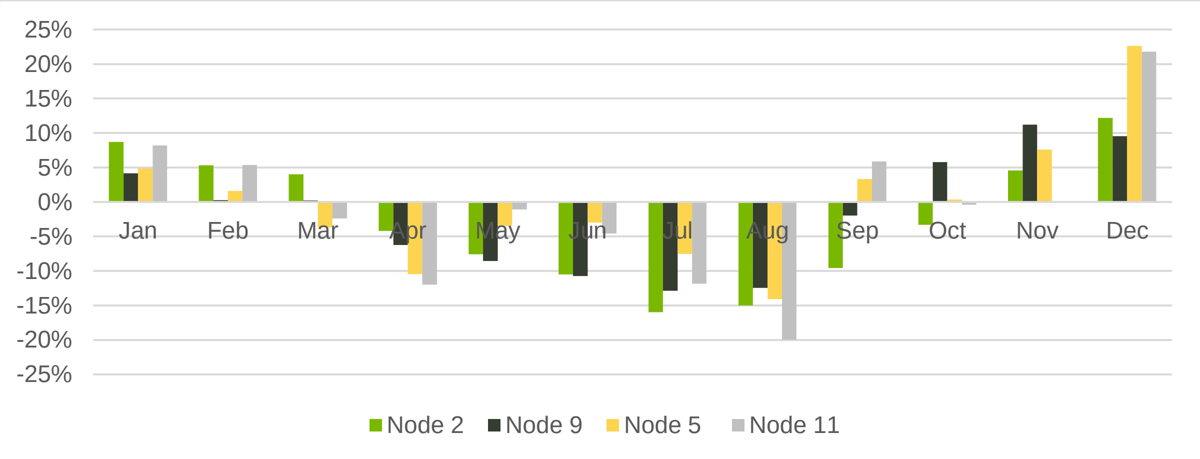


Figure A2-11: Percentage change between historical naturalised flow and naturalised flow with climate change

Figure A2-16 to Figure A2-19 illustrate the historical and future (climate change) monthly average flow, as well as the associated percentage change pertaining to each node, while Figure A2-12 to Figure A2-15 present flow duration curves for each node as well as the associated percentage change for different exceedance probabilities under climate change.

With respect to node 2 (Figure A2-16), high flows with a low exceedance probability (less than 20%) are expected to experience a smaller relative decrease compared to lower flows associated with high exceedance probabilities (greater than 80%); suggesting that the rivers will sustain lower flows in dry seasons and increase the frequency of no flow. Furthermore, the high flow scenarios also decrease in magnitude, suggesting an overall decrease in flow within the river. The northern and the southern nodes portray a similar trend, however the southern node, node 11 shows the smallest decrease in flow (Figure A2-19) when compared to the other nodes. Even though rainfall is projected to increase, the expected increase in temperature and associated evapotranspiration, will thus result in a net reduction in surface water runoff from the basin.

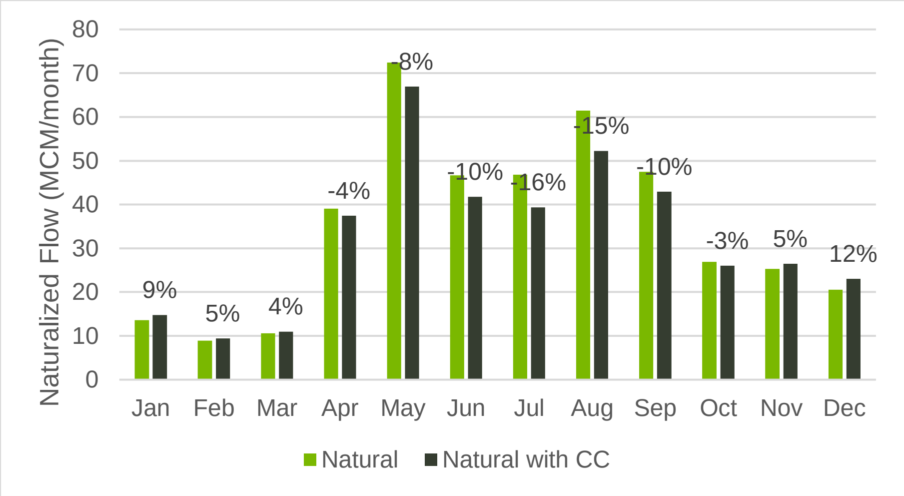


Figure A2-12: Monthly average flows and percentage change under current and future climate conditions - LVS Node 2

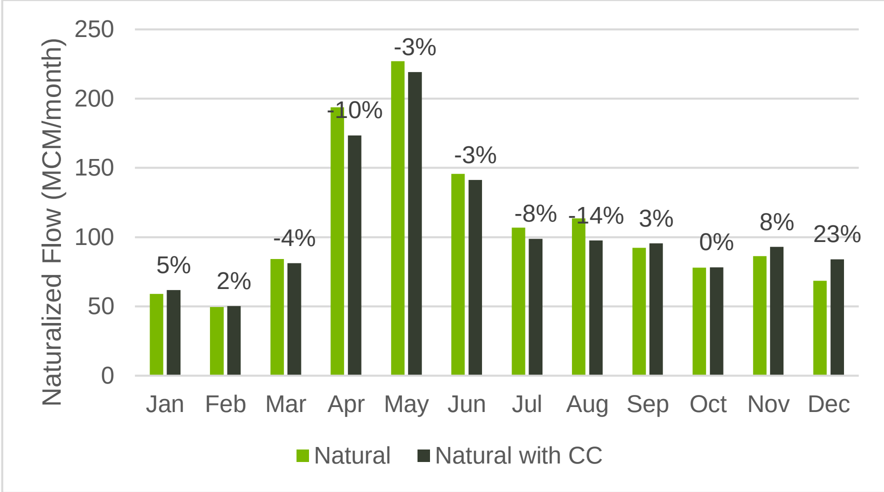


Figure A2-13: Monthly average flows and percentage change under current and future climate conditions - LVS Node 5

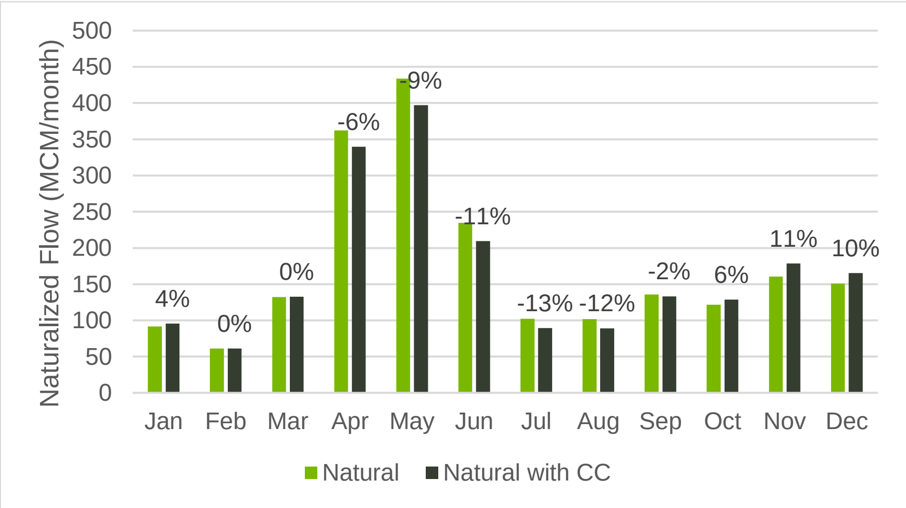


Figure A2-14: Monthly average flows and percentage change under current and future climate conditions - LVS Node 9

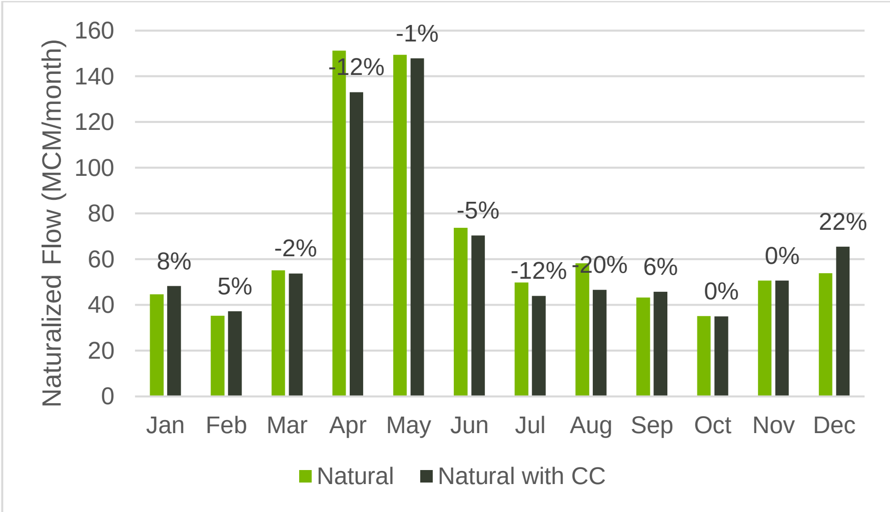


Figure A2-15: Monthly average flows and percentage change under current and future climate conditions - LVS Node 11

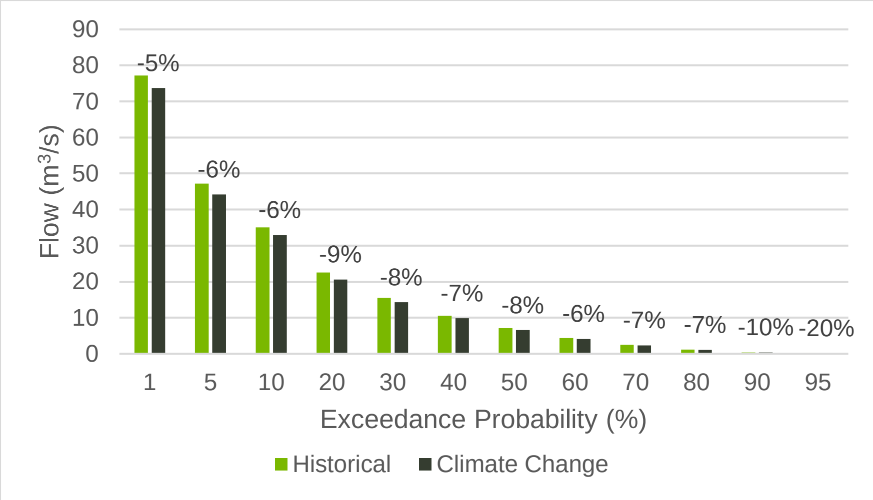


Figure A2-16: Monthly flow exceedance and percentage change under current and future climate conditions – LVS Node 2

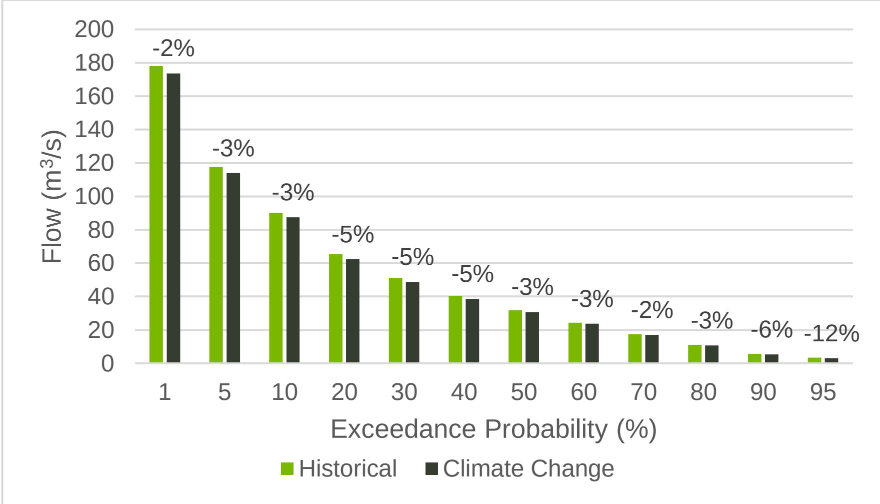


Figure A2-17: Monthly flow exceedance and percentage change under current and future climate conditions – LVS Node 5

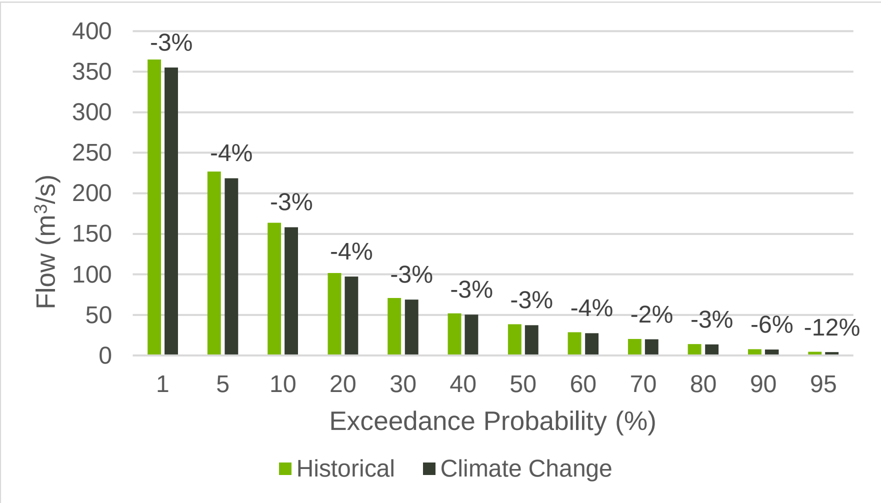


Figure A2-18: Monthly flow exceedance and percentage change under current and future climate conditions –LVS Node 9

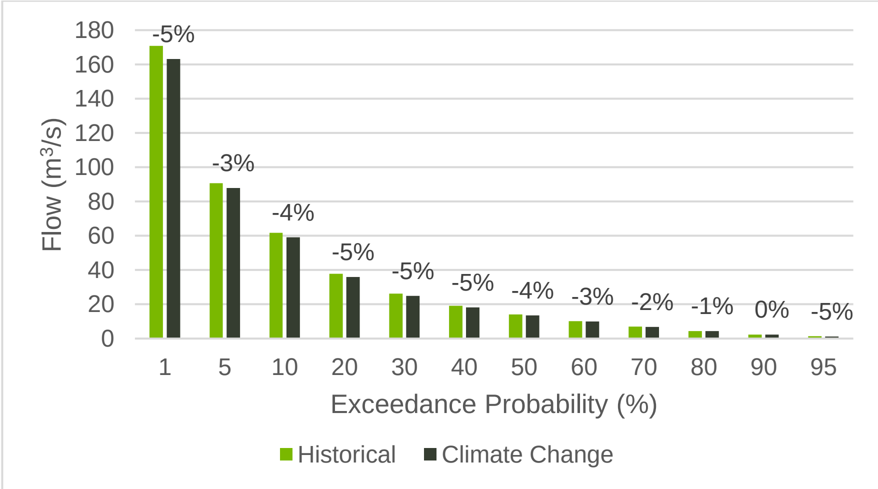


Figure A2-19: Monthly flow exceedance and percentage change under current and future climate conditions – LVS Node 11

A3: Surface water resources modelling

The main objectives of the surface water resources analysis for the Lake Victoria South Basin are to quantify the available surface water within the basin under natural conditions in both space and time, as well as to assess the present-day (baseline) surface water availability. This has been achieved through the development of a water resources systems model of the basin, which simulates the hydrological network, water demands and water resources infrastructure. MIKE HYDRO Basin, which incorporates the NAM rainfall-runoff model, was used as the water resources system model.

Hydrometeorological data collection and review

The Water Resources Authority (WRA) rainfall database contains historical daily data at 132 rainfall stations in the Lake Victoria South Basin, with data availability ranging from 1926 up to 2010. Of these, 36 stations with good quality records were selected. Raw data availability at each station is displayed in Figure A3-1, while the locations of the stations are shown in Figure A3-2.

Using monthly gap-filling tools, the station records were patched. The monthly gap filled data were disaggregated to daily data using nearby station daily rainfall patterns.

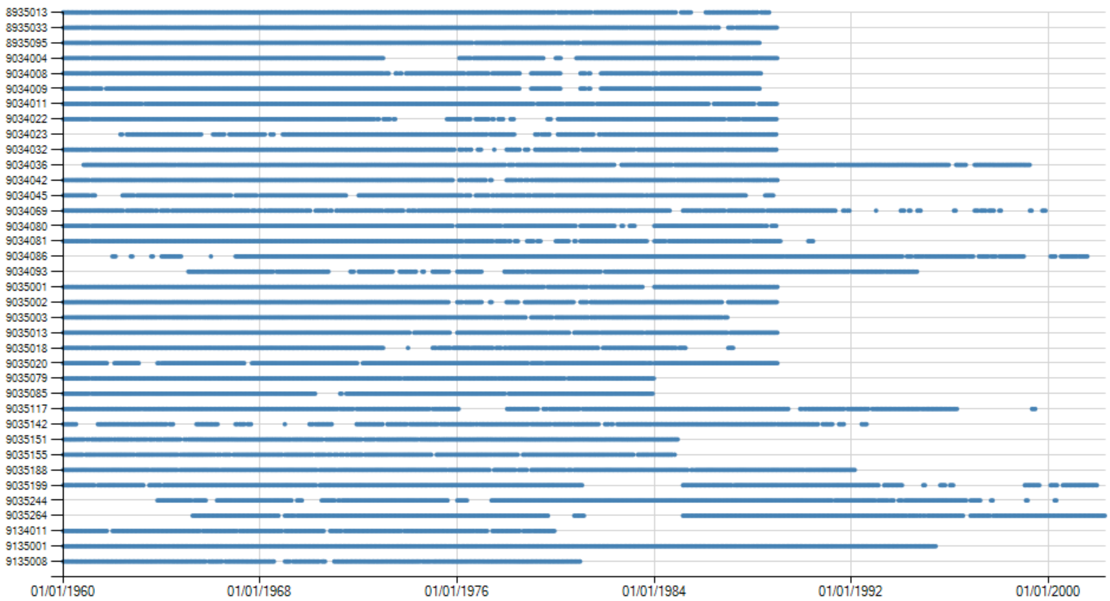


Figure A3-1: Data availability at selected rainfall stations

As the majority of the WRA data only extended up to Dec 1989, the Climate Hazards Group InfraRed Precipitation with Stations data (CHIRPS) dataset (Funk et al, 2015) was used to extend the rainfall datasets at the selected stations from 1989 to 2017. The CHIRPS dataset was identified for potential use, due to its relatively high resolution compared to other blended station data and satellite blended precipitation datasets.

CHIRPS is a 30+ year quasi-global rainfall dataset, spanning 50°S - 50°N (and all longitudes). CHIRPS incorporates 0.05° resolution satellite imagery with in-situ station data to create gridded rainfall time series starting in 1981 to near-present. CHIRPS was developed to support the United States Agency for International Development Famine Early Warning Systems Network (FEWS NET) and is freely available. CHIRPS data been used in studies to quantify the hydrologic impacts of decreasing precipitation and rising air temperatures in the Greater Horn of Africa, as well as support effective hydrologic forecasts and trend analyses in south-eastern Ethiopia (Funk, et al., 2015). CHIRPS daily precipitation data (Jan 1989 - Jan 2017) were extracted for multiple 0.05° grid cells corresponding to selected rainfall stations locations. The extracted CHIRPS records were used to extend the gap-filled observed rainfall records providing point rainfall time series for the period from Jan 1960 to Jan 2017.

Due to the relatively few rainfall stations in the Lake Victoria South Basin, as well as the limited availability of high elevation and near recent observed precipitation data, a Mean Annual Precipitation (MAP) surface for the basin was generated using the CHIRPS rainfall dataset (see Figure A3-3).

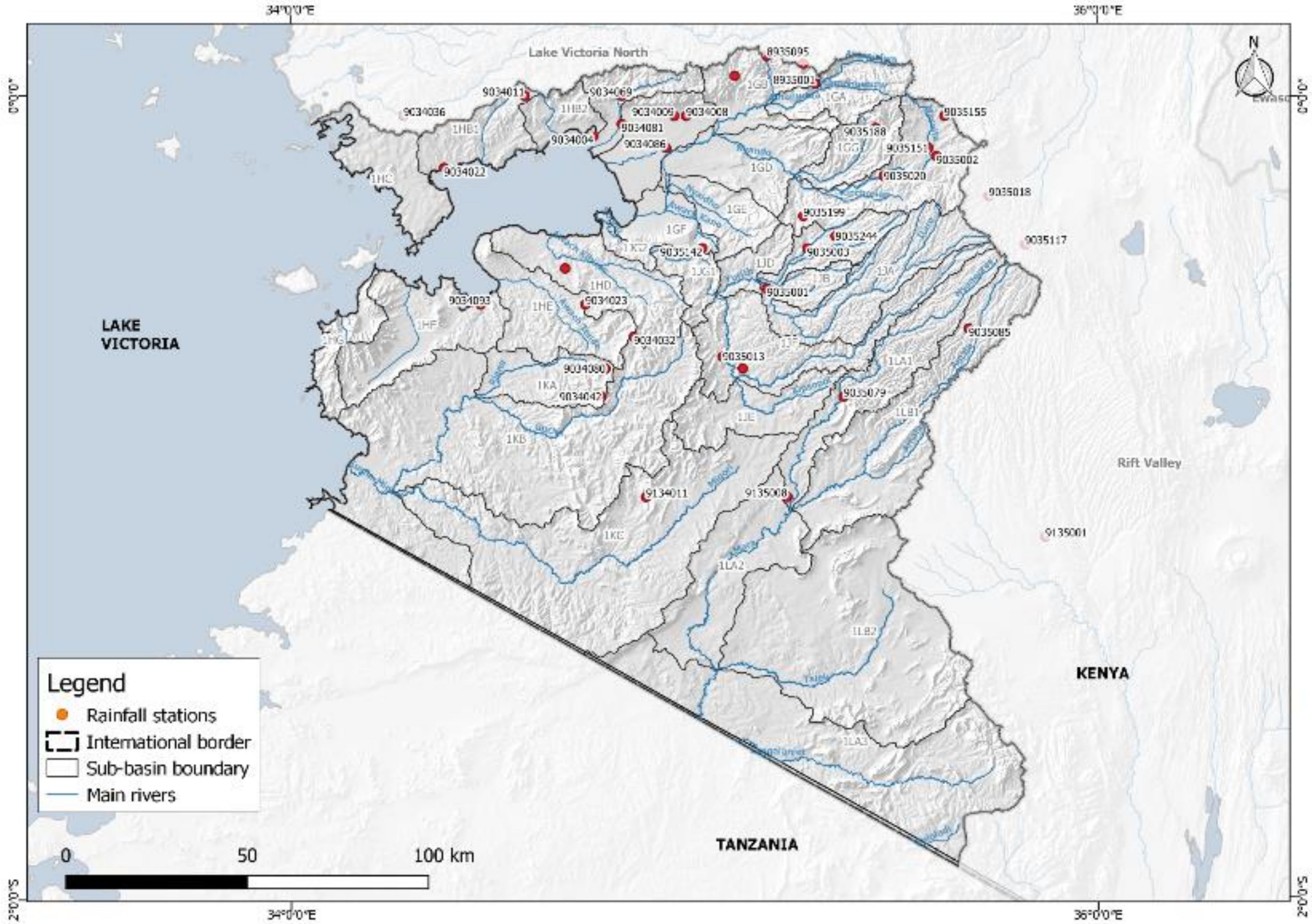


Figure A3-2: Location of selected rainfall stations

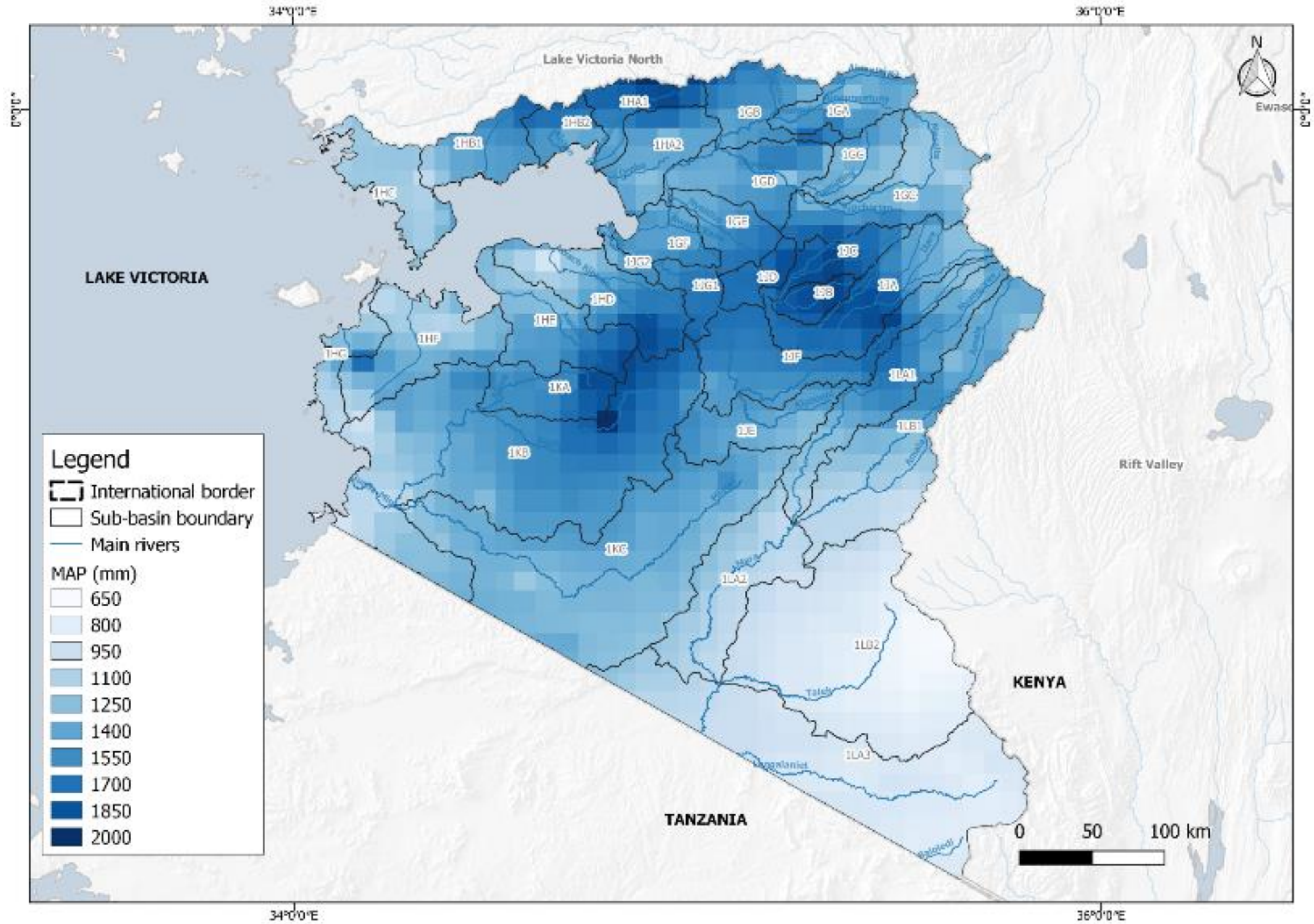


Figure A3-3: Mean Annual Precipitation

Streamflow data

In total, the Lake Victoria South Basin has historical daily water level records of varying quality and completeness for approximately 90 streamflow stations. Historical spot flow measurements of water level and discharge are available at 61 stations, with converted discharge records only available at 28 stations. A review of the available discharge records based on station location, records length, and data quality, resulted in an initial selection of 10 stations which are representative of the upper, middle and lower sections of the basin. Data availability at these stations, as sourced from WRA, is shown in Figure A3-4. Record periods at these stations vary between 10 and 50 years, however some stations are characterised by significant periods of missing data.

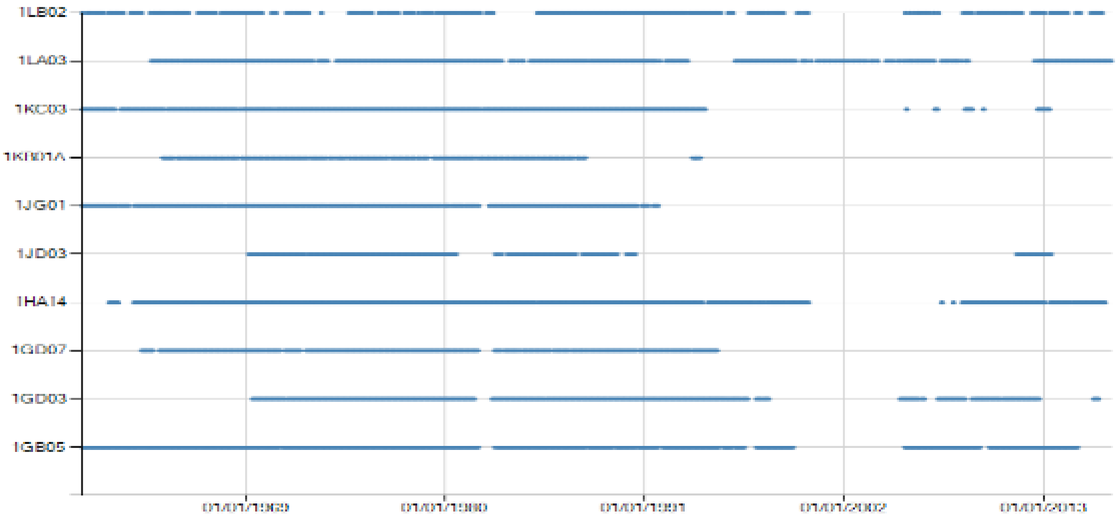


Figure A3-4: Data availability at selected river gauging stations

After quality control, which involved graphical analysis, mass plots and statistical analyses, anomalies and inconsistencies in some of the station records were identified. Eventually, only 10 stations were selected as listed in Table A3-1. These stations were used for calibration and validation of the rainfall-runoff model. Their locations within the basin are indicated in Figure A3-5.

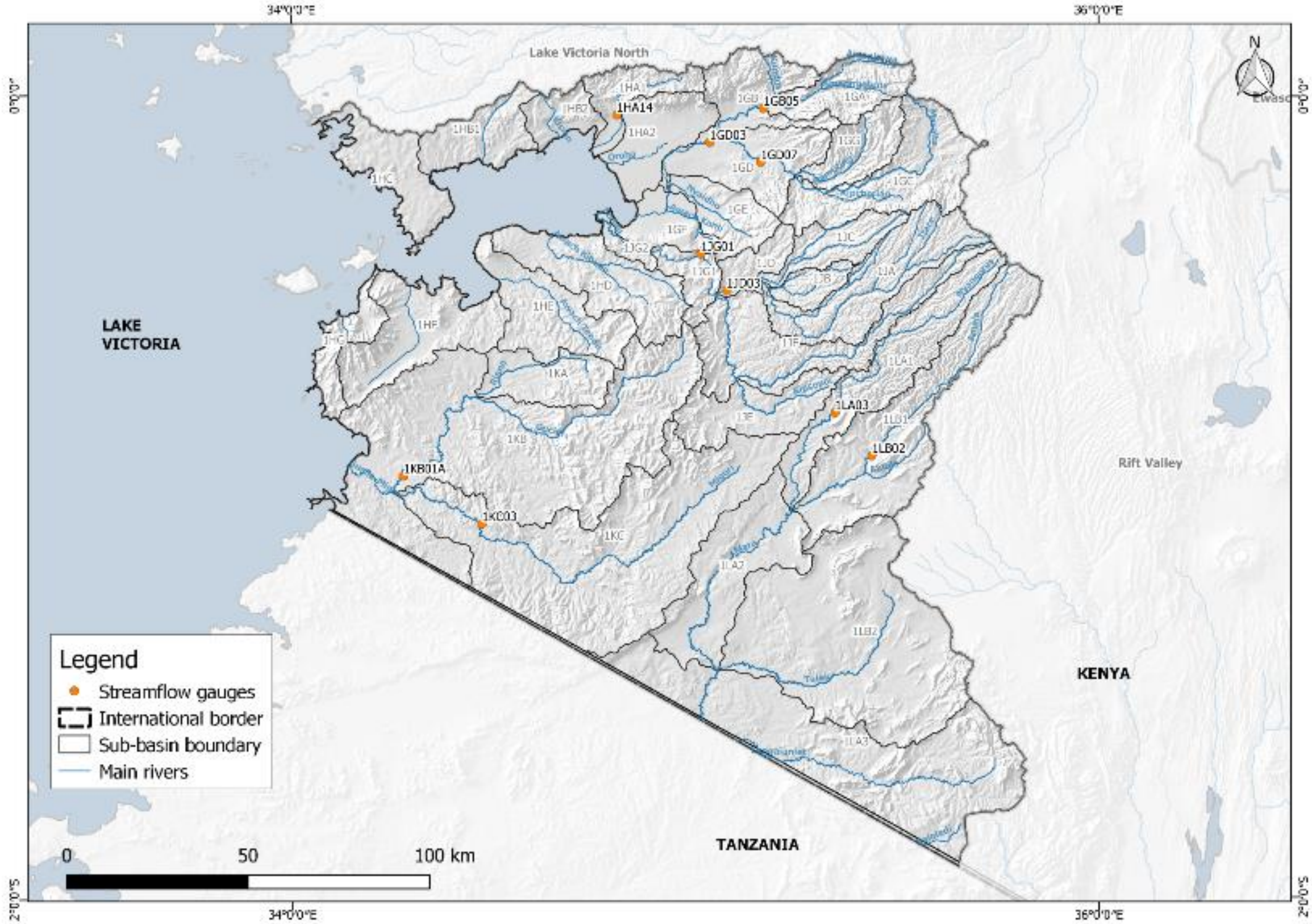


Figure A3-5: Locations of selected streamflow gauging stations

Table A3-1: Selected streamflow gauges for model calibration and validation

Station ID	Name	Longitude (°)	Latitude (°)	Catchment Area (km^2)
1GB05	AINAMATUA	35.1750	-0.0264	606
1GD03	NYANDO	34.9597	-0.1250	2 625
1GD07	NYANDO	35.1639	-0.1639	1 419
1HA14	AWACH	34.8042	-0.0472	104
1JD03	YURITH	35.0792	-0.4764	3 006
1JG01	SONDU	35.0083	-0.3931	3 287
1KB01A	GUCHA MACALDER	34.2750	-0.9542	3 115
1KC03	MIGORI	34.4708	-1.0639	3 046
1LA03	NYANGORES	35.3472	-0.7861	679
1LB02	AMALA	35.4375	-0.89722	697

Evaporation data

Potential or reference evapotranspiration (ETo) data is one of the key inputs for rainfall runoff modelling. An analysis of evaporation data in the WRA repository was undertaken to assess data availability. The WRA database contains eight evaporation stations in the Lake Victoria South Basin. However, stations are plagued with data availability issues as evident from Figure A3-6.

Observed evaporation data were thus considered insufficient for water resources modelling and gridded temperature data from the US National Oceanic and Atmospheric Administration (NOAA) was rather used to derive potential evaporation estimates in the basin. The NOAA dataset was derived from observed temperature data and consists of gridded average temperature data with a spatial resolution of 0.5° (approximately 50km over the equator) and a temporal resolution of one month for the period 1948-2017. The temperature based Blaney-Criddle method was used to convert the temperature data to monthly gridded reference ETo, from which a Mean Annual Potential Evapotranspiration map was developed for the Lake Victoria South Basin as shown in Figure A3-7.

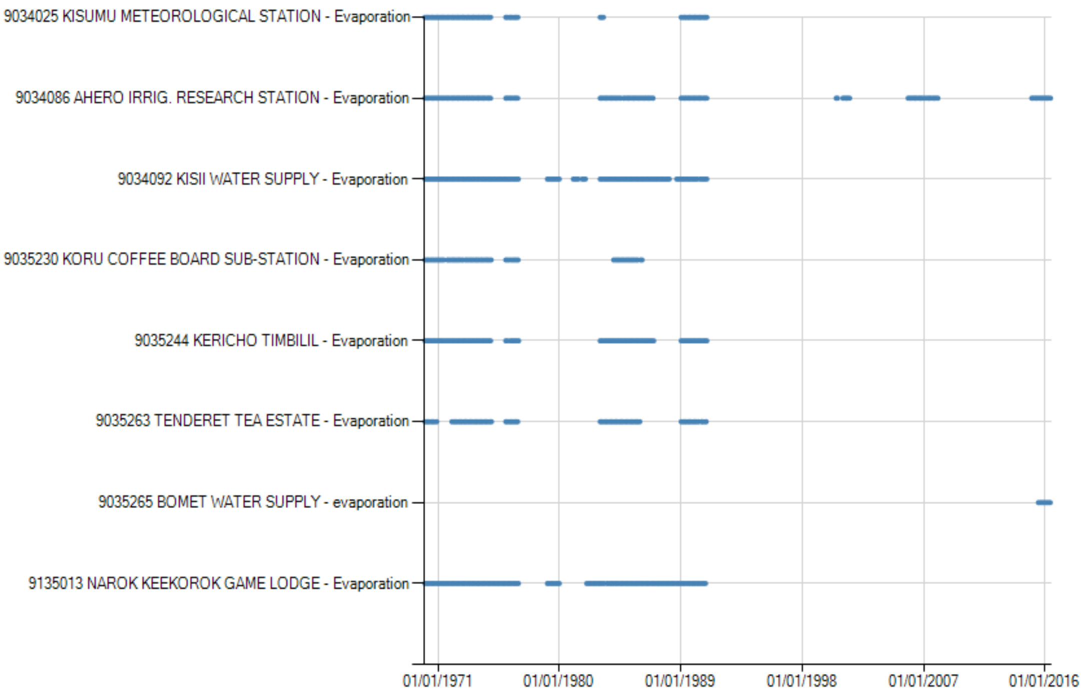


Figure A3-6: Data availability at evaporation stations

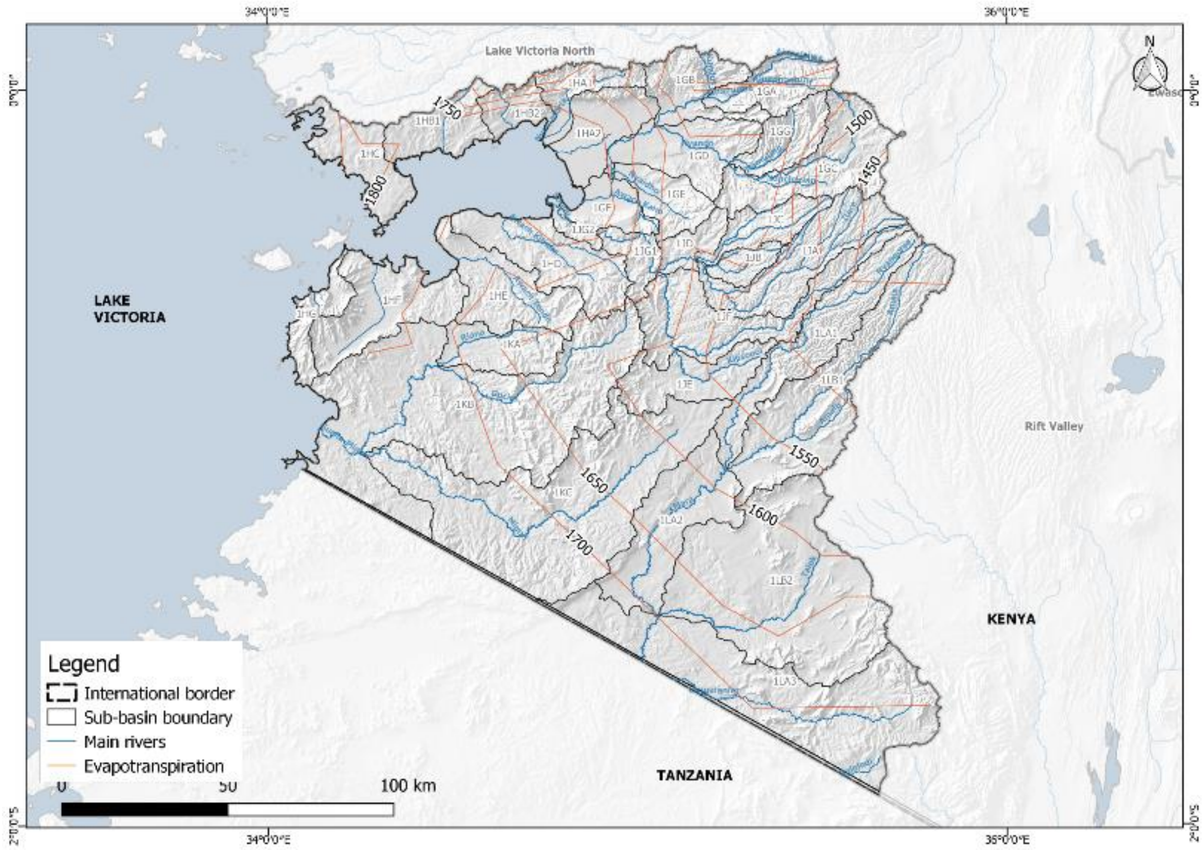


Figure A3-7: Mean annual evapotranspiration (mm)

Water Resources Model

MIKE HYDRO Basin is a commercially-available, multipurpose, map-based decision support tool developed by the Danish Hydraulics Institute (DHI) for integrated river basin analysis, planning and management (DHI, 2017). It is designed for analysing water sharing issues at international, national and local river basin level and includes the lumped and conceptual NAM rainfall-runoff model.

In essence, the purpose of the water resources simulation modelling as part of this study, was to provide a tool to determine the natural, current and future surface water balance of the Lake Victoria South Basin and to assess the impacts of future development opportunities in an integrated manner to support future water allocations and planning. The model was used, firstly, to evaluate the historic (natural) and present-day (baseline) water balance of the Basin and will be used to simulate the water balance under alternative future development, land-use and climate-change scenarios during the next model development phase.

Based on the availability of historical rainfall data, a simulation period from 1 Jan 1960 to 1 Jan 2017 was determined for the model simulations, which were conducted at a daily time-step.

The water resources modelling task involved the sequential steps listed below, each of which is discussed in more detail in the following sections:

1. Model sub-catchment delineation
2. Assignment of hydro-meteorological time series data to model sub-catchments
3. Model calibration and validation
4. Configuration of natural and present-day models

Catchment delineation

River network generation and catchment delineation of model sub-catchment areas within the Lake Victoria South Basin were based on the HydroSHED hydrologically conditioned 90 m SRTM DEM (NASA, 2009), processed within MIKE HYDRO Basin's catchment delineation tool. Sub-catchment areas were delineated upstream of points of interest such as WRA sub-basin outlets (i.e. 1GA, 1GB…), streamflow gauging stations, existing and proposed dams, tributary confluences, river diversion or abstraction points and proposed water resources development schemes. Figure A3-6 presents an overview of the Lake Victoria South Basin containing the final delineated model sub-catchments. In total, 52 sub-catchments were delineated.

Assignment of hydro-meteorological data

The NAM rainfall-runoff model, which is incorporated in the MIKE HYDRO Basin model, requires rainfall and evaporation time series data to be assigned to each model sub-catchment.

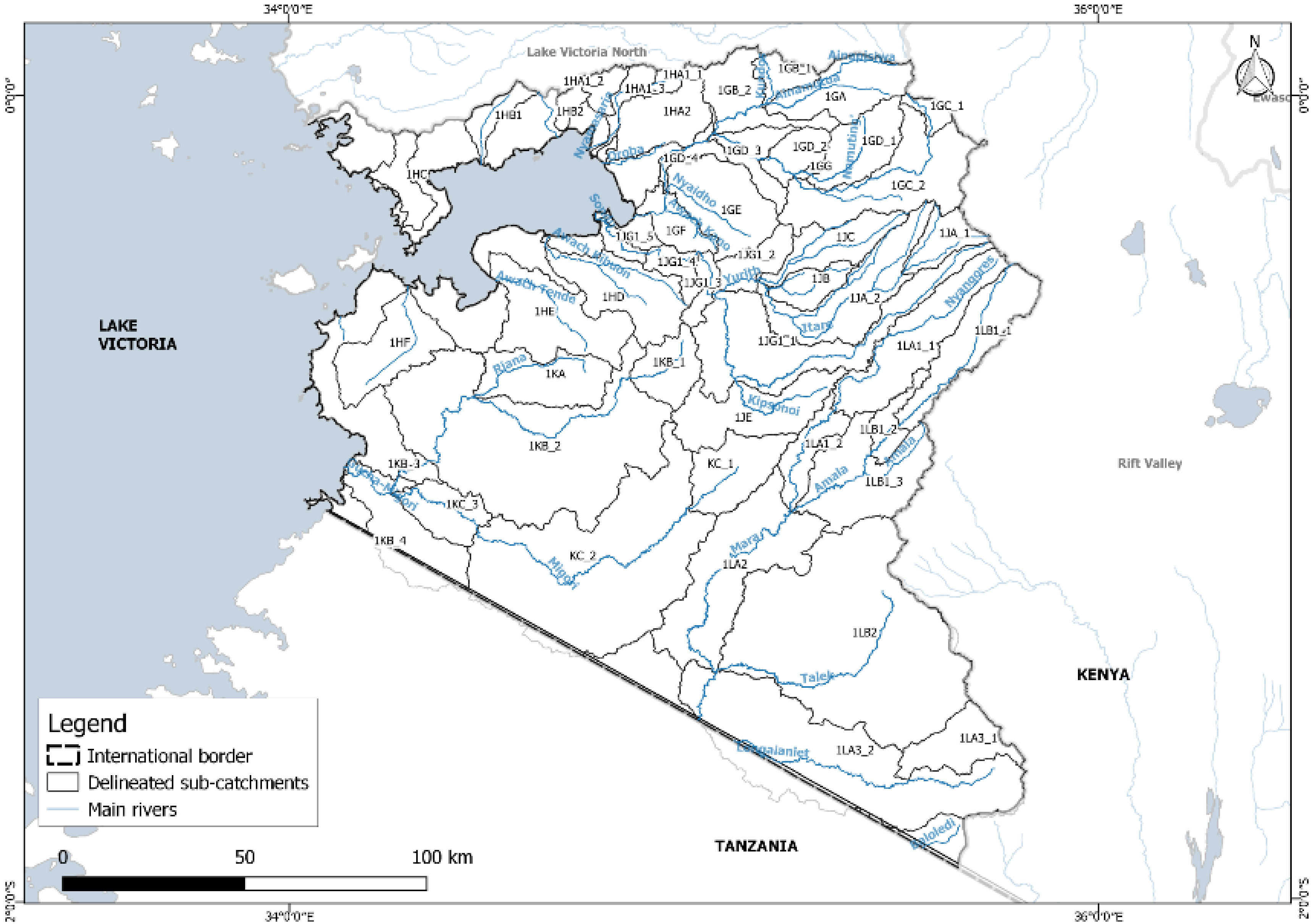


Figure A3-6: Delineated model sub-catchments in the Lake Victoria South Basin

The point rainfall data at the 36 rainfall stations across the Basin (see Section 2.1) were converted from units of millimetres per day to % MAP per day for the simulation period (1960 – 2017). Point rainfall time series were then converted to catchment (areal) rainfall time series with the use of Thiessen Polygons, resulting in a single, daily % MAP file for each modelled sub-catchment. The conversion of rainfall units from % MAP back to mm, was achieved though multiplication with the sub-catchment MAPs extracted from the CHIRPS-based MAP coverage.

Based on the constructed ETo surface for the Lake Victoria South Basin as discussed in Section 0, areal averaged monthly ETo values for each model sub-catchment were calculated and assigned. An example of calculated daily ETo values at locations in the upper, middle and lower Lake Victoria South Basin is shown in Figure A3-7.

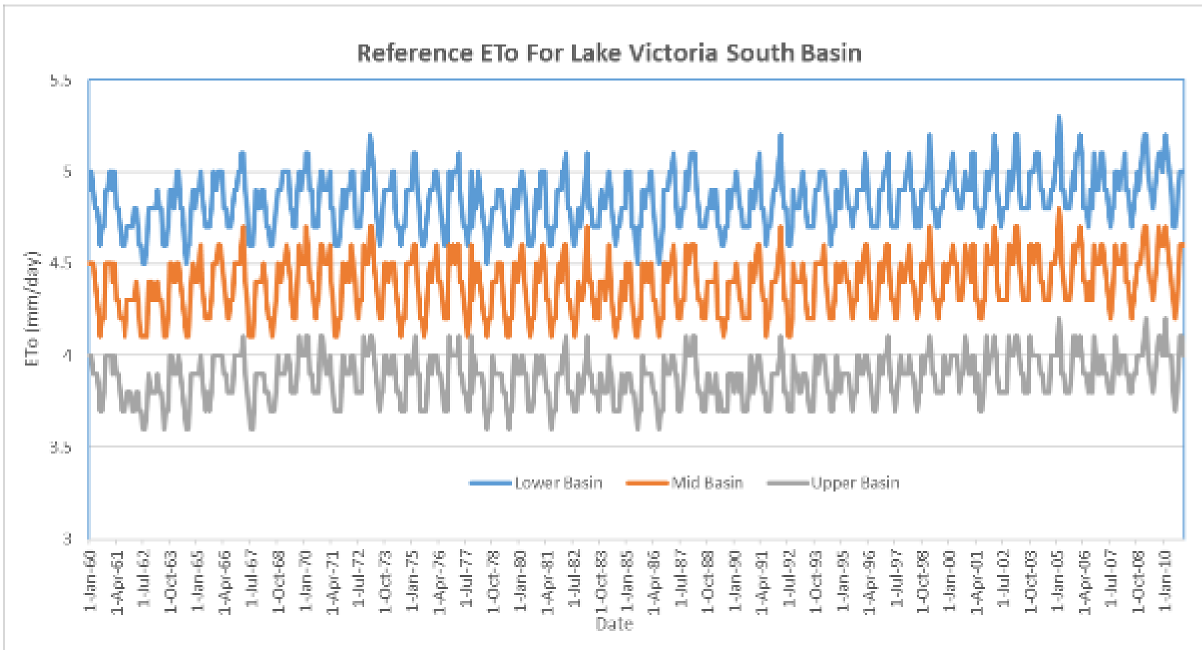


Figure A3-7: Typical reference ETo values in the upper, middle and lower Lake Victoria South Basin

Model Calibration

The calibration of the NAM rainfall-runoff model in the Lake Victoria South Basin was dependent on the availability of concurrent and good quality historical precipitation and streamflow data. On this basis, 7 flow gauging stations were chosen as calibration locations. The majority of potential calibration periods at these stations occurred between 1960 and 1990 - due to better observed data availability and apparent superior data quality compared to more recent time periods. Although the relatively undeveloped state of the identified calibration catchments during this time period meant that the catchments could be considered close to their 'natural' state, historical water demand data for calibration periods, from the WRA database, were added to downstream observed streamflow records at the calibration sites in order to 'naturalise' the observed flow records before calibration. A description of the NAM rainfall-runoff model calibration parameters is provided in Table A3-2.

Table A3-2: NAM rainfall-runoff calibration parameters

Category	Parameter Name	Parameter Abbreviation	Description	Typical Values

Surface-rootzone:	Maximum water content in surface storage	UMax	Represents the cumulative total water content of the interception storage (on vegetation), surface depression storage and storage in the uppermost layers (a few cm) of the soil.	10 mm-20 mm
Surface-rootzone:	Maximum water content in root zone storage	LMax	Represents the maximum soil moisture content in the root zone, which is available for transpiration by vegetation.	50 mm-300 m
Surface-rootzone:	Overland flow runoff coefficient	CQOF	Determines the division of excess rainfall between overland flow and infiltration.	0-1
Surface-rootzone:	Time constants for routing interflow	CKIF	Determines the amount of interflow, which decreases with larger time constants.	500 hrs - 1000 hrs
Surface-rootzone:	Time constants for routing overland flow	CK1	Determine the shape of Hydrograph peaks. The routing takes place through two linear reservoirs (serially connected) with different time constants, expressed in hours. High, sharp peaks are simulated with small time constants, whereas low peaks, at a later time, are simulated with large values of these parameters.	3 hrs - 48 hrs
Surface-rootzone:	Time constants for routing overland flow	CK2		
Surface-rootzone:	Root zone threshold value for overland flow	TOF	Determines the relative value of the moisture content in the root zone (L/Lmax) above which overland flow is generated. The main impact of TOF is seen at the beginning of a wet season, where an increase of the parameter value will delay the start of runoff as overland flow.	0% - 70% of Lmax. Max value 0.99
Surface-rootzone:	Root zone threshold value for interflow	TIF	Determines the relative value of the moisture content in the root zone (L/Lmax) above which interflow is generated.	-
Groundwater	Root zone threshold value for GW recharge	TG	Determines the relative value of the moisture content in the root zone (L/Lmax) above which groundwater (GW) recharge is generated. The main impact of increasing TG is less recharge to the groundwater storage.	0% - 70% of Lmax. Max value 0.99
Groundwater	Time constants for routing base flow	CKBF	Can be determined from the Hydrograph recession in dry periods. In rare cases, the shape of the measured recession changes to a slower recession after some time.	-
Groundwater	Lower base flow/recharge to lower reservoir	CQLow	Percentage recharge to the lower groundwater reservoir as percentage of the total recharge.	0% - 100%
Groundwater	Time constant for routing lower base flow	CKLow	Specified for CQLow > 0 as a baseflow time constant, which is usually larger than the CKBF.	-

Simulated streamflow sequences were calibrated against naturalised observed flow records through the iterative adjustment of the NAM model parameters until the 'goodness of fit' between the simulated and observed flow records was within acceptable standards. 'Goodness of fit' was assessed based on graphical comparison of time series and scatterplots, while various metrics and statistical indices such as average annual flow, standard deviation of annual flow, seasonality index, coefficient of determination and the Nash-Sutcliffe coefficient of efficiency were considered.

The Nash-Sutcliffe Efficiency (NSE) is a normalised statistic used to assess the predictive power of hydrological models by determining the relative magnitude of the residual variance compared to the measured data variance (Nash and Sutcliffe, 1970). NSE indicates how well the plot of observed versus simulated data fits the 1:1 line. NSE ranges between $-\infty$ and 1, with NSE equal to 1 being the optimal value. Values between 0 and 1 are generally viewed as acceptable levels of performance, whereas values smaller than 0 indicates that the mean observed value is a better predictor than the simulated value, which indicates unacceptable performance (Moriasi et al., 2007).

Calibrated NAM parameters at the calibration gauges are presented in Table A3-3 with calibration performance metrics per gauge summarised in Table A3-4. Calibration plots are presented in Figure A3-8 to Figure A3-14.

Table A3-3: Calibrated NAM model parameters

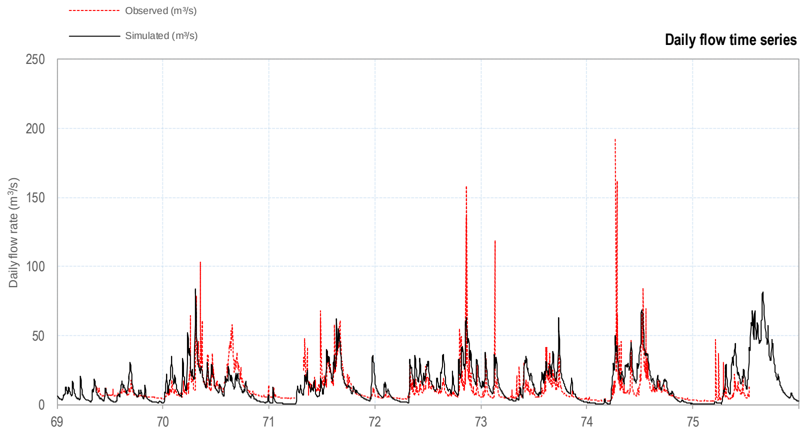
Gauge		Surface-rootzone							
Parameter Set	Gauge	Umax	Lmax	CQOF	CKIF	CK1	CK2	TOF	TIF
no.	ID	mm	mm	-	h	h	h	-	-
1	1GB05	15	390	0.4	2000	20	-	0.2	0
2	1GD03	10	200	0.1	2000	48	-	0.1	0
3	1GD07	12	150	0.2	2000	48	-	0.1	0
4	1HA14	5	70	0.2	200	30	-	0	0
5	1JD03	3	70	0.1	700	30	-	0	0
6	1JG01	2	70	0.4	1000	40	-	0	0
7	1KB01A	2	70	0.5	2000	40	-	0	0
8	1KC03	2	70	0.45	2000	30	-	0	0
9	1LA03	7	100	0.2	2000	40	-	0	0
10	1LB02	7	150	0.2	2000	40	-	0	0

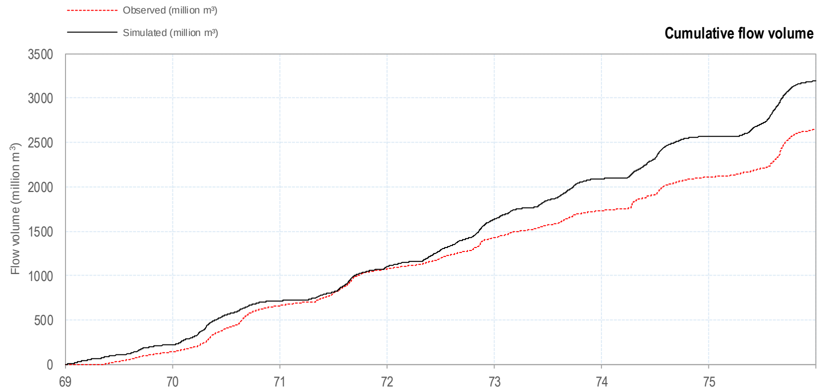
Gauge		Groundwater	
Parameter Set	Gauge	TG	CKBF
no.	ID	-	h
1	1GB05	0.4	2000
2	1GD03	0.12	500
3	1GD07	0.15	700
4	1HA14	0	500
5	1JD03	0	500
6	1JG01	0	1000
7	1KB01A	0	500
8	1KC03	0	500
9	1LA03	0.2	500
10	1LB02	0.3	500

Table A3-4: Calibration performance metrics

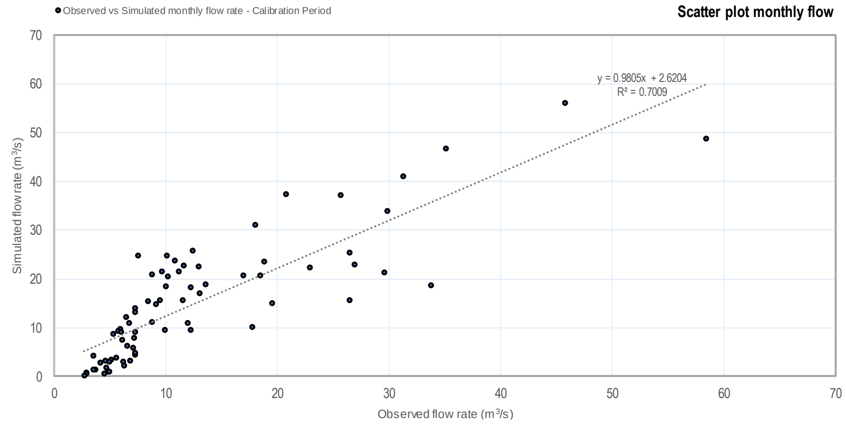
Station number	Catchment Area (km^2)	Calibration Period	Observed MAR (MCM)	Simulated MAR (MCM)	Coefficient of Determination (r^2)	Water Balance Error (WBL)	Nash-Sutcliffe efficiency (NSE)
1GD03	2 625	Jan 1969-Dec 1975	391	428	0.701	+8.6%	0.374
1GD07	1 419	Jan 1963-Dec 1974	248	251	0.354	+1.0%	0.184
1KC03	3 046	Jan 1965-Dec 1972	481	491	0.244	+2.1%	-0.114
1LA03	679	Jan 1977-Dec 1987	289	271	0.571	-6.8%	0.431
1GB05	606	Jan 1962-Dec 1973	113	101	0.639	-11.8%	0.154
1JG01	3 287	Jan 1964-Dec 1974	1 295	1 186	0.675	-9.2%	0.566
1KB01A	3 115	Jan 1971-Dec 1984	1 183	1 093	0.576	-8.2%	0.406

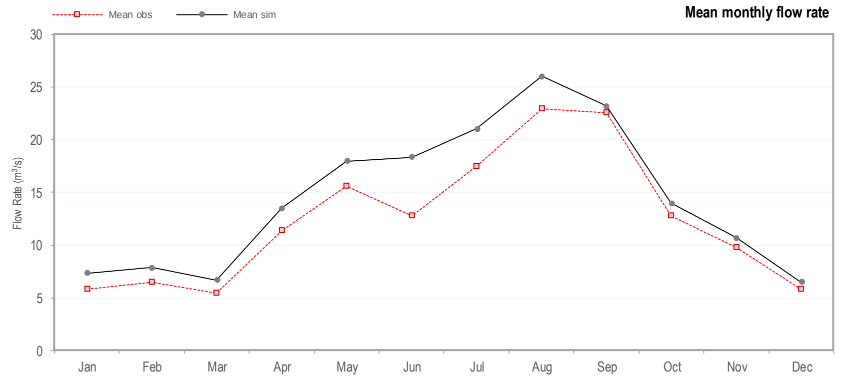
Calibration Results: 1GD03 - NYANDO   Catchment Area: 2625 km³   3/20/2019 3:02 PM





Calibration Results: 1GD03 - NYANDO   Catchment Area: 2625 km³   3/20/2019 3:02 PM





Performance Metrics

Node no. N61|Net flow to node

Coeff. of Determination (r^2) 0.701

Nash-Sutcliffe Coeff. of Efficiency 0.374

	Observed	Simulated	% Difference	Target %
Mean Annual Runoff (MAR) Jan- Dec [Mm³]	391.3	428.1	8.6%	± 4%
Annual Standard Deviation [Mm³]	63.2	113.2	44.2%	± 6%
Seasonal Index	29.08	16.12	-80.4%	± 8%

	Observed
Unit runoff [mm]	149.1
MAP [mm]	1419
Runoff %	11%

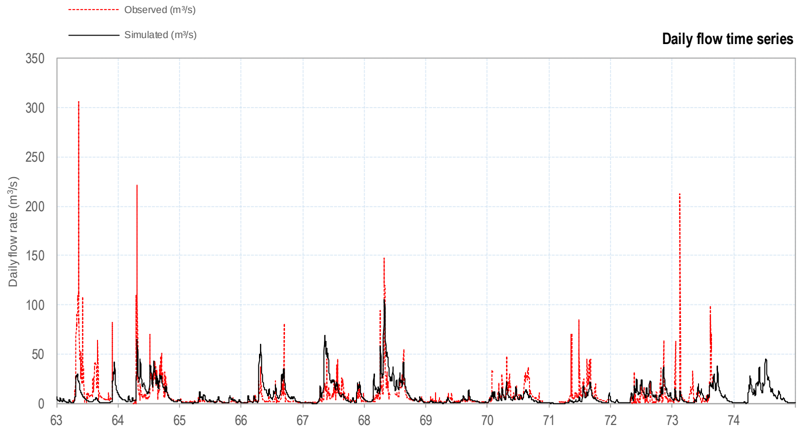
Node no. N61|Net flow to node

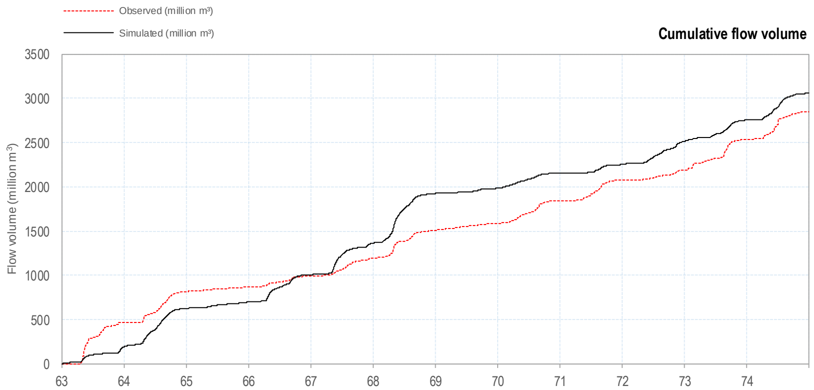
Average monthly flow rate [m³/s]

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average
Observed	5.9	6.5	5.4	11.4	15.6	12.7	17.5	22.9	22.6	12.7	9.8	5.8	12.4
Simulated	7.3	7.9	6.7	13.5	18.0	18.4	21.0	26.0	23.2	14.0	10.7	6.5	13.6
% difference	20.2%	17.9%	18.8%	15.8%	13.0%	30.6%	16.8%	12.1%	2.6%	8.9%	8.5%	10.4%	8.6%

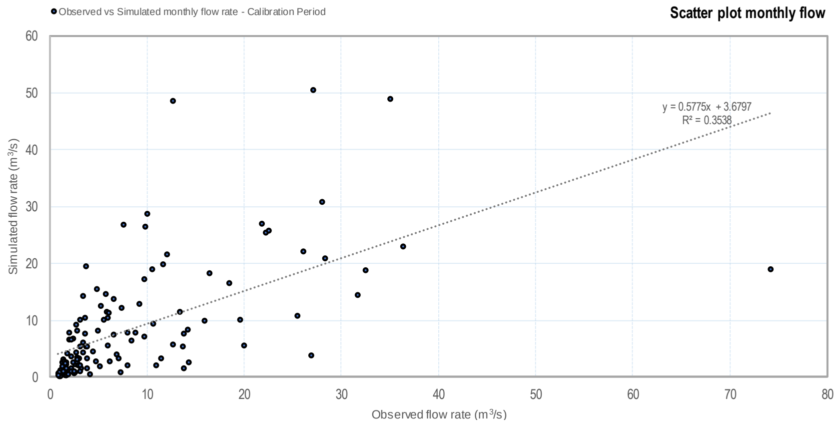
Figure A3-8: Calibration plot for streamflow gauge 1GD03

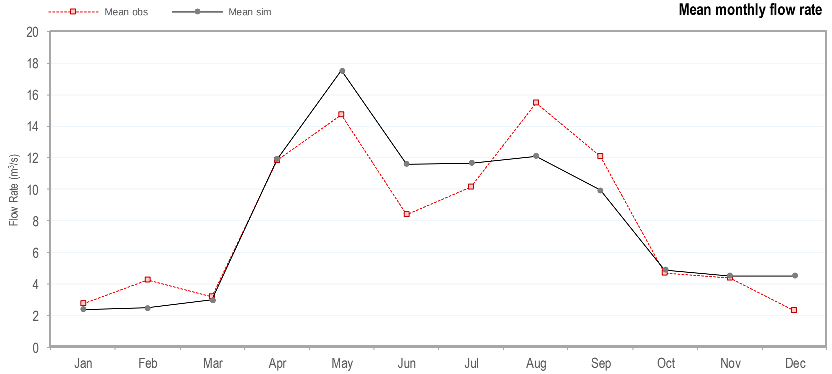
Calibration Results: 1GD07 - NYANDO Catchment Area: 1419 km³ 3/20/2019 5:23 PM





Calibration Results: 1GD07 - NYANDO Catchment Area: 1419 km³ 3/20/2019 5:23 PM





Performance Metrics

Node no. N60|Net flow to node

Coeff. of Determination (r^2) 0.354

Nash-Sutcliffe Coeff. of Efficiency 0.184

	Observed	Simulated	% Difference	Target %		Observed
Mean Annual Runoff (MAR) Jan- Dec [Mm³]	248.0	250.5	1.0%	± 4%	Unit runoff [mm]	174.8
Annual Standard Deviation [Mm³]	128.5	156.7	18.0%	± 6%	MAP [mm]	1364
Seasonal Index	25.94	26.00	0.2%	± 8%	Runoff %	13%

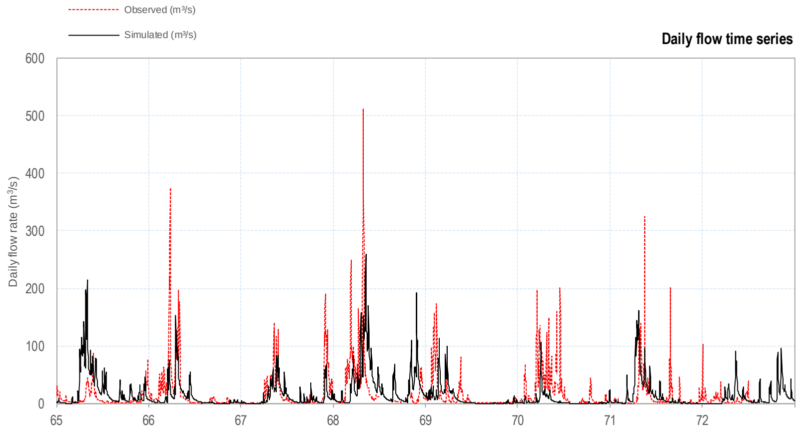
Node no. N60|Net flow to node

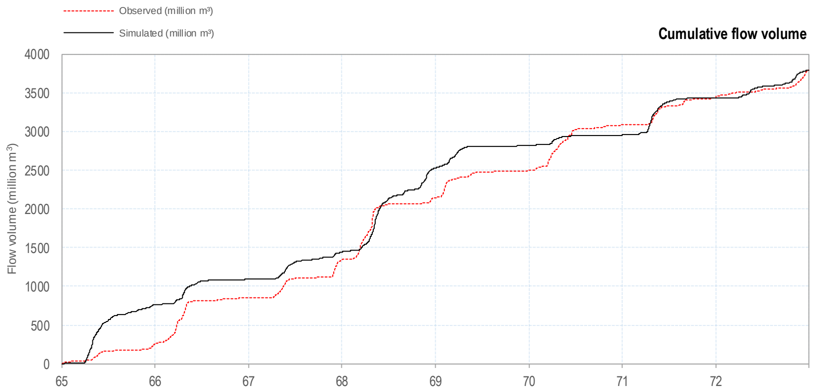
Average monthly flow rate [m³/s]

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average
Observed	2.8	4.3	3.2	11.9	14.7	8.4	10.1	15.5	12.1	4.7	4.4	2.3	7.9
Simulated	2.4	2.5	3.0	11.9	17.5	11.6	11.7	12.1	10.0	4.9	4.5	4.5	7.9
% difference	-16.6%	-71.7%	-6.4%	0.4%	16.1%	27.9%	13.2%	-28.1%	-21.7%	3.3%	3.2%	48.7%	0.9%

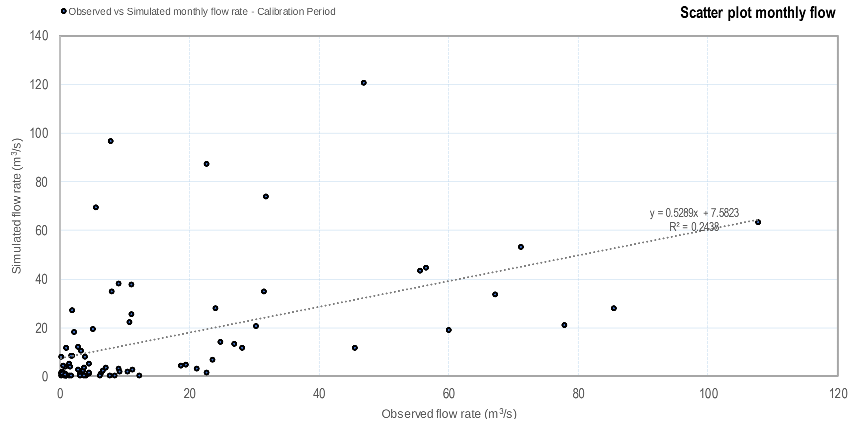
Figure A3-9: Calibration plot for streamflow gauge 1GD07

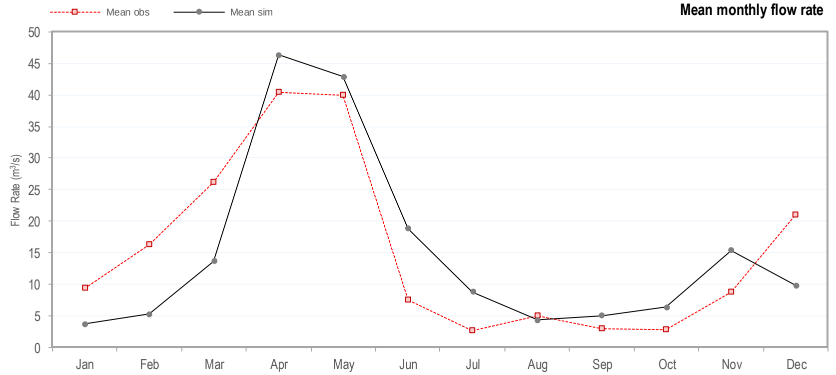
Calibration Results: 1KC03 - MIGORI Catchment Area: 3046 km³ 3/20/2019 5:25 PM





Calibration Results: 1KC03 - MIGORI Catchment Area: 3046 km³ 3/20/2019 5:25 PM





Performance Metrics

Node no. N64|Net flow to node

Coeff. of Determination (r^2) 0.244

Nash-Sutcliffe Coeff. of Efficiency -0.114

	Observed	Simulated	% Difference	Target %		Observed
Mean Annual Runoff (MAR) Jan- Dec [Mm³]	480.5	490.6	2.1%	± 4%	Unit runoff [mm]	157.7
Annual Standard Deviation [Mm³]	191.5	326.8	41.4%	± 6%	MAP [mm]	1338
Seasonal Index	33.70	37.11	9.2%	± 8%	Runoff %	12%

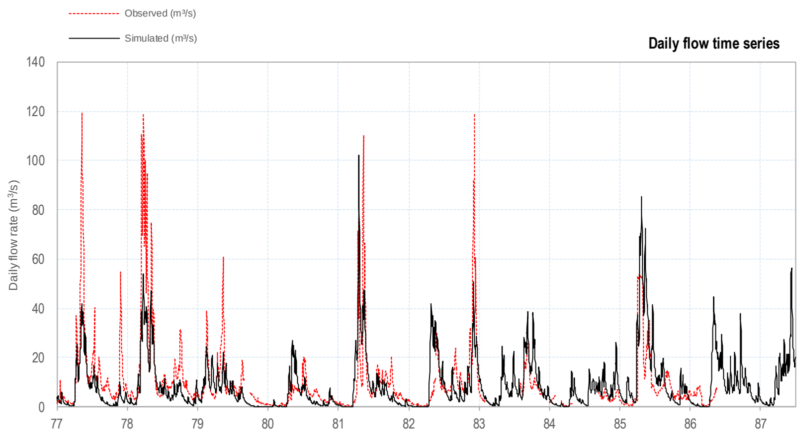
Node no. N64|Net flow to node

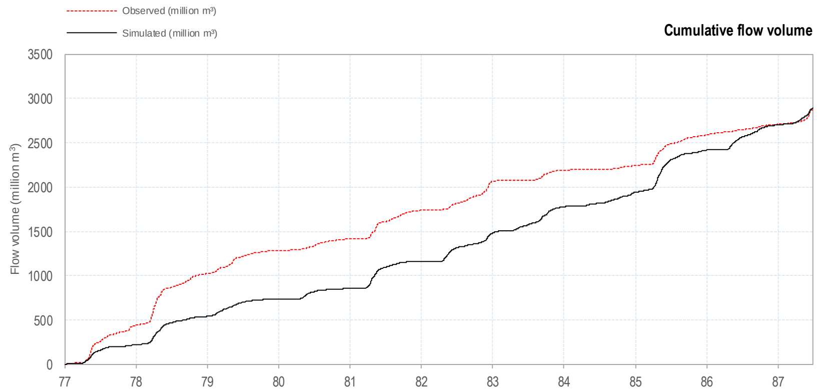
Average monthly flow rate [m³/s]

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average
Observed	9.4	16.3	26.1	40.4	39.9	7.5	2.7	4.9	3.0	2.8	8.8	20.9	15.2
Simulated	3.7	5.2	13.6	46.3	42.9	18.9	8.8	4.3	5.1	6.4	15.4	9.9	15.5
% difference	-151.8%	-211.4%	-91.7%	12.8%	7.0%	60.1%	69.5%	-14.2%	41.4%	55.4%	43.1%	-112.4%	2.1%

Figure A3-10: Calibration plot for streamflow gauge 1KC03

Calibration Results: 1LA03 - NYANGORES | Catchment Area: 679 km³ | 3/20/2019 5:28 PM





Performance Metrics

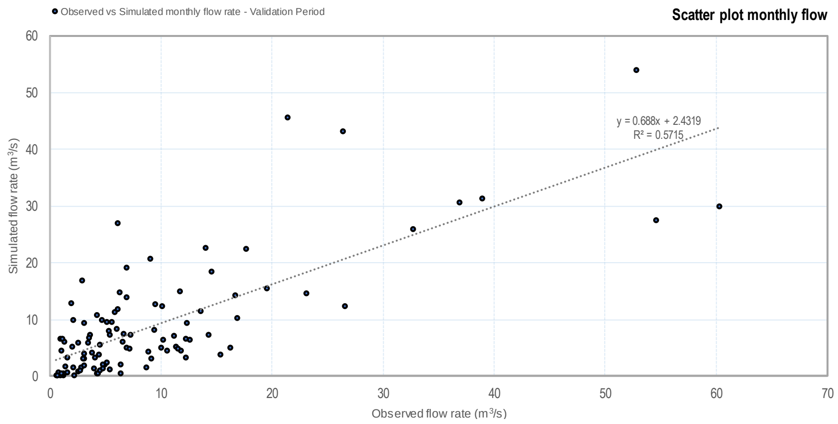
Node no. N68|Net flow to node

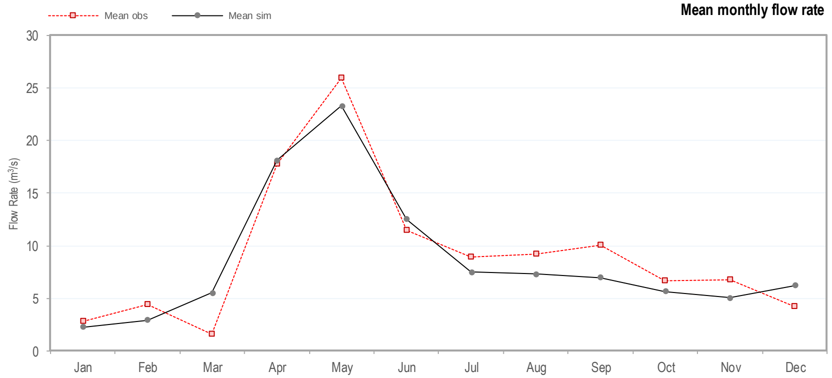
Coeff. of Determination (r^2) 0.571

Nash-Sutcliffe Coeff. of Efficiency 0.431

	Observed	Simulated	% Difference	Target %		Observed
Mean Annual Runoff (MAR) Jan- Dec [Mm³]	288.8	270.5	-6.8%	± 4%	Unit runoff [mm]	425.3
Annual Standard Deviation [Mm³]	155.6	100.1	-55.4%	± 6%	MAP [mm]	1487
Seasonal Index	27.04	26.59	-1.7%	± 8%	Runoff %	29%

Calibration Results: 1LA03 - NYANGORES | Catchment Area: 679 km³ | 3/20/2019 5:28 PM





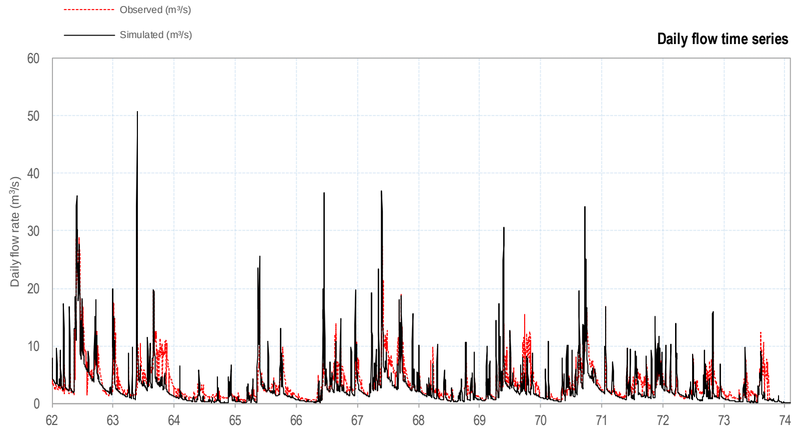
Node no. N68|Net flow to node

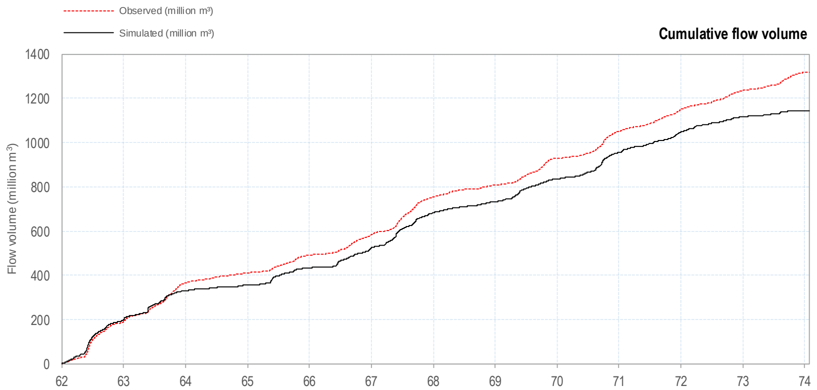
Average monthly flow rate [m³/s]

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average
Observed	2.8	4.4	1.6	17.8	25.9	11.5	8.9	9.2	10.1	6.7	6.8	4.2	9.2
Simulated	2.3	2.9	5.5	18.1	23.3	12.5	7.5	7.3	7.0	5.7	5.0	6.2	8.6
% difference	-22.8%	-51.8%	70.8%	1.9%	-11.2%	8.4%	-18.4%	-25.8%	-43.9%	-17.9%	-35.4%	32.2%	-6.7%

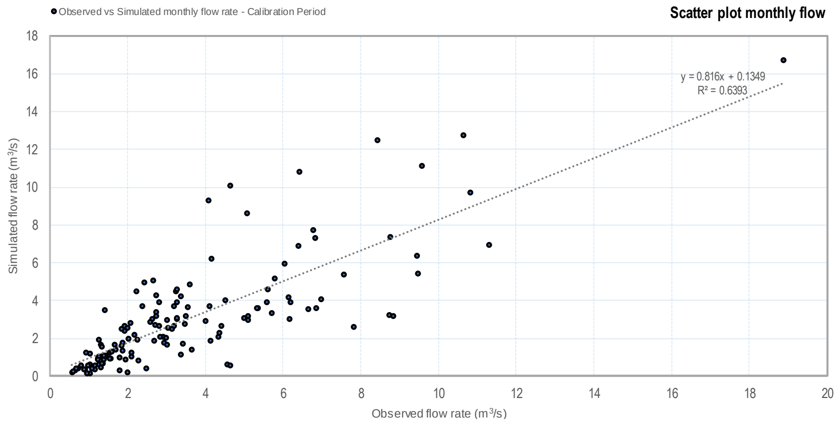
Figure A3-11: Calibration plot for streamflow gauge 1LA03

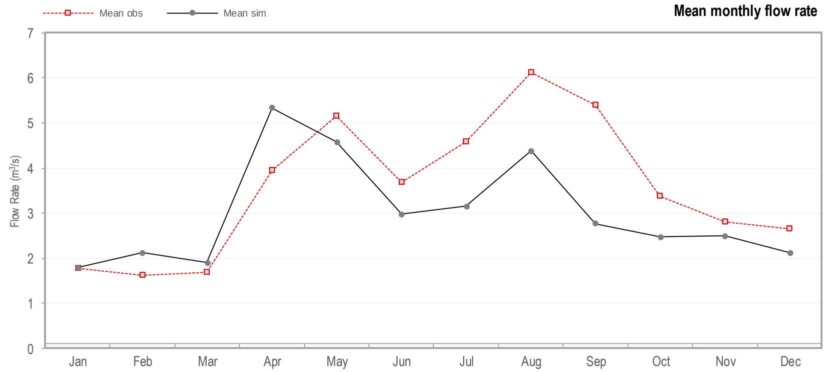
Calibration Results: 1GB05 - AINAMATUA Catchment Area: 606 km³ 3/20/2019 5:34 PM





Calibration Results: 1GB05 - AINAMATUA Catchment Area: 606 km³ 3/20/2019 5:34 PM





Performance Metrics

Node no. N59|Net flow to node

Coeff. of Determination (r^2)	0.639
Nash-Sutcliffe Coeff. of Efficiency	0.154

	Observed	Simulated	% Difference	Target %		Observed
Mean Annual Runoff (MAR) Jan- Dec [Mm³]	112.6	100.7	-11.8%	± 4%	Unit runoff [mm]	185.7
Annual Standard Deviation [Mm³]	55.4	51.0	-8.5%	± 6%	MAP [mm]	1442
Seasonal Index	16.61	14.53	-14.3%	± 8%	Runoff %	13%

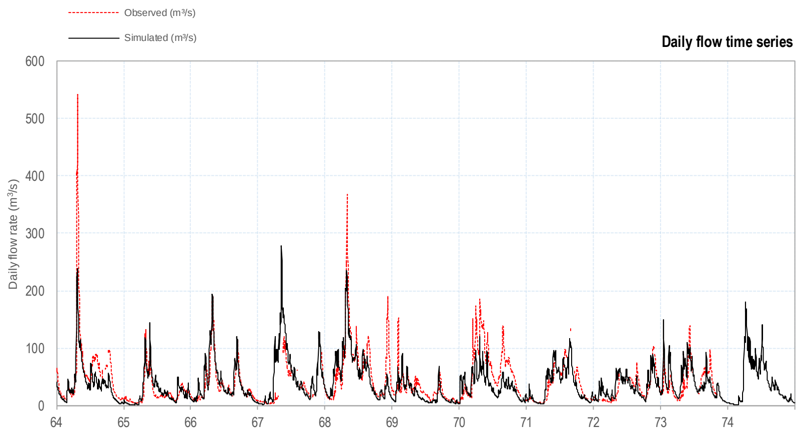
Node no. N59|Net flow to node

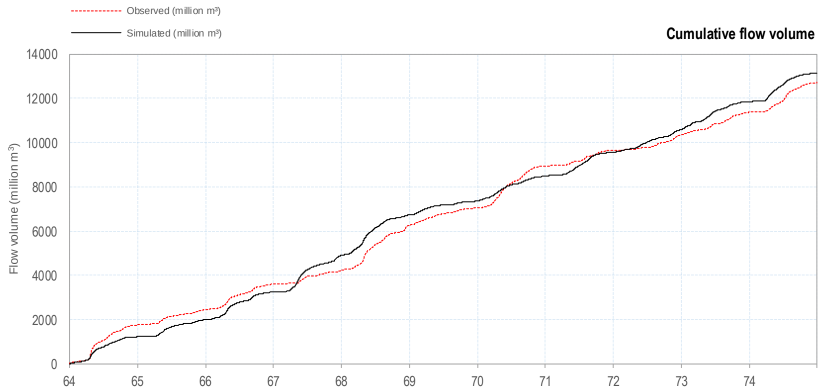
Average monthly flow rate [m³/s]

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average
Observed	1.8	1.6	1.7	3.9	5.1	3.7	4.6	6.1	5.4	3.4	2.8	2.7	3.6
Simulated	1.8	2.1	1.9	5.3	4.6	3.0	3.2	4.4	2.8	2.5	2.5	2.1	3.2
% difference	1.0%	23.2%	11.3%	26.0%	-12.4%	-23.9%	-45.3%	-39.6%	-94.6%	-36.7%	-12.4%	-25.4%	-11.8%

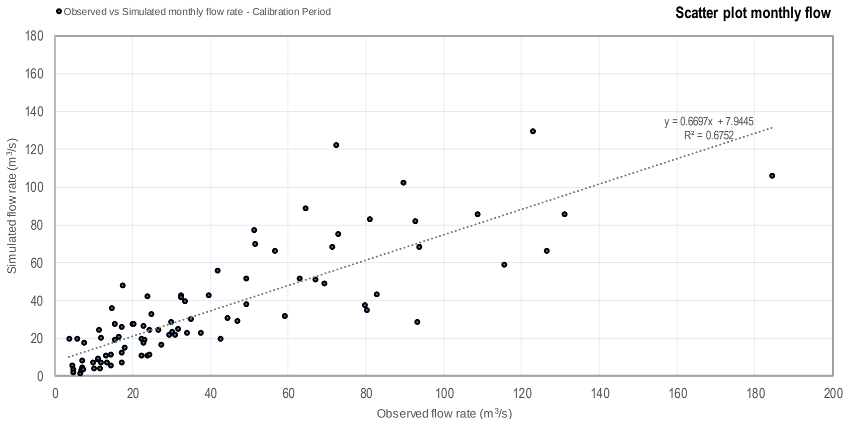
Figure A3-12: Calibration plot for streamflow gauge 1GB05

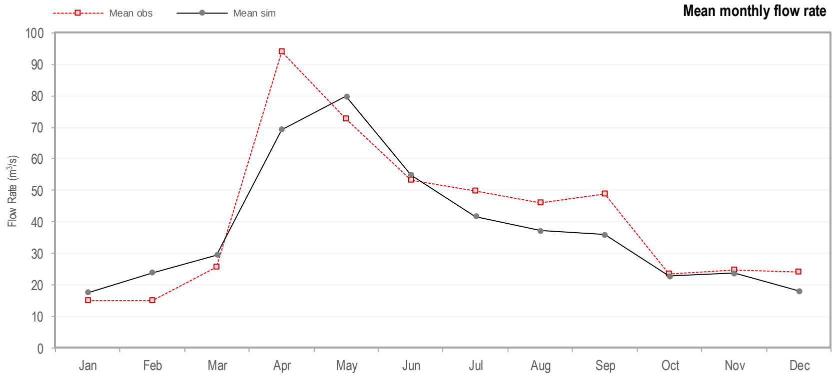
Calibration Results: 1JG01 - SONDU Catchment Area: 3287 km³ 3/20/2019 5:36 PM





Calibration Results: 1JG01 - SONDU Catchment Area: 3287 km³ 3/20/2019 5:36 PM





Performance Metrics

Node no. N63|Net flow to node

Coeff. of Determination (r^2) 0.675

Nash-Sutcliffe Coeff. of Efficiency 0.566

	Observed	Simulated	% Difference	Target %
Mean Annual Runoff (MAR) Jan- Dec [Mm³]	1295.2	1186.0	-9.2%	± 4%
Annual Standard Deviation [Mm³]	444.6	363.0	-22.5%	± 6%
Seasonal Index	17.31	18.95	8.7%	± 8%

	Observed
Unit runoff [mm]	394.1
MAP [mm]	1607
Runoff %	25%

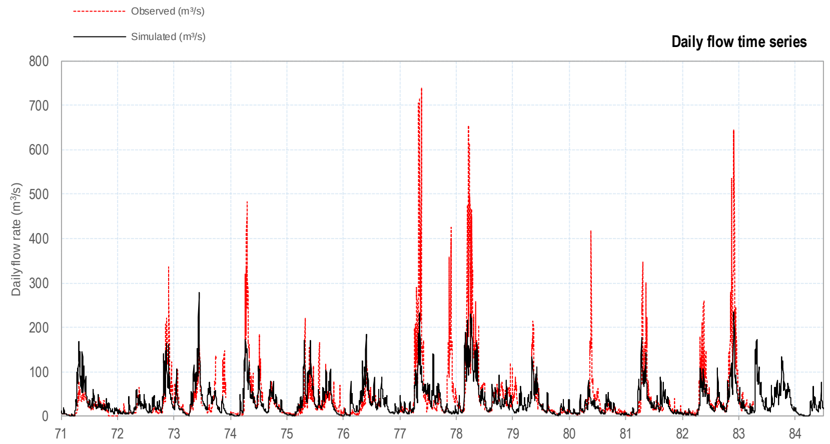
Node no. N63|Net flow to node

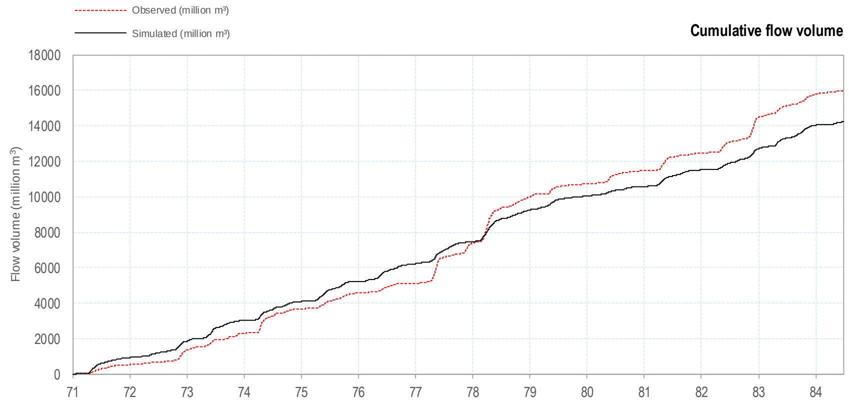
Average monthly flow rate [m³/s]

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average
Observed	15.1	15.0	25.7	93.9	72.6	53.2	49.8	46.0	49.0	23.4	24.6	24.3	41.0
Simulated	17.5	23.9	29.5	69.4	79.8	54.8	41.7	37.2	35.9	22.7	23.8	18.1	37.6
% difference	13.8%	37.2%	12.8%	-35.4%	9.1%	3.0%	-19.5%	-23.7%	-36.5%	-2.8%	-3.6%	-34.0%	-9.2%

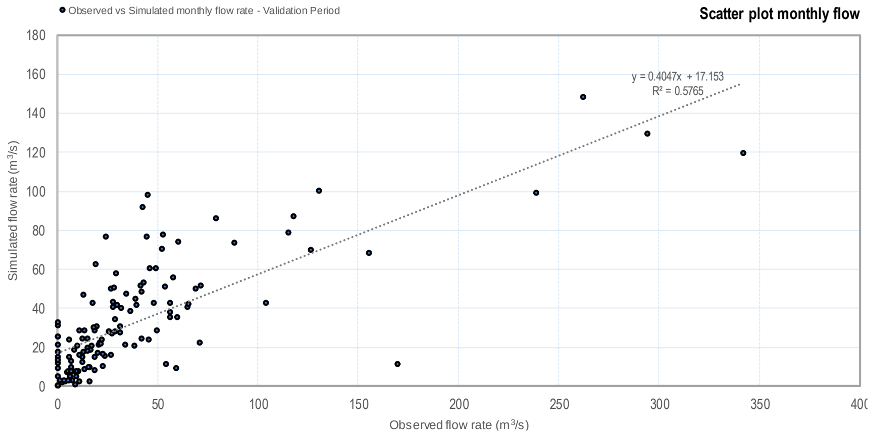
Figure A3-13: Calibration plot for streamflow gauge 1JG01

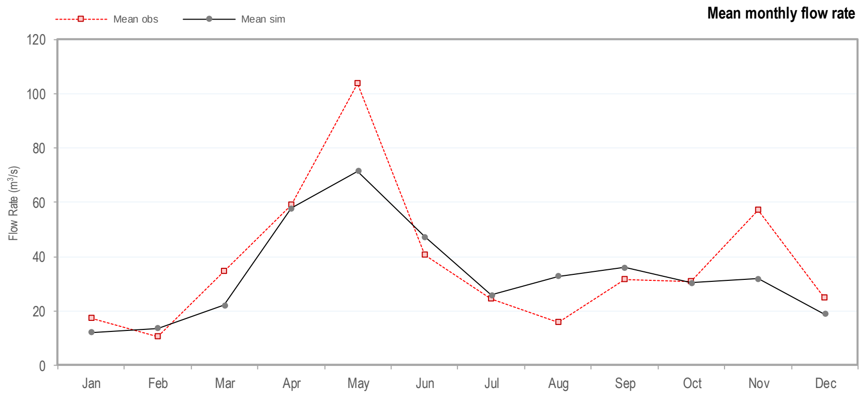
Calibration Results: 1KB01A - GUCHA MACALDER Catchment Area: 3115 km³ 3/20/2019 5:39 PM





Calibration Results: 1KB01A - GUCHA MACALDER Catchment Area: 3115 km³ 3/20/2019





Performance Metrics

Node no. N65|Net flow to node

Coeff. of Determination (r^2) 0.576

Nash-Sutcliffe Coeff. of Efficiency 0.406

	Observed	Simulated	% Difference	Target %		Observed
Mean Annual Runoff (MAR) Jan- Dec [Mm³]	1182.7	1093.0	-8.2%	± 4%	Unit runoff [mm]	379.7
Annual Standard Deviation [Mm³]	676.3	309.7	-118.3%	± 6%	MAP [mm]	1551
Seasonal Index	30.14	22.15	-36.1%	± 8%	Runoff %	24%

Node no. N65|Net flow to node

Average monthly flow rate [m³/s]

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average
Observed	17.1	10.6	34.5	59.0	103.6	40.5	24.4	15.6	31.7	30.8	57.2	24.9	37.5
Simulated	12.1	13.5	22.1	57.7	71.5	47.2	25.7	32.8	36.1	30.3	31.9	18.8	34.6
% difference	-41.8%	21.9%	-56.2%	-2.2%	-44.9%	14.2%	5.3%	52.4%	12.1%	-1.5%	-79.2%	-32.7%	-8.2%

Figure A3-14: Calibration plot for streamflow gauge 1KB01A

Model Validation

The calibrated NAM rainfall-runoff model was validated by comparing observed and simulated flows at three of the calibration flow gauging stations during different periods. The validation gauges are representative of the upper (1LA03), middle (1JG01) and lower (1KB01A) basin. Validation performance metrics are presented below while a comparison of daily simulated and observed flows is shown in in Table A3-5 and Figures A3-15 to A3-17.

In general, taking into account the relatively limited observed rainfall and flow data availability as well as data quality issues e.g. missing and exceeded data at many flow gauging stations, the calibration and validation results were deemed acceptable for the purposes of water resources assessment and planning.

Table A3-5: Validation at selected gauges

Station number	Catchment Area (km²)	Calibration Period	Observed MAR (MCM)	Simulated MAR (MCM)	Coefficient of Determination (r^2)	Water Balance Error (WBL)	Nash-Sutcliffe efficiency (NSE)
1LA03	679	Jan 1964-Dec 1969	251	267	0.479	+6.1%	0.420
1JG01	3 287	Jan 1977-Dec 1987	1 393	1 427	0.698	+2.4%	0.579
1KB01A	3 115	Jan 1965-Dec 1970	839	1 005	0.497	+16.5%	-0.014

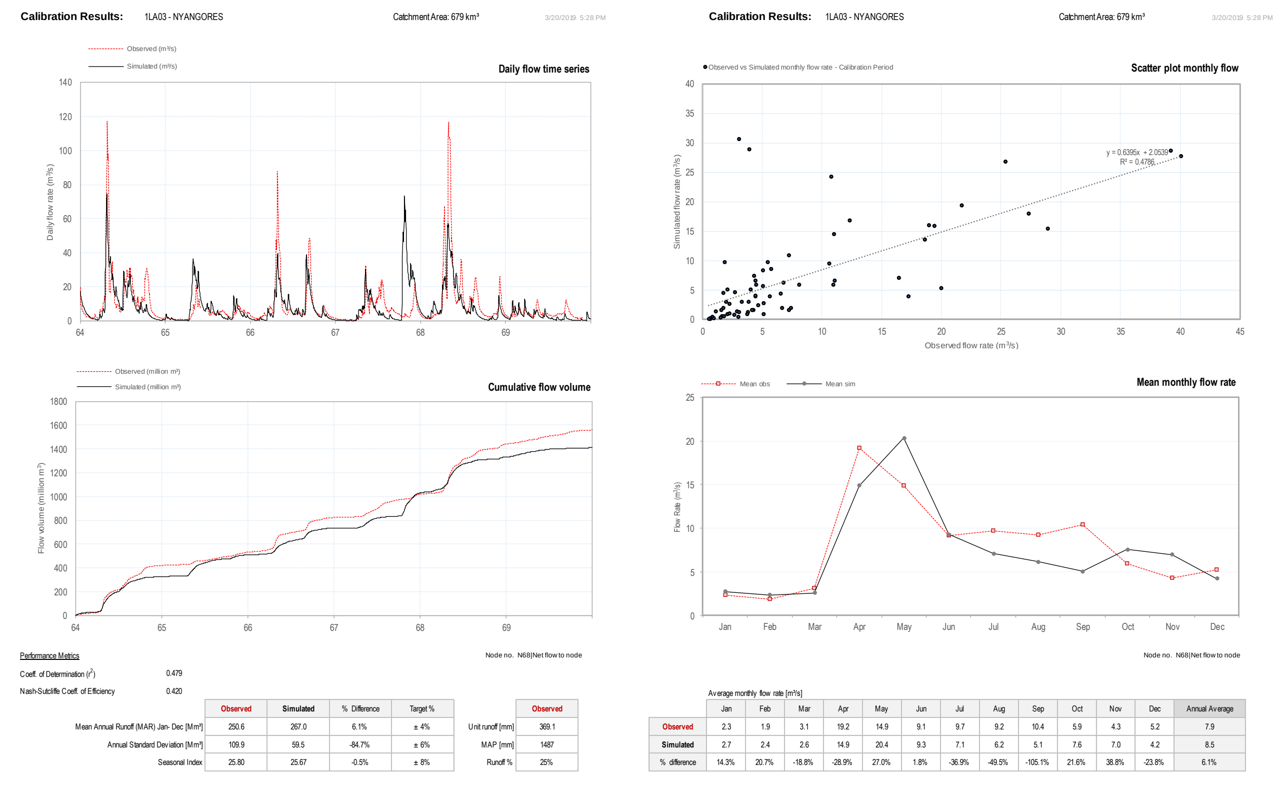
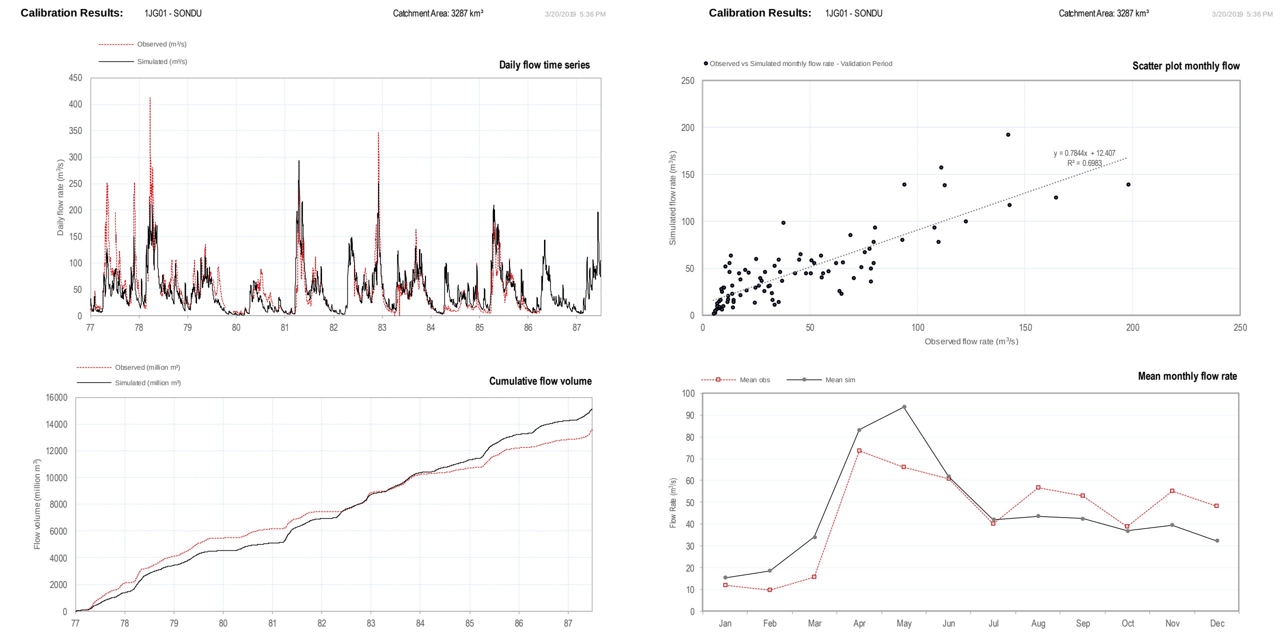


Figure A3-15: Gauge 1LA03 validation (1964 - 1969)



Performance Metrics

Node no. N63|Net flow to node

Coeff. of Determination (r^2) 0.698

Nash-Sutcliffe Coeff. of Efficiency 0.579

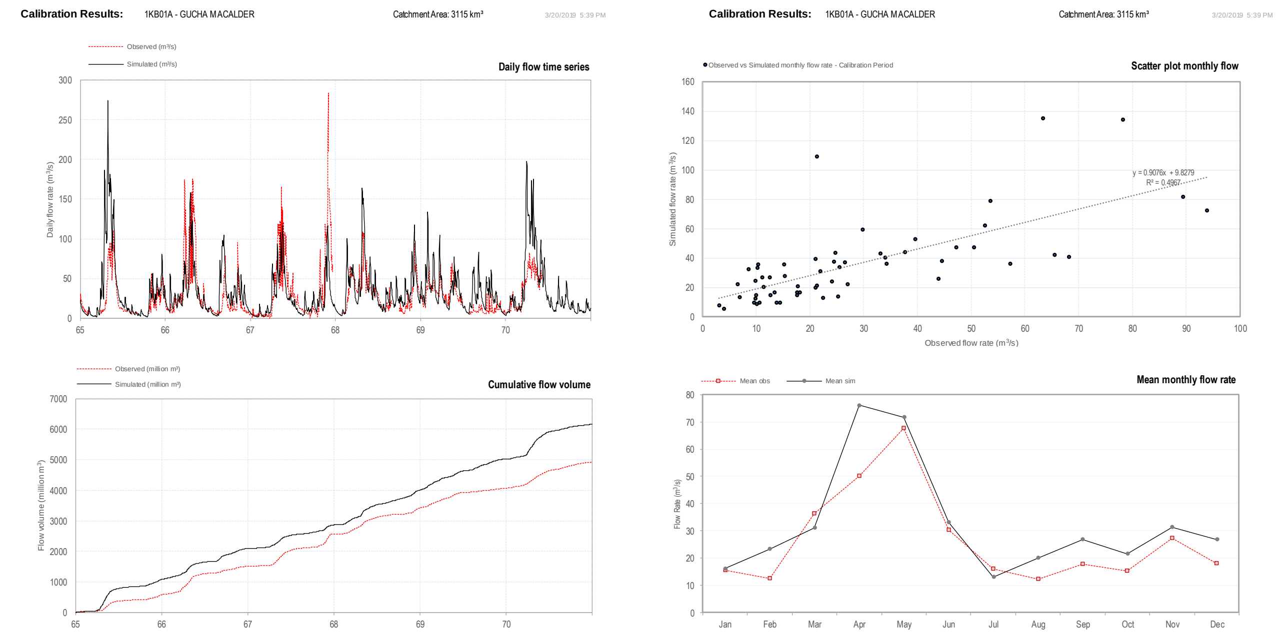
	Observed	Simulated	% Difference	Target %		Observed
Mean Annual Runoff (MAR) Jan- Dec [Mm³]	1393.1	1426.7	2.4%	± 4%	Unit runoff [mm]	423.8
Annual Standard Deviation [Mm³]	710.0	491.6	-44.4%	± 6%	MAP [mm]	1607
Seasonal Index	27.50	18.53	-48.4%	± 8%	Runoff %	26%

Node no. N63|Net flow to node

Average monthly flow rate [m³/s]

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average
Observed	12.0	9.6	15.6	73.8	66.1	60.8	40.2	56.8	52.8	38.8	55.1	48.2	44.1
Simulated	15.4	18.6	34.0	83.2	93.7	61.8	42.1	43.7	42.6	36.9	39.6	32.4	45.2
% difference	22.1%	48.1%	54.1%	11.4%	29.5%	1.6%	4.5%	-30.0%	-24.0%	-5.1%	-39.1%	-48.9%	2.4%

Figure A3-16: Gauge 1JG01 validation (1977 - 1987)



Performance Metrics

Node no. N65|Net flow to node

Coeff. of Determination (r^2) 0.497

Nash-Sutcliffe Coeff. of Efficiency -0.014

	Observed	Simulated	% Difference	Target %		Observed
Mean Annual Runoff (MAR) Jan- Dec [Mm³]	838.8	1005.1	16.5%	± 4%	Unit runoff [mm]	269.3
Annual Standard Deviation [Mm³]	#DIV/0!	141.5	#DIV/0!	± 6%	MAP [mm]	1551
Seasonal Index	24.94	18.65	-33.7%	± 8%	Runoff %	17%

Node no. N65|Net flow to node

Average monthly flow rate [m³/s]

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average
Observed	15.6	12.5	36.3	50.1	67.6	30.2	16.1	12.2	17.7	15.2	27.3	18.1	26.6
Simulated	16.2	23.3	31.1	76.1	71.8	33.2	13.0	20.1	26.9	21.6	31.4	26.9	31.9
% difference	3.7%	46.3%	-16.5%	34.2%	5.7%	8.8%	-23.8%	39.3%	34.1%	29.7%	13.0%	32.5%	16.6%

Figure A3-17: Gauge 1KB01A validation (1965 - 1970)

Model configuration

Assignment of calibrated NAM parameters to uncalibrated sub-catchments was based on a number of hydrological and physiographical criteria including proximity to the calibrated catchments, similarity in vegetation cover, soil depth and catchment MAP. For uncalibrated model sub-catchments situated between multiple calibrated catchments, transition parameter sets based on average parameter values were assigned. Table A3-6 presents the parameters assigned to each model sub-catchment.

Table A3-6: NAM model parameters assigned to model sub-catchments

General			Gauge	Surface-rootzone								Groundwater	
Catchment Identifier	Catchment Name	Area	Calibration Gauge	Umax	Lmax	CQOF	CKIF	CK1	CK2	TOF	TIF	TG	CKBF
ID	-	km^2	ID	mm	mm	( )	h	h	h	( )	( )	( )	h
C1	1GA	450.69	1GB05	15	390	0.4	2000	20	-	0.2	0	0.4	2000
C37	1GB_1	143.73	1GB05	15	390	0.4	2000	20	-	0.2	0	0.4	2000
C2	1GB_2	376.91	1GD03	10	200	0.1	2000	48	-	0.1	0	0.12	500
C57	1GC_1	75.126	1GD07	12	150	0.2	2000	48	-	0.1	0	0.15	700
C4	1GC_2	823.33	1GD07	12	150	0.2	2000	48	-	0.1	0	0.15	700
C58	1GD_1	365.21	1GD07	12	150	0.2	2000	48	-	0.1	0	0.15	700
C38	1GD_2	182.77	1GD03	10	200	0.1	2000	48	-	0.1	0	0	200
C39	1GD_3	216.9	1GD03	10	200	0.1	2000	48	-	0.1	0	0	500
C5	1GD_4	93.258	transition	7	135	0.1	450	30	-	0	0	0.05	500
C6	1GE	550.05	transition	7	135	0.1	450	30	-	0	0	0.05	500
C7	1GF	315.6	transition	2	70	0.1	450	30	-	0	0	0.05	500
C3	1GG	17.36	1GD07	12	150	0.2	2000	48	-	0.1	0	0.15	700
C59	1HA1_1	44.178	transition	7	135	0.1	1000	30	-	0	0	0.05	700
C36	1HA1_2	106.77	transition	5	70	0.2	200	30	-	0	0	0	500
C31	1HA1_3	112.87	transition	7	135	0.1	200	30	-	0	0	0.05	2000
C30	1HA2	406.92	transition	7	135	0.1	200	30	-	0	0	0.05	2000
C33	1HB1	470.8	transition	5	70	0.15	200	30	-	0	0	0.15	2000
C32	1HB2	256.7	transition	5	70	0.15	200	30	-	0	0	0.15	2000
C34	1HC	579.3	transition	5	70	0.15	200	30	-	0	0	0.15	2000
C28	1HD	800.2	transition	2	70	0.5	200	40	-	0	0	0	2000
C26	1HE	735.1	transition	2	70	0.5	200	40	-	0	0	0	2000
C29	1HF	881.6	transition	2	70	0.5	200	40	-	0	0	0	2000
C63	1HG	301.5	transition	2	70	0.5	200	40	-	0	0	0	2000
C51	1JA_1	213.58	transition	3	70	0.1	700	30	-	0	0	0	500
C10	1JA_2	638.2	transition	3	70	0.1	700	30	-	0	0	0	500
C12	1JB	179.02	transition	3	70	0.1	700	30	-	0	0	0	500
C9	1JC	335.72	transition	3	70	0.1	700	30	-	0	0	0	500
C40	1JD	205.39	1JG01	2	70	0.4	1000	40	-	0	0	0	1000
C15	1JE	577.82	1JG01	2	70	0.4	1000	40	-	0	0	0	1000
C50	1JF	998.52	1JG01	2	70	0.4	1000	40	-	0	0	0	1000
C41	1JG1_1	102.68	1JG01	2	70	0.4	1000	40	-	0	0	0	1000
C47	1JG1_2	134.46	1JG01	2	70	0.4	1000	40	-	0	0	0	1000
C8	1JG2	74.99	transition	10	100	0.4	1000	10	-	0	0	0	1000
C16	1KA	467.39	transition	2	70	0.4	1000	40	-	0	0	0	1000

General			Gauge	Surface-rootzone								Groundwater	
Catchment Identifier	Catchment Name	Area	Calibration Gauge	Umax	Lmax	CQOF	CKIF	CK1	CK2	TOF	TIF	TG	CKBF
ID	-	km^2	ID	mm	mm	( )	h	h	h	( )	( )	( )	h
C54	1KB_1	278.95	1KB01A	2	70	0.5	2000	40	-	0	0	0	500
C56	1KB_2	2307.1	1KB01A	2	70	0.5	2000	40	-	0	0	0	500
C43	1KB_3	56.529	1KB01A	2	70	0.5	2000	40	-	0	0	0	500
C19	1KB_4	551.19	1KB01A	2	70	0.5	2000	40	-	0	0	0	500
C61	1KB_5	291.2	transition	2	70	0.45	2000	30	-	0	0	0	500
C53	1KC_1	414.04	1KC03	2	70	0.45	2000	30	-	0	0	0	500
C42	1KC_2	2255.7	1KC03	2	70	0.45	2000	30	-	0	0	0	500
C18	1KC_3	287.56	1KC03	2	70	0.45	2000	30	-	0	0	0	500
C46	1LA1_1	691.89	1LA03	7	100	0.2	2000	40	-	0	0	0.2	500
C20	1LA1_2	239.29	1LA03	7	100	0.2	2000	40	-	0	0	0.2	500
C24	1LA2	1049.2	1LA03	7	100	0.2	2000	40	-	0	0	0.2	500
C60	1LA3_1	349.31	transition	17	150	0.2	2000	40	-	0	0	0.3	500
C25	1LA3_2	1898.6	transition	17	150	0.2	2000	40	-	0	0	0.3	500
C68	1LA3_3	207.9	transition	17	150	0.2	2000	40	-	0	0	0.3	500
C52	1LB1_1	546.08	transition	7	150	0.2	2000	40	-	0	0	0.3	500
C44	1LB1_2	148.05	transition	7	150	0.2	2000	40	-	0	0	0.3	500

A Natural MIKE HYDRO Basin model of the Lake Victoria South Basin was configured. The Natural model represents the pristine state of the basin before any man-made influences, i.e. no water use and no water related infrastructure. Figure A3-31 displays the Natural model configuration for the Lake Victoria South Basin. The relatively high spatial resolution that was adopted for model construction, in terms of number of model sub-catchments, is evident.

Figure A3-31: Lake Victoria South Basin Natural model configuration in MIKE HYDRO Basin

A4: Groundwater

The process used to quantify the groundwater potential followed four steps:

i. Develop a weighting system for the four groundwater yield-related criteria that takes the five groupings (from very high to very low) into account. The weightings provide numerical values to the groups whereby a favourable groundwater area is afforded a higher value than a poor groundwater area. These values are referred to as Group Weights in Table A4-1.
ii. Assign weightings to each of the four groundwater yield-related criteria (termed Layer Weight in Table A4-1). This step caters for placing greater value on Regional Permeability and Recharge than Secondary Permeability and Landforms as the former two criteria were considered to have a greater impact on groundwater availability than the latter two criteria.
iii. For each of the four groundwater yield-related criteria obtain a score by multiplying the Weights by the Layer Weights, and then summing the scores for the four groundwater yield-related criteria to give the percentage of groundwater recharge that could potentially be available for use.
iv. Multiply the percentage obtained in (iii) above by the groundwater recharge values obtained in Section 3.4 to obtain the rate at which groundwater is potentially available for use (Figure A4-1).

Table A4-1: The Weights and Layer Weights for the four groundwater yield-related criteria

Layer	Criteria	Layer weight	Groups and Group Weights					
			1	2	3	4	5	Total
1	Regional permeability	0.3	Very High 40	High 25	Medium 20	Low 10	Very Low 5	100
2	Secondary permeability	0.2	Very High 35	High 30	Medium 20	Low 10	Very Low 5	100
3	Landforms	0.2	Very High 40	High 30	Medium 15	Low 10	Very Low 5	100
4	Recharge	0.3	Very High 35	High 30	Medium 20	Low 10	Very Low 5	100

Using this GIS-based approach to estimate the abstractable proportion of recharge gives the following extreme values:

- An area rated as Very High for all four groundwater yield-related criteria gives an abstractable proportion of recharge value of 37.5%.
- An area rated as Very Low for all four groundwater yield-related criteria gives an abstractable proportion of recharge value of 5%.

This range is similar to the ~5 % to ~50 % that were obtained in neighbouring Ethiopia and South Sudan (ENTRO, 2016).

Note: For a detailed description of the approach which was followed for the assessment of groundwater resources, refer to "ISC Report C2-1: National Groundwater Potential Assessment".

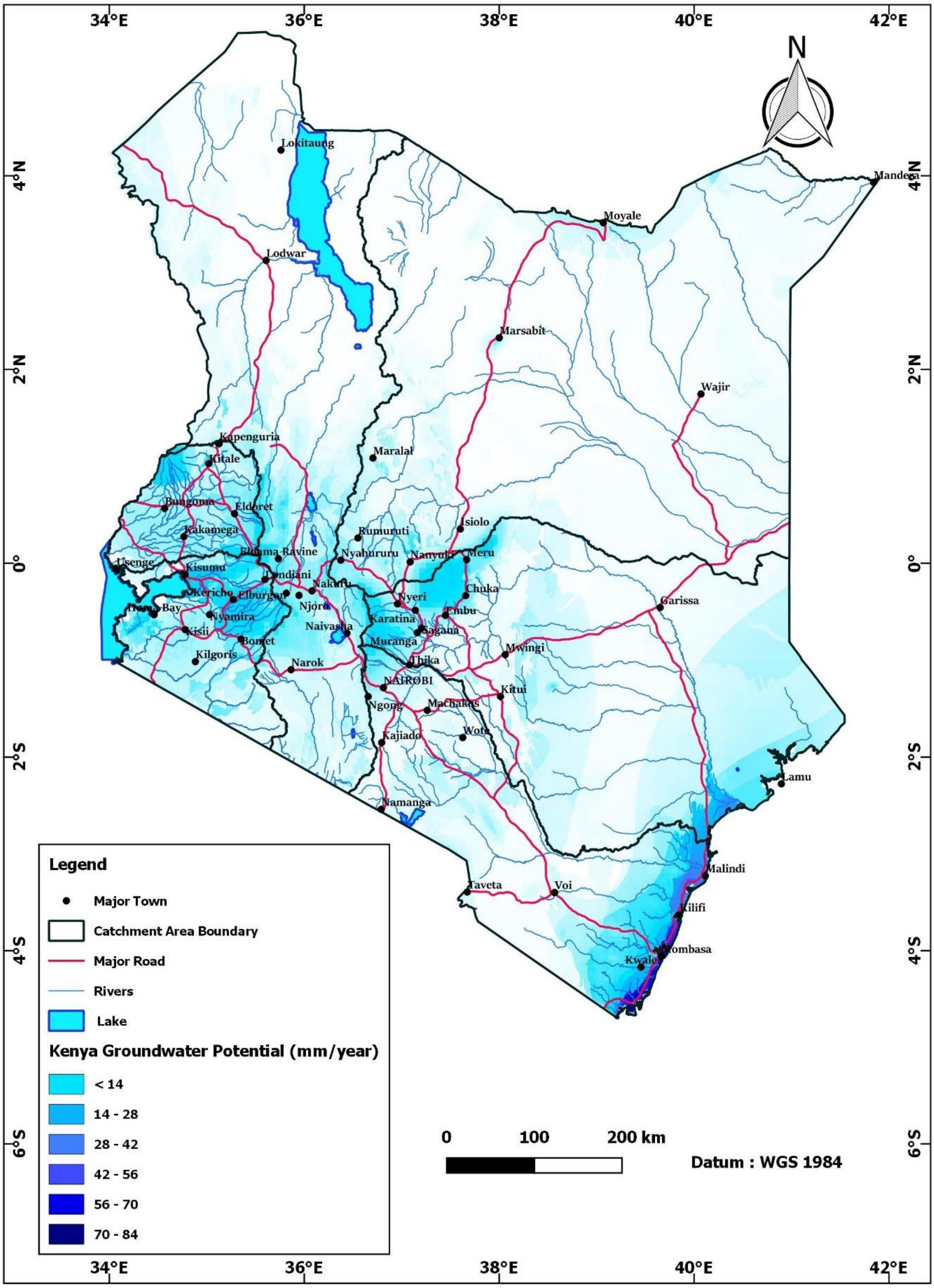


Figure A4 -1: Groundwater Potential in mm/year

A5: Environmental flows

In order to provide a scientific, high level approach towards the determination of provisional environmental flows to be used at basin-level water resource planning, so-called "Holding EFlows" were determined as ecological water requirements for sensitivity analysis purposes. These flows are coarse and provisional and their purpose is to provide interim numbers for insertion into basin-level water resource plans. They should not be used in detailed design, planning and operation of developments. Information for these latter purposes should come from higher confidence, more comprehensive EFlow assessments.

Note: *A detailed description of the methodogy which was used to derive the EFlows is presented in a stand-alone report: "KWSCRP: Holding environmental flows requirements for selected Kenyan rivers, Southern Waters, 2018".*

In essence the approach involved 5 key steps:

- Delineate the rivers into homogeneous biophysical river zones and social areas and assign representative nodes.
- Calculate the Hydrological Index (HI) for the rivers and use these to access EFlows recommendations for rivers with similar HI from the South African Desktop Model (Hughes & Münster, 2000).
- Review EFlows assessments done in similar southern and eastern African rivers to provide guidance on Holding EFlows allocations.
- Obtain naturalised and 'current day' (c. 2017) hydrological records for the study rivers for use in cross-checking the Holding EFlows against reality.
- Use Steps 2, 3 and 4 to estimate Holding EFlows to maintain the study rivers in a range of ecological conditions.

The approach also provided for the determination of the present ecological condition of representative reaches based on a "Habitat Integrity Method". Table A5-1 defines the ecological categories as used in the assessment of current ecological condition.

Table A5-1: Ecological condition and scores (Kleynhans, 1996)

CATEGORY	DESCRIPTION	SCORE (%)
A	Unmodified, natural	90-100
B	Largely natural with few modifications. A small change in natural habitats and biota may have taken place but the ecosystem functions are essentially unchanged.	80-90
C	Moderately modified. A loss and change of natural habitat and biota have occurred but the basic ecosystem functions are still predominantly unchanged.	60-79
D	Largely modified. A large loss of natural habitat, biota and basic ecosystem functions has occurred.	40-59
E	The loss of natural habitat, biota and basic ecosystem functions is extensive.	20-39
F	Modifications have reached a critical level and the lotic system has been modified completely with an almost complete loss of natural habitat and biota. In the worst instances the basic ecosystem functions have been destroyed and the changes are irreversible.	0

The EFlows assessment for the LVS Basin delineated the Basin into 39 sub-basins with five main components; the Lake Margin where small rivers flow into Lake Victoria and then the Nyando, Sondu, Gucha and Mara River basins. Nodes were assigned to represent each of the river types. The nodes were positioned at the downstream end of the reaches they represent. The current ecological condition of the rivers at the node locations were assessed at desktop level using a habitat integrity scoring method with limited field visits. Figure A5-1 indicates the locations of the representative nodes as well as the ecological condition of 5 representation reaches in the basin, while Table A5-2 summarises the hydro-geomorphological characteristics and the present ecological condition of the representative nodes in the LVS Basin.

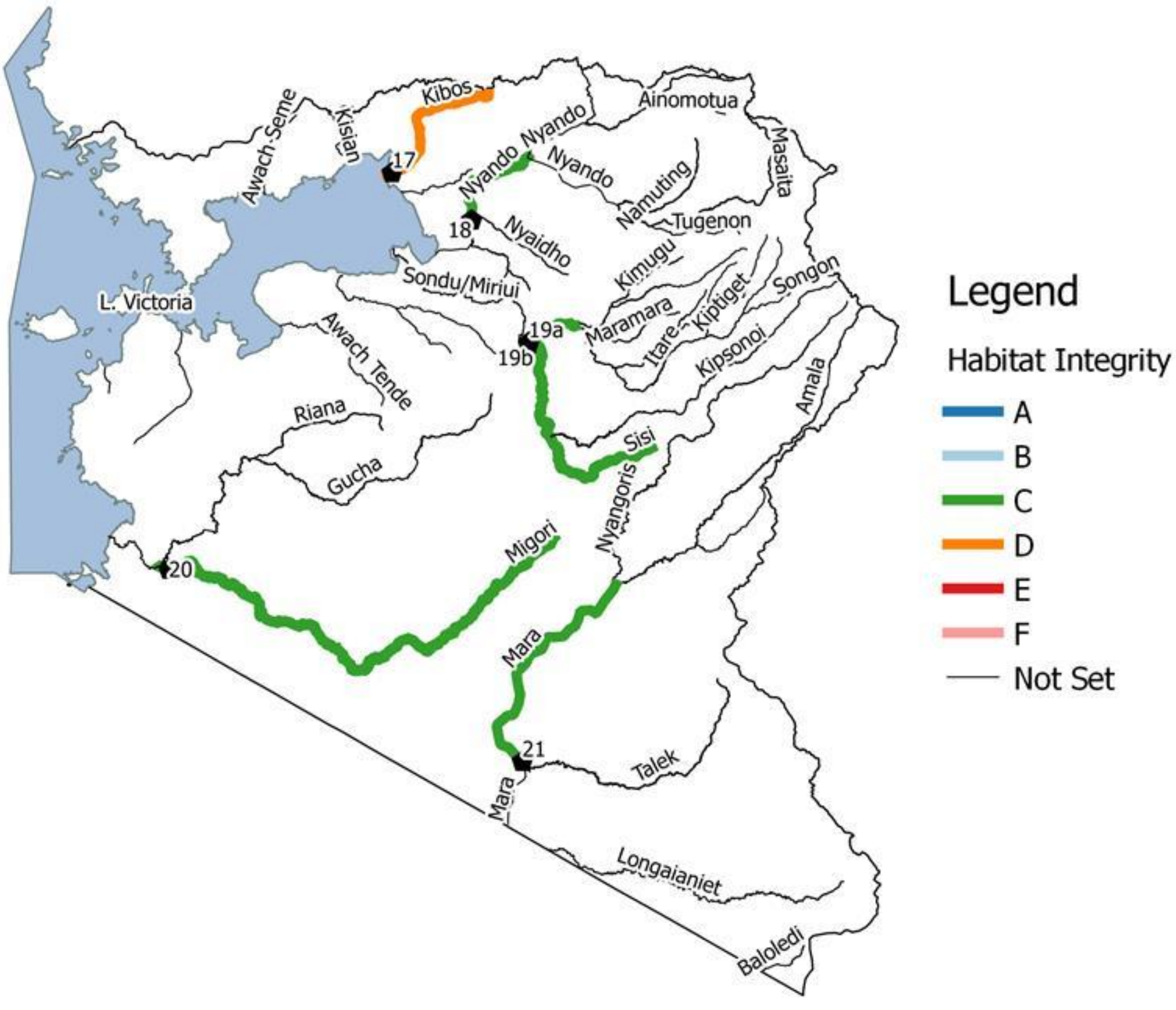


Figure A5-1: Ecological condition of 5 representative reaches in the LVS Basin

Table A5-2: Main hydro-geomorphological characteristics and 2018 ecological condition of representative nodes in the LVS Basin

Node		River	Description	Ecological condition	Zone	Rosgen (1994)	Coordinates	
#	Code						X	Y
22	17	Kibos	u/s Lake Victoria and d/s Kiboo Dam	D (54.7%)	Lake Margin	F	34.7552	-0.1266
23	18	Nyando	d/s Ainomotua River	C (68.3%)	Nyando River	F	34.9294	-0.2300
24	19a	Chemosiet	u/s confluence with Sisi River	C (68.3%)	Sondu River	F	34.0540	-0.4975
25	19b	Sisi	u/s confluence with Chemosiet River	C (68.3%)	Sondu River	F	35.0537	-0.5027
26	20	Migori	u/s confluence with Gucha River	C (70.0%)	Gucha River	F	34.2676	-0.9936
27	21	Mara	d/s cultivation	C (76.8%)	Mara River	E	35.0402	-1.1414

The Holding EFlows, as a percentage of natural flows, for all sub-basins in the LVS Basin are summarised in Table A5-3. It is important to note that further assessments would be required for all surface and groundwater resources in order to define the Resource Directed Measures for the Water Resource Management cycle.

Table A5-3: Holding EFlows as percentage of natural monthly flows in the LVS Basin

Zone	Sub-basins	HI		Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Lake Margin	1HA1, 1HA2, 1HB1, 1HB2, 1HD, 1HE,	1-6	A	73.0	100.0	100.0	73.0	73.0	73.0	100.0	100.0	73.0	73.0	73.0	73.0
			B	60.0	90.0	90.0	60.0	60.0	60.0	90.0	90.0	60.0	60.0	60.0	60.0
			C	40.0	60.0	60.0	40.0	40.0	40.0	60.0	60.0	40.0	40.0	40.0	40.0
			D	25.5	39.5	39.5	25.5	25.5	25.5	39.5	39.5	25.5	25.5	25.5	25.5
	1HC, 1HF, 1HG	n/a													
Nyando River	1GA, 1GB, 1GC, 1GG, 1GE, 1GF	1-6	A	73.0	100.0	100.0	73.0	73.0	73.0	100.0	100.0	73.0	73.0	73.0	73.0
			B	60.0	90.0	90.0	60.0	60.0	60.0	90.0	90.0	60.0	60.0	60.0	60.0
			C	40.0	60.0	60.0	40.0	40.0	40.0	60.0	60.0	40.0	40.0	40.0	40.0
			D	25.5	39.5	39.5	25.5	25.5	25.5	39.5	39.5	25.5	25.5	25.5	25.5
Sondu River	1GD, 1JA, 1JB, 1JC, 1JD, 1JE, 1JF, 1JG1, 1JG2	1-6	A	73.0	100.0	100.0	73.0	73.0	73.0	100.0	100.0	73.0	73.0	73.0	73.0
			B	60.0	90.0	90.0	60.0	60.0	60.0	90.0	90.0	60.0	60.0	60.0	60.0
			C	40.0	60.0	60.0	40.0	40.0	40.0	60.0	60.0	40.0	40.0	40.0	40.0
			D	25.5	39.5	39.5	25.5	25.5	25.5	39.5	39.5	25.5	25.5	25.5	25.5
Gucha River	1KA, 1KC, 1KB, 1LA1, 1LB1	1-6	A	73.0	100.0	100.0	73.0	73.0	73.0	100.0	100.0	73.0	73.0	73.0	73.0
			B	60.0	90.0	90.0	60.0	60.0	60.0	90.0	90.0	60.0	60.0	60.0	60.0
			C	40.0	60.0	60.0	40.0	40.0	40.0	60.0	60.0	40.0	40.0	40.0	40.0
			D	25.5	39.5	39.5	25.5	25.5	25.5	39.5	39.5	25.5	25.5	25.5	25.5
Mara River	1LA2, 1LB2, 1LA3	1-6	A	73.0	100.0	100.0	73.0	73.0	73.0	100.0	100.0	73.0	73.0	73.0	73.0
			B	60.0	90.0	90.0	60.0	60.0	60.0	90.0	90.0	60.0	60.0	60.0	60.0
			C	40.0	60.0	60.0	40.0	40.0	40.0	60.0	60.0	40.0	40.0	40.0	40.0
			D	25.5	39.5	39.5	25.5	25.5	25.5	39.5	39.5	25.5	25.5	25.5	25.5

A6: Multi-criteria analysis – indicators

Name	**Environmentally sensitive area (EN1.1)**
Type	Environment (EN)
Category	Footprint (1)
Motivation	Protection of ecologically sensitive areas will serve to protect the biodiversity and ecosystem services associated with such areas.
Description	Extent of ecologically sensitive area within dam / irrigation scheme footprint
Units	km^2

Source Data

Ecologically Sensitive Areas refer to those areas located within the primary impact zones that have been, or could potentially be, classified into one of the IUCN protected area management categories (www.iucn.org). The IUCN categories provide a global standard for defining and recording protected areas and are increasingly being incorporated into government legislation (**www.iucn.org**). The IUCN Protected Areas Categories System are as follows:

- Category Ia – Strict Nature Reserve
- Category Ib – Wilderness Area
- Category II – National Park
- Category III – Natural Monument or Feature
- Category IV – Habitat / Species Management Area
- Category V – Protected Landscape e.g. Water Towers
- Category VI – Protected area with Sustainable Use of Natural Resources

Typical areas in Kenya that could potentially be classified using the IUCN system include:

- Wetlands. Points identified as wetlands of international importance (www.ramsar.org).
- Birds. Points identified as Important Bird Areas (www.birdlife.org)
- National parks and reserves
- Gazetted water towers

Method of calculation: **Interrogation of spatial data (GIS)**

Intersect dam full supply / irrigation scheme clearing area with environmentally sensitive area(s)

References

African Development Bank (ADB) 2004. Group Policy on the Environment. February 20094.

Birdlife International. Important Bird Areas Programme. (www.birdlife.org).

International Finance Corporation (IFC). 2012. Performance Standard 6. Biodiversity Conservation and Sustainable Management of Living Natural Resources.

NEPAD 2003. Action plan for the environment initiative of the New Partnership for Africa's Development.

Ramsar (www.ramsar.org).

BirdLife International and NatureServe (2011) Bird species distribution maps of the world. BirdLife International, Cambridge, UK and NatureServe, Arlington, USA.

Name	**Carbon emissions (EN1.2)**
Type	Environment (EN)
Category	Footprint (1)
Motivation	Woody vegetation located within the area of inundation or irrigation area to be cleared could lead to generation of greenhouse gases.
Description	Potential carbon emission within dam footprint due to flooding and decomposition of woody biomass inundated; Potential carbon emission within irrigation scheme footprint due to clearing and burning of natural vegetation.
Units	million ton

Source Data

Woody biomass (Mg/ha) Carbon Dioxide Information Centre: Geographical Distribution of Woody Biomass Carbon in Tropical Africa: An Updated Database for 2000 (**https://cdiac.ess-dive.lbl.gov/**)

Method of calculation: **Interrogation of spatial data (GIS)**

Intersect dam full supply / irrigation scheme clearing area with woody biomass spatial data in Mg/ha.

References

African Development Bank (ADB) undated draft. Energy Sector Policy of the African Development Bank Group.

EDF 2007. Prefeasibility study of Mandaya Hydropower Project, Ethiopia. Eastern Nile Power Trade Programme Study. Module M5. Report prepared by EDF and Scott Wilson for the Eastern Nile technical Regional Office.

Gibbs, H.K. and S. Brown. 2007. Geographical Distribution of Woody Biomass Carbon in Tropical Africa: An Updated Database for 2000, NDP-055b. Available at [http://cdiac.ornl.gov/epubs/ndp/ndp055/ndp055b.html] from the Carbon Dioxide Information Center, Oak Ridge National Laboratory, Oak Ridge, Tennessee. doi: 10.3334/CDIAC/lue.ndp055.2007.

Global Land Cover 2000 Database. European Commission, Joint Research Centre, 2003. http://www-gen.jrc.it/glc2000.

Scanlon, A., Kile, R., and Blumstein, B. 2004. Sustainable hydropower - guidelines, compliance standards and certification. United Nations Symposium on Hydropower and Sustainable Development, Beijing 27-29 October 2004. Hydro Tasmania, Australia.

World Commission of Dams. 2000. Dams and development a new framework for decision-making. The Report of the Word Commission on Dams. London: Earthscan Publications, Thanet Press

Name	**Floodplain inundation (EN2.1)**
Type	Environment (EN)
Category	Downstream areas (2)
Motivation	Floodplains provide significant ecosystem services including biodiversity support, nursery areas for fish, and production of various natural resources, including timber, thatching grass and medicinal plants.
Description	Extent of floodplain inundation in river reach downstream of dam during wet season
Units	% Change from baseline

Source Data
Water resources simulation model output:
Timeseries of flow in river reach downstream of proposed dam

Method of calculation:	**Timeseries analysis**
Identify wettest month from Natural time series	
Extract annual wettest month timeseries from Baseline and Scenario simulation results	
Calculate median wettest month flow rates for Baseline and Scenario	
Calculate change in wettest month median flow rate: Scenario compared to Baseline % change	

References

Opperman, J.J., Moyle, P.B., Larsen, E.W., Florsheim, J.L., Manfree, A.D. Floodplains: Processes and Management for Ecosystem Services. University of California Press, 2017. Available at https://www.jstor.org/stable/10.1525/j.ctv1xxt6n

Name	**Ecological stress (EN2.2)**
Type	Environment (EN)
Category	Downstream areas (2)
Motivation	Wet and dry season low flows and within year flow variability are important drivers of instream ecological processes and associated river health. Aquatic biota have evolved life history strategies to cope with the natural stress regime, and any changes to the natural stress regime (increase or decrease) tend to reduce biodiversity because these changes produce conditions suitable to a few taxa only.
Description	Ecological stress rating in river reach downstream of proposed dam or large abstraction due to anticipated changes in key flow components
Units	Index (-5 to 0)

Source Data

Water resources simulation model output:

Timeseries of flow in river reach downstream of proposed dam / abstraction point

Method of calculation: **Timeseries analysis**

Dry season low flow

Identify driest month from Natural time series

Extract annual dry season timeseries for three consecutive dry months (driest month and adjacent months) from Baseline and Scenario simulation results

Calculate median dry season flow rate for Baseline and Scenario

Calculate change in dry season median flow rate: Scenario compared to Baseline % change

Wet season base flow

Identify wettest month from Natural time series

Extract annual wet season baseflow timeseries as average of months immediately before and after wettest month from Baseline and Scenario simulation results

Calculate median wet season base flow rate for Baseline and Scenario

Calculate change in wet season base flow median flow rate: Scenario compared to Baseline % change

Within year flow variability

Extract annual flow amplitudes - difference between max and min monthly flow rate - from Baseline and Scenario simulation results

Calculate median of annual flow amplitudes for Baseline and Scenario

Calculate change in median flow amplitude: Scenario compared to Baseline % change

Rating

		Dry / Wet Season Low Flows	Annual Flow variation
0	Zero	0	0
-1	Negligible	<20% gain <17% drop	6 - 10% gain 5 - 9% drop
-2	Low	20 - 49% gain 17 - 34% drop	11 - 24% gain 10 - 19% drop
-3	Moderate	50 - 99% gain 35 - 49% drop	25 - 99% gain 20 - 49% drop
-4	High	100 - 149% gain 50 - 59% drop	100 - 399% gain 50 - 79% drop
-5	Very High	>150% gain >60% drop	400>% gain <80% drop

References

Hijri, R., and Panella, T. 2003. Evolving policy reforms and experiences for addressing downstream impacts in World Bank Water Resources Projects. Rivers Research & Applications 19: 667-681.

World Bank. 2001. Making Sustainable Commitments: An Environment Strategy for the World Bank. World Bank: Washington, DC.

World Commission on Dams. 2000. Dams and Development: A New Framework for Decision Making. Earthscan Publications: London.

Name	**Wet season duration (EN2.3)**
Type	Environment (EN)
Category	Downstream area (2)
Motivation	The length of the wet season is important for biological production, flushing of fine sediments, channel maintenance and floodplain inundation.
Description	Duration of wet season (high flows) in river reach downstream of dam
Units	% Change from baseline

Source Data

Water resources simulation model output:

Timeseries of flow in river reach downstream of proposed dam

Method of calculation: **Timeseries analysis**

Identify 20th percentile exceedance flow rate from Natural time series

Calculate number of days during which the Natural 20th percentile flow rate is exceeded in Baseline and Scenario simulations

Calculate change in number of exceedance days: Scenario compared to Baseline % change

References

Opperman, J.J., Moyle, P.B., Larsen, E.W., Florsheim, J.L., Manfree, A.D. Floodplains: Processes and Management for Ecosystem Services. University of California Press, 2017. Available at https://www.jstor.org/stable/10.1525/j.ctv1xxt6n

Name	**Phytoplankton growth potential (EN3.1)**
Type	Environment (EN)
Category	Water quality (3)
Motivation	Retention time in dams is easy to measure and is directly related to the potential for phytoplankton biomass and algal blooms, such as potentially toxic blue-green algae (cyanobacteria), Microcystis. Rivers usually do not support large populations of plankton,

	except in their lower reaches, where current speeds are slow. The development of plankton populations is generally associated with standing water. Impoundments provide ideal conditions for the development of plankton, which respond rapidly to changes in flow conditions on account of their rapid life histories, which are typically measures in days or weeks. The availability of nutrients decreases as retention time increases, so small impoundments with short retention times can cause water quality to deteriorate for downstream users, whereas impoundments with long retention time can serve to improve water quality for downstream users.
Description	Potential for phytoplankton growth
Units	Phytoplankton growth risk (%)

Source Data

Water resources simulation model output

Timeseries of inflow into proposed dam

Timeseries of proposed dam storage volume

Method of calculation: **Timeseries analysis**

$y = x^{1.59}\ (0.13)\ (0.99^{x})$

where y = phytoplankton growth potential (%); x = retention time (days), calculated from the median annual storage divided by mean annual inflow into reservoir

References

Coveney, M. F., J. C. Hendrickson, E. R. Marzolf, R. S. Fulton, J. Di, C. P. Neubauer, D. R. Dobberfuhl, G. B. Hall, H. W. Paerl, and E. J. Phlips. 2011. Chapter 8. Plankton. In: St. Johns River water Supply Impact Study. St. Johns River Water Management District, Palatka, FL, USA. St. Johns River Water Management District, Palatka, Florida.

Wagner-Lotkowska, K. Izydorczyk, T. Jurczak & M. Tarczynska, P. Frankiewicz 2004. Ecohydrological methods of algal bloom control. In: Zalewski, M & Wagner-Lotkowska (Eds). Chapter 12: Reservoir & lake management: Improvement of Water Quality. Integrated watershed management – Ecohydrology 7 Phytotechnology Manual. United Nations Environmental Programme.

Name	**Aquatic macrophytes growth potential (EN3.2)**
Type	Environment (EN)
Category	Water quality (3)
Motivation	Floating macrophytes reduce the availability of light and oxygen in the water, with detrimental implications for biodiversity. The plants provide ideal habitat for bilharzia snails, and also increase evapotranspiration losses.
Description	Potential for macrophyte growth
Units	Aquatic macrophyte growth risk (%)

Source Data
Water resources simulation model output
Timeseries of flow in river reach downstream of proposed irrigation scheme return flow
Timeseries of irrigation scheme return flows
Nitrogen export coefficient

Method of calculation:	Timeseries analysis
$y = 108 / (1+((x/2.29)^{-0.83}))$	
where y = aquatic macrophyte growth potential (%); x = total nitrate concentration (mg/l) in receiving river immediately downstream of irrigation discharge point	

References

Coetzee, J. A and Hill, M. P. 2012. The role of eutrophication in the biological control of water hyacinth, Eichhornia crassipes, in South Africa. Biocontrol 57: 247-261.

Byrne, M., Hill, M., Robertson, M., King, A. J., Katembo, N., Wilson, J. Brudwig, R., Fisher, J. 2010. Integrated management of Water Hyacinth in South Africa. Development of an integrated management plan for water hyacinth control, combining biological control, herbicidal control and nutrient control, tailored to the climatic regions of South Africa. Water Research Commission Report No TT 454/10. Pretoria.

National Agricultural Research Organization (NARO) 2008. The national invasive species strategy, action plan and policy guidelines for Uganda. Report submitted to CABI, under the UNEP/GEF Project: Removing barriers to invasive plant management in Africa (UNEP/GEF Project No GFL 2328-2711-4890.

Name	**Water availability for riparian users (SL1.1)**
Type	Social (SL)
Category	Water availability (1)
Motivation	Upstream storage and flow regulation as well as large river abstractions may negatively impact dry season water availability in the river downstream and could impact riparian users
Description	Change in water availability during dry season
Units	% Change from baseline

Source Data
Water resources simulation model output
Timeseries of flow in river reach downstream of proposed dam / abstraction point

Method of calculation:	Timeseries analysis

Identify driest month from Natural time series

Extract annual dry season timeseries for three consecutive dry months (driest month and adjacent months) from Baseline and Scenario simulation results

Calculate median dry season flow rate for Baseline and Scenario

Calculate change in dry season median flow rate: Scenario compared to Baseline % change

References

Matunda, J.M. Sustainable management of riparian areas in Kenya:a critique of the inadequacy of the legislative framework governing the protection of sustainable management of riparian zones in Kenya. University of Nairobi, 2015.

Name	**Malaria susceptibility (SL2.1)**
Type	Social (SL)
Category	Community health and safety (2)
Motivation	The increased availability of open water (dams) and wetted areas (irrigation schemes) could potentially increase the risk of malaria
Description	Susceptibility of areas where new irrigation schemes and/or dams are proposed to malaria based on the WHO malaria incidence map for Africa
Units	Malaria endemicity (%)

Source Data

WHO Malaria incidence map of Africa (https://www.who.int/gho/map_gallery/en/)

Method of calculation:	Interrogation of spatial data (GIS)

Intersect dam full supply / irrigation scheme clearing area with WHO Malaria prevalence map and calculate average % malaria endemicity in footprint area(s)

References

Kibret, S., Lautze, J., McCartney, M., Nhamo, L., Yan, G. 2019. Malaria around large dams in Africa: effect of environmental and transmission endemicity factors. Malaria Journal 18, Article number 303 (2019)

World Health Organisation: Global Health Observatory Data. Available at https://www.who.int/data/gho

Name	**Commercial irrigation (SL3.1)**
Type	Social (SL)
Category	Food security and livelihoods (3)
Motivation	Development of large-scale, commercial irrigation stimulates the economy, creates jobs, improves food security and improves socio-economic conditions
Description	Extent of proposed large-scale irrigation schemes
Units	km^2

Source Data

Planned large scale irrigation (km^2)

Method of calculation: **Interrogation of spatial data (GIS)**

Sum all proposed large-scale irrigation scheme areas in study area

References

Gwiyani-Nkhomo, B. Irrigation development and its socioeconomic impact on rural communities in Malawi. Development Southern Africa, Vol 28, 2011 – Issue 2

Name	**Recession agriculture (SL3.2)**
Proxy	*Floodplain inundation (EN2.1)*
Type	Social (SL)
Category	Food security and livelihoods (3)
Motivation	Recessional agriculture is a form of agricultural cultivation that takes place on a floodplain. Farmers practice recessional agriculture by successively planting in the flooded areas after the waters recede. A reduction in annual flood levels could impact recession agriculture.
Description	Extent of floodplain inundation in river reach downstream of dam during wet season
Units	% Change from baseline

Source Data

Water resources simulation model output:

Timeseries of flow in river reach downstream of proposed dam

Method of calculation:	**Timeseries analysis**
Identify wettest month from Natural time series	
Extract annual wettest month timeseries from Baseline and Scenario simulation results	
Calculate median wettest month flow rates for Baseline and Scenario	
Calculate change in wettest month median flow rate: Scenario compared to Baseline % change	

References

Opperman, J.J., Moyle, P.B., Larsen, E.W., Florsheim, J.L., Manfree, A.D. Floodplains: Processes and Management for Ecosystem Services. University of California Press, 2017. Available at https://www.jstor.org/stable/10.1525/j.ctv1xxt6n

Name	**Fish production - dams (SL3.3)**
Type	Social (SL)
Category	Food security and livelihoods (3)
Motivation	This indicator is linked to areas that will become inundated through impoundment, and therefore represents the additional fish habitat created by impoundments.
Description	Potential fisheries production
Units	ton per annum

Source Data
Water resources simulation model output:
Timeseries of surface area in proposed impoundment

Method of calculation:	**Timeseries analysis**
$y = 13.143\ x^{0.8305}$	
where y = fish production (t/a); x = median area of inundation over simulation period (km^2)	

References

Bassa, G. K. 1986. Fishery resources of Southern Sudan. In A.B. Zahlan (ed.): The Agricultural sector of Sudan: Policy and systems studies, 291-299. London (UK), Ithaca Press.

Food and Agricultural Organisation of the United Nations (FAO) 2007. African water resource database. GIS-based tools for inland aquatic resource management. 2 Technical manual and workbook. CIFA Technical Paper 33/2.

Halls, A. S 1999. Spatial Models for the Evaluation and Management of Inland Fisheries. Final Report. FIR Plansys 23220 01 20, MRAG Ltd. London.

Welcomme, R. L. 2011. An overview of global catch statistics for inland fisheries. ICES Journal of Marine Science 68(8): 1751-1756.

Witte, F., de Graaf, M., Mkumbo, O. C., El-Moghraby, A. I. and Sibbing, F. A. 2009. Fisheries production in the Nile System. Dumont, H. J. (ed.). The Nile: origin, Environments, Limnology and Human Use. Springer. Monographiae Biologicae 89: P 723-747.

Name	**Fish production - river (SL3.4)**
Proxy	*Wet season duration (EN2.3)*
Type	Social (SL)
Category	Food security and livelihoods (3)
Motivation	The length of the wet season is important for biological production, flushing of fine sediments, channel maintenance and floodplain inundation.
Description	Duration of wet season (high flows) in river reach downstream of dam
Units	% Change from baseline

Source Data

Water resources simulation model output:

Timeseries of flow in river reach downstream of proposed dam

Method of calculation: **Timeseries analysis**

Identify 20th percentile exceedance flow rate from Natural time series

Calculate number of days during which the Natural 20th percentile flow rate is exceeded in Baseline and Scenario simulations

Calculate change in number of exceedance days: Scenario compared to Baseline % change

References

Opperman, J.J., Moyle, P.B., Larsen, E.W., Florsheim, J.L., Manfree, A.D. Floodplains: Processes and Management for Ecosystem Services. University of California Press, 2017. Available at https://www.jstor.org/stable/10.1525/j.ctv1xxt6n

Whitehead, P.J.P. Ministry of Forest Development, Game and Fisheries. The river fisheries of Kenya. The East African Agricultural Journal , April, 1960

Name	**Productive land use (SL3.5)**
Type	Social (SL)
Category	Food security and livelihoods (3)
Motivation	Protection of land that is currently productive will maintain livelihoods and social structures
Description	Extent of productive land area within dam / irrigation scheme footprint
Units	km^2

Source Data
World Bank Global Land Cover (Globcover): The GlobCover project has developed a service capable of delivering global composites and land cover maps using as input observations from the 300m MERIS sensor on board the ENVISAT satellite mission. The GlobCover 2009 land cover map is derived by an automatic and regionally-tuned classification of a time series of global MERIS (MEdium Resolution Imaging Spectrometer) FR mosaics for the year 2009. The global land cover map counts 22 land cover classes defined with the United Nations (UN) Land Cover Classification System (LCCS). (**https://datacatalog.worldbank.org/dataset/global-land-cover-2009**)

Method of calculation: **Interrogation of spatial data (GIS)**

Intersect dam full supply / irrigation scheme clearing area with GlobCover dataset

GlobCover productive land-use categories:

- Post-flooding or irrigated shrub or tree crops
- Post-flooding or irrigated herbaceous crops
- Rainfed croplands
- Rainfed herbaceous crops
- Rainfed shrub or tree crops (cash crops, vineyards, olive tree, orchards…)
- Mosaic cropland (50-70%) / vegetation (grassland/shrubland/forest) (20-50%)
- Mosaic cropland (50-70%) / grassland or shrubland (20-50%)
- Mosaic vegetation (grassland/shrubland/forest) (50-70%) / cropland (20-50%)
- Mosaic grassland or shrubland (50-70%) / cropland (20-50%)
- Mosaic forest (50-70%) / cropland (20-50%)

References

Perez-Hoyos, A., Rembold, F., Kerdiles, H., Gallego, J. Comparison of global land cover datasets for cropland monitoring. Remote sensing, Nov 2017. Available at **https://www.mdpi.com/journal/remotesensing**

Name	**Access to natural resources (SL3.6)**
Proxy	*Environmentally sensitive area (EN1.1)*
Type	Social (SL)
Category	Food security and livelihoods (3)
Motivation	Protection of ecologically sensitive areas will serve to protect natural resources.
Description	Extent of ecologically sensitive area within dam / irrigation scheme footprint
Units	km^2

Source Data
Ecologically Sensitive Areas refer to those areas located within the primary impact zones that have been, or could potentially be, classified into one of the IUCN protected area management categories (www.iucn.org). The IUCN categories provide a global standard for defining and recording protected areas and are increasingly being incorporated into government legislation (**www.iucn.org**). The IUCN Protected Areas Categories System are as follows:

- Category Ia – Strict Nature Reserve
- Category Ib – Wilderness Area
- Category II – National Park
- Category III – Natural Monument or Feature
- Category IV – Habitat / Species Management Area
- Category V – Protected Landscape e.g. Water Towers
- Category VI – Protected area with Sustainable Use of Natural Resources

Typical areas in Kenya that could potentially be classified using the IUCN system include:

- Wetlands. Points identified as wetlands of international importance (www.ramsar.org).
- Birds. Points identified as Important Bird Areas (www.birdlife.org)
- National parks and reserves
- Gazetted water towers

Method of calculation: **Interrogation of spatial data (GIS)**

Intersect dam full supply / irrigation scheme clearing area with environmentally sensitive area(s)

References

African Development Bank (ADB) 2004. Group Policy on the Environment. February 20094.

Birdlife International. Important Bird Areas Programme. (www.birdlife.org).

International Finance Corporation (IFC). 2012. Performance Standard 6. Biodiversity Conservation and Sustainable Management of Living Natural Resources.

NEPAD 2003. Action plan for the environment initiative of the New Partnership for Africa's Development.

Ramsar (www.ramsar.org).

BirdLife International and NatureServe (2011) Bird species distribution maps of the world. BirdLife International, Cambridge, UK and NatureServe, Arlington, USA.

Name	**Physical displacement (SL4.1)**
Type	Social (SL)
Category	Displacement (4)
Motivation	Displacement impacts are classified as physical and economic displacement. Physical displacement is associated with the displacement of local communities due to dam inundation, and or area taken up by irrigation schemes and canals.
Description	Physical displacement of people due to inundation by proposed dam / establishment of planned irrigation scheme
Units	number of people

Source Data
Africa High Resolution Population Density Maps (www.un-spider.org/links-and-resources/data-sources/africa-high-resolution-population-density-maps)
WorldPop database (https://www.worldpop.org/)

Method of calculation:	**Interrogation of spatial data (GIS)**
Intersect dam full supply / irrigation scheme clearing area with population density spatial data	

References

Facebook Connectivity Lab and Center for International Earth Science Information Network - CIESIN - Columbia University. 2016. High Resolution Settlement Layer (HRSL). Source imagery for HRSL © 2016 DigitalGlobe. Accessed DAY MONTH YEAR.

Lloyd, C. T., Sorichetta, A., Tatem A. High resolution global gridded data for use in population studies. Scientific Data 4, Article number 170001 (2017)

Name	**Energy generated (EC1.1)**
Type	Economic (EC)
Category	Energy (1)
Motivation	Hydropower generation is a key benefit linked to water resources development and stimulates socio-economic development at local, national and regional levels
Description	Average hydropower generated
Units	GWh/a

Source Data
Water resources simulation model output:
Timeseries of hydropower output at HP node

Method of calculation:	**Timeseries analysis**
Calculate average energy (GWh/a) generated over simulation period	

References

Degefu, D. M., He, W., Zhao, J.H. Hydropower for sustainable water and energy development in Ethiopia. Sustainable Water Resources Management 1, 305-314 (2015)

Name	**Crop production (EC2.1)**
Type	Economic (EC)
Category	Food production (2)
Motivation	Increased food production through irrigation is a key benefit linked to water resources development. It creates food security and stimulates socio-economic development.
Description	Crop yield
Units	million ton/a

Source Data

Water resources simulation model output:

Timeseries of crop water requirements

Timeseries of crop water deficit

Typical crop yields as provided by Food and Agricultural Organisation FAOSTAT (http://www.fao.org/faostat/en/#home)

Method of calculation: **Timeseries analysis**

Calculate maximum crop yield (t) based on irrigation scheme area (km2) and FAO crop yield (t/ha)

$y = 1.4493x^2 + 3.0897x - 0.6197$

where y = actual crop yield as proportion of maximum crop yield (%); x = water applied ratio (%)

References

Stone, L.R., Sclegel, A.J., Khan, A.H., Klocke, N.L., Aiken, R.M. Water supply/yield relationships developed for study of water management. Journal of natural resources and life sciences education. Vol 35 (2006)

Name	**Fish production - dams (EC2.2)**
Proxy	*Fish production - dams (SL3.3)*
Type	Economic (EC)
Category	Food production (2)
Motivation	This indicator is linked to areas that will become inundated through impoundment, and therefore represents the additional fish habitat created by impoundments.
Description	Potential fisheries production
Units	ton per annum

Source Data
Water resources simulation model output: Timeseries of surface area in proposed impoundment

Method of calculation:	Timeseries analysis
$y = 13.143\ x^{0.8305}$ where y = fish production (t/a); x = median area of inundation over simulation period (km^2)	

References

Bassa, G. K. 1986. Fishery resources of Southern Sudan. In A.B. Zahlan (ed.): The Agricultural sector of Sudan: Policy and systems studies, 291-299. London (UK), Ithaca Press.

Food and Agricultural Organisation of the United Nations (FAO) 2007. African water resource database. GIS-based tools for inland aquatic resource management. 2 Technical manual and workbook. CIFA Technical Paper 33/2.

Halls, A. S 1999. Spatial Models for the Evaluation and Management of Inland Fisheries. Final Report. FIR Plansys 23220 01 20, MRAG Ltd. London.

Welcomme, R. L. 2011. An overview of global catch statistics for inland fisheries. ICES Journal of Marine Science 68(8): 1751-1756.

Witte, F., de Graaf, M., Mkumbo, O. C., El-Moghraby, A. I. and Sibbing, F. A. 2009. Fisheries production in the Nile System. Dumont, H. J. (ed.). The Nile: origin, Environments, Limnology and Human Use. Springer. Monographiae Biologicae 89: P 723-747.

Name	**Urban supply (EC3.1)**
Type	Economic (EC)
Category	Water supply (3)
Motivation	Reliable supply of water to urban areas is imperative for economic growth and investment
Description	Water supplied to urban areas
Units	% of demand supplied

Source Data
Water resources simulation model output: Timeseries of urban demand Timeseries of urban water user deficit

Method of calculation:	Timeseries analysis
Urban supply ratio (%) = mean annual supply (MCM) / mean annual demand (MCM)	

References

Stéphanie dos Santos, E. Adams, G. Neville, Y. Wada, A. de Sherbinin, et al.. Urban growth and water access in sub-Saharan Africa: Progress, challenges, and emerging research directions. Science of the Total Environment, Elsevier, 2017, 607-608, pp.497 – 508.

Name	**Rural supply (EC3.2)**
Type	Economic (EC)
Category	Water supply (3)
Motivation	Reliable supply of water to rural areas is imperative for health and social welfare
Description	Water supplied to rural users
Units	% of demand supplied

Source Data

Water resources simulation model output:

Timeseries of rural demand

Timeseries of rural water user deficit

Method of calculation: **Timeseries analysis**

Rural supply ratio (%) = mean annual supply (MCM) / mean annual demand (MCM)

References

Cook, J., Kimuyu, P., Wittington, D. The costs of coping with poor water supply in rural Kenya. Water resources research. Vol 52 (2). Jan 2016. Available at https://doi.org/10.1002/2015WR017468

Name	**Irrigation supply (EC3.3 & EC3.4)**
Type	Economic (EC)
Category	Water supply (3)
Motivation	Reliable supply of water to irrigation areas is imperative for good crop yields
Description	Water supplied to irrigation users
Units	% of demand supplied

Source Data

Water resources simulation model output:

Timeseries of irrigation demand

Timeseries of irrigation water user deficit

Method of calculation:	Timeseries analysis
Irrigation supply ratio (%) = mean annual supply (MCM) / mean annual demand (MCM)	

References

Stone, L.R., Sclegel, A.J., Khan, A.H., Klocke, N.L., Aiken, R.M. Water supply/yield relationships developed for study of water management. Journal of natural resources and life sciences education. Vol 35 (2006)

Name	**Flood reduction (EC4.1)**
Type	Economic (EC)
Category	Flood damage (4)
Motivation	Large dams provide flood attenuation with potential flood risk reduction downstream
Description	Storage provided by dam as proportion of total natural runoff
Units	Ratio

Source Data

Water resources simulation model output:

Timeseries of inflow sequence into proposed dam

Full storage volume of proposed dam

Method of calculation:	Timeseries Analysis
Flood reduction benefit = Dam volume (MCM) / Natural Mean Annual Runoff at dam location (MCM)	

References

Volpi, E., Di Lazzaro, M., Bertola, M., Viglione, A. Fiori, A. Reservoir Effects on Flood Peak Discharge at the Catchment Scale. Water Resources Research, Vol 54 (11)

Name	**Employment – Commercial irrigation (EC5.1)**
Type	Economic (EC)
Category	Macro-economic (5)
Motivation	Development of large-scale, commercial irrigation creates jobs
Description	Extent of proposed large-scale irrigation schemes and potential income
Units	number of jobs

Source Data
Planned large scale irrigation (km^2)
Water resources simulation model output:
Timeseries of crop water requirements
Timeseries of crop water deficit
Typical crop yields - Food and Agricultural Organisation FAOSTAT (http://www.fao.org/faostat/en/#home)
Potential crop income - Food and Agricultural Organisation FAOSTAT (http://www.fao.org/faostat/en/#home)
Primary and secondary economic indicators

Method of calculation:	Macro-economic analysis
Use macro-economic model **(Annexure A6)** to analyse the impacts of commercial irrigation on regional economic activity and job creation	

References

Neubert, S. Poverty oriented irrigation policy in Kenya: Empirical results and suggestions for reform. German Development Institute, Discussion Paper. Dec 2007

Name	**Employment – Hydropower generation (EC5.2)**
Type	Economic (EC)
Category	Macro-economic (5)
Motivation	Development of hydropower creates direct and indirect employment
Description	Energy generated through hydropower
Units	number of jobs

Source Data
Water resources simulation model output:
Timeseries of hydropower output at HP node
Primary and secondary economic indicators

Method of calculation:	Macro-economic analysis
Use macro-economic model **(Annexure A6)** to analyse the impacts of energy generation on regional economic activity and job creation	

References

Renner, M., García-Baños, C., Khalid, A. The International Renewable Energy Agency. Renewable Energy and Jobs Annual Review 2019. International Renewable Energy Agency

Name	**Health cost related to water quality (EC5.3)**
Type	Economic (EC)
Category	Macro-economic (5)
Motivation	Poor water quality leads to direct and indirect costs associated with health issues
Description	Health costs related to poor water quality
Units	Relative to baseline

Source Data

Refer to Indicators EN3.1 and EN3.2

Primary and secondary economic indicators

Method of calculation: **Macro-economic analysis**

Use macro-economic model (Annexure A6) to analyse the potential impacts of poor water quality on health cost.

References

Clough, J. Africa's Water Quality A Chemical Science Perspective A report by the Pan Africa Chemistry Network. March 2010

Name	**Water resources development's contribution to GDP growth (EC5.4)**
Type	Economic (EC)
Category	Macro-economic (5)
Motivation	Water resources development and efficient management increases GDP
Description	GDP growth as a function of water resources development
Units	Relative to baseline

Source Data

Refer to Annexure A6

Primary and secondary economic indicators

Method of calculation:	Macro-economic analysis

Use macro-economic model **(Annexure A6)** to analyse the potential impacts of water resources development on GDP.

References

Blignaut, J, Van Heerden, J. The impact of water scarcity on economic development initiatives. Water SA vol.35 n.4 Pretoria Jul. 2009

Name	**Sediment load (EC6.1)**
Type	Economic (EC)
Category	Sediment (6)
Motivation	Land use cover and management affect erosion risk and potential sediment yield
Description	Potential soil loss and sediment loads in rivers
Units	Ratio (Potential sediment load / Baseline sediment load)

Source Data

Refer to Annexure A1

Method of calculation:	Spatial Analysis

Refer to Annexure A1

References

Lahlou, A. Environmental and socio-economic impacts of erosion and sedimentation in north Africa. Erosion and Sediment Yield: Global and Regional Perspectives (Proceedings of the Exeter Symposium, July 1996). IAHS Publ. no. 236, 1996. 491

A7: Macro-economic analysis

Background

To understand the role of water resources to the current economy and the potential for future development in Kenya, a set of macro-economic indicators were developed which relate to economic policy assessments, GDP, employment and government expenses. The purpose of this was to assess how alternative water resources development scenarios in individual river basins compare in terms of macro-economic impacts through water resources system components (irrigation, hydropower, etc. and macro-economic sectors (e.g. agriculture, manufacturing, etc.). Furthermore, it allows comparison of economic impacts linked to investments in water resources system components among the six river basins in Kenya and provide insight into the sectoral and total economic value of water resources development priorities and policies for Kenya.

Methodology

Both Primary and Secondary economic indicators were used in the macro-economic analysis.

Primary Economic Indicators

To analyse the impacts of regional water resources development on regional economic activity, Gross Value Added (GVA) was used for measuring gross regional domestic product as a measure of the output of entities smaller than the national economy. GVA is defined as GDP + subsidies - (direct, sales) taxes. The Kenya National Bureau of Statistics reports regional economic activity, as GVA, by 17 economic sectors. This was determined as overly detailed for the scope of this analysis and consequently the 17 sectors were aggregated to 4 economic sectors that better link to outputs of water resources analyses. The aggregation is presented in Figure A7-1.

1	Agriculture, forestry and fishing
2	Mining and quarrying
3	Manufacturing
4	Electricity supply
5	Water supply; waste collection
6	Construction
7	Wholesale and retail trade; repair of motor vehicles
8	Transport and storage
9	Accommodation and food service activities
10	Information and communication
11	Financial and insurance activities
12	Real estate activities
13	Professional, technical and support services
14	Public administration and defence
15	Education
16	Human health and social work activities
17	Other service activities

1	Agriculture
2	Industry, Commerical, & Services
3	Electric Genearation
4	Transport

Figure A7-1: Aggregation of Macro-Economic Sectors for the Hydro-Economic Analysis

Secondary Economic Indicators

Secondary indicators which were utilised and related to water resources analysis outputs include Employment and Government spending in the Health Sector.

Table A7-1 displays the relationship between the Economic Indicators and the water resources model outputs as incorporated into the Macro-Economic analysis.

Table A7-1: Linkages between the Economic Indicators and Hydro-Model Indicators

Economic Sector	Water Sector	Water resources model output	Units
Agriculture	Irrigation Supply	Irrigation supply	MCM/a
Industry, Commercial, Services	Urban Water Supply	Urban water supply	MCM/a
Energy	Hydropower Generation	Hydropower generated	GWh/a
Transport	Flood Control	Storage in large dams	Flood Control Index
Employment – Agriculture	Irrigation Area	Irrigation area	Hectare Irrigated
Employment -Industry	Energy Generation	Hydropower generated	GWh/a
Health Cost	Water Quality	Water quality index	Water Pollution Index

Data

The Kenya National Bureau of Statistics spatially disaggregated the Gross Domestic Product of Kenya to County level. The estimation for 17 economic sectors and 47 counties revealed that there are significant differences in the size of economy across counties. The average contribution per county to GVA over the period 2013-2017 is approximately 2.1 percent with a standard deviation of 3.2. As may be expected, this indicates large disparities in the size of GDP across the counties. Nairobi County takes the lead, contributing approximately 21.7 percent of GDP over the period, followed by Nakuru (6.1%), Kiambu (5.5%) and Mombasa counties (4.7%) (KNBS, 2019).

Table A7-2 shows estimates of GVA at current prices by County and by industry (sector). The breakdown indicates how much each county contributed to each economic activity. For instance Samburu Counry contributed KSh 10,847 million to the Agriculture, Forestry and Fishing sector in 2017.

Table A7-2: Gross Value Added (GVA) at current prices by county and by industry (sector).

		SECTORAL GVA (KSH Millions)					
ID	County	Agriculture	Industrial	Energy	Transport	Services	Total
30	BARINGO	53633	357	413	4737	33726	92866
36	BOMET	114076	5314	205	2512	37462	159569
39	BUNGOMA	107829	2024	433	10388	62835	183509
40	BUSIA	50020	453	246	3253	32740	86712
28	ELGEYO	127967	527	209	3579	27249	159531
14	EMBU	39794	2644	6503	10599	44194	103734
7	GARISSA	16845	1712	318	1410	19109	39394
43	HOMA	68247	958	486	5708	38799	114198
11	ISIOLO	3325	52	162	1030	11281	15850
34	KAJIADO	15954	7897	2789	7899	73266	107805
37	KAKAMEGA	95193	9451	975	7504	69440	182563
35	KERICHO	62765	13867	853	5787	53527	136799
22	KIAMBU	132421	54081	9533	29094	196789	421918
3	KILIFI	38319	11790	1471	11411	56304	119295
20	KIRINYAGA	41208	8110	826	9763	40929	100836
45	KISII	85550	3338	1149	9578	63931	163546
42	KISUMU	51445	24721	4106	19636	94581	194489
15	KITUI	41799	755	960	7147	50899	101560
2	KWALE	39610	1747	730	4198	39993	86278
31	LAIKIPIA	35489	823	723	5904	38156	81095
5	LAMU	18699	174	340	4171	9002	32386
16	MACHAKOS	56112	48155	9019	12736	106838	232860
17	MAKUENI	47606	1050	373	5276	46619	100924
9	MANDERA	14169	206	581	1155	18990	35101
10	MARSABIT	16078	85	259	337	17314	34073
12	MERU	124381	8401	1025	19072	76767	229646
44	MIGORI	40861	8726	352	6648	39750	96337
1	MOMBASA	1459	48506	20546	88308	173303	332122
21	MURANGA	89003	9679	1675	7005	65656	173018
47	NAIROBI	4102	375282	26878	184845	901216	1492323
32	NAKURU	301349	15408	36932	30640	133133	517462
29	NANDI	71213	4709	489	3300	39980	119691
33	NAROK	120355	2322	653	4601	51295	179226
46	NYAMIRA	56634	6728	489	3268	36120	103239
18	NYANDARUA	209519	1815	400	4269	29200	245203
19	NYERI	92859	5996	1703	12263	62140	174961
25	SAMBURU	10847	76	123	1234	14223	26503
41	SIAYA	50685	1282	390	3858	39050	95265
6	TAITA	19858	828	567	3109	27019	51381
4	TANA	18333	68	73	924	14100	33498
13	THARAKA	38740	317	210	2381	26044	67692
26	TRANS	50628	1058	810	7958	56229	116683
23	TURKANA	41493	153	2066	7750	26839	78301
27	UASIN-GISHU	63017	8628	1042	17552	72034	162273
38	VIHIGA	20160	2017	547	2292	34034	59050
8	WAJIR	20032	465	22	258	16382	37159
24	WEST	19311	2862	69	3904	20639	46785

Figure A7-2 presents total GVA by county with the six Kenya River Basins overlaid, while Figure A7-3 presents Agricultural GVA per county. These figures show how spatially varied the GVA values are- both within river basins and between river basins.

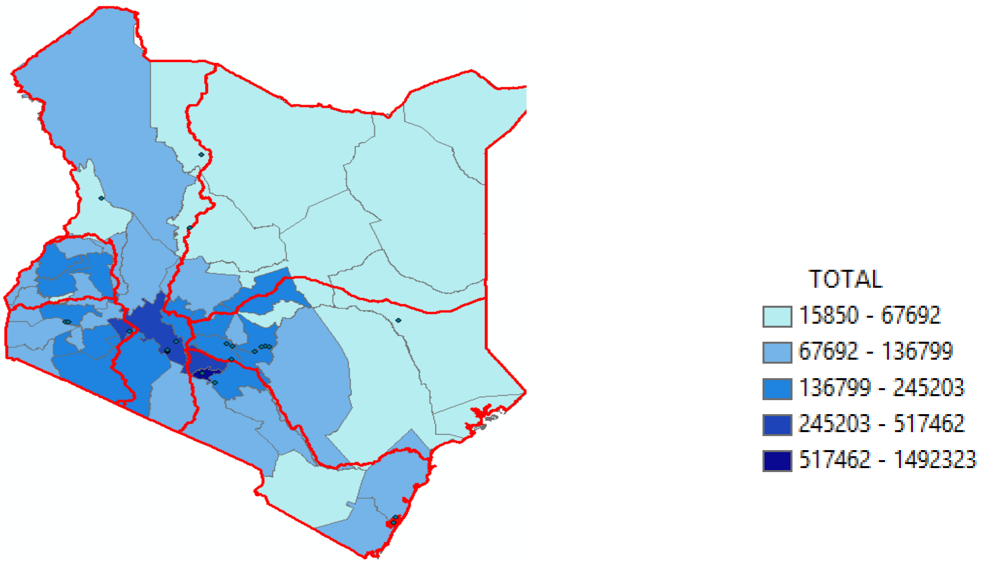


Figure A7-2: TOTAL GVA by County (KSH Millions)

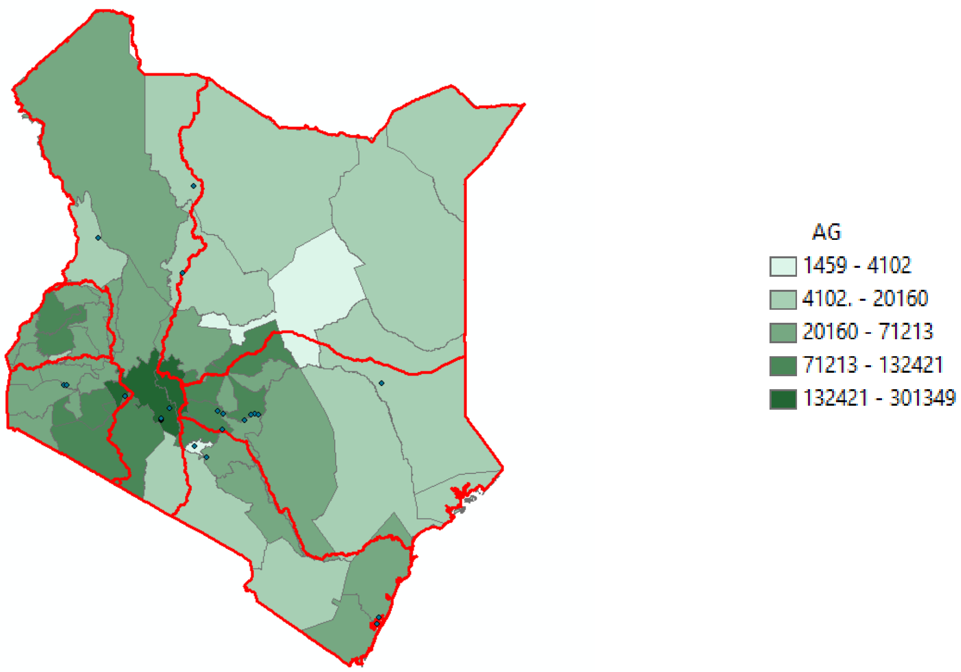


Figure A7-3: Agricultural GVA by County (KSH Millions)

Since the Hydro-Model Indicators are provided at River Basin level, the economic indicators needed to be calculated likewise. Using GIS tools, the area of each County in each river basin was estimated (Table A7-3) and a matrix of weights from Country to River basin was developed. With this matrix the

GVA per river basin could be estimated. Figures A7-4 and A7-5 show River Basin GVAs for Total GVA and Agricultural GVA respectively.

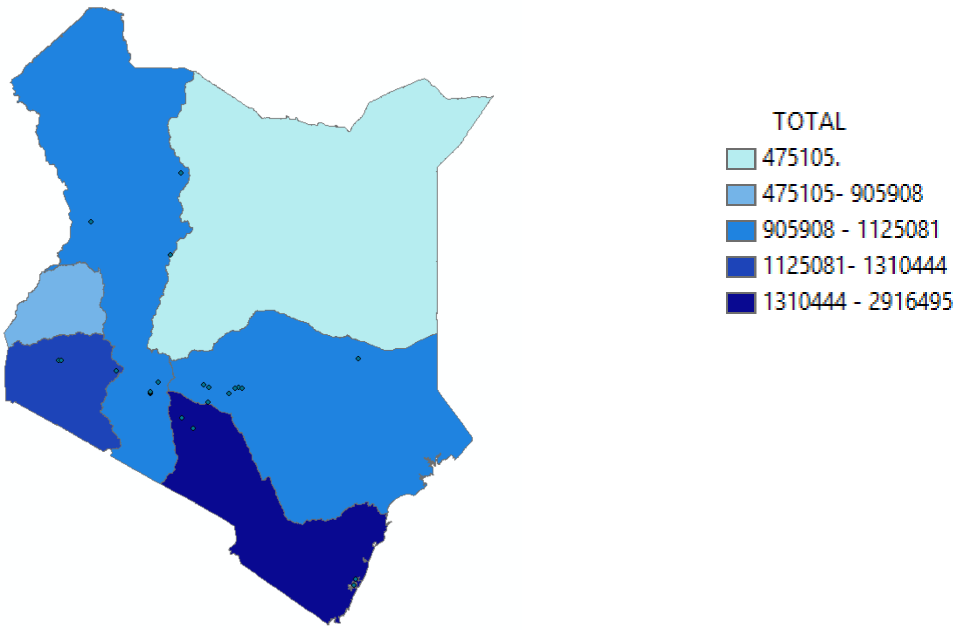


Figure A7-4: TOTAL GVA by River Basin'

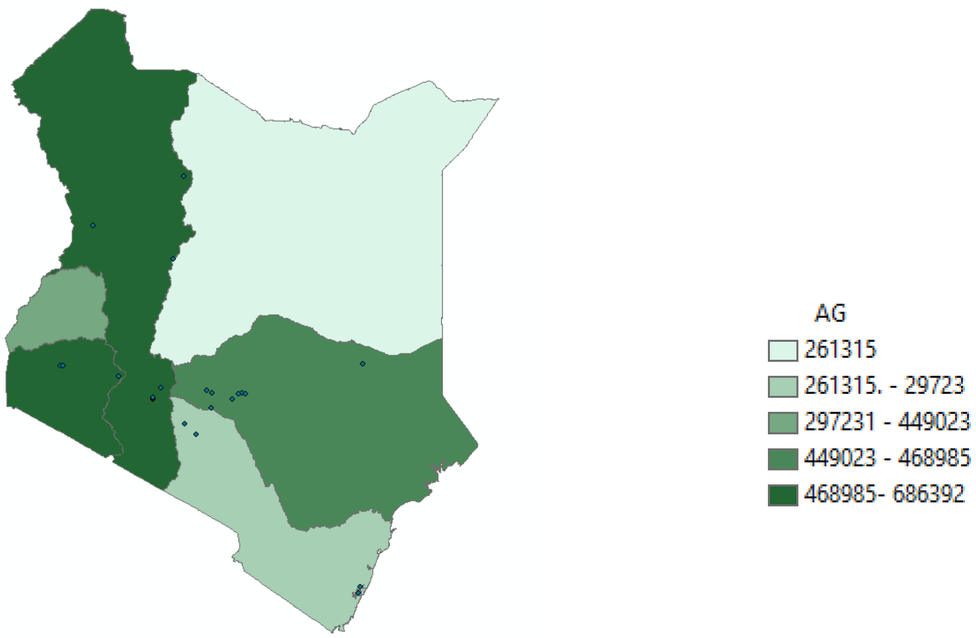


Figure A7-5: Agricultural GVA by River Basin

Table A7-3. TOTAL GVA by County

ID	County	ACA	southCA	LVNCA	LVSCA	RVCA	TCA
30	BARINGO					100%	
36	BOMET				100%		
39	BUNGOMA			100%			
40	BUSIA			100%			
28	ELGEYO				35%	65%	
14	EMBU						100%
7	GARISSA		32%				68%
43	HOMA				100%		
11	ISIOLO		89%				11%
34	KAJIADO	64%				36%	
37	KAKAMEGA			100%			
35	KERICHO				100%		
22	KIAMBU	78%				11%	12%
3	KILIFI	85%					15%
20	KIRINYAGA						100%
45	KISII				100%		
42	KISUMU				100%		
15	KITUI	4%					96%
2	KWALE	100%					
31	LAIKIPIA		88%			12%	
5	LAMU						100%
16	MACHAKOS	66%					34%
17	MAKUENI	100%					
9	MANDERA		100%				
10	MARSABIT		79%			21%	
12	MERU		47%				53%
44	MIGORI				100%		
1	MOMBASA	100%					
21	MURANGA						100%
47	NAIROBI	100%					
32	NAKURU				16%	84%	
29	NANDI			64%	36%		
33	NAROK				50%	50%	
46	NYAMIRA				100%		
18	NYANDARU A		38%			62%	
19	NYERI		30%				70%
25	SAMBURU		77%			23%	
41	SIAYA			52%	48%		
6	TAITA	100%					
4	TANA						100%
13	THARAKA						100%
26	TRANS			91%		9%	
23	TURKANA					100%	
27	UASIN-GISHU			100%			
38	VIHIGA			76%	24%		
8	WAJIR		100%				
24	WEST					100%	

Figure A7-6 displays the locations of existing electrical power generation stations across Kenya, which were used, along with the locations of proposed hydropower stations, to assess energy benefits.

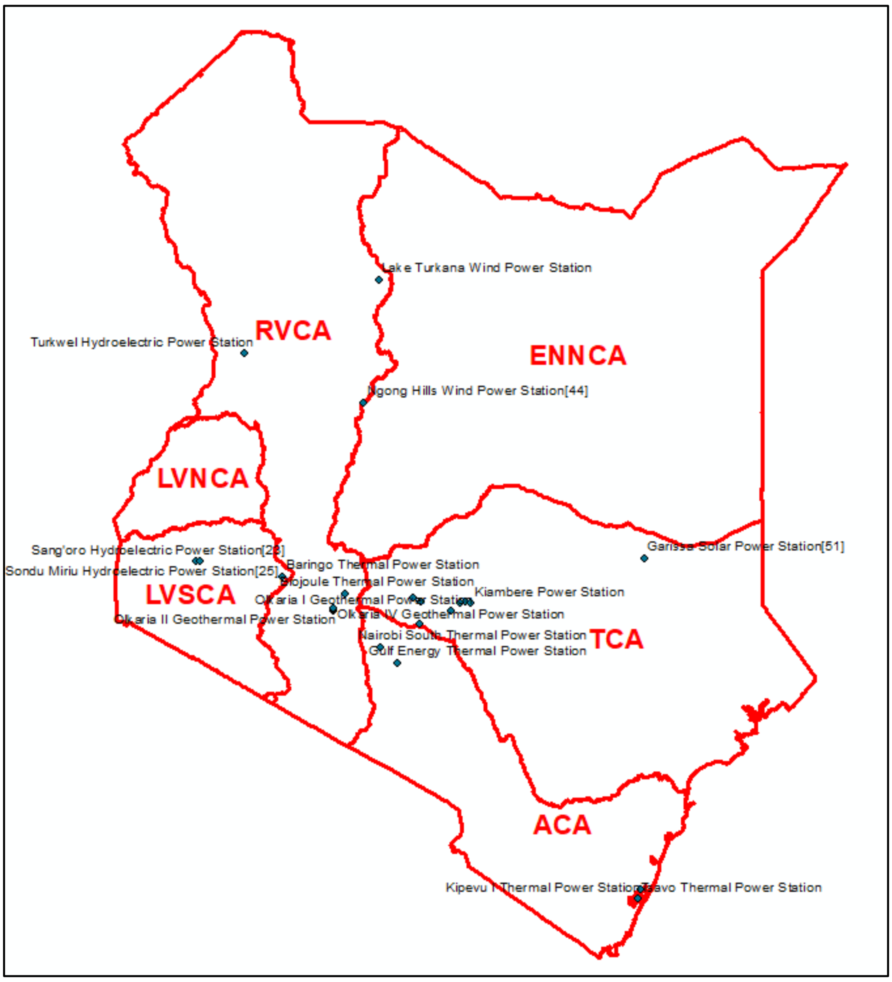


Figure A7-6: Electric Generation Stations in relation to river basins

Estimation of macro-economic indicators

Using the 2017 GVA data aggregated to the six river basins and the outputs from the water resources Baseline (current day) model, data coefficients were determined for each river basin, which were then used to generate primary and secondary economic indicators based on the water resources model outputs for each river basin and each scenario.

References

Power Africa, 2015 Development of Kenya's Power Sector 2015-2020

Trading Economics, 2019, Kenya - Total electricity output, https://tradingeconomics.com/kenya/total-electricity-output-gwh-wb-data.html

KNBS, 2019, Gross County Product. Kenya National Bureau of Statistics.

B1: Water availability, current water demands (2018) and water balance per sub-basin

Subbasin	Area (km2)	MAP (mm)	Water resources potential (MCM/a)			Q95 (MCM/a)	Current demand (MCM/a)					Water balance	
			Natural Surface Runoff	Groundwater sustainable yield	Total		Irrigation	Domestic / Industrial	Livestock	Wildlife & Fisheries	Total	(MCM/a)	%
1GA	443	1564	81	8	88	2.1	0.6	2.3	0.8	0.5	4	82	93%
1GB	512	1666	164	8	172	11.3	13.9	2.4	0.9	0.5	18	143	83%
1GC	883	1377	217	13	230	1.7	1.6	17.3	1.4	0.5	21	208	90%
1GD	640	1486	152	8	161	6.4	23.4	22.6	1.4	0.5	48	106	66%
1GE	365	1487	101	15	117	2.4	5.3	2.9	0.6	0.5	9	105	90%
1GF	310	1456	119	5	124	0.0	16.7	1.9	0.8	0.5	20	104	84%
1GG	376	1775	99	5	104	1.9	2.6	1.9	0.5	0.5	5	96	93%
1HA1	343	1559	110	8	118	15.2	4.6	19.1	0.9	0.5	25	78	66%
1HA2	527	1408	203	8	212	9.3	38.5	35.5	1.3	0.5	76	126	60%
1HB1	463	1619	178	4	183	26.3	14.4	3.6	1.3	0.5	20	137	75%
1HB2	252	1478	77	4	81	0.2	15.5	3.3	0.8	0.5	20	61	75%
1HC	569	1151	100	3	103	2.5	0.0	3.2	1.4	0.5	5	96	93%
1HD	786	1560	279	7	286	24.1	30.5	14.6	2.3	0.5	48	214	75%
1HE	722	1425	210	7	217	3.6	10.6	9.4	2.2	0.5	23	191	88%
1HF	866	1093	233	13	246	0.0	30.3	6.0	1.4	0.5	38	208	85%
1HG	296	1272	80	4	83	0.0	7.8	2.4	0.5	0.5	11	72	87%
1JA	837	1599	401	17	419	16.3	1.0	2.8	1.0	0.5	5	397	95%
1JB	176	1747	95	5	100	4.2	0.2	1.1	0.4	0.5	2	94	94%
1JC	330	1812	203	6	209	4.5	0.3	11.9	0.5	0.5	13	192	92%
1JD	202	1400	53	5	58	2.6	0.2	1.9	0.4	0.5	3	52	90%
1JE	548	1479	201	5	207	7.7	0.9	4.5	1.7	0.5	8	191	93%
1JF	981	1350	364	11	374	31.0	1.3	6.4	2.2	0.5	10	333	89%
1JG1	233	1531	114	2	116	0.8	2.2	3.1	0.8	0.5	7	109	94%
1JG2	74	1295	13	2	15	0.9	6.6	0.6	0.3	0.5	8	6	39%
1KA	459	1970	320	5	325	28.4	1.4	16.3	1.4	0.5	20	277	85%
1KB	3425	1176	935	33	969	62.1	18.8	63.6	9.8	0.5	93	814	84%
1KC	2906	1589	829	21	850	15.4	2.7	21.4	9.0	0.5	34	801	94%
1LA1	915	1429	274	13	288	3.8	1.0	9.0	2.2	0.5	13	271	94%
1LA2	1031	1193	75	9	84	0.0	0.3	1.5	2.3	0.5	5	79	95%
1LA3	2413	742	27	7	34	0.0	0.8	2.1	4.8	0.5	8	26	76%
1LB1	1389	1305	345	15	360	31.1	1.0	4.6	2.7	0.5	9	321	89%
1LB2	2633	984	115	15	130	0.0	0.6	1.4	3.6	0.5	6	124	95%
Total	**26906**	**-**	**6770**	**292**	**7062**	**316**	**256**	**300**	**62**	**15**	**633**	**-**	**-**

B2: Future (2040) water demands per sub-basin

Subbasin	Future water demand (MCM/a)				
	Irrigation	Domestic / Industrial	Livestock	Wildlife & Fisheries	Total
1GA	7.1	1.2	1.8	0.7	10.8
1GB	27.0	1.5	2.5	0.7	31.7
1GC	2.4	56.0	4.1	0.7	63.2
1GD	42.7	72.1	4.1	0.7	119.7
1GE	9.9	1.7	0.7	0.7	12.9
1GF	9.4	0.8	1.8	0.7	12.7
1GG	1.3	1.3	1.6	0.7	4.9
1HA1	9.2	195.3	2.5	0.7	207.7
1HA2	152.2	74.3	3.4	0.7	230.5
1HB1	9.5	2.7	3.4	0.7	16.3
1HB2	10.3	0.8	1.8	0.7	13.5
1HC	3.2	2.2	4.1	0.7	10.1
1HD	42.8	34.1	6.6	0.7	84.2
1HE	11.2	6.9	5.1	0.7	23.9
1HF	28.0	15.8	4.1	0.7	48.5
1HG	9.3	4.5	1.6	0.7	16.0
1JA	23.6	5.0	1.0	0.7	30.3
1JB	0.2	1.0	0.9	0.7	2.7
1JC	7.4	49.7	1.6	0.7	59.4
1JD	8.7	1.3	0.9	0.7	11.5
1JE	18.3	4.5	4.3	0.7	27.7
1JF	17.8	7.8	5.1	0.7	31.4
1JG1	106.4	2.6	1.8	0.7	111.4
1JG2	5.8	0.4	0.3	0.7	7.2
1KA	15.8	88.7	4.1	0.7	109.3
1KB	95.2	118.3	25.2	0.7	239.4
1KC	49.4	45.0	24.2	0.7	119.3
1LA1	11.6	30.2	5.9	0.7	48.3
1LA2	3.0	1.5	6.6	0.7	11.8
1LA3	61.0	1.9	11.9	0.7	75.4
1LB1	25.1	3.4	7.5	0.7	36.7
1LB2	25.1	1.2	10.0	0.7	36.9
Total	**850**	**834**	**161**	**21**	**1865**

C1. Environmental management

C1.1. Framework

To ensure quality of attention to environmental and social factors that affect the sustainable utilisation of water and allied resources in the LVS Basin, the legislative, policy and institutional framework for environmental management should govern the development, and implementation of the strategies, sub-plans and actions emanating from this LVS Basin Plan. This framework needs to be understood if the LVS Basin Plan is to attain the goals of social acceptability, economic viability and technical sustainability in line with internationally accepted standards for good practice.

- ***The Constitution of Kenya, 2010:*** is the supreme law in the Country providing the broad framework regulating all existence and development aspects of interest to the people of Kenya, and along which all national and sectoral legislative documents are drawn. Its Chapter V is entirely dedicated to land and environment, and a number of environmental principles feature in various parts. The Constitution embodies social and economic rights of an environmental character, such as the right to water, food and shelter, the right of every person to a clean and healthy environment, and the right to have the environment protected for the benefit of present and future generations through legislative measures.

- ***The National Environment Policy, 2012:*** provides a holistic framework to guide the management of the environment and natural resources in Kenya. It further ensures that the linkage between the environment and poverty reduction is integrated in all government processes and institutions to facilitate and realize sustainable development at all levels in the context of green economy enhancing social inclusion, improving human welfare and creating opportunities for employment and maintaining the healthy functioning of ecosystem.

- ***The Environmental Management and Coordination Act, 1999 (as amended 2015) Cap 387 (EMCA):*** is the framework law on the environment in Kenya. The EMCA was enacted to provide an appropriate legal and institutional framework for the management of the environment in Kenya. The Act was amended in May 2015 and took effect on 17 June 2015.

  The Act aims to improve the legal and administrative coordination of the diverse sectoral initiatives in the field of environment in order to enhance the national capacity for its effective management. In addition, the Act seeks to align the 77 sector specific legislations pertaining to the environment in a manner designed to ensure greater protection of the environment. This is in line with national objectives and sustainable development goals enunciated in the Agenda 21 of the Earth Summit held in Rio de Janeiro in 1992. The ultimate objective is to provide a framework for integrating environmental considerations into the country's overall economic and social development. In terms of environmental management, the EMCA provides a comprehensive legal and institutional framework for the handling of all environmental issues in Kenya and covers all sectoral laws.

  EMCA does not repeal the sectoral legislation but seeks to coordinate the activities of the various institutions tasked to regulate the various sectors. These institutions are referred to as Lead Agencies in EMCA.

The EMCA is supported by several subsidiary Regulations such as Solid Waste Management Regulations (2006), Environmental Management and Coordination (Water Quality) Regulations (2006) and Emissions Regulations (2007), as well as other pertinent International Environmental Regulations.

C1.1.1. National institutions

National institutions in Kenya who are involved with biodiversity and ecosystems management are listed below.

Table C1-1: Institutions and Ministries with mandates for biodiversity and ecosystems management

Ministry/ institution	Main roles and responsibilities	Legislative framework
Water Resources Authority (WRA)	Regulation of the management and use of water resources. This is done through permitting, b) support preparation of the Government's plans and programs for the protection, conservation, control and management of water resources through formulation of National Management strategy, c) formulation and enforcement of standards, procedures and Regulations for the management and use of water resources and flood mitigation. Protection of catchment areas, conservation of ground water, power to require permit applications or re-applications, agreements as to protection of sources of water, etc.,regulation of abstraction of ground water.	Water Act (2016).
Water Resource User Associations (WRUAs)	Ensure cooperative management of water resources at the sub-basin and community level.	Water Act (2016).
Ministry of Forestry and Wildlife	Formulate forestry and wildlife policies, initiate and oversee drafting of relevant legislation, sector coordination and guidance, monitoring and evaluation.	Forests Act (No. 7 of 2005) Wildlife (Conservation and Management) Act (Cap 376)
Kenya Wildlife Service (KWS)	Conserve wildlife and their ecosystems; National Ramsar administrative authority.	Wildlife (Conservation and Management) Act (Cap 376).
Kenya Forestry Service (KFS)	Conserve, develop and sustainably manage Kenya's forest resources for the country's social-economic development.	Forests Act (No. 7 of 2005).
Ministry of Environment and Mineral Resources	Formulate environmental laws and policies, monitor, protect, conserve and manage the environment and natural resources by ensuring sustainable utilisation.	Environmental Management and Coordination (Amendment) Act, 2015
National Environment Management Authority (NEMA)	Coordinate environmental management; provide guidance on the development of wetland management plans; ensure compliance of environmental laws.	Environmental Management and Coordination Act (No. 8 of 1999).
Ministry of Fisheries Development	Formulate policies, oversee drafting of relevant legislation, policy formulation, sector coordination and guidance, monitoring and evaluation.	Fisheries Act (Cap 378).
National Museums of Kenya (NMK)	Promote Kenya's heritage by collecting and preserving artefacts and research.	National Museums and Heritage Act (No. 6 of 2006).

Ministry/ institution	Main roles and responsibilities	Legislative framework
District Environmental Committees (DECs)	Provide technical support for environmental management including all ecosystems and integrate wetland protection into district development plans.	Environmental Management and Coordination Act (No. 8 of 1999).

The institutional framework for the implementation of EMCA and its Regulations include:

- The National Environment Council (The Council): is responsible for policy formulation and directions for the purposes of the EMCA. The Council also sets national goals and objectives and determines policies and priorities for the protection of the environment.
- The National Environmental Management Authority (NEMA): is the body charged with overall responsibility of exercising general supervision and co-ordination over all matters relating to the environment and to be the principal instrument of government in the implementation of all policies relating to the environment. Activities of NEMA are handled by three core directorates: Enforcement, Education and Policy.
- Lead Agencies: Lead Agencies are defined in Section 2 of EMCA as any Government ministry, department, parastatal, and State Corporation or local authority in which any law vests functions of control or management of any element of the environment or natural resource.
- County Environmental Committees (CEC): are the District level bodies chaired by respective County Commissioners and bringing together representatives from all the ministries; representatives from local authorities within the province/district; two farmers/pastoral representatives; two representatives from NGOs involved in environmental management in the province/district; and a representative of each regional development authority in the province/district. To each CEC in the country is attached a County Environmental Coordinator who serves as the secretary to the CEC, and as the NEMA Officer on the ground, is charged with responsibility of overseeing environmental coordination among diverse sectors.

C1.1.2. Strategic Environmental Assessment (SEA)

Role of SEA

Strategic Environmental Assessment (SEA) in the context of the Kenyan Environmental legislation refers to a range of analytical and participatory approaches that aim to systematically integrate environmental consideration into ***policies, plans and programmes*** and evaluate the interlinkages with economic and social considerations.

In the SEA process, likely significant effects of a policy, plan, or program on the environment, which may include secondary, cumulative, synergistic, short, medium and long term, permanent and temporary impacts are identified, described and evaluated in an environmental report.

This process extends the aims and principles of Environmental Impact Assessment (EIA) upstream in the decision-making process, beyond the project level and when major alternatives are still open (NEMA, 2011). SEA represents a proactive approach to integrating environmental considerations into the higher levels of decision making, consistent with the principles outlined in Agenda 21 (UNEP, 2007).

SEA can play an advocacy role, where its primary purpose is to raise the profile of the environment, and typically this would occur when the SEA is applied to a plan, policy or programme that has already been developed. In the context of the LVS Basin Plan however, SEA might be a better used in an integrative role, where the focus is on combining environmental, social and economic considerations into the planning process. In this way the SEA can promote an integrated system of planning that incorporates sustainability objectives at a policy, plan or programme level (DEAT, 2004).

There are a number of strategic decisions that are typically taken at the policy, plan and programme level that have an influence on downstream projects and developments. The role of SEA is to allow for the decision-maker to proactively determine the most suiTable Cevelopment type for a particular area, before development proposals are formulated and subjected to EIA (DEAT, 2004). In this way SEA can strengthen future EIAs by considering a broader range of alternatives, addressing cumulative effects, and facilitating the enhancement of a chosen level of environmental quality at a strategic level, thereby providing better context for EIA processes. The role of SEA and the role of EIA are complimentary, and SEA has the potential to make the EIA process more powerful. These tools can be utilised by WRA, BWRCs and WRUAs to vet the environmental integrity of developments in the LVS basin that are linked to water resources management. Developments that are most likely to have negative impacts on the resources can be prevented trough public consultation phases or public commenting phases.

Table C1-2: Comparison between the different roles offered through SEA and EIA (adapted from DEAT, 2004)

SEA: Policy, Plan and Programme Level	EIA: Project Level
Is pro-active and can inform future development proposals	Is reactive to a development proposal decision already taken
Is used to assess the effect of the existing environmental and socio-economic conditions on development opportunities and constraints	Is used to assess the effect of a proposed development on the environment and socio-economic conditions
Relates to areas, regions or sectors of development	Relates to a specific project
Enables the development of a framework against which positive and negative impacts can be measured	Enables the identification of project-specific impacts
Is a process aimed at the development of a sustainability framework to inform continuous decision-making over a period of time	Has a well-defined beginning and end and focuses on informing a specific decision
Is focussed on maintaining a chosen level of environmental quality and socio-economic conditions	Is focused on the mitigation of negative impacts and the enhancement of positive impacts
Has a wide perspective and includes a low level of detail to provide a vision and framework	Has a narrow perspective and includes intricate detail

Key aspects typically addressed under a SEA include developing baseline information, determining compatibility of proposed project interventions with the basin environment conditions, identifying and evaluating the significant environmental impacts of the proposed interventions in the basin plan, assessing the environmental costs and benefits of the proposed projects to the local and national economy, and evaluating and selecting the best project alternatives from the various options.

Issues to be considered are broad and generally relatem to destruction of the physical environment through deforestation and degradation, loss of biodiversity-destruction of flora and flora, increased human-wildlife conflict, increased demand for forest products, environmental pollution and catchment degradation, contamination of rivers, wetlands and ground water resources, climate change and related disasters like floods, drought, pests and diseases, overgrazing, increased urbanization, poor governance and weak institutions, and consumer rights and access to information.

The SEA provides every stakeholder a *locus standi* to address environmental degradation and undertaking specific EIA's for interventions proposed in the basin plan.

Specifically, the SEA will offer various opportunities among them:

- Improved processes of environmental administration and governance, so that the purpose and expectations of the various policies and legislation are fully attained.
- Enhanced engagement of communities and wider stakeholders in the basin in environmental issues and governance.
- Capacity building of all stakeholders to allow the processes of environmental administration and governance in the basin to be conducted with best practices and underlying goals as provided in the various statutes and policies.

SEA Challenges

Some of the expected challenges in implementing the SEA process include:

- Inadequate participation of the key stakeholders in the SEA process and conflicting mandates in the governance framework of the key natural resources in the basin.
- Lack of effective coordination among implementing agencies and institutions in the basin
- Lack of effective political will during the implementation of the SEA recommendations
- Lack of a benefit sharing framework of the key natural resources in the basin within the framework of an agreed public private partnership
- Lack of adequate resources to implement the recommendations in the SEA

Legislative Framework for SEA

The legislative framework for SEA in the Kenyan context includes:

- ***The Environmental Management and Coordination Act, 1999 (as amended 2015) Cap 387 (EMCA):*** Prior to amendment in 2015, EMCA addressed itself primarily to Environmental Impact Assessment (Section 58). However, the EMCA (as amended 2015) now also addresses Strategic Environmental Assessment. EMCA (as amended) Article 57 (A) (1) states that "*all Policies, Plans and Programmes for implementation shall be subject to Strategic Environmental Assessment*". It describes plans, programmes and policies as those that are-
    - Subject to preparation or adoption by an authority at regional, national, county or local level, or which are prepared by an authority for adoption through a legislative procedure by Parliament, Government or if regional, by agreements between the governments or regional authorities, as the case may be;
    - Determined by the Authority as likely to have significant effects on the environment.
- ***The Environmental (Impact Assessment and Audit) Regulations, 2003:*** Recognizes SEAs as a measure of environmental impact assessment at a strategic level for policy, plans and programmes. The Regulation's Part VI Sections 42 and 43 address Strategic Environment Assessments:
    - Section 42(1) requires Lead Agencies in consultation with NEMA to subject all policy, plans and programmes for implementation to a Strategic Environment Assessments.
    - Section 42(3) commits the Government and all Lead Agencies to incorporate principles of SEA in the development of sector or national policy.
    - Section 43(1) provides the requisite content for a Strategic Environmental Impact Report.
    - Section 43(2) requests certain information within the policy, plan or programme.

  - Section 43(3) commits the Government and all Lead Agencies to incorporate principles of SEA in the development of sector or national or regional policy.

- ***National Guidelines for Strategic Environmental Assessment in Kenya, (NEMA, Revised 2011):*** Increasingly, NEMA was faced with the challenges of the inadequacy of EIA to deal with cumulative, synergistic, secondary and long-term impacts. These impacts are better addressed if policies, plans and programmes are subjected to an SEA process. Consequently, NEMA formulated the National SEA guideline to give an understanding on the of the general principles, basic steps of SEA application, the tools and techniques to be adopted, the final output of the SEA process and enhance the practice of SEA in Kenya.

- ***Draft Environmental (Strategic Assessment, Integrated Impact Assessment and Audit) Regulations, 2018:*** NEMA has recently prepared draft Regulations, and as these are intended to repeal the Environmental (Impact Assessment and Audit) Regulations, 2003, their content will likely be of consequence to the LVS Basin Plan and its sub-plans. The overall objective of the Draft Environmental Regulations (2018) is to align processes with the EMCA following its amendment in 2015. The regulations also seek to address emerging issues such as environmental and social safeguard procedures; and Climate Change. Part VI 41(1) to 50(3) details the requirements for SEA.

Process of SEA

The SEA process described follows those set out in the **Draft** Environmental Regulations (2018). These regulations have undergone public consultation: stakeholder forums were held in March 2018, and a national validation workshop was held in Nairobi on 4th April 2018. It is therefore anticipated that these regulations will be enacted imminently.

The Draft Environmental Regulations (2018) (Section 41(1)) require that NEMA in consultation with county governments, Lead Agencies, institutions and private entities subject all proposals for policies, plans or programmes to an SEA, and describe the objectives of such a study in Section 42(2). The following legislated steps required for an SEA are described in Sections 42(1) to 50(3):

- **Step 1 - Screening:**
  - Step 1.1 – Programme Brief: The policy, plan or programme brief is to be submitted to NEMA for screening.
  - Step 1.2 – NEMA Review: NEMA will undertake a screening process and determine the need for an SEA. If an SEA is required, then NEMA will request a scoping study with the objective of defining the geographical and thematic scope of the assessment, and Step 2 is then applicable.
- **Step 2 – Scoping:**
  - Step 2.1 – Scoping Study: A licensed lead environmental expert/firm is to be appointed to undertake the scoping study.
  - Step 2.2 – Public Consultation: Consultation with the relevant government authorities, agencies and public is to be undertaken to obtain comment. The first of two mandatory public meetings is to be held in the Scoping stage.
  - Step 2.3 - Scoping Report: The licensed lead environmental expert/firm is to prepare and submit a Scoping Report to NEMA. The mandatory content of the Scoping Report is provided in Section 41(4).
- **Step 3 – Scoping Report Review:**

- Step 3.1 – NEMA Review: NEMA are to review the adequacy of the Scoping Report, and either approve it (thereby instructing the commencement of the SEA); or request additional information. Once the Scoping report is approved, then Step 4 is applicable.

- **Step 4 – SEA:**
  - Step 4.1 – SEA Study: The team of experts will undertake the SEA, and the mandatory process of conducting an SEA is described in Section 44(3)
  - Step 4.2 – Public Consultation: Consultation with the relevant government authorities, agencies and public is to continue to be undertaken to obtain comment. The second of two mandatory public meetings is to be held in the SEA stage.
  - Step 4.3 – SEA Report: A draft SEA Report is to be prepared and submitted to NEMA. The mandatory content of the SEA Report is provided in Section 44(2).

- **Step 5 – Draft SEA Report Review:**
  - Step 5.1 – NEMA Review: NEMA are to review the adequacy of the Draft SEA Report, once approved, Step 5.2 is applicable.
  - Step 5.2 – Organs of State: NEMA is to dispatch copies of the Draft SEA Report to the relevant County Government, Lead Agencies and stakeholders for comment within a stipulated timeframe.
  - Step 5.3 – General Public: NEMA are to provide notice of the availability of the draft report for comment and make it available for comment to the general public (as per specific public consultation steps described in Sections 46(2)(3)(4) and (5)) for a stipulated timeframe.
  - Step 5.4 – NEMA Review: Upon closure of the comment period, NEMA are to review the draft SEA Report and make comments on their review that are to be sent to the SEA team for inclusion in the draft SEA Report (a Technical Advisory Committee may be appointed by NEMA to undertake a detailed review, in which case their comments are also to be included in the draft SEA Report)

- **Step 6 – Revised SEA Report:**
  - Step 6.1 – Update Draft SEA: The draft SEA is to be revised to incorporate all comments and a Revised SEA Report is to be submitted to NEMA.
  - Step 6.2 – Validation Workshop: Upon verification of the revised report, the SEA team in consultation with NEMA is to hold a validation workshop with the public and stakeholders, and the report is to be updated accordingly as the “Final” version.

- **Step 7 – Final SEA Report:**
  - Step 7.1 – Final Submission: The Final SEA Report is to be submitted to NEMA together with the requisite forms as per Section 48.
  - Step 7.2 – Record of Decision: NEMA are to determine a Record of Decision within the requisite timeframes, and if this is an approval then NEMA are to include written conditions which are to be accepted by the proponent before implementing the plan or programme. If this is a rejection, then NEMA are to provide reasons for this.

- **Step 8 – Monitoring & Evaluation:**
  - Step 8.1 – Annual Reports: The proponent is to undertake monitoring and evaluation of the policy, plan or programme, and submit annual report to NEMA.
  - Step 8.2 – NEMA Evaluation: NEMA is to undertake a formal evaluation of the monitoring results within three years.

SEA in the context of the LVS Basin Plan

The SEA for the LVS Basin will in general conduct a detailed project life cycle analysis to identify known and/or foreseeable impacts, which can be positive or negative, and to develop mitigation and management measures to ensure sustainability of the projects identified under the Basin Plan.

The main recommendations for the LVS Basin Plan in terms of the legislated requirements for SEA are:

1. In the context of the LVS Basin Plan and its sub-plans, SEAs should be instituted as a set of core assessment activities that are integrated into all phases of the planning processes, rather than as separate procedures. This integrated assessment approach should evolve gradually and retain flexibility, initially through simple technical assessments and moving towards more sophisticated, open processes as the plans become more focused and concrete. The SEAs should be a continuous process that also addresses institutional and governance considerations at different tiers of decision-making.
2. A Programme Brief (as per Step 1 of the SEA Process described above) for the LVS Basin Plan should be prepared and submitted to NEMA, who can determine whether an SEA is required for the entire plan, or whether SEA's might be better applied to sub-plans and their resulting plans and programmes when more information is available, and when a defined stakeholder group can be determined.
3. The World Bank (2005) suggests that to better influence policies, plans or programmes, the SEA process should move towards a continuous process that also addresses institutional and governance considerations. It is recommended that the SEA activities that are immediately applied to the LVS Basin planning process include a detailed stakeholder analysis:

- There is a need to carry out a mapping and analysis of key institutions in the National and County Governments, civil and private sectors and their overlapping mandates while identifying opportunities for synergy. A detailed stakeholder analysis that is undertaken early on can offer great value to the LVS Basin planning process and can include a governance and institutional assessment to determine how these currently operate and are envisaged to change in the basin. Specifically, integrating SEA activities early on into the basin planning can offer various opportunities:
  - Improved processes of environmental administration and governance, so that the purpose and expectations of the various policies and legislation are fully attained.
  - Enhanced engagement of communities and wider stakeholders in the basin in environmental issues and governance.
  - Capacity building of all stakeholders to allow the processes of environmental administration and governance in the basin to be conducted with best practices and underlying goals as provided in the various statutes and policies.

4. Environmental problems are typically complex, uncertain, and occur at various scales affecting multiple people at different levels. In many cases, the problems are also caused by people. This therefore demands transparent decision-making and buy-in that considers the views of people interested in or affected by a given project. Stakeholder engagement is therefore increasingly embedded into environmental management.

   According to the SEA guidelines, the Kenyan government asks three relatively simple questions of a proposed plan:

   - Has there been effective co-operation between the SEA team and those responsible for developing the PPP?
   - Was there effective public involvement?
   - Was there effort to involve less powerful stakeholders in the consultation?

As detailed in the Inception and Interim Reports for the LVS Basin Plan, stakeholder consultation is deeply embedded into this process across Tasks 2 (Basin Planning) and 4 (Stakeholder Consultation). The focus of the stakeholder engagement included in these phases is to learn from the local ecological knowledge with existing catchment management practices; and to provide an enabling environment for implementation of the plans.

It is important to note that should the relevant plans go through an SEA and/or EIA process, the relevant stakeholder engagement guidelines must be followed, unless otherwise agreed upon with the NEMA. Such requirements would include making the SEA and/ or EIA reports available to the public for comment and provide opportunity to engage through public meetings. As has already been considered in Tasks 2 and 4, efforts to engage with vulnerable stakeholders must be specifically considered, considering alternative approaches where necessary.

As part of the decision-making process, the NEMA uses the submitted copies of the SEAs/ EIAs to distribute to the necessary commenting authorities. This provides another opportunity for the public to review and comment on the proposal before the NEMA provides an authorisation. During this time, it is important to consider the SEA and EIA regulations, and appoint a specific SEA expert to undertake this exercise.

C1.1.3. Environmental Impact Assessment (EIA)

Role of EIA

An EIA in the context of the Kenyan Environmental Legislation refers to a systematic examination that is conducted to determine whether a **programme, activity or project** will have any adverse impacts on the environment.

The main purpose of an EIA is to determine and evaluate the environmental implications of development and to inform decision-making at a project level. An EIA process focuses on the positive and negative environmental and social impacts of a specific development project once it has been designed, and proposes measures to mitigate the negative impacts, while maximising the positive ones (DEAT, 2004). The EIA process is seen as a tool to facilitate informed decision-making on sustainable development in Kenya.

The EIA process integrates environmental considerations into all stages of the planning and development process of a project and requires post-impact monitoring and management. Principles for good environmental assessment practice, includes (DEAT, 2002):

- Focus on the main issues.
- Involve the appropriate persons and groups.
- Link information to decisions about the project.
- Present clear options for mitigation for impacts and for sound environmental management.
- Provide information to decision-makers in a useful form.

Legislative Framework for EIA

The legislative framework for EIA in Kenya is set out below:

- ***The Environmental Management and Coordination Act, 1999 (as amended 2015) (EMCA):*** The Act provides a number of mechanisms to protect the environment one of which is environmental impact assessment. Project activities that are subject to an EIA process are set out in the Second Schedule of the EMCA. Sections 58 – 67, deal with the EIA process. All EIA’s need to be undertaken by a NEMA registered and licensed EIA/EA expert.

- ***The Environmental (Impact Assessment and Audit) Regulations, 2003:*** Recognises EIA as a means to determine whether a programme, activity or project will have an adverse impact on the environment.
    - Part I Section 4(1) prohibits anyone from implementing a project that is likely to have a negative environmental impact, or for which an EIA is required under the Act or Regulations, unless an EIA has been concluded and approved.
    - Part II Sections 7 – 10 set out the requirements and process for Project Report; and NEMA will either issue a license if satisfied that the project will not have significant environmental impact or that the report discloses sufficient mitigation measures OR will request an EIA if the project will have a significant environmental impact or that the report discloses insufficient mitigation measures.
    - Part III Sections 11 - 17 set out the requirements and process for Environmental Impact Assessment Study.
- ***Draft Environmental (Strategic Assessment, Integrated Impact Assessment and Audit) Regulations, 2018:*** Refers to Integrated EIA rather than EIA, although by definition this is deemed to be the same thing. The Regulation's requirements for an Integrated EIA differ from the previous 2003 Regulations in that the anticipated potential risks of a project or activity will dictate whether a simpler process termed a Project Report is necessary, or whether a full Integrated EIA is necessary.
    - Part I Section 4(1) prohibits anyone from implementing a project that is likely to have a negative environmental impact, or for which an EIA is required under the Act or Regulations, unless an Integrated EIA has been concluded and approved.
    - Part III sets out the requirements for a Project Report.
    - Part IV sets out the requirements for an Integrated EIA.

Process of EIA

The EIA processes described below follows those set out in the Draft Environmental Regulations (2018). Depending on the potential risk (low, medium or high) of a project activity, the proponent will either submit a Project Report or an EIA Study Report to the Authority:

- Part III 10 (1) require anyone undertaking a project listed as low or medium risk of the Second Schedule of the Act, to prepare a Project Report (low to medium risk projects and activities).
- Part IV 15(1) requires that an Integrated EIA study be undertaken for all high-risk projects tabulated in the Second Schedule of the Act (high risk projects and activities).

The following legislated steps required for a Project Report are described in Sections 10(1) to 14(4):

- **Step 1 – Project Report Preparation:**
    - Step 1.1 - Describe Project: The Project Report is to include content as required in Section 10(1)(a) to (o), which in summary includes project information, location and activities proposed, potential environmental; economic and socio-cultural impacts and possible mitigation options, accident and health and safety action plans, public participation issues, a climate change vulnerability assessment and an environmental management plan.
    - Step 1.2 – Public Consultation: Consultation with the public including at least one public meeting. The aim of the meeting would be to explain the project and it's social, economic and environmental impacts, and collate all oral or written comments on the proposed project and

attach the evidence of such public participation in the Project Report through signed attendance register, minutes and photographs.

  - Step 1.3 – Project Report Preparation: The licensed lead environmental expert/firm is to prepare a Project Report to NEMA.
  - Step 1.4 – Form 9 Application: an application for an environmental impact assessment license is to be submitted to NEMA and the appointed agent in the County.

- **Step 2 – Project Report Review:**
  - Step 2.1– Organs of State: NEMA is to dispatch copies of the Project Report to the relevant County Government, Lead Agencies and stakeholders for comment within a stipulated timeframe.

- **Step 3 – Project Report Determination:**
  - Step 3.1 – Decision: NEMA are to issue a license if the project will have no significant impact on the environment, or that the project report discloses sufficient mitigation measures. If this is a rejection then NEMA are to provide reasons for this and are to advise on suitable alternatives (in which case Step 3.2 is applicable).
  - Step 3.2 – Appeal: The proponent may appeal the decision within the stipulated timeframes.

The following legislated steps required for an Integrated EIA are described in Sections 15(1) to 31(2):

- **Step 1 – Scoping:**
  - Step 1.1 – Scoping Report: A scoping study is to be undertaken as per Section 15(3) and a Scoping Report of a content as described in Section 15(4) is to be prepared.
  - Step 1.2 - Terms of Reference: A ToR for the Integrated EIA is to be prepared.
  - Step 1.3 – Public Notification: Notification of the project intentions to the public is to be undertaken in accordance with Section 20(1).

- **Step 2 – Scoping Report Review:**
  - Step 2.1 – Submit to NEMA: The Scoping Report and ToR is to be submitted to NEMA for approval. Upon approval, Step 2.1 is applicable.
  - Step 2.1 – Appoint Team: A competent team of licensed environmental assessment experts are to be appointed to undertake the Integrated EIA.

- **Step 3 – Integrated EIA:**
  - Step 3.1 – Integrated EIA study: An Integrated EIA study is to be undertaken as per Section 19(a) to (d), and an Integrated EIA Report of a content as described in Section 21(1)(a) to (q) is to be prepared and submitted to NEMA.

- **Step 4 – Integrated EIA Review:**
  - Step 4.1 – Organs of State: NEMA is to dispatch copies of the report to the relevant Lead Agencies for comment within a stipulated timeframe.
  - Step 4.2 – General Public: NEMA are to provide notice of the availability of the report for comment and make it available for comment to the general public (as per specific public consultation steps described in Sections 24(1)(3) and (4) for a stipulated timeframe.

- Step 4.3 – Public Hearing: Upon receipt of written comment, NEMA may hold a public hearing as per Section 25 (1) to (7).

- **Step 5 – License:**

Step 5.1 – Record of Decision: NEMA are to determine a Record of Decision within the requisite timeframes, and if this is an approval then NEMA are to issue a license and include written conditions which are to be accepted by the proponent before implementing the project. If this is a rejection, then NEMA are to provide reasons for this.

C2. Catchment Management

C2.1. Legal and institutional environment

C2.1.1. National level

- At a National level natural resource use provides employment and income. Within the Lake Victoria North Basin small scale irrigation and pastoralism make up the majority of employment opportunities.
- The key ministries in Kenya responsible for enacting policies related to catchment management are the Ministry of Water and Sanitation, Ministry of Agriculture and Irrigation; and Ministry of Environment and Forestry.
- National policies and legislation feed into the local-level catchment management, where projects are implemented on the ground. It is therefore important to understand the underlying policies driving these projects as in most cases similar strategies are being implemented by different institutions.
- The National Environmental Management Agency (NEMA) is responsible for coordinating environmental management; providing guidance on the development of environmental management plans and ensure compliance of environmental laws. The Kenya Water Towers Agency (KWTA) is responsible for management of Kenya’s water towers. Kenya Forest Service (KFS) has a mandate to conserve, develop and sustainably manage Kenya’s forest resources for the country’s socio-economic development. Kenya Wildlife Service (KWS) has a mandate to conserve and manage wildlife in Kenya, and to enforce related laws and regulations. KWS is also the RAMSAR Administrative Authority.

C2.1.2. Basin and sub-basin level

- County governments’ Integrated Development Plans (IDPs) are meant to provide an overall framework for development in each county. The plans aim to coordinate the work of both levels of government in a coherent plan to improve the quality of life for all the people and contribute towards devolution. The first plans cover the period 2013 to 2017, the second plans over 2018 to 2022.
- The County governments rely on technical input and advice from the different agencies with a mandate to govern natural resources. A major issue is the mandates related to wetlands and riparian lands.

C2.1.3. National plans and policies

- The **Kenya Vision 2030 (2008)** set targets such as improved water and sanitation, increased agricultural production, a clean environment and more energy production by 2030. All of these cross-cutting targets impact catchment management.
- The **Kenya National Policy on Water Resource Management and Development (NPWRMD, 1999) p**rovides specific policy objectives including protection of water resources, supply of water while ensuring safe disposal of wastewater and environmental protection**.**
- In accordance with the Kenya Vision 2030 goal that agricultural production increase by 10% by 2019, various agriculture policies and strategies have been developed to guide this development (SEE IRR SECT ANAL). Transformation of smallholder, subsistence agriculture to modern agriculture was identified as a fundamental component, as was increased irrigation. An **Irrigation and Drainage Master Plan** was prepared in 2009 (MWI, 2009). This was followed by the **National Water Master Plan** (JICA, 2013) which evaluated irrigation potential against availability of water. Other ongoing national projects involve improving rainwater harvesting and storage for agriculture; rehabilitation and protecting water catchments; and implementing the irrigation flagship projects.
- The **National Environment Policy (NEP, 2013)** provides the goal of a better quality of life for present and future generations through sustainable management and use of natural resources. Guiding principles include an ecosystem approach to management, sustainable resource use as well as inclusion of communities in decision making.
- The **2010 Constitution in Article 69** recognises the importance of forests for sustainable development, the provides for the state to work towards increasing the country's forest cover to 10% of the land area of Kenya. The Constitution provides for two tiers of Government with the national government being responsible for policy development and regulation. The second tier of governance are 47 geographical units of devolved government, known as counties. Lake Victoria North Basin has nine counties, although some counties cross hydrological boundaries. These counties may be involved in various functions which are closely linked to catchment management.
- The **Water Act (2016)** gives the Water Resources Authority (WRA) a clear role in the regulation of water resources. However, there are some ambiguities in the Water Act that require resolution.
- The **Agriculture, Fisheries and Food Authority Act (Act No 13 of 2013)** provides for the regulation and promotion of agriculture. This is supported through the establishment of the Agriculture, Fisheries and Food Authority (AFFA) that is charged with, in consultation with County Governments, administering the **Crops Act (Act No 16 of 2013)** and the **Fisheries Act (CAP 378 of 1989)**.
- Directorates of the Agriculture, Fisheries and Food Agency (AFFA) include coffee; nuts and oil; fibre; horticultural crops; food crops; sugar; tea; pyrethrum and other industrial crops. The drive to increase agricultural development will require ongoing development in irrigation capacity. As such, a **draft Irrigation Bill** was developed in 2015 intended to repeal the Irrigation Act (CAP 347 of 2013). This amendment bill has yet to be enacted and provides for the establishment of a National Irrigation Development Service and strengthening of irrigation regulations.
- The **Environmental Management and Coordination Act (EMCA, 1999)** provided Kenya's first framework for environmental legislation. The EMCA recognises the importance of improving the legal alignment and administration across the various sectors that are engaged in the management and development of environmental resources.

- The **Forest Conservation and Management Act (2016)** mandates the Directorate of Natural Resources-Forest Conservation to formulating forest policies, initiating and overseeing drafting of relevant legislation, sector coordination and guidance, monitoring and evaluation.
- The **Wildlife Conservation and Management Act (2013)** mandates the Directorate of Natural Resources-Wildlife Conservation in formulating wildlife policies, initiating and overseeing drafting of relevant legislation, sector coordination and guidance, monitoring and evaluation.

C3. Water resources protection

C3.1. Legal and institutional environment

C3.1.1. National level

- The mandate for protecting water resources in Kenya falls on the **Water Resources Authority (WRA)** (the Authority) through Part III of the **Water Act of 2016** under the "Regulation of the Management and Use of Water Resources". A specific aspect which is addressed in the Act relates to the Authority "*prescribing criteria for classifying water resources for the purpose of determining Water Resources Quality Objectives for each Class of Water Resource*". Classifying and determining Water Resource Quality Objectives provide a series of measures to achieve protection while at the same time acknowledging the important role of water resources in supporting social and economic development. Further to the above, where the Authority considers a water resource vulnerable, special measures may be published in a Gazette to declare the catchment area a Protected Area. The Authority may then impose requirements or regulations and prohibit activities to ensure the protection of the area and water resources. The same is considered for the conservation of groundwater for public interest.
- The **National Environmental Management Authority (NEMA)** is responsible for coordination of environmental management, and the **Kenya Water Towers Agency (KWTA)** for coordination of the protection, rehabilitation, conservation, and sustainable management of Kenya's water towers, wetlands and biodiversity hotspots. Environmental Committees provide technical support for environmental management and provide input to provincial/district development plans.

C3.1.2. Basin and sub-basin level

- The 2016 Water Act outlines the designation of Basin areas, with functions of **Basin Water Resource Committees (BWRCs)** within each Basin clearly stated. Furthermore, the Act defines the establishment and functions of **Water Resource Users Associations (WRUAs)** i.e. associations of water resource users at the sub-basin level in accordance with Regulations prescribed by the Authority. These associations are community based for collaborative management of water resources and resolution of conflicts concerning the use of water resources.
- Protection of water resources in Kenya therefore starts at the National level with the WRA developing policies and legislation for protection of water resources. BWRCs then enact these measures to fulfil the water resource quality objectives for each class of water resource in a basin and need to put in place measures for sustainable management of the water resources; whilst at the sub-basin level more local level community-based management occurs through WRUAs.

C3.1.3. National plans and policies

- The **Kenya Vision 2030 (2008)** set targets such for a clean environment by 2030.

- The **Kenya National Policy on Water Resource Management and Development (NPWRMD, 1999)** provides specific policy objectives including protection of water resources.
- In the **Water Act (2016)**, the specific functions of the WRA which relate to water resources protection include:
  - formulate and enforce standards, procedures, and regulations for the management and use of water resources
  - regulate the management and use of water resources
  - receive water permit applications for water abstraction, water use and recharge and determine, issue and vary water permits; and enforce the conditions of those permits
  - In addition, the WRA has the power to:
  - collect, analyse and disseminate information on water resources
  - monitor compliance by water users with the conditions of permits and the requirements of the Act
  - issue permits for inter-basin water transfer
  - delegate regulatory functions to the Basin Water Resource Committees
- Part V of the **Environmental Management and Coordination Act (EMCA, 1999)** focuses on the protection and conservation of the environment. According to the Act, certain activities in relation to a river, lake or wetland require an environmental impact assessment. The Minister may also declare a lake shore, wetland, coastal zone or river bank to be a protected area and impose restrictions to protect them. The Minister may issue general and specific orders, regulations or standards for the management of a lake shore, wetland, coastal zone or river bank. Although it is acknowledged that environmental issues cut across different sectors, the Act emphasises the principles and provides guidance for improved environmental management.
- Other areas of relevance to water resources protection in Kenya, which are regulated by various government departments, include: protection of traditional interests of local communities customarily resident within or around a lake shore, wetland, coastal zone or river bank or forests defined as protected; protection of hill tops, hill sides, mountain areas and forests for sustainable utilisation and protection of water catchment areas; protection of forests on private land; conservation of biological resources in situ (related to buffer zones near protected areas and alien invasive species management); protection of environmentally significant areas; and protection of the coastal zone
- Consistency across the Water Act (2016) and the EMCA (1999) in relation to water resources protection is important to allow for a coordinated approach. In the Water Act (2016), as has been defined above, water resources have a wide-ranging definition ranging from surface water to groundwater resources; whilst the EMCA (1999) focuses on the surface water resources (river, lake, wetland, coastal zone) as well as the upper catchment areas. Although this is an institutional issue, it impacts the protection and management strategies for water resources.

C4. Groundwater management

C4.1. Legal and institutional environment

C4.1.1. National plans and policies

- The **Water Act (2016)** defines protection of groundwater under Section 22/23 and groundwater use is managed through Section 47 and 104.
- The **National Land Use Policy (2017)** considers surface and underground water bodies.

- Part VIII (Conservation Orders, Easements and Incentives, Wildlife Conservation Orders and Easements), S. 65 (4) of the **Wildlife Conservation and Management Act (2013)** which states, inter alia, "a wildlife conservation order or easement may be created so as to" (d), "preserve the quality and flow of water in a dam, lake, river or aquifer".
- The **Draft National Policy Groundwater Resources Development and Management (2013)** highlights a number of specific issues:
  - The availability and vulnerability of groundwater resources in Kenya are poorly understood;
  - The institutional arrangements for groundwater management in Kenya, including groundwater management capacity and financing are weak;
  - There is very limited integrated water resources management in Kenya, with groundwater and surface water typically being treated as separate water resources; and
  - There is very limited groundwater quality management in Kenya.
- Section 23 of the **Agriculture, Fisheries and Food Authority Act (2013)** relates to land preservation guidelines, on preservation of soil.
- Section 5.3 (Required Policy and Legal Reforms) of the **National Water Harvesting and Storage Management Policy (2010)**, recommended the formulation of a Policy on Ground Water Protection
- Section 5.1 of the **Draft National Policy on Trans-Boundary Waters (2009) relates to s**ustainable management and equitable utilization of trans-boundary water resources (para. 38: provision for "groundwater conservation areas" with respect to transboundary waters)
- Part XI of the **Water Resources Management Rules (2007)** relates to Protected Areas and Groundwater Conservation Areas.
- Section 25 of the **National Museums and Heritage Act (2006)** relates to the declaration of monuments.
- Section 2.1.2 of a **Sessional Paper No. 1 of 1999 on National Policy on Water Resources Management and Development indicates** "In addition, groundwater conservation zones need to be identified to avoid depletion of this resource".
- Part V of the **Environmental Management and Co-ordination Act (1999)** relates to the Protection and Conservation of the Environment, inter alia.
- **Masterplan for the Conservation and Sustainable Management of Water Catchment Areas in Kenya (MEMR, 2012)**
- **Kenya Water Towers Status Report; Saving our Future & Heritage, A Call To Action (KWTA, 2015).**

C5. Climate change adaptation

C5.1. Legal and institutional environment

C5.1.1. National level

- The Kenya Agricultural and Livestock Research organisation have a **National Strategy on Genetic Resources within the context of climate change (2016-2021)**

- The Ministry of Agriculture and Irrigation, Ministry of Transport, Infrastructure, Housing and Urban Development have a **Blue Economy Strategy (2017)**
- The National Treasury Ministry of Interior and Coordination have **Kenya's Disaster Risk Financing Strategy (2018-2022)** and **National Disaster Risk Management Policy (2017)**
- The National Drought Management Authority have a **National Drought Management Authority Act (No 4 of 2016), Ending Drought Emergencies Strategy** and **Public Finance Management (National Drought Emergency Fund) Regulations, 2018**.
- The Ministry of Energy has an **Energy Bill (2017)** – Part 3, section 43; Part 4, section 74 (i); and Part 9 address climate change-related issues.
- The Ministry of Environment and Forestry has an **Environmental Management and Coordination Act, 1999 (Cap. 387), Green Economy Strategy and Implementation Plan (GESIP 2016-2030)** and **Kenya Strategic Investment Framework on Sustainable Land Management (2017-2027).**
- The Kenya Forest Services and Ministry of Environment and Forestry have a **National Forest Programme (2017) – chapter on climate change and REDD + Readiness Plan and analysis (2013-2017)**
- The Ministry of Health has a **Health Act (No 21 of 2017)** – section on environmental health and climate change (Part VII, sections 68 and 69)
- The Ministry of Transport, Infrastructure, Housing and Urban Development has a **Kenya Building Research Centre: Strategic Plan, 2017/18-2021/22**
- The Ministry of Lands and Physical Planning has a **National Spatial Plan (2015-2045)**
- The Ministry of Transport, Infrastructure, Housing and Urban Development has an **Action Plan to reduce CO2 Emissions from Aviation (2015), Executive Order: The Nairobi Metropolitan Area Transport Authority (2017), Kenya National Aviation Action Plan for International Civil Aviation Organisation (ICAO) and Mitigation plan for International Maritime Organisation (IMO) (2017)**
- The Ministry of Water and Sanitation Water Act (No 43 of 2016) – establishes **National Water Harvesting and Storage Authority, Draft Water Harvesting and Storage Policy (2018)**
  Basin and sub-basin level

C5.1.2. Basin and Sub-basin level

- The Kenya Vision 2030 – the country's development blueprint – recognised climate change as a risk that could slow the country's development. Climate change actions were identified in the Second Medium Term Plan (MTP) (2013-2017). The Third Medium Term Plan (2018-2022) recognised climate change as a crosscutting thematic area and mainstreamed climate change actions in sector plans.

- The County Governments have a key delivery role in implementing the Climate Change Act, 2016, having jurisdiction, as set out in the Fourth Schedule (Part 2) of the Constitution, over sectors relevant for climate change such as agriculture, soil and water conservation, forestry, water and sanitation, and health. Article 203(2) of the Constitution requires that County governments be allocated a minimum of 15% of national revenue received annually, but the allocation often surpasses the minimum thus giving County governments considerable scope to influence climate change investments.

C5.1.3. National plans and policies

- **East African Climate Change Master Plan (EACCCMP, 2011-2031)** provide a long-term vision and a basis for Partner States to operationalise a comprehensive framework for adapting to and mitigating climate change, in line with the EAC Protocol on Environment and Natural Resources Management and with international climate change agreements.

- **East African Community Climate Change Policy and Strategy (2010)** was developed by the **East African Community (EAC)** Secretariat. This document guides partner countries with the preparation and implementation of collective measures to address climate change in the region.

- The **East African Community Climate Change Policy and Strategy (2010)** was developed by the **East African Community (EAC)** Secretariat. This document guides partner countries with the preparation and implementation of collective measures to address climate change in the region.
- The **African Union Agenda 2063** commits to climate change action to prioritise adaptation. It calls on member countries to implement the Programme on Climate Action in Africa, including climate resilience in agriculture.
- The **African Forest Landscape Restoration Initiative (AFR100)** aims to bring 100 million hectares of land in Africa into restoration by 2030.
- The **Constitution of Kenya** (2010) demands sustainable development and provides for the right to a clean and healthy environment through legislative and other measures.
- **National Climate Change Response Strategy (2010)** is Kenya's National Climate Change Response Strategy was the first national policy document on climate change. It aimed to advance the integration of climate change adaptation and mitigation into all government planning, budgeting and development objectives.
- Kenya's **National Climate Change Action Plan, 2013-2017** was a five-year plan that aimed to further Kenya's development goals in a low carbon climate resilient manner. The plan set out adaptation, mitigation and enabling actions.
- Kenya's **National Adaptation Plan 2015-2030** was submitted to the UNFCCC in 2017. The NAP provides a climate hazard and vulnerability assessment and sets out priority adaptation actions in the 21 planning sectors in MTP II.
- Kenya's **Nationally Determined Contribution (NDC) (2016)** under the Paris Agreement of the UNFCCC includes mitigation and adaptation contributions. In regard to adaptation, "Kenya will ensure enhanced resilience to climate change towards the attainment of Vision 2030 by mainstreaming climate change into the Medium Term Plans (MTPs) and implementing adaptation actions". The mitigation contribution "seeks to abate its GHG emissions by 30% by 2030 relative to the BAU scenario of 143 MtCO2-eq." Achievement of the NDS is subject to international support in the form of finance, investment, technology development and transfer and capacity development.
- The **Climate Change Act (No 11 of 2016)** is the first comprehensive legal framework for climate change governance for Kenya. The objective of the Act is to "Enhance climate change resilience and low carbon development for sustainable development of Kenya." The Act establishes the National Climate Change Council (Section 5), Climate Change Directorate (Section 0), and Climate Change Fund (Section 25).
- The objectives of the **Kenya Climate Smart Agriculture Strategy (KCSAS)** are to adapt to climate change and build resilience of agricultural systems while minimising greenhouse gas emissions. The actions will lead to enhanced food and nutritional security and improved livelihoods.
- The **Climate Risk Management Framework (2017)** for Kenya integrates disaster risk reduction, climate change adaptation, and sustainable development so that they are pursued as mutually supportive rather than stand-alone goals. It promotes an integrated climate risk management approach as a central part of policy and planning at National and County levels.

- The **National Climate Change Framework Policy (2018)** aims to ensure the integration of climate change considerations into planning, budgeting, implementation and decision-making at the National and County levels and across all sectors.

- The **National Climate Finance Policy (2018)** promotes the establishment of legal, institutional and reporting frameworks to access and manage climate finance. The goal of the policy is to further Kenya's national development goals through enhanced mobilisation of climate finance that contributes to low carbon climate resilient development goals.

- The Government of Kenya **Big Four Agenda (2018-2022)** establishes priorities areas for 2018 to 2022 of ensuring food security, affordable housing, increased manufacturing and affordable healthcare. Sector plans and budgets are to be aligned to the Big Four priorities.

- The **Climate Change Act, 2016 is** Key legislation guiding Kenya's climate change response, setting the legal basis for mainstreaming climate change considerations and actions into sector functions. The Act seeks to provide the "*framework for enhanced response to climate change and to provide for mechanisms and measures to achieve low carbon climate development*". The Act promotes a mainstreaming approach which includes integrating climate change in all sectors and at all levels. The Act applies to all sectors of the economy and at national and county levels. Specific objectives of the Act, that relate to water resources planning and development, include:

    - mainstream climate change responses into development planning, decision making and implementation;
    - build resilience and enhance adaptive capacity to the impacts of climate change;
    - formulate programmes and plans to enhance the resilience and adaptive capacity of human and ecological systems to the impacts of climate change
    - mainstream and reinforce climate change disaster risk reduction into strategies and actions of public and private entities;
    - mainstream the principle of sustainable development into the planning for and decision making on climate change response; and
    - integrate climate change into the exercise of power and functions of all levels of governance, and to enhance cooperative climate change governance between the national government and county governments.
- The Constitution of Kenya advances gender equality, stating in Chapter 4, the Bill of Rights that "women have the right to equal opportunities in political, economic and cultural spheres," and in order to achieve that equality, requires that government to put in place and implement affirmative actions that deliver equity for women. This commitment to gender equality and implementation of gender equity is taken up in section 7(6) of the Climate Change Act, 2016 that requires the President to ensure compliance with the two thirds gender principle when appointing members to the National Climate Change Council. Further, section 8(2)(c) of the Climate Change Act, 2016 obligates the Cabinet Secretary responsible for climate change affairs to formulate and implement a national gender and intergenerational responsive public education and awareness strategy.

C6. Flood and drought management

C6.1. Legislative and institutional environment

C6.1.1. National level

- The Constitution of Kenya (2010) requires the National Government to perform a wide range of water resource management functions. Relevant here is Section 24: Disaster management – The National Government will institute **<u>integrated flood and drought management plans</u>** to address water related disasters such as floods, droughts and landslides.

- The Water Act (No. 43 of 2016) provides a statutory foundation for flood and drought management plans. The Water Act aims "to provide for the regulation, management and development of water resources, water and sewerage services". Section 12 of the Act establishes a national Water Resources Authority (WRA) whose functions are "to formulate and enforce standards, procedures and regulations for the management and use of water resources and **flood mitigation**". The WRA must also "provide information and advice to the Cabinet Secretary for formulation of policy on national water resource management, water storage and **flood control strategies**".
- Section 32 of the Act establishes a national Water Storage Authority (WSA) whose functions and powers are "to undertake on behalf of the national government, the development of national public water works for water resources storage and **flood control**; collect and provide information for the formulation by the Cabinet Secretary of the national water resources storage and **flood control strategies**". The WSA must also "undertake on behalf of the national government **strategic water emergency interventions during drought**; and advise the Cabinet Secretary on any matter concerning national public water works for water storage and **flood control**".
- The National Drought Management Authority (NDMA) Act (No.4 of 2016) provides an important statutory foundation for drought management plans. The NDMA is an agency of the Government of Kenya under the Ministry of Planning and Devolution, mandated "to establish mechanisms **which ensure that drought does not result in emergencies** and that the impacts of climate change are sufficiently mitigated". The NDMA exercises its functions both at national level and Basin level, and in collaboration with county governments, also at county and community level. However, the NDMA's primary focus is on the 23 drought-prone counties, known as the ASAL (Arid and Semi-Arid Lands) counties.
- The National Disaster Operations Centre (NDOC) is responsible for **coordinating all disaster response operations in the country** – and was leading the country's El Niño flood response in 2015. It does this through partnering with other actors such as the police and the Kenya Red Cross. NDOC was established in 1997, following the El Niño floods, within the Ministry of Interior. Besides response, NDOC also plays a preparedness role by managing the country's disaster loss database. It has also led disaster drills for man-made disasters.
- The National Disaster Management Unit (NDMU) was established in 2013 as an effective and competent disaster management unit with an established command structure, budget and Standard Operating Procedures (SOPs) based on best practices. The NDMU, together with stakeholders, formulated the National Emergency / Disaster Plan and SOPs which were signed off in 2014. The Plan and SOPs recognizes the existence of other National and contingency plans. The National Plan and SOPs is anchored in the medium-term Phase Two of Vision 2030 in that it promotes safety, security and **protecting Kenyan assets from adverse impacts of hazards and disasters**.
- The mandates of the NDMA, NDOC and NDMU clearly overlap. The **Disaster Risk Management Bill**, currently under consideration, is aimed at bringing NDMA, NDOC and NDMU together as a new "Disaster Risk Management Authority".
- The Kenya Meteorological Department (KMD) of the Ministry of Environment and Mineral Resources issues regular short-term and seasonal rainfall forecasts for the whole country which form part of the structure of Kenya's **drought preparedness**.

C6.1.2. Basin and Sub-Basin level

- Section 27 of the Water Act specifies establishment of Basin Water Resources Committees responsible for the management of the water resources within a particular Basin area, with various powers and functions, among which is to advise the Water Resources Authority and county governments concerning **flood mitigation activities**. Each county government in a Basin has one representative on the Basin Water Resources Committee, which, in collaboration with the NDMA, must **develop drought contingency plans** for the ASAL counties and oversee their implementation as emergency response interventions. (It should be noted that at the time of writing the Basin Water Resources Committee for the Lake Victoria North Basin has not been established.)

- Section 29 of the Water Act specifies establishment of Water Resource Users Associations (WRUAs) at the sub-basin level as community-based associations for collaborative management of water resources and resolution of conflicts concerning the use of water resources. The Basin Water Resources Committees may contract WRUAs as agents **to perform certain duties** in water resource management.
- The NDMA issues regular **drought early warning bulletins** on a county basis which cover various bio-physical indicators, as well as a range of socio-economic impact indicators.

C6.1.3. National plans and policies

- The Water Resources Management Authority (WRMA) Strategic Plan for 2012 – 2017 (WRMA, 2013) specifies six strategic objectives for the WRMA covering the five financial years 2012/13 to 2016/17. Each strategic objective is served by various underlying strategies. Under strategic objective 5, "To heighten the national development agenda on water resources", two of the underlying strategies are "Develop i**ntegrated River Basin flood management plans**" and "Develop and implement programs to **strengthen communities' preparedness/adaptation** to impacts of climate change."
- Under the National Water Master Plan 2030 (known as NWMP 2030), developed as part of the above Strategic Plan, five development plans and three management plans were developed for each of six Basin areas that cover the whole of Kenya (WRMA, 2013). A **flood and drought management plan** featured among the latter three plans.
- The Ending Drought Emergencies Common Programme Framework (EDE-CPF) (NDMA, 2017) has three components: drought risk and vulnerability reduction, drought early warning and early response, and institutional capacity for drought and climate resilience and comprises six sets of interrelated action plans for ensuring **ongoing drought preparedness**. The EDE-CPF is currently being operationalised through its 3rd Medium-Term Plan 2018-2022 and is mainly focused on the ASAL counties (NDMA, 2017).

#	Category/Organization	Contact/Address	Phone	E-mail/Website
Government of Kenya				
1	Ministry of Water and Sanitation	Crispin Ouma Juma Director, Water Resources Maji House, Upper Hill		www.water.go.ke
2	Water Resources Authority	Mohammed Shurie, CEO NHIF Building, 10th floor, Upper Hill	0202732291 02729048/9	www.wra.go.ke
3	Kenya Water Towers Agency	Dr. Winnie Musila Director, Planning and Ecosystem Assessment, 15th floor, NHIF Bldg.	020 2711437	www.kwta.go.ke wmusila@yahoo.com
4	National Environmental Management Agency (NEMA)	Prof. Geoffrey Wakhungu Director General Popo Road, South C, off Mombasa Road		dgnema@nema.go.ke https://www.nema.go.ke
5	National Drought Management Authority (NDMA)	Chief Executive Officer Standard Street Lonrho House, 8th Floor Nairobi	020 2224324 0202227982	info@ndma.go.ke http://www.ndma.go.ke
6	Agriculture and Food Authority Horticulture Crops Directorate	Tea House; Naivasha Road, off Ngong Road Nairobi	0202536869 0202131560 / 0202088469	info@afa.go.ke www.afa.go.ke https://horticulture.agricultureauthority.go.ke
7	Kenya Forest Service	Kenya Forest Service Karura, off Kiambu Road Nairobi	020754904/5/6 2014663 2020285	info@kenyaforest service.org www.kenyaforestservice.org
8	Kenya Wildlife Service	Mary Kirabui KWS Headquarters Lang`ata Road, Nairobi		mkirabui@kws.go.ke
9	Kenya Electricity Generating Company PLC (KENGEN)	Engineer Willis Ochieng Stima Plaza, Phase III, Nairobi	0203666000	www.erc.go.ke pr@kengen.co.ke
GOK Regional and Sub-regional Offices				
Water Resources Authority				
1	David K.Mutai	RM/LVSCA		dkkmutai09@gmail
2	Josua O. Osio	SGWO/KSM -WRA		osiojoshua@yahoo.com
3	Edward B. Wekesa	SRM /KSM -WRA		ebwekesa66@gmail
4	Joseph Wendott	SRM Kisii		josephwendott@gmail
5	Wafula Chrispinus	SRM Kericho		wafulachrispinus@yahoo.com

Kenya Water Towers Agency				
1	Lake Region Regional Office	WRA Lake Victoria South Catchment Area Region Offices, Kisumu		kisumu@watertowers.go.ke
Kenya Forest Service				
1	Nyanza Conservancy	Nyanza Conservancy Kisumu Town	0202030569	hocnyanza@kenyaforestservice.org
Water Services Board				
1	Lake Victoria South Water Services Board	Lake Victoria South Water Works Development Agency Lavictors House, Off-Ring Road, Milimani, Kisumu	0572025128	info@lvswaterboard.go.ke https://www.lvswaterboard.go.ke
Regional Development Authority				
1	Lake Basin Development Authority	Kanyakwar, off Kakamega Rd., Kisumu	0202023414	info@lbda.co.ke www.lbda.co.ke
2	Managing Director	Raymond Omollo		romollov@yahoo.co.ke
County Government and Agencies				
Kisumu County				
1	Kisumu County Government	Prosperity House, next to Central Bank, Kisumu		Info@kisumu.go.ke https://www.kisumu.go.ke
2	CEC Water, Environment, Water, Irrigation and Natural Resources	Salmon Orimba		
3	Ag. Director Water Supply	Anne Kombya		salyanneati@yahoo.com
4	CEC, Agriculture, Livestock, Food, and Fisheries	Owuor Okuom		
5	Director Irrigation	Ernest M.Nyamori		nyamori.ernest@gmail.com
6	Director Infrastructure Development	Hesbon O. B Opuko		opukohesbon95@gmail
7	Director Environment	Ken Koyoh		koyooh2000@gmail.com
8	Director of Environment NEMA	Mr. Tom Togo NEMA County Offfice Kisumu-Kakamenga Rd. LBDA Residential Houses, Kisumu		togo_tm2@yahoo.com
9	County Environment Officer NEMA	Osiemo Ngira		herosiemo@yahoo.com
10	William Okoyo	Climate Change Officer		okoyowilliam@gmail.com
11	Kenya Forest Service	Ecosystem Conservator Kisumu Town		zmkisumu@kenyaforestservice.org
12	Kenya Marine and Fisheries Research Institute (KMFRI)	Nyanza, Kisumu		kisumucentre@kmfri.go.ke

Kericho County				
1	Kericho County Government	County Executive Building on Kericho - Nakuru Highway	030000398	info@kericho.go.ke https://www.kericho.go.ke
2	CEC, Water, Environment, Energy, Forestry and Natural Resources	Geoffrey Rutto		
3	CEC, Agriculture, Livestock and Fisheries	Philip Mason		
4	Chief Officer - Water, Environment, Energy, Forestry and Natural Resources	Eng. Willie Langat		
5	County Director of Environment, NEMA	Samuel Ondeng		sondeng@nema.go.ke
6	County Environment Officer NEMA	Clement Powon Kokaten		ckokaten@yahoo.com
Homa Bay County				
1	County Headquarters	Former Municipal Council Building		governor@homabay.go.ke www.homabay.go.ke
2	CEC, Water, Environment and Natural Resources	Dickson Nyawinda		nyakwarlanginyolunja@gmail.com
3	CEC, Agriculture and Food Security	Aguko Juma		
4	Deputy Director, Water	Livingstone Odundo		odundol@yahoo.com
5	County Director of Environment NEMA	John Maniafu		maniafujohn@gmail.com
6	County Environment Officer NEMA	Ruuben Ouma County Commissioner's Compound, Land Registry, Block A		jouma@nema.go.ke
7	Kenya Forest Service	Ecosystem Conservator Homa Bay		zmhomabay@kenyaforestservice.org
Kisii County				
1	Kisiii County Government	County Headquarters Block B-3, Kisii	05830005	info@kisii.go.ke https://www.kisii.go.ke/
2	CEC, Energy, Water, Environment and Natural Resources	Dr. Skitter W. Mbugua		---------
3	CEC, Agriculture, Livestock, Fisheries and Cooperative Development	Esman Nyandikah Onsarigo		---------
4	Zablon Ongori	Chief Officer, Water Principal Secretary		zabbwongori@gmail
5	Masiga Elvis	DD/Water Kisii		masigaelvis@gmail

6	County Director of Environment, NEMA	Leonard Ofula NEMA Office District Commissioner's Compound, Kisii		
7	County Environment Officer NEMA	Dennis Wafula		wdennis09@yahoo.com kisii@nema.go.ke
8	Kenya Forest Service	Ecosystem Conservator Kisii Town		zmkisii@kenyaforestservice.org
Migori County				
1	Migori County Government			migoricountygov@gmail.com. https://migori.go.ke
2	CEC, Water and Environment	Rebecca Maroa		rebeccagoti@gmail.com
3	County Director of Environment, NEMA	James Siaji		migori@nema.go.ke
4	County Environment Officer NEMA	Judy Susan Arieko Migori County HQs next to IFAD Hall, Migori		migori@nema.go.ke
5	Kenya Forest Service	Ecosystem Conservator Migori Town		zmmigori@kenyaforestservice.org
Nyamira County				
1	County Government	Old Nyamira South District Headquarters	058 6144288	info@nyamira.go.ke. https://www.nyamira.go.ke
2	Lawrence Mokaya	Director, Water		molawcoo@gmail.com
3	County Director of Environment, NEMA	Lekenit Patrick Purenia		lepapunema@yahoo.com
4	County Environment Officer NEMA	Richard Maina Mwangi		rmaina15@yahoo.com
5	Kenya Forest Service	Ecosystem Conservator KFS Building Behind Governor's Office Konate, Nyamira		zmnyamira@kenyaforestservice.org
Bomet County				
1	County Government	Off Narok Sotik Highway Bomet	0202084069/ 70	info@bomet.go.ke https://bomet.go.ke
2	CEC, Water Sanitation and Environment	Eng. Benson Kiplangat Sang		bksang52@gmail.com
3	Ag. Director, Water	Fredrick Ruto		fredrickwater@gmail.com
4	CEC, Agriculture, Livestock and Cooperatives	Julius K. Tuei	0202084070	
5	Director of Environment NEMA	Joseph Kopejo Next to County Social Devt. Office, Bomet		bomet@nema.go.ke
6	County Environment Officer NEMA	Naomi Odero		nodero@nema.go.ke
7	Kenya Forest Service	Ecosystem Conservator Bomet Town		zmbomet@kenyaforestservice.org
NGOs				

1	KEWASNET	Samson M. Shivaji, CEO Suite 2, Rosami Court, Muringa Road, Nairobi	0202656281	info@kewasnet.co.ke http://kewasnet.co.ke
2	WWF	Mvuli Park, Mvuli Rd., off Raphta Rd. Westlands, Nairobi		Info@wwfkenya.org
3	Kenya Red Cross	Nairobi South C Red Cross Road Off Popo Road, Nairobi	0203950000 0207030370	info@redcross.or.ke http://www.redcross.or.ke
Private Sector/WSPs				
1	Kisumu Water and Sanitation Company	Nafaka House along Oginga Odinga Street Kisumu		info@kiwasco.co.ke www.kiwasco.co.ke
2	Kericho Water and Sanitation Company	Temple Road next to Telkom House, Kericho		info@kewasco.co.ke https://www.kewasco.co.ke
3	Gusii Water and Sanitation Company	Opp. Kisii-Kilgoris Rd, Kisii	020 8029088	info@gwasco.co.ke http://www.gwasco.co.ke
4	Homa Bay Water and Sanitation Company	Along Tom Mboya University Road next to TSC, Homa Bay		info@homawasco.co.ke http://homawasco.co.ke
5	Nyanas WSC	Now under Kisumu Water and Sanitation Company		
6	Gulf WSC	" " " "		
7	Migori Water and Sanitation Company	Juliet Adhiambo Ag Managing Director Suna-Migori		jullietmn@yahoo.com info@miwasco.co.ke http://miwasco.co.ke/
8	Nyasare Water and Sanitation Company	Sirare Road Migori	0202110652 05920192	waternyasare@yahoo.com
Development Partners				
1	The World Bank	Josses Mugabi Hill Park Building Upper Hill, Nairobi	0203226000	jmugabi@worldbank.org https://www.worldbank.org/en/country/kenya
2	African Development Bank	Gabriel Negatu, Director Serge N'Guessan, Deputy Director Khushee Tower, Longonot Road, Upper Hill	020712925/ 020712926/ 0202712928	earc@afdb.org
3	JICA	Masahito Miyagawa, Representative Water & Environment Rahimtulla Tower, 10th-11th floors, Upper Hill	0202775000	Miyagawa.Masahito@jica.go.jp https://www.jica.go.jp/kenya
4	European Union	Union House Ragati Road, Nairobi	0202802000	Delegation-Kenya@eeas.europa.eu https://eeas.europa.eu/delegations/kenya

Key Strategic Area 1:	Catchment Management													
Strategic Objective:	**To ensure integrated and sustainable water, land and natural resources management practices**													
Strategy	**Activities**	**Target/Indicators (M&E)**	**CMS Strategic Action**	**Implementation horizon**	**Key role players**				**Budget (USD Million)**					**Funding source**
					National	**Basin**	**Local**	**Other**	**2020-2022**	**2022-2025**	**2025-2030**	**2030-2040**	**Total cost**	
Strategic Theme 1.1:	**Promote improved and sustainable catchment management**											Strategic theme 1.1 total:	4	
Theme priority:	**Very Important**													
1.1.1	**Promote sustainable land development and planning**													
i	MDAs and private sector to incorporate NEMA Environmental Sustainability Guidelines into relevant policies	NEMA Guidelines reflected in relevant policies		Short-term	NEMA MoWSI MoALF MoEF WRA KWS KWTA AFA	BWRC WWDA	CG WRUA	WSP CFA Private sector	-	0.7	-	-	0.7	MoEF NEMA CG
ii	Increase awareness of sustainable catchment management with relevant ministries (e.g. MWSI, MoALF, MoEF), WRUAs, CGs etc. through training, brochures, social media, internet, factsheets, forums and workshops.	Level of awareness re sustainable catchment management; Number workshops, trainings.	LA08 PA43	Immediate	WRA MoWSI MoALF MoEF NEMA	BWRC	CG WRUA	Media Development partner CFA CBO	1.4	-	-	-	1.4	MoWSI MoEF
iii	Integrate County Spatial Plan into the CIDPs including construction, restoration, rehabilitation and protection.	County Spatial Plans developed		Medium-term	MoLPP MoALF		CG WRUA		-	-	0.7	-	0.7	CG
1.1.2	**Strengthen participatory approaches**													
i	Devolve ownership of catchment management activities to WRUAs through SCMP development.	Sustainable catchment management activities incorporated in SCMPs; Number SCMPs developed	LA07	Immediate	WRA KWS KFS KWTA	BWRC	WRUA CG	CFA CBO	0.7	-	-	-	0.7	MoWSI WSTF
Strategic Theme 1.2:	**Sustainable water and land use and management practices**											Strategic theme 1.2 total:	5	
Theme priority:	**Critical**													
1.2.1	**Promote water conservation and management at catchment level**													
i	Embed catchment-based water conservation and management activities related to crop and livestock production in SCMPs: E.g. improved water use efficiency; water harvesting and storage; groundwater protection and infiltration	Improved understanding of water conservation and management; Reduction in water use; Increased water storage and water availability in the sub-catchment; Increased groundwater recharge	LA10	Immediate	WRA MoWSI KWTA MOALF	BWRC WWDA	WRUA CG	CBO	0.7	-	-	-	0.7	CG
ii	Promote catchment-based water conservation and management principles with relevant MDAs through training, forums and conferences.	Level of awareness regarding water conservation and management; Number trainings/forums/conferences held	LA10 PA43 WA16 WA17	Short-term	WRA MoWSI MoALF KWTA	BWRC WWDA	CG WRUA	CBO KALRO	-	0.7	-	-	0.7	CG
1.2.2	**Promote soil conservation and management at catchment level**													
i	Embed catchment-based soil conservation and management activities related to crop and livestock production in SCMPs: E.g rangeland management; erosion and runoff control measures; gully management and sediment trapping; stream/river bank management.	Improved understanding of soil conservation and management; Improved soil conservation within farms and rangeland; Sustainable land management; Improved soil conservation within Water Towers; Improved soil conservation within gazetted forests; Rangeland health; Reduced sedimentation	LA10	Immediate	WRA MoALF KWTA	BWRC	CG WRUA	NGO CFA CBO	1.4	-	-	-	1.4	MoWSI MoALF CG

Key Strategic Area 1:		Catchment Management													
Strategic Objective:		To ensure integrated and sustainable water, land and natural resources management practices													
Strategy		Activities	Target/Indicators (M&E)	CMS Strategic Action	Implementation horizon	Key role players				Budget (USD Million)					Funding source
						National	Basin	Local	Other	2020-2022	2022-2025	2025-2030	2030-2040	Total cost	
ii		Promote catchment-based soil conservation and management with relevant MDAs through training, forums and conferences.	Level of awareness regarding catchment-based soil conservation and management; Number trainings/forums/conferences held	LA10 PA43	Medium-term	WRA MoWSI MoALF NEMA	BWRC	CG WRUA	NGO KALRO CBO	-	-	0.7	-	0.7	MoWSI MoALF CG
1.2.3	Promote conservation agriculture and improved farm management														
i		Embed conservation agriculture and improved farm management activities related to crop and livestock production in SCMPs: E.g. climate smart agriculture; conservation agriculture; soil fertility management; natural farming; agroecological farming	Improved understanding of conservation agriculture; Number of times each farmer's land is tilled and total ha tilled; Concentration of soil carbon (g/km soil); Nutrients in soil; Active climate smart agriculture inclusive of conservation tillage, crop rotation/intercropping and soil cover; Active nutrient management; Number of farmers adopting climate smart agriculture and conservation agriculture	PA43	Immediate	WRA MoALF MoWSI MoEF NEMA	BWRC	WRUA CG	KALRO CFA CBO	0.7	-	-	-	0.7	MoWSI MoALF CG
ii		Promote conservation agriculture and improved farm management with relevant MDAs through training, forums and conferences.	Level of awareness re conservation agriculture and improved farm management; Number of training forums		Medium-term	WRA MoALF MoWSI MoEF KFS NEMA	BWRC	CG WRUA	KALRO CBO	-	-	0.7	-	0.7	MoWSI MoALF CG
Strategic Theme 1.3:		Natural resources management for the protection and sustainable use of natural resources											Strategic theme 1.3 total:	52	
Theme priority:		Critical													
1.3.1	Improved wetlands and lake management														
i		Delineate and classify lakes and wetlands at basin scale and conduct status quo assessment for significant wetlands considered as part of Resource Directed Measures	Significant lakes and wetlands - health and services assessed, delineated and classified	LA12-14	Short-term	MoEF NEMA WRA MoWSI NLC	BWRC	CG WRUA	CBO Wetlands International	-	1.4	-	-	1.4	MoEF
ii		Establish an effective and efficient institutional and legal framework for integrated management and wise use of wetlands which will enhance and maintain functions and values derived from wetlands in order to protect biological diversity and improve livelihood of Kenyans.	Clear mandates, roles and responsibilities regarding lake and wetland management		Short to medium-term	MoWSI MoEF WRA NEMA	BWRC	CG WRUA	Wetlands International	-	1.4	1.4	-	2.8	MoEF MoWSI
iii		Promote communication, education and public awareness among stakeholders regarding the importance of sustainable lake and wetland utilisation	Level of awareness regarding sustainable lake and wetland utilization; Regulatory compliance with National Wetlands Conservation and Management Policy; Number stakeholder consultation forums held	LA17	Short-term	MoEF NEMA WRA MoEd	BWRC	CG WRUA	Media NGO CBO	-	1.4	-	-	1.4	MoEF
iv		Improve scientific information and knowledge base on Kenyan wetland ecosystems through research and specific studies.	Number of research papers published; Number of studies completed; Improved knowledge base; Knowledge management system established.		Short to medium-term	MoEF NEMA WRA		WRUA	NGOs Universities	-	1.4	1.4	-	2.8	MoEF WSTF

Key Strategic Area 1:	Catchment Management													
Strategic Objective:	**To ensure integrated and sustainable water, land and natural resources management practices**													
Strategy	**Activities**	**Target/Indicators (M&E)**	**CMS Strategic Action**	**Implementation horizon**	**Key role players**				**Budget (USD Million)**					**Funding source**
					National	**Basin**	**Local**	**Other**	**2020-2022**	**2022-2025**	**2025-2030**	**2030-2040**	**Total cost**	
v	Strengthen institutional capacity on conservation and management of wetlands through training and capacity building.	Enhanced institutional capacity towards effective lake and wetland management; Number of staff trained		Medium-term	MoEF NEMA WRA MoWSI	BWRC WWDA	WRUA CG	CETRAD	-	-	1.4	-	1.4	MoEF
vii	Promote innovative planning and integrated management approaches towards wetlands conservation and management in Kenya through training, and capacity building.	Enhanced innovative planning and management for sustainable lake and wetland management; Regulatory compliance with National Wetlands Conservation and Management Policy.		Medium to long-term	MoEF NEMA WRA MoWSI	BWRC WWDA	CG WRUA	CETRAD	-	-	1.4	1.4	2.8	MoEF
viii	Promote partnership and cooperation at regional and international levels for the management of transboundary wetlands and migratory species.	Enhanced partnerships and cooperation regarding sustainable lake and wetland management and utilization; Number international treaties/agreements signed; Number joint initiatives done for wetland protection		Short to long-term	MoWSI MoEF WRA NEMA AFA MoFA MoEACRD		CG WRUA	NGO	-	0.2	0.2	0.4	0.8	MoEF
ix	Enforce wetland and lake buffers.	Wetland and lake buffers enforced	LA18-19	Short to long-term	NEMA WRA MoWSI		CG WRUA	NGO	-	1.4	1.4	2.8	5.6	MoEF
1.3.2	**Promote alternative and sustainable livelihoods**													
i	Promote alternative and sustainable livelihoods through local level initiatives.	Increase in alternative and sustainable livelihoods; Reduced encroachment and destruction of natural resources	PA26	Short to medium-term	MoALF MoEF		WRUA CG	KALRO CBO	-	2.1	2.1	-	4.2	MoALF WSTF
ii	Promote agroforestry (i.e. live fencing, medicinal trees, fodder trees, fruit trees) through local level initiatives.	Increase in Agroforestry; Increase in tree coverage; Number households supported through agroforestry		Short to long-term	KFS MoEF KWTA MoALF		WRUA CFA CG	KEFRI CBO	-	0.7	0.7	1.4	2.8	KFS MoALF
1.3.3	**Improved solid waste management**													
i	Implement improved household waste management with help of the county governments and other stakeholders.	Reduced household waste issues; Recycled waste products	LA23	Short-term	NEMA NETFUND MoEF MoH		CG	CBO NGO	-	1.4	-	-	1.4	MoEF CG
ii	Implement improved village waste management with help of the county governments and other stakeholders.	Reduced village waste issues; Reduced point source water pollution; Public Private Partnerships in waste collection	LA23	Short-term	NEMA NETFUND MoEF MoH		CG	NGO CBO Private sector	-	1.4	-	-	1.4	MoEF CG
iii	Consider developing recycling or buy-back centers as an alternative to current solid waste management.	Reduced solid waste	LA24	Medium-term	NEMA NETFUND MoEF MoH		CG	NGO CBO Private sector	-	-	1.4	-	1.4	CG
iv	Identify and map solid waste hotspots in 9 counties.	No. solid waste hotspots identified; Maps produced	LA20	Medium-term	NEMA NETFUND MoEF MoH		CG WRUA		-	-	1.4	-	1.4	CG
1.3.4	**Improved forestry management**													
i	Coordinate approach to forestry management – roles, responsibilities and mandates	Clear understanding of roles and responsibilities regarding forestry management; Reduced duplication of efforts in conservation; Increased inter-agency collaboration		Immediate	KWS KWTA KFS MoEF NEMA		CG WRUA	NGO CFA	0.7	-	-	-	0.7	MoEF CG

Key Strategic Area 1:	Catchment Management													
Strategic Objective:	**To ensure integrated and sustainable water, land and natural resources management practices**													
Strategy	**Activities**	**Target/Indicators (M&E)**	**CMS Strategic Action**	**Implementation horizon**	**Key role players**				**Budget (USD Million)**					**Funding source**
					National	**Basin**	**Local**	**Other**	**2020-2022**	**2022-2025**	**2025-2030**	**2030-2040**	**Total cost**	
ii	Promote international best practice in sustainable plantation forestry through training, and capacity building.	Forest density; Selection of beneficial trees for forest reserves; Number of people trained		Medium to long-term	KFS MoEF			CFA	-	-	0.2	0.4	0.6	MoEF
iii	Enhance protection of forest reserves through community involvement and enforcement	Protected forest density; Number of community groups involved		Short to long-term	KWS KWTA KFS MoEF		CG WRUA	CFA	-	1.4	1.4	2.8	5.6	MoEF
iv	Prevent slash and burn agriculture	Ha of forest preserved		Short-term	AFA MoEF KFS KWTA		CG	CFA	-	0.7	-	-	0.7	MoEF CG
1.3.5	**Removal of alien invasive species**													
i	Develop national program for utilising and controlling identified alien invasive species	Alien invasive control Plan		Short-term	KWS KWTA KFS MoEF NEMA			KEFRI	-	0.1	-	-	0.1	MoEF
1.3.6	**Improved fisheries management**													
i	Promote sustainable development and management of fisheries for maximum social and economic benefit.	Sustainable fishing		Short to medium-term	AFA MoALF		CG	KMFRI	-	0.7	0.7	-	1.4	AFA
1.3.7	**Improved energy management**													
i	Develop and enforce sustainable charcoal strategy.	Reduction in production and use of charcoal		Short to medium-term	MoEF NEMA KFS MoEn EPRA		CG	NGO CBO	-	0.7	0.7	-	1.4	MoEF
ii	Promote renewable energy sources.	No. renewable energy schemes implemented		Medium to long-term	MoEF NEMA MoEn EPRA REREC		CG	KenGen	-	-	2.8	5.6	8.4	CG
1.3.8	**Improved sand mine management**													
i	Collaborate with county governments in developing and implementing a sand harvesting policy.	Sand harvesting policy	LA09	Short-term	NEMA		CG		-	0.7	-	-	0.7	MoEF
ii	Enforcement of Sand Conservation and Utilisation Act	Regulated sand harvesting		Medium-term	NEMA		CG WRUA		-	-	0.4	-	0.4	MoEF
iii	Initiate study to identify alternative sources of building materials other than sand.	Alternative building materials identified and used	LA11	Short-term	NEMA WRA NCA				-	0.2	-	-	0.2	MoEF
iv	Initiate cross-boundary sand management in the basin	Coordination framework to standardize sand management and regulation developed		Medium-term	NEMA WRA		CG		-	-	0.4	-	0.4	MoEF

Key Strategic Area 1:	Catchment Management													
Strategic Objective:	**To ensure integrated and sustainable water, land and natural resources management practices**													
Strategy	**Activities**	**Target/Indicators (M&E)**	**CMS Strategic Action**	**Implementation horizon**	**Key role players**				**Budget (USD Million)**					**Funding source**
					National	**Basin**	**Local**	**Other**	**2020-2022**	**2022-2025**	**2025-2030**	**2030-2040**	**Total cost**	
Strategic Theme 1.4:	**Rehabilitation of degraded environments**										Strategic theme 1.4 total:		**24**	
Theme priority:	**Very Important**													
1.4.1	**Rehabilitation and Restoration Plan**													
i	Prepare rehabilitation and restoration program for Basin: Land, Riparian areas, Forests, Mining areas in collaboration with stakeholders.	No. rehabilitation and restoration programs developed	LA15	Short to medium-term	NEMA WRA KFS KWS KWTA MoALF	BWRC	CG WRUA	CBO CFA	-	1.4	1.4	-	2.8	MoEF
1.4.2	**Land restoration and rehabilitation of specific priority areas**													
i	Identify, review and update catchment degradation hotspot areas.	Catchment degradation hotspots identified	LA06	Short-term	WRA NEMA KFS KWTA	BWRC	CG WRUA		-	0.7	-	-	0.7	CG
ii	Collaborate with county governments in Soil and Water conservation measures (Strategy 1.2.2).	Soil and water management improvement; Number of collaborations	LA10	Short-term	WRA	BWRC	CG WRUA	NGO CBO	-	1.4	-	-	1.4	CG
1.4.3	**Site specific rehabilitation of degraded riparian areas**													
i	Identify and map urban river hotspot areas for clean-up campaigns.	Urban river hotspot areas identified and mapped	LA20	Short-term	WRA NEMA		CG WRUA		-	0.7	-	-	0.7	MoEF CG
ii	Carry out river clean-up activities in identified hotspot areas in collaboration with counties and key stakeholders.	Hotspots cleaned; Number of stakeholders engaged in clean-ups	LA21	Short-term	WRA NEMA		CG WRUA	CBO	-	1.4	-	-	1.4	MoEF CG
iii	Increase/maintain natural riparian vegetation cover.	Natural riparian vegetation cover increased/maintained	LA18	Short to long-term	WRA NEMA KFS		CG WRUA	CBO	-	1.4	1.4	2.8	5.6	CG
1.4.4	**Site specific rehabilitation of degraded wetlands.**													
i	Identify, review and update wetland degradation hotspot areas.	Wetland degradation hotspots identified and mapped		Short-term	NEMA WRA		CG	NGO CBO	-	0.7	-	-	0.7	MoEF CG
ii	Develop rehabilitation and restoration program for degraded wetlands.	Wetland rehabilitation program		Short-term	NEMA WRA NLC	BWRC	CG WRUA	NGO CBO	-	0.7	-	-	0.7	MoEF CG
iii	Increase/maintain natural wetland vegetation cover.	Natural wetland vegetation cover increased	LA18	Short to long-term	WRA NEMA KWS		CG WRUA	NGO CBO	-	0.7	0.7	1.4	2.8	MoEF CG
1.4.5	**Site specific rehabilitation of Gazetted forests or protected forests that have been degraded**													
i	Recommend identified areas for gazettement.	Gazette areas identified	LA16	Short-term	KFS WRA NEMA KWTA		CG		-	0.2	-	-	0.2	KFS
ii	Increase/maintain natural vegetation cover in protected areas	Natural vegetation cover increased/maintained; Number of indigenous species planted	LA18	Short to long-term	KWS KWTA KFS			CFA	-	0.6	0.6	1.2	2.4	MoEF KFS, KWTA

Key Strategic Area 1:		Catchment Management														
Strategic Objective:		**To ensure integrated and sustainable water, land and natural resources management practices**														
Strategy		**Activities**	**Target/Indicators (M&E)**	**CMS Strategic Action**	**Implementation horizon**	**Key role players**				**Budget (USD Million)**					**Funding source**
						National	**Basin**	**Local**	**Other**	**2020-2022**	**2022-2025**	**2025-2030**	**2030-2040**	**Total cost**	
iii	Undertake reforestation in prioritised degraded forest areas. Consider soil and water conservation techniques and beneficial/natural trees.		Ha forest cover increased; Number of indigenous trees planted		Short to medium-term	KWS KWTA KFS			CFA	-	1.4	1.4	-	2.8	MoEF KFS
1.4.6	**Mining area rehabilitation**														
i	Rehabilitate degraded sand mining areas.		Rehabilitated sand mining areas		Short-term	NEMA		CG WRUA		-	0.7	-	-	0.7	MoEF CG
ii	Rehabilitate prioritised abandoned mines and/or mining areas at active mines.		Revegetated mining areas and soil conservation techniques implemented		Short to medium-term	NEMA		CG WRUA		-	0.7	0.7	-	1.4	MoEF CG

Key Strategic Area 2:	Water Resource Protection													
Strategic Objective:	**To protect and restore the quality and quantity of water resources of the basin using structural and non-structural measures**													
Strategy	**Activities**	**Target/Indicators (M&E)**	**CMS Strategic Action**	**Implementation horizon**	**Key role players**				**Budget (USD Million)**					**Funding source**
					National	**Basin**	**Local**	**Other**	**2020-2022**	**2022-2025**	**2025-2030**	**2030-2040**	**Total cost**	
Strategic Theme 2.1:	**Classification of water resources**											Strategic Theme 2.1 total:	**0.1**	
Theme priority:	**Very critical**													
2.1.1	**Determine the baseline for Resource Directed Measures: Surface and groundwater assessments at appropriate scales to inform the classification of water resources in the basin.**													
i	Implement under Strategies: 8.1.1: Surface water resources assessment - surface water availability at relative scales 3.1.1: Groundwater assessment – assess groundwater availability in terms of quantity and quality													
2.1.2	**Determine Class of water resources**													
i	Classify all significant water resources in the Basin (conducted prior to Reserve and RQO determination)	Water resources classified; Water resources classification report	LA03-04	Immediate	WRA NEMA				0.05	-	-	-	0.05	WRA
Strategic Theme 2.2:	**Ecological Reserve**											Strategic Theme 2.2 total:	**2.5**	
Theme priority:	**Very Important**													
2.2.1	**Reserve determination**													
i	Determine the Reserve for prioritised water resources in the Basin (note Reserve required for RQOs)	Reserve determined	LA01 WA11	Immediate	WRA		CG		0.05	-	-	-	0.05	WRA
2.2.2	**Reserve compliance**													
i	Increase Reserve awareness through training, brochures, social media, internet, factsheets and SCMPs.	Level of awareness regarding Reserve; Number of trainings and awareness campaigns undertaken	WA17	Short to medium-term	WRA		WRUA		-	0.2	0.2	-	0.4	WRA WSTF
ii	Monitor and enforce Reserve compliance: Dam owners and operators, abstractors.	Environmental flows met	LA02 WA15	Medium to long-term	WRA	BWRC	WRUA		-	-	1	1	2	WRA WSTF
Strategic Theme 2.3:	**Resource Quality Objectives**											Strategic Theme 2.3 total:	**0.2**	
Theme priority:	**Critical**													
2.3.1	**Set Resource Quality Objectives**													
i	Determine the Resource Quality Objectives for prioritised water resources in the Basin	Resource Quality Objectives set	LA05 WA29	Immediate	WRA NEMA	BWRC	CG WRUA		0.2	-	-	-	0.2	WRA
Strategic Theme 2.4:	**Conservation and protection of ecological infrastructure**											Strategic Theme 2.4 total:	**2.0**	
Theme priority:	**Important**													
2.4.1	**Integrate environmental considerations into basin development and planning**													
i	Ensure compliance with Kenyan environmental legislation in planning policies, plans and programs related to basin planning and development	SSEAs successfully completed; Categorise and protect environmentally sensitive areas; Identify and define environmentally sensitive areas		Short to long-term	WRA NEMA	BWRC	WRUA		-	0.15	0.15	0.3	0.6	WRA
2.4.2	**Groundwater protection**													
i	Implement under Strategy 3.4.1 Groundwater source protection													
2.4.3	**Riparian areas protection**													
i	Protect and conserve prioritized riparian areas	Riparian areas defined and protected	WA36	Short to medium-term	NEMA WRA		WRUA		-	0.2	0.2	-	0.4	WRA

Key Strategic Area 2:		Water Resource Protection														
Strategic Objective:		To protect and restore the quality and quantity of water resources of the basin using structural and non-structural measures														
Strategy		Activities	Target/Indicators (M&E)	CMS Strategic Action	Implementation horizon	Key role players				Budget (USD Million)					Funding source
						National	Basin	Local	Other	2020-2022	2022-2025	2025-2030	2030-2040	Total cost	
2.4.4	Ecosystem services protection														
i	Protect and conserve sensitive ecosystems which provide important ecological services.		Environmentally sensitive areas protected	WA36	Short to medium-term	NEMA		WRUA		-	0.2	0.2	-	0.4	WRA
ii	Give monetary value to ecological infrastructure and ecosystem services		Payment for ecosystem services initiated		Long-term	WRA NEMA		WRUA		-	-	-	0.6	0.6	WRA WSTF

Key Strategic Area 3:	Groundwater Management													
Strategic Objective:	**The integrated and rational management and development of groundwater resources**													
Strategy	**Activities**	**Indicators (M&E)**	**CMS Strategic Action**	**Implementation horizon**	**Key role players**				**Budget (USD Million)**					**Funding source**
					National	**Basin**	**Local**	**Other**	**2020-2022**	**2022 - 2025**	**2025 - 2030**	**2030 - 2040**	**Total cost**	
Strategic Theme 3.1:	**Groundwater resources assessment, allocation, regulation**											Strategic theme 3.1 total:	**13**	
Theme priority:	**Critical**													
3.1.1	**Groundwater assessment – assess groundwater availability in terms of quantity**													
i	Implement aquifer mapping and groundwater modelling across the basin	Groundwater resources mapped	LA26	Immediate to short-term	WRA				1.75	1.75	-	-	3.5	WRA MoWSI
ii	Complete aquifer classification.	Aquifers classified		Immediate	WRA				0.05	-	-	-	0.05	WRA
iii	Improve estimates of sustainable groundwater yield in priority areas using advanced techniques	High confidence estimates of sustainable yield	WA12	Immediate to medium-term	WRA MoWSI				0.7	0.7	0.7	-	2.1	WRA MoWSI
3.1.2	**Groundwater assessment – assess groundwater quality and use**													
i	Prepare GW abstraction plan and undertake groundwater abstraction and water quality survey	Groundwater abstraction survey successfully completed		Immediate to short-term	WRA MoWSI	BWRC	CG	WRUA	1.4	1.4	-	-	2.8	WRA MoWSI
3.1.3	**Update and improve permit database**													
i	Reconcile PDB with groundwater abstraction survey results	PDB reconciled with groundwater abstraction survey results		Short-term	WRA				-	0.14	-	-	0.1	WRA
ii	Revise/adapt PDB to reflect new proposed Aquifer Classification	Revised PDB		Short to medium-term	WRA				-	0.7	0.7	-	1.4	WRA
iii	Develop system for on-line updating of drilling contractor information to improve borehole data capture via an online system	Revised PDB		Short to medium-term	WRA				-	0.45	0.45	-	0.9	WRA
3.1.4	**Groundwater allocation**													
i	Set National Resource Quality Objectives (RQOs)	Implement under Strategy 2.3.1: Set Resource Quality Objectives												
ii	Undertake groundwater balance to determine sustainable yield available	Groundwater balance	WA02	Immediate to short-term	WRA				0.05	0.05	-	-	0.1	WRA
iii	For each aquifer in the Basin, develop Allocation Plan and disaggregate to sub-basins.	LVS Basin Water Allocation Plans	WA13	Immediate to short-term	WRA	BWRC	CG	WRUA	1	1	-	-	2	WRA
Strategic Theme 3.2:	**Groundwater development**											Strategic theme 3.2 total:	**23**	
Theme priority:	**Very important**													
3.2.1	**Aquifer recharge**													
i	Conduct preliminary assessment of recharge areas from existing data. Define recharge areas for Priority Aquifers.	Groundwater recharge areas defined; Recharge water quality, quantity and mechanism determined		Short-term	WRA				-	0.7	-	-	0.7	WRA
ii	Roll out Managed Aquifer Recharge studies in the Basin	Managed Aquifer Recharge studies in the LVS Basin		Medium to long-term	WRA		CG	WSP Private sector (industry, agric., mining)	-	-	0.7	1.4	2.1	WRA

Key Strategic Area 3:	Groundwater Management													
Strategic Objective:	**The integrated and rational management and development of groundwater resources**													
Strategy	**Activities**	**Indicators (M&E)**	**CMS Strategic Action**	**Implementation horizon**	**Key role players**				**Budget (USD Million)**					**Funding source**
					National	**Basin**	**Local**	**Other**	**2020-2022**	**2022 - 2025**	**2025 - 2030**	**2030 - 2040**	**Total cost**	
3.2.2	**Local groundwater development: Reconciliation of water demands and groundwater availability and implementation of groundwater schemes**													
i	Assess allocable groundwater potential close to local demand centers and determine if groundwater resources could meet local demands.	Implement under Strategy 8.2.1: Updated planning for bulk water resources development												
ii	Implement groundwater abstraction schemes in accordance with groundwater development planning	Successful implementation of groundwater schemes in collaboration with Water Service Providers.		Short to long-term	WRA		CG	WSP	-	33	33	47	113	MoWSI
3.2.3	**Large scale groundwater development: Reconciliation of water demands and groundwater availability and implementation of groundwater schemes**													
i	Assess allocable groundwater potential close to major demand centers and determine if groundwater resources could meet demands.	Implement under Strategy 8.2.1: Updated planning for bulk water resources development												
3.2.4	**Conjunctive use: Reconciliation of water demands and groundwater availability**													
i	Implement under Strategies 3.2.2 and 3.2.3													
Strategic Theme 3.3:	**Groundwater asset management**											Strategic theme 3.3 total:	**4**	
Theme priority:	**Important**													
3.3.1	**Develop asset inventory**													
i	Develop a needs assessment for groundwater management needs	Needs assessment completed		Short-term	MoWSI WRA			WSP	-	0.1	-	-	0.1	MoWSI
Ii	Acquire necessary equipment and accessories for GW management	Equipment/accessories acquired		Short-term	MoWSI WRA			WSP	-	0.7	-	-	0.7	MoWSI
Iii	Establish Asset Inventory.	Asset inventory compiled (number of boreholes, Spatial data, Mechanical and Electrical Equipment; Civil infrastructure etc)		Short-term	MoWSI WRA			WSP	-	2.1	-	-	2.1	MoWSI
iv	Commission or develop an Asset Inventory database system.	Asset inventory database in place		Short-term	MoWSI WRA			WSP	-	0.1	-	-	0.1	MoWSI
3.3.2	**Develop asset management plan**													
i	Prepare groundwater asset management plan	Groundwater asset management plan		Short to medium-term	WRA			WSP	-	0.4	0.4	-	0.8	MoWSI
Strategic Theme 3.4:	**Conservation and protection of groundwater**											Strategic theme 3.4 total:	**6**	
Theme priority:	**Important**													
3.4.1	**Groundwater source protection**													
i	Assess LVS Basin GW Vulnerability	Groundwater vulnerability assessed	LA25	Short-term	WRA				-	0.1	-	-	0.1	WRA
iii	Assess which LVS Basin aquifers or parts of aquifers require formal protection.	Groundwater conservation areas (GCAs) identified		Short-term	WRA				-	0.1	-	-	0.1	WRA

Key Strategic Area 3:		Groundwater Management														
Strategic Objective:		**The integrated and rational management and development of groundwater resources**														
Strategy		**Activities**	**Indicators (M&E)**	**CMS Strategic Action**	**Implementation horizon**	**Key role players**				**Budget (USD Million)**						**Funding source**
						National	**Basin**	**Local**	**Other**	**2020-2022**	**2022 - 2025**	**2025 - 2030**	**2030 - 2040**	**Total cost**		
iv	Assess which LVS Basin aquifers contain important GDEs		Groundwater dependent ecosystems (GDEs) identified		Short-term	WRA				-	0.1	-	-	0.1		WRA
v	Develop a LVS Basin GW Protection Plan		LVS Basin GW Protection Plan	LY08	Short-term	WRA MoWSI NEMA MoICNG		CG WRUA	WSP Private sector (industry, agric., mining)	-	0.2	-	-	0.2		WRA
vi	Implement groundwater protection measures		Number of protected aquifers		Short to long-term	WRA				-	1	1	2	4		WRA
3.4.2	**Rehabilitate polluted aquifers, springs and wells**															
i	Define LVS Basin's polluted aquifers.		LVS Basin polluted aquifers identified	LA27	Short-term	WRA				-	0.2	-	-	0.2		WRA
ii	For each polluted aquifer, determine the optimum and most cost-effective way to rehabilitate it.		Rehabilitation plans for polluted aquifers	LA28	Short to medium-term	WRA				-	0.2	0.2	-	0.4		WRA
iii	Prioritise aquifers for rehabilitation and implement rehabilitation programmes.		Implementation of prioritised rehabilitation plans	LA28	Medium to long-term	WRA		WRUA		-	-	0.2	0.4	0.6		WRA

Key Strategic Area 4:	Water Quality Management													
Strategic Objective:	**Efficient and effective management of water quality to ensure that water user requirements are protected in order to promote sustainable socio-economic development in the basin**													
Strategy	**Activities**	**Target/Indicators (M&E)**	**CMS Strategic Action**	**Implementation horizon**	**Key role players**				**Budget (USD Million)**					**Funding source**
					National	**Basin**	**Local**	**Other**	**2020 - 2022**	**2020 - 2022**	**2025 - 2030**	**2030 - 2040**	**Total cost**	
Strategic Theme 4.1:	**Effective water quality data collection, information generation and dissemination, and knowledge management**									Strategic theme 4.1 total:			**8**	
Theme priority:	**Critical**													
4.1.1	**Implement routine surface and groundwater quality monitoring**													
i	Implement national water quality monitoring programme in the LVS Basin by ensuring technical staff are capacitated and laboratories can analyse the samples accurately and on time.	Number of samples collected and analysed	WA38	Immediate	WRA	WWDA			1	-	-	-	1	WRA
ii	Ensure data submitted to Mike Info WQ database, and that the data is reviewed, analysed, reported on, and acted on by catchment staff.	Number Water quality reports produced		Immediate	WRA				0.2	-	-	-	0.2	WRA
4.1.2	**Biological Water Quality Monitoring**													
i	Develop capacity to undertake biomonitoring in Kenya to assess aquatic ecosystem health.	Number of scientists capacitated to undertake biomonitoring; pilot sites identified and monitoring implemented; results integrated with WQ monitoring results	WA33-35	Immediate	WRA NEMA		WRUA	Universities KEWI	0.4	-	-	-	0.4	WRA
ii	Identify streams in the LVS Basin for piloting biomonitoring and undertake pilot studies.	Number biomonitoring sites; Number reports on pilot studies	WA33-35	Immediate	WRA NEMA			Universities KEWI	0.3	-	-	-	0.3	WRA
iii	Integrate the biomonitoring results with the water quality monitoring network to assess the overall fitness for use and ecosystem health of water resources.	State of the rivers report; Number of biomonitoring indices set	WA33-35	Short to long-term	WRA NEMA				-	0.1	0.1	0.1	0.3	WRA
4.1.3	**Undertake survey of pollution sources**													
i	Compile an inventory of surface water pollution sources.	Surface water pollution inventory	WA20-21	Immediate	WRA NEMA		WRUA		0.3	-	-	-	0.3	WRA NEMA
ii	Reconcile identified pollution sources against discharge licenses at NEMA and permits at WRA.	Reconciliation report	WA22	Short-term	WRA NEMA				-	0.05	-	-	0.05	WRA NEMA
iii	Undertake waste load assessment to assess cumulative impact of pollution sources concentrated in a specific river reach or sub-catchment	Number waste load assessments completed		Short to medium-term	WRA NEMA				-	0.2	0.2	-	0.4	WRA NEMA
iv	Effluent compliance monitoring should be undertaken at regular intervals	Number operational monitoring points and frequency of monitoring; Monitoring programme in place	WA23	Short to long-term	WRA NEMA WASREB			WSP	-	0.75	0.75	1.5	3	WRA NEMA
4.1.4	**Upgrade water quality testing laboratories**													
i	Upgrade central and regional laboratories in the LVS Basin to support the national water quality monitoring programme. These include, inter alia, the recruitment of more technical staff, equipping the laboratory and stocking it with reagents, procuring Field Testing Kits, operationalising the LIMS in the central and regional laboratories and participating in proficiency tests to acquire the	Laboratory upgrade plan completed, Upgrade plan implemented, LIMS operational, Q&A implemented, data sent to Mike Info; Number adequately equipped laboratories; Number ISO accreditations; Number trained staff	WA37	Immediate for central laboratory, short-term for regional laboratories	WRA NEMA		CG	CWTL	0.5	0.5	-	-	1	WRA MoWSI

Key Strategic Area 4:	Water Quality Management													
Strategic Objective:	**Efficient and effective management of water quality to ensure that water user requirements are protected in order to promote sustainable socio-economic development in the basin**													
Strategy	**Activities**	**Target/Indicators (M&E)**	**CMS Strategic Action**	**Implementation horizon**	**Key role players**				**Budget (USD Million)**					**Funding source**
					National	**Basin**	**Local**	**Other**	**2020 - 2022**	**2020 - 2022**	**2025 - 2030**	**2030 - 2040**	**Total cost**	
	necessary accreditation and ISO certification to enhance data credibility.													
4.1.5	**Institutionalise water quality data storage and management**													
i	All historical and new water quality data collected by WRA in the LVS Basin stored in Mike Info.	Historical data captured & quality controlled; Data from laboratories captured on time & quality controlled		Immediate	WRA NEMA				0.15	-	-	-	0.15	WRA
4.1.6	**Design and implement routine water quality status reporting**													
i	Routine water quality status reports should be designed and implemented to report on the water quality status in the LVS Basin, identify key water quality concerns, their causes and consequences, and recommend management actions to mitigate negative impacts.	WQ Status Reports produced		Short to long-term	WRA NEMA				-	0.15	0.15	0.3	0.6	WRA
Strategic Theme 4.2:	**Promote sound water quality management governance in the LVS Basin**											Strategic theme 4.2 total:	**2**	
Theme priority:	**Very Important**													
4.2.1	**Harmonise policies and strategies towards improved water quality management**													
i	Advocate for alignment of strategies to serve a common purpose of rehabilitating urban rivers and streams in the LVS Basin.	Policies and strategies reviewed for discrepancies; Policies and strategies aligned		Immediate to short-term	WRA NEMA MoALF MoWSI MoEF				0.5	0.5	-	-	1	WRA NEMA
4.2.2	**Coordination and cooperation mechanism on water quality issues established at a catchment level**													
i	Establish a coordination and cooperation mechanism to ensure there is alignment of actions to address water pollution management in the LVS Basin.	Inter-agency coordination body established and operational	WA39 WA43	Immediate	WRA NEMA	BWRC	CG WRUA	NGO CBO	0.1	-	-	-	0.1	WRA NEMA
ii	Embed water quality management activities related to domestic water use, crop and livestock production in SCMPs	Improved understanding of pollution sources in sub-catchments; Active water quality management; Number SCMPs developed with embedded water quality management activities		Immediate	WRA	BWRC	WRUA CG		0.3	-	-	-	0.3	WRA
iii	Promote water quality management with relevant MDAs through training, forums and conferences.	Level of awareness re water quality management; Number of participants at forums/conferences; Number of people trained on water quality management		Short-term	WRA	BWRC			-	0.05	-	-	0.05	WRA NEMA
Strategic Theme 4.3:	**Efficient and effective management of point and nonpoint sources of water pollution**											Strategic theme 4.3 total:	**185**	
Theme priority:	**Important**													

Key Strategic Area 4:		Water Quality Management													
Strategic Objective:		**Efficient and effective management of water quality to ensure that water user requirements are protected in order to promote sustainable socio-economic development in the basin**													
Strategy		**Activities**	**Target/Indicators (M&E)**	**CMS Strategic Action**	**Implementation horizon**	**Key role players**				**Budget (USD Million)**					**Funding source**
						National	**Basin**	**Local**	**Other**	**2020 - 2022**	**2020 - 2022**	**2025 - 2030**	**2030 - 2040**	**Total cost**	
4.3.1	**Improve sewerage systems and treatment**														
	i	Prepare rehabilitation plan for existing sewerage systems in urban areas incl. sewer pipes, pump stations, wastewater treatment works etc.	Number rehablitation plans		Short-term			CG	WSC	-	1.4	-	-	1.4	MoWSI
	ii	Implement rehabilitation plan for sewerage system incl. rehabilitation of existing wastewater treatment	Number successful completion of rehab works; Number of treatment works operating efficiently		Medium to long-term			CG	WSC	-	-	21	21	42	MoWSI
	iii	Prepare wastewater master plan for major urban centres: assess current capacity of wastewater treatment works, required and projected capacity, maintenance needs and budgets and capex budgets for expansion.	Number wastewater master plans completed		Short-term	MoWSI		CG	WSC	-	0.5	-	-	0.5	MoWSI
	iv	Construct new sewerage systems in urban areas and connect to existing / new WWTWs. Increase wastewater treatment capacity in urban areas by expanding existing / constructing new wastewater treatment plants.	Number new sewerage systems completed (area); Number existing WWTWs expanded; Number new WWTWs; Increased percentage in waste water treatment coverage		Medium to long-term			CG	WSC	-	-	28	56	84	MoWSI
	v	Promote wastewater treatment at source, especially at industrial sites, housing estates, hospitals, etc. With the objective of improving the quality of effluent discharges before it enters the environment or sewerage network.	Number of onsite WWT facilities; Current vs historical effluent quality; Number of Effluent Discharge Control Plans (ECDPs) in place		Short to long-term	NEMA WRA		CG	Industries Households NGO	-	1.4	1.4	2.8	5.6	MoWSI
4.3.2	**Cleaner production methods**														
	i	Support initiatives by the Kenya National Cleaner Production Center (KNCPC) to promote excellence in Resource Efficient and Cleaner Production in industries in the LVS Basin in order to reduce water usage and effluents, as well as their impacts on water quality in receiving water bodies.	Water consumption vs international norms; Effluent quality vs international norms; Current vs historical river water quality; Number initiatives on cleaner production increased		Short to medium-term	NEMA WRA KNCPC			Industries	-	0.5	0.5	-	1	MoWSI
4.3.3	**Urban stormwater, sanitation, and solid waste management, and protection of upper reaches of rivers**														
	i	Control sediment pollution from construction sites and unpaved urban roads in urban areas by adopting best urban stormwater management practices such as erecting sediment traps or screens, sediment detention ponds, etc.	Number urban stormwater BMPs implemented.		Short to medium-term	NEMA WRA KURA		CG	NGO	-	2.1	2.1	-	4.2	CG
	ii	Compel County Governments to maintain sewerage infrastructure and fix leaks or blockages as a matter of urgency to minimise sewage leaks into stormwater drains.	Number maintenance projects completed; Number of sewage blockages repaired; Tonnage of solid waste removed	WA39 WA43	Short-term	WRA NECC	WWDA	CG	WSP	-	1.75	-	-	1.75	WRA

Key Strategic Area 4:	Water Quality Management													
Strategic Objective:	**Efficient and effective management of water quality to ensure that water user requirements are protected in order to promote sustainable socio-economic development in the basin**													
Strategy	**Activities**	**Target/Indicators (M&E)**	**CMS Strategic Action**	**Implementation horizon**	**Key role players**				**Budget (USD Million)**					**Funding source**
					National	**Basin**	**Local**	**Other**	**2020 - 2022**	**2020 - 2022**	**2025 - 2030**	**2030 - 2040**	**Total cost**	
iii	Promote solid waste removal in urban centres and disposal at solid waste disposal sites that meet best national or international design standards.	Improved solid waste collection, transportation, treatment and disposal		Short-term	WRA NEMA		CG		-	1.75	-	-	1.75	CG
iv	Refurbish existing solid waste dumps to intercept and treat poor quality drainage water and prevent it from running into water courses.	Number drainage systems constructed to intercept the leachate		Medium to long-term	WRA NEMA		CG		-	-	1.75	3.5	5.25	CG
4.3.4	**Sanitation management in informal settlements**													
i	Protect receiving streams from pollution, especially urban rivers, by installing sewers or septic tanks to contain domestic wastes, managing urban solid wastes, and monitoring receiving streams for BOD and COD.	Number of sewers or septic tanks installed; Number of solid waste handling sites constructed; Number of water samples collected and analysed for BOD and COD; Reduction in number of non-designated dump sites		Short to medium-term	WRA NEMA NLC MoH			NGOs involved in urban upliftment	-	2.1	2.1	-	4.2	CG MoWSI
ii	Control of organic pollution from unplanned and un-sewered settlements/slums in all the major urban centres through installing sewers or septic tanks and promoting solid waste collection and removal from these settlements.	Length of sewers installed; No septic tanks installed; Tonnage of solid waste removed; Number solid waste service providers registered and active		Short to medium-term	WRA	WWDA	CG		-	7	7	-	14	CG MoWSI
iii	Support international aid / private sector projects that are designed to upgrade informal settlements and slums.	Number aid projects supported; Number of households supported		Medium to long-term	WRA MoTIHUDPW		CG	NGO	-	-	1.4	1.4	2.8	CG MoWSI
4.3.5	**Management of hydrocarbon pollution**													
i	Control of oil and grease pollution, spillage and leakages from petrol stations, trucks, pipelines and oil storage facilities by ensuring that all are equipped with functional oil and grease traps, and by monitoring nearby surface and groundwater for hydrocarbons.	Number of oil & grease traps installed; Number water samples collected and analysed for hydrocarbons; Reduced level of hydrocarbons in surface water and ground water		Short to long-term	NEMA WRA MoPM MoTIHUDPW		CG Local Government	Petrol stations Workshops	-	0.7	0.7	1.4	2.8	NEMA WRA
ii	Control dumping of used motor oil at informal workshops by promoting recycling of used oil, and monitoring stormwater drains for hydrocarbon pollution.	Volume of used oil recycled; Streams complying with Oil & Grease standards; Number informal workshops recycling used oil and using recycled oil		Short-term	WRA EPRA		CG		-	0.7	-	-	0.7	NEMA CG
iii	Protect groundwater against hydrocarbon contamination near petrol stations and dump sites by drilling observation wells at high risk areas and monitoring boreholes for hydrocarbons	Groundwater complying with Oil & Grease standards; Number observation wells drilled		Short-term	WRA EPRA		CG		-	0.5	-	-	0.5	WRA
4.3.6	**Sedimentation from unpaved roads**													
i	Control sediment pollution from unpaved roads by erecting sediment traps or vegetated buffer strips next to dirt and paved roads. Maintain stormwater drainage to prevent erosion next to roads and rehabilitate erosion gullies near roads.	Number of sediment traps installed; Number of buffer strips established; Reduction in sediment loads in samples analysed; Length of erosion gullies rehabilitated		Medium to long-term	MoTIHUDPW WRA KURA KeRRA		CG		-	-	1.4	2.8	4.2	CG

Key Strategic Area 4:	Water Quality Management													
Strategic Objective:	**Efficient and effective management of water quality to ensure that water user requirements are protected in order to promote sustainable socio-economic development in the basin**													
Strategy	**Activities**	**Target/Indicators (M&E)**	**CMS Strategic Action**	**Implementation horizon**	**Key role players**				**Budget (USD Million)**					**Funding source**
					National	**Basin**	**Local**	**Other**	**2020 - 2022**	**2020 - 2022**	**2025 - 2030**	**2030 - 2040**	**Total cost**	
4.3.7	**Management of agricultural impacts on sediments, nutrients, and agrochemicals**													
i	Control nutrients pollution from agricultural activities (N & P) in all farmed areas within the Basin by compiling & maintaining inventories of fertilizer use, and monitoring nutrients in receiving water bodies (rivers, reservoirs and lakes).	Inventory of fertilizer use established and maintained; Monitoring implemented; Number samples collected and analysed for nutrient content		Short to medium-term	WRA MoALF NEMA NIB		CG	Large commercial farmers	-	0.3	0.3	-	0.6	WRA
ii	Control agrochemical (pesticides and herbicides) residue pollution from farmlands by compiling an inventory of pesticide usage in the basin, and monitoring affected water bodies for residues. Promote efficient use of agrochemicals in the agricultural sector.	Inventory of pesticide use established and maintained; Monitoring implemented; Number of samples collected and analysed for agrochemical components		Short to medium-term	WRA MoALF NEMA NIB PCPB		CG	Large commercial farmers	-	0.35	0.35	-	0.7	CG
iii	Promote best irrigation management practices and encourage irrigators to retain, treat and recycle irrigation return flows before discharging it to the environment.	Compliance with nutrient objectives in rivers and lakes; Number of farmers practicing best irrigation management practices		Medium to long-term	WRA MoALF NEMA NIB		CG	Large commercial farmers	-	-	1.4	2.8	4.2	MoALF CG
iv	Training and awareness creation on nutrient pollution, agrochemical residue pollution, best irrigation management practices and good land management practices.	Number of training forums held; Number of farmer participants		Short-term	WRA MoALF NIB KALRO		CG WRUA	CBO Local farmers	-	1.4	-	-	1.4	MoALF CG
4.3.8	**Enforcement of effluent standards**													
i	Use the results of compliance monitoring of effluent discharge license or permit conditions to prosecute offenders that consistently violate their license/permit conditions and demonstrate no intention of meeting them.	Number of polluters prosecuted		Medium to long-term	NEMA WRA		CG	WWTW operators	-	-	0.5	1	1.5	WRA NEMA
4.3.9	**Control discharges from sand mining operations.**													
i	Implement under Strategy 1.3.8: Improved sand mine management													
4.3.10	**Rehabilitation of polluted aquifers, springs and wells**													
i	Implement under Strategy 3.4.2: Rehabilitate polluted aquifers, springs and wells													

Key Strategic Area 5:	Climate Change Mitigation, Adaptation and Preparedness													
Strategic Objective:	**To implement climate change mitigation measures in the water resources sector and to ensure water resource development and management are adapted and resilient to the effects of climate change**													
Strategy	**Activities**	**Target/Indicators (M&E)**	**CMS Strategic Area**	**Implementation horizon**	**Key role players**				**Budget (USD Million)**					**Funding source**
					National	**Basin**	**Local**	**Other**	**2020-2022**	**2020 - 2025**	**2025-2030**	**2030 - 2040**	**Total cost**	
Strategic Theme 5.1:	**Improved understanding of impacts of climate change on water resources planning and management at appropriate spatial scales**									Strategic theme 5.1 total:			**1**	
Theme priority:	**Critical**													
5.1.1	**Quantify climate change impacts (rainfall & temperature) on surface water and groundwater resources and demands in the LVS Basin at appropriate scales for planning and management**													
i	Use climate change databases, historical data and analytical tools (ISC and other) to identify trends and quantify climate change impacts on surface water and groundwater availability at relevant temporal and spatial scales: rainfall intensity; frequency of extreme rainfall events; rainfall seasonality; inter-and intra-annual rainfall variability; rainfall-runoff relationships; stream flow; groundwater recharge; irrigation demands	Quantification of climate trends and change impacts on surface water and groundwater availability at sub-basin scale	PA01 PA02 PA03 PA04 PA05 PA06	Immediate to short-term	WRA KMD				0.1	0.1	-	-	0.2	WRA
5.1.2	**Assess relevance, and scale of potential social, environmental and economic climate change impacts as defined in NCCAP in LVS Basin and its relation to water resources planning and management; prioritise areas for interventions**													
i	Assess potential social impacts: flooding; droughts; human conflict; migration; vulnerable groups; ocean acidification; agriculture; food production	Prioritised list of social impacts related to climate change in basin; Map of hotspots/high risk areas		Immediate to medium-term	NDMA NDOC CETRAD				0.1	0.1	0.2	-	0.4	WRA
ii	Assess potential environmental impacts: droughts; sea temperature; rising sea levels; ocean acidification; desertification; lad degradation; loss of biodiversity; deforestation; forest degradation	Prioritised list of environmental impacts related to climate change in basin		Immediate to medium-term	MoEF NEMA KFS CETRAD				0.1	0.1	0.2	-	0.4	WRA
iii	Assess potential economic impacts: irrigation water requirements; crop type and yield; GDP; public Infrastructure; hydropower; coastal assets; livelihoods and income generation.	Prioritised list of economic impacts related to climate change in basin; Economic valuation of impacts in the basin		Immediate to medium-term	MoEF MoALF	CETRAD			0.1	0.1	0.2	-	0.4	WRA
Strategic Theme 5.2:	**Climate change mitigation**									Strategic theme 5.2 total:			**10**	
Theme priority:	**Very important**													
5.2.1	**Promote the generation and use of clean energy**													
i	Make use of efficient energy technologies and techniques at household level (e.g. energy efficient lightbulbs, Solar cooker, Solar electrification, Solar borehole pump, Wind pump, Micro hydropower, Biogas digester, Energy efficient stoves and ovens, Heat retention cooker)	Ratio of energy efficient to non-efficient technology used in households; Number of energy saving technologies adopted; Number of households trained on the use of energy saving techniques		Medium to long-term	MoEn KPLCO			Private sector Households	-	-	2.3	4.7	7	MoEn CG
ii	Improve policies regarding renewable energy	The extent to which policies address renewable energy		Short-term	MoEn				-	0.1	-	-	0.1	MoEn
iii	Increase generation of clean energy	kWh of clean energy generated		Medium to long-term	MoEn KENGEN				-	-	1	2	3	MoEn

Key Strategic Area 5:	Climate Change Mitigation, Adaptation and Preparedness													
Strategic Objective:	**To implement climate change mitigation measures in the water resources sector and to ensure water resource development and management are adapted and resilient to the effects of climate change**													
Strategy	**Activities**	**Target/Indicators (M&E)**	**CMS Strategic Area**	**Implementation horizon**	**Key role players**				**Budget (USD Million)**					**Funding source**
					National	**Basin**	**Local**	**Other**	**2020-2022**	**2020 - 2025**	**2025-2030**	**2030 - 2040**	**Total cost**	
Strategic Theme 5.3:	**Climate change adaptation**											Strategic theme 5.3 total:	**20**	
Theme priority:	**Very important**													
5.3.1	**Promote climate resilient infrastructure**													
i	Incorporate flexible adaptation infrastructure principles in infrastructure planning and investment plans	Flexible approaches in which infrastructure is proactively designed/phased to accommodate climate uncertainty.		Immediate to short-term	MoLPP MoTIHUDPW		Local town planning CG		3.5	3.5	-	-	7	MoEF
ii	Promote improved capacity of stormwater systems and gutters	% of urban stormwater caught in stormwater systems; Number of dwellings with gutters		Short to medium-term	MoTIHUDPW NWHSA		Property owners Local town planning CG		-	3.5	3.5	-	7	MoEF CG
iii	Promote thermally resilient road and rail infrastructure using heat resistant materials	Number of infrastructure projects using heat resistant materials		Medium to long-term	MoTIHUDPW KENHA KURA		Property owners Local engineers and construction companies		-	-	0.2	0.5	0.7	MoEF
5.3.2	**Climate-related disaster risk management**													
i	Floods	Implement under Strategic Theme 6.1: Flood management												
ii	Droughts	Implement under Strategic Theme 6.2: Drought management												
iii	Increase food security through enhanced resilience of the agricultural sector	Increased food security		Short to medium-term	MoALF NDMA	Disaster management committees	CG	NGO	-	1	1	-	2	MoALF
iv	Reduce the incidence of malaria and other diseases expected to increase due to climate change	Reduced incidence of diseases		Short to medium-term	MoH		CG		-	1	1	-	2	MoH
5.3.3	**Promote agroforestry**													
i	Promote alternative and sustainable livelihoods	Implement under Strategy 1.3.2												
5.3.4	**Mainstream climate change adaptation in water resources strategy, planning and management at basin and catchment level**													
i	Implementation and enforcement of climate change regulatory frameworks in the water sector	Number of regulatory frameworks being implemented and enforced; Level of compliance		Short to medium-term	WRA MoWSI		CG WRUA		-	0.6	0.6	-	1.2	WRA
ii	Create awareness amongst communities of the upstream and downstream impacts of climate change throughout the basin	Level of awareness regarding climate change and adaptation measures at basin level	PA07 PA08 PA09	Short-term	WRA KMD		Local councilors CG WRUA		-	0.3	-	-	0.3	WRA
iii	Increase water storage	Implement under Strategic Theme 8.3: Water storage and conveyance												
5.3.5	**Enhance resilience of agricultural sector through climate smart agriculture**													
i	Promote conservation agriculture and improved farm management	Implement under Strategy 1.2.3												

Key Strategic Area 6:	Flood and Drought Management													
Strategic Objective:	**Establish and guide a structured programme of actions aimed at ensuring prevention, mitigation, timeous response and recovery from harmful impacts of floods & droughts**													
Strategy	**Activities**	**Target/Indicators (M&E)**	**CMS Strategic Theme**	**Implementation horizon**	**Key role players**				**Budget (USD Million)**					**Funding source**
					National	**Basin**	**Local**	**Other**	**2020-2022**	**2020-2025**	**2025-2030**	**2030-2040**	**Total cost**	
Strategic Theme 6.1:	**Flood management**											Strategic theme 6.1 total:	**12**	
Theme priority:	**Critical**													
6.1.1	**Undertake flood risk mapping**													
i	Conduct high-level assessments of the flood exposure of each village and town, as well as related transport, access and escape routes and river crossings in Siaya, Kisumu, Homa Bay, Migori and Kerichu counties, with a focus on the Lower Nyando, Lower Gucha Migori, Awach Kano, Lower Nyaidho, Nyamasaria, Luando, Ombeyi, Miriu and Oroba, Kuja and Sondu Rivers. Both the characteristics of past floods and flooding and the existing flood protection structures and drainage systems will be noted, and the risk of flooding will be determined by reviewing historical information about the frequency of high water levels and long-duration inundations.	Record of successful assessments.	WA45 WA46	Short-term	WRA	LVS Basin FRF; WRA RO	CG		-	0.9	-	-	0.9	MoWSI WRA
iii	Systematise the above information in a Flood Risk Register for the LVS Basin.	Flood Risk Register	WA47	Medium-term	WRA	LVS Basin FRF	CG		-	-	0.1	-	0.1	MoWSI
6.1.2	**Formalise institutional roles and partnership collaborations**													
i	Government institutions/agencies and other stakeholders with partnership roles in flood management will form the *LVS Basin Flood Response Forum (FRF)* under the auspices of the KMD to integrate all flood-relevant resource mobilisations and related interventions in the LVS Basin.	Establishment of the LVS Basin FRF; Number of stakeholder consultations held		Immediate	KMD; NDMU; NDOC	WRA RO; BWRC; MoH RO; MoTIHUDPW RO	Flood-prone county DRM Committee; WRUA; Village DRMC; CG	International Relief Aid agencies; Kenya Red Cross Society; NGO	0.2	-	-	-	0.2	KMD
ii	Establish a Secretariat for the *LVS Basin FRF* with accommodation in the WRA Regional Office.	Establishment of Secretariat; Records of meetings		Immediate	KMD; NDMU; NDOC	WRA RO	WRUA		1	-	-	-	0.5	KMD WRA
iii	Develop appropriate SOPs (standard operating procedures) for the *LVS Basin FRF.*	Agreement on SOPs		Immediate to short-term	WRA; KMD; NDMU; NDOC				0.02	0.03	-	-	0.05	KMD WRA
6.1.3	**Develop flood response protocol**													
i	Develop a flood response protocol through a multi-stakeholder approach with the following components: Formalised institutional roles and partnership collaborations; flood preparedness plans for flood-prone zones; key principle: better to protect more people from the frequent smaller floods, than fewer people from the rarer larger floods; flood early warning systems used to alert communities about larger floods; standard operating procedures (SOPs) that comprise sequential flood response actions.	Agreement on flood response protocol.	WA47	Short-term	KMD; NDMU; NDOC	LVS Basin FRF	WRUA		-	0.1	-	-	0.1	KMD WRA

Key Strategic Area 6:		Flood and Drought Management													
Strategic Objective:		Establish and guide a structured programme of actions aimed at ensuring prevention, mitigation, timeous response and recovery from harmful impacts of floods & droughts													
Strategy		Activities	Target/Indicators (M&E)	CMS Strategic Theme	Implementation horizon	Key role players				Budget (USD Million)					Funding source
						National	Basin	Local	Other	2020-2022	2020-2025	2025-2030	2030-2040	Total cost	
6.1.4	**Develop Integrated Flood Management Plans (IFMPs)**														
i		Update the existing IFMPs for the Nyando, Awach Kano and Gucha Migori River Catchments.	IFMP completed.	WA51	Short-term	WRA	LVS Basin FRF	CG		-	0.2	-	-	0.2	WRA
ii		Develop an IFMP for the Mara River catchment.	IFMP completed.	WA51	Short-term	WRA	LVS Basin FRF	CG		-	0.1	-	-	0.1	WRA
iii		Develop an IFMP for the Sondu River catchment.	IFMP completed.	WA51	Short to medium-term	WRA	LVS Basin FRF	CG		-	0.05	0.05	-	0.1	WRA
iv		Develop an IFMP for the Northern Shoreline River catchments.	IFMP completed.	WA51	Medium-term	WRA	LVS Basin FRF	CG		-	-	0.1	-	0.1	WRA
v		Develop an IFMP for the Southern Shoreline River catchments.	IFMP completed.	WA51	Medium-term	WRA	LVS Basin FRF	CG		-	-	0.1	-	0.1	WRA
6.1.5	**Implement flood management measures**														
i		The *LVS Basin FRF* will prioritise the Implementation Schedules of each of the above IFMPs. These non-structural and structural flood management/ counter measures will encompass the following: prevention measures; protection measures; preparedness measures; flood early warning systems; emergency response measures. These measures will be focused on flood-prone river reaches and flood-plains in each of the above flood-prone catchments in the LVS Basin. Wherever feasible, community-based flood early warning and flood preparedness approaches will be followed. Flash-flood-/mudslide-prone zones will receive a special focus.	All items on the Flood Risk Register completed; Implementation reports		Medium to long-term	WRA	LVS Basin FRF; WRA RO; BWRC; MoH RO; MoTIHUDPW RO	Flood-prone county DRM Committees; WRUA; Village DRMC	International Relief Aid agencies; NGO	-	-	1.5	3	4.5	WRA
ii		The *LVS Basin FRF* will provide a platform for coordinating the resourcing and supervision of the funding of the above re-prioritised non-structural and structural flood management/ counter measures. In all instances, labour-intensive approaches will be followed.	All items on the Flood Risk Register completed; Number of proposals submitted		Medium to long-term	WRA	LVS Basin FRF; WRA RO; BWRC; MoH RO; MoTIHUDPW RO	Flood-prone county DRM Committees; WRUA; Village DRMC	International Relief Aid agencies; NGO	-	-	1	2	3	WRA
6.1.6	**Capacity development**														
i		*Organisational alignment/ collaboration:* The *LVS Basin Flood Response Forum (FRF)* will expand organisational capacity in the LVS Basin by aligning the flood response roles and responsibilities of the government institutions/agencies, International Relief Aid Agencies, Kenya Red Cross, NGOs and other stakeholders with partnership roles in flood management.	Well-functioning LVS Basin FRF; Partnership & Collaboration working agreement	WA52	Immediate	KMD; NDMU; NDOC	LVS Basin FRF; WRA RO; BWRC; MoH RO; MoTIHUDPW RO			0.1	-	-	-	0.1	KMD

Key Strategic Area 6:	Flood and Drought Management													
Strategic Objective:	**Establish and guide a structured programme of actions aimed at ensuring prevention, mitigation, timeous response and recovery from harmful impacts of floods & droughts**													
Strategy	**Activities**	**Target/Indicators (M&E)**	**CMS Strategic Theme**	**Implementation horizon**	**Key role players**				**Budget (USD Million)**					**Funding source**
					National	**Basin**	**Local**	**Other**	**2020-2022**	**2020-2025**	**2025-2030**	**2030-2040**	**Total cost**	
ii	*Institutional technical skills:* Strategically expand institutional technical skills relevant to flood response activities across three different sets of competencies: (i) competence at translating Flood Early Warning Bulletin information to support prioritisation of resource mobilisations for humanitarian interventions; (ii) competence at logistical planning of required interventions followed by subsequent operationalisation; (iii) competence at communicating technical and logistical information in multi-stakeholder environments.	Increased effectiveness of the LVS Basin FRF participants at translating Flood Early Warning Bulletin information, logistical planning and communicating technical and logistical information.	WA54 WA56	Short-term	KMD; NDMU; NDOC; WRA	LVS Basin FRF; WRA RO; BWRC; MoH RO; MoTIHUDPW RO	Flood-prone county DRM Committees; WRUA; Village DRMC	Media	-	0.3	-	-	0.3	KMD
iii	*Community preparedness*: Community-based flood early warning drills as well as emergency evacuation drills will be prioritised by the Secretariat of the *LVS Basin FRF*, with the support of the NDMU/NDOC.	Communities successfully trained; Number of warning drills held	WA44	Short to long-term	KMD; NDMU; NDOC	LVS Basin FRF	Flood-prone county DRM Committees; WRUA; Village DRMC		-	0.3	0.3	0.6	1.2	KMD
Strategic Theme 6.2:	**Drought management**										Strategic theme 6.2 total:		**31**	
Theme priority:	**Very Important**													
6.2.1	**Formalise institutional roles and partnership collaborations**													
i	Establish a Secretariat for the *LVS Basin DRF* with accommodation in the Offices of one of the drought-prone counties.	Establishment of Secretariat		Immediate	NDMA; NDMU; NDOC				3.5	-	-	-	3.5	NDMA
ii	Develop appropriate SOPs for existing *LVS Basin Drought Response strategies*.	Agreement on SOPs		Short-term	NDMA; NDMU; NDOC; WRA		WRUA		-	3.5	-	-	3.5	NDMA
iii	Update existing stakeholder maps with respect to drought within the LVS basin.	Stakeholder maps generated; Number of key players identified		Short to medium-term	WRA		WRUA		-	0.07	0.07	-	0.14	WRA
6.2.2	**Develop drought response protocol**													
i	Develop a drought response protocol through a multi-stakeholder approach with the following components: Formalised institutional roles and partnership collaborations; drought preparedness plans for drought-prone zones; standard operating procedures (SOPs) that comprise sequential drought response actions; equitable allocation of water despite systematic restrictions of supply.	Agreement on drought response protocol.		Short-term	NDMA; NDMU; NDOC; MoDASAL	LVS Basin Drought Response			-	7	-	-	7	NDMA
6.2.3	**Improve drought preparedness**													
i	The *LVS Basin Drought Response strategy* must address five primary drought response needs, i.e. drought monitoring, drought early warning, drought severity assessment, mitigation interventions and recovery interventions.	Agreement on LVS Basin Drought Response mandate.		Short-term	NDMA; NDMU; NDOC; KMD	LVS Basin Drought Response	WRUA		-	3.5	-	-	3.5	NDMA

Key Strategic Area 6:	Flood and Drought Management													
Strategic Objective:	Establish and guide a structured programme of actions aimed at ensuring prevention, mitigation, timeous response and recovery from harmful impacts of floods & droughts													
Strategy	Activities	Target/Indicators (M&E)	CMS Strategic Theme	Implementation horizon	Key role players				Budget (USD Million)					Funding source
					National	Basin	Local	Other	2020-2022	2020-2025	2025-2030	2030-2040	Total cost	
ii	Drought monitoring, drought early warning and severity assessment will continue to be conducted by the NDMA, who issues regular Drought Early Warning Bulletins for ASAL counties.	Continuity of Drought Early Warning Bulletins		Short-term	NDMA; KMD; MoDASAL	LVS Basin Drought Response			-	3.5	-	-	3.5	NDMA
iii	Drought severity assessments by the national and county-level coordinating structures of the NDMA relevant to the LVS Basin must be reviewed and deliberated by the collaboration partnership participants in the *LVS Basin Drought Response strategy*. In the case of an adverse severity assessment, the *LVS Basin Drought Response* participants will have a common point of reference from which to systematically coordinate their various drought-relevant resource mobilisations and related interventions in the LVS Basin.	Successful collaboration by LVS Basin Drought Response participants in drought severity assessments and resulting mobilisations and interventions.		Short-term	NDMA	LVS Basin Drought Response	Drought-prone county DRM Committees; WRUA; Village DRMC	International Relief Aid agencies; Kenya Red Cross Society; NGO	-	1.4	-	-	1.4	NDMA
6.2.4	**Strengthen existing drought early warning systems**													
i	The NDMA issues regular Drought Early Warning Bulletins for ASAL counties. The LVS Basin does not have any ASAL counties, but sub-county Bulletins will be arranged for drought-vulnerable areas in the Kericho county.	Number of additional drought-prone LVS counties issuing Drought Early Warning Bulletins		Immediate	NDMA	LVS Basin Drought Response	CG		0.05	-	-	-	0.05	NDMA
ii	SOP responses based on the Bulletins' early warning findings and alerts will be an integrating force in the LVS Basin Drought Response. The sub-county scale of the Bulletins' reporting ensures that such responses can be spatially accurately focused. SOP responses will secure appropriate and timeous resource mobilisations and humanitarian interventions across all the collaborating partnerships at county, sub-county and local community scales for drought-vulnerable areas the Kericho county.	Successful implementation of SOPs on sub-county and local community scales.		Short-term	NDMA	LVS Basin Drought Response	Drought-prone county DRM Committees; WRA SRO; WRUA; Village DRMC	International Relief Aid agencies; Kenya Red Cross Society; NGO	-	1	-	-	1	NDMA, CG
iii	The monthly reports and maps detailing current and projected food insecurity in a number of regions in the world by the Famine Early Warning Systems Network (FEWS NET) will support the deliberations by the participants in the *LVS Basin Drought Response Strategy*.	Continuity in the use of FEWS NET monthly reports and maps.		Short-term	NDMA; Kenya Food Security Steering Group	LVS Basin Drought Response	WRUA		-	0.35	-	-	0.35	NDMA
6.2.5	**Capacity development**													
i	*Funding:* Secure a standing allocation from the recently-established National Drought Emergency Fund (DEF) to the *LVS* Basin's ASAL counties to ensure that finance for early drought response will always be available when needed.	Success at attaining an allocation from the National DEF.		Short-term	NDMA	LVS Basin Drought Response; National Treasury		International Relief Aid agencies	-	3.5	-	-	3.5	NDMA

Key Strategic Area 6:		Flood and Drought Management													
Strategic Objective:		Establish and guide a structured programme of actions aimed at ensuring prevention, mitigation, timeous response and recovery from harmful impacts of floods & droughts													
Strategy		Activities	Target/Indicators (M&E)	CMS Strategic Theme	Implementation horizon	Key role players				Budget (USD Million)					Funding source
						National	Basin	Local	Other	2020-2022	2020-2025	2025-2030	2030-2040	Total cost	
	ii	*Organisational alignment/ collaboration: LVS Basin Drought Response Strategy* will expand organisational capacity in the *LVS* Basin by aligning the drought response roles and responsibilities of the government institutions/ agencies, International Relief Aid Agencies, Kenya Red Cross, NGOs and other stakeholders with partnership roles in drought management.	Well-functioning LVS Basin Drought Response.		Immediate	NDMA	LVS Basin Drought Response; WRA RO; BWRC; MoALF RO; MoWSI RO; MoH RO	Drought-prone county DRM Committees; WRA SRO; WRUA; Village DRMC	International Relief Aid agencies; Kenya Red Cross Society; NGO	1.75	-	-	-	1.75	NDMA
	iii	*Institutional technical skills:* Strategically expand institutional technical skills relevant to drought response activities across three different sets of competencies: (i) Translating Drought Early Warning Bulletin information to support prioritisation of resource mobilisations for humanitarian interventions; (ii) Logistical planning of required interventions followed by subsequent operationalisation; (iii) Communicating technical and logistical information in multi-stakeholder environments.	Increased effectiveness of LVS Basin Drought Response, participants at prioritising resource mobilisations, logistical planning and communicating technical and logistical information.	WA54 WA56	Short-term	NDMA	LVS Basin Drought Response; WRA RO; BWRC; MoALF RO; MoWSI RO; MoH RO	Drought-prone county DRM Committees; WRA SRO; WRUA; Village DRMC	International Relief Aid agencies; Kenya Red Cross Society; NGO	-	1.75	-	-	1.75	NDMA

Key Strategic Area 7:		Hydrometeorological Monitoring														
Strategic Objective:		An operational and well-maintained hydromet network supported by effective and functional data management and information management systems.														
Strategy		Activities	Target/Indicators (M&E)	CMS Strategic Action	Implementation horizon	Key role players				Budget (USD Million)					Funding source
						National	Basin	Local	Other	2020-2022	2022-2025	2025-2030	2030-2040	Total cost	
Strategic Theme 7.1:		Improved monitoring network											Strategic Theme 7.1 total:	29	
Theme priority:		Critical													
7.1.1	Surface water monitoring: River flow														
i	Upgrade existing river flow gauging network based on recommendations in Monitoring Network Design Report (Interim Report 2 Volume 7A)		Number of operational stream flow gauges; Number of data sets recorded	MA04	Short-term	WRA KMD		WRUA		-	2.6	-	-	2.6	WRA
7.1.2	Monitoring: Dams and lakes														
i	Survey bathymetry; install level gauge, upgrade existing dam and lake gauging network (based on recommendations in Monitoring Network Design Report), settlement beacons on the crest, flow measuring gauge (V-notch) at any seepage collection points along the toe of the dam for dams for water level monitoring		Number of operational dam & lake instruments and gauges; Number of bathymetric surveys completed	LA07	Short to medium-term	WRA				-	0.5	0.5	-	1	WRA
7.1.3	Groundwater monitoring														
i	Design groundwater monitoring programme, to include defining Priority Aquifers and incorporating spring monitoring where relevant		Groundwater monitoring programme developed		Short to medium-term	WRA			WSP	-	4	4	-	8	WRA
ii	Acquire necessary tools for groundwater monitoring (rigs, loggers, telemetry etc.)		Plant/accessories acquired		Short to long-term	WRA			WSP	-	1	1	2	4	WRA
iii	Implement groundwater monitoring programme		Number of operational groundwater monitoring stations		Medium to long-term	WRA			WSP	-	-	1	2	3	WRA
7.1.4	Water quality monitoring: Surface water and groundwater														
i	Upgrade existing water quality monitoring network based on recommendations in Monitoring Network Design Report (Interim Report 2 Volume 7A)		Number of operational water quality monitoring stations		Short to medium-term	WRA				-	1	1	-	2	WRA
7.1.5	Meteorological monitoring														
i	Upgrade existing WRA rainfall station network based on recommendations in Monitoring Network Design Report (Interim Report 2 Volume 7A)		Number of operational WRA rainfall stations, Number of complete datasets		Short-term	WRA KMD				-	1	-	-	1	WRA
7.1.6	Flood early warning monitoring network														
i	Implement lower Awach Kano and Nyando Flood Early Warning System based on recommendations in Monitoring Network Design Report (Interim Report 2 Volume 7A)		Operational FEWS monitoring network		Short-term	WRA KMD				-	1	-	-	1	WRA
ii	Implement lower Gucha Migori Flood Early Warning System based on recommendations in Monitoring Network Design Report (Interim Report 2 Volume 7A)		Operational FEWS monitoring network		Short-term	WRA KMD				-	0.5	0.5	-	1	

Key Strategic Area 7:	Hydrometeorological Monitoring													
Strategic Objective:	**An operational and well-maintained hydromet network supported by effective and functional data management and information management systems.**													
Strategy	**Activities**	**Target/Indicators (M&E)**	**CMS Strategic Action**	**Implementation horizon**	**Key role players**				**Budget (USD Million)**					**Funding source**
					National	**Basin**	**Local**	**Other**	**2020-2022**	**2022-2025**	**2025-2030**	**2030-2040**	**Total cost**	
iii	Implement lower Sondu Flood Early Warning System based on recommendations in Monitoring Network Design Report (Interim Report 2 Volume 7A)	Operational FEWS monitoring network		Medium-term	WRA KMD				-	-	1	-	1	
7.1.7	**Metering of water use and abstractions**													
i	Develop implementation programme and implement metering of water use and abstractions (surface and groundwater)	No. operational water use and abstraction meters		Short to long-term	WRA WASREB		WWDA	WSP Private sector	-	1	1	2	4	WRA
Strategic Theme 7.2:	**Improved data and information management**											Strategic Theme 7.2 total:	**2**	
Theme priority:	**Critical**													
7.2.1	**Enhanced data management**													
i	Use MIKE Info database developed under ISC for capturing, storing and managing all hydromet data. Data protocols and procedures with regard to data collection, transfer, capture, storage, quality control and dissemination should be evaluated, standardised and improved where necessary in accordance with international best practice. Technical and computing capacity for processing, analysis and reporting of data should be addressed and enhanced.	Readily available, up-to-date and quality controlled hydromet data	MA09	Immediate to short-term	WRA				0.5	0.5	-	-	1	WRA
7.2.2	**Improved water resources information management systems**													
i	Use Knowledge base tools developed under ISC for dissemination of information products related to water resources management.	Knowledge products disseminated	MA12	Immediate to short-term	WRA				0.25	0.25	-	-	0.5	WRA
7.2.3	**Improved forecasting systems**													
i	Use real-time system developed under ISC for accessing, visualizing and analysing hydromet observations in near real-time to inform decision making with regard to flood forecasting and water resources management. Refer to Interim Report 1 Volume 7: Real-time System Report.	Operational forecasting system	MA11	Immediate to short-term	WRA				0.25	0.25	-	-	0.5	WRA

Strategy	Activities	Target/Indicators (M&E)	CMS Strategic Action	Implementation horizon	Key role players				Budget (USD Million)					Funding source
					National	Basin	Local	Other	2020-2022	2022-2025	2025-2030	2030-2040	Total cost	
Key Strategic Area 8:	**Water Resources Development and Management**													
Strategic Objective:	**To develop water resources as a key driver for sustainable economic and social development**													
Strategic Theme 8.1:	**Water Resource assessment, allocation and regulation**										Strategic theme 8.1 total:		**10**	
Theme priority:	**Critical**													
8.1.1	**Surface water resources assessment – surface water availability at relevant scales**													
i	Refine existing water resources models to improve estimates of surface water availability at relevant spatial scales for planning, management and allocation	Surface water resources availability and quantity mapped	WA02	Short-term	WRA				-	0.5	-	-	0.5	WRA
8.1.2	**Groundwater resources assessment – groundwater availability**													
i	Implement under Strategy 3.1.1: Groundwater assessment – assess groundwater availability in terms of quantity													
8.1.3	**Assess water use and fitness for use**													
i	Undertake surface water abstraction survey	Number of abstraction surveys completed	WA05	Short to medium-term	WRA			WRUA	-	3	3	-	6	WRA
ii	Undertake groundwater abstraction survey	Implement under Strategy 3.1.2: Groundwater assessment – assess groundwater quality and use												
8.1.4	**Update and improve permit database**													
i	Reconcile PDB with surface water and groundwater abstraction survey results	Updated PDB	WA14	Short to medium-term	WRA				-	0.75	0.75	-	1.5	WRA
8.1.5	**Water allocation**													
i	Set Resource Quality Objectives (RQOs) for surface water and groundwater in the LVS Basin	Implement under Strategy 2.3.1: Set Resource Quality Objectives												
ii	Conduct surface water balance at relevant spatial scale; Determine allocation status	Water balances; Allocation status report	WA07	Short-term	WRA				-	0.3	-	-	0.3	WRA
iii	Conduct groundwater balance at relevant spatial scale; Determine allocation status	Implement under Strategy 3.1.4: Groundwater allocation												
iv	Develop surface water allocation plans at sub-basin level	Water Allocation Plans		Short-term	WRA				-	1.5	-	-	1.5	WRA
v	Develop groundwater allocation plans at sub-basin level	Implement under Strategy 3.1.4: Groundwater allocation												
Strategic Theme 8.2:	**Water resources planning**										Strategic theme 8.2 total:		**4**	
Theme priority:	**Critical**													
8.2.1	**Updated planning for bulk water resources development**													
i	Undertake Kisumu Master Planning: Optimise large-scale, integrated bulk water supply system: Sources, Transfers, Dams, Treatment Works, Bulk distribution network, Conjunctive use	Up to date integrated master plan indicating detailed timelines, phasing and budgets	WA74	Short-term	WRA MoWSI NWHSA	WWDA	CG	WSC WSP	-	0.4	-	-	0.4	WSC MoWSI
ii	Prefeasibility/Feasibility of regional water supply schemes to meet major towns, rural domestic and/or small-scale irrigation demands: Sources, Transfers, Dams, Treatment, Bulk distribution network, Conjunctive use	Up to date master plan for rural water supply in LVS Basin indicating detailed timelines, phasing and budgets	WA74	Short-term	WRA MoWSI NWHSA	WWDA	CG		-	4	-	-	4	WWDA MoWSI

Key Strategic Area 8:	Water Resources Development and Management													
Strategic Objective:	**To develop water resources as a key driver for sustainable economic and social development**													
Strategy	**Activities**	**Target/Indicators (M&E)**	**CMS Strategic Action**	**Implementation horizon**	**Key role players**				**Budget (USD Million)**					**Funding source**
					National	**Basin**	**Local**	**Other**	**2020-2022**	**2022-2025**	**2025-2030**	**2030-2040**	**Total cost**	
Strategic Theme 8.3:	**Water storage and conveyance**											Strategic theme 8.3 total:	**3151**	
Theme priority:	**Very important**													
8.3.1	**Implement large dams: complete relevant feasibility and impact studies and plans; design and construct**													
i	Amala (175 MCM)	Dam construction completed and successful commissioning	WA74	Cost included under Rift Valley Basin Plan										
ii	Sand River / Naikara (1 MCM)			Long-term	NWHSA MoWSI	WWDA	CG		-	-	-	14	14	MoWSI
iii	Magwagwa (445 MCM)			Immediate to short-term	NWHSA MoWSI	WWDA	CG		107	710	-	-	817	MoWSI
iv	Itare (20 MCM)			Cost included under Rift Valley Basin Plan										
v	Londiani (25 MCM)			Short-term	NWHSA MoWSI	WWDA	CG		-	102	-	-	102	MoWSI
vi	Nyando / Soin-Koru (87 MCM)			Long-term	NWHSA MoWSI	WWDA	CG		-	-	-	290	290	MoWSI
vii	Kibos (26 MCM)			Immediate to short-term	NWHSA MoWSI	WWDA	CG		20	132	-	-	152	MoWSI
viii	Bunyunyu (6 MCM)			Short-term	NWHSA MoWSI	WWDA	CG		-	54	-	-	54	MoWSI
ix	Gogo Falls (348 MCM)			Medium-term	NWHSA MoWSI	WWDA	CG		-	-	541	-	541	MoWSI
x	Nandi Forest (220 MCM)			Long-term	NWHSA MoWSI	WWDA	CG		-	-	-	299	299	MoWSI
xi	Ilooiterre (14 MCM)			Medium-term	NWHSA MoWSI	WWDA	CG		-	-	63	-	63	MoWSI
8.3.2	**Maintenance of existing dams**													
i	Dredging of existing dams	Number of dams dredged		Long-term	NWHSA MoWSI	WWDA	CG		-	-	-	1	-	MoWSI
8.3.3	**Construct new water transfers**													
i	Itare Dam (LVS) to Rift Valley Basin	Volume of water transferred	WA74	Costed under Rift Valley Basin Plan										
ii	Amala Dam (LVS) to Rift Valley Basin													
i	Londiani Dam (LVS) to Sub-basin 1JC			Short-term	MoWSI	WWDA	CG		-	46	-	-	46	MoWSI
ii	Nandi Forest Dam (LVN) to LVS			Long-term	MoWSI	WWDA	CG		-	-	-	345	345	MoWSI
8.3.4	**Infrastructure development - small dams and pans**													
i	Develop programme for implementation of small dams & pans. Undertake relevant studies. Identify locations and types of dams to improve assurance of supply to local urban, domestic, small scale irrigation and livestock water users	Dam construction programme and investment plan – town and rural supply; Relevant feasibility studies and reports	WA74	Immediate to short-term	NWHSA MoWSI	WWDA	CG WRUA		1	1	-	-	2	MoWSI

Strategy	Activities	Target/Indicators (M&E)	CMS Strategic Action	Implementation horizon	Key role players				Budget (USD Million)					Funding source
Key Strategic Area 8:	**Water Resources Development and Management**													
Strategic Objective:	**To develop water resources as a key driver for sustainable economic and social development**													
					National	**Basin**	**Local**	**Other**	**2020-2022**	**2022-2025**	**2025-2030**	**2030-2040**	**Total cost**	
ii	Phased design and construction of identified small dams / pans: 154 MCM total storage	Number new dams constructed in accordance with international best practice	WA74	Immediate to long-term	NWHSA MoWSI	WWDA	CG WURA		53	118	118	118	407	MoWSI
8.3.5	**Provide other types of storage**													
i	Sand dams	Number of sand dams	WA74	Short to long-term	NWHSA MoWSI	WWDA	CG		-	4	4	4	12	MoWSI
ii	Artificial recharge	Successful implementation and operation of AR schemes	WA74	Short to long-term	NWHSA MoWSI	WWDA	CG		-	2	2	2	6	MoWSI
Strategic Theme 8.4:	**Groundwater development**													
Theme priority:	**Important**													
8.4.1	**Develop groundwater resources**													
i	Implement under Strategic Theme 3.2: Groundwater development													
Strategic Theme 8.5:	**Hydropower development**											Strategic theme 8.5 total:	**2**	
Theme priority:	**Important**													
8.5.1	**Large scale hydropower development**													
i	Magwagwa Multipurpose Dam Project (115 MW)	Large scale hydropower generation and integration with grid	WA74	Cost included under dam cost										
ii	Gogo Falls Multipurpose Dam Project (15 MW)			Cost included under dam cost										
iii	Amala Dam Multipurpose Dam Project Tunnel (144 MW in RV Basin)			Cost included under Rift Valley Basin										
8.5.2	**Small scale hydropower development**													
i	Assess potential for the development of small-scale hydropower plants, especially in the upper LVS Basin.	Small-scale hydropower generation and supply	WA74	Immediate to short-term	KENGEN MoEn				1	1	-	-	2	KENGEN, MoEn
Strategic Theme 8.6:	**Water for agriculture**											Strategic theme 8.6 total:	**993**	
Theme priority:	**Critical**													
8.6.1	**Large scale irrigation development: Develop new / expand existing irrigation schemes. Limit to max sustainable areas**													
i	Nyando (3 000 ha)	Irrigation area		Long-term	WRA MoWSI MoALF NIB	WWDA	CG		-	-	-	68	68	MoWSI
ii	Nandi Forest (7 300 ha)	Irrigation area		Long-term	WRA MoWSI MoALF NIB	WWDA	CG		-	-	-	166	166	MoWSI
iii	Lower Kuja (10 000 ha)	Irrigation area		Medium to long-term	WRA MoWSI MoALF NIB	WWDA	CG		-	-	162	66	228	MoWSI
iv	Ilooiterre (3 000 ha)	Irrigation area		Long-term	WRA MoWSI MoALF NIB	WWDA	CG		-	-	-	68	68	MoWSI

Key Strategic Area 8:		Water Resources Development and Management													
Strategic Objective:		**To develop water resources as a key driver for sustainable economic and social development**													
Strategy		**Activities**	**Target/Indicators (M&E)**	**CMS Strategic Action**	**Implementation horizon**	**Key role players**				**Budget (USD Million)**					**Funding source**
						National	**Basin**	**Local**	**Other**	**2020-2022**	**2022-2025**	**2025-2030**	**2030-2040**	**Total cost**	
v	Ahero / West Kano (4 150 ha)		Irrigation area		Long-term	WRA MoWSI MoALF NIB	WWDA	CG		-	-	-	94	94	MoWSI
vi	Kano Plain (15 000 ha)		Irrigation area		Immediate to short-term	WRA MoWSI MoALF NIB	WWDA	CG		22	318	-	-	340	MoWSI
vii	Nyabomite (1 000 ha)		Irrigation area		Long-term	WRA MoWSI MoALF NIB	WWDA	CG		-	-	-	21	21	MoWSI
8.6.2	**Promote water conservation in irrigation**														
i	Increase water use efficiency through the rehabilitation or improvement of irrigation technologies and techniques, and through the use of smart metering		Water efficiency in irrigation		Short to long-term	WRA MoWSI MoALF NIB	WWDA	CG		-	1	1	1	3	MoWSI
8.6.3	**Compile infrastructure development program for small scale irrigation. Develop new / expand existing irrigation schemes**														
i	Develop new small-scale irrigation schemes		Number of new small-scale irrigation schemes		Short to long-term	WRA MoALF NIB MoWSI	BWRC	CG WRUA		-	0.6	0.6	0.8	2	MoALF
ii	Provide farmers with appropriate technologies to abstract water from rivers and shallow boreholes: Treadle pumps, small motorised pumps, construct small weirs		Number of small-scale farmers using technology. Food security.		Short-term	WRA MoALF NIB MoWSI		CG WRUA		-	0.8	-	-	0.8	MoALF
iii	Refurbish existing small-scale irrigation schemes		Number of refurbished small-scale irrigation schemes		Short to long-term	WRA MoALF NIB MoWSI		CG WRUA		-	0.4	0.4	0.8	1.6	MoALF
8.6.4	**Aquaculture development**														
i	Promote aquaculture opportunities in basin - linked to new dams and improved flow regulation		Increased awareness of aquaculture		Short to medium-term	MoALF KMFRI	WWDA	CG		-	0.2	0.2	-	0.4	MoALF
ii	Develop aquaculture manual		Aqua culture manual		Medium-term	MoALF KMFRI	WWDA	CG		-	-	0.05	-	0.05	MoALF
iii	Rehabilitate aquaculture ponds and construct new ponds		Aquaculture development		Medium to long-term	MoALF KMFRI	WWDA	CG		-	-	0.1	0.1	0.2	MoALF
8.6.5	**Improved water supply reliability at local scale through construction of small dams / pans and/or development of local groundwater resources to provide carry-over storage during the dry season**														
i	Implement Under Strategies 8.3.2 and Strategy 3.2.2														
Strategic Theme 8.7:		Water based tourism and recreation											Strategic theme 8.7 total:	0.2	
Theme priority:		**Important**													
8.7.1	**Promote water-based tourism and recreation**														
i	Promote adventure tourism, leisure activities, recreational activities and resorts linked to large dams, especially at dams situated close to major cities.		Increase in water-based tourism		Short to long-term	KTF MoTW		CG	Tour operators	-	0.05	0.05	0.07	0.17	Private

Key Strategic Area 8:	Water Resources Development and Management													
Strategic Objective:	**To develop water resources as a key driver for sustainable economic and social development**													
Strategy	**Activities**	**Target/Indicators (M&E)**	**CMS Strategic Action**	**Implementation horizon**	**Key role players**				**Budget (USD Million)**					**Funding source**
					National	**Basin**	**Local**	**Other**	**2020-2022**	**2022-2025**	**2025-2030**	**2030-2040**	**Total cost**	
Strategic Theme 8.8:	**Non-conventional water resources**											Strategic theme 8.8 total:	**10**	
Theme priority:	**Very important**													
8.8.1	**Rainwater harvesting**													
i	Rainwater harvesting should be promoted - especially in rural areas.	Increased awareness of rainwater harvesting		Short-term	WRA MoWSI NWHSA		WRUA	NGO	-	0.1	-	-	0.1	WRA
ii	Supply and install tanks for rainwater harvesting.	Number of rainwater tanks installed		Short to medium-term	WRA MoWSI NWHSA	WWDA	WRUA	NGO	-	4	4	-	8	WRA
8.8.2	**Reuse**													
Not considered as an option in the LVS basin at this stage														
8.8.3	**Water Conservation and Demand Management (WCDM)**													
i	Evaluate WCDM as an integrated option to reduce water demand in urban centres	WCDM Measures; improved water efficiency and supply		Short-term	WRA, MoWSI WASREB		CG	WSP	-	0.15	-	-	0.15	WRA
ii	Implement WCDM measures	Adoption of water saving techniques		Short to medium-term	WRA MoWSI WASREB		CG	WSP	-	1	1	-	2	CG
Strategic Theme 8.9:	**Water resources systems operation**											Strategic theme 8.9 total:	**1**	
Theme priority:	**Important**													
8.9.1	**Optimise system operating rules**													
i	Evaluate and improve operation of existing stand-alone dams supplying individual towns and/or small-scale irrigation. Develop curtailment rules. Consider conjunctive use.	Optimised system operating rules - multipurpose dams, user priority classification, conjunctive use, curtailment rules; Number of operating rules registered with NEMA		Short to medium-term	WRA NEMA WASREB	WWDA	WRUA		-	0.1	0.1	-	0.2	MoWSI
8.9.2	**Conduct Annual Operating Analyses (AOA) to decide need for and severity of restrictions for the coming year based on current storage levels and anticipated demands**													
i	Configure planning models and undertake annual operating analysis	AOA Reports		Short to long-term	WRA MoWSI WASREB	WWDA	WRUA		-	0.15	0.1	0.15	0.4	MoWSI
8.9.3	**Maintenance of piped network**													
i	Monitor and evaluate NRW	NRW reports / Reconciliation strategies per water service area		Short to medium-term	WRA WASREB	WWDA	WSP		-	0.1	0.08		0.18	WASREB WSP
Ii	Reduce NRW through maintenance of piped network, leak detection, replacing of old pipes, minimisation of spillages, pressure management, introduction of district metering areas, configuration of reticulation network models and eliminating illegal connections.	Improved (reduced) NRW as depicted in reports		Medium to long-term	WRA WASREB	WWDA	WSP		-	-	0.07	0.15	0.22	WASREB WSP

Key Strategic Area 9:	Institutional Strengthening													
Strategic Objective:	**To achieve an appropriate balance between operational functionality and the need for effective oversight and governance.**													
Strategy	**Activities**	**Target/Indicators (M&E)**	**CMS Strategic Action**	**Implementation horizon**	**Key role players**				**Budget (USD Million)**					**Funding source**
					National	**Basin**	**Local**	**Other**	**2020-2022**	**2022-2025**	**2025-2030**	**2030-2040**	**Total cost**	
Strategic Theme 9.1:	**Promote improved and sustainable catchment management**										Strategic Theme 9.1 total:		**7**	
Theme priority:	**Critical**													
9.1.1	**Strengthen WRAs regulatory role**													
i	Separate out regulatory and management functions of the Authority and provide different reporting lines for these. Parallel improvement and strengthening of the regulatory approaches utilised by the WRA.	Regulatory and Management functions separated out.		Immediate	WRA, MoWSI				0.52	-	-	-	0.52	WRA GoK Donors
ii	Updating WRA's standards, policies and regulations in line with the WA2016	Guidelines, regulations		Immediate	WRA, MoWSI				0.5	-	-	-	0.5	WRA GoK Donors
iii	Undertake training and capacity building for the new legislative instruments	Training manuals, guidelines, regulations, workshops		Immediate to short-term	WRA	BWRC			0.34	0.34	-	-	0.68	WRA GoK Donors
iv	Hold stakeholder consultations for developing legislative instruments and implementation tools	Stakeholder engagement strategy; Stakeholder meetings held		Short-term	WRA, MoWSI			Private sector	-	0.15	-	-	0.15	WRA GoK Donors
v	Develop tools and systems to support implementation of the new legislative instruments	Guidelines, regulations, systems		Medium-term	WRA, MoWSI	BWRC			-	-	0.59	-	0.59	WRA GoK Donors
vi	Improve awareness creation of new legislative instruments and implementation tools	Brochures, media dissemination packages, information dissemination platforms	PA33	Medium-term	WRA, MoWSI	BWRC	CG		-	-	0.45	-	0.45	WRA GoK Donors
9.1.2	**Strengthen BWRCs**													
i	Translate lessons learnt from CAACs into improved operational modalities.	Improved channels of operation.		Immediate	WRA	CAAC			0.25	-	-	-	0.25	WRA GoK Donors
ii	Provision of secretariat services through ROs and SROs.	Secretariat services through ROs and SROs		Immediate to long-term	WRA				0.2	0.1	0.1	0.1	0.5	WRA GoK Donors
iii	Appropriate channels formed for recommendations from BWRCs to be taken on board by WRA.	Improved channels of communication.		Immediate	WRA	BWRC			0.07	-	-	-	0.07	WRA GoK Donors
iv	On-going training and capacity building.	Continued education on WRM		Short to long-term	WRA, MoWSI			Development partners	-	0.07	0.07	0.14	0.28	WRA GoK Donors
9.1.3	**Strengthen county governments engagements in WRM in the Basin**													
i	Clarify roles and responsibilities for county governments.	Clear roles and responsibilities for county governments		Immediate	MoWSI, WRA		CG		0.16	-	-	-	0.16	WRA GoK Donors
ii	Introduce more structured strategic planning and operational engagement.	Improved planning and operations		Immediate	MoWSI, WRA		CG		0.35	-	-	-	0.35	WRA GoK Donors
iii	Develop a basin or sub-basin level platform for engagement with county government.	Improved engagement	PA42	Immediate to medium-term	WRA	BWRC	CG, WRUA		0.4	0.3	0.3	-	1	WRA GoK Donors

Key Strategic Area 9:	Institutional Strengthening													
Strategic Objective:	**To achieve an appropriate balance between operational functionality and the need for effective oversight and governance.**													
Strategy	**Activities**	**Target/Indicators (M&E)**	**CMS Strategic Action**	**Implementation horizon**	**Key role players**				**Budget (USD Million)**					**Funding source**
					National	**Basin**	**Local**	**Other**	**2020-2022**	**2022-2025**	**2025-2030**	**2030-2040**	**Total cost**	
9.1.4	**Strengthen WRUAs**													
i	Strengthen linkages between county governments and WRUAs.	WRUAs linked with county governments	PA42	Immediate to long-term	WRA		CG, WRUA		0.3	0.3	0.3	0.6	1.5	WRA GoK Donors
ii	Ongoing training and capacity building.	Improved capacity	PA43 PA45	Short to long-term	WRA				-	0.1	0.1	0.2	0.4	WRA GoK Donors
Strategic Theme 2.2:	**Guidelines, codes of practice and manuals**											Strategic Theme 9.2 total:	**5**	
Theme priority:	**Very important**													
9.2.1	**Develop policies**													
i	Develop a Policy on Transboundary Waters incorporating relevant elements of Treaty obligations	Transboundary Waters Policy signed by all relevant governments		Immediate to short-term	EAC Govts of South Sudan, Ethiopia and Somalia, Ministry of Foreign Affairs, MoWSI, WRA				0.3	0.3	-	-	0.6	WRA GoK Donors
ii	Complete the development of a National Policy for the Protection of Groundwater with all key stakeholders involved.	National Policy for the Protection of Groundwater		Immediate to short-term	WRA, MoWSI				0.1	0.15	-	-	0.25	WRA GoK Donors
iii	Revise the National Water Quality Management Policy	Implement under Strategy 4.2.1: Harmonise policies and strategies towards improved water quality management												
iv	Review cross-sector policies, legislation and regulations relating to wastewater; streamline/clarify the roles of the Line Ministries, WRA, NEMA, the Counties and WSPs in relation to wastewater, to eliminate the dual mandates that the WRA and NEMA currently operate under in relation to 'polluter pays' and these agencies' revenue	Reviewed policies, legislation and regulation relating to wastewater		Immediate	WRA, MoWSI, NEMA, KFS		CG	WSP	0.5	-	-	-	0.5	WRA GoK Donors
9.2.2	**Develop guidelines to support specific water resources management activities**													
i	Develop / Update Guidelines on: - the allocation of GW from fossil aquifer or aquifers that experience episodic recharge - GW vulnerability assessments - preventing/containing saltwater intrusion - defining and protecting groundwater-dependent ecosystems (GDEs) - definition and selection of Priority Aquifers, including guidance on the development of monitoring networks, the selection of appropriate instrumentation and the installation of monitoring networks - dam safety - water allocation and water quality	Guidelines and thresholds for groundwater and surface water		Immediate	MoWSI, WRA, NEMA				0.07	-	-	-	0.07	WRA GoK Donors

Key Strategic Area 9:		Institutional Strengthening														
Strategic Objective:		**To achieve an appropriate balance between operational functionality and the need for effective oversight and governance.**														
Strategy		**Activities**	**Target/Indicators (M&E)**	**CMS Strategic Action**	**Implementation horizon**	**Key role players**				**Budget (USD Million)**					**Funding source**
						National	**Basin**	**Local**	**Other**	**2020-2022**	**2022-2025**	**2025-2030**	**2030-2040**	**Total cost**	
9.2.3 Develop Codes of Practice															
i		Relevant Codes of Practice for Water Resources Planning and Management	Codes of Practice completed		Immediate	MoWSI, WRA				0.35	-	-	-	0.35	WRA GoK Donors
ii		Enforce new and existing Codes of Practice in relation to WRPM	Codes of Practice compliance		Short to long-term	MoWSI, WRA		CG		-	0.5	0.5	1	2	WRA GoK Donors
9.2.4 Develop manuals															
i		Develop / Update National Manuals relevant to WRPM	National Manuals updated/ completed		Immediate to medium-term	MoWSI, WRA		CG	WSP, private sector (industry, agriculture, mining)	0.25	0.25	0.25	-	0.75	WRA GoK Donors

Key Strategic Area 10:	Enabling environment to support effective water resources planning and management													
Strategic Objective:	**To enhance human and institutional capacities for sustainable management of the water, land, ecosystems and related resources**													
Strategy	**Activities**	**Target/Indicators (M&E)**	**CMS Strategic Action**	**Implementation horizon**	**Key role players**				**Budget (USD Million)**					**Funding source**
					National	**Basin**	**Local**	**Other**	**2020-2022**	**2022-2025**	**2025-2030**	**2030-2040**	**Total cost**	
Strategic Theme 10.1:	**Development of institutional capacities to support improved water resource management and development**									Strategic Theme 10.1 total:			**25**	
Theme priority:	**Very Important**													
10.1.1 Strengthen policies and regulatory instruments														
Implement under Strategy 9.1.1: Strengthen WRAs regulatory role														
10.1.2 Enhancement of technical and management capacity														
i	Development and enhancement of technical and management capacity through focused training, continuous professional development, bursary schemes, audits, incentive schemes	Improved capacity of personnel and institutions		Short to long-term	WRA				-	0.78	0.78	1.56	3.12	WRA
10.1.3 Strengthen partnerships														
i	Develop a partnerships framework	Partnerships framework developed		Immediate	WRA, MoWSI			Private sector	0.35	-	-	-	0.35	WRA
ii	Identify potential partners	Inventory of potential partners		Immediate	WRA, MoWSI		CG	Private sector, Development partners	0.5	-	-	-	0.5	WRA
iii	Undertake stakeholder consultations	Stakeholder engagement strategy		Immediate to short-term	WRA, MoWSI			Development partners	0.12	0.13	-	-	0.25	WRA, private sector
iv	Undertake awareness creation and information dissemination activities	Brochures, information dissemination packages		Immediate to short-term	WRA		CG	Development partners	0.12	0.13	-	-	0.25	WRA
v	Develop and strengthen guidelines for MOU drafting and development	Partnerships framework, improved guidelines for MOU development		Short-term	WRA				-	1.5	-	-	1.5	WRA
vi	Strengthen existing partnerships, particularly on a local level	Existing partnerships strengthened		Immediate	WRA		WRUA	CG, NGO, Development partners	0.35	-	-	-	0.35	WRA
10.1.4 Strengthen stakeholder engagement														
i	Develop a basin-wide stakeholder engagement framework	Stakeholder engagement strategy developed		Immediate	WRA				0.09	-	-	-	0.09	WRA
ii	Undertake stakeholder analysis	Identified stakeholders		Immediate	WRA	BWRC	CG, WRUA		0.15	-	-	-	0.15	WRA
iii	Implement the stakeholder engagement framework	Stakeholder engagement, workshops, forums, expos held; Level of participation		Short to long-term	WRA	BWRC	CG, WRUA	NGO	-	0.2	0.2	0.4	0.8	WRA
iv	Strengthen stakeholder engagement platforms i.e. forums	Improved guidelines for forums; Improved stakeholder participation		Immediate to short-term	WRA	BWRC	WRUA		0.45	0.45	-	-	0.9	WRA
v	Undertake awareness creation and information dissemination activities	Brochures, media dissemination packages		Short-term	WRA	BWRC	CG	Media	-	0.45	-	-	0.45	WRA

Strategy	Activities	Target/Indicators (M&E)	CMS Strategic Action	Implementation horizon	Key role players				Budget (USD Million)					Funding source
Key Strategic Area 10:	**Enabling environment to support effective water resources planning and management**													
Strategic Objective:	**To enhance human and institutional capacities for sustainable management of the water, land, ecosystems and related resources**													
					National	Basin	Local	Other	2020-2022	2022-2025	2025-2030	2030-2040	Total cost	
10.1.5	**Improved research**													
i	Strengthen links with tertiary education / research institutions	Number of tertiary institutions linked		Immediate to medium-term	WRA, Research institutions				1.2	1.2	1.2	-	3.6	WRA
ii	Incorporate R&D into WRM planning and decision making	R&D plan incorporated		Immediate to short-term	WRA, Research institutions				0.15	0.1	-	-	0.25	WRA
iii	Invest in R&D to strengthen WRM	Financing for R&D		Short to long-term	WRA, Research institutions		CG	Private sector	-	2	2	4	8	WRA, Research institutions
iv	Establish a network of supporting research institutions	Network of research institutions		Immediate to medium-term	WRA, Research institutions				0.1	0.1	0.1	-	0.3	WRA, Research institutions
v	Manage data and knowledge generation and collation	Data generated, information generated, knowledge generated		Short-term	WRA, Research institutions				-	1.05	-	-	1.05	WRA, Research institutions
vi	Disseminate data, information and knowledge	Brochures, media dissemination packages, information dissemination platforms		Short-term	WRA, Research institutions			Media	-	0.45	-	-	0.45	WRA, Research institutions
vii	Develop strategic partnerships for R&D	Strategic partnerships for R&D; MoUs signed by institutions		Immediate to medium-term	WRA, Research institutions				0.1	0.1	0.1	-	0.3	WRA, research institutions
10.1.6	**Innovative financing**													
i	Promote innovative financing for basin level institutions (BWRCs, WRUAs, forums)	Secured financing		Immediate	WRA, WSTF	BWRC	WRUA, Forums	Development partners	0.25	-	-	-	0.25	WRA
ii	Develop internal resource mobilization strategies	Income generated		Immediate	WRA, MoWSI, WSTF	BWRC			0.5	-	-	-	0.5	WRA
iii	Develop external resource mobilization strategies	Income generated; Grants secured	PA58 PA59	Immediate	WRA, MoWSI, WSTF	BWRC		Development partners	0.45	-	-	-	0.45	WRA
iv	Exploring private sector financing channels	Private sector financing secured	PA62 PA63 PA64	Immediate to short-term	WRA	BWRC		Private sector	0.15	0.15	-	-	0.3	WRA, private sector
v	Strategic partnerships for resource mobilization	Financing secured, strategic partnerships framework		Immediate to short-term	WRA, MoWSI			Development partners, Private sector	0.23	0.23	-	-	0.46	WRA, sector institutions

F1: Development costs

Major projects

Estimated project costs for specific, proposed major projects were extracted from relevant planning and design study reports where available, and from prices reported on relevant agency and government department websites, escalated to 2020 prices. Key information sources and institutions which were consulted include NWMP 2030, JICA, 2013; IDA Funding Agency Project Appraisal Reports; Kenya Vision 2030 Flagship Projects *(**http://www.vision2030.go.ke/publication/vision-2030-flagship-projects-progress-report-nov-2014/**)*; Blue Economy Bankable Projects *(Kenya conference on sustainable blue economy. Nairobi, Nov 2018, Ondimu et al.);* Kenya National Investment Profile *(Water for agriculture and Energy. 2015. FAO, AgWA);* Kenya National Water Harvesting and Storage Authority *(**http://www.waterauthority.go.ke/**);* Kenya National Irrigation Board; Regional Development Authorities; Water Works Development Agencies

Dams

For major dams, the approach described above for Major projects was followed. The unit cost for major dams amounts to approximately USD 1 Million per MCM of storage provided.

For minor dams (typically between 1 MCM and 30 MCM storage), where no specific cost information was readily available, a cost curve was developed based on cost estimates done as part of the NWMP (JICA, 2013), extrapolated to 2020 prices as shown below.

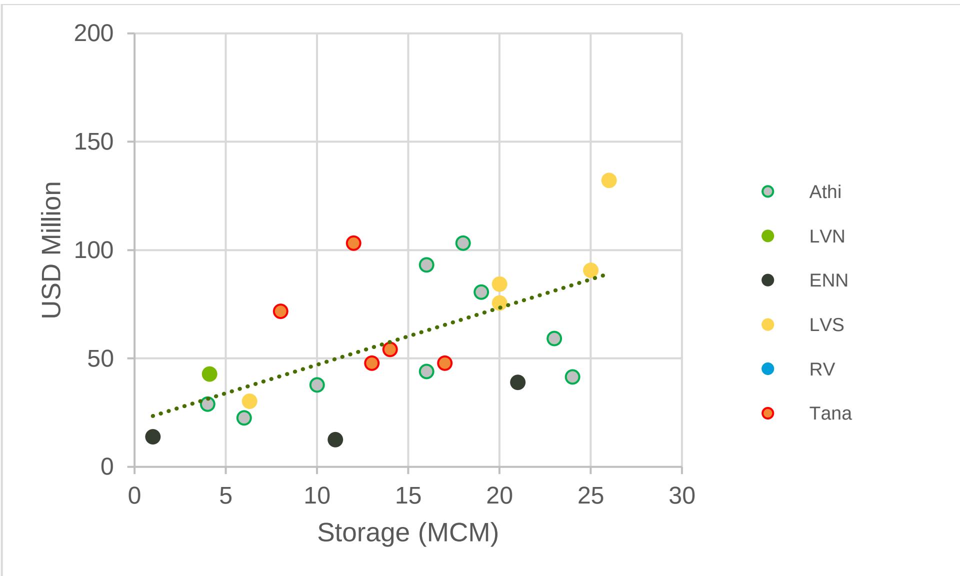


Figure F-1: Cost curve for dams smaller than 30 MCM

For small dams and pans, cost estimates obtained from Water Works Development Agencies project budgets were analysed and used to derive the following unit costs:

- 20 000 m^3 pan: USD 100 000
- 50 000 m^3 pan: USD 150 000
- 50 000 m^3 small dam: USD 175 000
- 100 000 m^3 small dam: USD 300 000

Irrigation

For large irrigation projects, the approach described above for Major projects was followed.

For schemes where no specific cost information was readily available, the following unit costs (complete) for large-scale and small-scale irrigation were derived:

- Large-scale irrigation: USD 19 700 /ha
- Small-scale irrigation: USD 9 500 /ha

The unit costs were based on information provided in the following sources: NWMP 2030 (JICA, 2013); FAO Investment Centre Technical Paper 5, Irrigation: Africa South of Sahara. Rome 1986; Kenya National Irrigation Board; IWMI Research Report 109. Costs and performance of irrigation projects: A comparison of Sub-Saharan Africa and other developing regions. (Inocencio et al, 2007)

Hydropower

For many of the planned major hydropower projects, the cost of the hydropower installation was included with the development cost of the dam.

Otherwise, a unit installation cost of USD 200 000 per MW installed was used based on international rates *(**https://www.hydro.org/**)*

Boreholes

For large groundwater development projects, the approach described above for Major projects was followed.

For individual boreholes, a cost of USD 20 000 per borehole was used based on typical costs in Kenya. This includes drilling and equipping of borehole with independent power supply. An average yield of 4.4 m3/h per borehole was assumed ***(https://constructionreviewonline.com/2018/03/water-borehole-services-kenya/)***

Bulk Water Transfers

For bulk water transfer projects, the approach described above for Major projects was followed. Where no specific information was available, tunnels were costed at a unit cost of USD 50 million/km.

Hydromet network

Costs associated with the procurement, installation and commissioning of monitoring stations and hydromet equipment were based on information and typical unit costs provided by WRA offices and/or suppliers.

Cost Benefit Analysis (2020)

- Electricity price: 0.15 USD million/GWh. ***(https://www.globalpetrolprices.com/Kenya/electricity_prices/)***
- Water supply price - urban: 2.9 USD/m3; Water supply price - rural: 1.65 USD/m3. (Gulyani, S et al. Water for the urban poor: Water markets, Household demand and Service preferences in Kenya. Water supply and sanitation sector board discussion paper series. Paper No. 5. Jan 2005)
- Irrigation: Unit crop yields and producer prices ***(http://www.fao.org/countryprofiles/index/en/?iso3=KEN);*** *Kenya Horticulture Validated Report 2015 – 2016. AFA – Horticultural Crops Directorate* (Avg. County values)
- Operation and Maintenance: Dams and hydropower - 2.5% of capital cost per annum; Irrigation- 0.5% of capital cost per annum.
- Discount rate: 10%

F2: Management costs

A stepwise approach for estimating costs associated with the implementation of management actions was followed:

i. Decide on the appropriate implementing agency at national, basin, county or local scale, based on defined mandates in relation to specific KSA activities. Implementing agencies include national government, sub-regional offices, county governments and WRUAs.
ii. The type of implementing agency defines the number of offices/units per Basin in the budget estimation calculation. In the case of a site- specific activity, such as the development of IFMPs, the number of sites was used to estimate the budget.
iii. Allocate budget over four time frames based on personal experience, professional consultation fees, management cost estimates as per NWMP 2030 and reference to local information. Timeframes are 2020-2022 (2 years), 2022-2025 (3 years), 2025-2030 (5 years) and 2030-2040 (10 years).
iv. Timeframes indicate which activities should be completed immediately (2022) or in the short (2025), medium (2030) or long-term (2040), as well as the duration of this implementation.

F3: General

- Upfront costs - Planning/Feasibility, Environmental Assessment, Design: 15% of capital cost
- Infrastructure replacement costs were not considered
- Annual inflation rate: 5%
- Exchange rate: 1 USD = 100 KES
- Desalination and water re-use plants were not costed as part of this Plan. Rather, the Plan recommended that the construction of such plants as alternatives to conventional surface water and groundwater resources development projects, be investigated in more detail for possible implementation in the next planning horizon.