Ministry of Water, Sanitation and Irrigation

Rift Valley 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

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Rift Valley Integrated Water Resources Management and Development Plan

FINAL

KENYA WATER SECURITY AND CLIMATE RESILIENCE PROJECT

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

Prepared for:

Ministry of Water, Sanitation and Irrigation

Water Resources Authority

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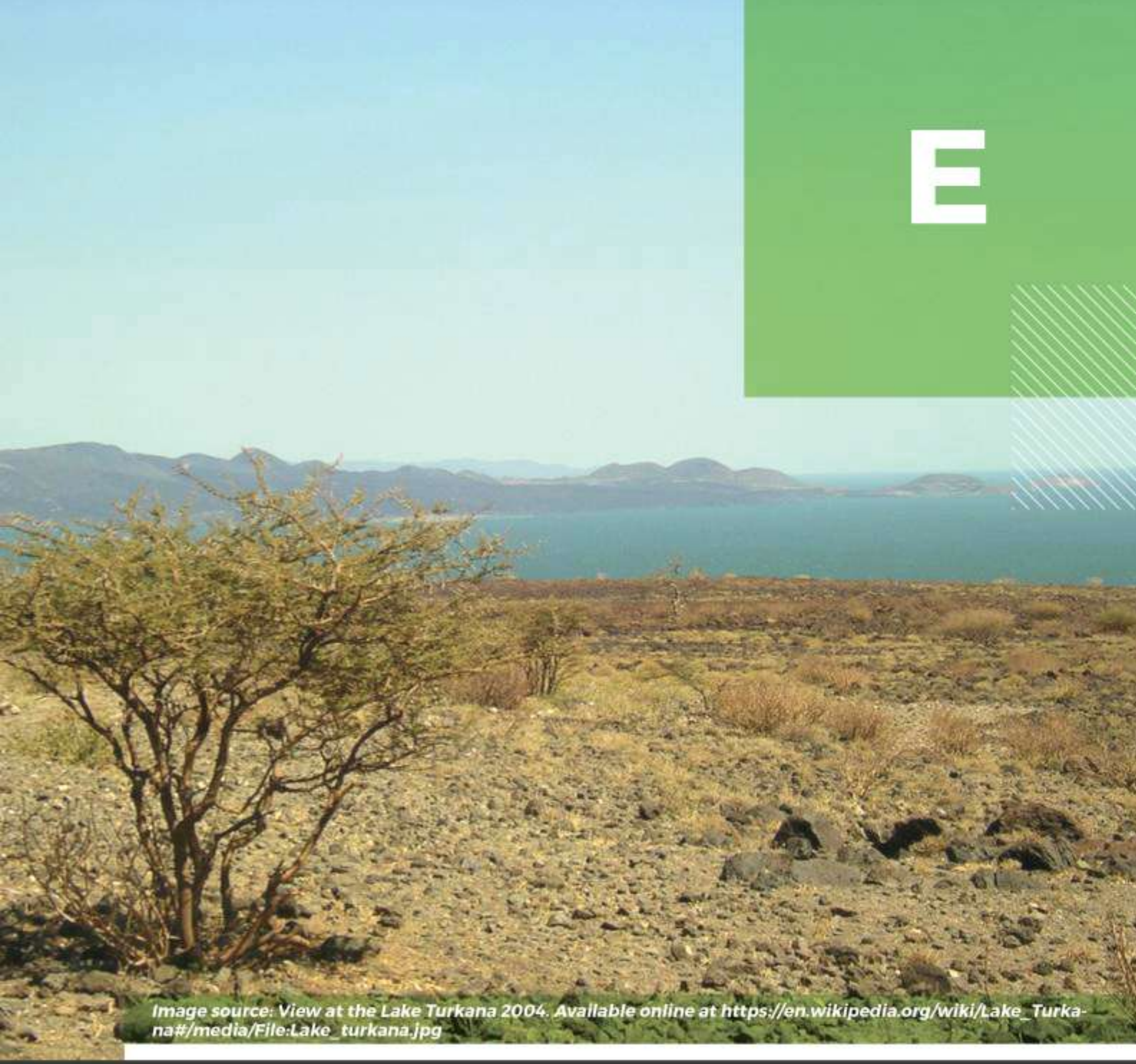

Image source: View at the Lake Turkana 2004. Available online at https://en.wikipedia.org/wiki/Lake_Turkana#/media/File:Lake_turkana.jpg

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Executive Summary

Water Resources Authority

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 Resource 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 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 Resource 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 resource 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 Rift Valley (RV) Basin. Integrated Water Resource 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 RV Basin is to provide a clear pathway for the sustainable utilisation and development of the water resources of the 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 RV Basin was developed, which reads as follows:

A model and sustainable basin providing equitable, adequate and high-quality water and ecological services for socio-economic development by 2040

E2. Biophysical environment

The RV Basin has an area of 131 423 km^2. It has a long, narrow shape bordering South Sudan and Ethiopia in the north and Tanzania in the south. The bottom half of the basin is bordered by the Lake Victoria North and South basins to the west, and the Athi and Tana basins to the east. The central and northern part of the basin is bordered by Uganda to the west and the Ewaso Ng'iro North Basin to the east. The RV Basin covers about 23% of Kenya's area and houses 13% of the total population of Kenya. Lake Turkana is located in the northern RV Basin and is the largest lake in Kenya. The major towns in the catchment are Nakuru, Narok, Kabarnet, Naivasha and Lodwar. Nakuru is the largest town in the basin and hosts an extensive industrial area. The northern part of the basin is classified as arid land and is one of the driest parts of the country. The central part of the basin is surrounded by the water towers of Cherangani Hills, Mau Forest and the Aberdare Range, forming the so-called 'Rift Valley' from which the basin derives its name.

The topography of the RV Basin varies from the mountainous areas in the central-southern part at elevations up to 2 600 masl to elevations of less than 500 masl at Lake Turkana in the north and about 600 masl at Lake Magadi in the far south. Most of the basin is gently sloping except for Chengani Hills and the Mau Escarpment along the central-southern western border and the Aberdares along the central eastern border. Other steep areas surround the Lerochi Plateau and the Chepanda Hills north of Nakuru. The RV Basin landforms are the result of volcanic activity creating complex landforms, plains and mountains. Lake Turkana forms the lowest feature in the Basin. he RV Basin is made up of Quaternary sediments, Tertiary and Quaternary volcanics and Basement rocks.

Drainage in the RV Basin is characterised by seven major lakes with their respective drainage basins:

Lake Turkana in the north of the basin is the largest lake in the basin and has a drainage area of about 123 000 km^2, including the Omo River catchment in Ethiopia. The lake has a surface area of approximately 7 500 km^2. The lake receives most of its inflow (more than 80%) from the Omo River, which enters the lake from Ethiopia in the North. The Kerio and Turkwel rivers are the major Kenyan rivers which drain to Lake Turkana from the south-west. The Kerio and Turkwel rivers are perennial along their upper reaches but intermittent along their lower reaches due to high seepage and evaporation losses. The second largest drainage basin (8 350 km^2) is Lake Magadi in the south of the RV Basin, which is mainly fed by underground rivers. The major rivers which feed Lake Baringo in the central part of the basin, with a drainage area of about 6 530 km^2, include the Perkerra River and the Molo River from the south and the Mukutan River from the east. Lake Naivasha has a drainage area of 3 130 km^2. The perennial Malewa and Gilgil rivers account for nearly 90% of the lake's inflow. In the central part of the basin, Lake Bogoria's drainage area is 1 140 km^2. The Waseges River (or Sandai River) is a river that rises on the slopes of the Nyandarua Plateau below the Aberdare Range, discharging into Lake Bogoria. Lakes Nakuru (1 624 km^2) and Elementaita (543 km^2) have much smaller drainage areas and are located close to Nakuru Town.

In addition to the above lakes and their respective drainage areas, the RV Basin has three more river basins: the Tarash River in the north-western part of the basin is a seasonal river which feeds the Lotikipi Swamp; the Suguta River is a seasonal river directly south of Lake Turkana; and the perennial Ewaso Ng'iro South River in the southern RV Basin which originates on the Mau Escarpment. It flows southwards and crosses the border into Tanzania, where it empties into Lake Natron.

The main wetlands in the RV Basin surround the seven major lake regions and support a variety of fauna. Only Lakes Baringo and Naivasha have fresh water, while the other lakes have saline water. Lake Turkana is the world's largest permanent desert lake and the world's largest alkaline lake. Turkana Lake is designated as a UNESCO World Heritage Site, while Lakes Baringo, Bogoria, Elmenteita, Naivasha and Nakuru are designated as Ramsar sites.

The rainfall seasonality in the RV Basin is complex, with ground altitude playing an important contributing factor. Average annual maximum day temperatures across the basin vary from 19°C to 35°C, while the average annual minimum night temperatures vary from 8°C to 23°. The northern part of the Basin is classified as arid land, the central part as humid and the southern part as semi-arid. The mean annual precipitation across the basin varies from less than 300 mm in some areas in the north to as high as 1 200 mm in some of the central areas. Towards the south of the basin, the mean annual precipitation reduces again to less than 800 mm. The mean annual precipitation across the basin is 510 mm. Most of the rainfall occurs during April and May and again from October to December August. The driest months occur between December and February.

The climate change analysis which was undertaken as part of this Consultancy showed a general increase (between 4% and 12% - increasing towards the north) in mean annual rainfall across the basin by 2050, while temperatures are also expected to increase by 2050. There is likely going to be increased climate variability between years and a consistent increase going forward will be unusual. This may result in years that have drought like character adjacent to flood seasons and an increase in the intensity of extreme events and will demand an adaptive resilience approach. Even though mean annual precipitation is projected to increase, the net effect on runoff due to increased temperature and evapotranspiration, will result in a reduction in mean annual runoff of about 3% by 2050.

Flooding is an issue in the RV Basin, especially in areas such as Narok, Lodwar, Mogotio and Marigat. Severe floods occur mainly around the water tower areas. Particularly in recent years, a lot of deaths caused by flash floods have been reported in mountainous areas that are located in the central part of the catchment area. Narok, which is located at the downstream of the confluence point of three rivers flowing from the Mau Forest, suffers from floods every rainy season. Most of the Basin is categorized as arid land (northern side) and semi-arid land (southern side), making drought management a challenge. Water use restriction levels are not clearly defined for the existing dams in the Basin, which cause operational issues during times of drought.

Vegetation cover is important, as dense vegetation cover will act to protect the land from erosion, 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.

Biodiversity in RV Basin is linked to water resources, wetlands and forest reserves or protected areas. There are several lakes and wetlands in the basin, which are important habitats for a variety of birdlife and wildlife. This includes crocodiles, several endangered bird species and large mammals such as hippopotamus. Lake Nakuru is a famous tourist attraction for its flamingo viewing. The RV Basin contains several environmentally protected areas, including six National Parks and four National Reserves. The total forested area in the Basin in 2010 was about 261 000 ha. However, according to recent satellite imagery, the forested area has decreased since 1990. Deforestation and forest degradation are rampant in the catchment, especially in the Mau Forest Complex and private forests to the west of Lake Naivasha. The RV Basin has seven gazetted Water Towers.

Land use in the RV Basin includes forest, grassland/rangeland and agricultural use. The Basin has a high population density and scattered urban and built-up areas in the middle sections of the Basin with the dominant land use being rain-fed agriculture and rangeland.

E3. Socio-economic environment

Water plays a key role in the socio-economic environment in the RV Basin. It is of critical importance for the agricultural sector, for industries, health, tourism and for improving the standard of living.

The total population of the RV Basin according to Census 2019 is estimated as 5.78 million, which is equivalent to a population density of 44 persons/km^2. Most of the population in the RV Basin currently reside in rural settlements, with only 24% of the population being located in urban areas. The population of the RV Basin is expected to increase significantly due to high projected growth rates, and an influx of people to urban areas.

The formal sector employs 40% of the labour force in RV. Small-scale irrigation, pastoralism and informal employment constitute 60% of the employment in the RV Basin. Most formal employment is in the urban centres although there is also formal employment in rural areas. The sources of livelihood vary across the basin, from formal employment in the urban areas to subsistence agriculture and crop/livestock production in the pastoral and farming areas. There is limited economic activity in the basin and the average poverty rate in the Basin is at 52%.

The RV Basin includes 12 counties, some of them only partly. The arid and semi-arid lands in the RV Basin are characterised by erratic and low rainfall and are prone to droughts. Most of the basin depends on pastoral activities for livelihood, and in times of prolonged drought, pastoralists lose livestock to disease and lack of pasture and water. Turkana County is the most food-insecure area in the country, with 19% of households having poor food consumption.

About 40% of the basin's population receive drinking water from unimproved drinking water sources (unregistered water vendors and water taken from lakes and streams without proper treatment), 28% receive piped water via a WSP and 32% receive water directly from boreholes and springs. Formal sewerage systems are limited in the Basin, with only 4% of the population (all of which are in urban areas) having access to sewerage systems. Pit latrines and septic tanks are used by 69% of the population, while 27% of the population have no form of sanitation system.

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. Turkana, West Pokot, Laikipia, Samburu, Elgeyo Marakwet, Baringo, Narok, Kajiado are high risk areas for 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, 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 RV 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 RV Basin were identified and prioritised during a two-day workshop with key stakeholders and classified under four categories and several sub-categories:

Table E1: Main categories under which key issues in RV 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; Limited 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 natural runoff in the RV Basin equals 2 682 MCM/a. The total natural runoff in the five main river systems in the RV Basin equals 2 280 MCM/a - about 80% of the total basin runoff. The Kerio River contributes about 26% (587 MCM/a), and the Turkwel River 29% (656 MCM/a). The Kerio and Turkwel rivers are perennial along their upper reaches but intermittent along their lower reaches due to high seepage and evaporation losses. The Ewaso Ng'iro South River has a natural MAR of 431 MCM (19% of the major river runoff) at the border with Tanzania. The Perkera and Molo rivers contribute 343 MCM/a (15%) and the Malewa and Gilgil rivers 263 MCM/a (12%). The Omo River, which discharges into Lake Turkana from Ethiopia, has a natural mean annual runoff of 15 469 MCM/a and contributes more than 80% of the total inflow into Lake Turkana. The total natural runoff from the other catchments in the RV Basin equals 402 MCM/a.

The annual groundwater recharge for the RV Basin was estimated at 3 168 MCM/a, with a sustainable annual groundwater yield of 398 MCM/a. Good groundwater potential is found in the southern and central RV Basin.

The climate change analysis which was undertaken as part of this Consultancy showed that projected future precipitation totals are varied across the RV Basin. The RCP 4.5 analysis predicted that the Mean Annual Precipitation across the RV Basin would increase by 10%, from 510 mm to 562 mm by 2050, while day and night temperatures in the basin are expected to increase by up to 1.24°C and 1.46°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 RV Basin to assess the potential impacts on runoff. Even though mean annual precipitation is projected to increase, the net effect on runoff due to increased temperature and evapotranspiration, will result in a reduction in runoff by between 1% and 10%, with some sub-basins slightly lower or higher. The total surface water runoff from the five main river systems in the RV Basin is projected to decrease with 2.9% to 2 214 MCM/a under RCP 4.5. It was found that groundwater recharge will increase as well as the potential groundwater yield which is expected to increase by 3% to 411 MCM/a under RCP 4.5.

The total current estimated water demand (2018) in the RV Basin equates to 481 MCM/a as shown below. Most of the water is needed for irrigation and domestic / industrial use.

Table E-2: Current water requirements in the RV Basin per main sector

Sector	Total (MCM/a)
Irrigation	**204**
- Small scale / Private	164
- Large-scale	40
Domestic and Industrial	**192**
- Urban centres	39
- Basin-wide	153
Livestock	**80**
Other	**5**
Total	**481**

The 2018 water balance in the RV Basin in terms of natural surface water runoff and sustainable groundwater yield, the ecological reserve and current (2018) water demands is summarised below. The current water demand constitutes about 13% of the total water resources available for use in rivers and sustainably utilisable groundwater.

Table E-3: RV Basin (2018) water balance (MCM/a)

	Surface water (MCM/a)	Groundwater (MCM/a)	Total (MCM/a)
Natural / Available water	2 682	398	3 080
Ecological reserve	(251)	-	(251)
		Total	**2 829**
		Water demand (2018)	(481)
		Balance	**2 348**

The scenario evaluations which were undertaken as part of this Study concluded that the expected growth in irrigation and urban centre water demands by 2040 will result in a significant reduction in supply reliability. A key priority for the development of water resources in the Basin should therefore concern improved water supply to the main urban centres and for the extensive areas of planned irrigation. The full extent of the originally planned large-scale irrigation development in the basin is not feasible and is constrained by the availability of water and the potentially significant impact on the various lakes in the basin due to over-abstraction in the catchments which feed the lakes.

The scenario analysis highlighted the imperative that water demand management be implemented in all urban areas, that planned irrigation areas be reduced and that 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 1 784 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 RV 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 RV Basin per main sector

Sector	MCM/a
Irrigation	**920**
Domestic and Industrial	**708**
- Urban centres	211
- Basin-wide	497
Livestock	**146**
Other	**10**
Total	**1 784**

Water quality in the RV Basin is a critical issue, especially as all of the major rivers drain into lakes which are either Ramsar or UNESCO World Heritage sites. Water quality across the basin is heavily impacted by point and non-point sources of pollution, with the latter closely linked to the management and utilisation of land. Typical point sources of pollution in the RV Basin include raw sewage from urban areas in some sub-counties, effluent from horticultural farms and livestock-based industries, leachates and solids from solid waste dumps. Non-point pollution comprises atmospheric deposition, stormwater runoff from farms, and soil erosion from areas devoid of vegetation cover. The quality of water resources has deteriorated due to increased anthropogenic activities. Unsustainable farming practices and poor management of croplands is also evident in many parts of the basin.

The RV Basin currently has 79 recorded stream flow monitoring stations, of which 64 are known to be operational. The majority of the currently operational stations are manually operated. 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. There are 6 lake monitoring stations in the RV Basin of which 4 are operational (Lake Turkana, Bogoria, Lake Baringo and Lake Naivasha).

There are 42 surface water quality and 16 effluent stations in the RV Basin. Currently, the water quality monitoring programme operated by WRA faces the challenges of insufficient qualified and trained staff and also a shortage of adequate 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. There are currently 39 groundwater monitoring stations in the RV Basin, of which 30 are operational. All the wells are also tested for water quality. The current groundwater monitoring network is inadequate while maintenance of monitoring wells is also a concern.

E6. Current water resources development and water allocations

Existing large-scale water resources developments in the RV Basin include four large dams and some large-scale irrigation schemes. Turkwel Dam (1 641 MCM) on the upper Turkwel River is used for hydropower generation and irrigation supply. The dam is the third largest hydroelectric power plant in Kenya, having an installed capacity of 106 MW. Chemususu Dam (11 MCM) on an upper tributary of the Perkerra River supplies water for domestic use and irrigation. Kirandich Dam (4.5 MCM), close to Kabernet Town, is used for domestic water supply. Chemeron Yatoi Dam (2.3 MCM) is used for local water supply but has lost a lot of storage due to sedimentation. The Chemususu, Kirandich and Chemeron dams are all located in the central part of the RV Basin in the Lake Baringo catchment. In addition to the dams, there are two river intake structures in the basin used to divert water for domestic supply: Turasha Intake Weir on the Turasha River, a tributary of the Malewa River (in the Lake Naivasha catchment), and the Narok Intake Weir on an upper tributary of the Ewaso Ng'iro South River.

Three large-scale irrigation schemes exist in the basin with a total area of about 2 600 ha. The Perkerra Scheme is located about 100 km north of Nakuru close to Marigat. The scheme gets it water from the Perkerra River and Chemususu Dam. Other schemes include the Katilu Scheme along the Turkwel River downstream of Turkwel Dam and the Wei-Wei Irrigation Scheme, a run-of-river scheme in the upper Turkwel River catchment

Construction on various large dams in the RV Basin is about to start, is underway, or has started but are currently on hold due to contractual, financial and/or other issues. These dams include the Muruny-Siyoi Dam in West Pokot as part of the Kapenguria Water Supply Project and the Arror multipurpose dams on upper tributaries of the Kerio River in Elgiyo Marakwet County, which will have installed hydro-electric capacity of 60 MW and will supply water for about 2 000 ha of irrigation. The Lowaat Dam on the Kerio River and the Radat Dam on the Perkerra River in Turkana and Baringo counties respectively, will also be used for irrigation supply.

Most of the water currently consumed in the RV Basin is for irrigation and domestic and industrial use. Water is mainly sourced directly from groundwater, rivers, lakes, small dams and pans, with some towns and irrigation schemes being supplied from larger dams. Supply reliability in most parts of the basin is reasonable. However, frequent shortages are experienced during the dry season due to lack of storage, often exacerbated by the late start of the wet season. Non-consumptive use in the basin is linked to the generation of hydropower at Turkwel Dam.

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 (2010) WRA Guidelines for Water Allocation, a high level analysis was conducted to assess the water allocation status in the RV 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 some sub-basins 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. It is important to note that the above water allocation balance calculations only took into account the incremental surface water runoff generated in each sub-basin and did not accommodate excess water (river flow) from upstream sub-basins.

E7. Evaluation of scenarios

Scenario evaluation was undertaken to assess different development and management scenarios and to identify a sustainable development pathway for the RV 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 RV Basin and provides a baseline against which future scenarios are evaluated. The scenario reflects exiting 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

This scenario represents the “do nothing” case - a possible worst-case scenario. It assumes that current projects under implementation are completed, yet there is no further investment in water resources infrastructure and development including large-scale irrigation although 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 lack of 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 urban 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. 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. The scenario also focuses on reducing the impact of consumptive use on lake inflows under future development, by limiting the total future water use in the basin to 60% of the total water resources available, mainly by capping irrigation development.

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

- 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
- Maximum consumptive water use should not exceed 60% of total future water availability in the basin on average

Two 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

In order to provide a scientific-based, transparent and consistent approach towards the evaluation of water resources development and management alternatives (scenarios) in the RV 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 RV 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 irrigation demands typically range from 10% to 35%, mainly due to shortfalls during the dry season.

- The expected growth in hydropower, urban and rural domestic demands, livestock and irrigation water requirements by 2040 will result in a reduction in supply reliability across the basin and will require interventions for the development of water resources in the RV Basin. These interventions include new storage dams, inter- and intra-basin transfers, water demand management measures, conjunctive use depending on groundwater availability and quality, as well as consideration of measures for rainwater harvesting
- In order to reduce the expected loss in storage in existing and proposed dams, catchment management measures and programmes should be implemented as a matter of priority in the upstream catchment to reduce loss in active storage.
- 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.
- The full extent of the originally planned large-scale irrigation development in the basin is not feasible and is constrained by the availability of water and the potentially significant impact on the various lakes in the basin due to over-abstraction in the catchments which feed the lakes.
- Large-scale irrigation will require the construction of various large dams to ensure an acceptable reliability of supply and the development of operating rules which prioritise irrigation water use.
- It is imperative 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.
- The analyses have shown that levels in Lakes Turkana, Baringo, Bogoria, Naivasha and Nakuru are very sensitive to the proposed upstream developments and the associated increase in water use. Of critical importance, therefore, is a specialised and detailed assessment on environmental flow requirements for these lakes, the incorporation of these requirements in the water allocation plans and enforcement to ensure compliance with minimum releases.
- The planned Ewaso Ng'iro Project along the Ewaso Ng'iro South River, which includes three cascading dams with a combined installed hydropower capacity of 180 MW requires the transfer of water from the LVS Basin to make the scheme viable.
- The water which will be transferred from the Amala River in the LVS Basin will also allow the development of irrigation along the lower Ewaso Ng'iro South River. However, it is imperative that careful consideration be given to the operating rules for the transfer/cascade scheme to ensure minimal environmental impact on Lake Natron.
- The Kerio River catchment offers significant potential for irrigation development. However, this will require the construction of large dams for regulation of flows. The generation of hydropower will be a secondary benefit at some of the proposed dams.
- An expansion of the existing Perkerra Irrigation Scheme will require the construction of another large dam on the Perkerra River – especially as the current allocation of water for irrigation from the existing Chemususu Dam will be required for domestic supply in future.
- Increased hydropower releases from the existing Turkwel Dam will allow the expansion of large-scale irrigation along the Turkwel River downstream to some extent, while the dam will also be able to supply the future demands associated with the Tullow Oil field developments in Turkana County as well as future demands associated with the proposed LAPSSET resort city at Kalokol in Turkana County.

- The regulation of flows related to the Gibe I to IV hydropower cascade schemes along the Omo River and the development of the Lower Omo Valley Irrigation Scheme in Ethiopia, as well as the planned Todonyang-Omo Irrigation Scheme to be situated in Kenya just south of the Ethiopian border along the north-western shoreline of Lake Turkana, will have a significant impact on the Lake Turkana lake levels and development should therefore be limited.
- The construction of Malewa Dam will improve the assurance of supply to Naivasha and surrounding areas in the short term. However, it is imperative that significant minimum flow (environmental) releases for Lake Naivasha are incorporated in the operating rules of Malewa Dam.
- The expected increase in the future water demands of Nakuru and surrounding towns in the central RV Basin, will exceed the local water availability and it is imperative that water from Itare Dam in the LVS Basin be transferred into the RV Basin to augment water supply to Nakuru, Kuresoi, Molo, Njoro and Rongai in the Rift Valley Basin.
- The net impact of climate change in the basin will be less water availability and increased irrigation demands. This highlights the importance of providing storage and the need for water demand management. Climate change is thus anticipated to have a negative impact on the RV Basin and highlights the importance of development and management interventions to mitigate climate risks and improve resilience.
- 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

E8. Proposed development pathway

The essence of the proposed water resources development plan for the Rift Valley Basin, up to 2040, is to expand irrigation in the basin in line with water availability, especially in the Turkwel, Kerio, Perkerra and Ewaso Ng'iro South catchments as well as next to Lake Turkana; to ensure a reliable supply of water to meet the expected growth in urban water demands; to increase hydropower production in the basin; to implement the identified schemes which will export water from the Lake Victoria South Basin 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. 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 should be implemented for both small and large-scale irrigation and for urban centres.

Note: It is imperative that any large-scale water resources developments in the RV Basin are preceded by detailed, scientifically based studies on the potential impacts of water abstractions on downstream lakes, which should quantify and prescribe the minimum flows required to maintain the environmental and social sustainability of the various lakes in the basin.

E9. Water resources development investment plan

The following specific interventions are proposed:

- Construction of two multipurpose dams in the Kerio River catchment viz. Embobut and Arror dams which will provide water for large scale irrigation, hydropower, flood control and water supply in general.
- Construction of the Upper Narok multipurpose dam in the upper Ewaso Ng'iro South River catchment. This dam will provide water for urban users as well as large scale irrigation and flood control.
- Construction of the Lowaat and Radat dams on the lower Kerio and Perkerra rivers respectively, to mainly supply water for large-scale irrigation development.

- Construction of the Waseges Dam on the Waseges River to support irrigation development in the lake Bagoria catchment.
- Construction of Malewa Dam on the Malewa River to improve water supply to Naivasha Town and Gilgil.
- Construction of Siyoi Muruny Dam for local water supply as part of the Kapenguria Water Supply Project.
- Implementation of the Ewaso Ng'iro Multipurpose Project which includes three cascading dams along the Ewaso Ng'iro South River viz. Oletukat Olenkululu, Leshota and Oldorko dams and the installation of hydropower capacity of 180 MW. This project also entails the construction of Amala Dam on the Amala River, an upper tributary of the Mara River in Lake Victoria South Basin, from where water will be diverted via a tunnel to the upper Ewaso Ng'iro South River, as well as the development of about 15 000 ha of irrigation in the Ewaso Ng'iro South Valley.
- The construction of Itare Dam on the Itare River, an upper tributary of the Sondu River in Lake Victoria South Basin, to supply water to the RV Basin via an inter-basin transfer (tunnel). This water will augment the supply to Nakuru Town and address water shortages in Molo, Njoro and Rongai along the way.
- The expansion of irrigation along the Perkerra River, Kerio River and Ewaso Ng'iro South River using the storage provided by the new dams to be constructed.
- Prioritising environmental water requirements of lakes in water allocation.
- Implementation of the Todonyang-Omo Irrigation Scheme along the north-western shore of Lake Turkana, using water from the Omo River.
- The expansion of large-scale irrigation along the Turkwel River downstream of Turkwel Dam.
- Re-allocating water from the existing Turkwel Dam to meet the expected water demands for oil production in Turkana County as well as the anticipated water requirements linked to the development of Eliye Springs Resort as part of LAPSSET, on the western shore of Lake Turkana
- Addressing transboundary issues in the Lake Turkana catchment through an integrated catchment management plan with Ethiopia. Although a number of independent, international studies have been commissioned by various institutions in an attempt to evaluate and quantify the possible hydrological impact of the Gibe Hydropower Schemes and proposed large scale irrigation on the hydrological characteristics of Lake Turkana, it is imperative that a joint transboundary study involving Ethiopia and Kenya be initiated with the intent to ultimately reach a mutually beneficial Agreement with regard to the development and management of the Turkana Basin based on international law and best practice.
- 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.
- Implementation and enforcement of the Q95 flow downstream of proposed dams and large-scale irrigation schemes to maintain the ecological health of the rivers.

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

Table E5. RV Basin Water Resources Development Investment Plan

Proposed Infrastructure Development - Water Resources, Hydropower & Large-Scale Irrigation							Expenditure (USD Million)																						
									Phasing (Year)																				
Scheme		1:10 Yield (MCM/a)	Purpose				Feasibility ESIA / Design	Capital	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
			Water Supply	Hydropower	Flood Control	LS Irrigation																							
Multi-purpose Dam Projects	Capacity						53	350																					
Arror	70 MCM; 60 MW	42		💧		💧	28	189	63	63	63																		
Upper Narok	10 MCM	9	💧			💧	6	38								6	19	19											
Embobut	40 MCM; 45 MW	26		💧		💧	18	123													18	62	62						
Inter-basin Transfers							118	787																					
Itare Dam (LVS) / Transfer to Rift Valley Basin	20 MCM; 41 MCM/a	13	💧				45	301	100	100	100																		
Amala Dam (LVS) / Transfer to Rift Valley Basi	175 MCM; 82 MCM/a	68		💧			73	486										36	36	162	162	162							
Hydropower							153	1017																					
Ewaso Ng'iro South (LENSDEP): Oletukat	406 MCM; 25 MW	-		💧			86	573																		43	43	287	287
Ewaso Ng'iro South (LENSDEP): Leshota	247 MCM; 56 MW	-		💧			40	269															20	20	135	135			
Ewaso Ng'iro South (LENSDEP): Oldorka	95 MCM; 99 MW	-		💧		💧	26	175											13	13	88	88							
Dams - water supply (domestic)							27	177																					
Malewa	73 MCM	28	💧				22	146				11	11	49	49	49													
Siyoi-Muruny	17 MCM	9.6	💧				5	31		5	10	10	10																
Dams - large scale irrigation							80	534																					
Lowaat	383 MCM	226				💧	58	386									29	29	129	129	129								
Radat	135 MCM	81				💧	19	127							10	10	42	42	42										
Waseges	5 MCM	3.1				💧	3	21			3	11	11																
Small dams / pans & Boreholes							33	221																					
Dams and pans	61 MCM	-	💧				22	148	11	11	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
Groundwater (Boreholes)	153 MCM/a	-	💧				11	73	5	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Large Scale Irrigation Schemes (excl. dams)							133	886																					
Arror	2 000 ha	-				💧	6	39		6	13	13	13																
Expand Turkwel Dam	Expand by 4 000 ha	-				💧	9	59	4	4	20	20	20																
Turkwel Sugar	6 000 ha	-				💧	18	118		9	9	39	39	39															
Upper Narok	2 000 ha	-				💧	6	39										6	39										
Lower Ewaso Ng'iro South	15 000 ha	-				💧	44	296												22	22	49	49	49	49	49	49		
Embobut	1 000 ha	-				💧	3	20														3	10	10					
Waseges	470 ha	-				💧	1	4				1	2	2															
Todonyang-Omo	2 000 ha	-				💧	6	39							3	3	13	13	13										
Lowaat	10 000 ha	-				💧	30	197										15	15	66	66	66							
Perkerra	Expand by 5 000 ha	-				💧	11	74							6	6	25	25	25										
								O&M Cost	4	8	14	16	19	21	23	24	27	30	37	46	57	68	71	73	78	83	84	92	99
								Total Annual Cost (USD Million)	**188**	**212**	**244**	**133**	**137**	**123**	**101**	**108**	**167**	**227**	**361**	**449**	**553**	**509**	**224**	**164**	**273**	**321**	**188**	**390**	**397**

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

In order to comprehensively and systematically address the range of water resources related issues and challenges in the RV Basin and to unlock the value of water as it relates to socio-economic development, ten key strategic areas were formulated for the RV 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	6.5	32.6	29.0	21.2	**89**
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	16.0	30.4	22.6	40.3	**109**
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	4.1	25.6	71.9	95.8	**197**
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	11.0	10.7	7.1	**33**

Key Strategic Areas and Themes		Budget (USD Million)				
		2020-2022	2022-2025	2025-2030	2030-2040	Total
KSA 6	**Flood and drought management** - Flood management - Drought management	6.4	35.2	3.9	6.8	**52**
KSA 7	**Hydromet monitoring** - Improved monitoring network - Improved information management	1.0	13.1	5.8	6.0	**29**
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	255	403	939	2439	**4 036**
KSA 9	**Strengthen Institutional frameworks** - Promote improved and sustainable catchment management - Guidelines, codes of practice and manuals	5.3	2.6	2.9	2.0	**13**
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		**301**	**563**	**1 095**	**2 626**	**4 585**

E11. Roadmap for the Basin Plan

In order to ensure the successful implementation of the strategies and actions presented in the RV 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.

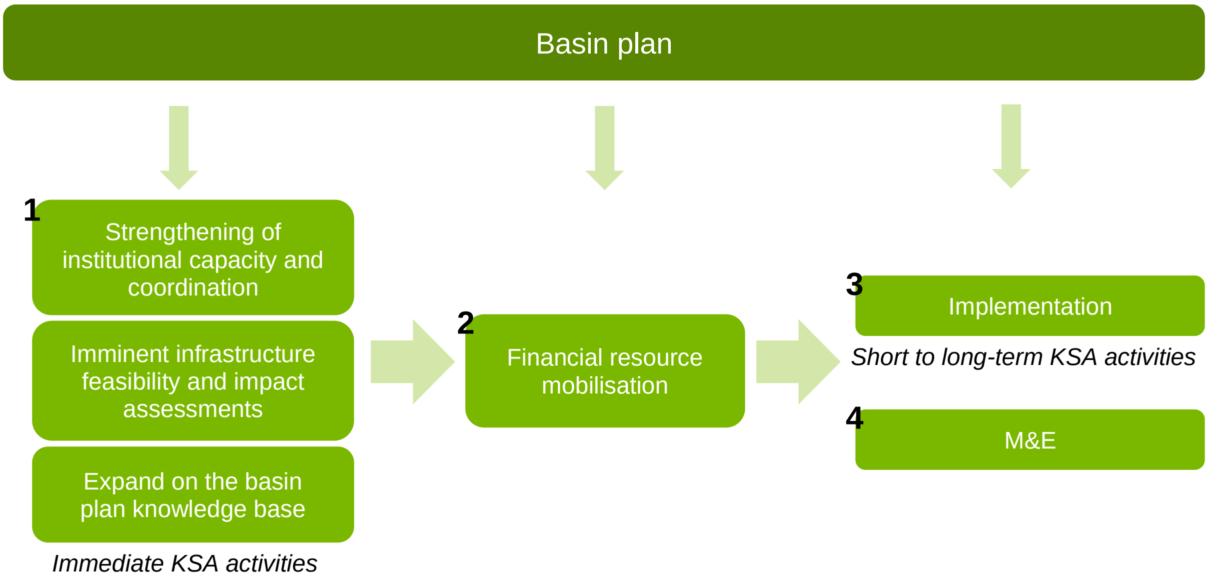

Figure E1: Roadmap for implementation of the Basin Plan

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Abbreviations and Acronyms

ASAL	Arid or Semi-Arid Land
AAS	Atomic absorption spectrometry
ADCP	Acoustic Doppler current profiler
AGOA	African Growth and Opportunity Act
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
CGs	County Governments
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
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

ERC	Energy Regulatory Commission
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
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
IDP	Integrated Development Plan
IPCC	Intergovernmental Panel on Climate Change
IUCN	International Union for Conservation of Nature
IWRM	Integrated Water Resources Management
KCCAP	Kenya Climate Change Adaptation Programme
KCDP	Kenya Coastal Development Programme
KCSAS	Kenya Climate Smart Agriculture Strategy
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
MAE	Mean Annual Evaporation
MAP	Mean Annual Precipitation
masl	Metres above sea level
MAR	Mean Annual Runoff
MCM	Million Cubic Metre
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
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
NET	National Environmental Tribunal
NGO	Non-Governmental Organisation
NIA	National Irrigation Authority
NLC	National Land Commission
NPS	Nonpoint source
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
PDB	Permit Database
RCP	Representative Concentration Pathways
REA	Rural Electrification Agency
RO	Regional Office
RQOs	Resource Quality Objectives
RV	Rift Valley
SANBI	South African National Biodiversity Institute
SCMP	Sub-Catchment Management Plan
SOPs	Standard operating procedures
SRO	Sub-Regional Office
TAMS	Tibbetts-Abbott-McCarthy-Stratton (first National Water Master Plan, 1977)
WAP	Water Allocation Plan
WASREB	Water Services Regulatory Board
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

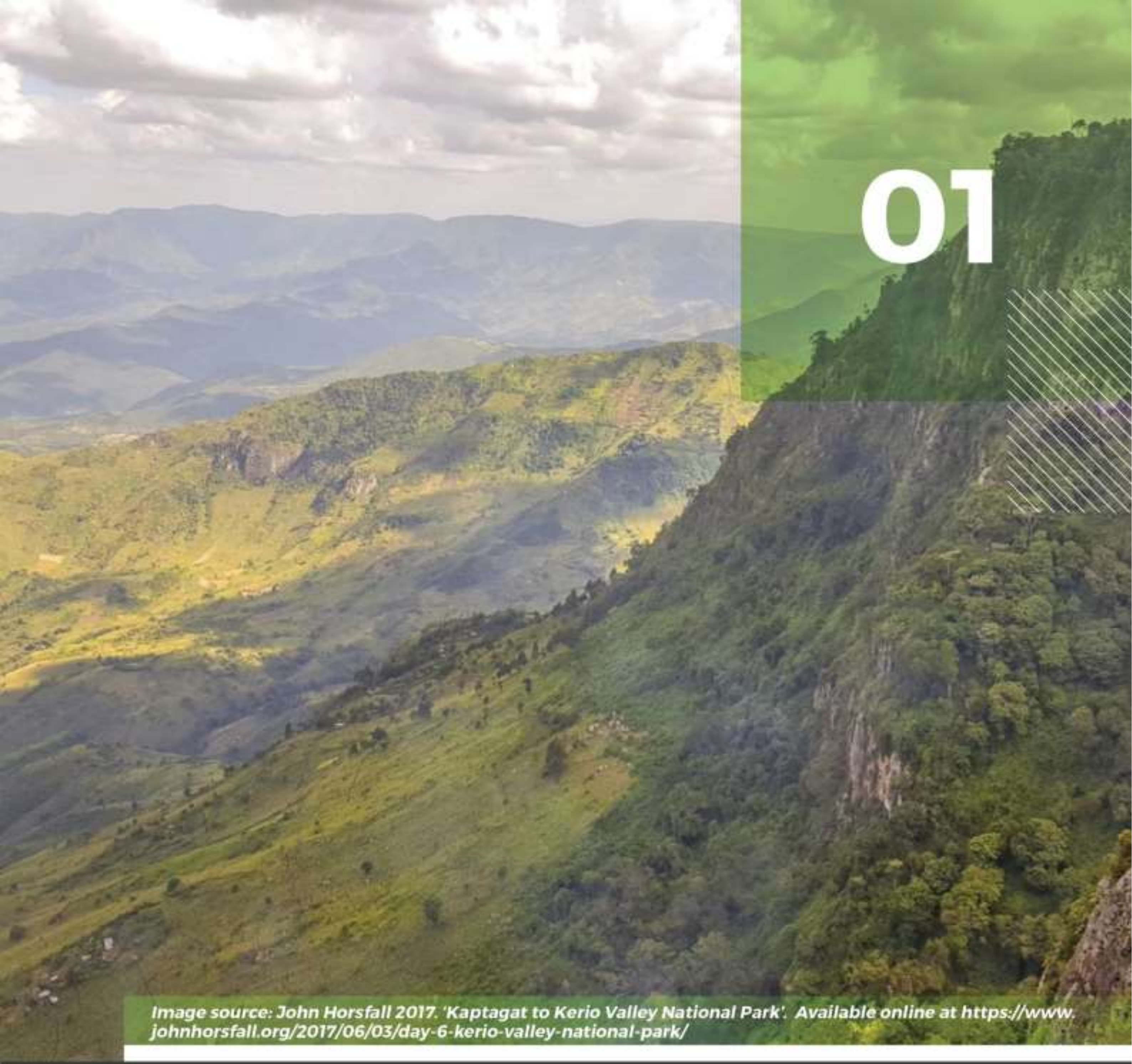


Image source: John Horsfall 2017. 'Kaptagat to Kerio Valley National Park'. Available online at https://www.johnhorsfall.org/2017/06/03/day-6-kerio-valley-national-park/

01

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 the 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 Plan 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 Rift Valley (RV) Basin**.**

Figure 1-1: RV Basin location map

1.2 Objectives of the Basin Plan for the RV Basin

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 RV Basin is to provide a clear pathway for the sustainable utilisation and development of the water resources of the RV 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 RV Basin Plan

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

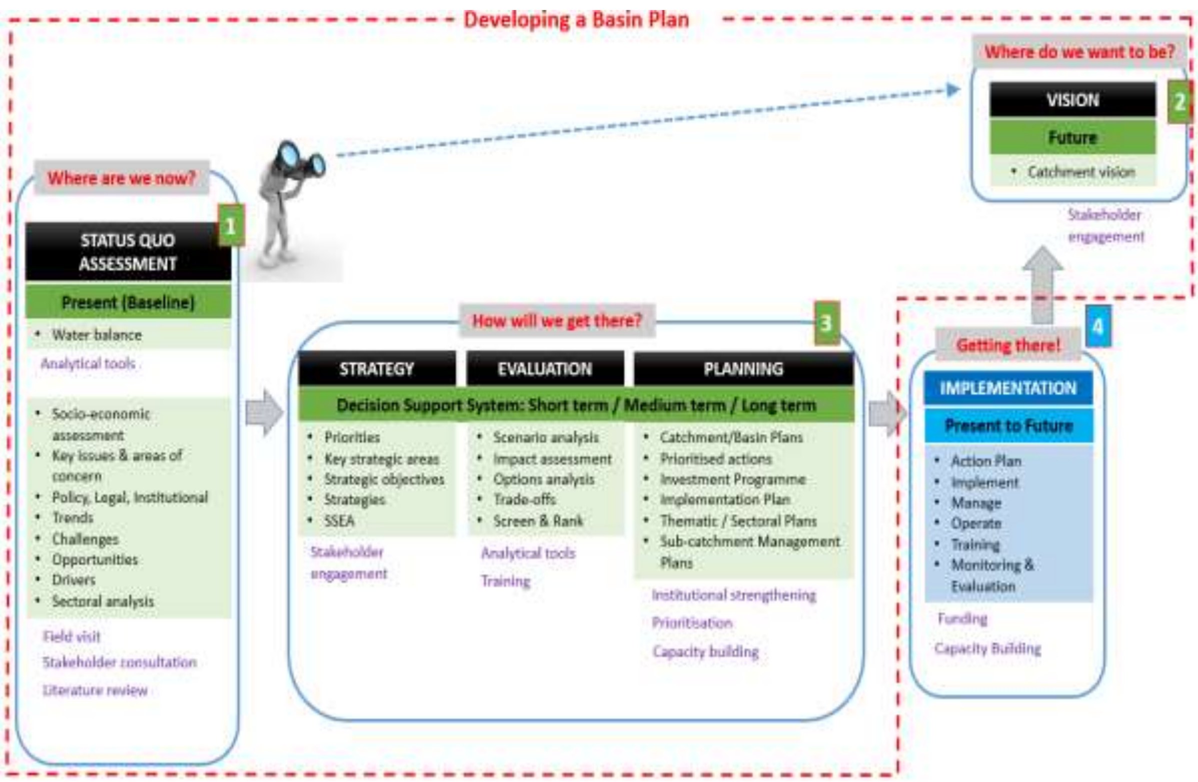


Figure 1-2: Conceptual approach to basin planning

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 RV Basin.

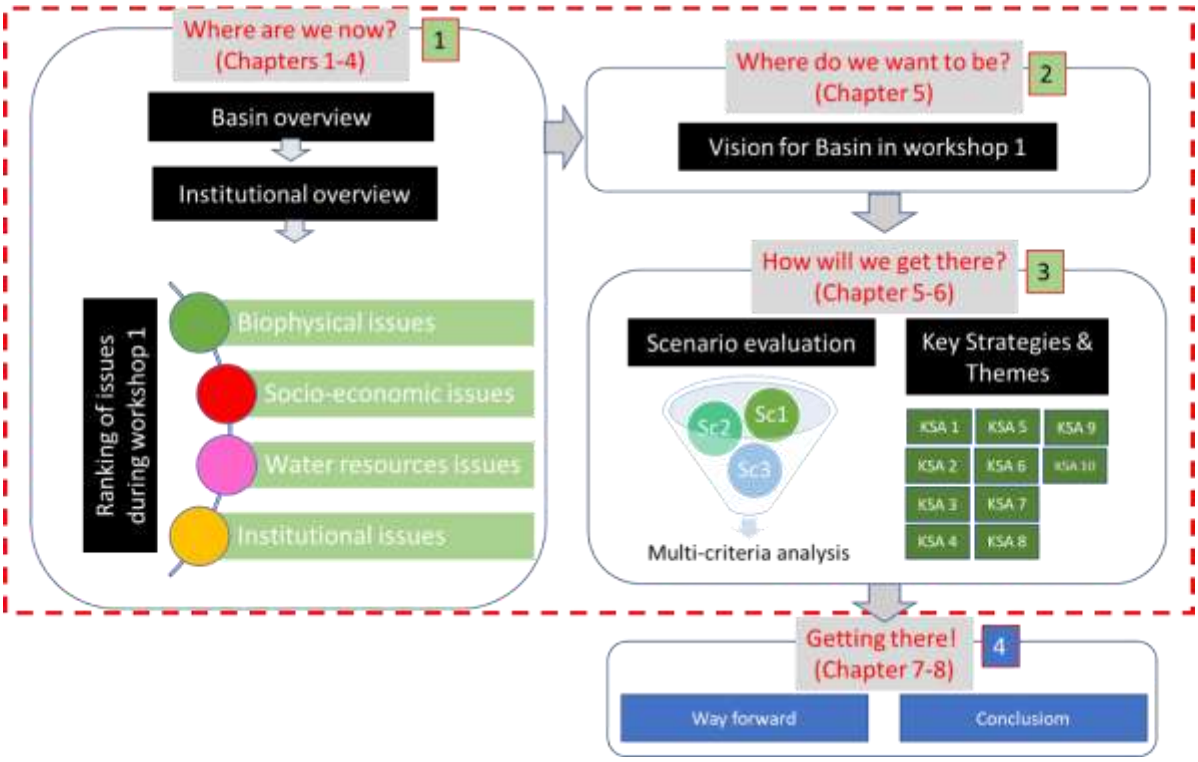


Figure 1-3: Key stages in development of RV Basin Plan

1.4 Structure of the 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 hydro-meteorological 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: Andrew Owuor 2012 'Lake Baringo, Kenya'. Available online at https://commons.wikimedia.org/wiki/File:Lake_Baringo_Kenya.jpg

02

Basin Overview

2 Basin Overview

2.1 Introduction

The RV Basin has an area of 131 423 km^2 [1]. It has a long, narrow shape bordering South Sudan and Ethiopia in the north and Tanzania in the south. The bottom half of the basin is bordered by the Lake Victoria North and South basins to the west, and the Athi and Tana basins to the east. The central and northern part of the basin is bordered by Uganda to the west and the Ewaso Ng'iro North Basin to the east. The RV Basin covers about 23% of Kenya's area and houses 13% of the total population of Kenya. Lake Turkana is located in the northern RV Basin and is the largest lake in Kenya. An overview of the RV Basin, showing the major towns, roads and existing dams is shown in Figure 2-1.

The RV Basin includes 12 counties, some of them only partly, as they cross hydrological boundaries (Figure 2-2). The main counties situated within the RV Basin are as follows: Turkana; Marsabit; Samburu; West Pokot; Elgeyo Marakwet; Baringo; Laikipia; Nyandarua; Nakuru; Narok; Kajiado and Kiambu.

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

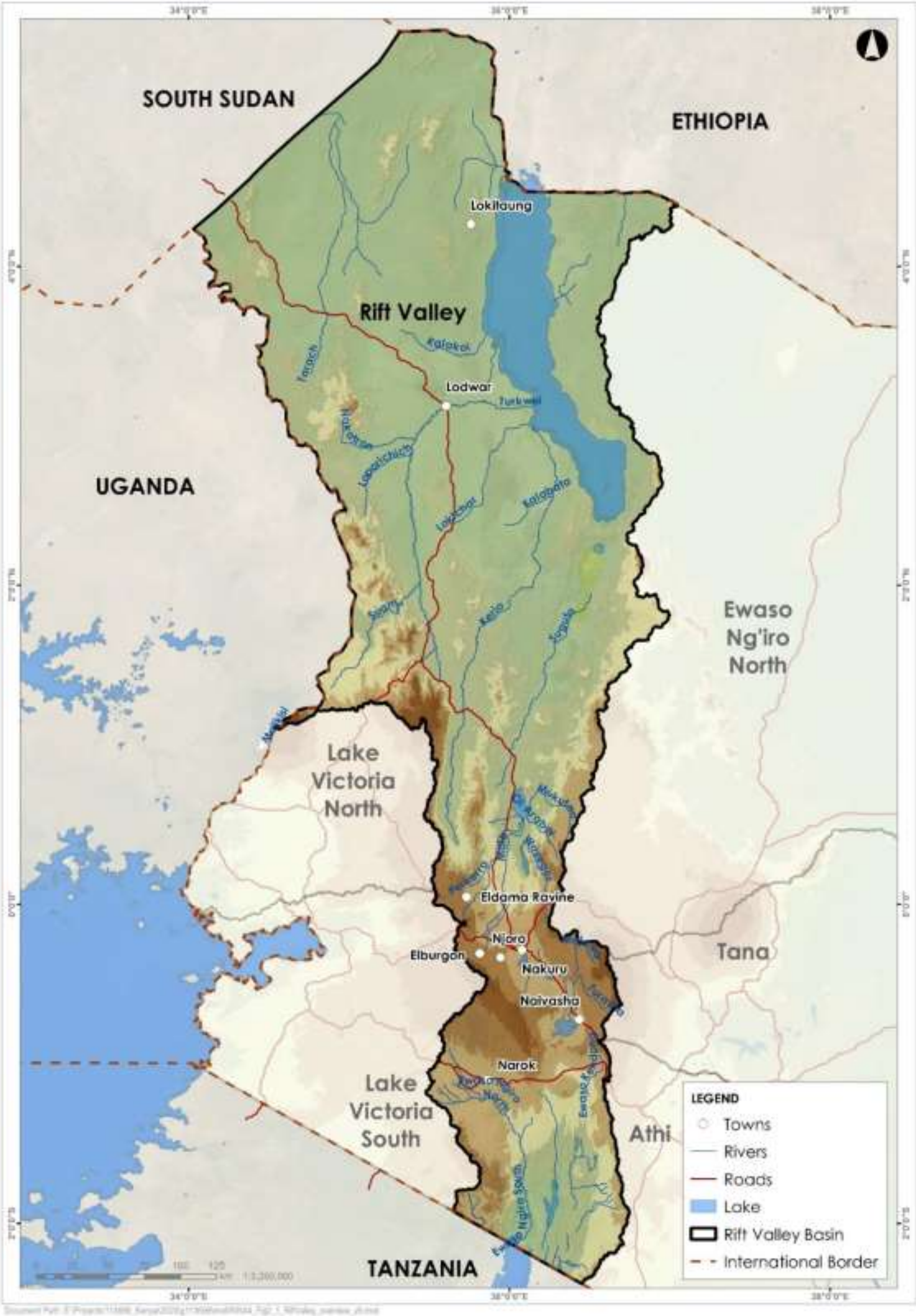


Figure 2-1: Overview map of RV Basin

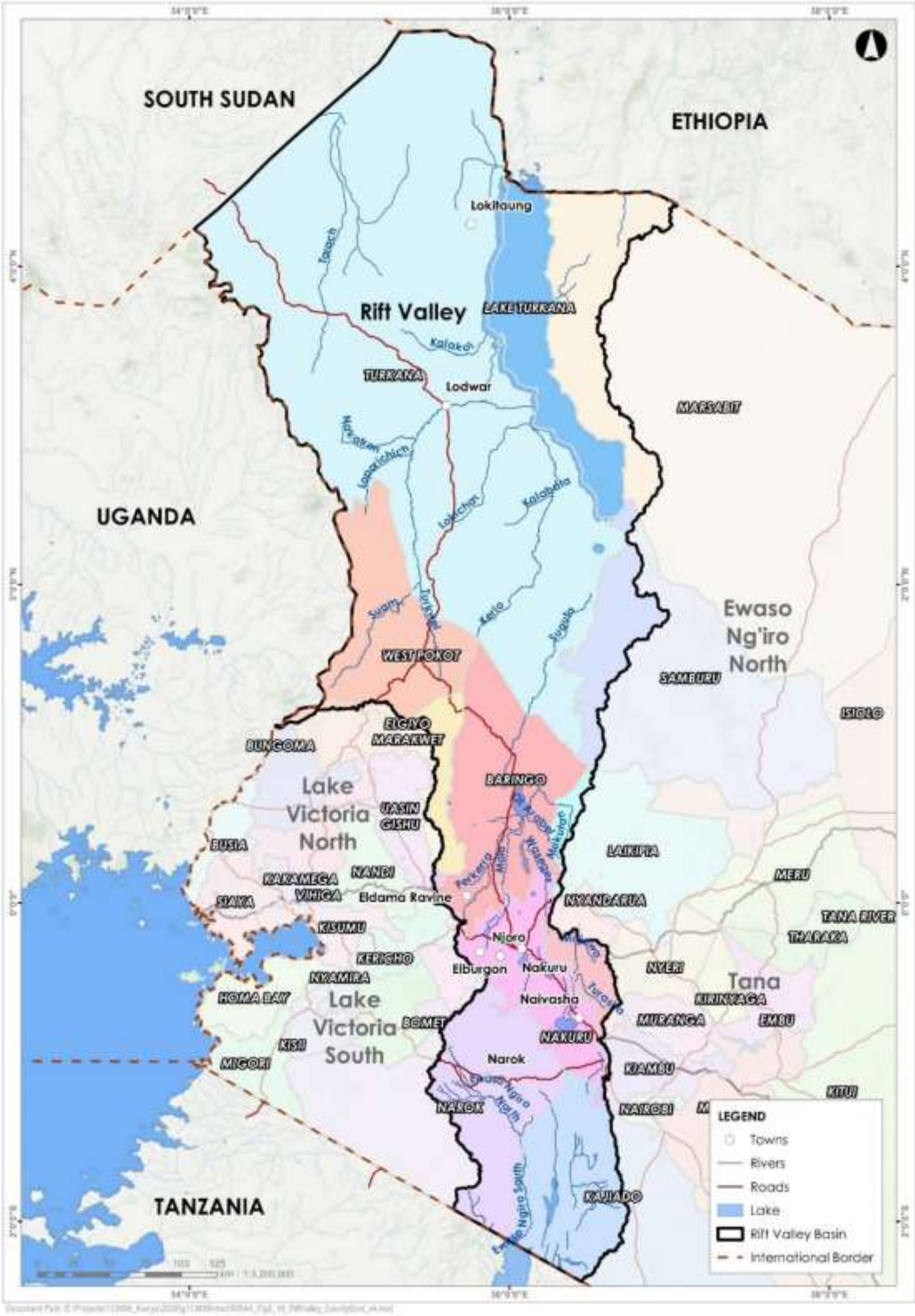


Figure 2-2: Counties within the RV Basin

The major towns in the catchment are Nakuru, Narok, Kabarnet, Naivasha and Lodwar. Nakuru is the largest town in the basin and hosts an extensive industrial area. The northern part of the basin is classified as arid land and is one of the driest parts of the country. The central part of the basin is surrounded by the water towers of Cherangani Hills, Mau Forest and the Aberdare Range, forming the so-called ‘Rift Valley’ from which the catchment gets its name.

2.2 Bio-physical

2.2.1 Physiography

2.2.1.1 Topography and landforms

As evident from Figure 2-3 the topography of the RV Basin varies from the mountainous areas in the central-southern part at elevations up to 2 600 masl to elevations of less than 500 masl at lake Turkana in the north and about 600 masl at Lake Magadi in the far south.

The terrain slope categories within the RV Basin are shown in Figure 2-4. Most of the basin is gently sloping except for Chengani Hills and the Mau Escarpment along the central-southern western border and the Aberdares along the central eastern border. Other steep areas surround the Lerochi Plateau and the Chepanda Hills north of Nakuru.

The RV Basin landforms are the result of volcanic activity creating complex landforms, plains and mountains. Lake Turkana forms the lowest feature in the Basin, within surrounding plains and mountains. Between the Aberdares and the mountains bordering Lake Victoria North and Lake Victoria South, the landforms consist of plateaux, hills, mountains and volcanic shield/craters. Figure 2-5 displays the dominant landforms in the RV Basin.

2.2.1.2 Soils

The Soil Atlas of Africa (Jones et al., 2013) was used as a reference for the soil types found across the RV Basin due to its detailed soil mapping base. A soil map of the Basin is included as Figure 2-6 while the main soil types found are listed in Table 2-2.

The main soil types in the northern parts of the catchment are Solontez, Fluvisols (floodplains), Arenosols, Planosols, Regosols and Cambisols. The central parts of the catchment are made up of mainly Regosols, Arenosols, Calcisols, Planosols and Nitisols. The southern parts of the catchment are made up of mainly red Nitosols, Cambisols, Planosols, Phaeozems, Regosols and Andosols.

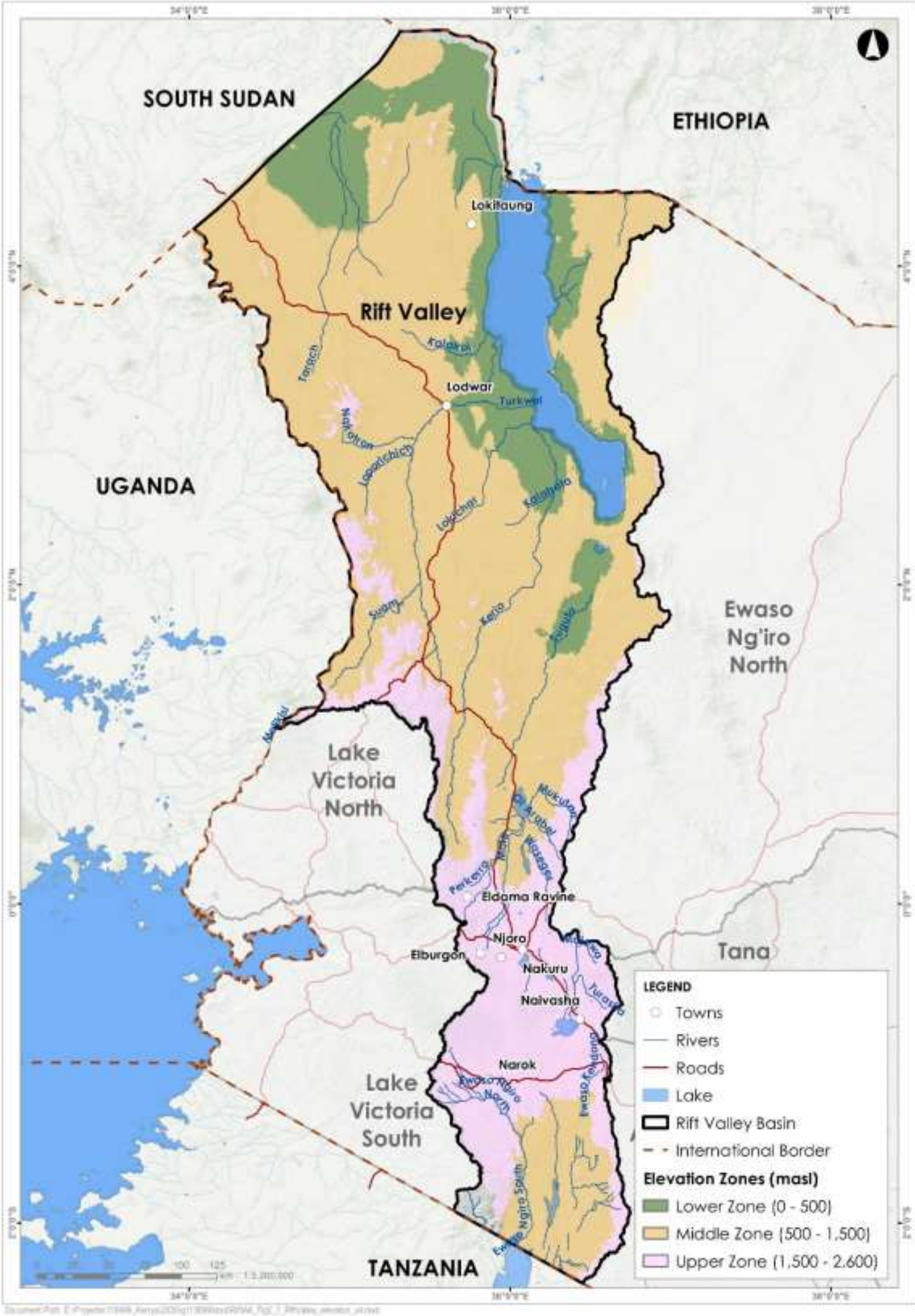


Figure 2-3: Elevation zones in the RV Basin

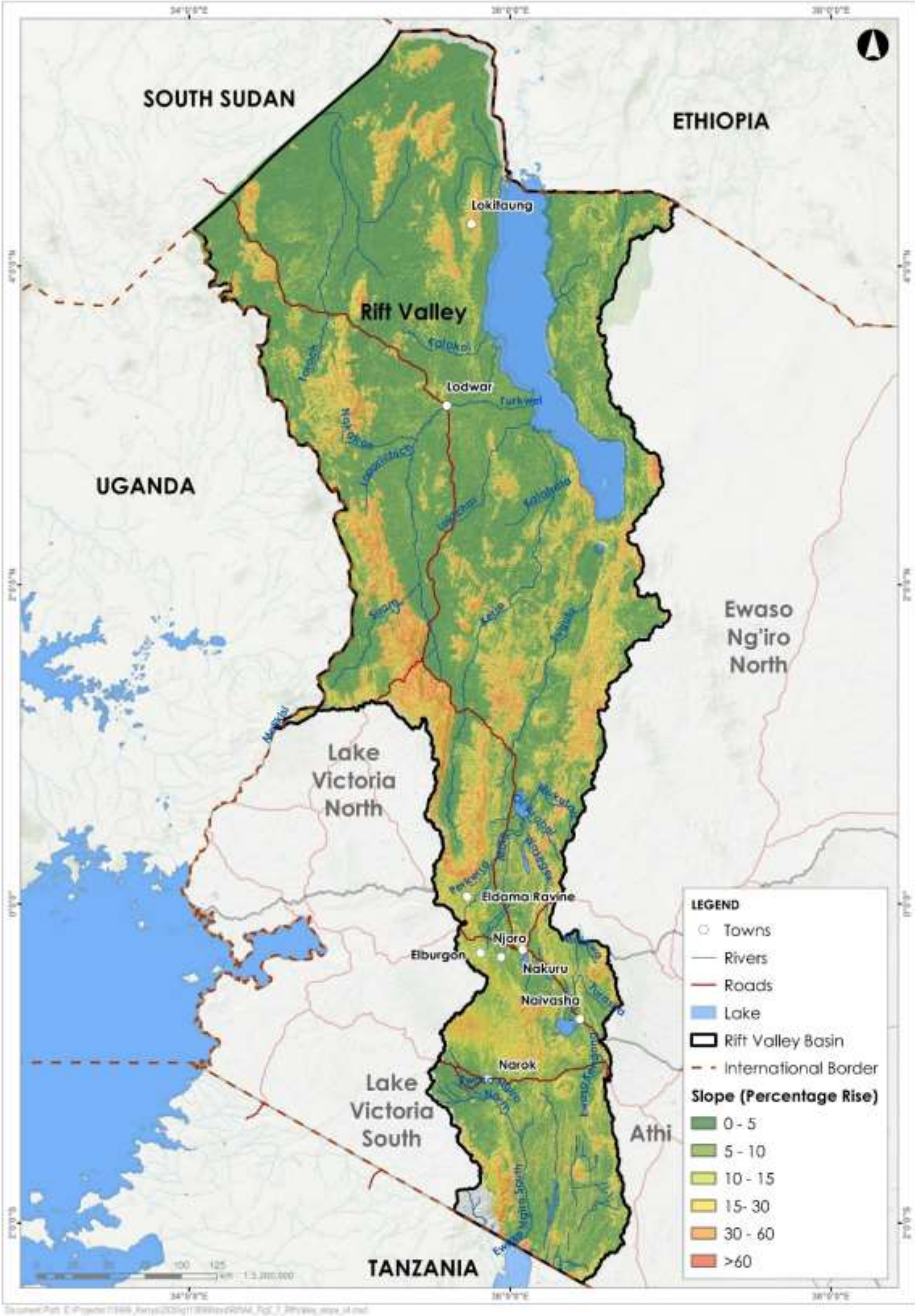


Figure 2-4: Slope categories in the RV Basin

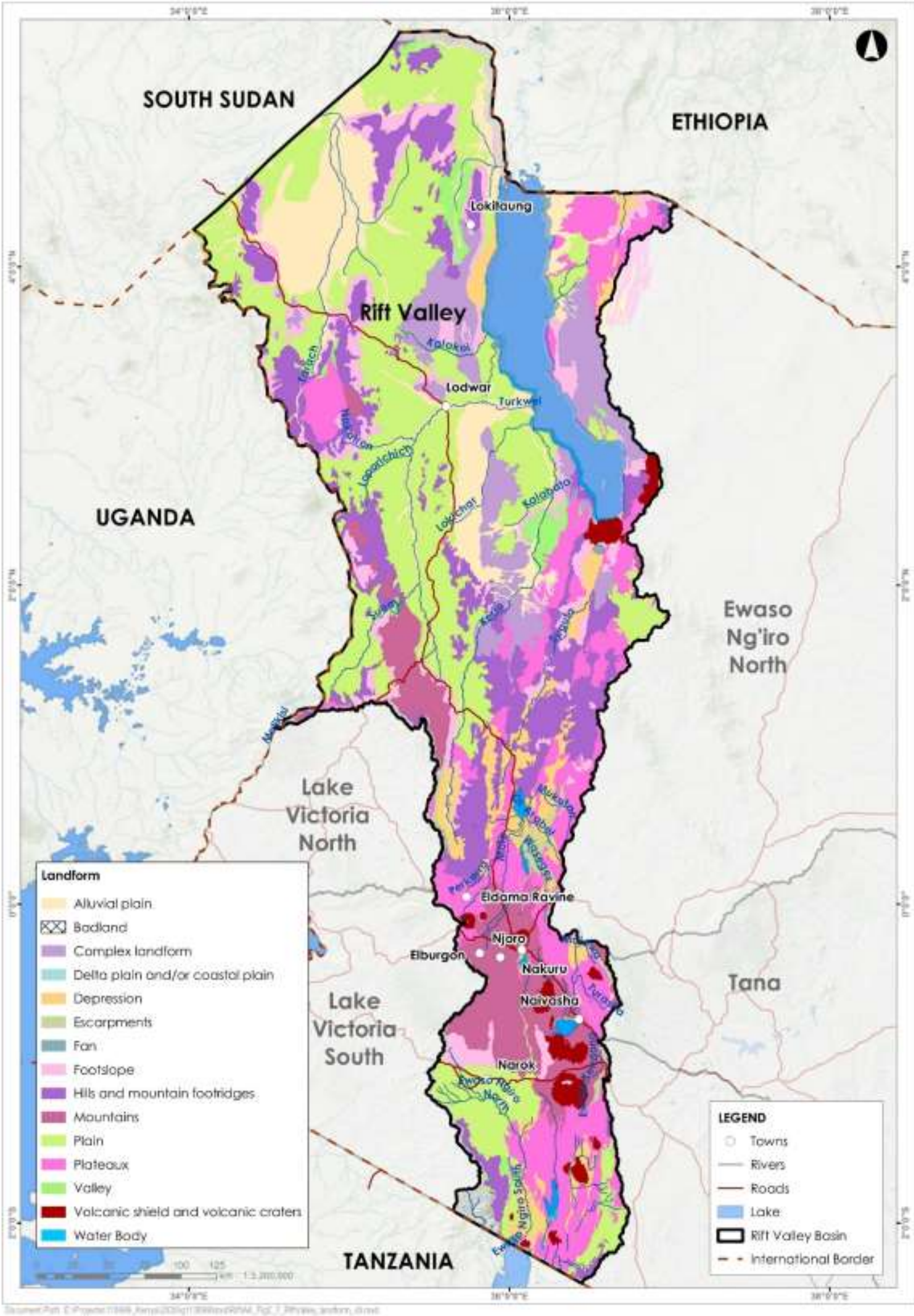


Figure 2-5: Landforms of the RV Basin

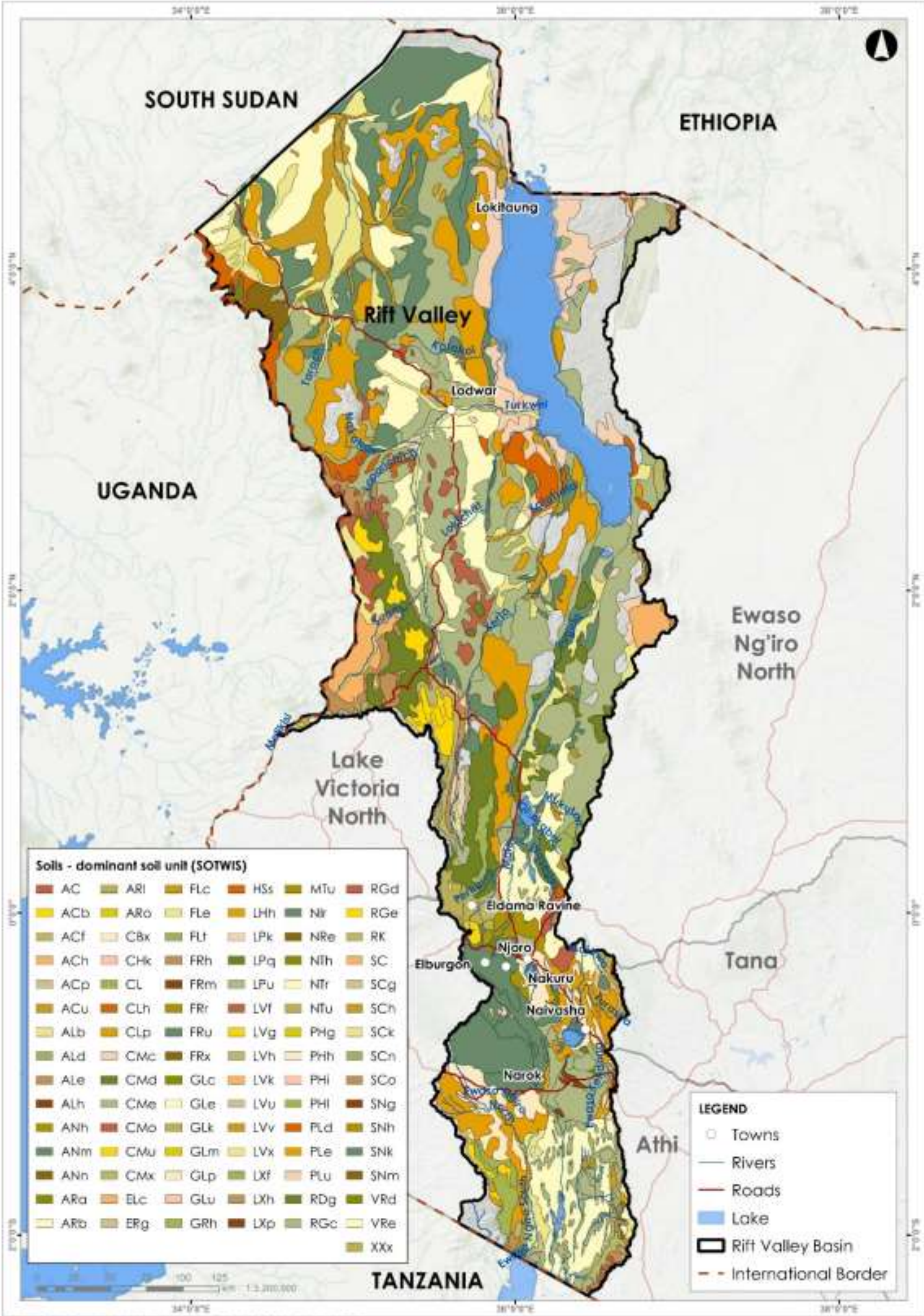


Figure 2-6: Soils in the RV Basin

Table 2-1: Soil Classification Indexes for the RV Basin

Soil Index	Description	Soil Index	Description	Soil Index	Description
ACh	Haplic Acrisols	**GLe**	Eutic Gleysols	**PHl**	Luvic Phaeozems
ACu	Humic Acrisols	**HSs**	Terric Histosols	**PLd**	Dystric Planosols
ANh	Haplic Andosols	**LPk**	Rendzic Leptosols	**PLe**	Eutric Planosols
ANm	Mollic Andosols	**LPq**	Lithic Leptosols	**PLu**	Umbric Planosols
ARb	Cambic Arenosols	**LVf**	Ferric Luvisols	**RGc**	Calcaric Regosols
CLh	Haplic Calcisols	**LVh**	Haplic Luvisols	**RGd**	Dystric Regosols
CMc	Calcaric Cambisols	**LVk**	Calcic Luvisols	**SCg**	Gleyic Solonchaks
CMd	Dystric Cambisols	**LVv**	Vertic Luvisols	**SCh**	Haplic Solonchaks
CMe	Eutric Cambisols	**LVx**	Chromic Luvisols	**SCk**	Calcic Solonchaks
CMu	Humic Cambisols	**LXh**	Haplic Lixisols	**SNg**	Gleyic Solonetz
CMx	Chromic Cambisols	**NTh**	Haplic Nitisols	**SNk**	Calcic Solonetz
FLc	Calcaric Fluvisols	**NTr**	Rhodic Nitisols	**SNm**	Mollic Solonetz
FLe	Eutric Fluvisols	**NTu**	Humic Nitisols	**VRe**	Eutric Vertisol
FRu	Humic Ferralsols	**PHh**	Haplic Phaeozems		

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

Soil Type	Description
Solonetz	Alkaline soils. Clay-rich subsoil. High sodium content. Supports natural habitats. Utilised for grazing. Flat lands in hot, dry climate or former coastal deposits.
Fluvisols	Found in flood plains, lakes, deltas or marine deposits. High agricultural potential, but risk of flooding or waterlogging.
Arenosols	Sandy textured soils that exhibit only a partially formed surface horizon that is low in humus and they are lacking subsurface clay accumulation.
Planosols	Characterised by a subsurface layer of clay accumulation. Occur in low-lying areas that can support either grass or open forest vegetation.
Regosols	Characterised by unconsolidated parent material that may be of alluvial origin and by the lack of significant soil horizon formation because of dry or cold climatic conditions.
Cambisols	Young soils. Various characteristics depending on factors. One of the better agricultural soils due to good nutrient-holding capacity.
Calcisols	Characterised by a layer of translocated calcium carbonate at some depth in the soil profile. Usually well drained soils and are relatively fertile because of high calcium content.
Nitisols	The most inherently fertile of the tropical soils because of the high nutrient content and deep, permeable structure. Iron oxides and water play an important part in creating the soil structure and the influence of biological activity results in homogenization of the upper soil profile.

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. The upper Basin has a high potential for erosion considering the inherent soil and slope characteristics, and high rainfall erosivity. The lower Basin has a lower potential for erosion due to the reduced slopes and rainfall erosivity. Vegetation cover provides a greater influence on erosion rates in the upper Basin.

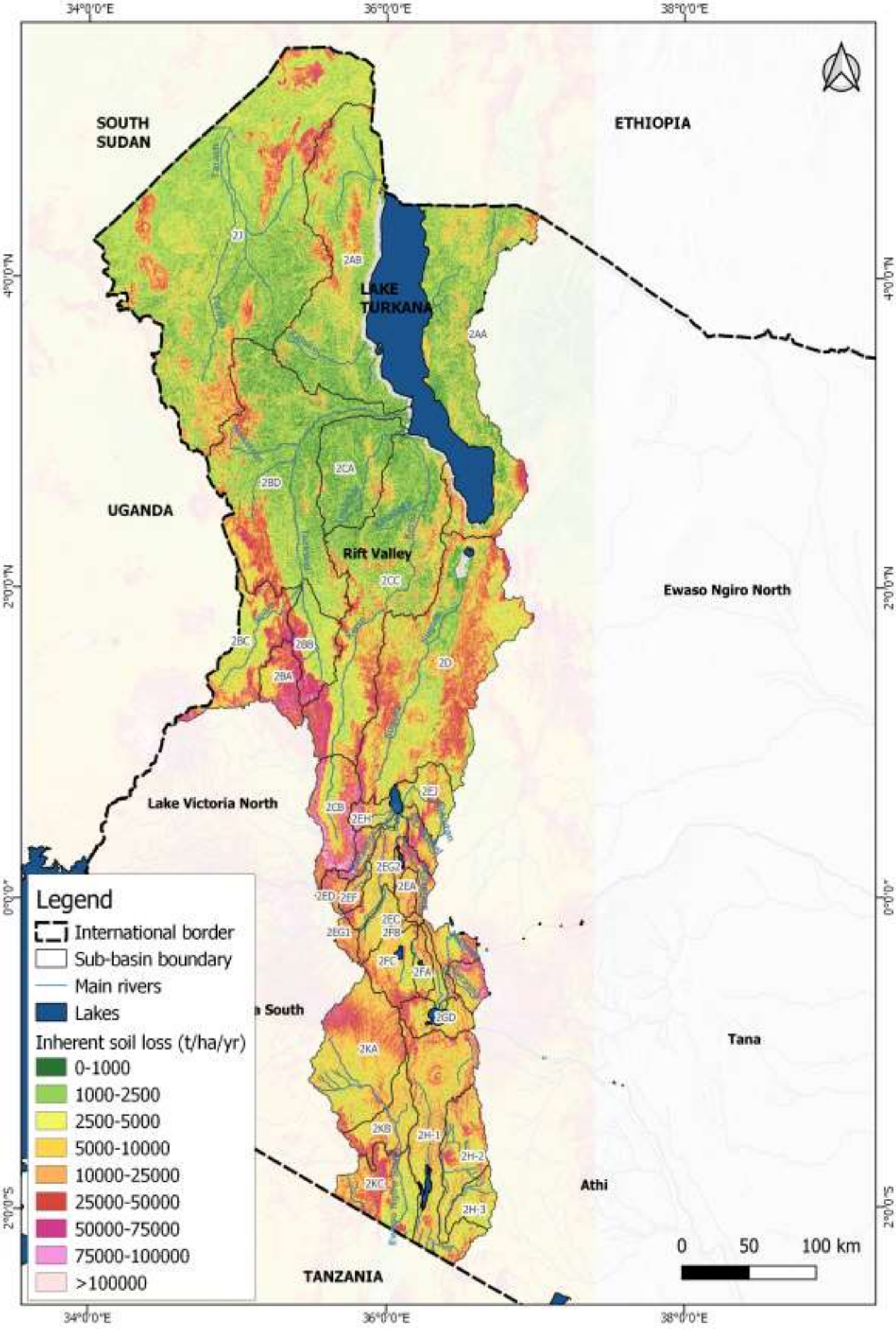


Figure 2-7: RV Basin Inherent Soil Erosion Risk (C and P factor not included)

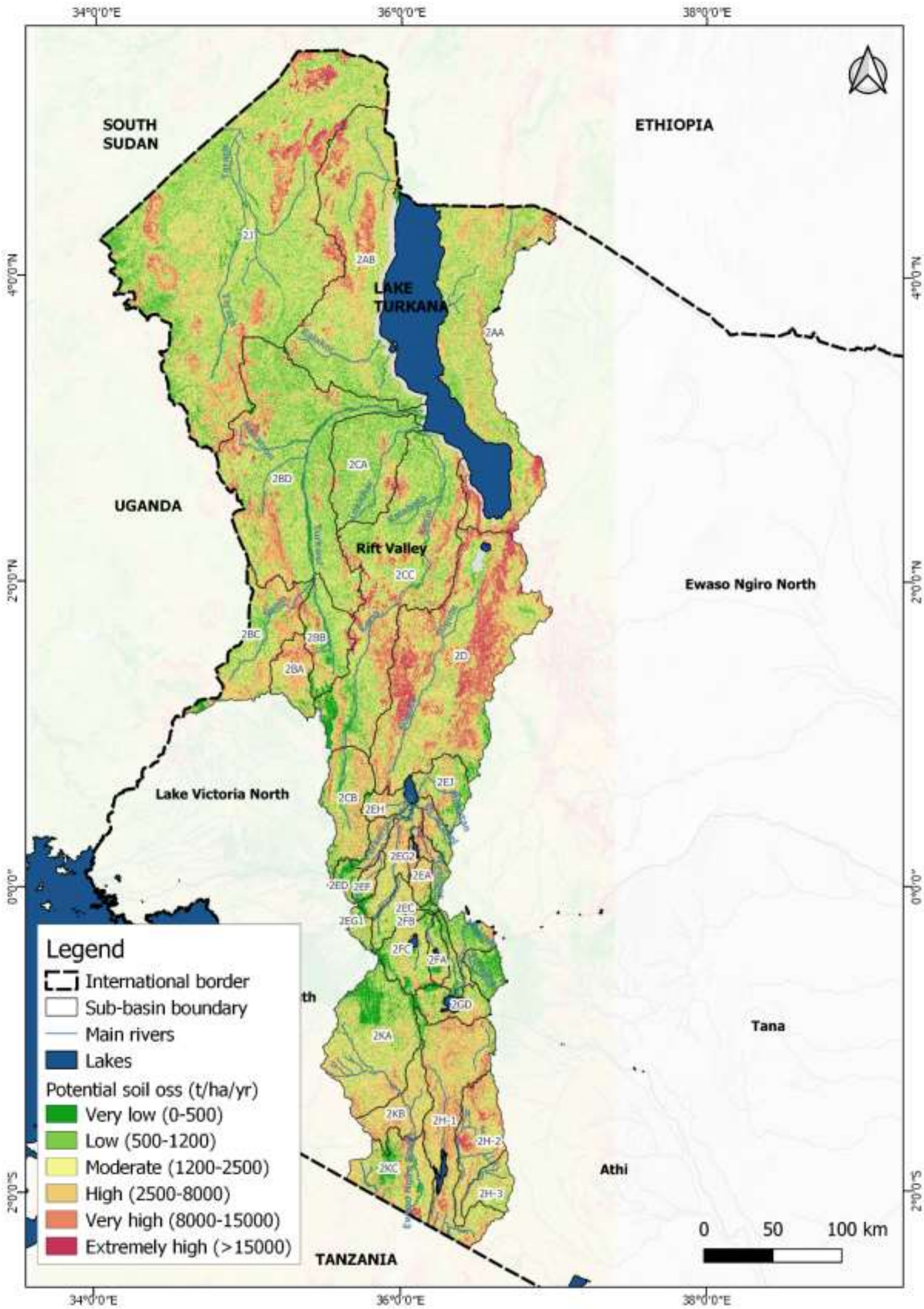


Figure 2-8: RV Basin Potential Soil Erosion Risk

2.2.1.3 Geology and hydrogeology

Geology and groundwater characteristics

The RV Basin is made up of Quaternary sediments, Tertiary and Quaternary volcanics and Basement rocks (Figure 2-9). The underlying geology relates to the formation of the East African Rift, formed through the diversion of the Somalian plate from the Nubian plate which initiated approximately 25 million years ago. This formation is characterized by volcanic activity, brittle faulting and large half graben systems filled with river and lake sediments.

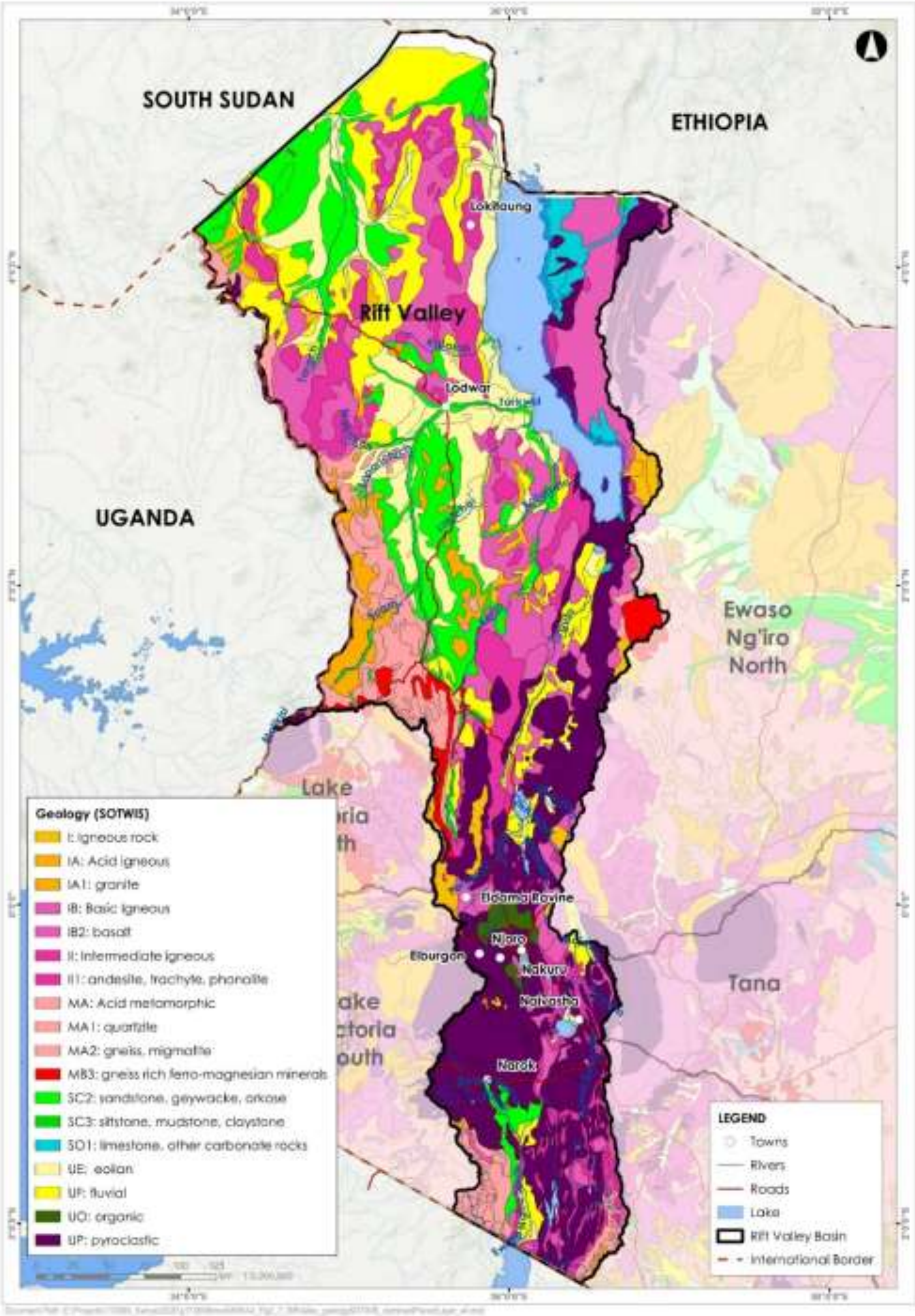


Figure 2-9: Geology in the RV Basin

The RV Basin is characterised by complex, faulted and internally-drained basins all contained within the Gregory RV. This makes a simple description of the Basin impossible. This section briefly introduces each of the main basins, starting from the south. Focus is placed on the means by which the basin lakes are supported by surface groundwater inflows and outflows, as this determines how groundwater moves in each of these basins and defines groundwater availability. In the majority of cases, groundwater flows from the elevated, humid Rift rims, that lie east and west of the Valley, towards the lakes that form the sump in each basin. In the sections that follow, less detail is provided for the more populous sub-basins for which groundwater resources data are readily available (Naivasha, Nakuru and Baringo in particular). Greater detail is provided for the sparsely populated ASAL sub-basins, for which groundwater data are relatively sparse and the level of understanding lower.

- Ewaso Ng'iro South basin

The perennial Ewaso Ng'iro South River derives much of its stream flow from the Mau, but some additional sub-surface inflow may occur from the ephemeral streams that drain the eastern flank of the Loita Hills and the Nguruman Escarpment. These streams are perennial until they meet the colluvial deposits at the base of the Nguruman Escarpment, into which they percolate, resulting in shallow groundwater recharge. The entire basin is underlain by volcanic rocks and associated sediments, except for the Loita Hills, which are folded and faulted metamorphic Basement.

- Magadi basin

The Magadi Basin is separated from Ewaso Ng'iro South basin by a line of horsts west of Lake Magadi. The horsts reflect the intense south-north faulting that characterises much of the RV (Baker, 1958, 1963). The surface water catchment is almost entirely ephemeral throughout, with groundwater flowing from the area south of Mount Suswa, supplying the soda springs around the Lake that maintain the trona deposits. This is supplemented by sub-surface leakage from the Ewaso Ngiro South (Becht et al., 2006; Eugster, 1970). There is a single significant spring-fed stream (the Little Ewaso Kedong) that discharges from the base of the Kikuyu Escarpment in Kiambu County. This discharged between 2 811 and 5 563 m^3/d as a monthly average between 1959 and 2009 (Gitiligini Ltd, 2010). Water quality is excellent (TDS 176 mg/L, fluoride 0.39 mg/L; *ibid.*).

Research has shown that underground discharge from Lake Naivasha supports Lake Magadi (Becht et al., 2006). This basin is entirely underlain by volcanic rocks and associated sediments, including the Magadi Trona Beds that support the soda ash mine at Magadi. Groundwater availability is good in the upper part of the basin, south east of Naivasha. Paron et al. (2013) report transmissivities of 400 m^2/d in this area. However, groundwater is hard to obtain in the middle and lower Magadi basin, with considerable drilling depths required to reach water. D. J. Allen et al. (1989) observed that a 300 m deep borehole drilled east of Mount Suswa was dry. Water is often of poor quality here (EC > 3,000 μS/cm). Shallow well and seepage waters east of Lake Magadi have TDS ranges of 175 to 2 000 mg/L, with fluoride from 1.0 to 3.2 mg/L (Jones *et al*, 1977). Two NAWARD water analyses for groundwaters close to the eastern edge of the Magadi basin are reasonably good (TDS 250 to 752 mg/L, fluoride <LoD to 2.0 mg/L).

- Naivasha basin

The Naivasha lake is fed by perennial and ephemeral surface water flows from the eastern side of the RV (the Aberdares), supplemented by groundwater inflows from the eastern and western sides of the Lake (Becht et al., 2006). Sub-surface outflows head northwards beneath the surface water divide expressed by Eburru volcano to Lakes Elmenteita, Nakuru, Bogoria and Baringo, and southwards to Lake Magadi. The geology is entirely volcanic (Pleistocene and Holocene), with extensive lake bed deposits present around the Lake and the lower parts of the basin (Government of Kenya, 1988; Thompson & Dodson, 1963). Groundwater from the Naivasha basin can be fluoride rich, in cases at very significant concentrations (6 to 25 mg/L) (Water and Sanitation for the Urban Poor, 2011). Yields from boreholes can be very substantial, over 200 m^3/hr (Reta, 2011)[2].

- Lake Elmenteita basin

Lake Elmenteita is fed by sub-surface water from the losing streams that otherwise flow into it during wet seasons (the Mereroni, Mbaruk and Kariandusi streams). Hot springs along the base of the Mbaruk Fault and at Cole's Spring (today the Kekopey Spring) (McCall, 1967) also feed the tributary streams and the Lake. The Lake is also fed by groundwater flowing from the fresh Lake Naivasha to the south (Becht et al., 2006). Natural groundwater fluoride concentrations are typically high (0.03 to 21.5 ppm, mean 6.57, SD±6.07 ppm) (Wambu & Muthaki, 2011).

- Nakuru basin

Lake Nakuru is largely fed by rainfall, groundwater (from the Rift margins to the east and west), by sub-surface discharge from Lake Elmenteita, perennial losing streams, and possibly directly from Lake Naivasha (Becht et al., 2006). The Njoro River is a losing stream through much of its length, losing water to the numerous faults that criss-cross the basin (McCall, 1967). The groundwater resources of the Nakuru area have long been exploited for public, farm, private and commercial/industrial water supply (McCall, 1958; Water Resources Management Authority, 2015b). The Kabatini aquifer system is a key component in Nakuru water supply, suppling the bulk of municipal supply from four wellfields (Water Resources Management Authority, 2015b). Fluoride is very often a problem natural constituent in Nakuru basin groundwaters, with average values of 11.1 mg/L (Gevera & Mouri, 2018).

- Bogoria basin

Thermal spring discharge into Bogoria Lake has been estimated at 6.7 MCM/a (Institute of Hydrology, 1985), while total groundwater inflow is estimated at 28 million m^3/yr (Becht et al., 2006). There is also believed to be sub-surface inflow from Lake Nakuru (Becht et al, 2006). Groundwater availability is poor to good (Olago et al., 2009; Paron et al., 2013), and is typically of poor quality (EC > 3,000 µS/cm), particularly in the lower parts of the basin near the lake, where groundwater fluoride in thermal spring waters in the Lake margins average 127 mg/L, while typically being less than 2 mg/L in the upper parts of the basin where recharge occurs (Institute of Hydrology, 1985). The basin is bordered by fault-scarps and is entirely underlain by volcanic rocks (Hackman et al., 1988)

- Baringo basin

The Baringo basin is a closed basin hosting the freshwater Lake Baringo, with sub-surface discharge to the north (Becht et al., 2006). Aquifers are widespread and poor to good in water quality (Olago et al., 2009; Paron et al., 2013), and frequently contain excessive concentrations of fluoride, ranging from <1.55 to >12 mg/L (Kenya Bureau of Standards, 2010). The basin is entirely underlain by volcanic and associated rocks (Ministry of Energy and Regional Development, 1987), including the significant palaeolake deposits of the Lukeino Formation in the Tugen Hills (Pickford & Senut, 2001).

- Suguta basin

The Suguta basin is defined by the Suguta Trough, with west and eastern margins bounded by Rift faults (Key & Ridgway, 1987; Ochieng & Kagasi, 1988). In addition to rainfall-generated streamflow, the Suguta River receives considerable volumes of thermal spring flow, particularly at the Kapedo (1 m^3/s) and Lurosio Springs. The Kapedo spring flow forms the Suguta River's baseflow (D. J. Allen & Darling, 1992). Isotope studies show that a proportion of these waters originated in part from Lake Baringo (about 30%), later confirmed by Becht et al. (2006). The geology and hydrogeology of the Suguta is discussed exhaustively by Dunkley et al. (1993) and D. J. Allen & Darling (1992), and show that groundwater is apparently quite widely available (yields ranging from 103 to 1 088 m^3/d). Groundwater is typically of poor quality, due to excessive fluoride. Samples from three boreholes in the upper Suguta Valley had TDS ranges from 622 to 5 090 ppm, and fluoride from 10.1 to 14.0 ppm. Thermal spring

[2] When describing groundwater resources availability, we use the following classification: <5 m^3/hr as poor; 5-10 m^3/hr as moderate; 10-36 m^3/hr as good; >36 m^3/hr as high.

fluoride concentrations are typically a lot higher (fluoride between 27 to 110 mg/L), and fluoride concentrations in the Suguta River are also excessive, due to the Kapedo and Lorusio Springs fluoride concentrations (36 to 90 mg/L in the river) (Dunkley et al., 1993). Most of the basin is underlain by volcanic rocks and associated sediments. However, the north-eastern part of the basin drains basement groundwater from the Tum area (Ol Doinyo Nyiru), and further south the Baragoi River drains basement groundwater from west of Baragoi and the Merti Plateau (Ministry of Water Development, 1991).

- Kerio sub-basin

Groundwater availability is reasonably good [2], particularly in the upper part of the basin. The Upper Kerio and Western Tugen Hills support a regional aquifer, which is recharged by the Tugen hills. Groundwater in the upper-middle part of the Kerio is less readily available, but even so, successful boreholes can support yields up to 40 m^3/hr (Wangati & Said, 1997). Most of the upper basin is underlain by volcanic and associated sediments. The middle and lower parts are underlain by Basement and volcanics, and the Turkana Grit and associated sediments of Cretaceous or Miocene age (Wescott et al., 1993). These include the recently-described Kalapata Beds aquifer (Water Resources Authority, 2019b).

- Turkwel sub-basin

The Turkwel river flows northwards then eastwards over alluvium and underlying Basement to Lodwar, where Upper Miocene volcanics and lacustrine/alluvial sediments underlie the Town (Olago, 2018). The sedimentary and volcanoclastic sequence in the Lodwar area hosts an aquifer of considerable importance for Lodwar Town, which the Lodwar water utility exploits from boreholes along the Turkwel bankside (capable of up to 60 m^3/hr; SWIFT, ND). This aquifer is partly maintained by direct recharge, and partly by bankside recharge from the Turkwel (itself in part sustained by releases from the Turkwel Dam). The river flows east to discharge into a delta-form of sediments and then into Lake Turkana south of Eliye Springs. The delta sediments host a moderate to good freshwater aquifer. Recent work has determined the presence of a significant groundwater resource in the Loperot area, in the south-central part of the Turkwel basin (Water Resources Authority, 2019; and water permit paperwork issued to Tullow Oil). This has yet to be studied in detail, but boreholes are used to provide water for the community and petroleum drilling purposes. Exploratory boreholes drilled at Lokichar and Kaesomalit in this aquifer were tested at 36 and 66 m^3/hr respectively. The aquifer is comprised of shallow tuffs, fresh and fractured sandstones (Kalapata Beds), and produces water of reasonable quality, with EC ranges of 320 to 1 590 µS/cm, and fluoride of 1.03 to 2.28 mg/L (Water Resources Authority, 2018e, 2018d). This aquifer straddles the Kerio-Turkwel basin boundary.

- Turkana sub-basin

Minor aquifers occur in the coastal zone of Lake Turkana, either in young lacustrine sediments or Plio-Pleistocene sediments; groundwater is often brackish or saline (Water Resources Authority, 2019b).

- Loperot sub-basin

Loperot hosts a useful aquifer system in phonolites and rhyolites underlying Lokichoggio (Schwartz et al., 1991). A significant aquifer that provides water to the refugee complex in the Kakuma-Kalobeyei area, comprising alluvial sediments and fractured rhyolites (Baumann et al., 2017); and a putative aquifer in the thick Miocene-Pliocene sediments underlying the Lotikipi Plain (International Groundwater Resources Assessment Centre, 2013). The Lokichoggio aquifer is of moderate capacity, with boreholes producing up to 10.3 m^3/hr (Department for International Development, 2001) of marginally acceptable water (EC 1 020 to 3 600 µS/cm, fluoride ≈1.6 mg/L) (Schwartz et al., 1991); it just about meets the need of the Town, though concerns were aired about depletion during the years Lokichoggio was the logistic base for Operation Lifeline Sudan; these concerns were apparently unfounded, though the WRA still considers this aquifer at risk (Water Resources Management Authority, 2007a). Boreholes screened solely in the Kakuma alluvial sediments can produce up to 45 m^3/hr of excellent quality water (TDS 380 mg/L, fluoride 0.9 mg/L); boreholes screened in the weathered rhyolite are characterised by lower yields and fluoride concentration as high as 8 mg/L (fluoride range 1·5–8·4 mg/L; Bauman et al, 2017). A recent Lancet paper describes osteofluorosis in a Kakuma refugee resettled in Canada after drinking groundwater containing excessive fluoride over a six-year period (Fabreau et al., 2019). A 350 m-deep exploratory borehole drilled in the Lotikipi Plain 40 km east north east of Lokichoggio obtained reasonably abundant volumes of water (36 m^3/hr) (Water Resources Authority, 2019b); however, the water from these boreholes is non-potable; TDS 5 770 ppm, sodium 2 010 ppm, chloride 2 570 ppm and nitrate 187 ppm (Turkana and Marsabit Exploratory Drilling Programme).

WRMA aquifer classification

At present, the aquifer classification system in place in Kenya is described by Water Resources Management Authority (2007). A new classification system was developed as part of this consultancy and is proposed in section 6.4.3.

The Water Resources Management Authority (2007) classification system is partly demand-oriented and partly geo-political. There are five classes, 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 RV Basin’s aquifers under the current classification are summarised in Table 2-3 below.

Table 2-3: Current classification of aquifers in the RV Basin

Name	Dominant lithology	Status
Strategic		
Nakuru Town aquifers		
Town area	Basalt lavas and volcanoclasts (intergranular and fissure)	**ALERT – over-abstraction**. Key groundwater resource for Nakuru; yield ranges in boreholes 5 – 150 m^3/hr.
Lake Nakuru	Alluvium and lacustrine material (intergranular)	
Kabatini	Basalt lavas and volcanoclasts (intergranular and fissure)	
Lake Naivasha	Alluvial (intergranular) and trachyte lavas (fissure)	**ALARM – over-abstraction**. Source for Naivasha Town.
Major		
Olbanita-Subukia	Basalts and pyroclasts	**SATISFACTORY.**
Ngata-Ogilgei	Superficial deposits and Menengai Pumices.	**SATISFACTORY**.
Kabarnet	Kabarnet Trachytes	**SATISFACTORY**. Groundwater used to supplement surface water supply (private abstractors).
Lokichoggio	Alluvium over olivine basalts (intergranular and fissure flow)	**ALERT**. Highest borehole density in the District at that time.

Name	Dominant lithology	Status
Minor		
Ewaso Ng'iro South volcanics	Miocene to Pleistocene trachytes, phonolites and basalts (fissure flow).	**SATISFACTORY.**
Poor		
West Pokot	Fresh phonolites	**SATISFACTORY**.
Lower Keiyo-Marakwet	Weathered phonolites	**SATISFACTORY**.
Kinangop	Weathered volcanics (trachytes, basalts)	**SATISFACTORY**.
Kerio Valley	Pleistocene trachytes, baalts and pyroclasts (intergranular and fissure flow)	**SATISFACTORY**. Little-known aquifer system.
Ewaso Ng'iro South Basement	Weathered/poorly weathered pre-Cambrian metamorphics (intergranular and fissure)	**SATISFACTORY**.
Turkana colluvium/alluvium	Alluvium or colluvium over volcanics or pre-Cambrian metamorphics	**SATISFACTORY**.
West Pokot Basement	Weathered/poorly weathered pre-Cambrian metamorphics (intergranular and fissure)	**SATISFACTORY**.
Special		
Njoroi	Miocene-Pleistocene interbedded pyroclasts lake beds and trachytic lavas (intergranular and fissure)	**ALARM**. Key resource for commercial irrigation, over-abstraction taking place.
Rongai		
Kakuma	Alluvium and fractured rhyolites (intergranular and fissure)	**ALERT**. Refugee water supply (possible over-abstraction, water quality issues).
Lodwar	Turkwel alluvium over phonolites, trachytes and olivine basalts	**ALERT**. Sole water supply source for Lodwar (salinisation, possible pollution risk).
Eldama Ravine	Tuffs and phonolites, volcanoclastic sediments	**ALERT**. Possible over-abstraction.
"Non-aquifer"		
None designated.		

2.2.1.4 Drainage

Drainage in the RV Basin is characterised by seven major lakes with their respective drainage basins.

Lake Turkana in the north of the basin is the largest lake in the basin and has a drainage area of about 123 000 km^2, including the Omo River catchment in Ethiopia. The lake has a surface area of approximately 7 500 km^2. The lake receives most of its inflow (more than 80%) from the Omo River, which enters the lake from Ethiopia in the North. The Kerio and Turkwel rivers are the major Kenyan rivers which drain to Lake Turkana from the south-west. The Turkwel River originates from the eastern slopes of Mount Elgon and the Chengani Hills and has a catchment area of 19 820 km^2, while the Kerio River originates from the Mau Forest Complex and has a catchment area of 13 930 km^2. The Kerio and Turkwel rivers are perennial along their upper reaches but intermittent along their lower reaches due to high seepage and evaporation losses. Smaller seasonal rivers which drain into Lake Turkana from the western side include Lokichar and Kalakoi rivers

The second largest drainage basin (8 350 km^2) is Lake Magadi in the south of the RV Basin, which is mainly fed by underground rivers.

The major rivers which feed Lake Baringo in the central part of the basin, with a drainage area of 6 530 km^2, include the Perkerra River and the Molo River from the south and the Mukutan River from the east.

Lake Naivasha, next to Naivasha Town, has a drainage area of 3 130 km^2. The perennial Malewa and Gilgil rivers account for nearly 90% of the lake's inflow, with the seasonal Karati River also contributing. The Turasha River is a major tributary of the Malewa River.

In the central part of the basin, Lake Bogoria's drainage area is 1 140 km^2. The Waseges River (or Sandai River) is a river that rises on the slopes of the Nyandarua Plateau below the Aberdare Range. It enters Lake Bogoria from the north after passing through a swamp.

Lakes Nakuru (1 624 km^2) and Elementaita (543 km^2) have much smaller drainage areas and are located close to Nakuru Town.

In addition to the above lakes and their respective drainage areas, the RV Basin has three more river basins: the Tarash River in the north-western part of the basin is a seasonal river which feeds the Lotikipi Swamp; the Suguta River is a seasonal river directly south of Lake Turkana which flows northward through the Suguta Valley in the rainy season, forming the temporary Lake Alablad, a dry lake that combines with Lake Logipi at the northern end of the valley; and the perennial Ewaso Ng'iro South River in the southern RV Basin which originates on the Mau Escarpment. It flows southwards and crosses the border into Tanzania, where it empties into Lake Natron. The RV Basin is divided into 35 sub-basins, 2AA to 2KC.

The upper (central and north) Basin includes sub-basins 2H-1 (Lake Magdi), 2H-2, 2H-3, 2KA, 2KB, 2KC, 2GA, 2GB, 2GC, 2GD (Lake Naivasha), 2FA (Lake Elementatita), 2FB, 2FC (Lake Nakuru), 2EA, 2EB (Lake Bogoria), 2EC, 2ED, 2EF, 2EG1, 2EG2, 2EH, 2EJ, 2EK.

The lower (south) Basin includes 2AA, 2AB, 2BA, 2BB, 2BC, 2BD, 2CA, 2CB, 2CC, 2D, 2J.

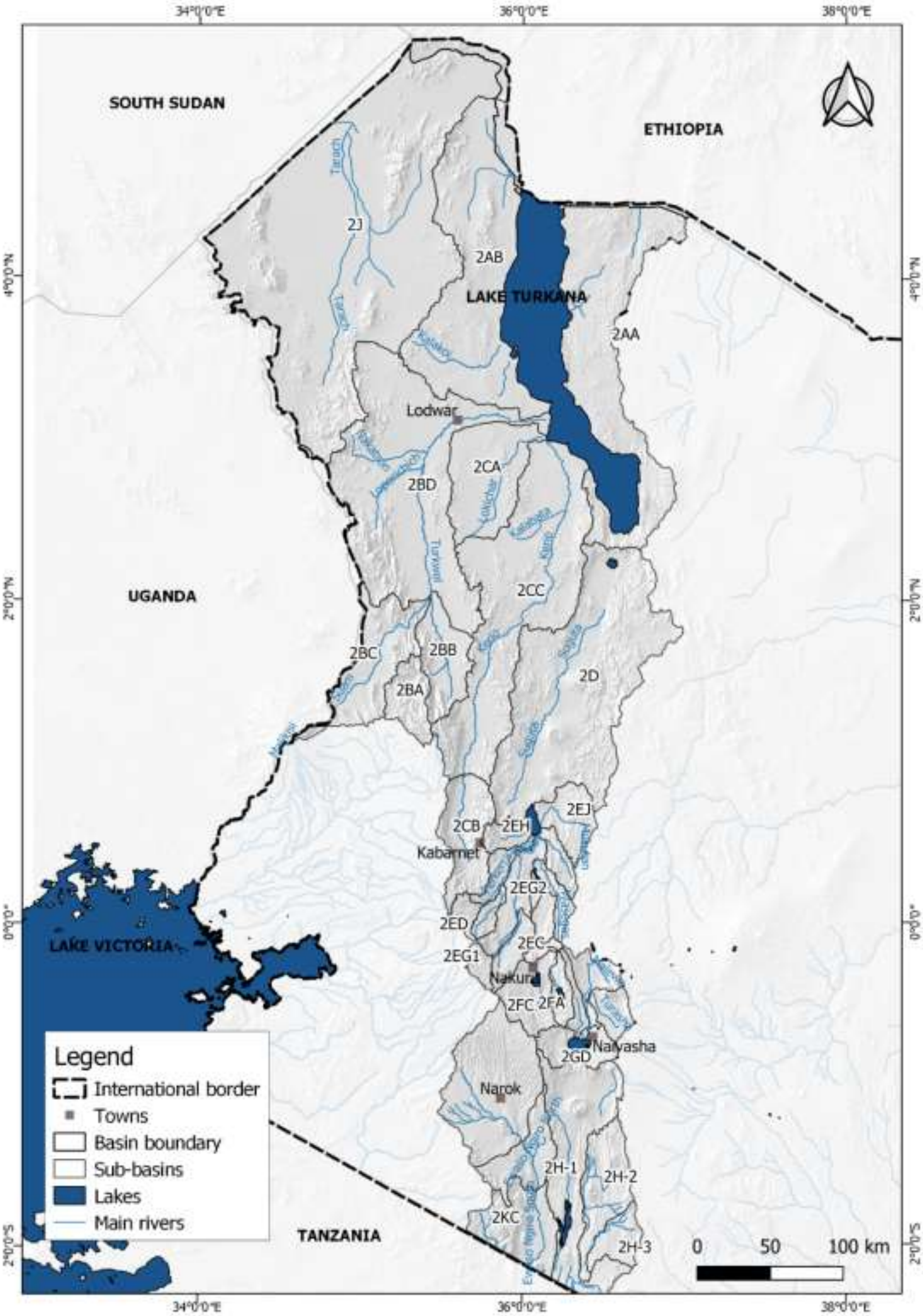


Figure 2-10: Drainage network and sub-basins of the RV Basin

2.2.1.5 Lakes and wetlands

There are seven major lakes in the RV Basin, namely Lake Turkana, Baringo, Bogoria, Nakuru, Elementaita, Naivasha and Magadi. Only Lakes Baringo and Naivasha have fresh water, while the other lakes have saline water.

Lake Turkana is the world's largest permanent desert lake and the world's largest alkaline lake. It has a surface area of about 7 500 km^2 and a maximum depth of 120 m. Rainfall at the lake is very limited and its water level is mainly determined by the balance between inflows from rivers and evaporation. The lake has no outflow. It is an important resource for communities in the surrounding desert region, migratory birds and local wildlife. In 1997, Lake Turkana was designated as a UNESCO World Heritage Site for the region’s extraordinary biodiversity.

Lake Naivasha has a maximum area of about 180 km2. There is no visible outlet, but since the lake water is relatively fresh it is assumed to have an underground outflow. The lake supplies domestic water to Naivasha, irrigation water to various horticultural farms along its banks and water to the Olkaria Geothermal Power Station south of the lake. The lake was designated as a Ramsar Site in 1995.

Lake Baringo has a surface area of about 120 km^2 and is fed by several rivers. It has no obvious outlet, however the water is assumed to seep through lake sediments into the faulted volcanic bedrock and as a result the lake is a freshwater lake. It has a very rich diversity of birdlife and has also been designated as a Ramsar Site.

Lake Bogoria is a shallow lake just north of the equator. It includes the Kesubo Swamp to the north and various geysers and hot springs along its banks and in the lake itself. It is designated as a Ramsar Site.

The surface areas of the other lakes in the basin vary from 20 to 130 km^2 and include three more Ramsar Sites viz. Lakes Nakuru, Bogoria and Elementaita. Lake Nakuru is known for its spectacular bird populations including both the Lesser and greater Flamingo. Lake Bogoria, Lake Elmenteita, and Lake Magadi are also at times home to large populations of lesser flamingos. Lake Elmenteita is also a Ramsar Site. The main wetlands in the RV Basin surround the seven major lake regions and support a variety of fauna, including large hippopotamus, zebra, giraffe, buck, birdlife, reptiles and amphibians.

The Shompole Swamp on the Ewaso Ng’iro South River floodplain provides water for domestic use and livestock, especially during times of low rainfall, and is home to a variety of faunal and floral species. The Lotikipi Swamp is in Turkana County near the South Sudanese border. Conflicts have arisen over the shared wetland area, especially during dry seasons when this permanent swamp is a sought-after resource. The major wetlands are shown in Figure 2-11.

Figure 2-11: Major wetlands in the RV Basin

2.2.2 Climate

2.2.2.1 Current climate

The rainfall seasonality is complex in the RV Basin (Indeje et al., 2001), changing within tens of kilometres with ground altitude playing an important contributing factor. Figure 2-12 displays the mean annual precipitation and average temperatures across the basin. Average annual maximum day temperatures across the basin vary from 19°C to 35°C, while the average annual minimum night temperatures vary from 8°C to 23°. The northern part of the Basin is classified as arid land, the central part as humid and the southern part as semi-arid. The mean annual precipitation across the basin varies from less than 300 mm in some areas in the north to as high as 1 200 mm in some of the central areas. Towards the south of the basin, the mean annual precipitation reduces again to less than 800 mm. The mean annual precipitation across the basin is 510 mm.

Most of the rainfall occurs during April and May and again from September to November. The driest months occur between December and February.

The variation of temperature and precipitation at Kakuma (north) and Nakuru (central) is shown in Figure 2-13.

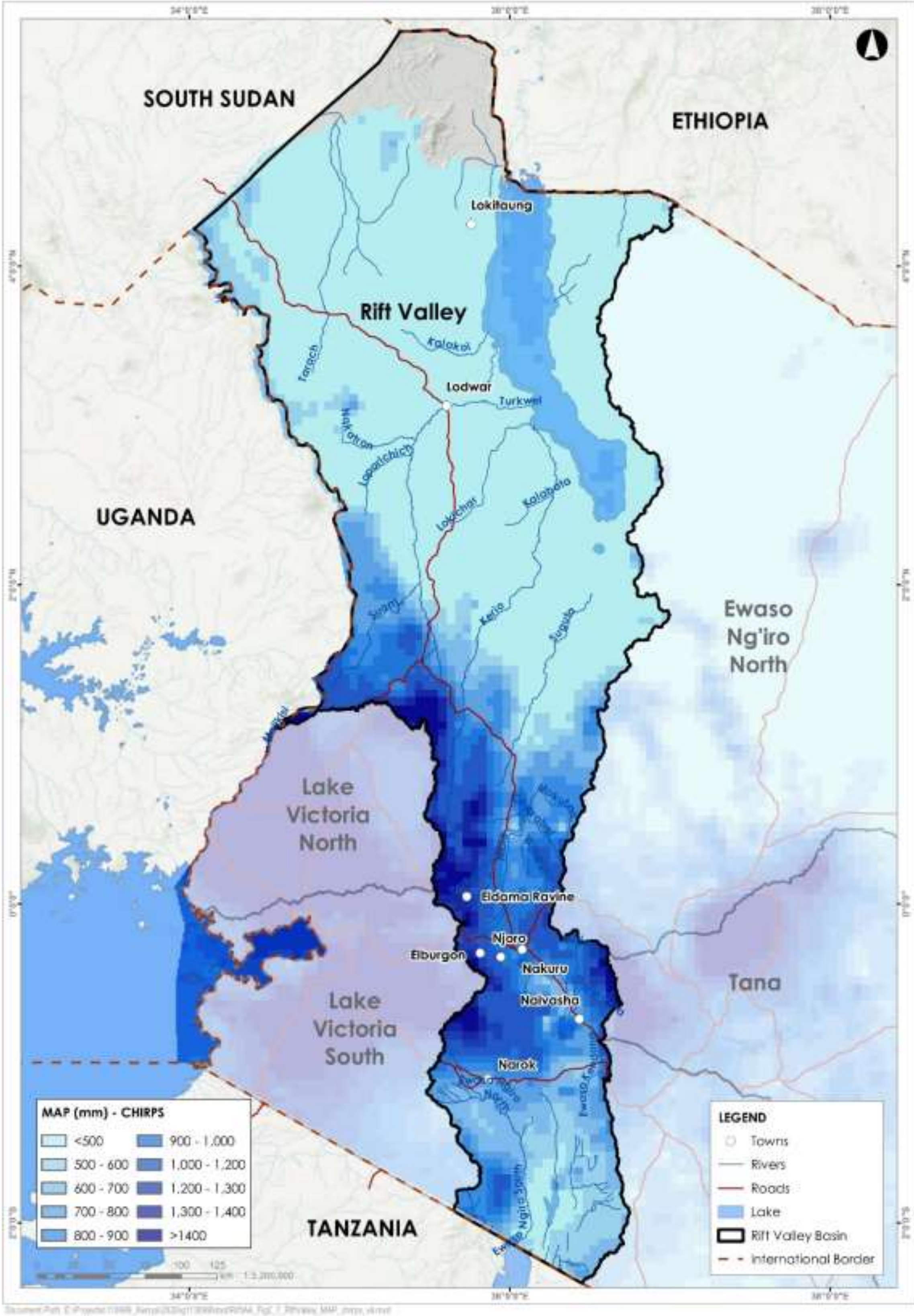


Figure 2-12: Mean annual precipitation across the RV Basin

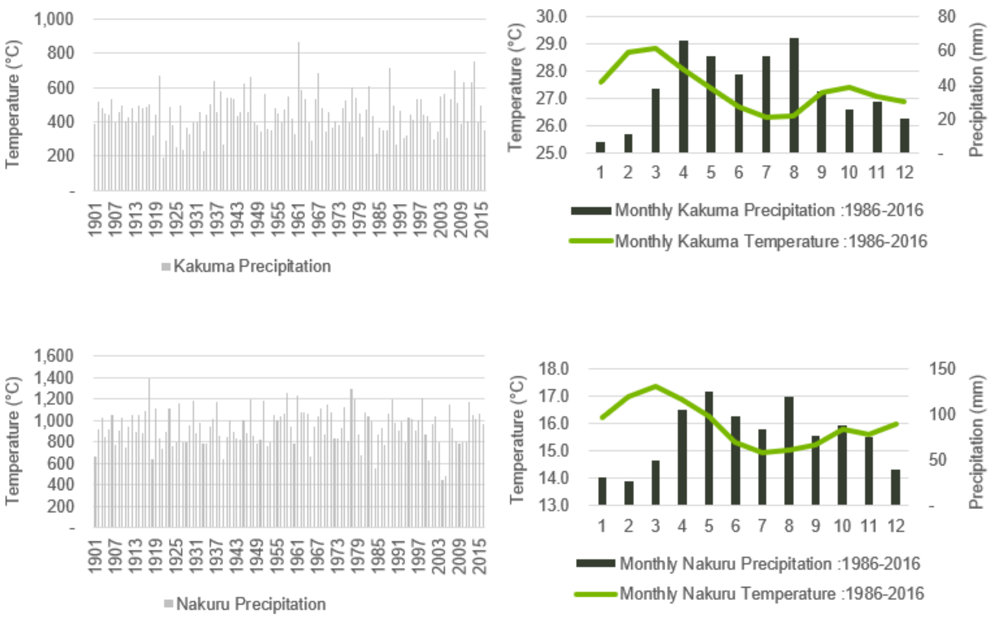


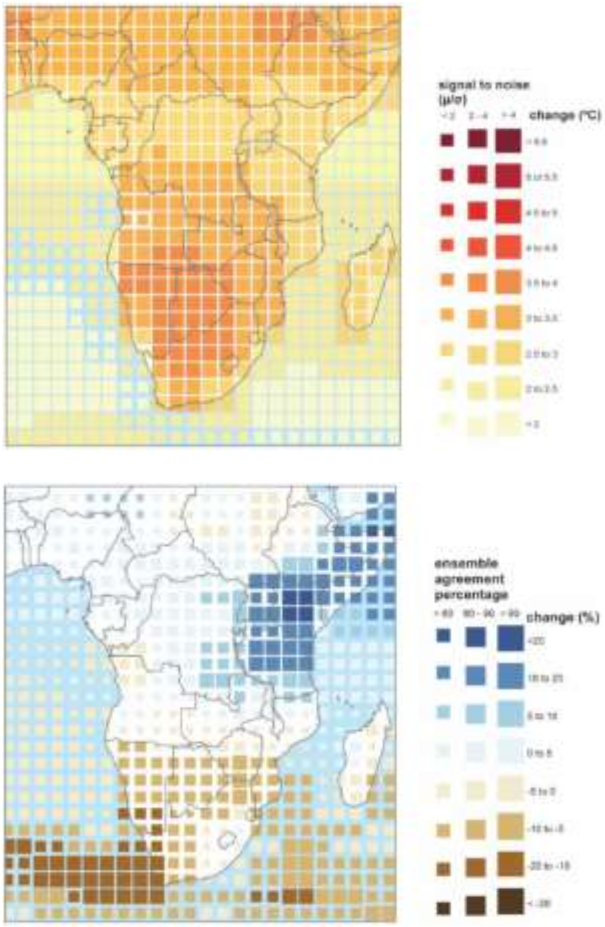
Figure 2-13: Variation of precipitation and max. temperature at Kakuma and Nakuru in RV Basin

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 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.

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 RV 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 because 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.



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

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

The climate change analysis which was undertaken as part of this Consultancy (refer to **Annexure A2**), showed a general increase (between 4% and 12%) - increasing towards the north, in mean annual rainfall across the basin, with the average MAP of the basin increasing from 510 mm to 562 mm by 2050 under RCP 4.5. Day and night temperatures are also expected to increase by 1.24°C and 1.46°C respectively.

The climate analysis on precipitation, indicates a consistent increase in future precipitation and precipitation shift during the 'short' rainy season from October to November shifting it to September to November. During the 'long' rainy season an increase in precipitation is also expected, a significant increase in precipitation is expected in February, shifting the long rainy season to start earlier. Furthermore, the northern sub-basins are expected to become wetter than the southern sub-basins. During the dry season historically from June to October, the precipitation only decreases during May and June. The variability in rainfall is expected to increase during both rainy seasons and the rainfall is expected to increase in intensity and shift earlier.

Projected sub-basin precipitation and temperature changes under climate change scenario RCP 4.5 were superimposed on the hydrological model of the RV Basin to assess the potential impacts on runoff. The climate analysis on flow indicates an overall decrease in flow; decreasing significantly over the dry months from May to October and increasing slightly during the 'short' and 'long' rainy season. The total surface water runoff from the RV Basin is projected to decrease by 2.9% by 2050. Furthermore, it is expected that the lower flows in the river will increase in magnitude, while the higher flows will decrease slightly in magnitude, suggesting that river flow becomes less variable.

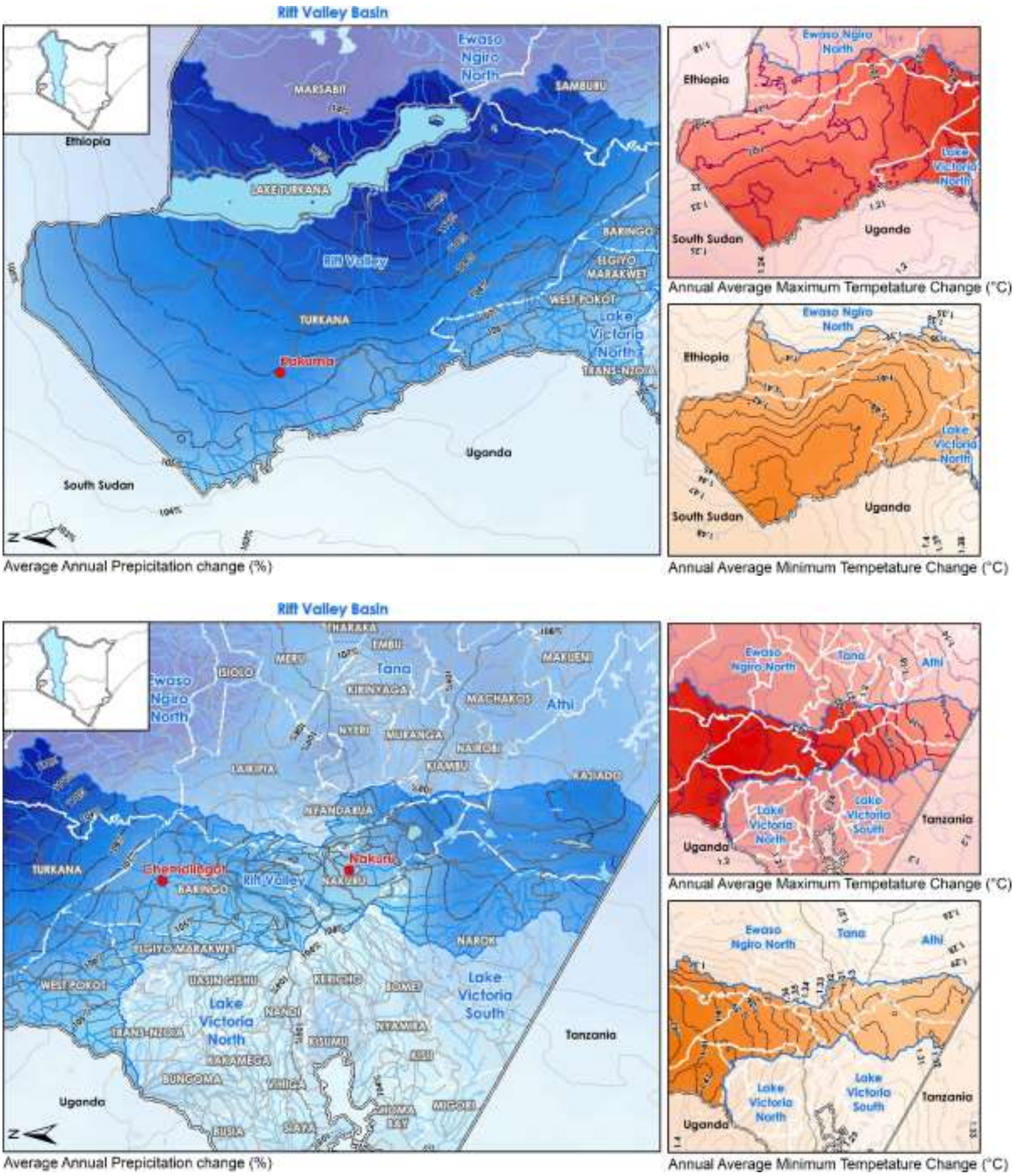


Figure 2-15: Change in Annual Precipitation, Max and Min Temperature in 2050 (RCP 4.5)

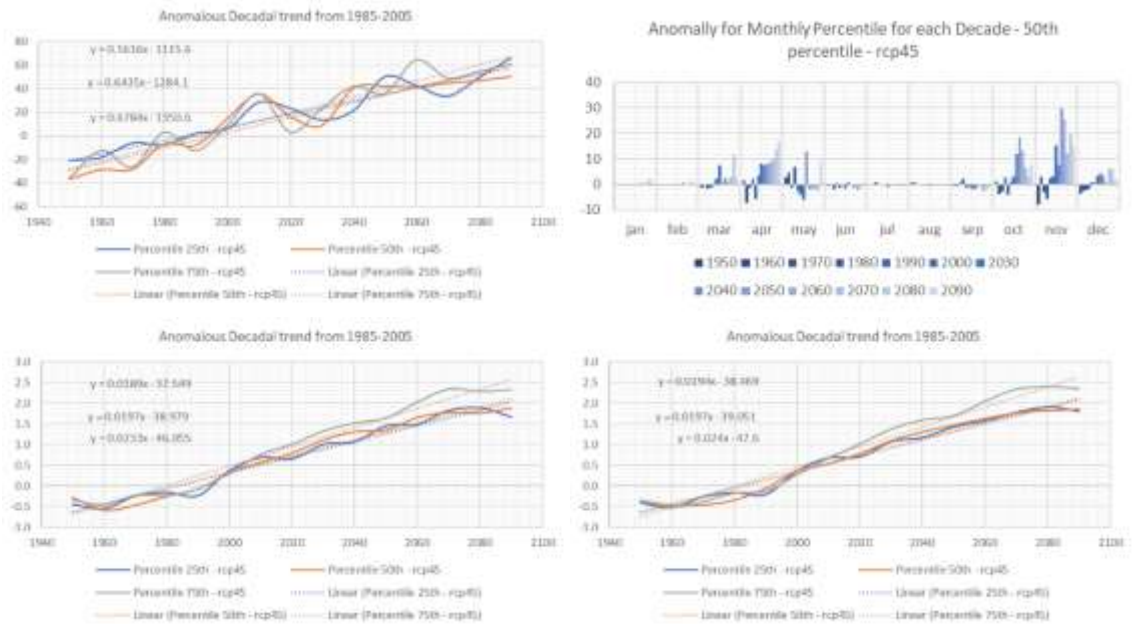


Figure 2-16: Projected Tmax anomalies in the RV Basin by 2050 (RCP 4.5)

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 the 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 RV Basin. (A high cover management factor indicates poor vegetation cover and vice versa).

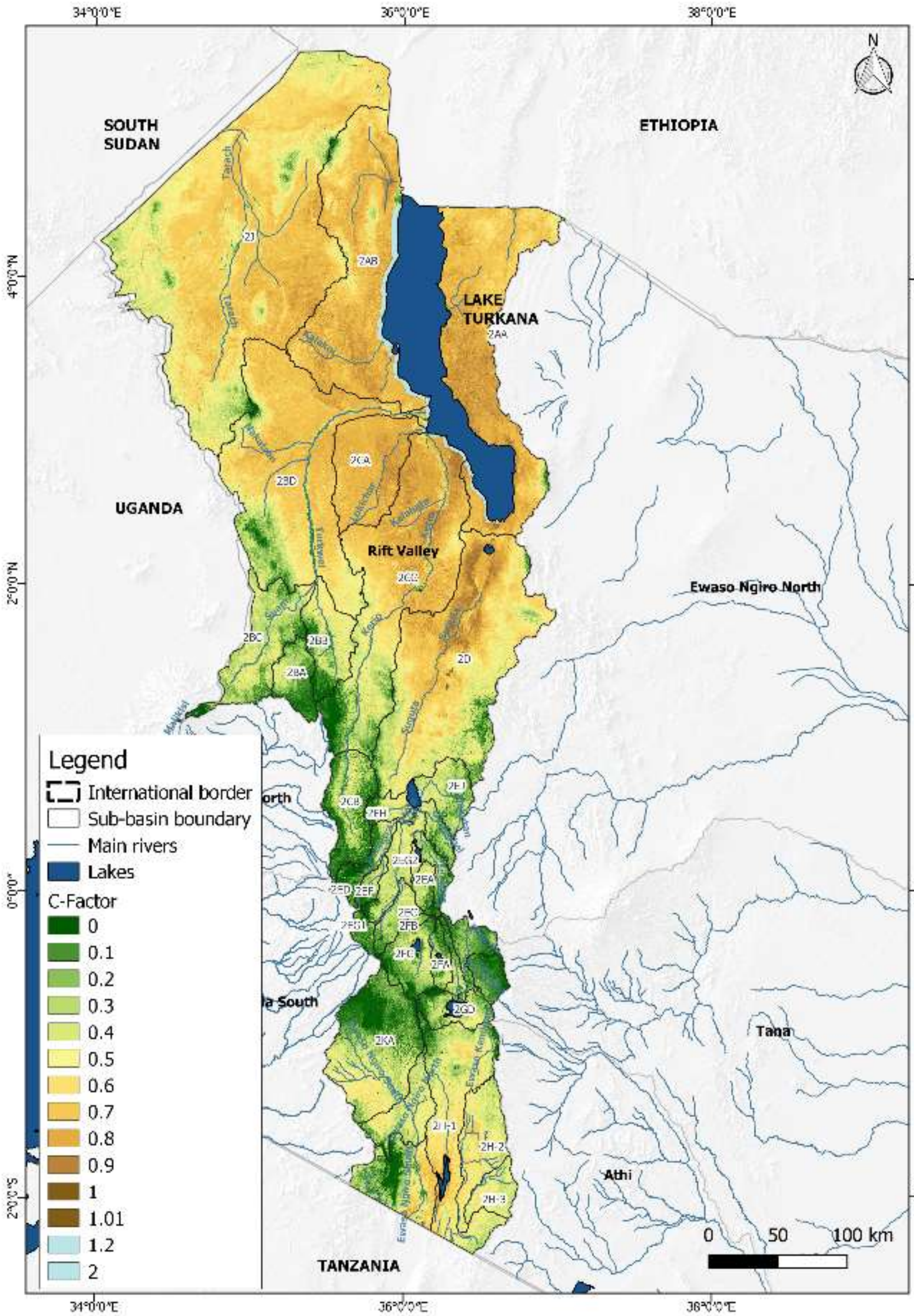


Figure 2-17: Vegetation cover in the RV Basin

The northern catchment surrounding Lake Turkana is mainly semi-desert vegetation covered with scattered shrubs. The southern parts of the catchment are covered by bushland and grassland vegetation, while the mountainous central region is covered by forest vegetation. Table 2-2 lists some of the main forested hills in the RV Basin.

2.2.3.2 Biodiversity

Biodiversity in RV Basin is linked to water resources, wetlands and forest reserves or protected areas. There are several lakes and wetlands in the basin, which are important habitats for a variety of birdlife and wildlife. This includes crocodiles, several endangered bird species and large mammals such as hippopotamus. Lake Nakuru is a famous tourist attraction for its flamingo viewing. Turkana Lake is designated as a UNESCO World Heritage Site, while five of the lakes in the basin are designated as Ramsar sites including Lakes Baringo, Bogoria, Elmenteita, Naivasha and Nakuru.

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

Forest Mountain /Hill	Catchment	County
Kijabe Hill, Kikuyu Escarpment C, Kikuyu Escarpment A, Kingatua,	2H-1	Kiambu
Loita	2KC, 2KB	Norok
Maasai Mau, Ol Pusimoru	2KA	Narok
Eburu	2FC	Nakuru
Aberdares_C, Kipipiri	2GD, 2GC	Nyandarua
Mau Narok, Eastern Mau	2FC	Nakuru
Nakuru	2FC	Nakuru
Menengai	2FB	Nakuru
Bahati	2FA, 2FC, 2EC, 2EB, 2EA	Nakuru
Olarebel	2EK	Baringo
Molo, West Molo	2EG1	Nakuru
Mount Londiani, Kilombe Hill	2EG1, 2EG2, 2EF	Baringo
Maji Mazuri, Lembus_B, Chemorogok, Lembus_A, Timboroa	2ED, 2EE, 2ED, 2CB	Baringo
Perkerra Catchment, Klaptimom, Sanao, Mtarakwa, Sekenwo, Chepkuchumo, Mukobe, Kabarak, Kimojoch	2EE, 2CB	Baringo
Kinyo, Tarambus, Marop, Chebartiogon, Pemwai, Mosegem, Sokta	2EH	Baringo
Katimok, Kessop, Kapchemutwa	2CB	Baringo
Saimo	2D	Baringo
Sogotio, Kipkunurr, Embobut,	2CC	Elgiyo Marakwet
Lelan_A	2BB	West Pokot
Lelan_B, Lelan_C, Kamatira	2BA	West Pokot
Kekerr	2BB, 2BC	Elgiyo Marakwet
Loima Hills	2BD, 2J	Turkana
Mount Nyiro	2D	Samburu
Mount Kulal	2AA	Marsabit

2.2.3.3 Protected areas

The RV Basin contains several environmentally protected areas, including six National Parks and four National Reserves. The largest protected areas are the Sibiloi National Park, with an area of 1 570 km^2 and the South Turkana National Reserve, with an area of 1 109 km^2. The Kenya Wildlife Services (KWS) is responsible for the management of National Reserves in Kenya. The Kenya Forest Services (KFS) is responsible for the conservation, sustainable development, management and utilisation of the country's forest resources. The total forested area in the Basin in 2010 was about 261 000 ha. According to recent satellite imagery, the forested area has decreased substantially since 1990. Deforestation and forest degradation are rampant in the catchment, especially in the Mau Forest Complex and private forests to the west of Lake Naivasha. 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 RV Basin has seven gazetted Water Towers.

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

County	Water Tower	Forest	Protected area	Lake / Wetland
Narok	Loita Hills Enoosupukia Hill (N) Mau Forest Complex Nguruman Escarpment (N) Mount Suzwa (N)	Loita Hills		
Kajiado	Nguruman Escarpment (N) Mount Suzwa (N)			Lake Magadi Shompole Swamp
Nakuru	Subukia Escarpment (N)		Hells Gate National Park Mount Longonot National Park Lake Nakurur National Park	Lake Nakuru Lake Naivasha Lake Elmenteita
Nyandarua	Aberdares; MountKipipiri	Kipipiri		
Baringo	Tugen Hills (N)		Lake Bogoria National Park Kamnarok National Reserve	Lake Baringo Lake Bogoria
Laikipia	Maramanet			
Elgiyo Marakwet	Kaptagat Hills (N) Cherangani Hills		Kerio Valley National Reserve	
West Pokot	Kamelei/Chesuko Hill (N) Karasuk Hills (N)		Nasolot National Reserve	
Turkana	Loima Hills (N)		South Turkana NR	Lake Turkana Lotikipi Swamp
Marsabit	Mount Kulal		Sibiloi National Park	
Samburu	Mount Nyiro			

N: Non-gazetted

Figure 2-18: Protected areas across the RV Basin

2.2.3.4 Land use

Land use in the RV Basin includes forest, grassland/rangeland and agricultural use. The Basin has a high population density and scattered urban and built-up areas in the middle sections of the Basin with the dominant land use being rain-fed agriculture and rangeland.

Figure 2-19 shows the major land use and land cover types in the RV 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 apparent from the assessment that most of the RV Basin has a soil capability of 1-3 (i.e. arable land) and that the tops of hills and mountains and steep slopes have a soil capability of 5-8 (i.e. non-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 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. Most of the basin has sustainable cropland use, except in the upper zone of the catchment. The highest level of unsustainable cropland use occurs in sub-basin 2BA, followed by 2ED and 2GD (Figure 2-20).

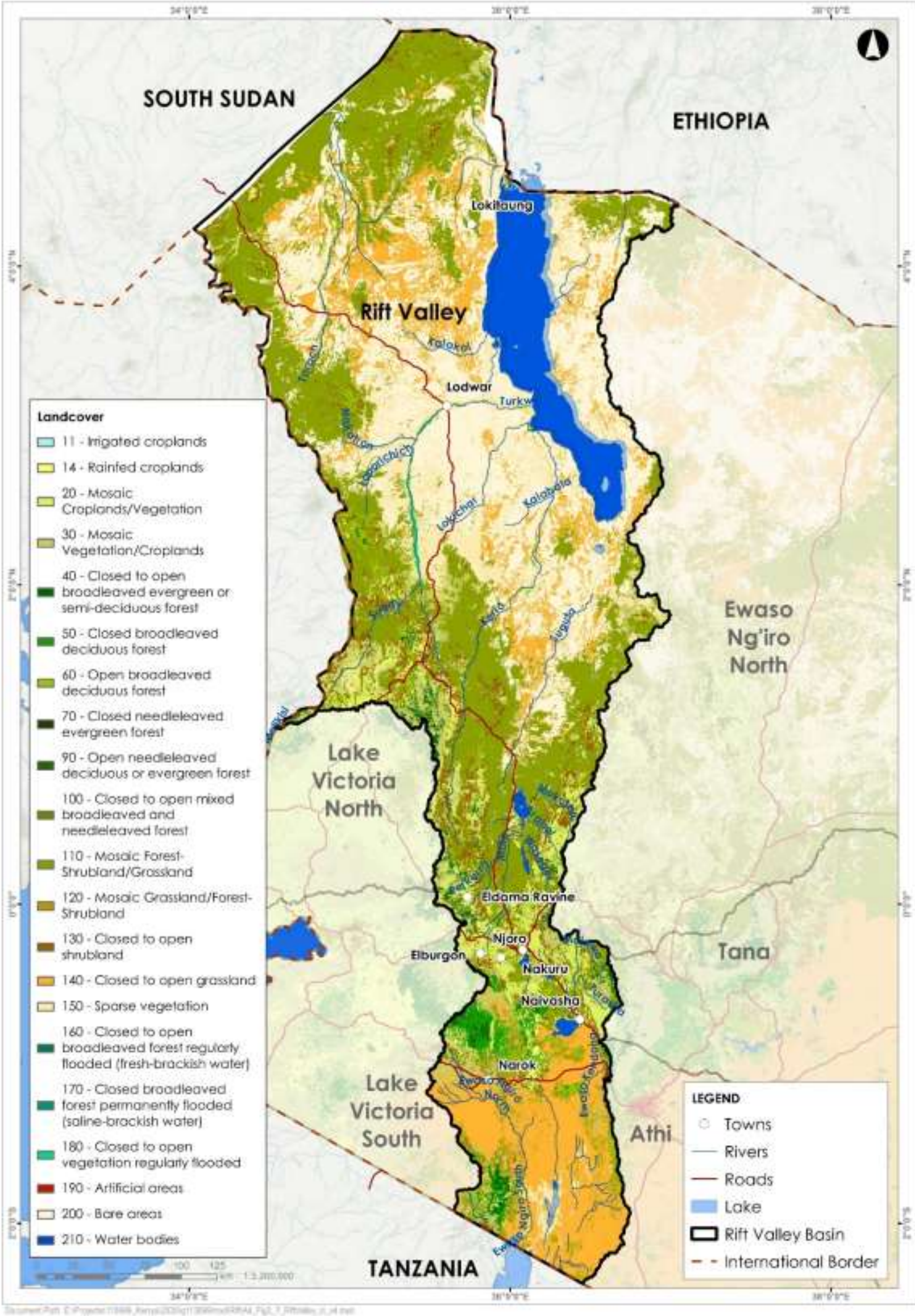


Figure 2-19: RV Basin land cover map

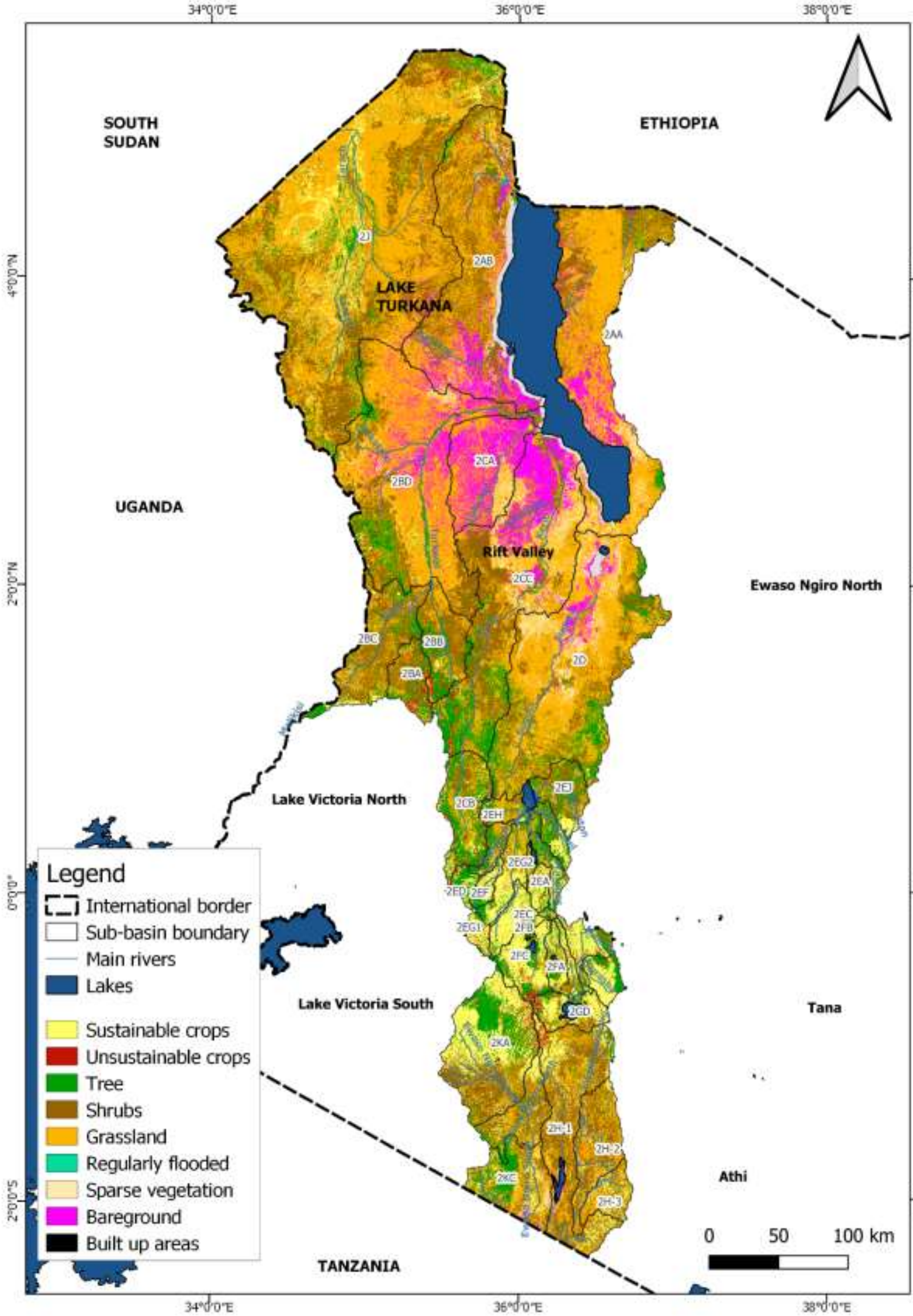


Figure 2-20: Sustainability of current land use in the RV Basin

2.3 Socio-economics

Water plays a key role in the socio-economic environment in the RV 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), the Socio-economic Atlas of Kenya (Wiesmann et al., 2016) as well as County Fact Sheets (Commission on Revenue Allocation, 2013). The total population of the RV Basin in 2019 was estimated as 5.78 million, which is equivalent to a population density of 44 persons/km^2.

Most of the population in the RV Basin currently reside in rural settlements, with only 24% of the population being located in urban areas. The population of the RV Basin is expected to increase significantly, especially in urban areas. Projections based on Census 2009 (Kenya National Bureau of Statistics, 2009) population data and United Nations population growth rates as estimated in the Kenya Vision 2030, predict that the population is expected to increase by 53% to 7.45 million in 2030. The rural population is projected to reduce from 3.45 million in 2010 to 2.96 million in 2030. The urban population is projected to increase from 1.41 million to 4.49 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 RV Basin is 0.8, which indicates that, on average, about two thirds of 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 RV Basin and the average poverty rate in the Basin is at 52%. The RV Basin includes 12 counties, some of them only partly. The economic activities per main county are described Table 2-6:

Table 2-6: Main economic activity of each county

County	Economic activity	Reference
Turkana	Turkana County borders South Sudan to the north, Uganda to the west and Ethiopia to the north east. The topography of the county includes low-lying open plains and mountain ranges. The Turkana County mountain ranges, namely Loima, Lorengippi, Mogila, Songot, Kalapata, Loriu, Kailongol and Silale, support important economic activities, such as honey production, livestock grazing during the dry season, wood and charcoal production. Lake Turkana, which is in the eastern region of the county, supports the fisheries industry of the county, the common species caught are Tilapia and Nile perch. Livestock keeping is also common in the pastoral areas. Tourist attractions include Lake Turkana, Sibiloi National Park and other wildlife and birdlife attractions.	County Government of Turkana, 2018

County	Economic activity	Reference
Marsabit	Marsabit County falls with the ASAL region extending over an extensive plain and is located in northern Kenya. The county has no permanent river but has four drainage systems. Chalbi Desert receives run-off from the surrounding hills and mountains, Milgis and Merille Rivers flow eastward and drain into the Sori Adio swamp, the Dida Galgallu plains receive runoff from the eastern slopes of Hurri Hills and Lake Turkana into which seasonal rivers from Kulal and Nyiru mountains drains to. Nomadic pastoralism is the major economic activity in the Marsabit County, and crops are grown in the highlands surrounding Marsabit town where rainfall is relatively high. There is potential for future developments in the tourism industry due to the diverse wildlife and birdlife and rich cultural heritage.	County Government of Marsabit, 2018
Samburu	Samburu County lies within the ASAL region. The county lies on the northern interface between highlands and lowlands. Pastoralism is a major economic activity in Samburu County, while a small portion of the inhabitants practise agricultural related activities. The main tourist attraction is the Samburu National Reserve.	County Government of Samburu, 2018
West Pokot	The topography of West Pokot County includes Cherangani Hills in the south-east region and dry plains in the north-east region. The main economic activities in the county include retail and wholesale trading, agricultural production (namely honey processing, crop and livestock farming) and industries. The large Turkwel Hydropower Station provides the main source of power to the county. Tourism also contributes to the economy, and some of the attractions include Saiwa Swamp National Park and the Prison Museum.	County Government of West Pokot, 2018
Elgeyo Marakwet	More than 80% of the population engage in farming and related activities. The county is also known for its unique tourism, which boosts the county's revenue. Collaboration through the North Rift Economic Block also enhances trade and investment opportunities. The dominant land use and economic activity in Elgeyo Marakwet is agriculture. There is very little industry in the county at present and development plans include proposals to increase the levels of production and industry in the county, which will lead to an increased demand for energy and to increase the efficiency of energy consumption. Renewable energy sources will be targeted, including hydro, solar and wind energy. The Arror and Embobut Rivers have been identified as potential sources of hydro-electric power.	County Government of Elgeyo Marakwet, 2018
Baringo	The main economic activity of Baringo County is agriculture. Lake Baringo is one of the two freshwater lakes in the RV Basin. The lake supports 80% of the total fish production in Baringo County. Kerio Valley, one of the prominent topographical features of the county, is situated in the western region. The Loboi Plain, which is covered by latchstring salt-impregnated silts and deposits, is in the eastern region of the county. The lake is also a tourist attraction due to the large variety of wildlife, fish and birds. Another popular tourist attraction is the Lake Bogoria National Reserve.	County Government of Baringo, 2018
Laikipia	In Laikipia County, the main economic activity is agriculture, including food crops, cash crops, horticulture and dairy products. The area is a popular tourist destination due to its wildlife conservation areas and ranches.	County Government of Laikipia, 2018
Nyandarua	The major economic activities in Nyandarua County include agriculture, quarrying and trade. The Nyandarua County topography is a result of volcanism and faulting that created the two major land forms, namely the Great Rift Valley to the west and the Aberdare Mountain Ranges to the east. There are eight main rivers in the county, namely Malewa, Pesi, Turasha, Chania, Kiburu, Mkungi and Kitiri Rivers. Agriculture is important in the county due to the fertile soils and favourable climate. The county has a high production of potatoes, cabbages, carrots, peas and milk.	County Government of Nyandarua, 2018

County	Economic activity	Reference
Nakuru	The main economic activities in Nakuru County are agriculture, tourism and financial services. 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 along with aquaculture. Lake Nakuru is a famous tourist attraction for its flamingo viewing.	County Government of Nakuru, 2018
Narok	The Narok County hosts the Maasai Mara National Reserve, which is famous for its annual wildebeest migration, and the tourist industry is the largest economic contributor in the county. 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
Kajiado	Kaijiado County mainly consists of Arid and Semi-Arid Land (ASAL) where livestock production is the main activity. The county however has a total estimated area of 1 068 ha and 50.6 ha under food crop and cash crop respectively. The main food crops grown in the county include maize, beans, potatoes and vegetables. Commercial farming of onions and tomatoes is largely practiced in Loitokitok, Isinya and Nguruman (RV Basin). NIA established Isinet irrigation project with 700 acres under production and Entarara irrigation scheme with 80.9 ha under production. Opportunities in the sector are limited by the semi-arid nature of the county, though greenhouse technologies are increasingly being used for high value crops. Kajiado County has a very conducive environment for companies to set up manufacturing and processing pants. This is due to availability of expansive land, underground water resources, raw materials and affordable labour force. Existing manufacturing industries in Kajiado County include a steel melting plant in Isinya, Isinya Feeds production plant located near Isinya, Allied East Africa Ltd Liquefied Petroleum Gas Cylinder Manufacturer and Revalidator located near Kitengela and Kitengela Glass located opposite the Nairobi National Park. Industries currently under construction include a steel Mill, a cooking oil factory and a gas production plant.	County Government of Kajiado, 2018
Kiambu	Kiambu County relies mostly on agriculture and industries to sustain its economy. Agriculture includes small scale farmers growing tea and coffee, commercial horticulture under greenhouses and plantations of pineapples within the county.	County Government of Kiambu, 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 formal sector employs 40% of the labour force in RV. Small-scale irrigation, pastoralism and informal employment constitute 60% of the employment in the RV Basin.

Livelihood 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 in Table 2-7.

Table 2-7: Main livelihood activity of each county

County	Livelihood activity	Reference
Turkana	Only 4% of the population are employed in the formal economy, while 50% are employed in the informal sector and 45% are employed in agriculture or pastoralism	County Government of Turkana, 2018
Marsabit	Only 7% of the population are employed in the formal economy, while 10% in the urban and 8% in the rural areas are self-employed.	County Government of Marsabit, 2018
Samburu	Unemployment is extremely high.	County Government of Samburu, 2018
West Pokot	Only 8% of the population are employed in the formal economy. The informal economy contributes 53% employment and agriculture or pastoralism contributes to 39% of employment.	County Government of West Pokot, 2018
Elgeyo Marakwet	Up to 14% of the population are employed in the formal economy, while 44% are employed in the informal economy. This is made up of self-employed such as Jua-kali, other self-employment, agriculture and the private sector.	County Government of Elgeyo Marakwet, 2018
Baringo	Up to 17% of the population are employed in the formal economy, while 37% in the urban and 48% in the rural areas are self-employed.	County Government of Baringo, 2018
Laikipia	Up to 24% of the population are employed in the formal economy and 43% are employed in the informal sector. The self-employed are mainly small-scale agriculture: crop farmers or pastoralists	County Government of Laikipia, 2018
Nyandarua	Only 15% of the population are employed in the formal economy, while 27% are in the informal economy and 58% are involved in agriculture or pastoralism.	County Government of Nyandarua, 2018
Nakuru	Up to 33% of the population are employed in the formal economy, while 41% are in the in the informal economy and 27% are in agriculture or pastoralism.	County Government of Nakuru, 2018
Narok	Only 12% of the population are employed in the formal economy, while 46% are in the informal economy and 42% are involved in agriculture or pastoralism.	County Government of Narok, 2018
Kajiado	Up to 36% of the population are employed in the formal economy, while 47% are involved in the informal economy and 17% are involved in agriculture or pastoralism.	County Government of Kajiado, 2018
Kiambu	Most of the wage earners in Kiambu county are employed in the coffee/tea estates and horticulture. Self-employed persons are linked to construction companies, super markets, jua kali, manufacturing, hotels and bars. The level of unemployment is 60%, most of the unemployed having no skills. Small land holdings are mostly found in the upper parts of the county, with most farmers converting farms into residential plots to supplement the meagre income from farms.	County Government of Kiambu, 2018

2.3.3 Standard of living

2.3.3.1 Water supply and sanitation

There are currently four large dams in the RV Basin. Water is also stored in small dams and pans with a total combined storage volume of about 12 MCM (Water Resources Management Authority, 2013). There are currently more than 2 000 boreholes in the Basin, with a total abstraction volume of 198 MCM per annum.

About 40% of the basin's population receives drinking water from unimproved drinking water sources (unregistered water vendors and water taken from lakes and streams without proper treatment), 28% receive piped water via a WSP and 32% receive water directly from boreholes and springs.

The Rift Valley Water Works Development Agency contracts WSPs to provide potable water to the population. There are eight urban WSPs and five rural WSPs, and together these WSPs have a supply capacity of 97 916 m³/day. The non-revenue water (NRW) of these WSPs ranges from 30% to 95% (average of 57%), which largely contributes to the low number of people receiving piped water.

Formal sewerage systems are limited in the Basin, with only 4% of the population (all of which are in urban areas) having access to sewerage systems. Pit latrines and septic tanks are used by 69% of the population, while 27% of the population have no form of sanitation system.

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.

The land tenure trends for the counties in RV Basin are as follows:

Table 2-8: Land tenure of each county

County	Land tenure	Reference
Turkana	There is no land in Turkana county with title deeds. The land is held in trust for the community by the County Council of Turkana.	County Government of Turkana, 2018
Marsabit	Only 2% of the county land is registered as most of the land is communal. The scattered settlement patterns usually follow access to land, water and productivity. The settlements along the Great North Road are growing rapidly and need to be planned for.	County Government of Marsabit, 2018
Samburu	The county has 43 registered group ranches, occupying 40% of the county. Up to 16% of the county is public land (i.e. reserves, gazetted forest etc) and private land mainly occurs in the urban centres.	County Government of Samburu, 2018
West Pokot	An estimated 80-90% of land in West Pokot has title deeds, although less than 40% of farmers have title deeds.	County Government of West Pokot, 2018
Elgiyo Marakwet	There are 50% farmers owning title deeds in the county. Embobut. Kapkore forest and Kipkabus forest have incidences of landlessness and squatting due to displacement.	County Government of Elgeyo Marakwet, 2018
Baringo	Up to 45% of land is under private/free hold tenure, 55% is communal and 20% is leasehold. Although most of Baringo has limited landlessness there are incidents in urban centres Mogotio and Marigat where squatters have become resident.	County Government of Baringo, 2018

County	Land tenure	Reference
Laikipia	Up to 65.3 of landowners have title deeds. The county has seen an emergence of increased landlessness, with squatters increasing in Kwa Mbuzi, Kahurura, Kandutura, Ontulili villages.	County Government of Laikipia, 2018
Nyandarua	Up to 90% of households owning land have title deeds.	County Government of Nyandarua, 2018
Nakuru	About 72.5% of landowners have title deeds. The bulk of the land holdings in the county are small-scale, mainly in high-potential areas.	County Government of Nakuru, 2018
Narok	Up to 85% of land owners have received title deeds. Most of the land in the county is owned by individuals as freehold and mainly where subsistence farming is practiced. Less than 20% of households are considered to be landless, mostly those impacted by post-election issues and Mau Forest evictions.	County Government of Narok, 2018
Kajiado	Land is mainly used for livestock rearing and crops. Nomadic pastoralism is predominant in the county. Most land in the rural areas have no title deeds.	County Government of Kajiado, 2018
Kiambu	Officially 85% of land owners have received title deeds. Within the registered there is a large number of land that has been subdivided and titles have not been registered.	County Government of Kiambu, 2018

2.4 Water resources

2.4.1 Surface water resources

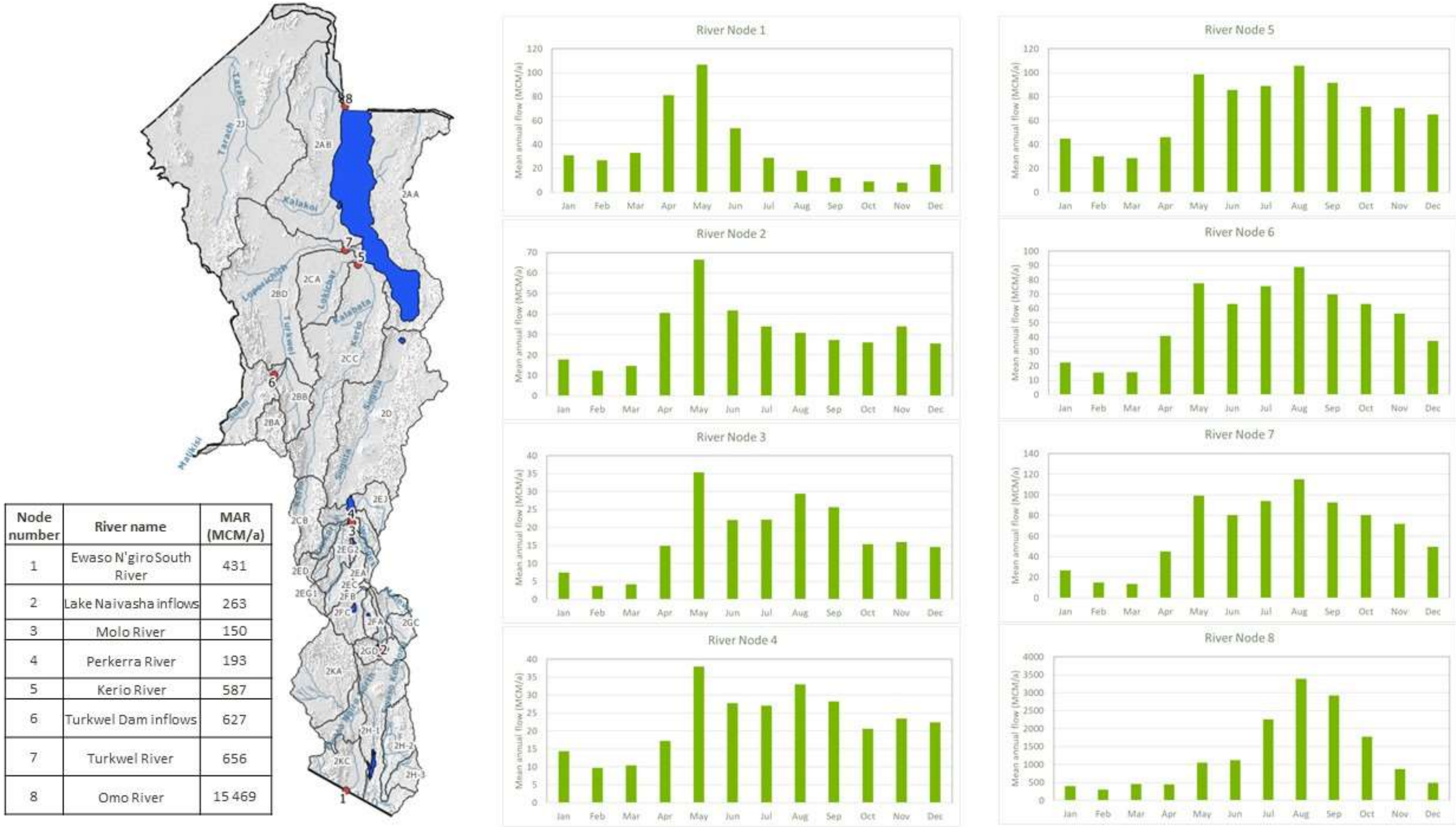
2.4.1.1 Conceptual approach to surface water resources assessment

A surface water resources analysis for the RV Basin (Se **Annexure A3**) was undertaken to quantify the available surface water within the basin under natural conditions in both space and time. 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 several 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 RV Basin are provided in "ISC Report C1-6: Rift Valley Surface Water Resources Assessment".

2.4.1.2 Surface water resources potential

The total natural runoff in the RV Basin equals 2 682 MCM/a. The total natural runoff in the five main river systems in the RV Basin equals 2 280 MCM/a - about 80% of the total basin runoff. The Kerio River contributes about 26% (587 MCM/a), and the Turkwel River 29% (656 MCM/a). The Kerio and Turkwel rivers are perennial along their upper reaches but intermittent along their lower reaches due to high seepage and evaporation losses. The Ewaso Ng'iro South River has a natural MAR of 431 MCM (19% of the major river runoff) at the border with Tanzania. The Perkera and Molo rivers contribute 343 MCM/a (15%) and the Malewa and Gilgil rivers 263 MCM/a (12%). The Omo River, which discharges into Lake Turkana from Ethiopia, has a natural mean annual runoff of 15 469 MCM/a and contributes more than 80% of the total inflow into Lake Turkana. The total natural runoff from the other catchments in the RV Basin equals 402 MCM/a. Figure 2-21 displays the simulated natural Mean Annual Runoff (MAR) at key locations across the RV Basin.



Node number	River name	MAR (MCM/a)
1	Ewaso N'giro South River	431
2	Lake Naivasha inflows	263
3	Molo River	150
4	Perkerra River	193
5	Kerio River	587
6	Turkwel Dam inflows	627
7	Turkwel River	656
8	Omo River	15 469

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

2.4.1.3 Seasonal flow variability

Generally, the rivers originating in the central part of the RV Basin have elevated flows between April and September, with pronounced wet months during April and August. The driest season occurs during Jan to March. The Ewaso Ng'iro South River is characterised by very high flows during April and March and a second high flow season in December and January.

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, as a proportion of the total annual natural flow volume per sub-basin. It is evident that in almost all of the sub-basins, only 14% or less of the annual flow occurs during the three driest months.

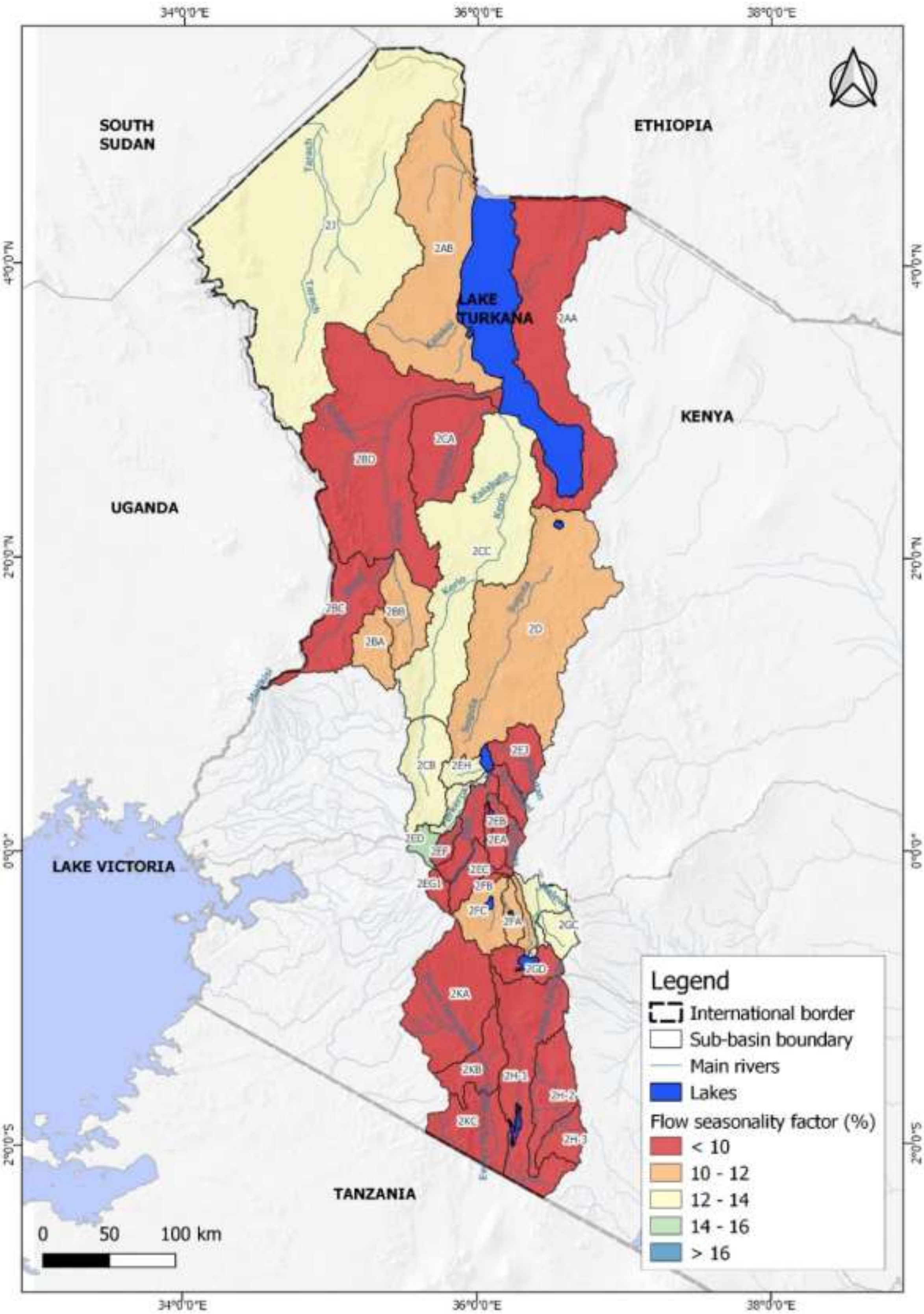


Figure 2-22: Flow seasonality Index per sub-basin

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. Figure 2-23 displays the annual variability of natural flow in four of the main rivers in the basin. It highlights the significant inter-annual flow variability, which supports the need for the provision of more storage within the basin to improve resilience and assurance of supply.

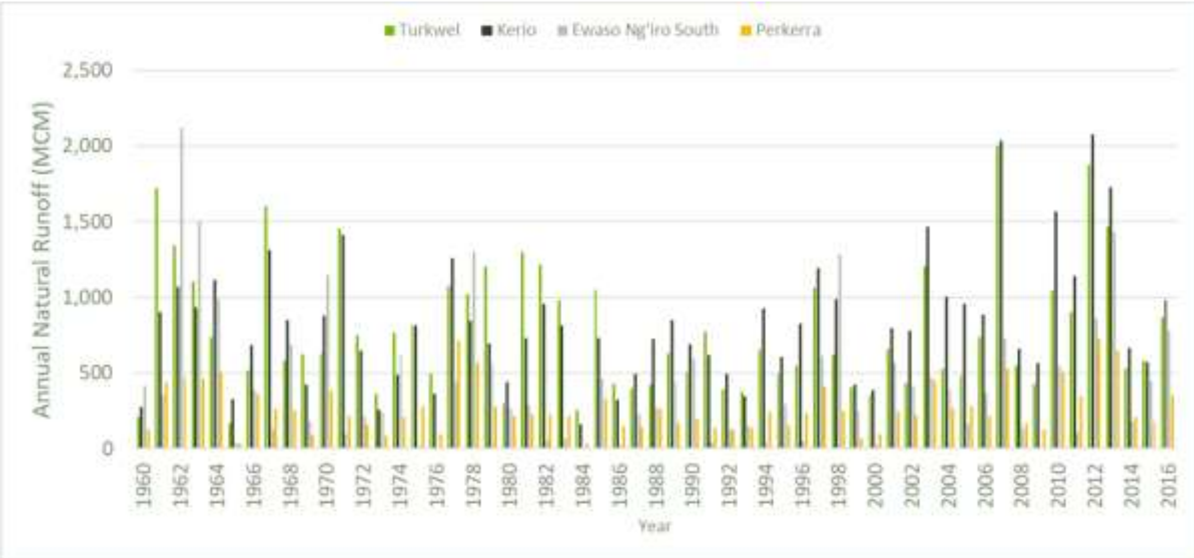


Figure 2-23: Annual flow variability in the main rivers in the RV Basin

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 unit runoff in the upper Kerio, Turkwel, Perkerra and Malewa rivers. In general, these high unit runoff values correspond to Cherangani Hills, the Mau Forest Complex and the Aberdare Range, where most of the flow in the basin originates. Most of the other sub-basins have unit runoff values of less than 100 mm/a.

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, the Turasha, Perkerra, Malewa, Suam, Molo and upper Ewaso Ng'iro South Rivers display high runoff coefficients between 5% and 15%, going up to above 20% in the Malewa and upper Kerio River catchments. The majority of the southern and northern basin, however, is characterised by runoff coefficients below 5%. The average runoff coefficient in the basin equals 4.0%.

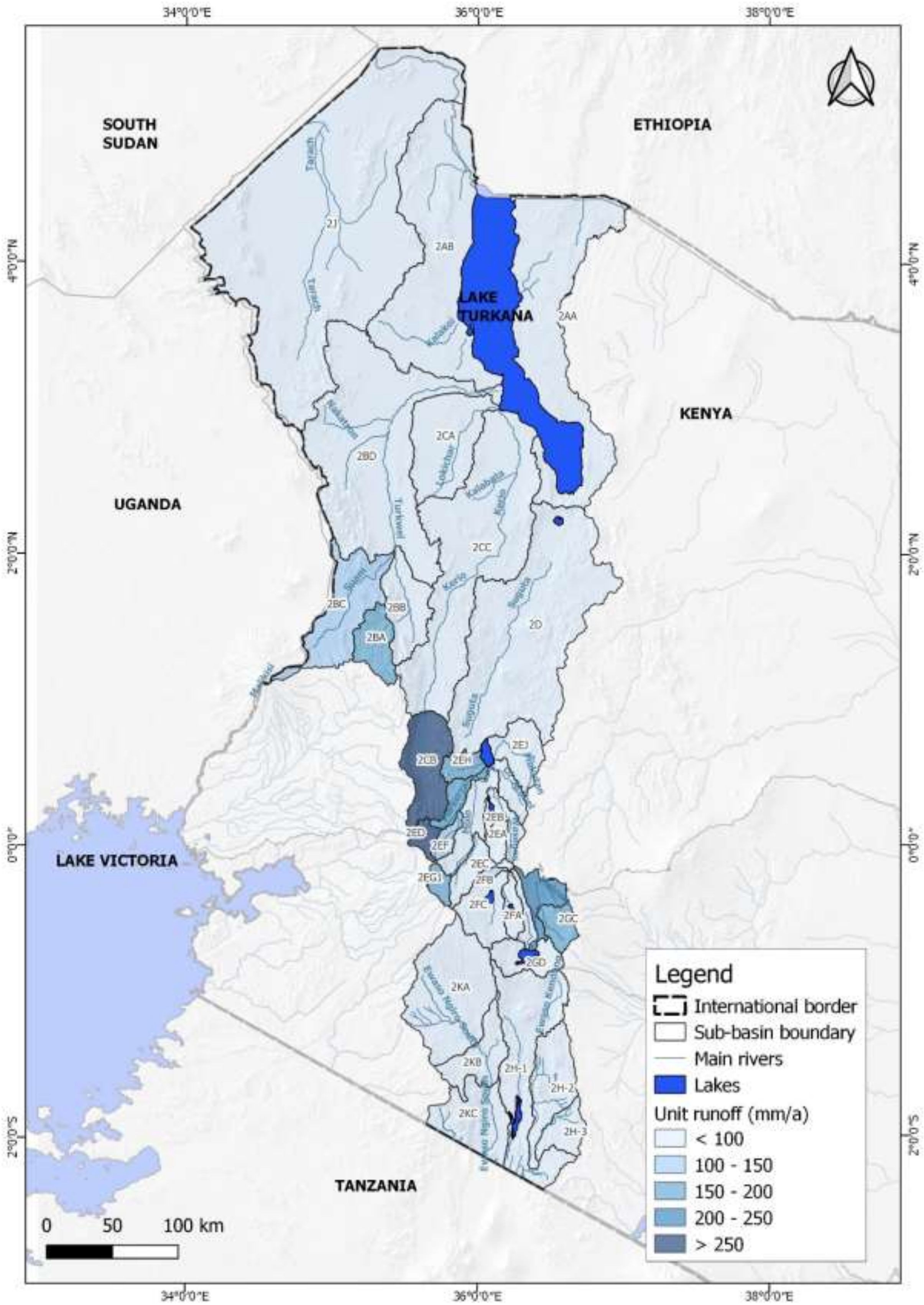


Figure 2-24: Unit runoff per sub-basin

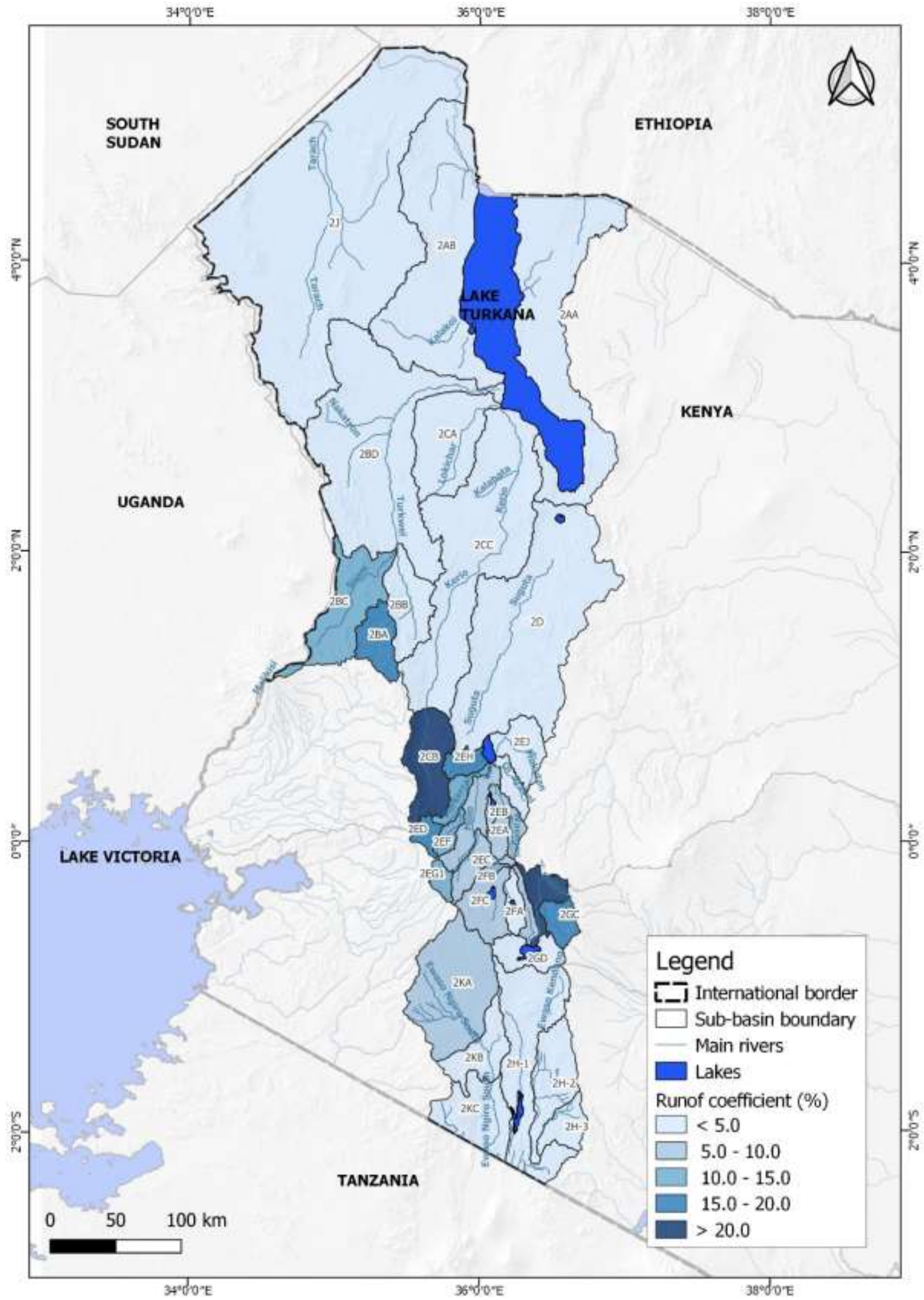


Figure 2-25: Runoff coefficient per sub-basin

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 RV Basin. The RCP 4.5 analysis predicted that the Mean Annual Precipitation across the RV Basin would increase by 10%, from 510 mm to 562 mm by 2050, while day and night temperatures in the basin are expected to increase by up to 1.24°C and 1.46°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 RV Basin to assess the potential impacts on runoff. Even though mean annual precipitation is projected to increase, the net effect on runoff due to increased temperature and evapotranspiration, will result in a reduction in runoff. Figure 2-26 shows that the natural runoff in the basin is expected to decrease in most sub-basins by between 1% and 10%, with some sub-basins slightly lower or higher. The total surface water runoff from the five main river systems in the RV Basin is projected to decrease with 2.9% to 2 214 MCM/a under RCP 4.5.

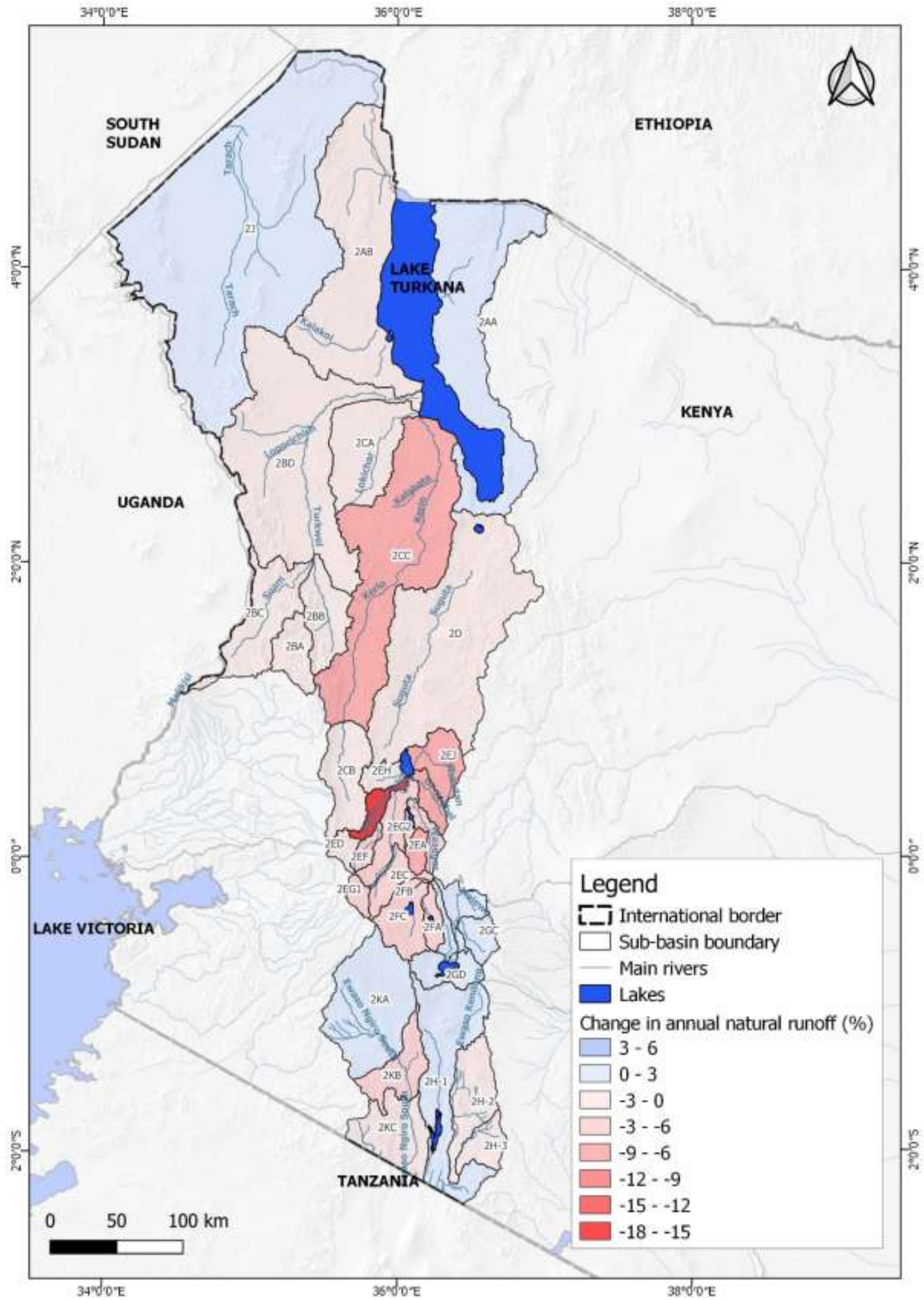


Figure 2-26: Climate change impacts on natural runoff in the RV Basin 2050 (RCP 4.5)

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 RV Basin was undertaken as part of this Consultancy (See **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 RV Basin was estimated at 3 168 MCM/a, with a sustainable annual groundwater yield of 398 MCM/a. This is significantly more than the Kenya National Water Master Plan (NWMP) 2030 sustainable groundwater yield estimate of 102 MCM/a for the RV 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. Figure 2-27 and Figure 2-28 display the recharge and potential groundwater availability in the RV Basin. Good groundwater potential is found in the southern and central RV Basin.

Annexure B lists the groundwater potential per sub-basin.

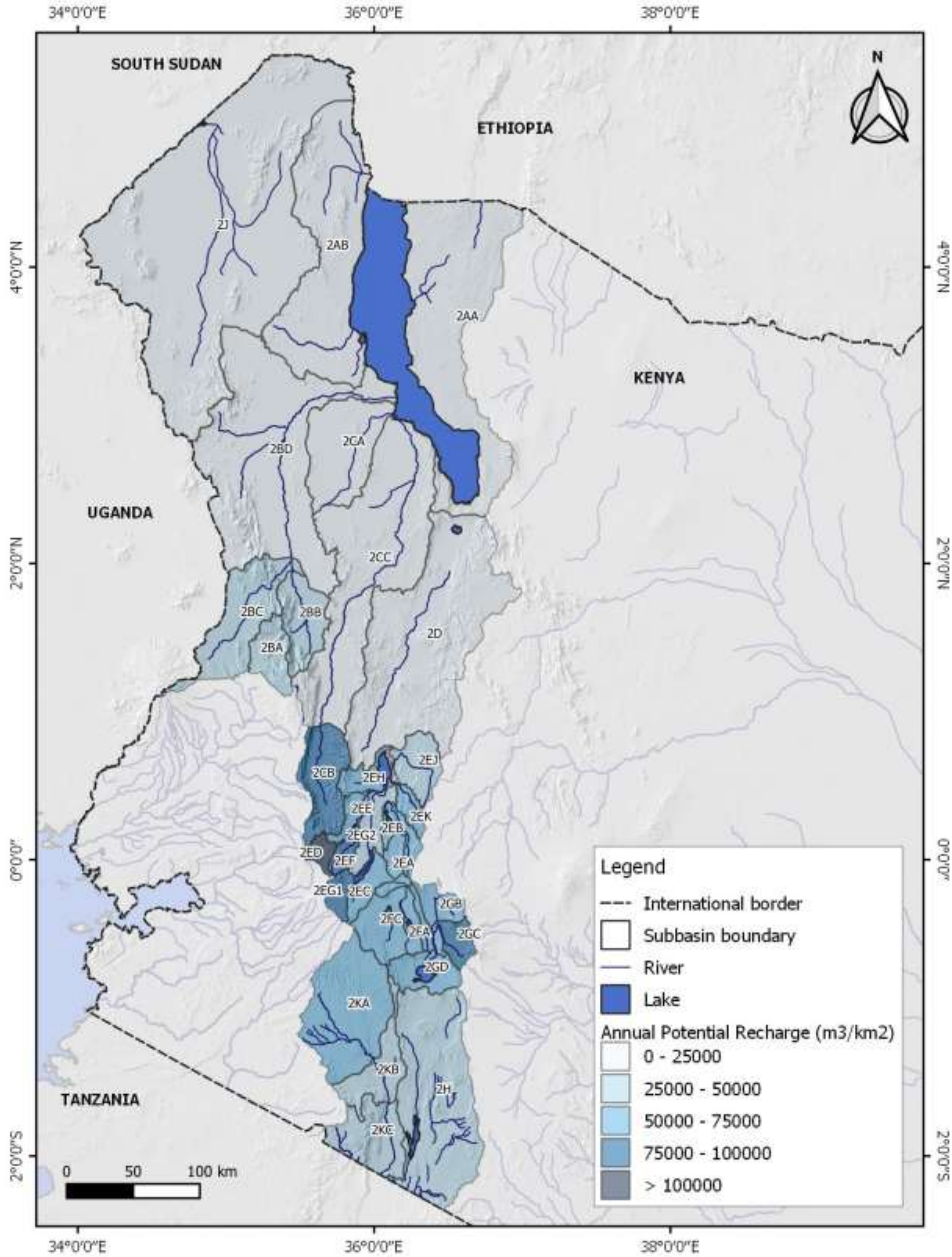


Figure 2-27: Estimated annual groundwater recharge per sub-basin

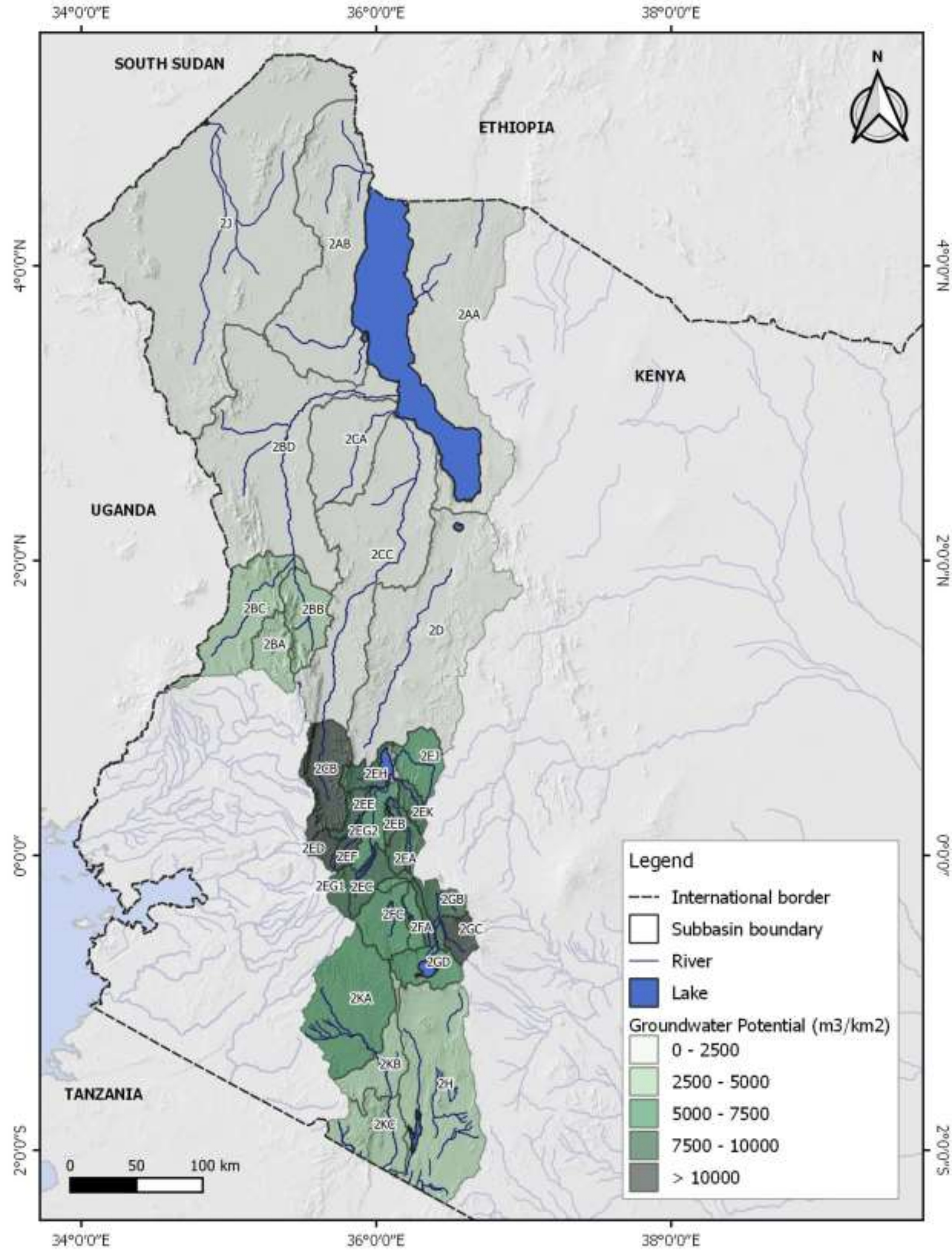


Figure 2-28: Estimated annual groundwater potential per sub-basin

2.4.2.3 Impacts of climate change on groundwater resources

Projected sub-basin precipitation and temperature changes under climate change scenario RCP 4.5 (refer to **Annexure A2**) were superimposed on the groundwater model of the RV 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 3 262 MCM/a, while the potential groundwater yield is expected to increase by 3% to 411 MCM/a under RCP 4.5.

2.4.3 Current water requirements

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

2.4.3.1 Irrigation water requirements

Irrigation area

To estimate irrigation water requirements in the RV 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 study, several sources were consulted:

To estimate current (2018) irrigation water requirements in the RV Basin as part of this Consultancy, information on the location and spatial extent of irrigated areas, as well as information on crop types, cropping patterns and cropping intensities were sourced from several sources. 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 et al., 2017), 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.

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 an 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 2-9. The total current (2018) irrigated area in the RV Basin is estimated as 11 075 ha. This represents an increase of about 16% compared to the 2010 irrigation area of 9 587 ha as determined in the NWMP 2030 and confirms the increase in irrigation in the basin.

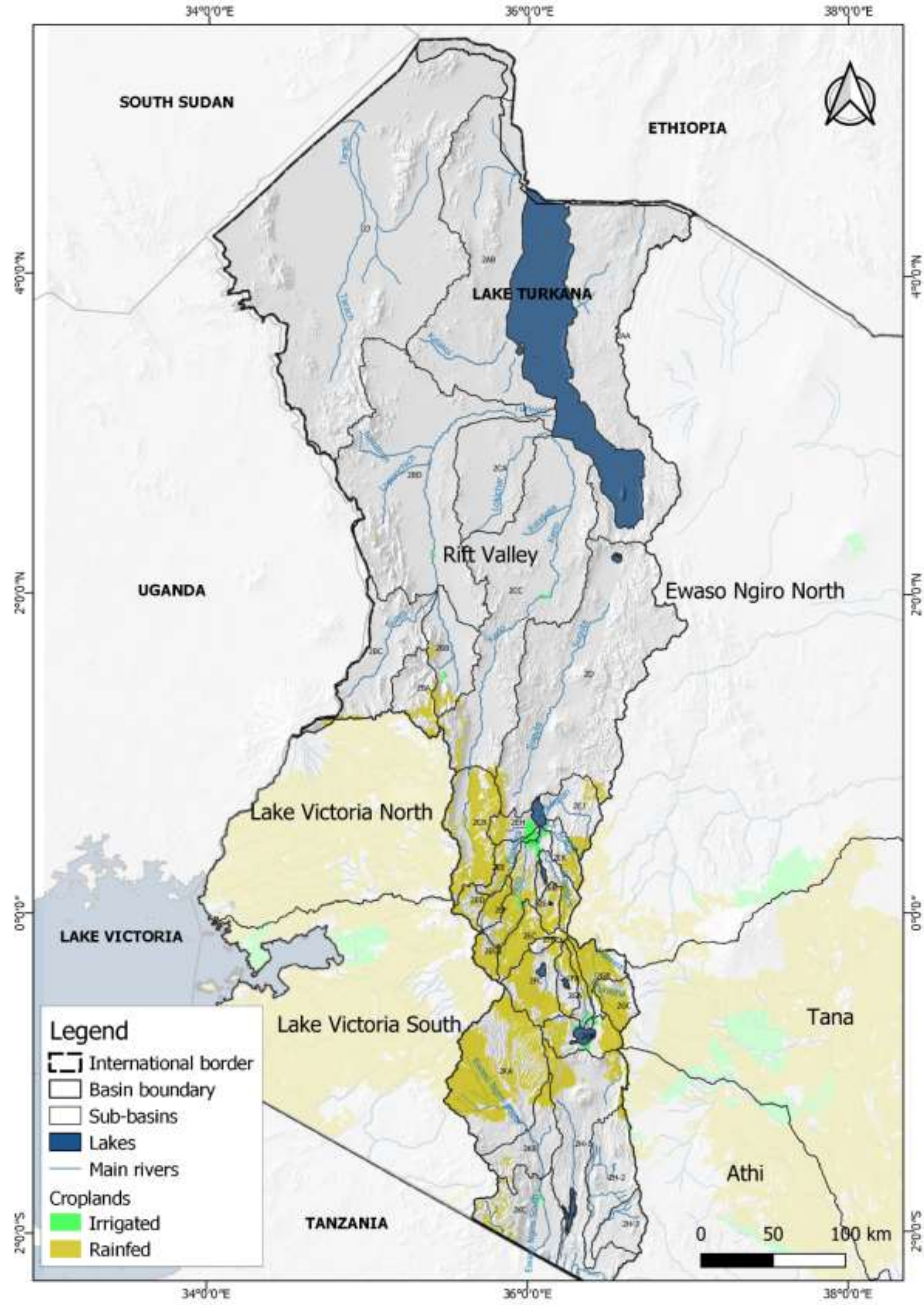


Figure 2-29: Irrigated crops in the RV Basin (RCMRD Kenya Crop Mask, 2015)

Table 2-9: Irrigated areas per sub-basin (2018)

Sub-basin	Irrigated Area (ha)	Sub-basin	Irrigated Area (ha)	Sub-basin	Irrigated Area (ha)
2AA	0	2EC	153	2GA	59
2AB	331	2ED	100	2GB	117
2BA	302	2EE	890	2GC	96
2BB	327	2EF	94	2GD	209
2BC	797	2EG1	92	2H-1	839
2BD	1918	2EG2	0	2H-2	464
2CA	120	2EH	146	2H-3	0
2CB	594	2EJ	271	2J	0
2CC	979	2EK	130	2KA	110
2D	920	2FA	99	2KB	109
2EA	82	2FB	27	2KC	293
2EB	146	2FC	263	**Total**	**11 075**

Irrigation water demand

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 (R. G. 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 RV Basin was calculated as 204 MCM/a.

2.4.3.2 Domestic and Industrial water requirements

For the main urban centres in the RV 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.

For the remainder of the RV 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 total domestic and industrial water demand in the RV Basin supplied from surface water resources was estimated at 93 MCM/a. In addition, 98 MCM/a for domestic and industrial supply is abstracted from groundwater, which brings the total domestic and industrial demand in the RV Basin to 192 MCM/a.

Table 2-10: Current water demands for the major urban areas in the Rift Valley Basin

Urban centre	Total (MCM/a)
Eldama Ravine	1.5
Molo	3.4
Kabernet	1.2
Nakuru	15.2
Naivasha	14.0
Narok	3.2
Total	**38.5**

2.4.3.3 Livestock water requirements

The livestock water demands in the RV 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 80 MCM/a as the demand for 2018.

2.4.3.4 Wildlife and fisheries

Water demands for wildlife and fisheries in the RV Basin is negligible. Consequently, the water demand figure of 5 MCM/a as stated in the NWMP 2030 was accepted as the current demand.

2.4.3.5 Total water requirements

The total current estimated water demand (2018) in the RV Basin equates to 481 MCM/a as shown below. Most of the water is needed for irrigation, livestock and domestic / industrial use.

Table 2-11: Current (2018) water requirements in the RV Basin per main sector

Sector	Total (MCM/a)
Irrigation	**204**
- Small scale / Private	164
- Large-scale	40
Domestic and Industrial	**192**
- Urban centres	39
- Basin-wide	153
Livestock	**80**
Other	**5**
Total	**481**

Figure 2-30 shows the distribution of current water demands across the RV Basin.

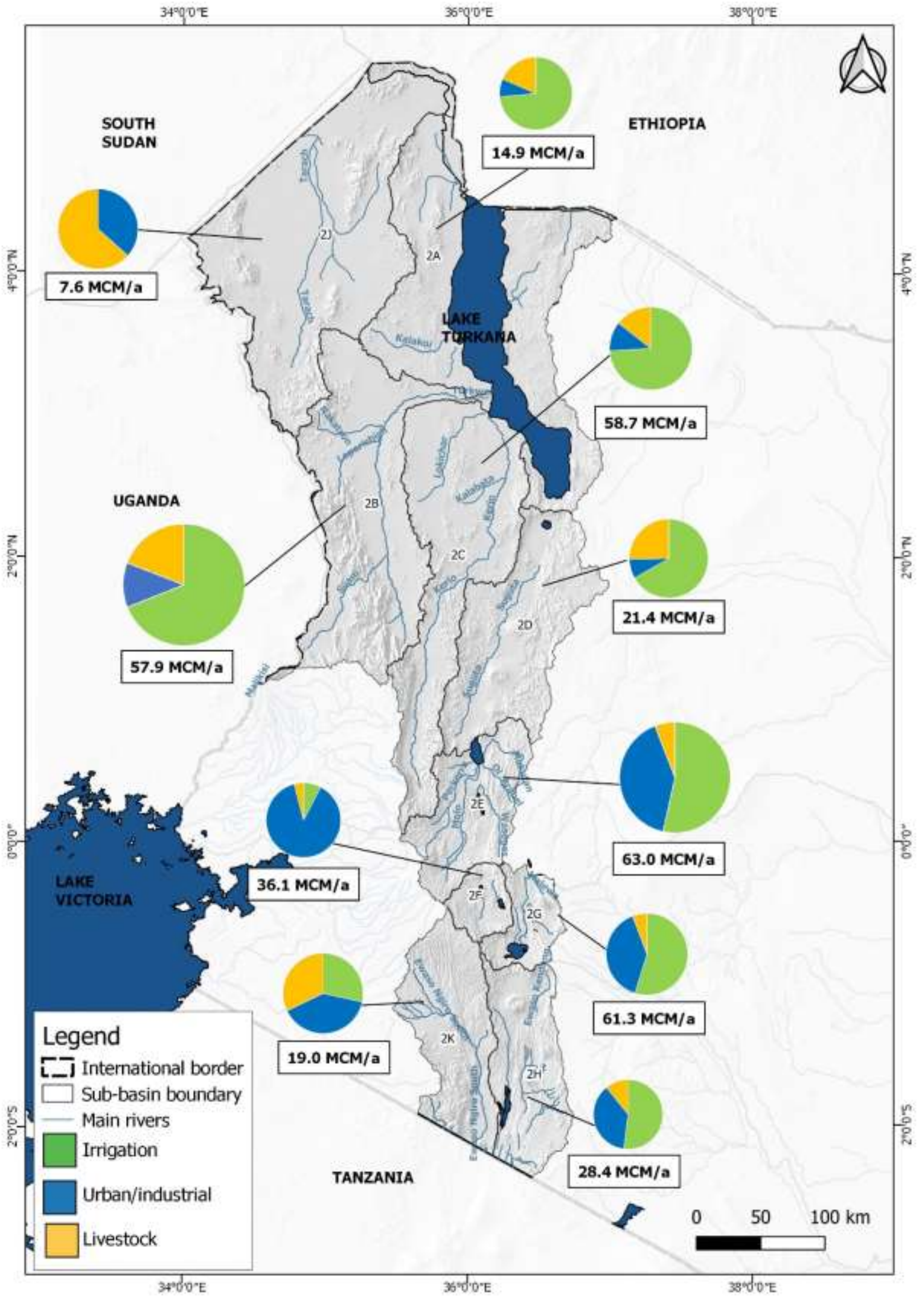


Figure 2-30: Present-day water requirements across the Rift Valley Basin

2.4.4 Current large-scale water resources infrastructure

The existing large-scale water resources developments in the RV Basin are briefly presented below.

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 are currently four large dams in the RV Basin. The dams are used for domestic and irrigation water supply in the RV Basin and for hydropower generation. Key characteristics of the dams are presented in Table 2-12.

Table 2-12: Existing dams larger than 1 MCM: Key characteristics

Dam Name	Location		Purpose	Storage Capacity (MCM)
	Lat	Long		
Turkwel Dam	1.898056	35.333611	Irrigation & Hydropower	1 641
Chemususu Dam	0.087785	35.633027	Domestic	10.9
Chemeron Yatoi Dam	0.507077	35.965959	Irrigation	2.3
Kirandich Dam	0.501272	35.781454	Domestic	4.5

2.4.4.2 Water transfers

Details on the existing intra-basin transfers in the RV Basin are presented below.

Table 2-13: Intra-basin water transfers

Transfer Source	Town supplied	Transfer volume (MCM/a)
Chemususu Dam	Supplies Nakuru, whilst supplying Mogotio Town on the way	15.2
Turasha Intake Dam	Supplies Nakuru County, Naivasha, Gilgil and rural users (20%)	5.8

2.4.4.3 Large-scale irrigation schemes

As mentioned in Section 2.4.3.1, information on existing large-scale irrigation schemes in the basin was obtained from the NWMP 2030 and validated with information provided by the NIA and the Department of Irrigation at the Ministry of Agriculture, Livestock and Fisheries. 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 RV Basin is summarised in Table 2-14 below.

Table 2-14: Existing large-scale irrigation areas

Large-scale Irrigation	Irrigation area (ha)
Perkerra	890
Wei Wei	570
Turkwel	1 080

2.4.4.4 Groundwater development and use

Current groundwater use in the RV Basin is estimated at 198 MCM/a. The percentage of the total water demand in each sector that is supplied from groundwater is shown in Table 2-15. Groundwater supply for each sector was determined from information in the Permit Database and the NWMP 2030. The use of groundwater for domestic water supply is higher in rural areas than urban areas in the RV Basin.

Table 2-15: Groundwater contribution to meeting water demand in the RV Basin (%) per sector

Use	Domestic (basin-wide)	Livestock	Large-scale irrigation	Small-scale irrigation	Industrial	Other
% met by groundwater	47%	38%	0%	42%	5%	0%

In the lower parts of the central basin groundwater is made extensive use of, particularly in Naivasha, Nakuru and Baringo. In all these basins, groundwater is readily available at shallow to moderate depths and yields are often high. Boreholes in these basins support private and public water supply, intensive commercial irrigation, commerce and industry, wildlife and tourism, and extensive pastoralism. In Nakuru, Baringo and Turkana Counties, large volumes of groundwater are used for the development of geothermal and petroleum resources, as a key component in drilling fluids.

Community-based urban or peri-urban groundwater supply systems are relatively widespread, established to meet the shortfalls in utility water supply (Gevera & Mouri, 2018). Community water supply systems in rural areas are also widespread, with County Integrated Development Plans (CIDPs) all strongly supporting the 'solarisation' of such projects. The CIDPs also broadly support and have budgeted for the protection of unprotected groundwater sources (springs and shallow wells).

Large-scale groundwater use for commercial irrigation is common in Nakuru and Baringo Counties, sometimes supplementing surface water sources, sometimes not. Specific groundwater irrigation 'hotspots' include the entire Naivasha basin, the Rongai area in Nakuru County, Ol Kalou and the Molo-Elburgon-Njoro axis. A large body of academic work describing water resources in the Naivasha basin exists, drawn from studies carried out by Earthwatch/University of Leicester (Harper et al., 2003) and the International Institute for Geo-Information Science and Earth Observation (ITC, The Netherlands; e.g. Becht et al., 2006).

Large-scale groundwater use helps drive the geothermal power industry; a typical geothermal well requires up to 100 000 m^3 of drilling fluid make-up water to drill (Ogola et al., 2002). While most if not all the water used for geothermal development in the Naivasha basin comes from Lake Naivasha (three surface water permits for 7 056 m^3/d), in other areas significant groundwater use occurs (Water Resources Management Authority, 2007b). Exploratory geothermal drilling in the Menengai Crater (Nakuru) has relied on groundwater from the Olbanita area, and future geothermal development in the Suswa area is expected to rely heavily or exclusively on groundwater. Geothermal development in the Paka-Silali area relies on surface water from Lake Baringo (Geothermal Development Company (GDC), 2019; Water Resources Management Authority, 2007b).

Large-scale groundwater use also drives the oil exploration industry. Tullow Oil Kenya have constructed a significant number of boreholes to meet drilling fluid make-up, camp and community water needs. Continued access to reliable groundwater is a key element in the Final Investment Decision to be agreed between the Government of Kenya and Tullow[3]. The aquifer exploited by Tullow is the recently-described Kalapata Beds sandstone aquifer, with test discharges of up to 65 m^3/hr achieved (Water Resources Authority, 2019b). Tullow have also developed community water supply boreholes and systems, claiming to have spent around KShs 200 million drilling more than 30 community boreholes around Turkana County (Tullow Oil Kenya, 2019).

2.4.4.5 Ongoing major water projects

Construction on various large dams in the RV Basin is about to start, is underway, or has started but are currently on hold due to contractual, financial and/or other issues. These dams include the Muruny-

[3] "Agreements Over Land Title & Water Supply Key to Reaching Lokichar FID by End of 2019 – Tullow Oil". **https://www.oilnewskenya.com/agreements-over-land-title-water-supply-key-to-reaching-lokichar-fid-by-end-of-2019-tullow-oil/**.

Siyoi Dam in West Pokot as part of the Kapenguria Water Supply Project and the Arror multipurpose dams on upper tributaries of the Kerio River in Elgiyo Marakwet County, which will have installed hydro-electric capacity of 60 MW and will supply water for about 3 000 ha of irrigation. The Lowaat Dam on the Kerio River and the Radat Dam on the Perkerra River in Turkana and Baringo counties respectively, will also be used for irrigation supply.

2.4.5 Water balance

The 2018 water balance in the RV Basin in terms of natural surface water runoff and sustainable groundwater yield, the ecological reserve and current (2018) water demands in the RV Basin is summarised in Table 2-16. The current water demand constitutes about 17% of the total water resources available for use.

Table 2-16: RV Basin water balance

	Surface water (MCM/a)	Groundwater (MCM/a)	Total (MCM/a)
Natural / Available water	2 682	398	3 080
Ecological reserve	(251)	-	(251)
		Total	**2 829**
		Water demand (2018)	(481)
		Balance	**2 348**

Due to climate change impacts, the natural surface water runoff is expected to decrease to 2 604 MCM/a, while the groundwater yield is projected to increase to 411 MCM/a by 2050.

Note: Future water balance scenarios which assess climate change impacts on future water availability and requirements are addressed in Section 5 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 most of the sub-basins still have surface water available, except for 2AB, 2BD, 2CA, 2GD and 2H-1.

It is important to realise that although the sub-basin water balances might indicate that the total annual demand in a sub-basin is less than the water resources available 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 (Section 5).

The current estimated groundwater use in the RV Basin equates to 198 MCM/a, which is about 50% of the estimated sustainable groundwater yield of 398 MCM/a. This leaves 200 MCM/a of groundwater available for potential use in the RV Basin. The current surface water demand in the Basin was estimated at 283 MCM/a, which is about 10% of the surface water available in rivers - taking into consideration the ecological reserve (Q95), calculated as 251 MCM/a.

The current-day water availability and use in the RV Basin is displayed in Figure 2-32.

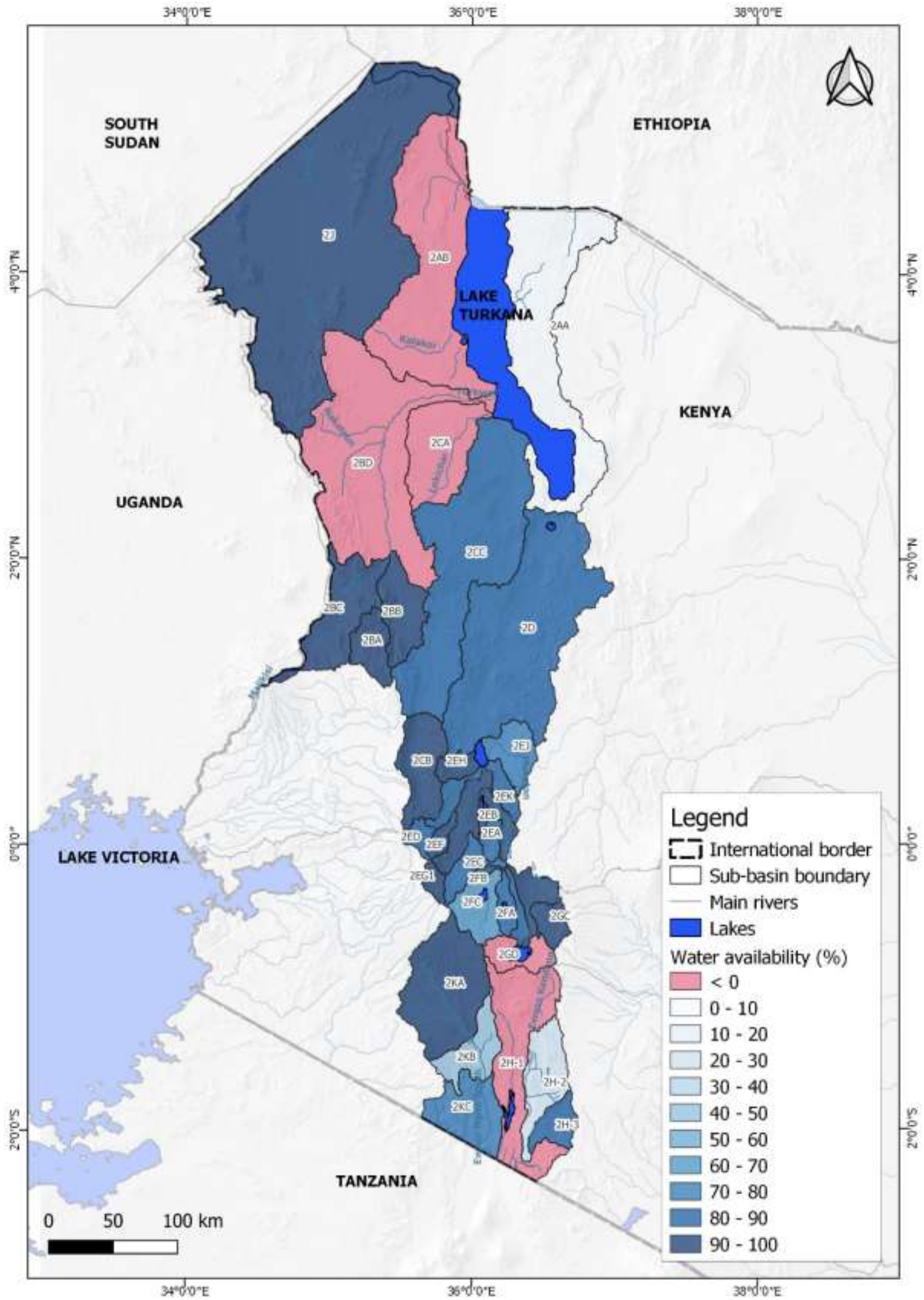


Figure 2-31: Surface water balance per sub-basin

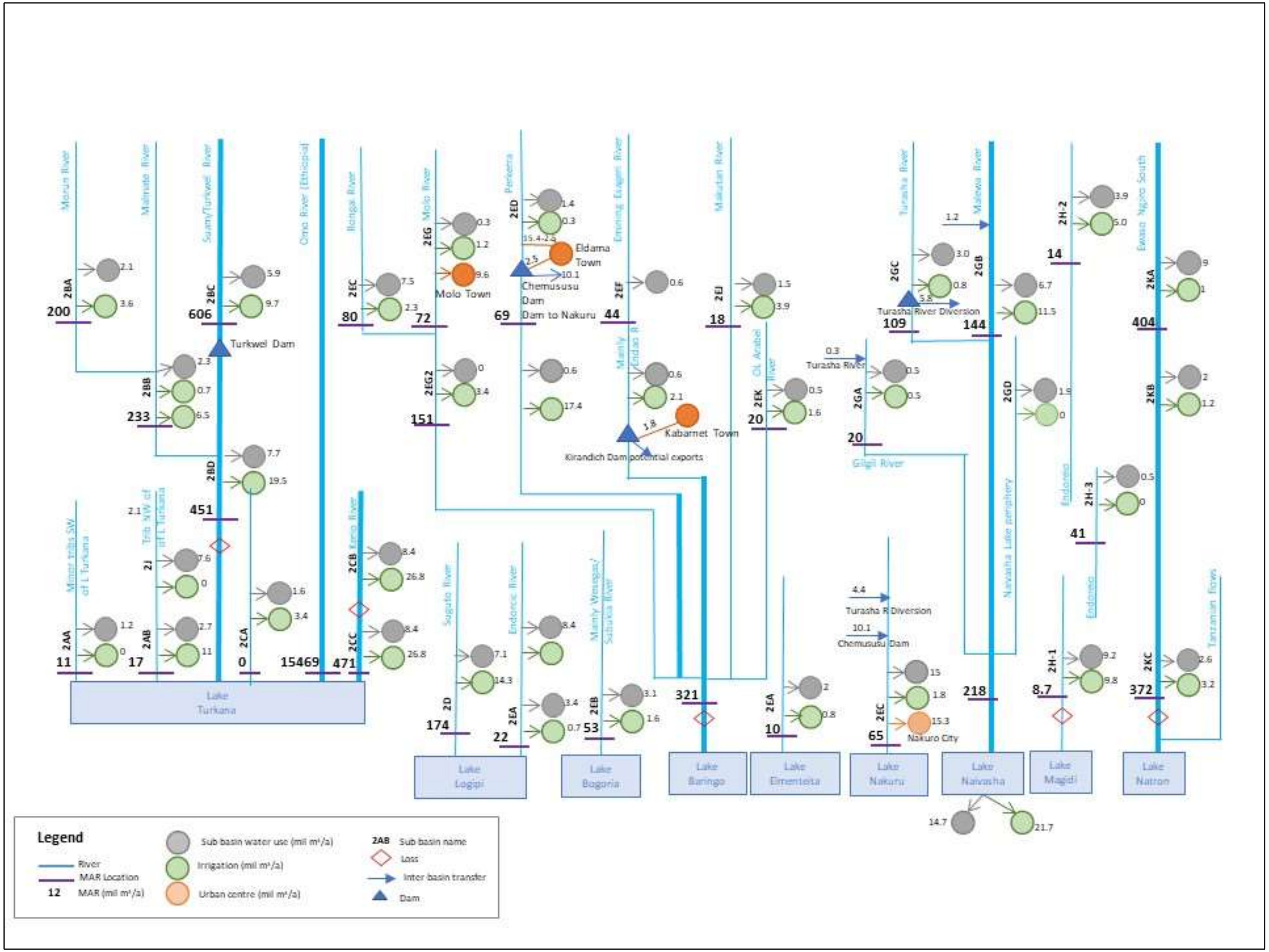


Figure 2-32: Current-day water availability and use in the RV Basin

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 RV 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 RV 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.

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.

2.4.7 Water quality

Water quality in the RV Basin is a critical issue, especially as all the major rivers drain into lakes which are either Ramsar or UNESCO World Heritage sites. Water quality across the basin is heavily impacted by point and non-point sources of pollution, with the latter closely linked to the management and utilisation of land. The quality of water resources has deteriorated due to increased anthropogenic activities. Unsustainable farming practices and poor management of croplands is evident in many parts of the basin. Major water pollution threats include urban runoff, municipal waste, industrial waste, sedimentation and agrochemicals. Water quality issues also stem from inadequate monitoring and compliance control, the use of fertilisers, poor sewerage disposal management and sedimentation of water bodies. Typical point sources of pollution in the RV Basin include raw sewage from urban areas in some sub-counties, effluent from horticultural farms and livestock-based industries, leachates and solids from solid waste dumps. Non-point pollution comprises atmospheric deposition, stormwater runoff from farms, and soil erosion from areas devoid of vegetation cover.

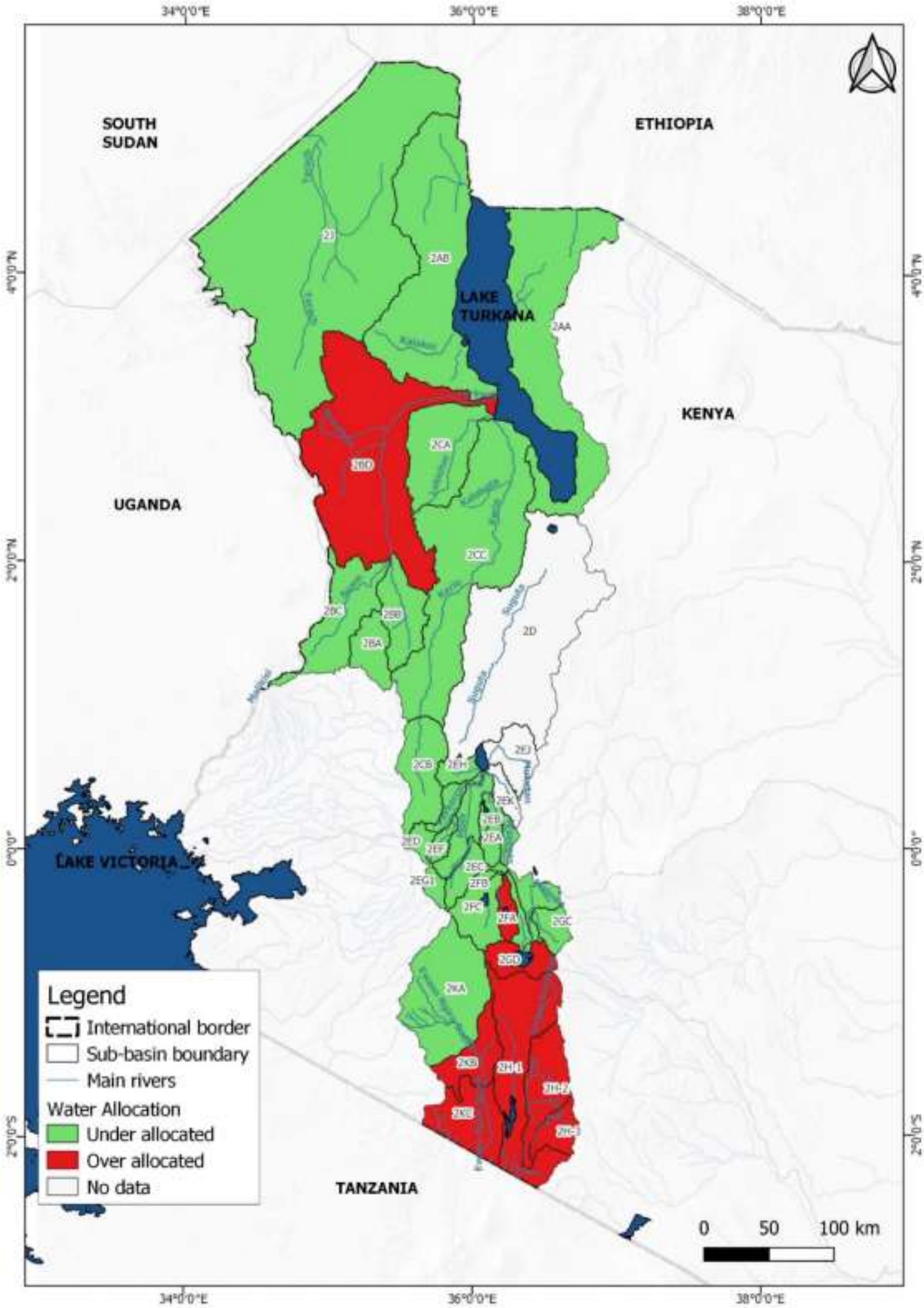


Figure 2-33: Surface water allocation status per sub-basin (2018)

The most common pollutants in the RV Basin include:

- Industrial effluents from cities and towns
- Municipal/domestic sewage from urban settlements
- Solid wastes from dump sites
- Nutrients and pesticide residues, from agro-based industries, flower and horticultural farms
- Sediment loads from degraded farmlands
- Soil erosion from overgrazed lands
- Storm runoff from roads and urban centres including oil spills
- Oil drilling wastes
- Leachates from Pit latrines, Septic tanks and feedlots
- Acaricides from cattle dips

2.4.8 Existing hydrometeorological monitoring network

2.4.8.1 Stream flow measurement

In 2018, the RV Basin had 79 recorded stream flow monitoring stations, of which 64 were known to be operational. Table 2-17 provides details on the operational stream flow monitoring network in the RV Basin. From Table 2-17 it is evident that most currently operational stations are manually operated. Figure 2-34 displays the spatial distribution of the operational (2018) stream flow monitoring stations in the RV Basin for which information is available.

Table 2-17: Current stream flow monitoring stations in RV Basin

SRO	Operational			
	Telemetric	Automatic	Manual	Total
Kabarnet	2	0	20	**22**
Kapenguria	1	0	7	**8**
Lodwar	0	0	2	**2**
Naivasha	1	3	12	**16**
Narok	1	0	15	**16**
Total	**5**	**3**	**56**	**64**

Most of the operational river gauging stations are rated sections. Most are read manually by gauge readers, with 8 automatic stations (5 of which are fitted with telemetry). Rating curves are updated yearly at the National office and distributed to the regional and sub-regional offices for use. However, challenges remain because many of the stations are also inaccessible during high flow conditions.

2.4.8.2 Monitoring of dam and lake levels

There are currently 6 lake monitoring stations in the RV Basin, of which 4 are operational (Lake Turkana, Begonia, Lake Baringo and Lake Naivasha). They are all manually operated (Figure 2-34). Historical data for these 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 RV basin.

Figure 2-35 displays the spatial distribution of the operational meteorological stations in the RV 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 2-18).

Table 2-18: Number of water quality monitoring stations in the RV Basin (2018)

RV Basin water quality stations	No. of current stations (2018)
Surface water	43
Effluent stations	16
Groundwater	39
Total	**98**

Currently, the water quality monitoring programme operated by WRA faces the challenges of inadequately qualified and trained staff and also 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 below.

Table 2-19: 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- NO^{2-}, NO^{3-}, PO_4^{3-}, TSS
Surface water quality monitoring stations	Flow, pH, DO, Temperature, TSS Conductivity, TDS, Nutrients- NO^{2-}, NO^{3-}, PO_4^{3-}.
Ground water quality monitoring stations	pH, DO, Temperature, TSS Conductivity, TDS, Nutients-NO_2^-, NO_3^-, PO_4^{3-}.

2.4.8.5 Groundwater level monitoring

In 2015, there was a total of 33 groundwater monitoring points across the RV Basin (Water Resources Management Authority, 2015b). In 2018, 18 groundwater monitoring points were known to be operational (seven strategic, six major, five minor and none in Special aquifers) (Water Resources Authority, 2018f). Out of these, two boreholes are dedicated monitoring sites. The 2019 draft Hydrogeological Mapping of Turkana Aquifers (Water Resources Authority, 2019b) presents recommendations for additional monitoring boreholes in Turkana County. 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. Abstraction monitoring is done on an ad hoc basis. 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 and implementation of formal guidelines for groundwater abstraction surveys, using electromagnetic flow meters (Water Resources Authority, 2019a).

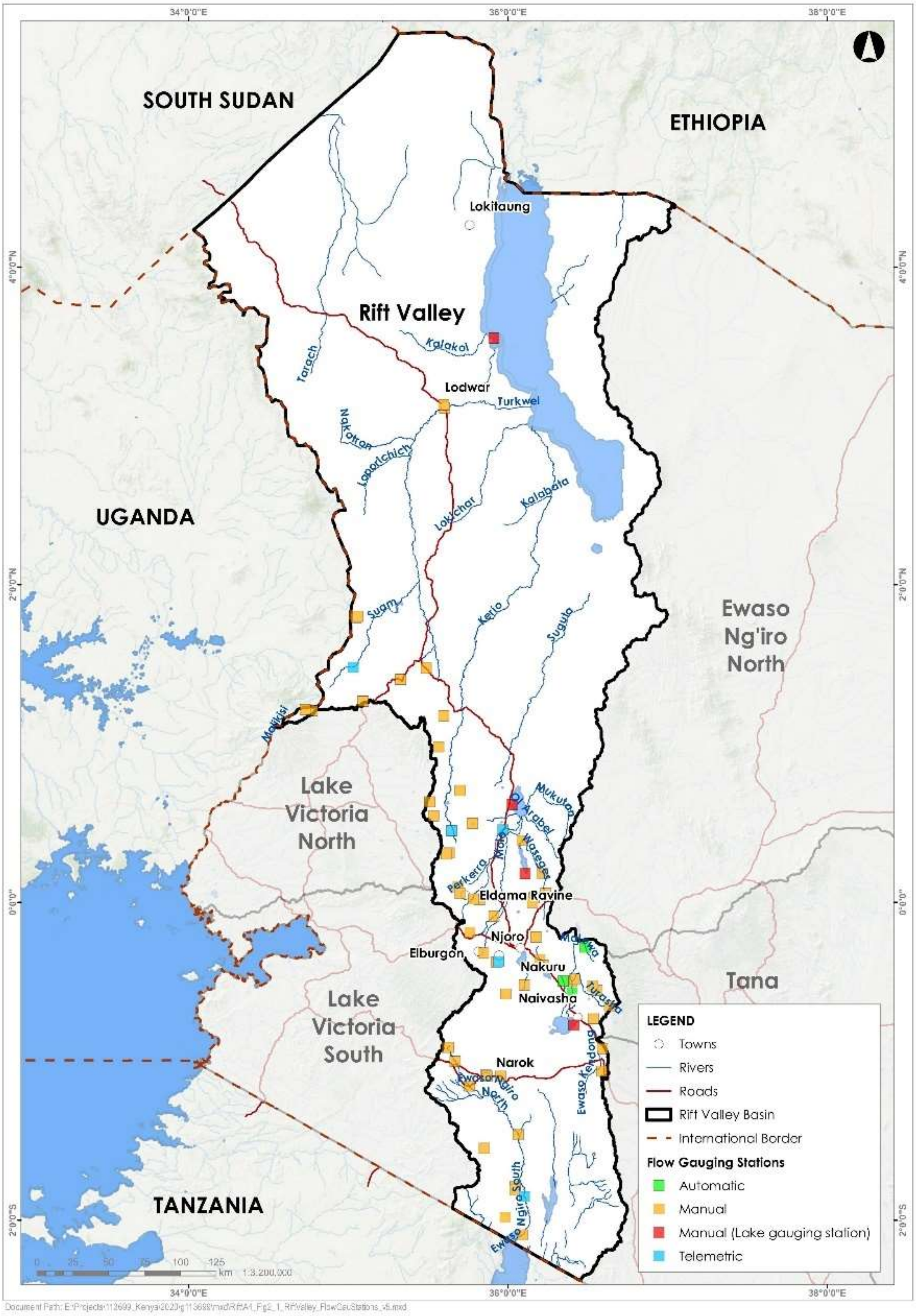


Figure 2-34: Locations of operational stream flow gauging stations in the RV Basin

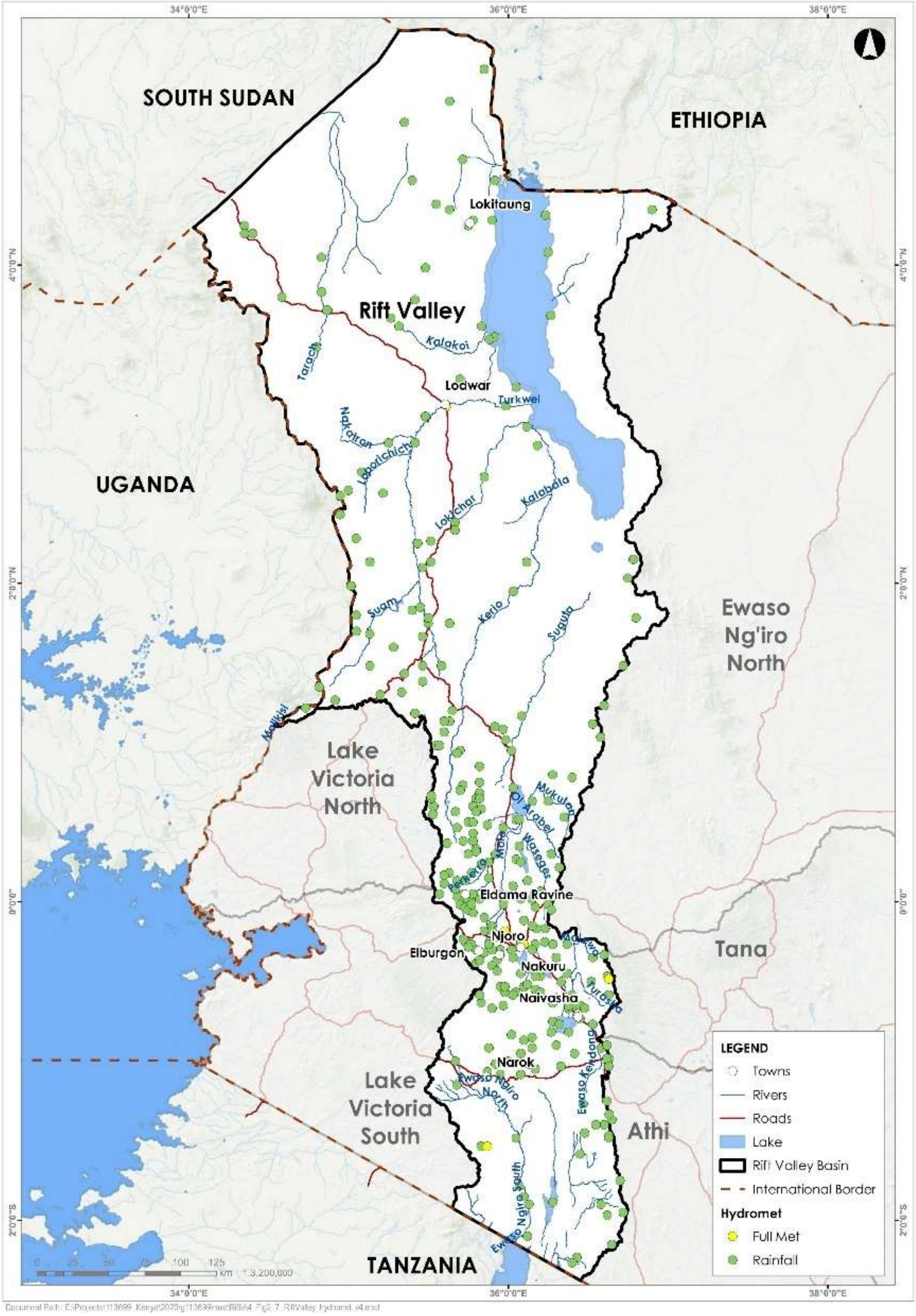


Figure 2-35: Locations of operational meteorological stations in the RV Basin

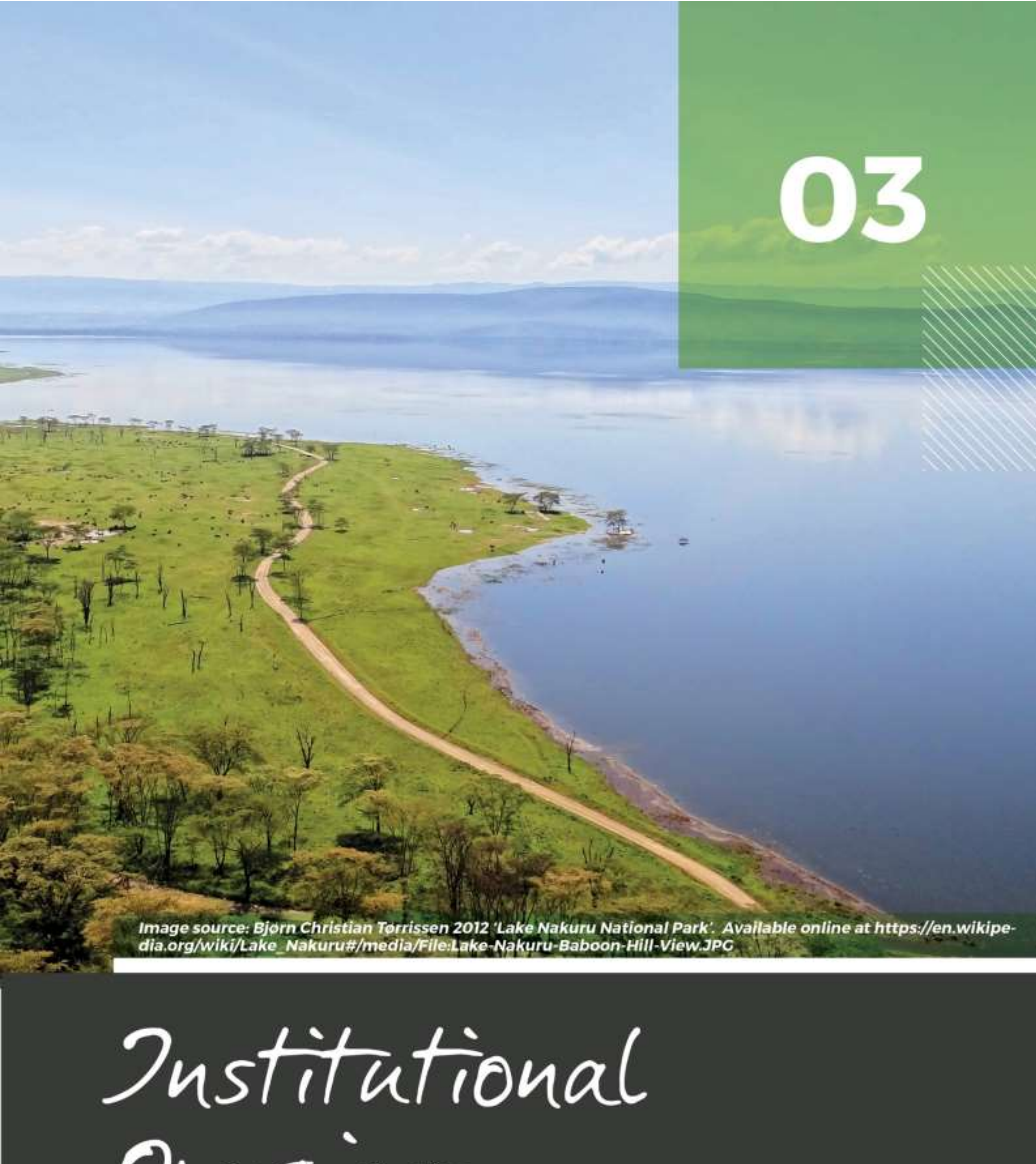


Image source: Bjørn Christian Tørrissen 2012 'Lake Nakuru National Park'. Available online at https://en.wikipedia.org/wiki/Lake_Nakuru#/media/File:Lake-Nakuru-Baboon-Hill-View.JPG

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.

Annexure C provides an overview of the legal, institutional and policy framework relating to environmental and integrated water resources management.

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, Mount Kenya and Mount 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' (Government of Kenya, 1999) 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, 1999), 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 RV 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 RV Basin and these are presented below.

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 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 have developed over time and this has enabled successive adjustments in order to improve the way water (and other natural resources) are managed and sustainably developed.

In March 2003 the GoK **Water Act** *(Act No. 8 of 2002)* came into effect. This Water Act 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 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. 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 several 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.

A range of legislative instruments underpins 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 (ERC). In 2009, the ERC 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 resource 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 services providers. - Evaluate and recommend water and sewerage tariffs to the county water services providers and approve the imposition of such tariffs in line with consumer protection standards. - Set licence conditions and accredit water services 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.
Water Sector Trust Fund (WSTF)	- Financing provision of water and sanitation 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)	- Arbitration of 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.

Institution	Roles and responsibilities*
Water Works Development Agencies	- Undertake the development, maintenance and management of the national public water works within its area of jurisdiction. - Operate waterworks 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 such County Governments and water services providers within its area as may be requested.
Kenya Water Towers Agency	- 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	- Provides 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 RV Basin is managed by five WRA Sub-Regional Offices (SROs) with the WRA Regional Office (RO) located in Nakuru. The Basin has been delineated into ten 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 RV Basin

Sub-Region	WRA SRO	CMUs
Lower Turkwel	Lodwar	Lake Turkana Basin, Lokitipi Plains
Upper Turkwel	Kapenguria	Upper Turkwel
Lakes Baringo/ Bogoria	Kabarnet	Upper Kerio, Suguta River, Lakes Baringo/ Bogoria
Lakes Naivasha/ Nakuru	Naivasha	Lakes Nakuru/ Elementaita, Lake Naivasha
South Rift Valley	Narok	Upper and Lower Ewaso Ng'iro South

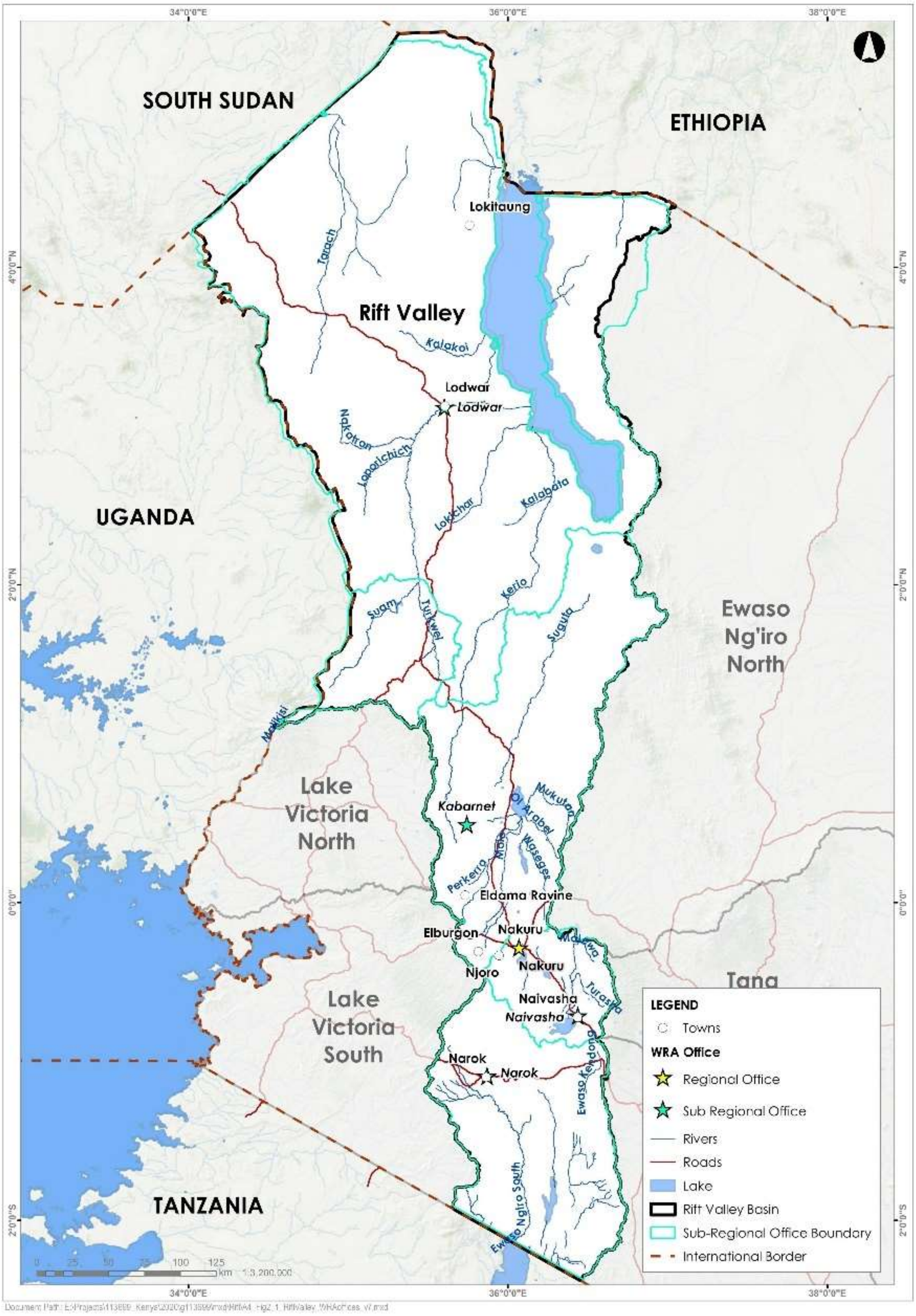


Figure 3-1: WRA Offices and sub-regions in the RV Basin

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 shall operate under the regulations made by the Authority Water Act 4 (a) including 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 twelve counties within the RV Basin, only four 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 Turkana, Marsabit, Samburu, West Pokot, Eligiyo Marakwet, Baringo, Lakipia, Nyandarua, Nakuru, Narok, Kajiado and Kiambu.

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

The MaMaSe Sustainable Water Initiative is a transboundary water partnership initiative that aimed at improving water safety and security in the Mara River Basin to support structural poverty reduction, sustainable economic growth and conservation of the basin's ecosystems. In this four year programme the people and institutions in the basin were supported in a process of structural change, promoting water-wise economic development that lifts people out of poverty and sets them on a sustainable path to improved wellbeing and self-reliance. The Initiative was financially supported by the Netherlands Embassy in Nairobi and consists of a broad-based public private partnership including international and Kenyan government agencies, civil society, private sector, NGOs, and knowledge institutions. It was led by UNESCO-IHE together with WWF Kenya.

As the implementation of the RV 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.

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 D**).

3.2 Existing Development Plans and Sectoral Perspectives

To ensure that this Basin Plan is representative and aligned with current plans and strategies related to water resources planning and management in the RV 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 RV Basin are also presented in this Section.

3.2.1 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 RV 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 RV Basin Plan, specifically the sub-plans as outlined in chapter 7.

3.2.2 Catchment management strategy

The RV Catchment Management Strategy (CMS) (Water Resources Management Authority, 2015b) was completed in 2014 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 RV CMS

Strategy	Theme	Objective
Water resource protection	Water resource protection	– To ensure all effluent dischargers comply with permitting conditions – Set the RQOs – To improve water quality monitoring (rationalizing network, enhance consistency, upgrading, resource allocation) – To collaborate with County Governments and other stakeholders in agro-chemical use, sanitation and solid waste management
	Catchment protection and conservation	– To restore and protect degraded water catchments. – Identify and recommend Vulnerable ecosystems for gazettement – To collaborate with County Governments and other stakeholders in soil and water conservation – To enhance capacity in catchment protection and conservation.
Resource augmentation adaptation and development	Flood and drought management	– To enhance capacity on IFDM (CGs, WRUAs, WRMA staff). – To develop and operationalize IFDM plans in collaboration with County Governments (CGs) and other Stakeholders – To mainstream Flood and Drought management in SCMPs
	Climate change adaptation	– To strengthen monitoring systems for enhanced information gathering – To enhance capacity and create awareness on Regional Climate Modelling results on climate change effects – To localize RCM results to the Sub Basin Level – To authenticate and create an inventory of potential water storage areas to increase storage – To enhance efficiency in water, use and maintain reserve flows
	Water resources infrastructure development	– To regulate water resources infrastructure development for safety and ensuring maintenance of downstream flow – To identify potential sites for water resources infrastructure development – To participate in the development of the Codes of practice for surface water – To enforce Codes of practice for surface water Infrastructure Development
	Rights based approach	– To build capacity of WRMA staff, WRUAs CBOs and Service Providers to implement Livelihood – To implement Livelihood enhancement projects
	Livelihoods enhancement	– To build capacity of WRMA staff, WRUAs CBOs and Service Providers to implement Livelihood – To implement Livelihood enhancement projects
Implementation, information management	Institutional strengthening	– To enhance the capacity of RO, SROs and WRUAs to effectively undertake IWRM

Strategy	Theme	Objective
and financing		– To build capacity for the County Governments to effectively participate in water resources management – To enhance capacity of WRUAs to undertake IWRM activities – To enhance collaboration with stakeholders on WRM issues
Monitoring and management		– To optimize water resources monitoring network – To enhance data management system (data collection, analysis, storage and dissemination) – To upgrade water resources information system – To establish an effective monitoring and evaluation system for CMS implementation

3.2.3 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 83 WRUAs out of a potential 175 WRUAs have been formed in the RV 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 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 oversee 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 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 48 SCMPs have been developed in the RV Basin.

3.2.4 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 key aspects of each CIDP for the main counties situated in the RV Basin are presented in Table 3-5.

Table 3-5: Key aspects of the CIDPs relevant to RV Basin

County	Water and Sanitation	Agriculture	Natural Resources
Turkana	Programmes include increasing urban and rural water supply, construction of small dams and pans and water quality mapping. Flagship projects include drilling boreholes.	Programmes include developing agricultural markets and products, establishing a training centres for farmers, expanding existing irrigation schemes and providing agricultural mechanisation. Flagship projects include developing an Integrated Food Security Master Plan and developing innovative agricultural technologies.	Programmes include catchment conservation, soil and water conservation, afforestation, management of alien invasive species, renewable energy, mineral, oil and gas exploration.
West Pokot	Programmes include water resources management (i.e. water supply infrastructure development) and water catchment protection.	Programmes include crop development and management, agribusiness development and marketing, irrigation development and management, livestock production, livestock disease management and control, fisheries development and management	Programmes include forest conservation and management, climate change adaption and mitigation, environmental and wildlife conservation and land reclamation.
Marsabit	Programmes include the establishment of new water sources (i.e. boreholes), construction of medium and mega dams, construction of pans, construction of rock catchments, construction of underground tanks, water harvesting, extension of pipelines, storage tanks, solar and wind energy for water pumping, water provision during drought. Flagship projects include Marsabit urban sewerage system and Moyale town water supply and sewerage system.	Programmes include crop and land development, food security initiatives, crop pests and disease management and control, agribusiness and value addition, climate change action plan, contingency for disaster management, livestock production and management, promotion of climate smart practices, Kenya Smart Agriculture Project, beekeeping and veterinary services.	Programmes include protection and restoration of water towers, soil management, climate change adaptation and mitigation, protection and conservation of forests, dryland and farm tree planting, promotion of alternative energy, protection of wildlife corridors and buffer zones and rangeland restoration.
Baringo	Programmes include water resource development and management (i.e. increasing water supply, rainwater harvesting, flood control, construction of small dams and pans, ground water development), sewerage and sanitation services and irrigation infrastructures.	Programmes include crop and land development, fisheries development and management, livestock development and management. Flagship projects include the establishment of Napeleny, Napeikore, Kangoria, Kariron & Kopo-Akalis Irrigation Schemes.	Programmes include environmental conservation and management (i.e. solid waste management, river bank, wetland and spring protection), natural resource conservation, exploitation and management (i.e. forest conservation, catchment protection, soil and water conservation, renewable energy development, mining and quarrying development, climate change adaptation and mitigation and wildlife conservation and management).

County	Water and Sanitation	Agriculture	Natural Resources
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 Town.	Programmes include training and extension services, livestock resource management and development, crop development and fisheries development.	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.
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 training and extension services, sustainable environmental management and inclusion, crop development and management, fisheries development and management and veterinary services development.	Programmes include afforestation and climate change mitigation and adaptation.
Kaijiado	Programmes include piped water supplied to households, boreholes drilled, public institutions ensured water supply, dams/pans constructed, improved water supply services, stormwater infrastructure developed, and catchment areas conserved. Irrigation programmes include increasing acreage under irrigation and increasing storage capacity.	Programmes include improving extension services, reduced incidence of crop pest and disease attack, supply of agricultural machines, soil and water conservation, supply of farm inputs, post-harvest management, small scale irrigation and value addition, climate smart agriculture promoted and Agricultural Sector Development Support Project (ASDSP II).	Programmes include policy development, climate change training, solid waste and pollution control, forest and riparian area restoration and rehabilitation of quarries.
Elgeyo Marakwet	The county has four gazetted water supply systems namely: Kaptarakwa, Kapkor, Chepkoris, and Chepsigot. Others are community managed. The average walking distance to the nearest water source is 2.5 km. There are no sewage systems in the county at present. The average percentage of households with latrines is 87%, and those with septic tanks is 2%. Programmes include increased access to clean and safe water, improved liquid and solid waste management systems, promotion of public awareness of water conservation and efficient water use, construction of dams and pans, de-silting of dams, strengthening Water and Sanitation Providers, establishment of sewerage systems, spring protection.	Programmes include crop development, agricultural extension and training services, sustainable land management, irrigation, livestock development, trade and industry development, cooperative development, veterinary services, tourism development, and trade and industry development.	Programmes include sustainable land management and conservation of the environment, wetland conservation, conservation of water catchment areas, mainstreaming of climate change actions, tourism development, Rimoi National Reserve development, and culture and heritage preservation, promotion of alternative energy sources, and improved solid waste management.

County	Water and Sanitation	Agriculture	Natural Resources
Nyandarua	Programmes include supplying potable water to county residents, sewerage and sanitation services, construction of small dams and pans, increasing water supply and storage capacity for irrigation.	Programmes include crop development, livestock development, veterinary services and fisheries development. Flagship projects include, construction of a potato processing plant and a sugar beet processing plant, bamboo farming, establishing a milk processing plant in Ol Kalou and providing countywide agricultural extension services.	Programmes include establishing a county Environmental Committee, solid waste management, wastewater management and creating public awareness on environmental issues.
Samburu	Programmes include rehabilitation, augmentation and maintenance of existing water supplies (i.e. extension of pipelines, treatment system, boreholes, repair pipelines), water source development (i.e. boreholes and springs/wells), rainwater harvesting, water and sanitation services planning and design, water regulation, drought mitigation (i.e. water trucking, emergency boreholes, repair water bowsers, boreholes spares, storage tanks). Flagship projects include Seiya Mega dam, Milgis Mega dam, Medium dams along Rigrig drainage channel, solid waste management and sewerage treatment.	Programmes include livestock development and management, veterinary services management, crop development and management, food security schemes (i.e. fisheries development and management, irrigation development and management (i.e. water harvesting and irrigation schemes, irrigation schemes infrastructure development). Flagship programmes include promotion of agribusiness, strategic feedlots, disease free compartments, pasture and fodder establishment, promotion of agritourism and ending drought emergencies (i.e. range seeding, livestock identification, slaughter house construction, drought escaping crops and promoting conservation agriculture).	Programmes include solid waste management, water catchment protection and management (i.e. protection of riverine ecosystems along rivers and within Ndoto, Nyiri and Kirisia catchments, protection of key wetlands and springs), sustainable forest management, environmental planning and management. Sustainable land management is promoted through programmes such as rangelands management and soil conservation and management.

3.2.5 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. However, there are two regional bodies within the RV Basin who are responsible for development activities within an area of jurisdiction, namely the Kerio Valley Development Authority (KVDA) and the Ewaso Ng'iro South Basin Development Authority (ENSDA).

The **KVDA** area of jurisdiction covers approximately 73 600 km^2, comprising of the Suam, Kerio, Baringo, Turkana, Suguta River Catchments. The mandate of KVDA is to plan, initiate, co-ordinate and monitor implementation of development programmes and projects within its area of operation. KVDA therefore undertakes programmes that promote environmental conservation, water development, food security, employment creation and community empowerment.

The **ENSDA** area of jurisdiction covers approximately 47 000 km^2, comprising of the Nyandarua, Kajiado, Nakuru and Narok Counties. The mandate of ENSDA is to promote, implement and coordinate integrated multi-sectoral social-economic development within its area of jurisdiction.

3.2.6 Projects planned by Water Works Development Agencies

The Rift Valley Water Works Development Agency (RVWWDA) is operational in the RV Basin. The WWDA has ongoing and proposed projects that vary from drilling of boreholes, construction of water supplies from these boreholes, rehabilitation and expansion of water supplies, drought mitigation studies, construction of rain water harvesting structures, to major dam and water resource projects.

The RVWWDA is establishing a water supply borehole in Hell's Gate National Park to supply Hell's Gate, Masai Cultural Centre, Olemayani Ndogo, Olemayani Kubwa, Narasha, Iseneto, Suswa Town and Olasiti. Furthermore, the RVWWDA is implementing the Itare Dam Water Supply Project.

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

3.2.7 Sectoral perspectives

3.2.7.1 Water supply and sanitation

The total storage volume of the existing dams in the RV Basin is about 1 665 MCM, of which only 1% is stored in small dams and pans (Water Resources Management Authority, 2013). Further water resources development is essential to satisfy the growing future water demands.

According to the NWMP 2030 about 40% of the population in the RV Basin receives drinking water from unimproved sources (unregistered water vendors and water taken from lakes and streams without proper treatment), while about 31% of the population get drinking water from springs, wells and boreholes. The urban population that receives piped water from WSPs is 52%. There are eight urban WSPs and five rural WSP, and together these WSPs provide a capacity of almost 98 000 m^3/day. Of the eight urban WSPs, four have records of more than 50% of non-revenue water.

The RV Basin has a limited sewerage system coverage ratio of just 4%. About 69% of the population use on-site sanitation facilities such as septic tanks and about 27% 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 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.

3.2.7.2 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). Electricity generation capacity in Kenya currently amounts to about 2 000 MW and comprises 39% from geothermal, 45% from hydro, 14% from fossil fuels, and about 2% from solar, biogas and wind. 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.

The National Water Resource Management Strategy (Government of Kenya, 2006) 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.

There is currently one hydropower scheme in the RV Basin, namely the Turkwel Hydropower Station at Turkwel Dam. It is in the upper reach of the Turkwel River and has an installed capacity of 106 MW.

Kenya is endowed with geothermal resources mainly located in the RV, with geothermal power potential estimated at between 7 000 MW and 10 000 MW. Currently about 200 MW is generated by Olkaria Geothermal power station next to lake Naivasha and this is expected to increase to 576 MW within the next 20 years. Lakes Baringo, Bogoria and Magadi have also been identified as potential geothermal sites.

Only about 16% of the population in the RV Basin has access to electricity. Paraffin is commonly used for lighting in households without access to electricity, and about 93% of the population use biomass (burning of fire wood and charcoal), as a source of energy for cooking. The RV Basin stakeholders will need to develop specific plans based on distributed generation and renewable energy to expand energy access to many users in this region.

The RV holds a variety of mineral deposits for mining opportunities. These include small deposits of gold in West Pokot and Turkana counties; Gemstones in West Pokot, Turkana, Kajiado and Baringo counties; Gypsum in Turkana and Kajiado counties; Diatomite in Baringo and Nakuru counties, and Soda Ash, Feldspar, Limestone, Marble and Granite in Kajiado County. Some mining activities in the basin include:

- Tata Chemicals Magadi, which operates in the Lake Magadi region, is Africa’s largest soda ash producer with an annual production of about 360 000 tonnes of Soda Ash. Commercial trona (hydrated sodium bicarbonate carbonate) mining is also undertaken in this area as it is one of the few locations in the world where trona forms naturally.
- Kenya Fluorspar Company Limited has been mining Fluorspar in the Kerio Valley since 1971, with a production of over 100 000 tonnes of fluorspar annually.
- Africa Diatomite Industries Limited has been mining diatomite in Gilgil (Nakuru County) for export since its establishment in 1942.

3.2.7.3 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, 2010a).

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 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 limited 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 RV Basin include irrigation, livestock and fisheries. These demands are projected to increase significantly due to population and economic activities. The total crop area in the basin in 2011 was estimated at approximately 304 000 ha, with a current (2018) irrigation area of about 11 000 ha, less than 4% of the cultivated area. However, the irrigation area in the basin is projected to increase to about 120 400 ha by 2040.

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.

3.2.7.4 Forestry, land use and catchment management

In 2010, the total forest area in the RV Basin was about 261 000 ha. Forest reserves in the basin largely cover the areas surrounding the major water towers of the catchment, as well as groundwater recharge areas. These reserves include Cherangani Hills, the Aberdare Range and the Mau Forest Complex. These reserves are located mainly in West Pokot, Elgeyo Marakwet, Samburu and Nyandarua 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 (The Constitution of Kenya, 2010). A total area of 1 010 000 ha of forestation is proposed in the NWMP 2030 for RV 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 RV Basin hosts 7 gazetted and 9 non-gazetted water towers. The Forest Management and Conservation division under the 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, pastoral and livelihood activities that are incompatible with the capacity of the land are some of the major land use issues in the RV Basin. The forest and land use management schemes being promoted by different counties are discussed in **Section 4.4.** above.

3.2.7.5 Biodiversity, protected areas and tourism

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

The RV Basin has several lakes and wetlands that are important habitats for a variety of birdlife and wildlife. Lake Turkana is the largest saline lake in East Africa and the largest desert lake in the world. The area including the lake is now listed as one of the UNESCO World Natural Heritage Sites in terms of rich biodiversity conservation and natural geographic characteristic. The lake has also an important ecosystem for migratory birds and world's biggest habitat of crocodiles. The wetland ecosystems of the RV Basin are environmentally sensitive areas under threat from human encroachment. Five of the lakes and surrounding wetlands in the RV Basin have been designated as Ramsar sites: Lakes Baringo, Bogoria, Elmenteita, Naivasha and Nakuru. 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 RV 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 RV Basin are increased degradation through human encroachment for settlement, expansion of crop production, urbanization, livestock grazing and commercial activities such as brick-making and sand harvesting. 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 RV 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.

The main tourist attractions in the RV Basin are the many National Parks and Reserves. These include Lake Turkana, Sibiloi National Park, Saiwa Swamp National Park, Lake Bogoria, Lake Baringo and Amboseli National Park. Lake Nakuru is a famous tourist attraction for its flamingo viewing. 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: Mutua Matheka 2017. 'Lake Magadi by Bine and other Stories. Available online at http://mutua-matheka.co.ke/blog/lake-magadi-by-bike-and-other-stories/

Key Issues, Challenges and Trends

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 RV 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 RV 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 RV 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.

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 RV Basin under the above categories.

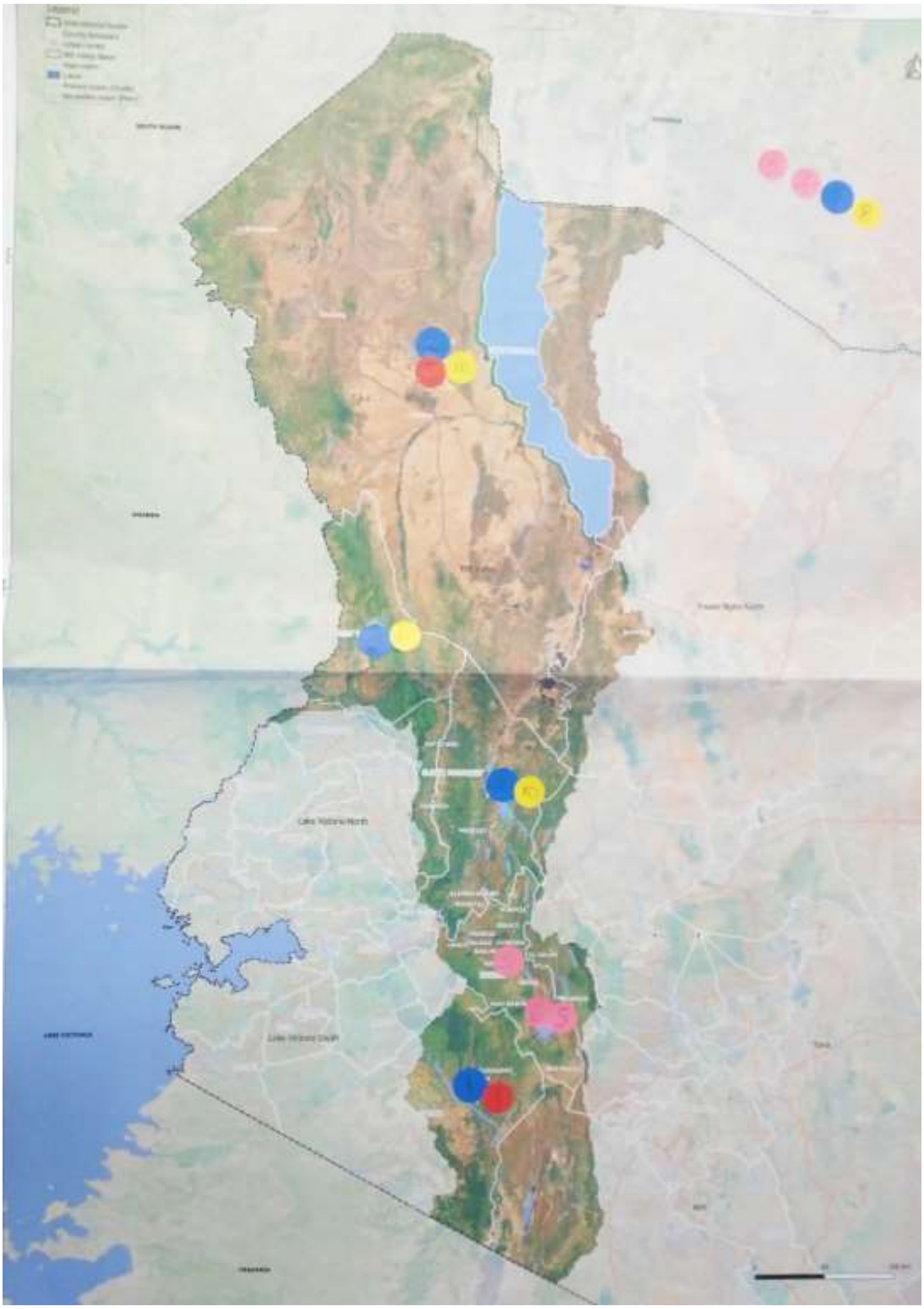


Figure 4-1: Example of outputs from the workshop for the RV Basin

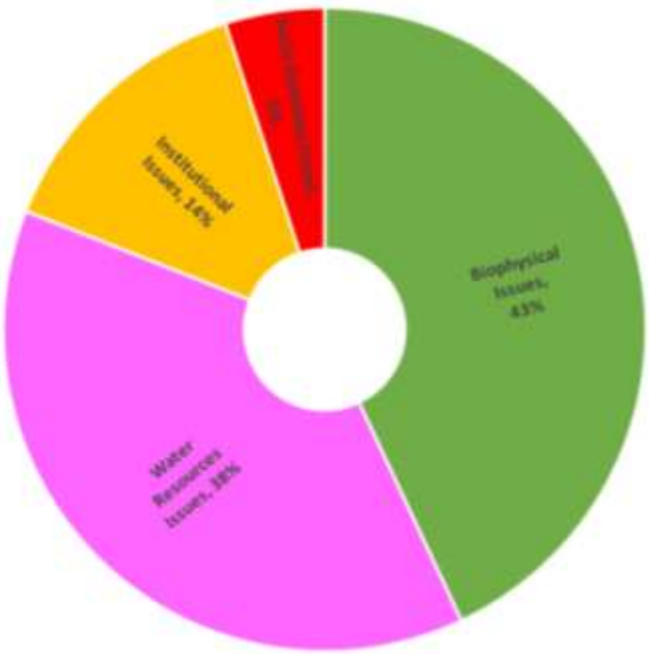


Figure 4-2: Frequency of identified key issues in the RV Basin

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.

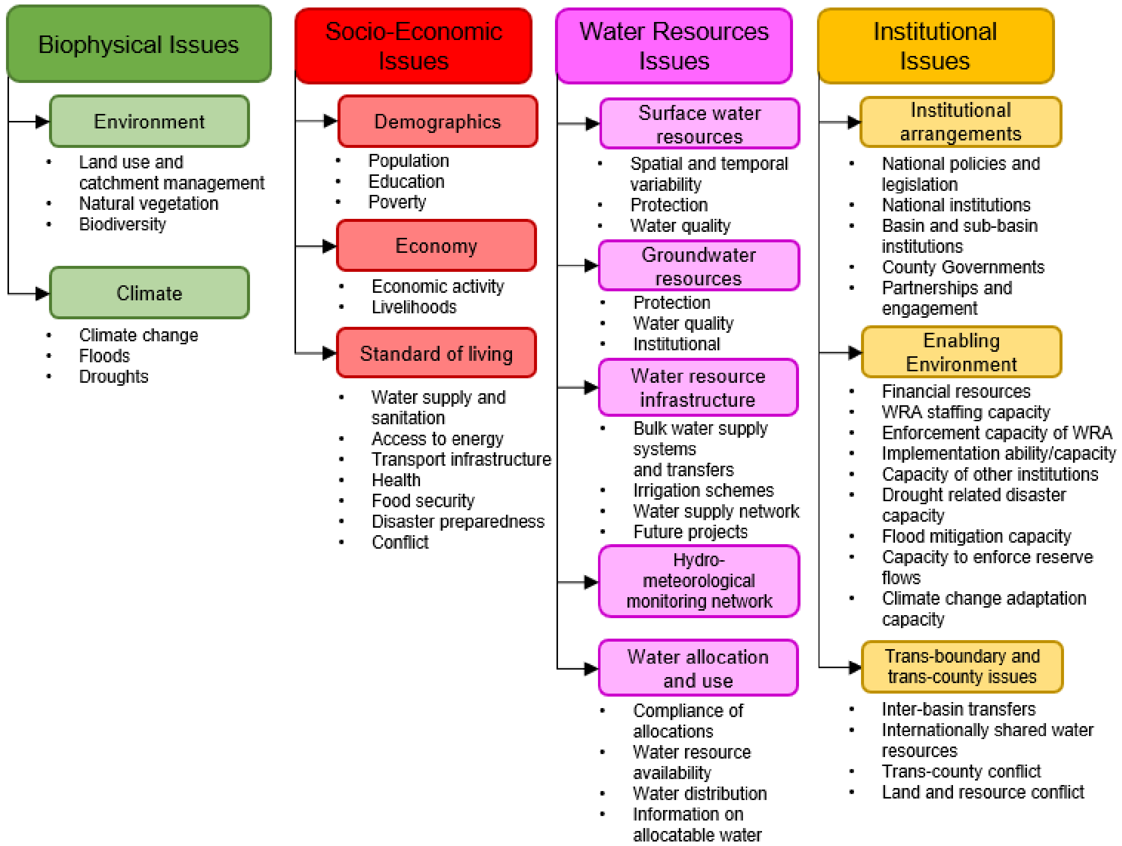


Figure 4-3: Key issues framework

4.3 Biophysical issues

Biophysical issues were ranked highest in the RV Basin. Poor land use/catchment management was considered the most important, followed by droughts.

4.3.1 Environment

The environment encompasses the land, vegetation and biodiversity of the RV Basin. The RV Basin, with its seven lakes and highly variable climate, supports some of the largest biodiversity in Kenya. 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.

Flamingos at Lake Naivasha
citizentv.co.ke/news/naivasha-residents-forcefully-re-open-blocked-corridor-162151

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, 2010a). 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 RV 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, 2010a).

Unsustainable agricultural practices and expansion

In comparison to other basins in Kenya, the RV Basin supports a significant number of large-scale and commercial farms near the lakes and rivers, with small-scale rain-fed farming remaining important further away from these water bodies. Increasing population has seen 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.

Examples of unsustainable agricultural/pastoral practices and expansion:

Land degradation due to poor agricultural activities, overstocking and deforestation in Narok East, Narok West and parts of Narok South have resulted in the destruction of the upper catchment areas and the rangelands (County Government of Narok, 2018).

Poor rangeland management

There are many ranches and pastoralist areas in the rangelands of the RV 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. This land use is under threat due to droughts increasing pressure on available pasture and limited water resources. 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:

In Samburu County, the number of livestock exceeds the rangeland's carrying capacity as there are no livestock grazing controls. It has led lack of tree succession (commonly seen are mature trees with very little or no undergrowth/saplings) (County Government of Samburu, 2018).

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 is carried out along river Kerio and is a major source of county revenue. It is also a source of sediment pollution responsible for the degradation of the river (County Government of Elgeyo Marakwet, 2018).
- Sand harvesting in the Suswa area and sections of the Greater Mara region (Narok County) has been overexploited, leaving the land bare and further exacerbating soil erosion, low water retention and incidences of flash floods (County Government of Narok, 2018).
- Nyandarua County has seen an increase in unregulated sand harvesting in Miharati (County Government of Nyandarua, 2018).

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:

- Mining activities are impacting water quality in Kerio Valley, Magadi area and Lake Elementaita area (County Government of Elgeyo Marakwet, 2018)
- Diatomite mining at Kariandusi in Gilgil Sub-County around Lake Elementaita, and other on-going mineral extraction activity is causing water quality issues, and many quarries are not rehabilitated (County Government of Nakuru, 2018).

- Nyandarua County has seen an increase in unregulated quarrying activities (especially in Olkalou, Kipipiri and Kinangop) (County Government of Nyandarua, 2018).

Land use change

Land in the ASALs is considered to be under-exploited for agricultural production and is being promoted as an area for land-use change from rangeland to cultivation through irrigation (Government of Kenya, 2010a). This may be a long-term strategy, but small-scale farmers are already implementing similar strategies, although cultivation may not be appropriate in most ASAL areas with limited rainfall and poor soil conditions. 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.

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 Nakuru and other large cities in the basin.

4.3.1.2 Natural vegetation

The major contributors to the loss of natural vegetation in the RV Basin are land encroachment and deforestation. 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 vegetation.

The density of vegetation cover on the land is important, as dense vegetation cover will protect the land from 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.

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 in the highlands also had tree gain over the period 2001-2012.

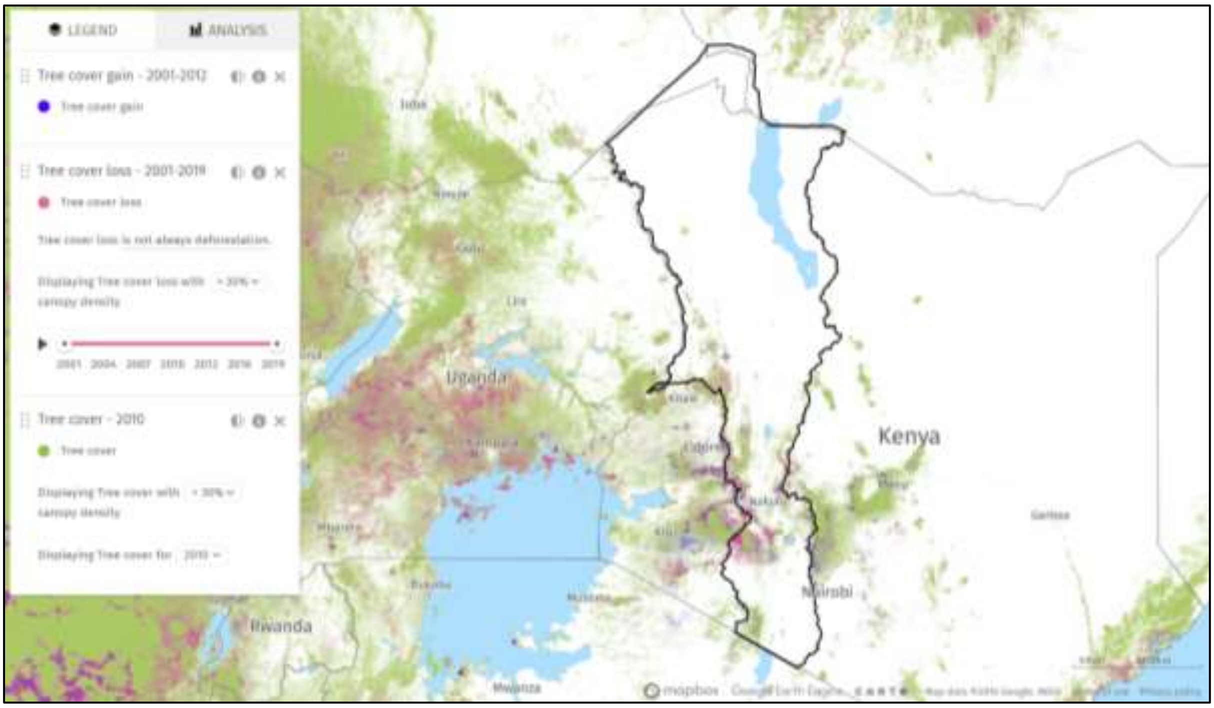


Figure 4-4: Tree loss and tree gain for RV Basin according to Global Forest Watch

Deforestation

In the RV Basin, the Cherangani Hills and Mau Forest complex serve as the major water towers for the Basin and groundwater recharge areas (Water Resources Management Authority, 2015b). These forests have been threatened by human encroachment and there is a need to protect them. In order to achieve the targets of Kenya Vision 2030 about 1 010 000 ha of forestation in proposed in the Basin (Water Resources Management Authority, 2013).

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

- Due to continuous deforestation over many years, the volume of water in the major rivers of the RV Basin has been decreasing. The forest reserves in Narok county, especially Nyakweri Forest and the Maasai Mau, are also degraded due to charcoal burning and illegal logging activities (County Government of Narok, 2018). Charcoal burning is largely prevalent in Kongelai, Marich and Sigor in West Pokot county. Human encroachment to forest has adversely effected Pokot South Sub-County (County Government of West Pokot, 2018).
- There is high rate of deforestation in Baringo County due to increase in population, change in land use and charcoal burning as well as timber production (County Government of Baringo, 2018).

Encroachment of aquatic land

Wetlands and seasonal rivers (laghas) in the RV 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):

- In Nakuru County, farming and other human activities along the rivers, lakes and wetlands lead to disposal of chemicals into the water bodies, hence polluting the water and endangering aquatic life (County Government of Nakuru, 2018)
- Encroachment of land in fragile areas such as water catchments, forests, wetlands and conservation areas has led to desertification in Kajiado county and the breakdown of natural ecological cycles (County Government of Kajiado, 2018)

Invasive alien species

The main threat from alien invasive plants is Prosopis Juriflora (commonly known as Mathenge). The tree spreads rapidly, outcompeting natural vegetation and reducing grazing areas. This contributed to rangeland degradation. Other invasive species are Lantana camara, Solanum spp. and Opuntia spp. become an issue when forest cover is cleared. Bluegum trees are often planted as a fast-growing tree that is readily available for timber, and are responsible for drying up wetlands in Nyandarua County (County Government of Nyandarua, 2018).

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.

Threatened ecosystems

The RV 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:

- Cherangani and Kaptagat ecosystems, among other forests, are mainly threatened by deforestation (including commercial and illegal logging and forest encroachment). Overgrazing has led to the destruction of natural vegetation and soil erosion in these sensitive ecosystems (County Government of Elgeyo Marakwet, 2018).
- West Pokot county's ecosystems include Montane rain forests, savannah, woodlands, and dry forests. The broad diversity of the county's ecosystems boasts an enormous range of flora and fauna species. Cherangany forest hosts a large biodiversity and is the county's water tower. However, soil erosion and degradation is a major challenge for this ecosystem (County Government of West Pokot, 2018).

Inadequate reserve flow requirements

Reserve flows are currently determined using the 95th percentile of the naturalised present daily flow duration curve. There are currently inadequate reserve flows determined for the major rivers in the RV Basin, as well as minimal environmental monitoring taking place.

Wildlife impacts

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

Examples of wildlife impacts:

- Human-wildlife conflict has also been experienced in Baringo County, and mostly affects the rangeland parts of Marigat, Mogotio and East Pokot, as well as forested highlands of Baringo North and Baringo Central. Human-wildlife interaction has resulted in human death and loss of livestock and crops in the County (County Government of Baringo, 2018).
- Human Elephant Conflict is the main form of human-wildlife conflict in Samburu county. Wildlife roams freely in the county, and frequently encroaches into grazing land and agricultural fields which are constantly expanding. People are also encroaching into wildlife habitat in search of pastures for livestock, thus further fuelling the conflicts. Some of the worst affected areas include Lonjorin and Ngare Narok (County Government of Samburu, 2018).

4.3.2 Climate

The central parts of the RV Basin receive the highest rainfall, with rainfall decreasing towards the north and south. 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

Rainfall events will become more unpredictable and intense, droughts are more likely, and temperatures are expected to swing to extremes on either end of the spectrum due to climate change. Changing rainfall seasonality will have a particular impact on farm crop selection and planting regimes in the RV Basin and is already experienced. With more rain falling, as heavy storm events it will be less effective, and there will be increased erosion, increased streamflow, and an increased risk of flooding and greater environmental degradation. Higher evaporative demand will also offset any benefits of increased rainfall, also resulting in less effective rainfall (Omwoyo et al., 2017). These changes will 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 (Government of Kenya, 2010b). The climatic issues in the RV Basin include inadequate preparedness for floods and droughts, which impacts communities, the economy and infrastructure among other things.

The sections below provide examples of the issues linked to floods, and droughts in the RV Basin. They specifically discuss the effects on people, the economy, infrastructure, and the rise of conflict.

Increasing intensity of extreme events

An increase in the intensity of extreme events may result in the event of a combination, or all, of the following scenarios:

- Increased intensity of rainfall
- Increased frequency of floods
- Prolonged droughts
- Increased frequency of droughts

As a result, the issues associated with each of these scenarios may be heightened.

Increasing temperature and evaporation rates

An increasing temperature predicted for Kenya may result in an increase in evaporation rates and general harsher weather conditions. Water quantity will be affected as a result, as well as water quality due to higher temperatures, land use changes, impacts on rivers and lakes, changes to physical-chemical parameters, micro-pollutants and biological parameters. Rising temperatures provide environments conducive for malaria vectors to thrive, therefore creating health issues. Maximum temperatures in the RV Basin is expected to rise by up to 1.24°C by 2050.

Unpredictable and irregular weather conditions

Kenya's weather patterns have started changing and are becoming more unpredictable. As most of the land use in the RV Basin is agriculture and pastoralism, the inconsistent rainfall makes rainfed agriculture and locating water sources difficult. The unpredictability also makes long-term planning difficult and creates uncertainty in prioritisation of short-term adaptation strategies. According to the CMS (Water Resources Management Authority, 2015b) rainfall intensity in the RV Basin is likely to increase in both rainy seasons, but particularly in the Short Rains (October to December). Rainfall seasonality is likely to remain the same although there will be more intense rainfall in the short rains, with likely acceleration in soil erosion following a dry spell.

Increased frequency of droughts

Droughts, which are likely to occur with similar frequency as now but with increasing severity across the RV Basin (Water Resources Management Authority, 2015b), will increase the issue of water scarcity, food insecurity and inflation. It will also lead to increased malnutrition, stunting in young children and loss of lives, and an increase in the number of children dropping out of school due to families migrating to better lands.

Examples of climate change impacts:

- Turkana County has experienced the effects of climate change over time. The climate in the county has always been hot and dry but this has worsened over time, with cyclic spells of droughts becoming the norm, something that was not observed in the past (County Government of Turkana, 2018).
- According to the Nyandarua CIDP (2018), the county previously experienced rainfall throughout the year, but nowadays there are two distinct rain seasons; March to May and September to December. This has resulted in changing farming patterns and famine. Crop loss has become common due to low temperatures leading to frost bite, and diseases such as malaria (which was never prevalent) have become common among cattle and effect the productivity.
- As part of disaster risk management, the Nakuru CIDP suggests that droughts may occur in Naivasha, Gilgil, Lower Subukia and Rongai with medium severity, while flooding may occur in Naivasha, Rhonda, Kaptembwo and Maai-Mahiu with high severity (County Government of Nakuru, 2018).
- Drought is commonly experienced along the Kerio Valley in the dry months of January to March (County Government of Elgeyo Marakwet, 2018).
- Drought and famine is one of the main environmental threats currently faced in Narok County, where over 30% of the population resides in the semi-arid areas (County Government of Narok, 2018).
- According to the Baringo CIDP, droughts are the number one environmental threat in the county. Droughts occur frequently, due to changing rainfall patterns, causing livestock deaths and the loss of agricultural produce (County Government of Baringo, 2018). Societal factors such as poor land-use practices, conflicts, poverty, poor communication, poor infrastructure and lack of traditional coping mechanisms exacerbate the effects of droughts in the county.
- Feedback from Workshop 1 indicated that Basin-wide, there has been an increase in frequency and severity of droughts and floods, extreme temperature changes and poor distribution of rainfall.

4.3.2.2 Floods

Flooding is an issue in the RV Basin, especially in areas such as Narok, Lodwar, Mogotio and Marigat. Severe floods occur mainly around the water tower areas. Particularly in recent years, a lot of deaths caused by flash floods have been reported in mountainous areas that are located in the central part of the catchment area. Narok, which is located at the downstream of the confluence point of three rivers flowing from the Mau Forest, suffers from floods every rainy season.

Issues regarding the preparedness for floods that occur in the RV Basin have affected many of the Basin's communities, the economy, and infrastructure which has led to conflict on a number of occasions. Flood prone areas within the Basin include the Narok, Lodwar, Mogotio and Marigat Counties (Water Resources Management Authority, 2015b). As part of this Consultancy, the local government and stakeholders were consulted to determine which areas were the most effected by flooding and required updated hydrometeorological infrastructure. Lodwar, Perkerra and Narok Town were pinpointed as the important areas in the RV Basin, with the Perkerra flood prone area being deemed the most crucial for monitoring development. The inadequate preparedness for floods has caused land degradation, loss of soil fertility, 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.

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, the 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:

- In Elgeyo Marakwet county, floods are common during the rainy season between the months of April and August, which affects the escarpment and lowlands of the Kerio Valley. Landslides are also experienced during these floods, resulting in property damage and the loss of lives. The effects of landslides are exacerbated by overgrazing and loss of natural vegetation (County Government of Elgeyo Marakwet, 2018).
- Landslides and flooding frequently affects parts of Muino, Sondany and Ptirap in Pokot Central Sub-County, and parts of Kongelai and Sigor divisions have experienced adverse soil erosions with huge gulley erosion, due to flooding (County Government of West Pokot, 2018).
- Environmental degradation and a changing climate have resulting in soil erosion and floods, effecting 12 wards in Baringo County, including Barwesa, Saimosoi, Kisanana. Mogotio, Marigat, Mochongoi, Kabarnet, Koibatek, Emining, Ilchamus, Ribkwo and Loyamorok (County Government of Baringo, 2018).
- Discussions during the workshop (April 2019) raise the issue of flooding most predominantly in the areas of Narok town, Perkerra River and Turkana. In these areas, the workshop participants associated flooding with catchment degradation, riparian encroachment, river bank erosion, changing of river courses, and geology and topography.

Economic impacts of floods

The agricultural sector and 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. Livestock farmers may incur profit loss due to floods causing livestock diseases and deaths. 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 resulting from shutdowns.

Examples of economic impacts of floods:

For the last two and a half decades, Turkana County has frequently suffered from failures of the annual rains. However, 2006, 2007 and 2011 witnessed a higher than expected rainfall. This resulted to flash floods with many parts of the county experiencing loss of livestock and pastures. The flash floods of 2006 also caused serious livestock diseases (County Government of Turkana, 2018). As agriculture and pastoralism is the main economic activity for much of the basin, these floods have had far reaching economic consequences.

Damage to infrastructure

Floods can cause major damage to infrastructure depending on the severity of the flood. Access roads and reservoirs can become damaged due to floods and flash floods. Various seasonal pans also fill up with sediment during flash floods.

4.3.2.3 Droughts

The northern part of the RV Basin is classified as arid land, while the central part is humid, and the southern part is semi-arid land. The arid and semi-arid areas are particularly affected by droughts, however, the extent and magnitude of the effects of droughts varies across the Basin. All of the CIDPs in the basin report droughts, and many of them list drought as the number one environmental threat. The water scarcity that accompanies periods of droughts has numerous negative impacts on people, and the economy. 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

The following sections provide examples of the issues caused by the inadequate preparedness for droughts in the Basin.

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.

Economic impacts of droughts

The agricultural sectors of all of 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. Various areas in the Basin have been susceptible to losses in the agricultural sector due to droughts. The livestock sector experiences several issues because 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:

- Water availability is essential to the economic development of the RV Basin, where the economic sector is largely dominated by agricultural production. The livelihoods of small-scale farmers and pastoralist are particularly vulnerable to the impacts of droughts, as they are reliant on rainfall, small dams and pans, and other water sources that are typically not climate resilient.
- Droughts have an impact on the agricultural activities of the different Counties particularly due to loss of crops and livestock, which are reported across most of the counties.
- Pastoralism and agro-pastoralism are the main livelihoods in Turkana County, and are threatened by persistent droughts and its impact on increasing livestock diseases. Domestic animals provide the main coping mechanism for the population, and do not fetch enough money to enable families to purchase food on the market, thus lowering the purchasing power of much of the population. This cyclic problem has resulted in a large reliance on relief aid (County Government of Turkana, 2018).
- In Samburu county, rainfall periods are becoming shorter and more unpredictable, and prolonged droughts more frequent and severe, leading to massive loss of livestock, poor crop yields, increased vulnerability to food insecurity, high prevalence of malaria and livestock diseases, and migration and displacements. Persistent drought has over the years remained a challenge to livestock keeping in Samburu County, which is a key sub-sector in the economy of the county (County Government of Samburu, 2018).
- Frequent droughts have led to a high occurrence of nutrition related ailments in children in Kajiado County, with far reaching socio-economic impacts (County Government of Kajiado, 2018).
- Nyandarua County faces regular crop loss, because of temperatures leading to frost bite, and diseases such as malaria (which was never prevalent) have become common among cattle and effect the productivity.

Conflict due to droughts

Droughts result in scarcity of water, and 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. Human conflict due to water scarcity has been reported within the RV Basin in the past (Water Resources Management Authority, 2014). 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 coming into contact with 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). Drought is the cause of many transboundary conflicts as it worsens water scarcity and thus results in County Government's fighting for water supply for their residents (i.e. transboundary conflict).

Example of conflict due to droughts:

Nasolot Game Reserve, which has good variety of wild animals, is the only game reserve in the West Pokot County. The elephants found in Nasolot game reserve are among the largest elephants found in the world, and drought and encroachment on wildlife habitat has resulted in human-wildlife conflict; a major concern in the game reserve (County Government of West Pokot, 2018).

4.4 Socio-economic issues

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

4.4.1 Demographics

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

4.4.1.1 Population

Increased population growth

The RV 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.

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.

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.

Minimal understanding and awareness

There is a 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.

Inadequate education of water resources from a young age

Understanding brings awareness, which raises the concern of the inadequate 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 RV Basin due to poverty are described below.

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.

Lack of finances

Poverty affects the financial capacity of individuals to pay for services. This means that certain areas of the RV 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.

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 RV Basin, discussed below, will influence the planning for water resources.

https://rethink.earth/how-kenyas-herders-got-their-livestock-insured/

4.4.2.1 Economic activity

Plans for new infrastructure

With the projected increase in urbanisation in RV Basin it is important to provide for a growing population in certain areas. New infrastructure will put increasing pressure on water resources.

Example of new infrastructure:

- The governments of Kenya and Uganda have agreed to rehabilitate, operate and maintain their combined railway system across the RV Basin. Uganda relies on the Kenyan port of Mombasa for sea access, a route facilitated by the Rift Valley Railways (RVR) public–private partnership.
- The RV has a huge potential for geothermal energy, and multiple development projects are on-going in the basin. They will require additional infrastructure, such as roads and water supply.

Agriculture

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.

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, 2010a). 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 RV Basin vary from pastoralism to subsistence agriculture and crop/livestock farming. Threats to these activities include the following:

Crop and livestock disease

Pests and disease cause heavy loss through deaths, reduced productivity and loss of markets for products (Government of Kenya, 2010a). 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.

An increase in livestock diseases and deaths due to climate change and drought are reported across the basin.

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 RV 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 40% of the RV Basin's population get drinking water from unimproved water sources, and 32% 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:

The population growth is expected to be relatively low therefore the scale of urban water supply is relatively smaller than in other Basins. Planning for the RV Basin is divided into a northern arid area and a southern non-arid area. These areas have different characteristics and challenges for water supply and sanitation. Just over half of the RV Basin's urban population receives piped water from a WSP, whilst 14% of the rural population receives piped water from a WSP (Water Resources Management Authority, 2013). Most 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 10% of the urban population has access to formal sewerage systems. A significant portion (41%) of the rural population do not have any treatment facilities and resort to unsanitary waste disposal and open defecation (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 RV 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

It has been estimated, by the Socio-economic Atlas of Kenya (Wiesmann et al., 2016), that approximately 80% of all communicable diseases are water-related and include water-borne diarrhoea, trachoma, cholera, typhoid and bilharzia. It is anticipated that flooding risks would increase in the basin due to urbanisation and the effects of climate change. It is anticipated that the increase in temperatures due to climate change would provide an environment conducive for malaria vectors to thrive. Turkana, West Pokot, Laikipia, Samburu, Elgeyo Marakwet, Baringo, Narok, Kajiado are the main counties that have experienced malaria as a top disease, causing morbidity (County Government of Baringo, 2018; County Government of Elgeyo Marakwet, 2018; County Government of Kajiado, 2018; County Government of Laikipia, 2018; County Government of Narok, 2018; County Government of Samburu, 2018; County Government of Turkana, 2018; County Government of West Pokot, 2018).

4.4.3.5 Food security

The arid and semi-arid lands in the RV Basin are characterised by erratic and low rainfall and are prone to droughts, especially in the Turkana County area. The high drought-prone areas frequently experience a high number of poor growing seasons, which negatively affects food security. Most of the basin depends on pastoral activities for livelihood, and in times of prolonged drought, pastoralists lose livestock to disease and lack of pasture and water.

Turkana County is the most food-insecure area in the country, with 19% of households having poor food consumption and a further 24% having borderline food consumption. This is due to the high prevalence of droughts, low education levels, high unemployment and poverty levels and poorly integrated markets. Baringo County is also highly food-insecure, with more than 25% of households having poor or borderline food consumption, followed by West Pokot County with between 20 and 25% of households having poor or borderline food consumption.

Short term food security outlook

Below-average rainfall in the long rainy season from March to May 2017 led to food shortages across most of the pastoral and agricultural areas in the RV Basin. Crop and livestock productivity was below-average, limiting household income and increasing staple food prices.

Typically, rangeland conditions in the pastoral areas deteriorate because of below-average rainfall as livestock productivity decreases. Conflicts are then more likely to occur due to limited resources and increased migration paths. During droughts, poorer households increase reliance on coping strategies such as charcoal sales, remittances and humanitarian assistance to meet their minimum food needs.

The short-term food security outlook shows that the southern parts of the RV Basin were in a minimal food-insecurity phase, while the central-northern pastoral areas were in a stressed or crisis phase during 2018.

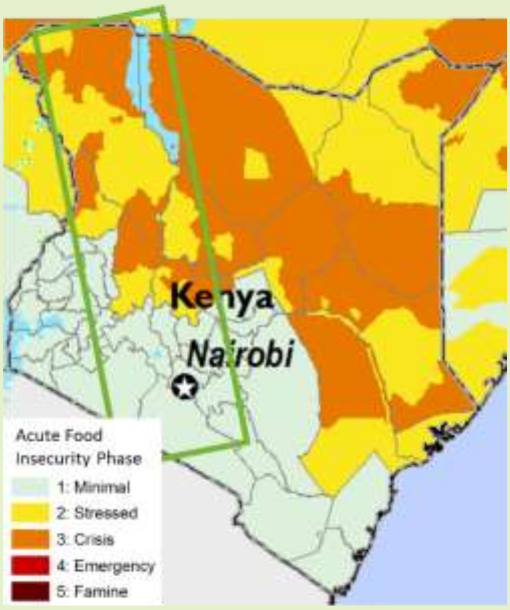


Figure 4-5: Short-term food security outlook in RV Basin (2018)

Food insecurity is closely linked to droughts in the dry regions of RV Basin. The lack of irrigation systems and reliance on rain for crop production is another reason resulting in low crop yields and thus leading to food insecurity.

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.

Rain-fed agriculture

Crop production in the drier areas of the RV basin, such as Turkana County, is predominantly rain fed. This is practiced by agro-pastoralists mostly growing maize, beans, green grams, sorghum, millet, mangoes, paw paws, watermelon and vegetables. The production of these crops is mainly at subsistence level (County Government of Turkana, 2018).

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 RV 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 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 inadequate preparedness for a disaster event. The issues and challenges involved are discussed further below.

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.

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.

4.5 Water resources availability, management and development issues

Water resources availability, management and development issues were ranked second (after Biophysical issues) in terms of frequency in the RV Basin. The main sub-issue was water quantity followed by water quality.

4.5.1 Surface water resources

The RV Basin has a complex water resources system and has many water resources challenges. The basin has generally low rainfall, placing increasing pressure on the numerous natural lake and groundwater resources. Water quality degradation (both natural and anthropogenic causes) and over abstraction are the greatest threats to the basin. Irrigation is by far the greatest demand in the Basin, with many large-scale and corporate irrigation schemes, which are expected to increase in the future. The main surface water issues are described below:

Perkerra River Gorge
musbaibe.blogspot.com/2007_12_30_archive

4.5.1.1 Spatial and temporal variability

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

Water security

Most parts of the RV basin are characterised by low rainfall and semi-arid to arid conditions. High precipitation does however occur in the central part of the RV Basin, where many of the lakes are found, and the population density in these areas is high (corresponding to major towns such as Nakuru). In these areas, there is a high demand for water, which often surpasses the current water supply capacity in key areas. The basin also has high irrigation demands, supporting many large scale and commercial farms, such as tea and flower farms. Many of the rivers and lakes in the basin have natural or anthropogenic contaminants, making the water supply inconsistent and pushing the need for the development of other sources.

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:

- Turkana County covers some of the driest parts of the RV Basin in the north. In the county, average distances between the nearest water points are 5-10 km, but in areas like Kibish, Lorengippi, Lomelo and Mogila, these distances can be 10-20 km (County Government of Turkana, 2018).
- A large part of Nakuru County's water supply comes from permanent rivers, and 63% of the population have access to improved treated water. However, water supply for sanitation still remains low, with most of the residents of Nakuru County disposing human waste through pit latrines, and only 15% of the households being connected to the main sewer (County Government of Nakuru, 2018).
- A significant area of Baringo County is arid in nature, and water from vendors (concentrated in the urban areas) only reach a small percentage of the population. The average distance to the nearest water point is 5 km, which is well below the acceptable standards (County Government of Baringo, 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 RV Basin are discussed below:

Illegal abstraction

An unfair distribution of water resources has resulted in the illegal abstraction of surface water resources. This is a concern in the high lying headwater regions, as over-abstraction limits water availability for downstream users.

Lack of water for development

There is a concern associated with inadequate water resources for proposed projects to be developed, particularly large scale and commercial irrigation projects.

Inadequate RQOs

The Resource Quality Objectives (RQOs) for the water resources in the RV Basin are currently inadequate. 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 RV Basin due to pollution emanates, among many other things, from the inadequate 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 RV Basin are centred around both urban and agricultural quality issues, as well as the inherent saline and low quality of water resources.

Salinity

Only Lakes Baringo and Naivasha have fresh water, while the other lakes have saline water.

Sedimentation

Sedimentation negatively affects the water quality of the rivers and limits surface water storage. Extreme rainfall events have recently increased flash floods and sedimentation in the lower Basin. Poor land use management, rangeland management and deforestation also contribute to the high sediment loads in rivers. Stormwater from urban areas gets washed into rivers, carrying the sediments from the roads and pavements.

The most common sedimentation issues in the Basin are:

- Sediment loads from degraded farmlands
- Soil erosion from overgrazed lands and un-tarmacked roads

Erosion and consequent sedimentation is also evident on the riparian reserves, and hill slopes and unpaved roads in the smaller towns and rural areas throughout the basin.

Dumping of solid waste

The dumping of solid waste contributes to surface water pollution. Issues are usually linked with informal settlements. Urban centres, such as Nakuru, have established solid waste management systems, and in the case of Nakuru, this has undergone huge reformations that are still ongoing. However, 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.

Sanitation

Many urban centres usually have unplanned informal settlements, often with high population densities. These areas lack sewer systems and on-site sanitation is used to dispose of faecal matter. These wastes often find their way into nearby water courses and can contaminate shallow groundwater.

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. This is particularly problematic in the major towns of Narok, Magadi, Nakuru, Lodwar, Kabarnet and Kapenguria.

Non-point sources

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

Example of water quality issues:

- Pollution from flower farms is a great threat to the sustainability of Lake Naivasha, and other lakes in the RV Basin. Fertiliser residue and agrochemicals enter the water bodies from runoff and get trapped in the sediment. Major sources of pollution are the farms along the rivers Molo, Njoro, Perkerra and Malewa, and the horticultural and flower farms around Naivasha and Nakuru areas.
- Some of the water quality threats to Lake Naivasha include heavy sedimentation, and clearing of natural vegetation for agriculture, and over-harvesting of papyrus whose purpose is to maintain the water quality of the lake.

4.5.2 Groundwater resources

Groundwater in the RV basin is generally hard and saline, with high fluoride levels throughout the basin. Due to the high reliance on groundwater, in both urban and rural areas, over-abstraction is a serious cause of concern.

The main issues regarding groundwater quality and quantity are described below.

Shallow borehole in Kihoto estate, Naivasha
www.the-star.co.ke/news/2016-03-27-19-new-cholera-cases-reported-in-naivasha

4.5.2.1 Protection

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 unsustainable use of groundwater is a concern for the RV Basin. Groundwater issues have resulted from minimal protection of groundwater, which is discussed further below.

Groundwater protection programs

The National Water Quality Management Strategy (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.

Groundwater recharge areas

Except for one numerical model which has been developed for the Merti aquifer (Blandenier, 2015), elsewhere there are no groundwater models of the RV Basin and often a poor level of understanding of aquifers. There is a need to select Priority Aquifers for modelling, then prioritise these and develop models; this inevitably requires 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
- GW levels
- GW abstraction
- Water quality (both surface and GW).

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.

Unsustainable groundwater use

Numerous major urban areas in the RV basin rely heavily or solely on groundwater to meet their domestic water demands. Lake Naivasha aquifer is the primary source for Naivasha town and is showing signs of over abstraction. A very large number of boreholes also support commercial irrigation. Kakuma aquifer is the primary supply for the refugee water supply, and showing signs of over-abstraction. The quality of the Kabitini aquifer is better than most, and it therefore provides 80% of the domestic water supply to Nakuru. The WRA considers groundwater resources in the Nakuru area to be under threat of over-abstraction (Water Resources Management Authority, 2007c). The Njoroi and Rongai aquifers (in Nakuru County) are both key resources for commercial irrigation, and are at risk of over-abstraction. Lodwar aquifer is the sole water supply source for the town of Lodwar, and at risk of over-abstraction and salinisation.

The level of over-abstraction at the local level from other aquifers in the RV Basin is poorly understood; some possible hotspots have been described above (e.g. Lokichoggio, Kakuma, Lodwar). Some Basement aquifers may have suffered localised depletion. The National Groundwater Balance Report (Water Resources Authority, 2019c) shows that the areas within the RV Basin where abstraction exceeds recharge are limited to the high population density, including central RV basins in Nakuru and Naivasha, and sub-basins 2FB (Menengai), 2FC (lower Nakuru) and 2GD (lower Naivasha). The imbalance is particularly marked in the Naivasha sub-basin.

Transboundary aquifers

The East African Community Protocol on Environment and Natural Resource Management (East African Community, 2018). Article 13 (Management of Water Resources): "The Partner States shall develop, harmonise and adopt common national policies, laws and programmes relating to the management and sustainable use of water resources", is not yet ratified by Tanzania. The Draft National Policy on Trans-Boundary Waters (Ministry of Water and Irrigation, 2009), provides limited guidance or intent on transboundary GW resources. There are three transboundary aquifers in the RV Basin out of eight across the country (Nijsten et al., 2018):

- AF39, the Mount Elgon aquifer. Total area 4 900 km^2, shared with Uganda.
- AF46, the Sudd aquifer (ILEC et al., 2015). Total area of 330 000 km^2, shared with Ethiopia, South Sudan and Sudan.
- AF72, Rift Aquifer. Total area of 19 000 km^2, shared with Tanzania and the Athi Basin.

A transboundary aquifer policy needs to be developed; the National GW Policy (Ministry of Water and Irrigation, 2013), lists the following activities required to improve transboundary GW management ("Issue 9"):

Table 4-1: **Proposed transboundary aquifer (TA) policy measures**

Issue	Objective	Policy direction	Activity	Timeframe
Transboundary aquifers not well known, characterised nor managed	TAs well known, characterised and managed by countries sharing TAs	Implement appropriate new policies and institutions to ensure seamless management of TAs	a) Identify and demarcate TAs; b) Collect information; c) Promote information sharing and adopt international good practices; d) Expand transboundary water unit to Department	Short- to long-term

There is also the National Land Use Policy (Ministry of Lands and Physical Planning, 2017), which specifically describes measures to be adopted in relation to the definition and management of transboundary groundwater resources.

4.5.2.2 Water quality

Natural contaminants (fluoride and TDS) are distributed in groundwater across the RV Basin. Salinisation and natural contaminants are the main contributors to poor groundwater quality in the RV Basin. There are currently no Groundwater Quality Management Plans for areas with a high level of risk to groundwater quality issues.

Fluoride

The major water quality constraint across much of the Basin is naturally elevated concentrations of fluoride, something which is broadly understood by the public (Akinyi, 2013). Fluoride is present at significantly high concentrations in surface and groundwaters, often exceeding the Kenya Standard of 1.5 mg/L (Kenya Bureau of Standards, 2007). Naivasha shows particularly high levels of fluoride, and is more likely to occur in groundwaters at elevations <2 000 mamsl than above 2 000 mamsl (Olaka et al., 2016). This has major impacts on human health. A recent Lancet paper describes osteofluorosis in a Kakuma refugee resettled in Canada after drinking groundwater containing excessive fluoride over a six-year period (Fabreau et al., 2019).

Salinity

Naturally high salinity and EC values are present in groundwater across the basin, and are increased by over-abstraction.

Heavy metals

The significance of mining leachate from the currently moribund Kenya Fluorspar Company mine at Kimwarer in the Kerio Valley has been reported, affecting the water quality of the Kimwarer River and shallow groundwater (Nguta et al., 2010). Excessive concentrations of fluoride and heavy metals have been reported.

Fertiliser and pesticides

Pollution of surface and groundwaters in the Central Rift by agricultural fertilisers has been reported (Olago et al., 2009). Organochloride and organophosphorus pesticides have been measured in Lake Naivasha waters, sediments and organisms, though not at concentrations of health concern (Gitahi et al., 2002). Where surface waters are polluted, bank-side recharge to alluvial aquifers may lead to localised groundwater pollution. While the absolute concentrations of the pesticides are not of concern, they serve to illustrate that catchments that drain agriculturally-rich areas (such as the upper parts of the Rift Valley Basin) are capable of the long-distance transport of potentially harmful pollutants. The current status of pollution by pesticides in the RV Basin is not known. At-risk aquifers would include all riverside alluvial aquifers, or aquifers recharged indirectly from surface waters.

4.5.2.3 Institutional

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 the 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 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). Further potential conflict between national and County Governments is likely, regarding the sharing of natural resources benefits (cf. t*he Natural Resources (Benefit Sharing) Bill*, 2014; *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.

Inadequate monitoring

Monitoring status has improved significantly in the past decade, with a total of 12 groundwater monitoring points (5 Strategic, 3 Major and 4 Minor), of which 75% are operational (Water Resources Authority, 2018f); none were reported in the 2014-15 reporting period (Water Resources Management Authority, 2016). 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. This is changing, however; an additional 25 dedicated monitoring boreholes are being constructed in the Basin in 2018-19, of which:

The UNHCR and other bodies associated with the management of the refugee camps possess a large body of water level, abstraction and water chemistry data relating to the Dadaab Merti, which could usefully be incorporated into the RV Basin monitoring database. Data exists in Lane (1995), GIBB Africa Ltd (2004), Government of Kenya et al. (2010) and Blandenier (2015). The water level monitoring network operated by UNICEF/CARE Kenya in Dadaab has been terminated, but there are enough abandoned boreholes within the camps that at least one could be adopted as a monitoring point. Three monitoring boreholes were constructed in the Central/Eastern Merti in the early 1990s; one between Ifo and Dagahaley Camps, one at Dadaab Airstrip and a third in the former DO's compound in Liboi. The borehole at the Dadaab Airstrip is close enough to the Town water supply borehole that it is influenced by it; a similar situation exists for the Liboi monitoring borehole. The third monitoring borehole has been 'lost', after insecurity prevented access to it in 1993/4. It may be possible to trace it on the ground, but it is possible that it was vandalised.

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, 2018c).

Groundwater permit classification challenges

The water permit database has proven to be challenging to use and there remain numerous duplicate or out-of-date entries.

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 (<<1 m^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.

4.5.3 Water resources infrastructure

Few large dams exist in the RV Basin, and the bulk of the water comes from lakes, rivers, small dams and pans, and groundwater. The key issues regarding water resources infrastructure in the RV Basin are described below.

4.5.3.1 Bulk water supply systems and transfers

The main issue of bulk water supply systems in the RV Basin is inadequate storage for various uses. The design of dams and other infrastructure is important to maintain the capacity designed for. There has been evidence that some irrigation dams as well other infrastructure is undersized for floods, which raises the question of whether floods were considered during the design of the infrastructure.

4.5.3.2 Irrigation schemes

There are currently limited major irrigation schemes in RV Basin, which support a very large commercial agricultural sector, one of the largest in the country. Further irrigation development is being planned and will help relieve the problem of food insecurity and support economic development.

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

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.

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.

Priority areas for groundwater resource development

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

4.5.4 Hydrometeorological monitoring network

The current monitoring network in the RV Basin 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 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

One of the key challenges across most of the RV Basin is limited water resource availability. 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 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 resource availability

One of the key challenges across part of the RV Basin, in the arid and semi-arid areas, is limited water resource availability, particularly of good quality of water. The discrepancy in water availability verses water demand in parts of the basin creates challenges in allocation of water.

4.5.5.3 Water distribution

The water supplied in the RV 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.

4.5.5.4 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 RV Basin, with transboundary / trans-county conflict and institutional arrangements as the priority sub-issues.

4.6.1.1 National policies and legislation

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.

Conflicting policies, regulations and mandates

During an ISC workshop on institutional issues, stakeholders noted that basin wide, issues of overlapping mandates, unclear policies and conflicting sectoral laws was a challenge. This is noted in the Physical Planning Act, and Agricultural/Land Acts, which holds a different definition 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. Concerns were raised that there are some laws that do not align with the newly promulgated Water Act. Furthermore, minimal coordination between national government and county government of the basin was also highlighted as a key challenge during the workshop

Revenue collection and resource mobilisation challenges

Currently, the billing system is not integrated with the PDB thus lowering revenue billed. Initial consultations by ISC indicate that there is a need to explore innovative additional revenue streams to increase 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'. Revenue collection rates for WRA are low due to inadequate resources to facilitate this process. However, the Authority has recently incorporated electronic payment services through Mpesa, a mobile money transfer platform that will significantly increase the revenue collected because of the convenience it offers the water users. Also, there are on-going discussions on acquiring an integrated system that will increase efficiency in the permitting and commercial processes at WRA.

Non-compliance to effluent discharge regulations

In 2014, the WRA recorded 16 major effluent dischargers on the RV Basin of which only 2 major effluent dischargers were issued with effluent discharge (ED) permits (Water Resources Management Authority, 2016). Issuance of ED permit is contingent on compliance to the Effluent Discharge Control Plan (EDCP). The low number of effluent dischargers with ED permits implies that pollution control in the basin is weak and water quality levels in the basin have weakened due to the non-compliance to effluent discharge regulations. Poor compliance to effluent discharge regulations can be ascribed to capacity constraints in human resources, inadequate financial resources and lack of adequate infrastructure. Lake Naivasha is one of only two lakes with fresh water (other lakes in the basin have brackish to saline waters) has good to poor water quality with the lower parts of the lake experiencing high siltation mainly due to agricultural pollutants. Lake Nakuru is under threat due to poor waste management from Nakuru town.

4.6.1.2 National institutions

Uncoordinated institutional roles

The uncoordinated roles of the various organisations cause not only poor efficiency, but also conflict between the organisations. WRA, KFS and KWT 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 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.

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, to implement sub-catchment based water resources management interventions. Also, water resources management is a function that has been devolved to the CGs, while WRA performs regulation of the CG’s management of water resources.

4.6.1.3 Basin and sub-basin institutions

Dormant or potential WRUAs

In 2019, the RV Basin had 83 operational WRUAs out of a potential 175 WRUAs and 48 Sub Catchment Management Plans (SCMPs) had been developed. The large number of dormant or potential WRUAs in the basin needs attention particularly regarding financing and capacity building. Despite their importance, many WRUAs in the basin do not have the implementing capacity and have insufficient levels of professionalism both in the field of water management as well as in the field of prevention and resolution of conflict. In addition, several WRUAs lack financial stability which has reduced their ability to execute their SCMPS and ultimately become passive and hollow institutions.

The unclear role of the BWRCs

There are conflicting mandates for the BWRCs in the Water Act (2016) where they have both advisory and executive functions. ISC has an understanding that the BWRCs will remain advisory for the foreseeable future with a long-term plan of making the BWRCs have an executive role. There is a need to develop tools to support the operationalisation of the BWRCs, when they are finally established, and to ring-fence WRA staff at the Ros who will provide both technical and secretariat services to the BWRCs. The actual responsibility and how the BWRCs will work with WRA at the regional offices will only be clear once the mandates are agreed upon.

Expansive area of jurisdiction

The RV Basin consists of a number of closed basins and covers an area of about 131 500 km². It encompasses the basins discharging into Lake Turkana in the North through the Turkwel and Kerio rivers and those draining into Lake Natron in the south through the Ewaso Ng’iro South River. The smaller lakes such as Baringo, Bogoria, Nakuru, Elementeita, Naivasha and Magadi also form individual basins. The dispersed make-up of the sub-basin’s presents complexities in the management of water resources from a single central as a result each of the WRA sub-regional and local offices in the RV basin need to have a strong enabling environment.

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 Forests 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

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.

Limited 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.

Minimal coordination also exists between county government and national departments as well as national agencies responsible for natural resource management. The poor of coordination has been perpetuated by the limited priority placed on intergovernmental relations and cooperative governance for the different spheres of government. The current platforms aimed at improving intergovernmental relations should be strengthened to ensure coherence across different spheres of government.

4.6.1.5 Partnerships and engagement

Limited partnerships

There are few partnerships covering the sub-catchments of the basin. The partnership varies between operating at a sub-basin level and localised level in addition, the level of development of the partnerships also range between fledgling and established. Some of the localised fledgling partnerships have inadequate well trained human resources and financial resources to pursue partnership activities. While some of the more established partnership struggle with influencing government to improve water resource management and sustaining the partnership momentum long after the donor agencies have exited the partnership.

The Imarisha Navaisha multi-stakeholder partnership operating in the Lake Naviasha sub-basin is one of the more established partnerships operating in the basin. Through the partnership steps are being taken in order to improve water security for social and economic development of the region whilst protecting Lake Navaisha and surrounding water sources. Given the strategic need to have more localised partnerships in the basin more efforts need to be vested in supporting the establishment of partnerships and the mobilisation of resources to support partnership activities.

Limited coordination between stakeholders

There is currently inadequate coordination between the WRA, WRUAs and the County Governments, which leads to poor urban planning and uncontrolled development. Poor coordination between the WRA and County governments also affects the way environmental trade-offs from the development are managed. Therefore, improved coordination between the three stakeholders is important for creating alignment in the protection and development of water resources.

Low public awareness of WRA's mandate

Generally, there is low public awareness of WRA in the RV Basin. Some of the stakeholders in the basin are unaware of WRA's role in regulating the use and management of water resources. Those that are aware of WRA's mandate sometimes criticise the Authority of weak performance. Thus, there is urgent need to create awareness and understanding of WRA mandate as a Regulator through activism and engagement with other partners. This can be achieved by articulating WRA's functions well, demonstrating ways of measuring results achieved and packaging results in ways attractive to different stakeholders in the basin. Improved enforcement of offenders is also another alternative that will enable water users to realise the value addition of WRA's services for the fees they remit to the Authority.

4.6.2 Enabling environment

Key enabling environment issues in the basin include inadequate resources (financial, equipment, materials, office space, monitoring stations and laboratories). These issues and challenges are cross-cutting across all regional offices of WRA. However, key issues and challenges specific to the RV Basin are described below.

4.6.2.1 Inadequate financial resources

WRA has insufficient funding, which results in a clear gap in financing, that in turn affects operational activities which have a bearing on quality and quantity of outputs by the Authority. This has negatively affected procurement of modern equipment, upgrading existing stations, improving monitoring networks, increasing staffing capacity, training etc. However, although approved recurrent budgets over the years has increased steadily, though with a small percentage and actual funds released for operations have also improved over recent years in line with the available funding, the financing gap has been significant with FY2016/17 having a financing gap of KES 819 million. 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 Public Private Partnership arrangement.

Current funding includes WSTF financing for WRUAs as well as African Development Bank funding for the Kenya towns sustainable water supply and sanitation programme through which WRA is being facilitated in institutional strengthening and funding of WRUAs.

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.

Some of the issues arising from inadequate financial resources are inadequate office space and equipment, inadequate vehicles and/or fuel and inadequate laboratory facilities.

Inadequate office space and equipment

An assessment conducted by the *Working Committee on Transitional of Water Resources Management Authority to Water Resources Authority* in 2018, revealed that the RV Basin has limited office space coupled with inadequate office equipment as well as limited water resource data gathering and monitoring equipment. Furthermore, the assessment findings identified that the water resource data gathering and monitoring equipment is in need of maintenance, repair or upgrade. 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.

Inadequate vehicles and/or fuel

The RV Basin has a cumulative total of 9 vehicles distributed as follows; Nakuru (3), Naivasha (2), Narok (1), Kabarnet (1), Kapenguria (1) and Lodwar (1). The report produced by the Working Committee on Transitional of Water Resources Management Authority to Water Resources Authority recommended that each sub basin office should have a minimum of 3 vehicles. Only one of the sub-basin offices is within this recommendation, the limited vehicles in the other sub basin offices affects the operational efficiency of the basin and has negative effects on the day to day activities. This for example affects the data collection, monitoring and compliance activities of the basin. Aging of the vehicles and poor operation and maintenance of vehicles also exacerbates the situation.

Inadequate laboratory facilities

The WRA has laboratory facilities in Nakuru regional office which measure three water quality parameters namely: physical, chemical and microbial. For some of the facilities, there is no clear indication regarding the conditions of the facilities and conditions of equipment. Given the inadequate data collection and monitoring equipment including the delipidated state of existing data collection and monitoring equipment, there is a high probability that that the laboratory facilities are inadequate, and functionality of facilities oscillates between poor and good.

4.6.2.2 WRA staffing capacity

The RV basin has a regional office in Nakuru and sub regional offices in Naivasha, Eldoret, Kabarnet, Narok, Kapenguria and Lodwar. Combined, the regional office and sub regional offices have a staff complement of 116 people of which the Lodwar sub regional office has the lowest number of staff with 8 people. Given the expansive area of jurisdiction in the Rift valley and the configuration of the sub-catchments, understaffing threatens the operational viability of the basin to undertake effective water resource management. The employment of staff in technical, professional and para-technical positions is required in order to improve the functioning of WRA offices including the presence and oversight of the WRA.

4.6.2.3 Enforcement capacity of WRA

The enforcement capacity of the WRA in the RV Basin is weak. This is likely due to the fact that enforcement is a centralised function operating from HQ with the legal department taking the lead, and with enforcement being executed at the RO and SRO level, with inadequate staff and communication with HQ. In addition, the legal department has approximately 17 trained 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, there should also be upskilling of existing staff in order to undertake compliance and enforcement activities.

4.6.2.4 Implementation ability/capacity

Despite the development of the catchment management strategy for the basin there is no clear indication on progress in implementing strategic action of the strategy. This implies that there is limited ability to implement strategic plans in the basin as result improved focus in strengthening the capacity of the WRA to implement strategic plans is required. The implementation of long-term plans requires adequate financial and capacitated human resources, given the inadequacy of these resources in the basin, it becomes a struggle for the WRA to improve implementation of strategic actions identified in long-term plans. Therefore, specific bottlenecks regarding human and financial resources affecting the implementation of long-term plans needs to be assessed and corrective measures should be undertaken to address bottlenecks.

4.6.2.5 Capacity of other institutions

There are a range of capacity challenges affecting the institutions operating in the basin. Capacity challenges include minimal technical staff, inadequate facilities and infrastructure as well inadequate compliance and enforcement capacity. KFS, NEMA and County Governments are just some of the institutions that are facing capacity constraints. 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. The deterioration of wetlands indicates a capacity gap within NEMA regarding oversight on wetlands including inadequate capacity to enforce compliance measures.

4.6.2.6 Capacity in WRA to deal with drought related disasters

The RV basin does not have an adequate drought management plan. The current drought management strategic action includes implementing water use restrictions during drought periods. However, reference water levels for restriction are not clearly determined in the basin. This means there is an operational issue from the viewpoint of clear timing for actions against drought (Water Resources Management Authority, 2013).

A drought disaster management plan including water use restriction of five dams has not been implemented (Water Resources Management Authority, 2013). The dams are for hydropower, irrigation and domestic water supply purposes. In 2010, as a part of the Arid Land Resources Management Project II institutional arrangement for drought disaster management at local levels for all the arid and semi-arid land districts were developed. However, there is no clear indication whether these institutions are adequately capitated with human and financial resources and there is also limited clarity regarding the legal status of the institutions.

4.6.2.7 Capacity in WRA with regards to flood mitigation

A systematic flood disaster management plan has not been implemented in the RV basin because neither setting of warning water levels at major river gauge stations nor construction of flood control structures has been confirmed (Water Resources Management Authority, 2013). There is also no clear indication regarding the WRA’s capacity to address urban floods due to poor drainage especially in Narok and Nakuru where there is a high prevalence of urban floods. The RV Basin lacks capacity in flood forecasting, early flood warning systems and overall flood management to deal with flood related disasters. Greater importance should be placed in capacitating the basin to develop flood management measures that are structural and non-structural.

4.6.2.8 Capacity to enforce reserve flows

There is currently inadequate capacity (number of staff and technical capacity) in the WRA to carry out environmental monitoring and to enforce the implementation of reserve flows. The absence of sufficient environmental policies and regulations at county level also constrains efforts to enforce environmental conservation. Furthermore, only minimal reserve determination has been undertaken for all water sources in the basin.

4.6.2.9 Capacity of WRA with regards to climate change adaptation strategies

The Government of Kenya has developed various climate change tools to steer climate change response including and not limited to the National Climate Change Action Plan (Government of Kenya, 2013b), NDC submitted to UNFCCC in 2016 and the National Adaptation Plan (Government of Kenya, 2016). The issue arises with inadequate knowledge and ability to implement these adaptation strategies as well as insufficient staff capacity. Available funding and investments for continuous implementation, assessment and maintenance of the strategies poses an issue. WRA does not have a department or desk to specifically address climate change issues, rather climate change is blended into programme and project activities on a case by case basis.

4.6.3 Transboundary and trans-county issues

The RV basin shares surface water resources with Ethiopia, Uganda and Tanzania, and aquifers with Ethiopia, Uganda, Tanzania, South Sudan and Sudan. There are potential conflicts between these countries if water resources are not managed and developed cooperatively. There are also conflicts between counties due to disparities in water use between upstream and downstream users.

4.6.3.1 Inter-basin transfers

Currently there are no inter-basin transfers in the region however, the National Water Master Plan proposes the development of two inter-basin transfers to meet the growing water demands of the basin ahead of 2030. The transfers are to be from Itare and Londiani dams in Lake Victoria South (LVS) Basin to Nakuru area as well as from Amala Dam to the basin. The transfer volume from Itare Dam will be 41 MCM/year while the transfer volume from Amala Dam will be 82 MCM/year (Water Resources Management Authority, 2013). The water transferred from the LVS basin will support domestic use, irrigation and hydropower generation.

4.6.3.2 Internationally shared water resources

There are several internationally shared rivers and aquifers in the RV basin. Lake Turkana with a surface area of 7 500 km² shares its water resources with Ethiopia in its northern end. Major rivers flowing into Lake Turkana are the Turkwel, Kerio and Omo Rivers. The Omo River contributes more than 80% of Lake Turkana's inflow and its entire drainage area lies in the territory of Ethiopia. As result developments and activities on the river could affect the quantity and quality of water flowing into the Lake Turkana. The building of Gibe III dam which is aimed at supporting hydropower electricity generation and irrigation on the Omo River has resulted in conflict between Lake Turkana interest groups located in Kenya and the Ethiopian government. It is estimated that the dam will reduce flow from Omo River into Lake Turkana, negatively affect ecology of areas downstream and affect food security for communities living downstream of the community. Despite the regional importance of the Lake no specific transboundary agreement has been formed between the two countries to jointly develop the Lake's waters.

The RV Basin shares the Ewaso Ng'iro South River with Tanzania. The river feeds Lake Natron south of the border in Tanzania and any development on the Kenyan side will potentially impact the ecologically important lake.

Cross-border tensions between Kenya and Uganda over the waters of Turkwel drainage basin have been reported. Ugandan tribes relying on water from the basin are fighting with the Kenyan tribes over the availability of water.

4.6.3.3 Trans-county conflict

Intra-basin and trans-county disputes over water and land in Turkana and West Pokot counties have been reported. The conflicts are due to the limited availability of water to support domestic and livestock as well as unwillingness to share water resources by tribes. Furthermore, the conflict is also in part fuelled by the cultural practice of livestock raiding and the associated desire for revenge.

4.6.3.4 Land and resource conflict

The RV is a relatively peaceful place, although conflicts escalate during periods of electioneering. Access to land and mistrust create volatile situations, particularly in the Narok, Burnt Forest, Molo and Kuroshio. Amongst the more pastoralist communities such as the Pokot, Marakwet and Turkana conflicts over commonly shared resources (i.e. water and grazing land) are experienced. The management of land issues shows signs of vested political interests, with local communities rarely involved in the decision-making process about how land is allocated (for instance, for re-settling landless communities' humanitarian emergencies, or resource exploitation. Local communities often see allocations as unjust and a means of depriving them of ancestral lands.

Image source: Sutirta Budiman 2019 'Maasai Mara National Reserve, Narok County, Kenya'. Available online at https://unsplash.com/photos/PdiOj8kRy28

05

Vision and Scenario Evaluation

5 Vision and Scenario Evaluation

5.1 Introduction

This Section describes the definition and evaluation of different scenarios which were considered during the development of the RV Basin Plan. The main objective of the scenario evaluation was to assess and quantify the potential impacts and benefits of proposed water resources development interventions in the RV Basin in terms of environmental, socio-economic and macro-economic parameters, and to assess whether the available water resources in the basin are sufficient to sustain the anticipated growth in water requirements linked to population growth, urbanisation, improved living standards and increased irrigation. Based on the scenario evaluation results, a sustainable development pathway is presented for the RV Basin, which aims to minimise environmental and social impacts and maximise socio-economic benefits, taking into consideration the availability of water.

5.2 Vision for RV Basin

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

> *A model and sustainable basin providing equitable, adequate and high-quality water and ecological services for socio-economic development 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.

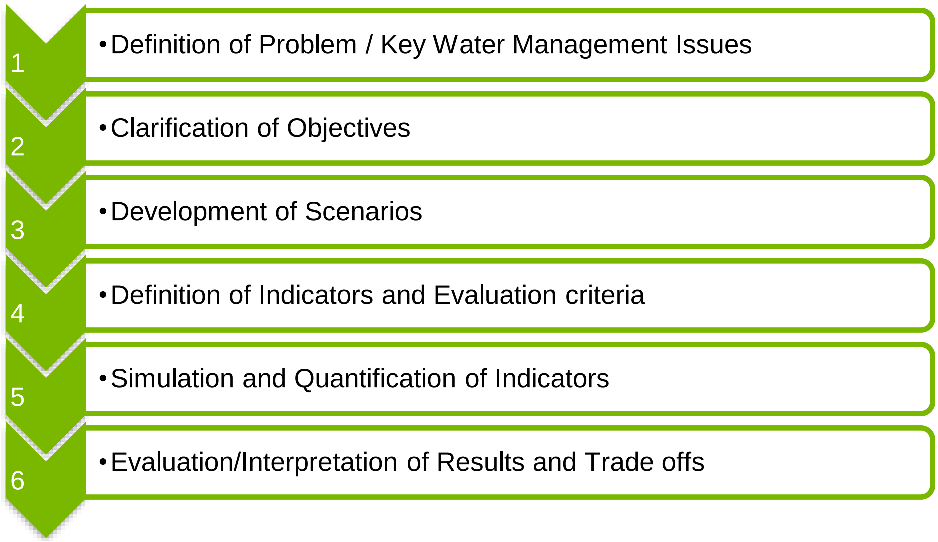


Figure 5-1: Scenario Evaluation (adapted from Kusek & Rist, 2004 and World Bank, 2008)

The key aim of the RV 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.**

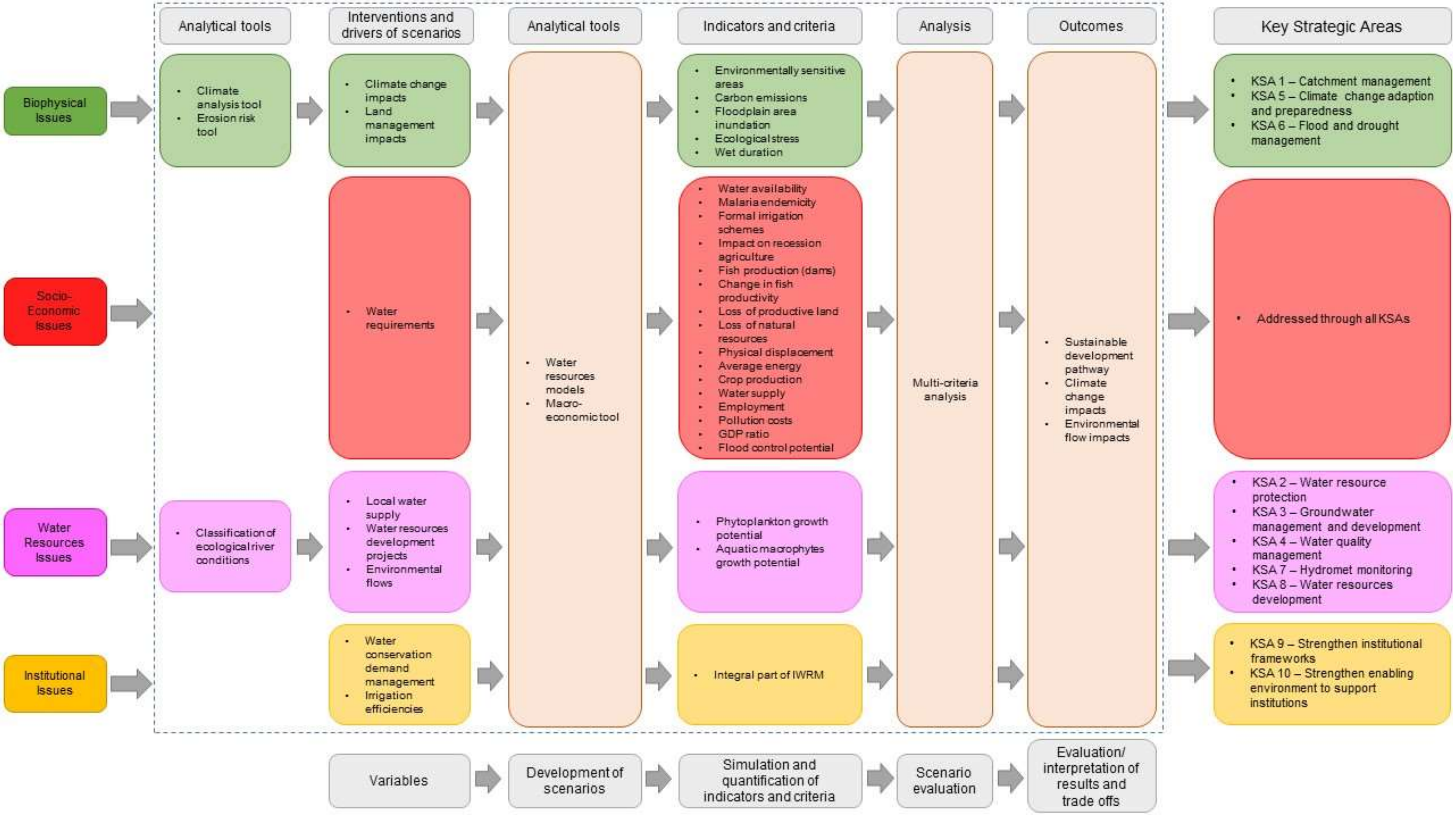


Figure 5-2: Approach to scenario development and evaluation

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 RV 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.

5.4.2 Socio-economic

5.4.2.1 Future water requirements

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

Irrigation water requirements

To estimate future (2040) small-scale irrigation areas in the RV 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 2030.

The growth in large-scale irrigation area up to 2040 in the RV Basin was based on the expected growth in large-scale irrigation as per Table 5.1 – validated with the Department of Irrigation at the Ministry of Agriculture, Livestock and Fisheries.

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.

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 RV Basin, information per sub-basin was sourced from the NWMP 2030 and CIDPs as relevant.

The NWMP 2030 estimated 2030 water demands based on expected population growth in urban and rural areas, assumptions regarding 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 2030.

Livestock and wildlife water requirements

Current estimated livestock and wildlife water demands in the RV Basin were extrapolated to 2040 based on observed trends. Growth factors were calculated per sub-basin using data from the NWMP 2030.

5.4.3 Water resources

5.4.3.1 Local water supply

As evident from Sections 2.4, there are still surface water resources available in the RV Basin 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 RV 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 RV 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 this Basin Plan, information on water resources development schemes in the RV 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 below. 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 and schemes in the RV Basin

Dams and Hydropower				
Name	**Sub-basin**	**County**	**Proposed Storage (MCM)**	**Purpose**
Arror Dam	2CC	Elgiyo Marakwet	70	Large scale irrigation: Arror Scheme Hydropower (60 MW)
Siyoi-Muruny	2BA	West Pokot	17	Water supply (West Pokot County)
Gibe IV / Koysha	n.a. (Ethiopia)		6 000	Large scale irrigation: Lower Omo Valley (Ethiopia)

Dams and Hydropower				
				Large scale irrigation: Todonyang-Omo Scheme (Kenya) Hydropower (2160 MW)
Malewa Dam	2GB	Nyandarua	73	Water supply (Gilgil & Naivasha Town, Nakuru County)
Upper Narok Dam	2KA	Narok	10	Water supply (Narok Town) Large scale irrigation: Upper Narok Scheme
Oletukat-Olenkuluo Dam	2KA	Narok	406	Hydropower (25 MW)
Leshota Dam	2KB	Narok	247	Hydropower (56 MW)
Oldorko Dam	2KB	Narok	95	Hydropower (99 MW) Large scale irrigation: Lower Ewaso NS Scheme
Embobut	2CC	West Pokot	40	Large scale irrigation: Embobut Scheme Hydropower (45 MW)
Waseges Dam	2EB	Baringo	5	Irrigation: Waseges Scheme
Lowaat Dam	2CC	Turkana	537	Large scale irrigation: Lowaat Scheme
Radat Dam	2EE	Baringo	267	Large scale irrigation: Expand Perkerra Scheme
Transfers				
Scheme	**Sub-basin**	**Counties**	**Proposed capacity (MCM/a)**	**Purpose**
Malewa Dam	2GB	Nyandarua Nakuru	42	Water supply to Naivasha, Gilgil and Nakuru County
Itare Dam Inter-basin transfer (from LVS)	1LA	Nakuru	41	Assume 100% of transfer is supplied to Nakuru Town and surrounding urban areas
Amala Dam Inter-basin transfer (from LVS)	1LB1	Bomet Narok	82	100% of transfer is used for the HEP, Irrigation of the Ewaso Ng'iro South Development.

Large-scale irrigation				
Scheme	**Sub-basin**	**County**	**Proposed Area (ha)**	**Source**
Lower Omo	n.a. (Ethiopia)		208 655	Gibe I-V Dams on Omo River
Arror Dam Irrig.	2CB	Elgiyo Marakwet	3 000	Arror Dam.
Turkwel Dam Small Scale irrig. (replaces present day Turkwell irrigation.)	2BD	Turkana	4 000	Turkwel Dam
Turkwel Dam Sugar (was Turkwel & Kerio Valley Irrig.)	2BD	Turkana	25 000	Turkwel Dam
Upper Narok Dam	2KA	Narok	2 000	Upper Narok Dam
Oldorko Scheme (Lower Ewaso Ng'iro Scheme)	2KC	Narok	15 000	Ewaso Ng'iro South Development incl. Amala Transfer and Oletukat, Leshota and Oldorko Dams
Embobut Dam Irrig.	2CC	Narok	2 000	Embobut Dam.
Waseges Dam & Irrig.	2EB	Baringo	470	Waseges Dam
Todonyang-Omo Irrig.	2AB	Turkana	10 000	Gibe I-V Dams on Omo R
Lowaat Dam	2CC	Turkana	14 000	Lowaat Dam
Total Perkerra Irr. (inc. portion supplied from	2EE	Baringo	11 000	Radat Dam and Perkerra R

Large-scale irrigation				
Radat Dam)				

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 RV 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 5-2 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 RV 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 current projects under implementation are completed, yet there is no further investment in water resources infrastructure and development including large-scale irrigation although 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 lack of 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 urban 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. 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. The scenario also focuses on reducing the impact of consumptive use on lake inflows under future development, by limiting the total future water use in the basin to 60% of the total water resources available, mainly by capping irrigation development.

Note: It is imperative that any large-scale water resources developments in the RV Basin are preceded by detailed, scientifically based studies on the potential impacts of water abstractions on downstream lakes, which should quantify and prescribe the minimum flows required to maintain the environmental and social sustainability of the various lakes in the basin.

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

- 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
- Maximum consumptive water use should not exceed 60% of total future water availability in the basin on average

Two 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

Table 5-2: Scenario definition

Category	Type	Scenario 0	Scenario 1	Scenario 2A	Scenario 2B	Scenario 3A	Scenario 3B
Water resources development	Large dams	Gibe I (Ethiopia)	Gibe I (Ethiopia)	Gibe I (Ethiopia)	Gibe I (Ethiopia)	Gibe I (Ethiopia)	Gibe I (Ethiopia)
		Gilgel Gibe II (Ethiopia)	Gilgel Gibe II (Ethiopia)	Gilgel Gibe II (Ethiopia)	Gilgel Gibe II (Ethiopia)	Gilgel Gibe II (Ethiopia)	Gilgel Gibe II (Ethiopia)
		Gibe III (Ethiopia)	Gibe III (Ethiopia)	Gibe III (Ethiopia)	Gibe III (Ethiopia)	Gibe III (Ethiopia)	Gibe III (Ethiopia)
		Turkwel	Turkwel	Turkwel	Turkwel	Turkwel	Turkwel
		Chemususu	Chemususu	Chemususu	Chemususu	Chemususu	Chemususu
		Chemeron Yatoi	Chemeron Yatoi	Chemeron Yatoi	Chemeron Yatoi	Chemeron Yatoi	Chemeron Yatoi
		Kirandich	Kirandich	Kirandich	Kirandich	Kirandich	Kirandich
			Arror	Arror	Arror	Arror	Arror
			Siyoi-Muruny	Siyoi-Muruny	Siyoi-Muruny	Siyoi-Muruny	Siyoi-Muruny
				Gibe IV/Koysha (Ethiopia)	Gibe IV/Koysha (Ethiopia)	Gibe IV/Koysha (Ethiopia)	Gibe IV/Koysha (Ethiopia)
				Malewa	Malewa	Malewa	Malewa
				Upper Narok	Upper Narok	Upper Narok	Upper Narok
				Oletukat-Olenkuluo	Oletukat-Olenkuluo	Oletukat-Olenkuluo	Oletukat-Olenkuluo
				Leshota	Leshota	Leshota	Leshota
				Oldorko	Oldorko	Oldorko	Oldorko
				Embobut	Embobut	Embobut	Embobut
				Waseges	Waseges	Waseges	Waseges
				Lowaat	Lowaat	Lowaat	Lowaat
				Radat	Radat	Radat	Radat
	Hydropower	Gibe I (184 MW) (Ethiopia)	Gibe I (184 MW) (Ethiopia)	Gibe I (184 MW) (Ethiopia)	Gibe I (184 MW) (Ethiopia)	Gibe I (184 MW) (Ethiopia)	Gibe I (184 MW) (Ethiopia)
		Gilgel Gibe II (420 MW) (Ethiopia)	Gilgel Gibe II (420 MW) (Ethiopia)	Gilgel Gibe II (420 MW) (Ethiopia)	Gilgel Gibe II (420 MW) (Ethiopia)	Gilgel Gibe II (420 MW) (Ethiopia)	Gilgel Gibe II (420 MW) (Ethiopia)
		Gibe III (1 870 MW) (Ethiopia)	Gibe III (1 870 MW) (Ethiopia)	Gibe III (1 870 MW) (Ethiopia)	Gibe III (1 870 MW) (Ethiopia)	Gibe III (1 870 MW) (Ethiopia)	Gibe III (1 870 MW) (Ethiopia)
		Turkwel (106 MW)	Turkwel (106 MW)	Turkwel (106 MW)	Turkwel (106 MW)	Turkwel (106 MW)	Turkwel (106 MW)
			Arror (60 MW)	Arror (60 MW)	Arror (60 MW)	Arror (60 MW)	Arror (60 MW)
				Gibe IV/Koysha (2 160 MW)	Gibe IV/Koysha (2 160 MW)	Gibe IV/Koysha (2 160 MW)	Gibe IV/Koysha (2 160 MW)
				Oletukat-Olenkuluo (25 MW)	Oletukat-Olenkuluo (25 MW)	Oletukat-Olenkuluo (25 MW)	Oletukat-Olenkuluo (25 MW)
				Leshota (56 MW)	Leshota (56 MW)	Leshota (56 MW)	Leshota (56 MW)
				Oldorko (99 MW)	Oldorko (99 MW)	Oldorko (99 MW)	Oldorko (99 MW)
				Embobut (45 MW)	Embobut (45 MW)	Embobut (45 MW)	Embobut (45 MW)

Category	Type	Scenario					
		0	1	2A	2B	3A	3B
Water resource development	Inter-basin transfers			Itare Dam (from LVS)	Itare Dam (from LVS)	Itare Dam (from LVS)	Itare Dam (from LVS)
				Amala Dam (from LVS)	Amala Dam (from LVS)	Amala Dam (from LVS)	Amala Dam (from LVS)
	Intra-basin transfers	Chemususu Dam to Eldama Ravine, Mogotio and Nakuru	Chemususu Dam to Eldama Ravine, Mogotio and Nakuru	Chemususu Dam to Eldama Ravine, Mogotio and Nakuru	Chemususu Dam to Eldama Ravine, Mogotio and Nakuru	Chemususu Dam to Eldama Ravine, Mogotio and Nakuru	Chemususu Dam to Eldama Ravine, Mogotio and Nakuru
		Turasha intake to Nakuru County, Gilgil and Naivasha	Turasha intake to Nakuru County, Gilgil and Naivasha	Turasha intake to Nakuru County, Gilgil and Naivasha	Turasha intake to Nakuru County, Gilgil and Naivasha	Turasha intake to Nakuru County, Gilgil and Naivasha	Turasha intake to Nakuru County, Gilgil and Naivasha
		Kirandich Dam to Kabarnet and subbasin 2CB	Kirandich Dam to Kabarnet and subbasin 2CB	Kirandich Dam to Kabarnet and subbasin 2CB	Kirandich Dam to Kabarnet and subbasin 2CB	Kirandich Dam to Kabarnet and subbasin 2CB	Kirandich Dam to Kabarnet and subbasin 2CB
				Malewa Dam to Nakuru County, Gilgil and Naivasha	Malewa Dam to Nakuru County, Gilgil and Naivasha	Malewa Dam to Nakuru County, Gilgil and Naivasha	Malewa Dam to Nakuru County, Gilgil and Naivasha
	Small-scale irrigation (ha)	8 302	30 184	30 184	30 184	15 000	15 000
	Large-scale irrigation (ha)	Lower Omo (Ethiopia) 208 655 ha	Lower Omo (Ethiopia) 208 655 ha	Lower Omo (Ethiopia) 208 655 ha	Lower Omo (Ethiopia) 208 655 ha	Lower Omo (Ethiopia) 208 655 ha	Lower Omo (Ethiopia) 208 655 ha
		Turkwel Dam (1 081 ha)	Turkwel Dam (1 081 ha)	Turkwel Dam (500 ha)	Turkwel Dam (500 ha)	Turkwel Dam (500 ha)	Turkwel (4500 ha)
		Perkerra (890 ha)	Perkerra (890 ha)	Perkerra (11 008 ha)	Perkerra (11 008 ha)	Perkerra (5 890 ha)	Perkerra (5 890 ha)
		Wei Wei (569 ha)	Wei Wei (569 ha)	Wei Wei (569 ha)	Wei Wei (569 ha)	Wei Wei (569 ha)	Wei Wei (569 ha)
			Arror Dam (3 000 ha)	Arror Dam (3 000 ha)	Arror Dam (3 000 ha)	Arror Dam (2 000 ha)	Arror Dam (2 000 ha)
				Turkwel Dam Sugar (2 500 ha)	Turkwel Dam Sugar (2 500 ha)	Turkwel Dam Sugar (6 000 ha)	Turkwel Dam Sugar (6 000 ha)
				Upper Narok Dam (2 000 ha)	Upper Narok Dam (2 000 ha)	Upper Narok Dam (2 000 ha)	Upper Narok Dam (2 000 ha)
				Oldorko Scheme (15 000 ha)	Oldorko Scheme (15 000 ha)	Oldorko Scheme (15 000 ha)	Oldorko Scheme (15 000 ha)
				Embobut Dam (2 000 ha)	Embobut Dam (2 000 ha)	Embobut Dam (1 000 ha)	Embobut Dam (1 000 ha)
				Waseges Dam (470 ha)	Waseges Dam (470 ha)	Waseges Dam (470 ha)	Waseges Dam (470 ha)
				Todonyang-Omo (1 000 ha)	Todonyang-Omo (1 000 ha)	Todonyang-Omo (2 000 ha)	Todonyang-Omo (2 000 ha)
				Lowaat Dam (14 164 ha)	Lowaat Dam (14 164 ha)	Lowaat Dam (10 164 ha)	Lowaat Dam (10 164 ha)
	Small dams/pans (MCM)	12	12	12	12	73	73
	Groundwater use (MCM/a)	197	197	197	197	350	350

Category	Type	Scenario					
		0	1	2A	2B	3A	3B
Environment	Ecological reserve	No	No	Q95	Q95	Q95	EFlows
Catchment	Forests	Current	10% reduction	10% reduction	10% reduction	10% improvement	10% improvement
	Erosion risk – sediment (million t/a)	29.3	32.5	31.5	31.5	26.7	26.7
Climate	Climate change	No	Yes	Yes	No	Yes	Yes
Water demand (MCM/a)	- Irrigation	204	564	1 414	1 338	920	920
	- Domestic/industrial	192	758	758	758	708	708
	- Other	85	156	156	156	156	156
	Total	481	1 478	2 328	2 252	1 784	1 784

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 5-3 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 5-3: Structured indicators for evaluation of water management interventions

Category	Type of Measurement		
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.	Leading indicators: - Advance measures of whether an expected change will occur for outcomes and impacts.	Cross-cutting indicators: - Measures of crosscutting concerns at all levels	Exogenous or external indicators: - measures of necessary external conditions that support achievement at each level
Outcome indicators: measures of short-term change in performance, behaviour or status of resources for target beneficiaries and other affected groups.			
Output indicators: measures of the goods and services produced and delivered by the project.			
Process indicators: measures of the progress and completion of project activities within planned work schedules.			
Input indicators: measures of the resources used by the project.			

Table 5-4 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 5-4: 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
			4	Lake inflows
	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 5-5 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 5-6 indicates the evaluation criteria as calculated for each scenario of the RV 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 5-7 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 5-5: 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
		Lake inflows	million m3/a	Total river inflows to lakes	-
	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 5-6: Scenario evaluation criteria

Dimension	Category	Criteria	Unit	SC0	SC1	SC2A	SC2B	SC3A	SC3B
ENVIRONMENT	Footprint areas	Environmentally sensitive areas	Area (km^2)	n/a	13	41	41	41	41
		Carbon emissions dams	tons	n/a	13300	44766	44766	44766	44766
		Carbon emissions LIR	tons	n/a	75425	1670502	1670502	1670502	1670502
	Downstream areas	Floodplain area inundated	% change from baseline	n/a	-16.6	-35.2	-26.0	-25.5	-21.5
		Ecological stress	Index (-5 to 0)	n/a	-2.8	-3.5	-3.5	-3.2	-2.4
		Wet duration	% change from baseline	n/a	-20.0	-32.8	-31.2	-28.1	-27.2
		Lake inflow	change from baseline (MCM/a)	n/a	-538	-1722	-1626	-749	-543
	Water quality	Phytoplankton growth potential	Average growth potential %	71.2	77.3	66.8	67.4	66.2	83.0
		Aquatic macrophytes growth potential	Index (-5 to 0)	-0.3	-0.8	-1.4	-1.4	-1.7	-1.4
SOCIAL	Water availability	Change in availability of water for riparian users	% change from baseline	n/a	-47.1	-49.2	-51.1	-45.8	-30.8
	Community health and safet	Malaria endemicity	Malaria endemicity (km^2)	12	14	70	70	70	70
	Food security and livelihoods	Formal irrigation schemes	Area (km^2)	25.4	55.4	880.4	880.4	499.7	499.7
		Impact on recession agriculture	% change from baseline	n/a	-16.6	-35.2	-26.0	-25.5	-21.5
		Fish production (dams/lakes)	tons/annum	81	106	674	674	674	628
		Change in fish productivity	% change from baseline	n/a	-2.8	-3.5	-3.5	-3.2	-2.4
		Loss of productive land	Area (km^2)	n/a	15	67	67	67	67
		Loss of natural resources	Area (km^2)	n/a	1.3	41	41	41	41
	Displacement	Physical displacement	Number people	n/a	399	26147	26147	26147	26147
ECONOMIC	Energy	Avg energy	GWh/annum	429	506	1276	1321	1294	1297
	Food production	Crop production (formal irrigation)	Million ton/annum	0.004	0.03	0.33	0.33	0.25	0.17
		Fish production (dams/lakes)	tons/annum	81	106	674	674	674	628
	Water supply	Urban water supply	Ratio	0.95	0.77	0.87	0.87	0.91	0.83
		Domestic water supply	Ratio	0.71	0.66	0.65	0.66	0.80	0.80
		Formal irrigation water supply	Ratio	0.99	0.68	0.53	0.55	0.94	0.81
		Small-scale irrigation water supply	Ratio	0.66	0.59	0.56	0.55	0.80	0.80
	Employment	Employment formal irrigation	Jobs/annum	5080	15080	180566	180566	225708	225708
		Employment hydropower	Jobs/annum	858	1011	2553	2642	3236	3242
	Pollution costs	Pollution cost index - dams and formal irrigation	Ratio of baseline	1.0	1.2	1.2	1.2	1.3	1.4
	Sediment	Sediment potential index	Ratio of baseline	1.00	1.10	0.89	0.89	0.89	0.90
	Primary GDP	GDP index	Ratio of baseline	1.0	2.3	5.8	5.8	6.5	6.1
	Flood control	Flood control potential	Ratio	0.45	0.49	0.98	0.98	0.99	0.98

Table 5-7: Criteria weightings

Dimension	Category	Criteria	ECON	ENV	SOC
ENVIRONMENT	Footprint areas	Environmentally sensitive areas	28	1	31
		Carbon emissions dams	29	2	30
		Carbon emissions LIR	30	3	29
	Downstream areas	Floodplain area inundated	24	4	28
		Ecological stress	26	5	26
		Wet duration	25	7	27
		Lake inflows	31	9	23
	Water quality	Phytoplankton growth potential	27	6	25
		Aquatic macrophytes growth potential	23	8	24
SOCIAL	Water availability	Change in availability of water for riparian users	22	12	18
	Community health and safety	Malaria endemicity	21	18	11
	Food security and livelihoods	Formal irrigation schemes	18	14	1
		Impact on recession agriculture	20	13	10
		Fish production (dams/lakes)	14	16	2
		Change in fish productivity	19	15	4
		Loss of productive land	16	11	14
		Loss of natural resources	17	10	15
	Displacement	Physical displacement	15	17	16
ECONOMIC	Energy	Avg energy	10	29	12
	Food production	Crop production (formal irrigation)	8	27	13
		Fish production (dams/lakes)	9	24	9
	Water supply	Urban water supply	2	20	6
		Domestic water supply	3	21	8
		Formal irrigation water supply	4	22	20
		Small-scale irrigation water supply	12	23	19
	Employment	Employment formal irrigation	5	25	5
		Employment hydropower	6	26	3
	Pollution costs	Pollution cost index related to dams and formal irrigation schemes	7	19	21
	Sediment	Sediment potential index	13	31	22
	Primary GDP	GDP index	1	28	7
	Flood control	Flood control potential	11	30	17

5.7 Scenario evaluation

5.7.1 Sustainable development pathway analysis

The objective of this evaluation was to compare the benefits and impacts under three development scenarios: Scenario 1, where there is significant growth in water demand without investment in water resources infrastructure vs. Scenario 2A, which involves full development in water resources infrastructure and irrigation as per existing plans vs Scenarios 3A, which aims for more sustainable development.

The results of the analysis are summarised in Table 5-8.

- The business as usual scenario (Scenario 1) scores lowest under Economic, mainly due to the impacts of increased water demands without associated investment in storage infrastructure.
- Scenario 3A ranks above Scenarios 1 and 2A from an Economic and Social perspective. This is mainly due to a more reliable supply of water as a result of improved irrigation efficiencies and a reduction in urban demands through water demand management; thus, increasing crop production and socio-economic outputs.
- Scenarios 1 scores the highest from an Environmental perspective due to the limited environmental impacts from large dam and irrigation scheme footprint areas.
- The implementation of Q95 as a minimum release under Scenarios 2A and 3A leads to an improvement to the aquatic environment. However, this is not enough to outscore Scenario 1 Environmentally.
- Scenario 3A scores higher than Scenario 2A from an Environmental perspective due to more efficient water use and the reduction in irrigation areas (consumptive use) to limit the impact on lake inflows.

Table 5-8: Scenario scores and ranking for the full and sustainable development comparison

	ECON	ENV	SOC
SC1	0.422	0.605	0.428
SC2A	0.505	0.423	0.532
SC3A	0.563	0.464	0.589
SC1	3	1	3
SC2A	2	3	2
SC3A	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 RV 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 irrigation demands typically range from 10% to 35%, mainly due to shortfalls during the dry season.
- The expected growth in hydropower, urban and rural domestic demands, livestock and irrigation water requirements by 2040 will result in a reduction in supply reliability across the basin and will require interventions for the development of water resources in the RV Basin. These interventions include new storage dams, inter- and intra-basin transfers, water demand management measures, conjunctive use depending on groundwater availability and quality, as well as consideration of measures for rainwater harvesting
- In order to reduce the expected loss in storage in existing and proposed dams, catchment management measures and programmes should be implemented as a matter of priority in the upstream catchment to reduce loss in active storage.
- 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.
- The full extent of the originally planned large-scale irrigation development in the basin is not feasible and is constrained by the availability of water and the potentially significant impact on the various lakes in the basin due to over-abstraction in the catchments which feed the lakes.
- Large-scale irrigation will require the construction of various large dams to ensure an acceptable reliability of supply and the development of operating rules which prioritise irrigation water use.
- It is imperative 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.
- The analyses have shown that levels in Lakes Turkana, Baringo, Bogoria, Naivasha and Nakuru are very sensitive to the proposed upstream developments and the associated increase in water use. Of critical importance, therefore, is a specialised and detailed assessment on environmental flow requirements for these lakes, the incorporation of these requirements in the water allocation plans and enforcement to ensure compliance with minimum releases.
- The planned Ewaso Ng'iro Project along the Ewaso Ng'iro South River, which includes three cascading dams with a combined installed hydropower capacity of 180 MW requires the transfer of water from the LVS Basin to make the scheme viable.

- Water will be transferred from the Amala River in the LVS Basin will also allow the development of irrigation along the lower Ewaso Ng'iro South River. However, it is imperative that careful consideration be given to the operating rules for the transfer/cascade scheme to ensure minimal environmental impact on Lake Natron.
- The Kerio River catchment offers significant potential for irrigation development. However, this will require the construction of large dams for regulation of flows. The generation of hydropower will be a secondary benefit at some of the proposed dams.
- An expansion of the existing Perkerra Irrigation Scheme will require the construction of another large dam on the Perkerra River – especially as the current allocation of water for irrigation from the existing Chemususu Dam will be required for domestic supply in future.
- Increased hydropower releases from the existing Turkwel Dam will allow the expansion of large-scale irrigation along the Turkwel River downstream to some extent, while the dam will also be able to supply the future demands associated with the Tullow Oil field developments in Turkana County as well as future demands associated with the proposed LAPSSET resort city at Kalokol in Turkana County.
- The regulation of flows related to the Gibe I to IV hydropower cascade schemes along the Omo River and the development of the Lower Omo Valley Irrigation Scheme in Ethiopia, as well as the planned Todonyang-Omo Irrigation Scheme to be situated in Kenya just south of the Ethiopian border along the north-western shoreline of Lake Turkana, will have a significant impact on the Lake Turkana lake levels and development should therefore be limited.
- The construction of Malewa Dam will improve the assurance of supply to Naivasha and surrounding areas in the short term. However, it is imperative that significant minimum flow (environmental) releases for Lake Naivasha are incorporated in the operating rules of Malewa Dam.
- The expected increase in the future water demands of Nakuru and surrounding towns in the central RV Basin, will exceed the local water availability and it is imperative that water from Itare Dam in the LVS Basin be transferred into the RV Basin to augment water supply to Nakuru, Kuresoi, Molo, Njoro and Rongai in the Rift Valley Basin.

Additional considerations need to be made to ensure the chosen pathway is sustainable in all three dimensions:

- The deterioration of the basin in the business as usual scenario (Scenario 1), due to continuous deforestation and overgrazing, is not explicit in the analysis, with Scenario 1 ranking highest from an Environmental perspective. This is due to the nature of the analysis and the fact there is only one criterion which assesses catchment management intervention impacts/benefits. Nevertheless, it is imperative that catchment management interventions linked to reforestation, improved land-use management and reduced overgrazing are integrated into the sustainable development pathway.
- The sustainable development pathway aims to limit or avoid any development in environmentally sensitive areas. However, the results of this analysis should be supported by Environmental Impact Assessments (EIAs) and Environmental Management Plans (EMPs) for each scheme before implementation. This was accommodated to some extent through qualitative indicators as part of individual scheme analyses (refer to Section 6.9.6).
- The financial viability of schemes was not explicitly addressed in the scenario analysis and evaluation. Individual scheme evaluations (refer to Section 6.9.6), however, included cost-benefit analyses which is essential for identifying the most sustainable and economically beneficial schemes.

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 5-9:

Table 5-9: Scenario scores and ranking for the climate change comparison

	ECON	ENV	SOC
SC2A	0.537	0.413	0.557
SC2B	0.549	0.435	0.571
SC2A	2	2	2
SC2B	1	1	1

- Scenario 2B (without climate change), ranks above Scenario 2A (with climate change) from an Economic, Social and Environmental perspective. Although the rainfall increased under the climate change scenario, the increasing temperatures due to climate change result in increased evapotranspiration, more evaporation loss from dams, higher crop water requirements, and generally lower social and economic indicator values.
- The net impact of climate change in the basin will be less water availability and increased irrigation demands. This highlights the importance of providing storage and the need for water demand management. Climate change is thus anticipated to have a negative impact on the RV Basin and highlights the importance of development and management interventions to mitigate climate risks and improve resilience.

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 and Scenario 3B with EFlow holding flows. Note that only riverine environmental flows were considered and not lake water requirements – although development under Scenario 3 was limited in order to reduce the impact of consumptive use on lake inflows under future development. This was achieved by limiting the total future water use under Scenario 3 in the basin to not exceed 60% of the total water resources available, mainly by capping irrigation development

The results of the analysis are summarised in

Table 5-10.

- As expected, Scenario 3A scores lower than Scenario 3B from an environmental perspective. This confirms the inadequacy of the Q95 constant environmental flow to mimic the natural flow in the rivers, which leads to a deterioration of river health with associated environmental impacts. In contrast, the much higher EFlows, which also introduces intra-seasonal variability, translate into higher environmental indicator values and a corresponding higher environmental score.
- 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 much higher. This results in lower storage volumes in the dams and less water availability for development, reducing the supply reliability of the urban and irrigation demands. As a result, crop production and assurance of supply to urban users are reduced.

Table 5-10: Scenario scores and ranking for the environmental flow comparison

	ECON	ENV	SOC
SC3A	0.557	0.414	0.568
SC3B	0.526	0.434	0.560
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.

Image source: Gopal Vijayaraghavan 2011 'Lake Naivasha'. Available online at https://www.flickr.com/photos/t3rmin4t0r/6333265443/in/album-72157627999091363/

Key Strategies and Themes

6 Key Strategies and Themes

6.1 Introduction

The key aim of the RV Basin Plan is to provide a clear way forward for the integrated management and development of the water resources of the RV 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 RV Basin and to unlock the value of water as it relates to socio-economic development, ten Key Strategic Areas (KSAs) were formulated for the RV 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 ten KSAs are discussed in detail in the following sections in terms of 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.

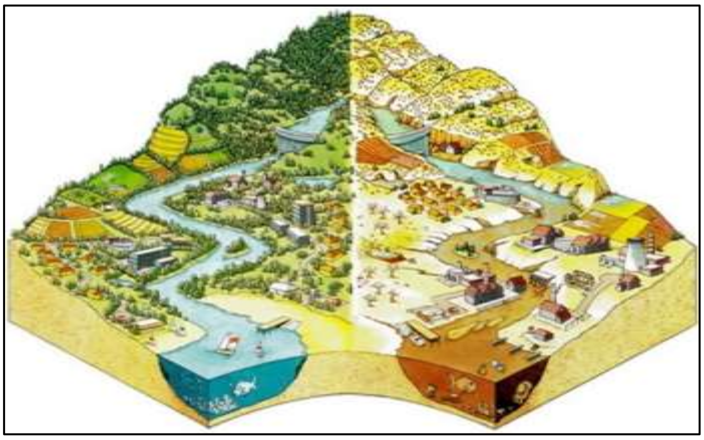


Figure 6-1: Illustration of good (left) and poor (right) state of both land and water resources in a catchment

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.

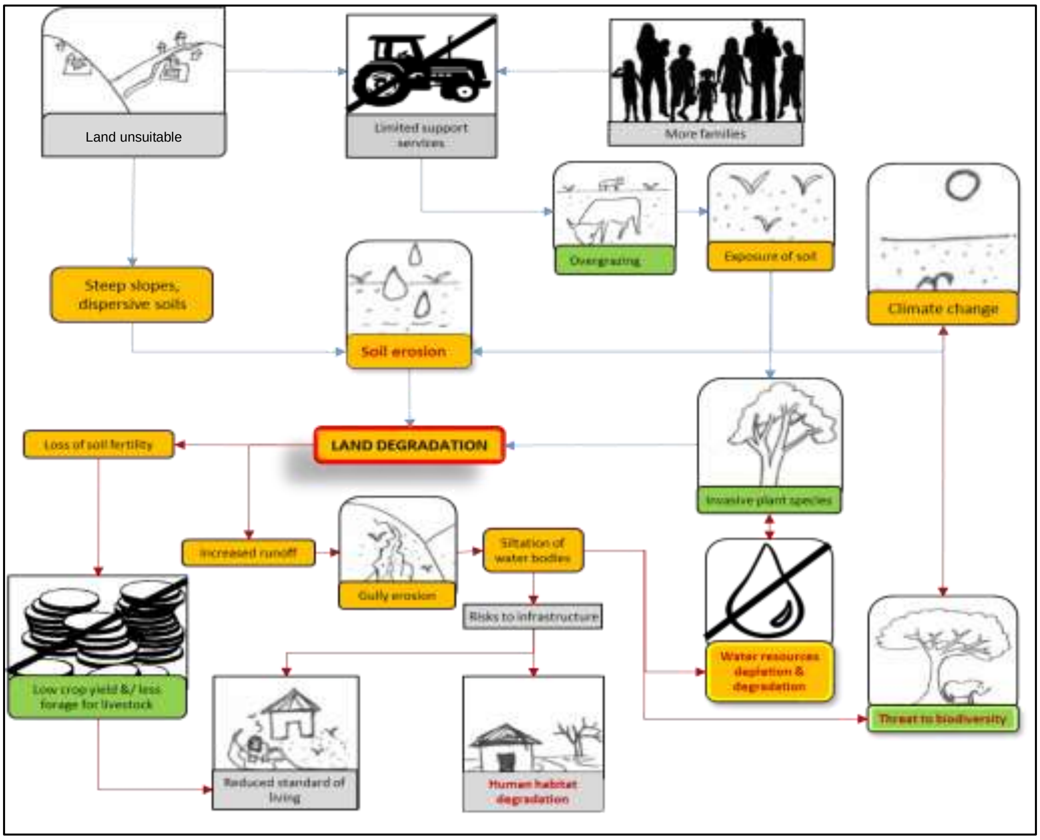


Figure 6-2: An example of the interconnected links of land degradation

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.

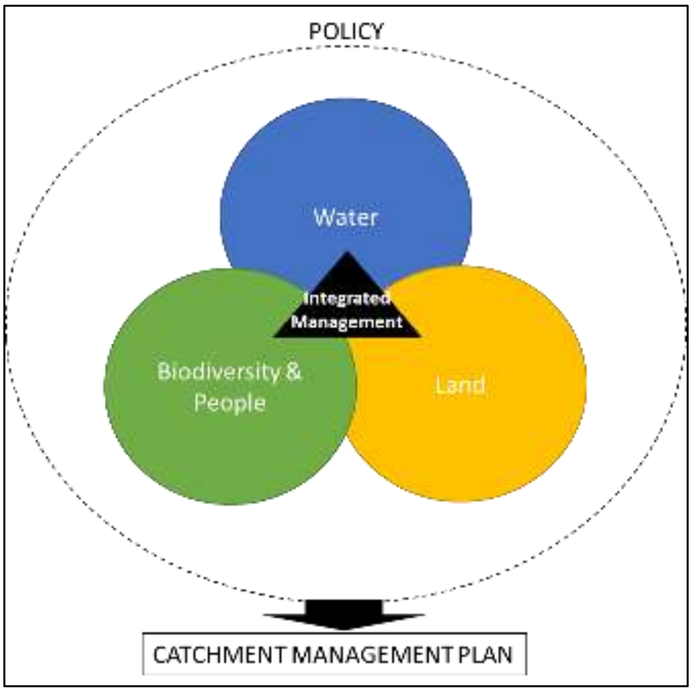


Figure 6-3: The interaction of different management strategies for Catchment Management

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.

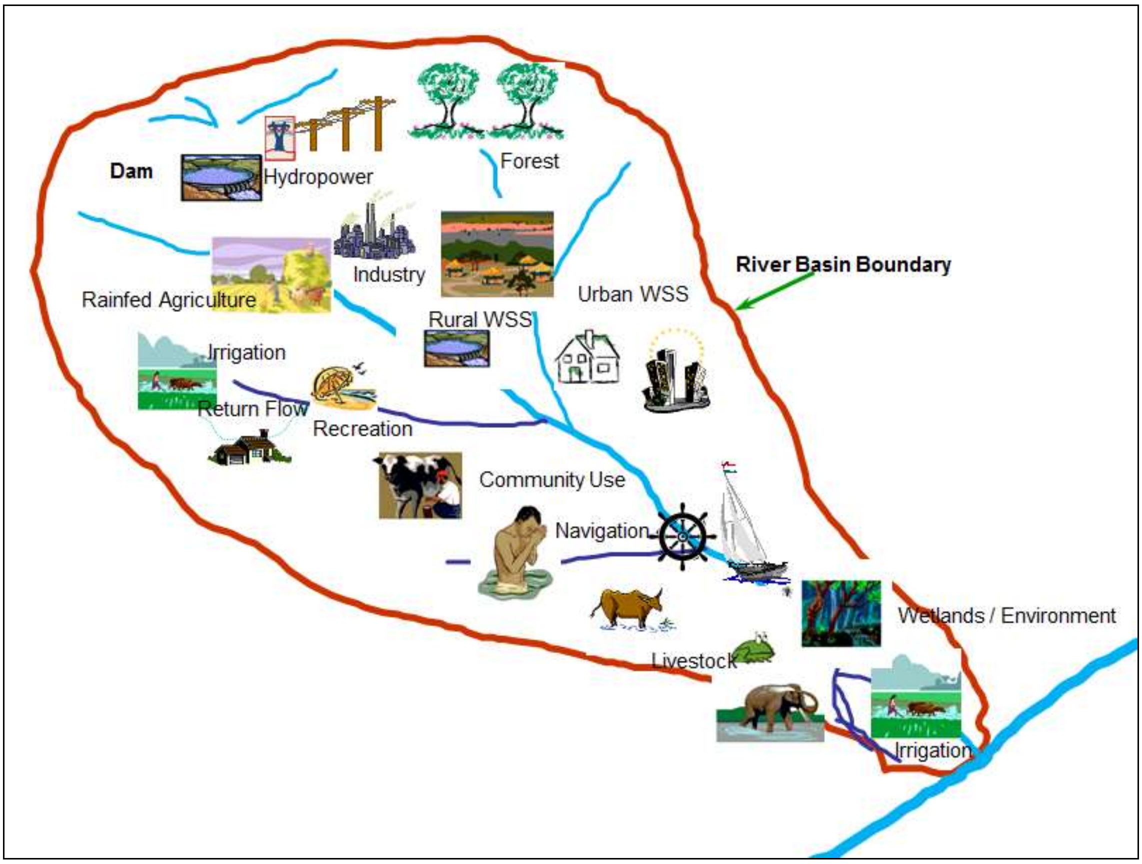


Figure 6-4: Illustration of water and land use activities within a catchment

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 RV 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:

1. **Water resource-based:** WRA/BWRC/WRUA
2. **Land/Agricultural based:** AFFA/Extension officers/Pastoralists
3. **Environmental/Biodiversity based:** NEMA/KWTA/KFS/KWS
4. **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 RV Basin is managed by five WRA Sub-regional offices, which manage ten Catchment Management Units (CMUs) based on hydrological, water resources and land use considerations. Some of the WRA offices in the RV Basin have jurisdiction over expansive areas. This, combined with the issue of understaffing, makes it difficult to manage the entire area.

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 Catchment Management Strategy was developed for the RV Basin for the period 2015-2022 (Water Resources Management Authority, 2015b). 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 loss of wetlands, soil erosion and collapsing river banks, loss of vegetation cover, encroachment on riparian areas (Lakes, springs and wetlands), siltation, sedimentation and pollution from solid waste disposal. 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 RV Basin has 83 existing WRUAs out of a potential 175 WRUAs needed to cover the whole basin. The gap of 92 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. To date, 48 SCMPs have been developed in the RV Basin.

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

Upper RV		
	WRA SR / SRO / CMUs	Lower Turkwel / Lodwar / Lake Turkana Basin, Lokitipi Plains Upper Turkwel / Kapenguria / Upper Turkwel Lakes Baringo and Bogoria / Kabarnet / Upper Kerio, Suguta River, Lakes Baringo and Bogoria
	Issues	- Loss of wetlands - Soil erosion - Loss of vegetation cover - Sedimentation - Pollution from solid waste disposal - Weak collaboration with County governments - Limited WRUAs formed - Need new SCMPs - Limited staff capacity - Inadequate information sharing about water resources - Increase in subsistence leading to greater water stress - Water scarcity conflicts

Lower RV		
	WRA SR / SRO / CMUs	Lakes Naivasha and Nakuru / Naivasha / Lakes Nakuru, Elementaita, Naivasha South Rift Valley / Narok / Upper and Lower Ewaso Ng'iro South
	Issues	- Loss of wetlands - Soil erosion - Loss of vegetation cover - Sedimentation - Pollution from solid waste disposal - Weak collaboration with County governments - Limited WRUAs formed - Need new SCMPs - Limited staff capacity - Inadequate information sharing about water resources - Increase in subsistence leading to greater water stress - Water scarcity conflicts

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. The ASDS 2010-2020 (Government of Kenya, 2010a) 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, 2010a), restoring this will require reseeding and range pitting, bush control, soil conservation and water rehabilitation and development. The ASDS 2010-2020 (Government of Kenya, 2010a)) 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/agricultural institutions operating at local level in the RV Basin and relevant issues

Upper RV		
	AFFA/extension services	Turkana, Samburu, West Pokot, Elgeyo Marakwet, Baringo
	Pastoralists	Turkana, West Pokot, Elgeyo Marakwet, Baringo counties
	Issues	- Frequent droughts and inadequate response plans leading to food insecurity. - Frequent flooding in the Turkwell Riverine Zone, causing major damages to crops and farming equipment, which leads to high food insecurity - Conflict over fishing sites and rangelands - Soil erosion due to overgrazing - Livestock diseases - Poor rangelands and agricultural methods - Overstocking - Unsustainable mining causing water quality issues - Unsustainable sand causing sediment pollution and river degradation, such as along the Kerio River
Lower RV		
	AFFA/extension services	Baringo, Nakuru, Nyandarua, Narok, Kajiado
	Pastoralists	Baringo, Narok, Kajiado counties
	Issues	- Shortages of pastures and water - Livestock diseases and high cost of veterinary drugs - Flooding especially in areas of Narok, Lodwar, Mogotio and Marigat. - Soil erosion due to overgrazing and deforestation of the Mau forest complex - Poor rangelands and agricultural methods - Overstocking - Unsustainable mining (e.g. mining around Lake Elementaita is causing water quality issues). - Unsustainable sand harvesting in the Suswa area and sections of the Greater Mara region

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 and 24 non-gazetted, water towers in Kenya. In the RV Basin the 8 gazetted water towers include Loita Hills, Mau Forest Complex, Mount Kipipiri, Cherangani Hills, Mount Kulal and Mount Nyiro, Maramanet and the Aberdares.

The Forest Management and Conservation division under the 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 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 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 and Lakes in the RV 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 RV Basin and relevant issues

Upper RV		
	Gazetted Water Towers (KWTA)	Mount Kulal, Mount Nyiro, Cherangani Hills, Maramanet
	National Parks (KWS)	South Island, Central Island, Sibiloi
	Issues	- Destruction of riparian zones and landslides - Land encroachment increasing human-wildlife contact - Deforestation due to changing land use, charcoal burning and timber production. - Pollution, encroachment and over-abstraction of wetlands - Over-grazing and destruction of rangelands Soil erosion and degradation of the Cherangany forest and water tower.
Lower RV		
	Gazetted Water Towers (KWTA)	Loita Hills, Mau Forest Complex, Mount Kipipiri, Aberdares
	National Parks (KWS)	Lake Nakuru, Hell's Gate, Mount Longonot

Upper RV		
	Issues	- Deforestation due to illegal logging, charcoal burning and forest encroachment (Gatumbiro, Karima and Tumutumu Hill forests, Cherangany and Kaptagat ecosystems, and Nyakweri Forest and the Maasai Mau among other forests) - Poor farming methods resulting in riparian areas being destroyed and landslides - Degradation of lakes due to human encroachment and pollution. - Drying up of wetlands due to alien plant species such as blue gums.

6.2.3.4 Governance-based issues

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 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 inadequate coordination and poor resource use due to the independent nature of County planning.

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

Upper RV		
	Counties	Turkana, West Pokot, Baringo, Elgeyo Marakwet, Samburu, Marsabit, Laikipia
	Issues	Turkana - Cyclic spells of drought becoming the norm, resulting in an increasing reliance on food aid. - Flash flooding resulting in loss of livestock and pastures, and livestock diseases - Difficult access to water, particularly in Kibish, Lorengippi, Lomelo and Mogila. - Transboundary water conflict West Pokot - Soil erosion and degradation of the Cherangany forest ecosystem - Charcoal burning in Kongelai, Marich and Sigor, and human encroachment on forests in Pokot South Sub-County Baringo - Frequent droughts causing livestock deaths and the loss of agricultural produce - Poor land use practices - Environmental degradation, soil erosion and floods - Deforestation due to changing land use and charcoal burning - Human-wildlife conflict in the rangeland parts of Marigat, Mogotio

Upper RV		
		and East Pokot, as well as forested highlands of Baringo North and Baringo Central - Water from vendors only reaching a small percentage of the population - Pollution and encroachment on lake Baringo and Bogoria Elgeyo Marakwet - Drought along the Kerio Valley in the dry months - Flooding during the rainy season resulting in landslides - Overgrazing and loss of natural vegetation - Unsustainable sand harvesting and mining activities along the Kerio river, impacting water quality - Deforestation and overgrazing threatening the Cherangany and Kaptagat ecosystems Samburu - The number of livestock exceeds the rangeland’s carrying capacity as there are no livestock grazing controls - Human Elephant Conflict due to encroachment in Lonjorin and Ngare Narok
Lower RV		
	Counties	Nakuru, Narok, Kajiado, Nyandarua. Kiambu
	Issues	Nakuru - Inadequate sewage treatment and human waste pollution - Dumping of solid wastes - Fertiliser and agrochemical pollution from horticultural and flower farms, particularly along the rivers Molo, Njoro, Perkerra and Malewa - Poor urban drainage - Water quality threats to Lake Naivasha including sedimentation, agricultural and human pollution, clearing of natural vegetation for agriculture, and over-harvesting of papyrus - Diatomite mining at Kariandusi in Gilgil Sub-County around Lake Elementaita, and other on-going mineral extraction activity is causing water quality issues - Over abstraction of groundwater Narok - Drought and famine in semi-arid areas - Inadequate preparedness for floods - Catchment degradation, riparian encroachment and river bank erosion exacerbating flooding - Land degradation due to poor agricultural activities, overstocking and deforestation in Narok East, Narok West and parts of Narok South - Unsustainable sand harvesting in the Suswa area and sections of the Greater Mara region - Charcoal burning and illegal logging activities degrading the Nyakweri Forest and the Maasai Mau - Inadequate sewage treatment Kajiado - Frequent droughts resulting in malnutrition - Encroachment of land in fragile areas such as water catchments, forests, wetlands and conservation areas leading to desertification - Unsustainable mining activities impacting water quality in Lake Magadi - Municipal wastes and untreated sewage impacting Lake Magadi

Lower RV		
		Nyandarua - Livestock diseases and crop loss due to changing climate conditions - Unregulated sand harvesting in Miharati, and quarrying activities in Olkalou, Kipipiri and Kinangop - Degradation of Lake Ol'bollosat due to encroachment and pollution from human settlements and agricultural activities - Bluegum trees drying up wetlands

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).

In order to comprehensively and systematically address the range of catchment management issues identified in the RV 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.

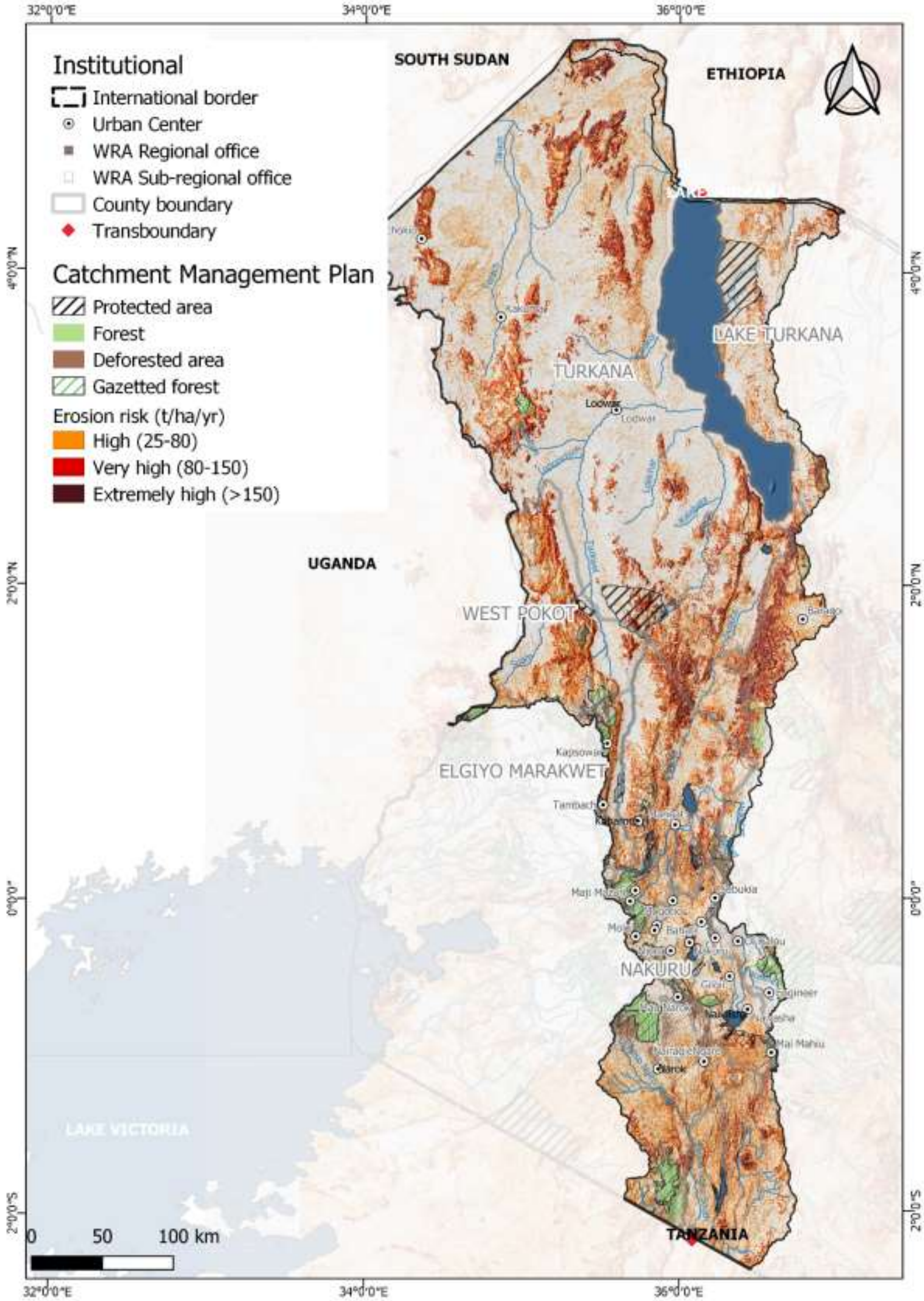


Figure 6-5: Catchment management considerations in RV Basin

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 RV 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.

1.1.2	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 IDPs.

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 RV 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 Lower RV 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 county IDPs, 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

1	Key Strategic Area:	Catchment Management

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 RV 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.
- **Rock catchments**, runoff from bare rock areas can be captured by designing rock catchments. The underlying geology, soil and vegetation cover needs to be accounted for when designing a rock catchment. This has been successful in Marsabit County during seasonal rainfall.

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 RV 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 RV 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 RV 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 county IDPs 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.

1	Key Strategic Area:	Catchment Management

The ASDS (Government of Kenya, 2010a) emphasizes the need to restore rangelands through reseeding and range pitting, bush control, soil conservation and water resource development and management. The county IDPs 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 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.

1	Key Strategic Area:	Catchment Management

- **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 county IDPs 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, 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.

1.3	Theme:	Natural resources management for the protection and sustainable use of natural resources
1.3.1	Improved wetlands and lake management	

1	Key Strategic Area:	Catchment Management

According to the RV Basin Catchment Management Strategy (Water Resources Management Authority, 2015b), wetlands are under threat from human encroachment for settlement, expansion of crop production and livestock grazing. For example, Lake Naivasha was designated as a Wetland of International Importance (Ramsar Site) in 1995. Despite this, the pressure exerted on the Lake has increased as anthropogenic activities have intensified throughout its catchment.

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 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 county IDPs. 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.

1. 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

1	Key Strategic Area:	Catchment Management

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.

2. 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.

3. 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 inadequate 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 (Ministry of Environment and Natural Resources, 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. Dryland forests offer great potential for intensified afforestation but woody vegetation in the arid and semi-arid areas are unique and require special attention. Most county IDPs promote reforestation through agroforestry, and in some cases water catchment areas are being protected through the use of alien trees. Consideration needs to be made to the objective of these programmes 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 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:

- Ring barking
- Strip barking
- Hand pull

2. Utilising and controlling blue gum (eucalyptus) trees

Blue Gum trees, if left unmanaged, will invade and replace indigenous vegetation by monopolising the water

1	Key Strategic Area:	Catchment Management

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 county IDPs 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.

1.4.3	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

1	Key Strategic Area:	Catchment Management
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. Many of the forested areas in the RV Basin have had significant vegetation cover loss since the early 2000s. The county IDPs 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 Water Act 2016 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 WRA. 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, consider 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.

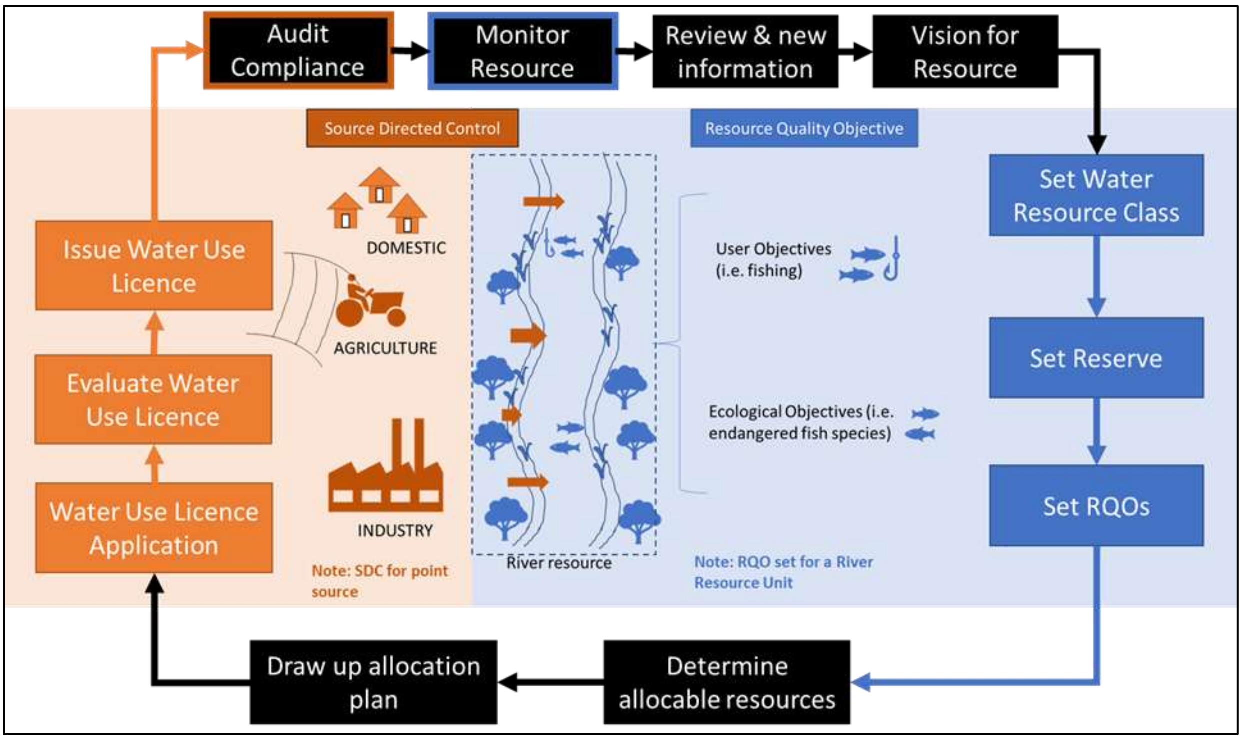


Figure 6-7: Water resources management cycle

Classifying water resources and determining Resource Quality Objectives follow aligned steps as shown in *based on Department of Water Affairs, 2007, 2011

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 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.

*based on 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.

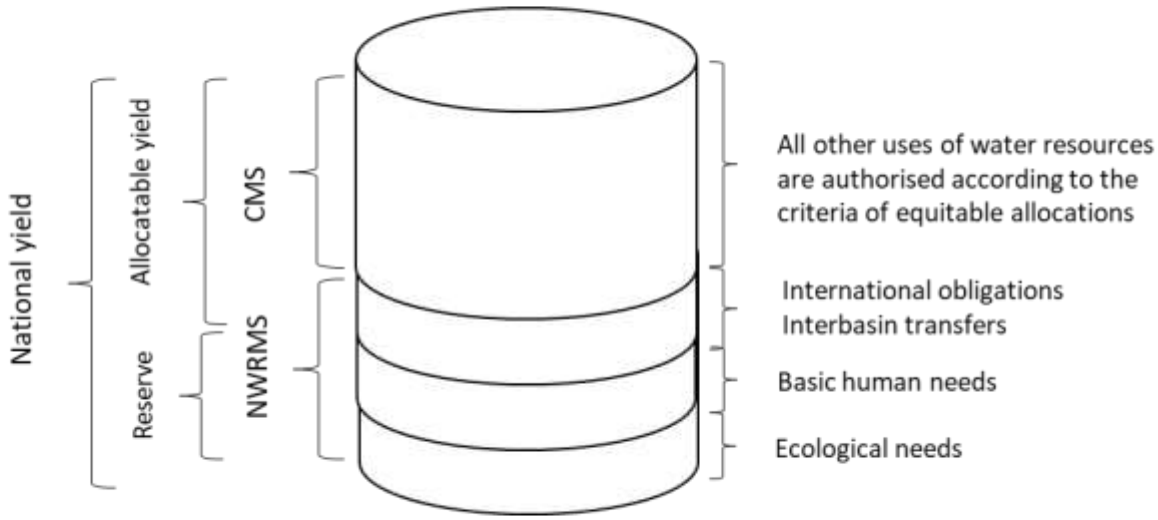


Figure 6-9: The total water resource, comprised of the Reserve and allocatable resource (Water Resources Management Authority, 2010)

6.3.3 Water resources protection in the RV Basin

6.3.3.1 Water resource protection under the Water Act

In accordance with the 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 RV Basin has 83 existing WRUAs out of a potential 175 WRUAs needed to cover the whole basin. The gap of 92 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: Important water resource protection areas in the RV Basin

Basin	Counties	WRA SRO	Lakes and Wetlands	Gazetted Water Towers (KWTA)	Forests
Lower RV	Nyandarua, Nakuru, Narok, Kajiado and Kiambu.	Naivasha Narok	Lake Magadi, Shompole Swamp, Lake Nakuru, Lake Naivasha, Lake Elmenteita	Loita Hills, Mau Forest Complex, Mount Kipipiri, Cherangani Hills, Aberdares, Mount Kipipiri	Loita Hills, Mau Forest
Upper RV	Turkana, Marsabit, Samburu, West Pokot, Eligiyo Marakwet, Baringo, Laikipia	Lodwar Kapenguria Kabarnet	Lake Baringo, Lake Bogoria, Lake Turkana, Lotikipi Swamp	Mount Kulal, Mount Nyiro, Maramanet, Cherangani Hills	Maramanet, Kipipiri

6.3.4 Strategy

In previous Sections of this Report, water resource protection issues have been identified. Environmental nodes have also been identified for environmental flow monitoring (Figure 6-10).

In order to comprehensively and systematically address the water resources protection issues and challenges in the RV 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.

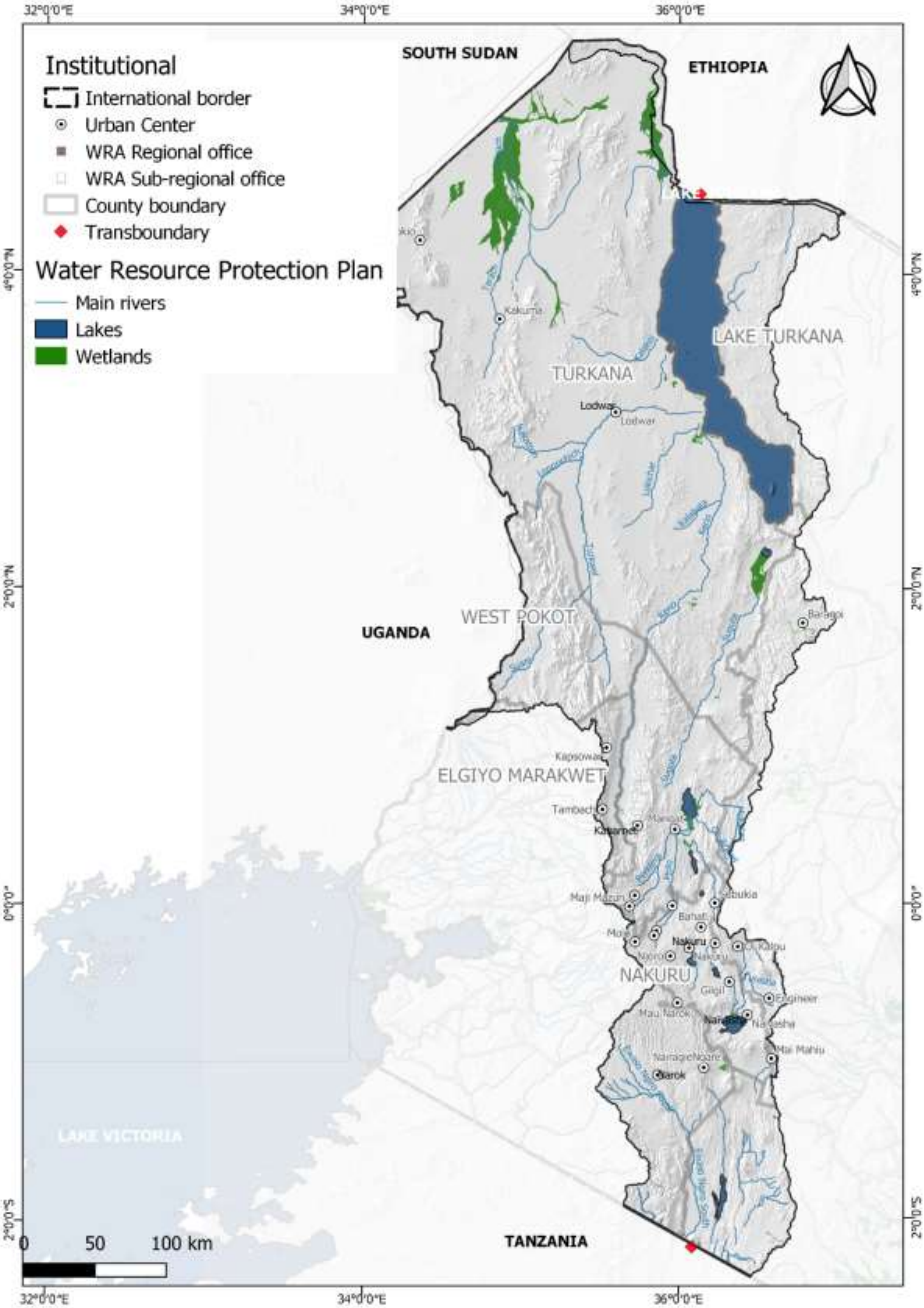


Figure 6-10: Water resources protection considerations in RV Basin

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 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 RV 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 RV 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 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 RV 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 RV 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		

2	Key Strategic Area:	Water Resources Protection
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 et al., 2011). A Final 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 RV 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 availability and potential

A high-level groundwater assessment to quantify the groundwater resources of the RV Basin was undertaken as part of this Consultancy and is presented in Section 2.4.2. It shows that in 2018, the annual groundwater recharge for the RV Basin was estimated at 3 168 MCM/a, with a sustainable annual groundwater yield of 398 MCM/a. Considering the potential impacts of climate change on recharge and groundwater potential, t was found that the recharge in the basin will increase by 3% to 3 262 MCM/a, while the potential groundwater yield is expected to increase by 3% to 411 MCM/a by 2050. **Annexure B** lists the groundwater potential per sub-basin.

6.4.3 Groundwater use

In the humid, high-lying parts of the RV Basin (the Northern, Eastern and Southern Mau, and Elgon and the Cherangani Hills to the west; and the western Aberdares and rift uplands south and north of the Aberdares to the east), surface water is widely available and heavily exploited for water supply. Many of these surface water resources are near full exploitation, and attention has shifted to groundwater development. Springs and shallow wells are in widespread use in the highest parts of the Basin, supplementing perennial surface water supplies. Groundwater quality can be poor, with excessive fluoride being a common natural contaminant.

In the lower parts of the central basin groundwater is made extensive use of, particularly in Naivasha, Nakuru and Baringo. In all these basins, groundwater is readily available at shallow to moderate depths and yields are often high. Boreholes in these basins support private and public water supply, intensive commercial irrigation, commerce and industry, wildlife and tourism, and extensive pastoralism. In Nakuru, Baringo and Turkana Counties, large volumes of groundwater are used for the development of geothermal and petroleum resources, as a key component in drilling fluids.

In the more arid parts of the Basin groundwater is used to meet public and private water demand, and to support extensive pastoralism. This is particularly the case in Turkana County and the drier parts of Baringo County, where protracted drilling programmes have been implemented over the years. 179 boreholes were drilled from 1981 to 1986 by the Diocese of Lodwar in Turkana County (Diocese of Lodwar, n.d.). More recently, a 70 boreholes programme was completed in Baringo County (County Government of Baringo, 2018).

Elsewhere, localised and often poor aquifers serve rural communities and small centres across the Basin; these are small-scale but nevertheless important in terms of local water supply. This illustrates the importance of groundwater to human livelihoods and development in the RV Basin, particularly in the ASAL areas.

6.4.3.1 Urban groundwater use

Major towns or settlements in the RV Basin which depend to some extent on groundwater are listed below:

Baragoi Town

Baragoi relies on groundwater resources to partly meet its water supply needs; demand is given as 1 500 m^3/d, supply limited to 200 m^3/d (County Government of Samburu, 2018; Ministry of Water Development, 1991).

Kabarnet Town

Kabarnet is predominantly served by surface water from Kirandich Dam, and private boreholes are used by individuals and institutions to supplement public water supply (Water Resources Management Authority, 2007a).

Kakuma Town

Kakuma and the associated refugee camps at Kakuma and Kalobeyei rely entirely on groundwater to meet water supply needs. At least 19 boreholes supply the Camps and the Town (Baumann et al., 2017; Gicheruh, 2015; Sottas, 2013), serving at least 185 000 refugees (UNHCR, n.d.) and 120 000 people in Kakuma Town (Baumann et al., 2017). Test yields up to 60 m^3/hr have been achieved (Gicheruh, 2015). These waters are of variable quality. The best quality water and highest yields comes from boreholes screened entirely in the alluvial sediments, with EC ranging from 405 to 1 488 µS/cm and fluoride from 1.20 to 2.05 mg/L. Boreholes screened in sediments and fractured rhyolites had ECs from 656 to 5 270 µS/cm and fluoride 2.9 to 6.54 mg/L. Shallow wells (<15 m deep) yield waters with EC from 423 to 2 470 µS/cm and fluoride from 0.34 to 4.22 mg/L. The shallowest groundwaters (from dug scoops in the *lagha* sediments, typically <1 m deep) were the freshest and least fluoridated of all; EC 306 to 522 µS/cm and fluoride 0.60 to 1.01 mg/L. However, while scoops and shallow wells were the most likely sources to be contaminated by bacteria, most boreholes showed some bacterial contamination (Sottas, 2013).

Lodwar Town

Lodwar Water and Sewerage Company (LAWASCO) relies exclusively on groundwater to meet water demand from at least six boreholes: three operating off solar panels at 60, 24 and 10 m^3/hr (SWIFT, ND), and one yielding up to 96 m^3/hr from an alluvial and volcanic aquifer. Abstraction was 1.71 MCM in 2016/17, or an average of 4 671 m^3/d to 35 824 people (Water Services Regulatory Board, 2018). However, more recent data suggest that more than this is now pumped; typical daily yields in early 2018 were 6 928 m^3/d (Dulo & Odira, 2018) from up to 10 boreholes (Olago, 2018). Water quality is marginal; some of the three boreholes in the Lodwar aquifer sampled for the Turkana Aquifer Mapping Project exceed a number of KEBS Standards; pH (Standard 6.5 – 8.5); pH at one site was 8.79; sodium (200 mg/L); all three sites exceed the Standard, range 256 to 574 mg/L; fluoride (1.5 mg/L); two sites exceed the standard, range 0.97 to 2.56 mg/L; hardness (300 mg/L as $CaCO_3$); one site is slightly too high, range 5.31 to 314 mg/L as $CaCO_3$; and TDS (1 000 mg/L); two sites exceed the standard, range 777 to 1 160 mg/L. Bicarbonate concentrations are high (527 to 1 490 as HCO_3^-), and explain the high TDS; these are sodium bicarbonate waters.

Naivasha Town

Naivasha Water, Sewerage and Sanitation Company Ltd (NAIVAWASS) supplies groundwater to Naivasha Town and the vicinity from 13 boreholes at six different sites. Average production in 2016/17 was 3 120 m^3/d to 120 100 people (Water Services Regulatory Board, 2018). The NAIVAWASS website states that current supply is 4 000 m^3/d against a current water demand of 9 000 m^3/d demand[4]. Significant numbers of private water supply boreholes exist in and around the Town, and while the utility does not supply irrigators with water, a very large number of boreholes support commercial irrigation. Naturally elevated fluoride is well known to be a widespread problem in the Naivasha catchment, with concentrations ranging from <1.5 to >10 mg/L (Water Resources Authority, 2019c). In the Marera-Karagita area (on the south-east shore of the lake), fluorides in groundwater ranged from 8.5 to 21.2 mg/L (World Wildlife Fund, personal communication). Elevated fluoride is more likely to occur in groundwaters at elevations <2 000 mamsl than above 2 000 mamsl (Olaka et al., 2016).

[4] **https://www.naivashawater.co.ke/water/**

Nakuru Town and rural areas

In 2016/17, Nakuru Water and Sanitation Services Company Limited (NAWASSCO) supplied an average of 30 430 m^3/d to 442 703 people in and around Nakuru Town (Water Services Regulatory Board, 2018). It relies on a mix of seven water sources, four of which are boreholes from the Kabatini well field (from the Company website[5]):

- Kabatini wellfield; eight boreholes (wellfield production ranges from 9 460 to 16 014 m^3/d, 2012-13) (Water Resources Management Authority, 2015a)
- Nairobi Road wellfield; three boreholes (wellfield production ranges from 2 269 to 2 599 m^3/d, 2012-13; *ibid.*)
- Baharini wellfield, Lanet; five boreholes (wellfield production ranges from 4 848 to 7 722 m^3/d, 2012-13; *ibid.*)
- Olbanita wellfield; eight boreholes (this wellfield was planned to supply 15 000 m^3/d; AfDB, 2012).

NWMP 2030 state that total groundwater supply was 33 200 m^3/d at that time.

Clearly, groundwater is an essential component in Nakuru water supply. The RV CMS states that the Kabatini aquifer system provides 80% of the water supplied to Nakuru Town and the Bahati area. The quality of Kabatini aquifer groundwaters appears to be better than most Central Rift Valley groundwaters; in one borehole each from Kabatini, Baharini and Olbanita, the EC range was 200 to 599 µS/cm and TDS 130 to 371 mg/L. In one sample, pH slightly exceeded the KEBS Standard (8.57; the maximum is 8.50). Iron and manganese were frequent infringers of the Standard; iron ranges 0.01 to 2.04 mg/L (standard 0.3 mg/L) and manganese 0.01 to 2.04 mg/L (standard 0.5 mg/L). Fluoride often exceeds the Standard (1.5 mg/L); range 0.37 to 3.82 mg/L. In a few isolated instances, coliforms have been measured (Water Resources Management Authority, 2015b). The relatively modest fluoride concentrations in the Kabatini aquifer contrasts strongly with other aquifers in the Nakuru basin, where fluoride ranges from 0.5 to 72 mg/L and where 87% of groundwaters exceed the WHO Guideline of 1.5 mg/L (Gevera *et al*, 2018).

The WRA considers groundwater resources in the Nakuru area to be under threat of over-abstraction (Water Resources Management Authority, 2007c).

The Nakuru Rural Water and Sanitation Company Ltd (NARUWASCO) covers a supply area of over 7 000 km^2 with a population of over 1.1 million (company website[6]). WASREB (2018) give the following data for 2016/17: 23 510 m^3/d serving 108 745 people. It principally serves Molo, Elburgon, Njoro and Rongai (Water Resources Management Authority, 2013), from surface water sources 11 boreholes of 1 040 m^3/d (Water Resources Management Authority, 2013).

Narok Town

NWMP 2030 lists that Narok has one borehole of 180 m^3/d.

Ol Kalou Town

The Ol Kalou Water and Sanitation Company (OLWASCO) serves the town from a surface water system based on gravitational flow from the Malewa River. Water Services Regulatory Board (2018) gives average production as 1 100 m^3/d to 33 800 people in the period 2016/17. In addition, several boreholes are connected to the water supply system to augment surface water during January to March; boreholes in the Ol Kalou area are reported to yield between 1.1 and 27.3 m^3/hr (Rift Valley Water Services Board, 2016).

[5] https://nakuruwater.co.ke/our-sources-and-the-sewer/

[6] https://www.naruwasco.co.ke/?page_id=9

6.4.3.2 Conjunctive use

There is quite extensive conjunctive use in place in the RV Basin at present, though this is restricted to the humid higher elevation zones where surface waters are perennial; the following public water supply systems include both surface and groundwater sources:

- Naivasha Town is supplied from surface (Malewa River) and groundwaters from 13 boreholes around the Town.
- The City of Nakuru relies on 24 boreholes constructed in the Kabatini aquifer system; and on surface water from the Mereroni, and Malewa Rivers, and from the Chemususu Dam (in Baringo County).
- Narok relies primarily on surface water, but a single borehole supplements supply.
- Nakuru Rural Water principally serves Molo, Elburgon, Njoro and Rongai from both surface and groundwater sources; the Turasha Dam on the Malewa River and springs and 11 boreholes
- Ol Kalou Town relies mainly on an intake on the Malewa River, but this is supplemented by at least three boreholes during the January to March dry season.

In the humid upland areas, numerous irrigated floricultural and commercial vegetable farms use the whole range of water sources – groundwater, surface water, rainwater harvested from greenhouse roofs and in many cases, re-cycling of hydroponic water or treated water. An effort should be made to document them by combing through the permit database by Water User ID.

- In the Naivasha basin, commercial irrigators combine surface, groundwater and rainwater harvesting to safeguard their businesses. Typical examples include Aquila Development Company Limited, Finlays Horticulture, Marula Estates, Ol Njorowa Ltd, Oserian Development Company Ltd, Vegpro Limited and Wetam Investments Ltd. The Flower Business Park (Prigal Ltd) combines groundwater use with intensive rainwater harvesting (Mohammedjemal, 2006).
- In the Nakuru basin, similar trends are observed; private sector conjunctive users include: Delamere Estate Ltd (Soysambu) and Gogar Farms Ltd, Molo River Roses Ltd, Roseto Ltd and Sierra Flora Ltd (all Rongai).
- In the Baringo basin, private sector conjunctive water users include Mau Flora Farm, in the Eldama Ravine area.

6.4.4 Proposed aquifer classification

The current classification system of aquifers in the RV 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 Table 6-9 and Figure 6-11

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: Proposed classification, aquifer use management and aquifer health management are included in “ISC Report D2-2: Groundwater Monitoring and Management Guideline”.

Table 6-9: Proposed classification of aquifers in the RV Basin

Name	Geology/lithology	Area (km²)	Depth range (m)	Yield potential (m³/day)	Dominant flow type(s)	Typical water quality	Status
STRATEGIC AQUIFERS							
Lotikipi Basin	The aquifer is made up of a series of sediments, including alluvial sands, clays and gravels – detritus derived from undifferentiated Basement	9 469	Multilayer; <100 to >200	>240	Intergranular	EC>3000 µS/cm	Alert
Napuu	The Napuu aquifer is located along the Turkwel River valley, within the Lodwar Trough, which is one arm of the Lodwar-Loperot Trough. The aquifer is a water body within the Turkana Lake Beds aquifer. It comprises alluvial sands and gravels, in a paleochannel of Turkwel River	1	30-70	>864	Intergranular	EC>1500 µS/cm	Alert
MAJOR AQUIFERS							
Aberdare Volcanics	The Aberdare volcanics comprise Miocene Simbara basalts in the upper reaches of the aquifer, known as Samburu basalts in the lower reaches, overlaid by Rumuruti phonolites.	4 996	Multi-layer, 50-200; 250 near rift escarpment	<240	Fracture and intergranular	EC<1000 µS/cm	Alert
Central Rift Basin	Central Rift Basin aquifer discharges into the Lake Bogoria, with local base levels and lakes Nakuru, Elmenteita and Naivasha. Dominant rock types include Tertiary phonolites and Quaternary basalts, trachytes, tuffs and pyroclastics	9 435	50-150; multi-layer	<240	Fracture and intergranular	EC<1500	Satisfactory
Turkwel Basin Sediments		4 807	>200	>864	Intergranular	EC<1500 µS/cm	Satisfactory
MINOR AQUIFERS							
North Rift Volcanics	The Suguta Trough is the central feature of this aquifer. It comprises Upper Miocene and Pliocene phonolites, trachytes and olivine basalts overlaid by Pleistocene trachytes, basalts and pyroclastics	20 989	<50	<86	Fracture and intergranular	EC>1500 µS/cm	Alert
Kerio Beds Aquifer	The western escarpment aquifer boundary runs on hornblende gneisses and hornblende-garnet gneisses, overlain by Kerio Valley Beds in the valley bottom. On the eastern scarp the aquifer rises from the valley bottom into Kabarnet trachytes. These are underlain by the Eron basalts and Ewalel phonolites, all part of the Tugen Hills Group. A shallow valley bottom aquifer in the Kerio Beds is a product of hill wash made up of a mixture of Basement and volcanic material.	2 949	50-100	<86	Intergranular and fracture flow	EC<1500 µS/cm; high fluoride	Satisfactory
Magadi Basin	Comprises Quaternary and Tertiary volcanics from Mau and Suswa deposited into the Magadi Trough. Younger Quaternary volcanics consist of Suswa Phonolites, Longonot Trachyte and Kedong Valley flood deposits. Older Quaternary volcanics include Mau Ashes, Lower sequence of Longonot	15 944	70-160; 250-300 near rift escarpment	<240	Fracture intergranular and	EC>1500 µS/cm	Alert

Name	Geology/lithology	Area (km^2)	Depth range (m)	Yield potential (m^3/day)	Dominant flow type(s)	Typical water quality	Status
	volcanics, Legemunge Beds, Magadi Trachytes and Limuru Trachytes among others. Deeper aquifers are made up of Tertiary volcanics - Olorgesailie volcanics, Mau tuffs and Ol Esayeti basalts						
North-western Basement	The rocks comprise coarse-grained migmatitic gneisses and granitoid gneisses, often leucocratic and pink, grey or buff in colour. The rocks are psammitic in composition. They lack the diversity of high-grade regional metamorphic types which characterize Basement System rocks in other parts of the country. The gneisses have variable amounts of biotite or hornblende with locally abundant epidote, and more rarely, garnet.	21 108	<100	<86	Intergranular and fracture	EC>1 000 µS/cm	Alert
Turkana Lake Beds	The aquifer material consists of deposits of grey, reddish or yellowish calcareous grits. There are horizons of sub-rounded to rounded pebbles derived from Basement System rocks, in a clayey calcareous matrix.	3 153	<120	<240	Intergranular	Chloride rich; low fluoride	Alert
Turkana Volcanics East	These are Tertiary volcanics, which include, in succession, augite and analcime basalts, phonolites and nephelinites, olivine basalts and the younger rhyolites. Analcime basalts are mainly found in the Turkana Volcanics East, on the Pelekech, Lapur Range, Kalimapus and Murua Dou hills. They are thoroughly jointed and fractured and affected by numerous faults. Consequently, the are more easily weathered compared to the other lava flows. The analcime basalts reach a maximum of 1 200 m thickness.	8 267	>50	<240	Fracture and intergranular	EC<3 000 µS/cm	Alert
Turkana Volcanics West and North	Olivine basalts are the bulk of the Turkana Volcanics West and North, with smaller outcrops in the east. They are coarsely porphyritic in texture and have relatively high resistance to weathering compared to the analcime basalts, which leads to steeper topography where they are found. The olivine basalts occasionally lie discordant with the older basalts; hence their contact is of interest to groundwater occurrence. There are occasional occurrences of andesites	1 815	>50	<240	Fracture and intergranular	EC<3000 µS/cm	Alert
Turkana Volcanics South	Consists of rhyolites directly overlying Basement rocks, with intercalated andesites. The rhyolites include bedded pyroclastic horizons, composed of angular fragments of pumiceous tuff.	4 886	<100	<240	Fracture and intergranular	EC<1 500 µS/cm	Alert
Lapur Aquifer	A Jurassic sandstone aquifer (Lapur Sandstones) that underlie the younger volcanics. The sandstones are based out by Basement complex.	136	<50	<240	Intergranular and fracture	EC>1 500 µS/cm	Alert
Nakalale and Gatome	The composition of the sediments suggests that they are derived from Turkana Grits. Superficial sediments consist of sandy mixed sediments, with rounded pebbles and reworked volcanic sediments, lava fragments. In certain areas	5 090	<50	<86	Intergranular	EC>3 000 µS/cm	Alert

Name	Geology/lithology	Area (km^2)	Depth range (m)	Yield potential (m^3/day)	Dominant flow type(s)	Typical water quality	Status
	nodular pea-sized kunkar limestone of varying shades of off-white have developed.						
POOR AQUIFERS							
Kibish Sediments	Mainly Plio-Pleistocene unconsolidated sands, with some gravels and clays. These are lacustrine and fluviatile deposits that are related in origin to the proto Omo delta and Lake Turkana. In places the sediments thin down over the Basement rocks.	505	<50?	<86?	Intergranular	Brackish	Alert
Turkana Grits	The grits are Jurassic similar to the Lapur Sandstone; their typical occurrence is at Muruanachok Hills northwest of Lodwar	253	<100	<240	Intergranular	EC<1 500 µS/cm	Alert*
Koobi Fora Beds	The Koobi Fora formation is a Pliocene to Pleistocene sedimentary sequence deposited by fluvial activity in the East Turkana Basin. It is made up of lacustrine and fluvio-deltaic sediments. It has 8 members divided by persistent tuff beds identified by their chemical compositions. Basal members are Lonyumun, Loiti, Lokochot, Tulu Bor and Bulgi. These were previously referred to as the Lower Koobi Fora. The three upper members are KBS, Okote and Chari (Upper Koobi Fora Formation).	1,774	60-100	<86	Intergranular	EC>1 000 µS/cm; Fl^{-}>10 mg/l	Alert

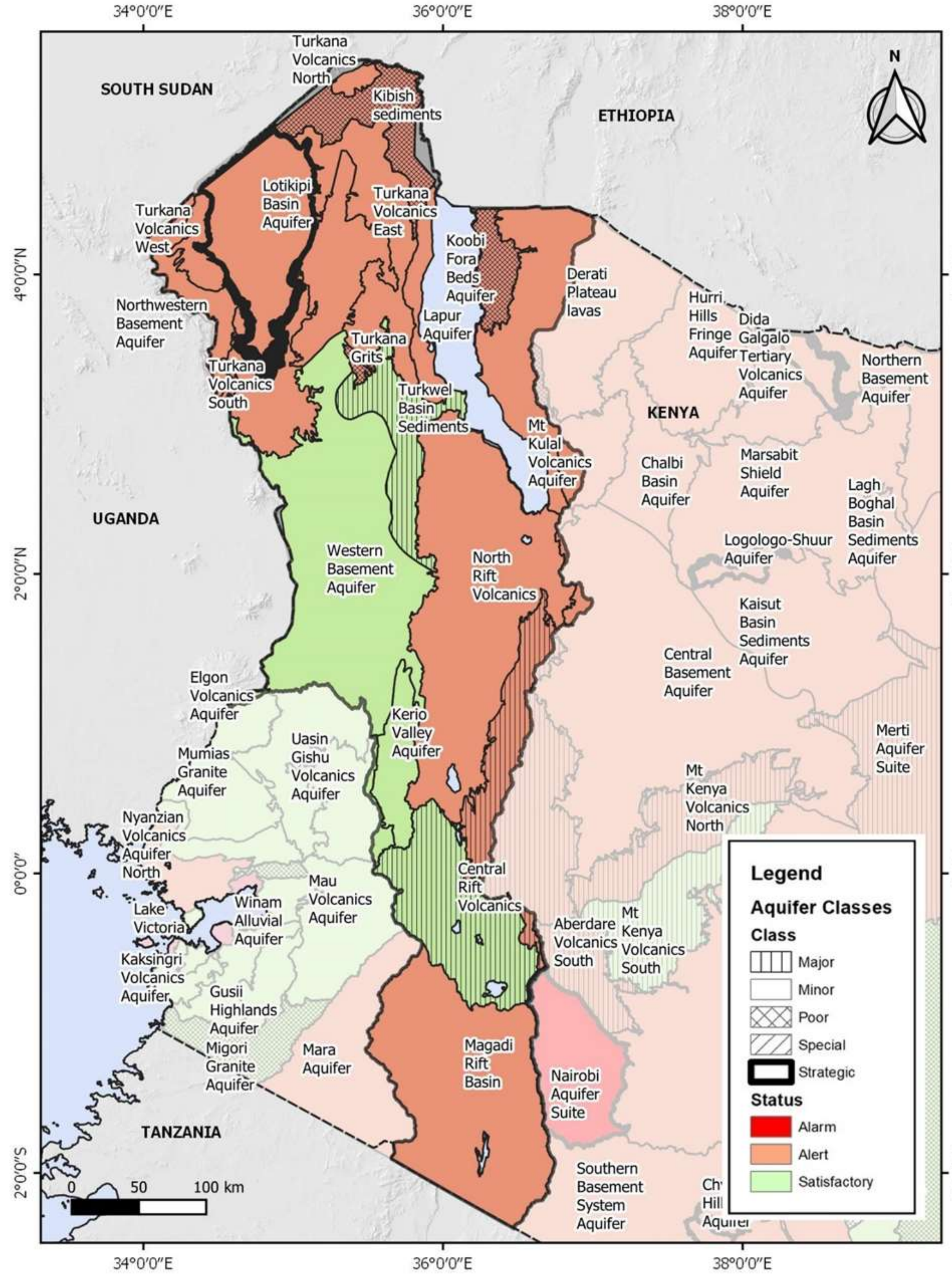


Figure 6-11: Proposed aquifer classification of the RV Basin

6.4.5 Key groundwater issues and challenges in the RV 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 vulnerability of RV Basin aquifers is largely unknown, as few aquifers have been studied at the appropriate level of detail.

While relatively few studies have been carried out, there is broad evidence showing that pollution and over-abstraction have already occurred in groundwater systems in the RV Basin. Measures aimed at addressing vulnerability should include:

- Define vulnerable aquifers (through abstraction and groundwater quality surveys; and the review of data)
- Delineate vulnerable aquifers (through GIS and mapping on the ground)
- Develop methods to protect vulnerable aquifers

Several "Groundwater conservation areas" exist in Kenya. The Naivasha area is a protected area under S. 22 of the Water Act, covering both surface and groundwaters; this legislation is to be updated (Water Resources Authority, 2018c, 2018b, 2018a).

6.4.5.2 Over-abstraction

Numerous major urban areas in the RV basin rely heavily or solely on groundwater to meet their domestic water demands (such as Naivasha and Nakuru). Notable aquifers facing over-abstraction are listed below.

- **Naivasha:** Lake Naivasha aquifer is the primary source for Naivasha town and is showing signs of over abstraction. A very large number of boreholes also support commercial irrigation.
- **Kakuma:** Kakuma aquifer is the primary supply for the refugee water supply, and showing signs of over-abstraction
- **Nakuru:** The quality of the Kabitini aquifer is better than most, and it therefore provides 80% of the domestic water supply to Nakuru. The WRA considers groundwater resources in the Nakuru area to be under threat of over-abstraction (Water Resources Management Authority, 2007c). The Njoroi and Rongai aquifers (in Nakuru County) are both key resources for commercial irrigation, and are at risk of over-abstraction.
- **Lodwar:** Lodwar aquifer is the sole water supply source for the town of Lodwar, and at risk of over-abstraction and salinisation.

The level of over-abstraction at the local level from other aquifers in the RV Basin is poorly understood; some possible hotspots have been described above (e.g. Lokichoggio, Kakuma, Lodwar). Some Basement aquifers may have suffered localised depletion.

The National Groundwater Balance Report (Water Resources Authority, 2019c) shows that the areas within the RV Basin where abstraction exceeds recharge are limited to the high population density, including central Rift Valley basins in Nakuru and Naivasha, and sub-basins 2FB (Menengai), 2FC (lower Nakuru) and 2GD (lower Naivasha). The imbalance is particularly marked in the Naivasha sub-basin.

6.4.5.3 Water quality

The major water quality constraint across much of the RV Basin is naturally elevated concentrations of fluoride, something which is broadly understood by the public (Akinyi, 2013). Fluoride is present at significantly high concentrations in surface and groundwaters, often exceeding the Kenya Standard of 1.5 mg/L (Kenya Bureau of Standards, 2007). Naivasha shows particularly high levels of fluoride, and is more likely to occur in groundwaters at elevations <2 000 mamsl than above 2 000 mamsl (Olaka et al., 2016). This has major impacts on human health. A recent Lancet paper describes osteofluorosis in a Kakuma refugee resettled in Canada after drinking groundwater containing excessive fluoride over a six-year period (Fabreau et al., 2019). Naturally high salinity and EC values are also present in groundwater across the basin, and are increased by over-abstraction.

Generally, the extent and significance of groundwater pollution in the RV Basin is relatively unknown. However, given high population densities in the humid parts of the RV Basin and reported experiences in this and other Basins, shallow groundwater pollution is likely to be more widespread than currently reported.

Pollution of surface and groundwaters in the Central Rift by agricultural fertilisers has been reported (Olago et al., 2009). Organochloride and organophosphorus pesticides have been measured in Lake Naivasha waters, sediments and organisms, though not at concentrations of health concern (Gitahi et al., 2002). Where surface waters are polluted, bank-side recharge to alluvial aquifers may lead to localised groundwater pollution. While the absolute concentrations of the pesticides are not of concern, they serve to illustrate that catchments that drain agriculturally-rich areas (such as the upper parts of the Rift Valley Basin) are capable of the long-distance transport of potentially harmful pollutants. The current status of pollution by pesticides in the RV Basin is not known. At-risk aquifers would include all riverside alluvial aquifers, or aquifers recharged indirectly from surface waters.

Surface waters in the central part of the basin (Naivasha, Nakuru and Baringo) are known to be polluted (Kirianki et al., 2018; Kiruki et al., 2011), so where these recharge local groundwater resources (which in many cases they do), those aquifers are vulnerable to pollution. Kiruki *et al* also tested Nakuru municipal water, and found some areas in which bacterial contamination was found.

In Kakuma, scoops and shallow wells were the most likely sources to be contaminated by bacteria, but most boreholes also showed some bacterial contamination (Sottas, 2013). The significance of mining leachate from the currently moribund Kenya Fluorspar Company mine at Kimwarer in the Kerio Valley has been reported, affecting the water quality of the Kimwarer River and shallow groundwater (Nguta et al., 2010). Excessive concentrations of fluoride and heavy metals have been reported.

6.4.5.4 Other issues and challenges

Regulatory

Poor planning and minimal 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 regarding 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, 2012).

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 (*The Natural Resources (Benefit Sharing) Bill*, 2014; *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.

Inadequate monitoring

The current state of groundwater monitoring in the RV basin is presented in section 2.4.8.5.

Field water quality data collection is also 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 (Water Resources Management Authority, 2015b).

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, 2018c).

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.

Outdated borehole inventory

Borehole data have been and are stored in several 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.

Insufficient information on groundwater recharge and potential

Updated high level estimates of groundwater recharge and potential have been completed as part of this Consultancy (see Section 2.4.2). A few models or partial models are available across the country (NAS, Msambweni aquifer, Chyulu Hills aquifer and Baricho palaeochannel aquifer), but few in the RV Basin. Interesting small-scale models of bankside sand dam recharge have been generated, but these are of very small scale and are not very relevant at the Basin scale (Borst & de Haas, 2006).

Elsewhere there are no models and often a poor level of understanding. 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 of 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.

Transboundary aquifers

There are three transboundary aquifers in the RV Basin, out of eight across the country (Nijsten et al, 2018)

- AF39, the Mount Elgon aquifer. Area covers 4 900 km^2, shared with Uganda. Comprises a combination of trachytes and metamorphic Basement (ILEC et al., 2015).
- AF46, the Sudd aquifer (ILEC et al., 2015). This covers an estimated area of 330 000 km^2, shared with Ethiopia, South Sudan and Sudan. It comprises "*sedimentary deposits and sedimentary rocks – sandstone*" (*ibid.*). A very small proportion of this lies within Kenya, in the Ilemi Triangle area.
- AF72, Rift Aquifer; a total of 19 000 km^2, shared with Tanzania. The extreme eastern edge of this aquifer lies in the Athi Basin; the boundaries of this aquifer system are ill-defined; it comprises volcanic rocks (ILEC et al., 2015).

The East African Community Protocol on Environment and Natural Resource Management (East African Community, 2018), Article 13 (Management of Water Resources) addresses transboundary water resources: "The Partner States shall develop, harmonise and adopt common national policies, laws and programmes relating to the management and sustainable use of water resources". The EAC has not yet been ratified by Tanzania.

Nationally, the Draft National Policy on Trans-Boundary Waters (Ministry of Water and Irrigation, 2009), provides limited guidance or intent on transboundary GW resources. The statement is brief, and cited in full below (S. 5.1, para. 38):

> *"Consideration will also be given by the Government to the feasibility of declaring vulnerable trans-boundary catchment areas as "protected areas" under the provisions of the Water Act, 2002. This allows the Minister to declare an area to be a protected area if special measures are necessary for the protection of the area. A similar mechanism exists with respect to groundwater, in which case the protected area is designated a "groundwater conservation area." This mechanism may be useful with respect to shared water resources such as Lake Jipe or, in the case of groundwater, the Merti Aquifer, which are vulnerable to unsustainable exploitation and, because of their trans-boundary character, limited effective frameworks for sustainable management."*

A transboundary aquifer policy needs to be developed for Kenya.

The National GW Policy (Ministry of Water and Irrigation, 2013), lists the following activities required to improve transboundary GW management ("Issue 9"):

Table 6-10: Proposed transboundary aquifer (TA) policy measures

Issue	Objective	Policy direction	Activity	Timeframe
Transboundary aquifers not well known, characterised nor managed	TAs well known, characterised and managed by countries sharing TAs	Implement appropriate new policies and institutions to ensure seamless management of TAs	a) Identify and demarcate TAs; b) Collect information; c) Promote information sharing and adopt international good practices; d) Expand transboundary water unit to Department	Short- to long-term

Finally, the National Land Use Policy (Ministry of Lands and Physical Planning, 2017) specifically describes measures to be adopted in relation to the definition and management of transboundary GW resources.

Climate change

That climate change will affect Kenya is largely unquestioned. Numerous global climate models forecast increasing temperatures, deeper dry seasons and more intense rainfall. The effects of both floods and drought have been significant, adversely affecting gross domestic product (GDP). Adverse effects on the water sector are well documented (Mogaka et al., 2005; Mwangi & Mutua, 2015).

Kenya has developed a Climate Change Adaptation Plan (Government of Kenya, 2016), which "recognizes that climate change is a cross-cutting sustainable development issue with economic, social and environmental impacts". The Plan is underpinned by the Climate Change Act.

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 (also see conjunctive use). In the longer term, the effects of climate change on RV Basin aquifers are uncertain, though as adduced above, a slight increase in mean annual recharge is likely. Sea level rise will affect coastal aquifers in hydraulic continuity with the sea (coastal sediments).

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, 2018c, 2018a). 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.

Enforcement of conditions of Authorisations to construct boreholes

Due to inadequate 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 RV Basin, Table 6-11 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 6-11: 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	

3	Key Strategic Area: Groundwater management
	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 RV 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 RV Basin.
3.1.3	Update and improve permit database
	The 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 so as to allow the capture of digitised borehole completion records (BCRs).
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 et al., 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 (Water Resources Authority, 2019a) discusses the determination of water balances and accommodates both surface water and groundwater. Current groundwater potential by sub-basin in the RV 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.

3	Key Strategic Area:	Groundwater management
	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 of 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 RV 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. **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. Other 'Sponge City' initiatives may be possible in ASAL Basement aquifers in the Rift Valley Basin, particularly in Kitui County. Asala (2017) describes the application of GIS and remote sensing in determining areas where recharge could be augmented, using Machakos County as a case study. **Managed aquifer recharge (MAR):** First mentioned in the 1999 Policy document (Government of Kenya, 1999) 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, 2018c). 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 several 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, particularly in Kitui and the eastern parts of Machakos Counties. There is some scope for the further development of sand dams in areas underlain by siliceous Basement in the RV Basin (e.g. western Samburu County). **Ad hoc Managed Aquifer Recharge:** Ad hoc Managed Aquifer Recharge may occur in the RV Basin but has yet to be described. **Unintentional Aquifer Recharge:** In the Rift Valley Basin, at a farm south west of Lake Naivasha, rainwater runoff from greenhouses is diverted away from the site and in doing so traverses a fault expressed at surface. This structural feature absorbs most of the runoff from a 30 ha surface area, estimated at 0.18 MCM/yr. **Managed Aquifer Recharge potential in the RV Basin:** One academic MAR study has been carried out in Kenya, in the Rift Valley Basin. Mohammedjemal (2006) studied the feasibility of recharging a depleted shallow sedimentary aquifer in Naivasha with up to 7 000 m^3/d by means of a recharge basin with a surface area of 9 600 m^2, combined with recharge wells. The optimum recharge efficiency was 89% and the unit recharge cost KShs. 0.56/m^3. Recharge via sand dams in seasonal streams in areas underlain by siliceous metamorphic Basement; Kitui County (as Ngunga example).	
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 RV Basin is largely ad hoc at present, heavily under-written at the WSB 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. Specific aquifers that hold good potential and should be assessed are as follows:	

3	Key Strategic Area:	Groundwater management
	The Turkana aquifer	
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 - When refurbishment commences, ensure that the process is monitored and funds spent on it are tracked	

3	Key Strategic Area:	Groundwater management
	- 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	
	GW 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 RV Basin groundwater. **Groundwater conservation areas:** As above for Groundwater Conservation Areas; assess which RV 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 RV 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 RV Basin’s polluted aquifers**: Use the Guidelines for Groundwater Quality Surveys in Kenya (WRA, 2018d) 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. T**he 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 6-12) and for effluent discharge limits for discharges into sewers and water bodies (Table 6-13) 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 6-12: 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 6-13: Kenya Effluent Discharge Standards into water bodies and sewers

Parameters	Unit	Effluent Discharge Standards	
		Discharge into environment	Discharge into public sewer
Temperature	°C	±3 ambient temp.	20-30
pH	pH Scale	6.5-8.5	6-9
Conductivity	µ S/cm	-	-
BOD5 days at 20 ^{0}C	mgO_2/l	30	500
COD	mgO_2/l	50	1000
Total Alkalinity	$mgCaCO_3/l$	-	-
Total Suspended Solids	mg/l	30	250

Parameters	Unit	Effluent Discharge Standards	
		Discharge into environment	Discharge into public sewer
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 quality pollutants and pollution sources

In order to develop and successfully implement a Water Quality Management Plan for the RV 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. Many RV Basin rivers carry naturally high suspended solid loads but it is aggravated by changes in land-use. Sediment loads have further increased through extensive agricultural activities and practices, construction activities, unpaved roads and road construction, over-grazing, destruction of the riparian vegetation, sand mining activities, and the physical disturbance of land by industrial and urban developments.

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 RV 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 (NO_2, NO_3, NH_4, PO_4). 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 of 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 several 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), and nanoparticles. 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.

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 EPA 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 1 46 000 people compared to the large scale mining that employs about 9000 workers (PACT and Alliance for Responsible Mining (ARM), 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.

Water quality in the RV Basin, especially downstream of urban centres, is impacted by pollution from industries, informal settlements, indiscriminate disposal of wastes, etc.

The most common pollutants in RV Basin typically include:

- Industrial Effluents from cities and towns; Municipal/Domestic sewage from urban settlements
- Solid wastes from Dump sites
- Nutrients and Pesticide Residues, from Agro-based industries; Coffee, Rice and Flower farms and Tea/Plantation factories; Horticultural farms
- Sediment loads from degraded farmlands
- Soil erosion from overgrazed lands and un-tarmacked roads
- Storm runoff from roads and urban centres
- Oil and grease from oils spills, garages and petrol stations
- Oil Drilling Wastes in Turkana County

- Leachates from pit latrines, septic tanks and feedlots
- Acaricides from Cattle dips

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.

6.5.4 Water Quality Status of Water bodies within the RV Basin

The RV Basin Catchment Management Strategy summarised the overall status as varied across the Basin (Water Resources Management Authority, 2015b). It was concluded that the quality of water resources has deteriorated due to increased anthropogenic activities and that both point- and non-point sources of pollution were prevalent in the area. Table 6-14 below identifies some of the actual sources of pollution within the RV Basin and Figure 6-12 shows the water quality characteristics of water bodies within the RV Basin.

Table 6-14: Major sources of pollution in RV Basin

Basin	Type of Pollution	Sources of Pollution
Upper/Northern Basin	Municipal wastes and untreated sewage	Towns of Lodwar, Kabarnet and Kapenguria
	Agrochemicals	Farms along the rivers Molo, Njoro, Perkerra and Malewa
	Mining activities	Kerio Valley,
	Industrial waste discharges	Towns of Lodwar, Kabarnet, Kapenguria
	Soil erosion and sediment	Evident on riparian reserves, and hill slopes and unpaved roads in the smaller towns and rural areas
	Salinity	Some Groundwater sources
	Oil Drilling Wastes	
Middle Basin	Municipal wastes and untreated sewage	Towns of Nakuru, Naivasha
	Agro chemicals	Horticultural and flower farms around Naivasha and Nakuru area
	Mining activities	Lake Elementaita area
	Industrial waste discharges	Towns of Nakuru and Naivasha
	Soil erosion and sediment	Evident on riparian reserves, and hill slopes and unpaved roads in the smaller towns and rural areas
	Salinity	Some Groundwater sources
Lower/Southern Basin	Municipal wastes and untreated sewage	Towns of Narok, Magadi
	Agro chemicals	From isolated farms
	Mining activities	Magadi area
	Industrial waste discharges	From towns of Narok and Magadi
	Soil erosion and sediment	Evident on riparian reserves, and hill slopes and unpaved roads in the smaller towns and rural areas
	Salinity	Some Ground water sources

6.5.4.1 Rivers and Lakes in the Upper Basin

The upper part of the RV Basin is drained by the Kerio River, Turkwel River and Suam. Both Kerio and Turkwel drain into Lake Turkana. There are also the smaller lakes of Logitipi and Kamnarok, which are shrinking fast due to droughts.

The increase in population growth and the pressure exerted on land and water resources, has led to severe land degradation and pollution of the rivers from anthropogenic activities and domestic effluent from urban settlements. These rivers have also been polluted by effluent from agro-based activities such as tea, coffee and horticulture farming. Industrial effluents from towns such as Lodwar and Kabarnet, also contribute to the pollution of these rivers.

The rivers look brown and are laden with silt and sediment from the farms and contain nutrients from the fertilizers used on the farms as well as pesticide residues. All these rivers show high levels of colour and turbidity, bacterial contamination, diminished dissolved oxygen levels and moderately high levels of BOD and COD.

Lake Turkana is a semi-saline lake. The salinity is on the increase due to reduced flows from the Omo, Turkwel and Kerio rivers. The lake supports a thriving fish industry.

6.5.4.2 Rivers and Lakes in the Middle Basin

Middle RV Basin is drained by the seasonal rivers of Perkerra which flows to Lake Baringo, Weseges, that flows to Lake Bogoria and River Molo and Njoro which flow to Lake Nakuru. River Malewa flows into Lake Naivasha. Other smaller rivers include River Gilgil and Wanjohi. In this region also we have Lake Elementaita. Activities on the catchments include, small scale intensive farming and livestock rearing. Crops grown include tea, coffee and maize, beans and potatoes. There are also many flower farms around Naivasha town, Subukia area and along river Njoro. On the drier areas, pastoralism is practiced. The area is prone to incidences of gross pollution from such agro-activities. In addition to industrial effluent from the major towns, the other pollution threat is also from bacterial contamination from domestic sewage emanating from urban and rural settlements.

These rivers have also been polluted by effluent from agro-based industries such as tea, coffee and horticulture. Industrial effluents from factories in towns such as Nakuru, Naivasha, Narok. These rivers look turbid and brown and are laden with silt and sediment and carry nutrients from the fertilizers used on the farms, and pesticide residues. Downstream of towns the rivers are laden with pathogenic bacteria. All the rivers show high levels of colour and turbidity, bacterial contamination, diminished dissolved oxygen levels and moderately high levels of BOD and COD.

Lakes Nakuru and Bogoria are alkaline saline and with high Fluoride levels, with average pH values over 9.5. They act as habitats for the lesser flamingos and have National Parks which are great tourist attractions.

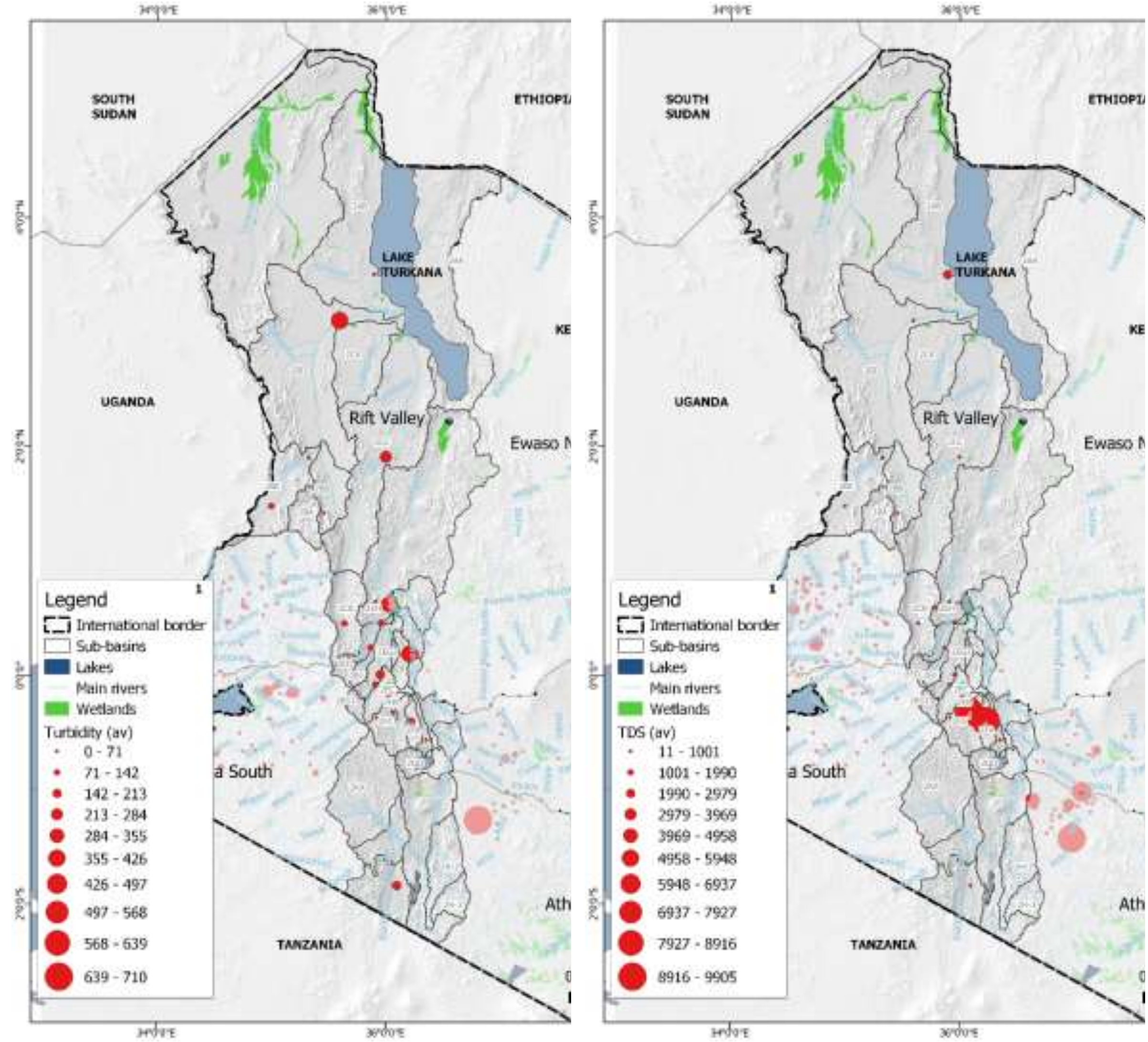
On the other hand, Lake Baringo and Lake Naivasha are fresh. The water quality of Lake Naivasha is fairly good and the lake supports a fisheries industry and many other economic activities such as flower farms and hotels on its shores. However, these activities are polluting the lake and should be regularly monitored for compliance with EDS.

The water of Lake Baringo is coloured brownish red, from the heavy sediment brought down by the Perkerra River. The high colour and turbidity have a negative effect on the fisheries of the lake.

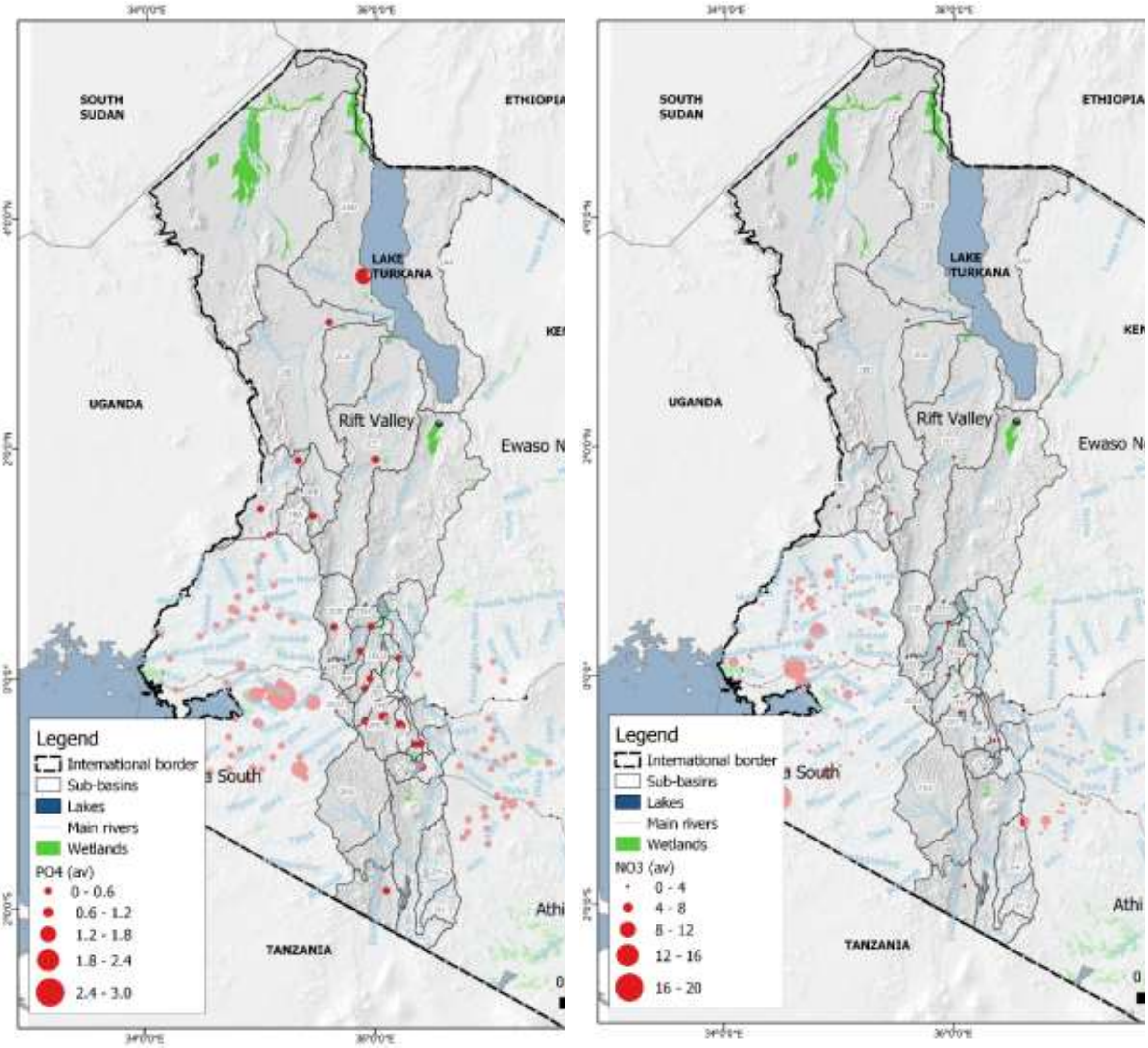
6.5.4.3 Rivers and Lakes in the Lower Basin

The only river draining the lower Basin is the Ewaso Ngiro South. The only lake is Magadi. The most critical water quality issue in the lower basin is sediment and turbidity giving the water a dark brown colour especially during rains. No other major pollution threats are evident as population is small and pastoralist.

Lake Magadi is very saline with average pH values greater than 10. Soda Ash is mined from Lake Magadi for export to China and Japan.


SOUTH SUDAN
ETHIOPIA
LAKE TURKANA
UGANDA
Rift Valley
Ewaso N
a South
TANZANIA
Ath
Legend
International border
Sub-basins
Lakes
Main rivers
Wetlands
Turbidity (av)
0 - 71
71 - 142
142 - 213
213 - 284
284 - 355
355 - 426
426 - 497
497 - 568
568 - 639
639 - 710
TDS (av)
11 - 1001
1001 - 1990
1990 - 2979
2979 - 3969
3969 - 4958
4958 - 5948
5948 - 6937
6937 - 7927
7927 - 8916
8916 - 9905

a. b.



c. **d.**

Figure 6-12: The water quality monitoring stations in RV Basin with turbidity (a), TDS (b), PO_4 (c) and NO_3

** Note: data limitations meant that water quality maps for other parameters could not be developed*

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 RV 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 RV 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 RV Basin, Table 6-15 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 6-15: 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 RV catchment. 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. A number of strategies have been identified to support water quality monitoring.		
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 RV 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	Key Strategic Area:	Water Quality Management (SW and GW)
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 RV 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), especially in the upper RV 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 RV 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 RV Basin should be enforced. This database should also serve as the approved database for all reporting and assessment of water quality data in the RV 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 RV 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 RV Basin**
With so many institutions involved in different aspects of water quality management in the RV 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 RV 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 with regard to 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 RV Basin. WRA should advocate alignment of strategies to serve a common purpose of rehabilitating urban rivers and streams in the RV 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 RV 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.		
4.3	**Theme:**	**Efficient and effective management of point and nonpoint sources of water pollution**
The water quality challenges in the RV 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,		

4	Key Strategic Area:	Water Quality Management (SW and GW)

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 RV 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, a number of 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 are 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 KNCPC to promote excellence in Resource Efficient and Cleaner Production in industries in the RV Basin in order to reduce water usage and effluents, as well as their impacts on water quality in receiving water bodies.

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	Key Strategic Area:	Water Quality Management (SW and GW)
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 unsewered 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		
4.3.11	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

7.8.1 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, 2010b) 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, 2012) 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 CIDPs and to develop relevant county legislation.

The National Climate Change Action Plan (NCCAP) 2013 to 2017 (Government of Kenya, 2013b) 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, 2018) 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 6-16: Priority climate change actions (Government of Kenya, 2018)

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, 2016) 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 RV 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 RV 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.

7.8.2 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 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. Draft National Climate Change Action Plan: 2018-2022.

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.

7.8.3 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 6-17. Aspects which relate to water resources management and planning are highlighted.

Table 6-17: Potential climate change impacts (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 into 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.
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 have to travel long distances to **search for wate**r.
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.

Environmental impacts	
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.
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

7.8.4 Strategy

Projected sub-basin precipitation and temperature changes under climate change scenario RCP 4.5 were superimposed on the hydrological model of the RV Basin to assess the potential impacts on runoff. Even though mean annual precipitation is projected to increase, the net effect on runoff due to increased temperature and evapotranspiration, will result in a reduction in runoff. The total surface water runoff from the RV Basin is projected to decrease with almost 3% by 2050 under RCP 4.5.

The climate change strategy for the RV 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, 2012) 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 RV Basin, Table 6-18 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 RV Basin.

Table 6-18: 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 RV 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 RV Basin and its relation to water resources planning and management; prioritise areas for interventions	
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**
5.2.1	Promote the generation and use of clean energy	
Promote the usage of renewable energy source just as hydropower, wind power and solar geysers.		
5.3	**Theme:**	**Climate** change adaptation
5.3.1	Develop 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.		
5.3.4	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	Key Strategic Area:	Climate Change Adaptation and Preparedness
5.3.5	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.		
5.3.6	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 RV Basin

6.7.2.1 Frequency and extent of floods in the RV 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, 2 000 flood-related human deaths and a further 5 600 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).
- 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 the *Elgiyo-Marakwet*, *Samburu, Laikipia, West Pokot and Turkana,* counties were impacted to varying degrees (Huho et al., 2016).
- Widespread flooding and occasional landslides during March–May 2013 displaced 140 000 people and led to 96 deaths. The *Baringo, Laikipia, Samburu and Turkana counties* in the RV Basin were impacted to varying degrees (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. RV Basin counties that were impacted were *Narok, Turkana and West Pokot* (International Federation of Red Cross, 2016a).
- Widespread flooding and occasional landslides during April and May 2016 displaced 49 000 people and caused 100 deaths. RV Basin counties, *Turkana and Baringo*, were severely impacted (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. No RV Basin county was severely impacted (Davies, 2017).
- Widespread flooding and various landslides during March-May 2018 impacted more than 800 000 people across Kenya, including in various RV Basin counties: *Nakuru, Baringo, Laikipia, Samburu and Turkana.* 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 were lost, while about 100 schools were flooded (OCHA, 2018).

6.7.2.2 Flood-prone areas in the RV Basin

The chronic flood-prone areas in the RV Basin are as follows (Government of Kenya, 2009; Water Resources Management Authority, 2015b):

- Flash-floods: *Narok county* (flash-floods along streams originating in high-elevation Mau Forest zones caused by deforestation); *Laikipia, Nakuru, Baringo and West Pokot counties* (due to poor cultivation practices on steep slopes). It should be noted that, in rural areas in the RV Basin, flash-floods are a primary cause of flood-related deaths and destruction of transport infrastructure, water supply infrastructure and riparian homesteads.
- Long-duration flooding (up to a month): *Nakuru and Baringo counties* (caused by the Molo and Perkerra rivers overflowing its banks in both urban and agricultural areas *en route* to Lake Baringo; *Narok county* (caused by an upper tributary of the upper Ewaso Ng'iro South River); *Turkana county* (caused by the lower Turkwel River overflowing its banks near Lodwar Town and along multiple meanders before it exits into Lake Turkana.
- Short-to-medium duration flooding (1 – 5 days): Common in *Narok, Nakuru and Mogotio Towns* due to inadequate urban drainage infrastructure. Occasional riparian and floodplain damage along the lower Kerio River in *Turkana county*.

6.7.2.3 Frequency and extent of droughts in the RV Basin

During the past two decades Kenya has experienced five widespread multi-year droughts with devastating socio-economic and environmental consequences. The table below provides an outline of these five droughts. Given that climate distribution of the RV Basin is categorised as arid in its northerly counties and semi-arid in its southerly counties, most of the counties of the RV Basin were either severely or partially impacted by these droughts. The central region in and around Nakuru Town was often the exception.

Table 6-19: Widespread Kenyan droughts since the year 2000 (Huho et al., 2016; Reliefweb, 2018)

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.

6.7.3 Drought-prone areas in the RV Basin

The climate of four counties in the RV Basin can be categorised as arid (*Turkana, Marsabit, West Pokot, Samburu*), while seven counties have semi-arid climates (*Baringo, Laikipia, Elgiyo Marakwet*, *Kajiado, Kiambu, Narok, Nyandarua*). Under these precarious climate conditions, it follows that, if consecutive rainfall seasons should fail, such as occurred during the years indicated in Table 7-18, emergency drought conditions would eventually develop in some or all of these eleven counties.

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 RV Basin, that have been compiled during the recent past.

6.7.4.1 National Water Master Plan 2030, Volume II Part D – Rift Valley Catchment Area

The Water Master Plan for the RV Basin consists of eight component plans, one of which is a flood and drought disaster management plan.

Flood disaster management plan

The proposed components of the flood disaster management plan for the RV Basin distinguished between “structural” and “non-structural” measures, as follows:

- Implementation of Flood Control Measures in the Narok and Mogioto districts: This includes various structural flood control measures such as construction of new dykes, reinforcing or heightening of existing dykes, widening of high-water channels by realignment of the existing dykes, widening of the low-water channels by excavation.
- Preparation of flood hazard maps and evacuation plans covering all flood-plains in the Narok and Mogioto districts: The maps and evacuation plans were to be developed by the WRMA RV Regional Office. The flood disaster management plan mentions flood warnings and dissemination of flood information but is silent about whose responsibility that should be.
- Flood discharge control by a multipurpose dam plus river improvement works: Allocation of flood control capacity in the Upper Narok Dam, which is also proposed in the water resources development sub-sector of NWMP 2030, and preparation of a reservoir operation rule considering optimal flood control operation.
- Implementation of Urban Drainage Measures in Nakuru Town and Narok Town: 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. These works would be the responsibility of the county governments and local authorities.

Drought disaster management plan

The proposed components of a drought disaster management plan for the RV Basin were as follows:

- Preparation of drought operating rules for six existing reservoirs and ten proposed reservoirs, as well as of drought-based restrictions placed on water supplies to the different water-user sectors.
- Establishment of a Basin Drought Conciliation Council for the Rift Valley system, with legal status to avoid water conflict during droughts. The 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.

6.7.4.2 RV Catchment Area Catchment Management Strategy 2014 – 2022 (Water Resources Management Authority, 2015b)

In the RV CMS, five levels of structural/non-structural flood and drought interventions are envisaged: regional, sub-regional, county governments, WRUAs and local communities. Table 6-20 presents a generic summary of the proposed interventions.

Table 6-20: Levels of flood and drought management envisaged for the RV Basin (Water Resources Management Authority, 2015b)

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.
	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:

Develop and implement Integrated Flood and Drought Management Plans in collaboration with Stakeholders.

Objectives and Strategic Actions:

- To enhance capacity on IFDM (CGs, WRUAs, WRMA staff).:
  - Carry out three training needs assessments for WRMA, WRUAs and County Governments.
  - Prepare and implement three training plans.
  - Carry out research on flooding of six Rift Valley lakes (Baringo, Bogoria, Nakuru, Naivasha, Solai & Elementaita).
  - Undertake sediment load monitoring through 12 surface water monitoring stations leading into the lakes.
  - Establish flood early warning systems in four flood-prone river basins (Marigat area-Perkerra, Narok Town-Enkare Narok, Mogotio area-Molo and Lodwar Town-Kawalathe).

- To develop and operationalise a framework for collaboration with County Governments and other Stakeholders regarding IFDM:
  - Establish four IFMCs and seven IDMCs with membership from CGs, other Stakeholders and existing WRUAs.
  - Develop four flood and seven drought hazard maps.
  - Develop four IFMPs and seven IDMPs and initiate implementation of prioritised activities.
- To mainstream Flood and Drought Management in Sub-Catchment Management Plans:
  - Review the 40 existing SCMPs to include Flood and Drought Management (FDM) activities.
  - Develop 32 new SCMPs to include Flood and Drought Management activities.
  - Implement FDM activities in the SCMPs.

Some of these Strategic Actions were to be completed between 2015 and 2020, while the rest were planned to be continuous and long-term.

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

- Integrated Flood and Drought Management Plans for the complete RV Basin were completed in 2015 as part of the CMS.
- The National Hydrometeorological Network Design Project for the Republic of Kenya, currently underway, has designed a provisional network of 13 meteorological and 30 river gauging stations (telemetric or automatic or manual) for the RV 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, 2017a).
- 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

- The WRA RV Regional Office has not yet implemented a drought disaster management operation based on three water level warnings and related discharges, namely Normal, Alert, and Alarm levels, at suitable river gauging stations as a reference level. The above three triggers should indicate that water use restrictions by regulating water intakes were required.
- Sourcing financing for implementation of the flood and drought management components of the RV Basin CMS: In 2014 the cost of this work was estimated as about USD 4 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 hydrometeorological 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 RV 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 RV 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 Department for International Development (DFID) found that coordination between national and local actors in humanitarian resource mobilisation was generally incoherent (Development Initiatives, 2017). 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 National Disaster Management Unit (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 1 200 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 6-13).

In order to comprehensively and systematically address the flood and drought issues and challenges in the RV Basin, the table below sets out two Strategic Themes with specific Strategies under each Theme. The Themes address Flood and Drought Management.

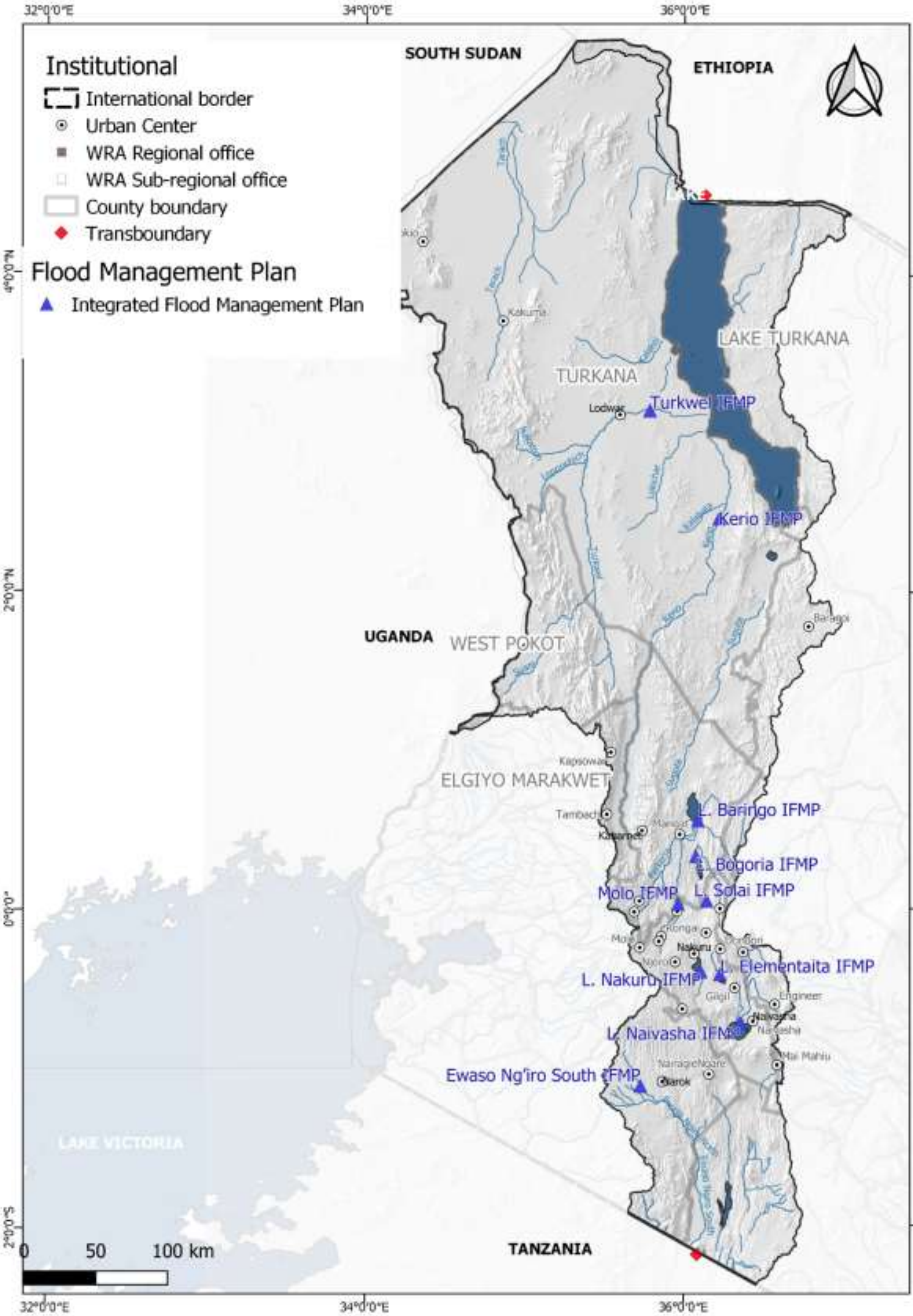


Figure 6-13: Flood management plan for RV Basin

Table 6-21: Strategic Framework – Flood and drought management

6.Key Strategic Area		Flood and drought management
6.1	**Theme:**	**Flood management**
6.1.1	Undertake flood risk assessment	
The most flood-prone zones in the RV Basin are located in the following counties: *Narok* (flash-floods from the Mau Forest due to deforestation as well as urban flooding in Narok Town due to poor drainage); *Nakuru* (caused by the Molo/Perkerra River overflowing its banks in both urban and agricultural areas *en route* to Lake Baringo as well as urban flooding in Nakuru Town due to poor drainage); *Narok* (caused by an upper tributary of the upper Ewaso Ng'iro South River as well as flash-floods due to poor cultivation practices on steep slopes); *Baringo* (caused by the Molo River overflowing its banks in agricultural areas and in Mogotio Town *en route* to Lake Baringo as well as flash-floods and mudslides due to poor cultivation practices on steep slopes); *West Pokot* (flash-floods and mudslides due to poor cultivation practices on steep slopes); *Turkana* (the Turkwel River flooding Lodwar Town and its lower meandering reaches prior to flowing into Lake Turkana as well as riparian and flood plain damage along the lower Kerio River). High-level assessments will be made of the flood exposure of each village and town in the above 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 RV Basin, which will provide a starting point for the Integrated Flood Management Plans discussed below.		
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[7]: - 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 objectives of the flood response protocol (see 6.1.3) are achieved. To this end, it is proposed that a *RV Basin Flood Response Forum (FRF)* be established that integrates all flood-relevant resource mobilisations and related interventions in the RV Basin by the various collaboration partnerships listed above. The *RV 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 *RV Basin FRF* must be systematised through the development of appropriate standard operating procedures (SOPs)[8].		

[7] 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.

[8] 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 implementing actions that should be taken and by which actors within their sphere of responsibilities – linking up with their contingency plans. (3)

6.Key Strategic Area	Flood and drought management
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 protocol 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.

6.1.4	Develop Integrated Flood Management Plans

An Integrated Flood Management Plan (IFMP) will be developed for each of the flood-prone catchments in the RV Basin, namely the Upper Ewaso Ng'iro South, Molo, Turkwel, Kerio and Mau Forest catchments, as well as for the six lakes, Baringo, Bogoria, Nakuru, Naivasha, Solai and Elementaita. 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 and lake environment.
- Overview of the statutory, institutional and civil society stakeholder context of each catchment and lake.
- Characteristics of floods and flooding in each catchment and lake environment, 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 above flood-prone catchment IFMPs that cover the RV Basin, will be reviewed by the *RV 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 RV 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 above flood-prone catchments in the RV River Basin. Wherever feasible, *community-based* flood early warning and flood preparedness approaches will be followed.

The *RV 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

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).

6.Key Strategic Area	Flood and drought management

Capacity for flood management in the RV 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 RV 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 *RV FRF* introduced in Sub-Section 6.1.2.

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 RV 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.

6.2	Theme:	Drought management
6.2.1	Formalise institutional roles and partnership collaborations.	

The existing government institutions and agencies and other stakeholders with partnership roles in drought management are as follows[9]:

- 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.

6.2.2	Develop drought response protocol.

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 $\Rightarrow$ early warning alerts $\Rightarrow$ severity trigger alerts $\Rightarrow$ pro-active resource mobilisations $\Rightarrow$ recovery interventions.

Objectives of the drought response protocol:

- Minimise the impact of water shortages on the quality of life of affected communities.

[9] 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.

6.Key Strategic Area	Flood and drought management
- Minimise environmental impacts. - Ensure equitable allocation of water despite systematic restrictions of supply. - Accelerate restoration of prior homestead environments and livelihoods of affected communities.	
6.2.3	Improve drought preparedness.
The above RV 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 RV Basin must be reviewed and deliberated by the collaboration partnership participants in the RV Basin Drought Response. In the case of an adverse severity assessment, the RV Basin Drought Response participants will have a common point of reference from which to launch and systematically coordinate their various drought-relevant resource mobilisations and related interventions in the RV Basin.	
6.2.4	Strengthen existing drought early warning systems
The NDMA currently issues regular Drought Early Warning Bulletins for ASAL counties. Given that about 80% of the RV Basin area can be classified as arid and semi-arid, all the counties outside the central highlands are included in the NDMA Bulletins. SOP responses based on the Bulletins' early warning findings and alerts must be an integrating force in the above RV *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 RV Basin. The Famine Early Warning Systems Network (FEWS NET), which produces monthly reports and maps detailing current and projected food insecurity in several regions in the world, has a Regional Office in Kenya and FEWS NET outputs will support the deliberations by the participants in the *RV Basin Drought Response*.	
6.2.5	Capacity development
Capacity for drought management in the RV 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 RV Basin's 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 RV 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 *RV Basin Drought Response* introduced in Sub-Section 7.2.1. **Institutional technical skills:** The approach here 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 RV 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 RV Basin

A brief overview of the existing hydrometeorological monitoring network in the RV 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 RV 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 sub-regional offices for use. Flow measurement for checking and updating rating curves are typically done manually with flow meters. However, local offices often do not have 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, 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 and extensive agriculture through much of the basin, the RV is prone to numerous pollution threats, with most of the lakes being at high risk of pollution. 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 inadequately qualified and trained staff and limited operational resources to facilitate regular sampling and laboratory analysis. The Regional Laboratory in Nakuru is small, equipped with only basic equipment and is manned full-time by only 1 WQ&PCO. The optimal number of staff in a Regional Laboratory should be 5. Currently it is capable of analysing both physicochemical parameters, but no pesticide residues and heavy metals on samples. The Nakuru Laboratory needs urgent upgrading by procuring advanced equipment and hiring more staff.

Furthermore, the mandates and roles and responsibilities of the different institutions involved in water quality management in the RV 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 RV Basin, there is currently a total of 30 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 RV 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 RV Basin entailed an assessment of the existing and historical network in the RV Basin against specific criteria. The result is a stream flow monitoring network design for the RV Basin consisting of 79 stations (Table 6-22). It is recommended that the non-operational stations be refurbished, 19 stations be upgraded from manual to automatic and 1 station be upgraded from manual to telemetric. The upgrading of stations is pending decisions around procurement. For sustainability, the stations will be installed in a phased implementation approach. The current procurement plan details each sub-region receiving three telemetric stations, but the procurement process is ongoing.

Table 6-22: Proposed stream monitoring network for the RV Basin

Sub-Regional Office	Total Number of surface water Stations			
	Telemetric	Automatic	Manual	TOTAL
Kabarnet	3	8	17	**28**
Kapenguria	1	2	8	**11**
Lodwar	0	2	1	**3**
Naivasha	1	8	12	**21**
Narok	1	2	13	**16**
TOTAL	**6**	**22**	**51**	**79**

Figure 6-14 to Figure 6-18 display the locations of the proposed surface water gauging stations and meteorological stations per SRO area.

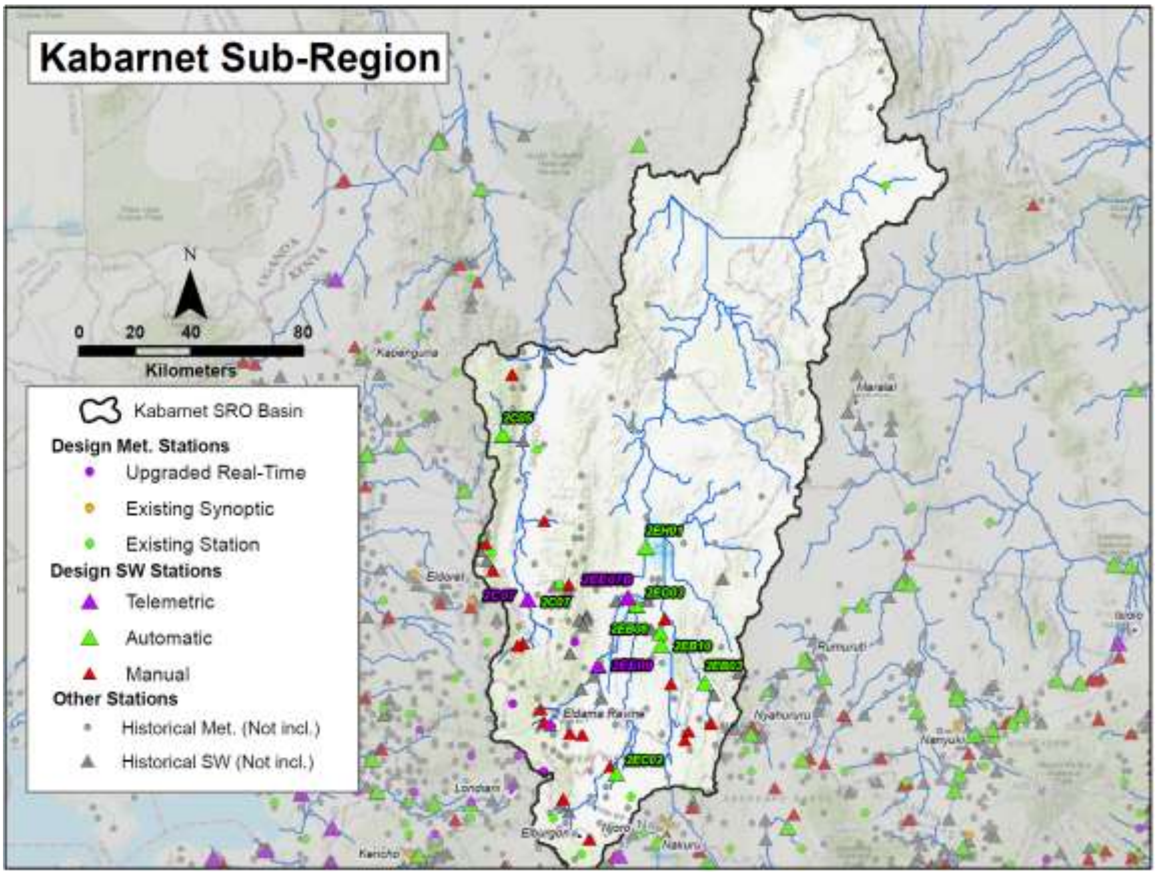


Figure 6-14: Kabarnet sub-region: Proposed flow and met monitoring network

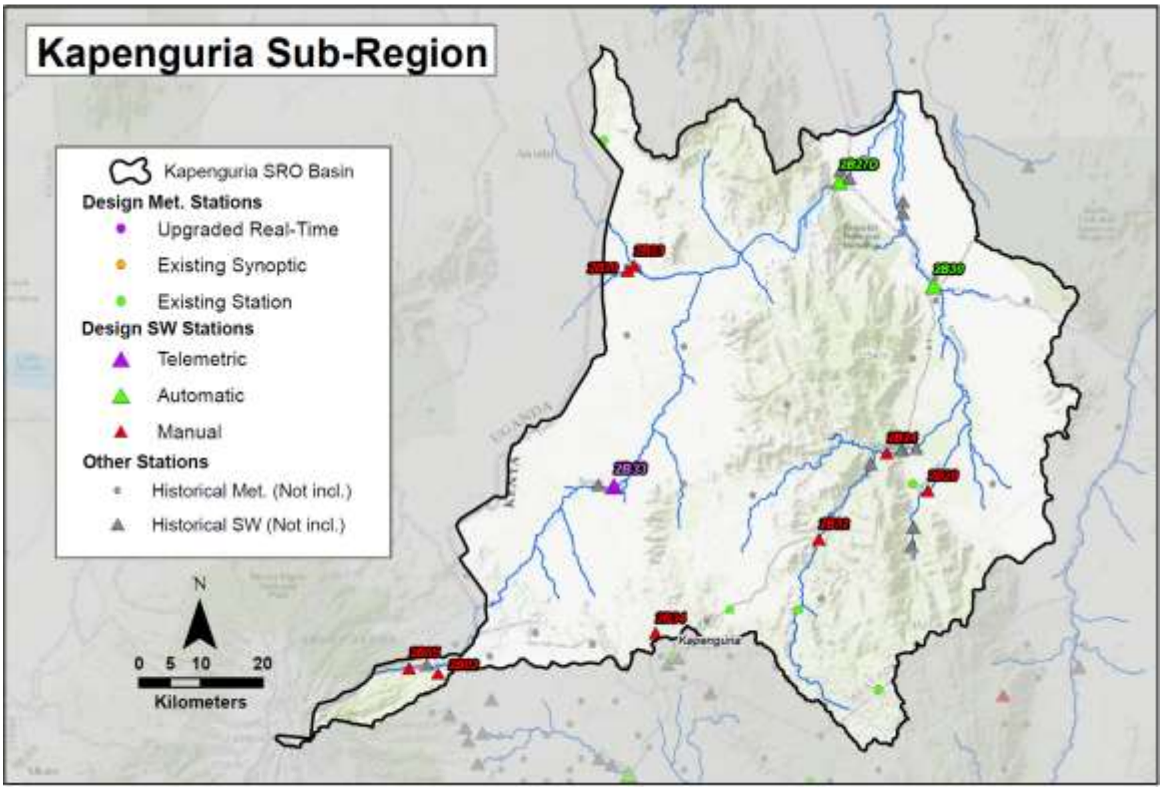


Figure 6-15: Kapenguria sub-region: Proposed flow and met monitoring network

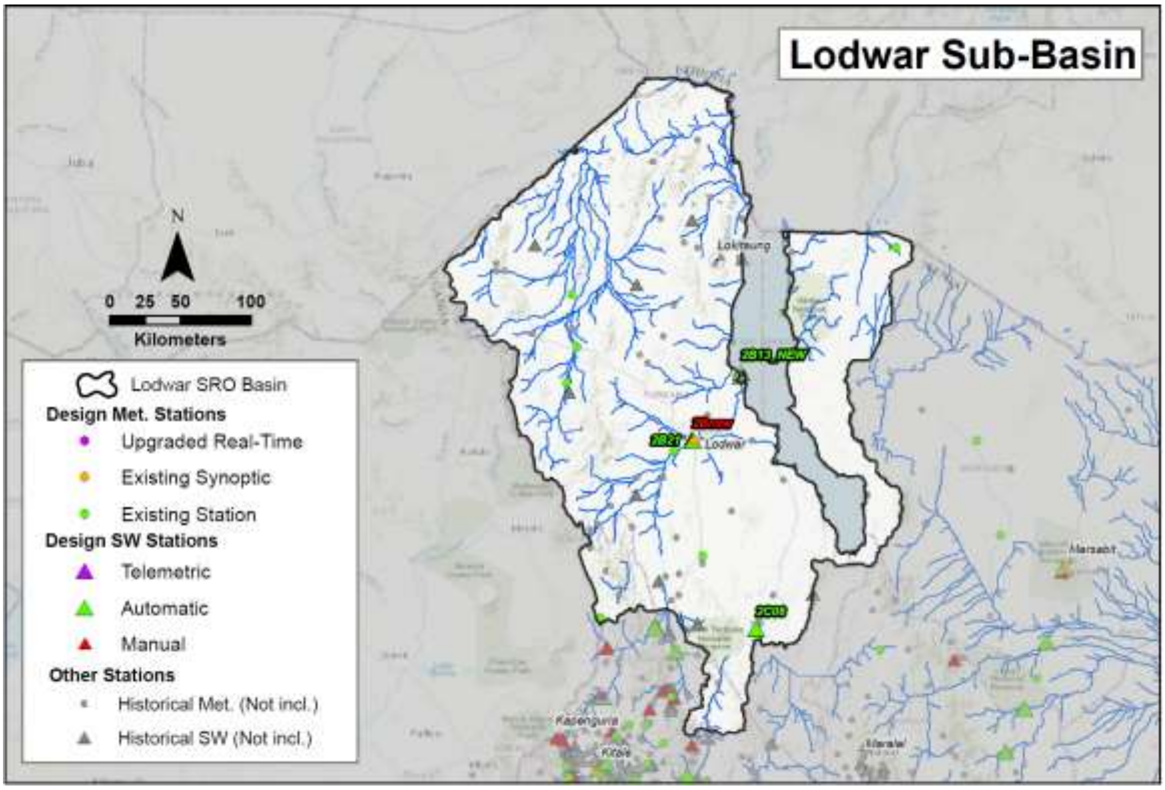


Figure 6-16: Lodwar sub-region: Proposed flow and met monitoring network

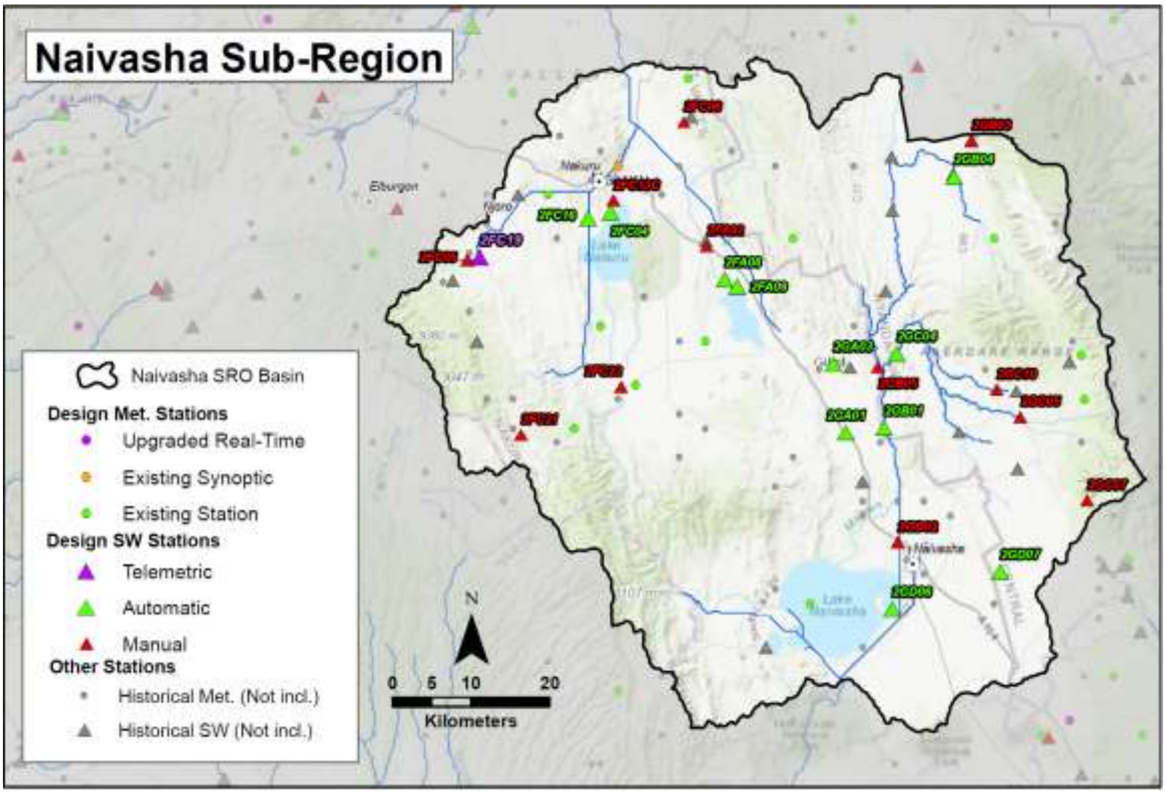


Figure 6-17: Naivasha sub-region: Proposed flow and met monitoring network

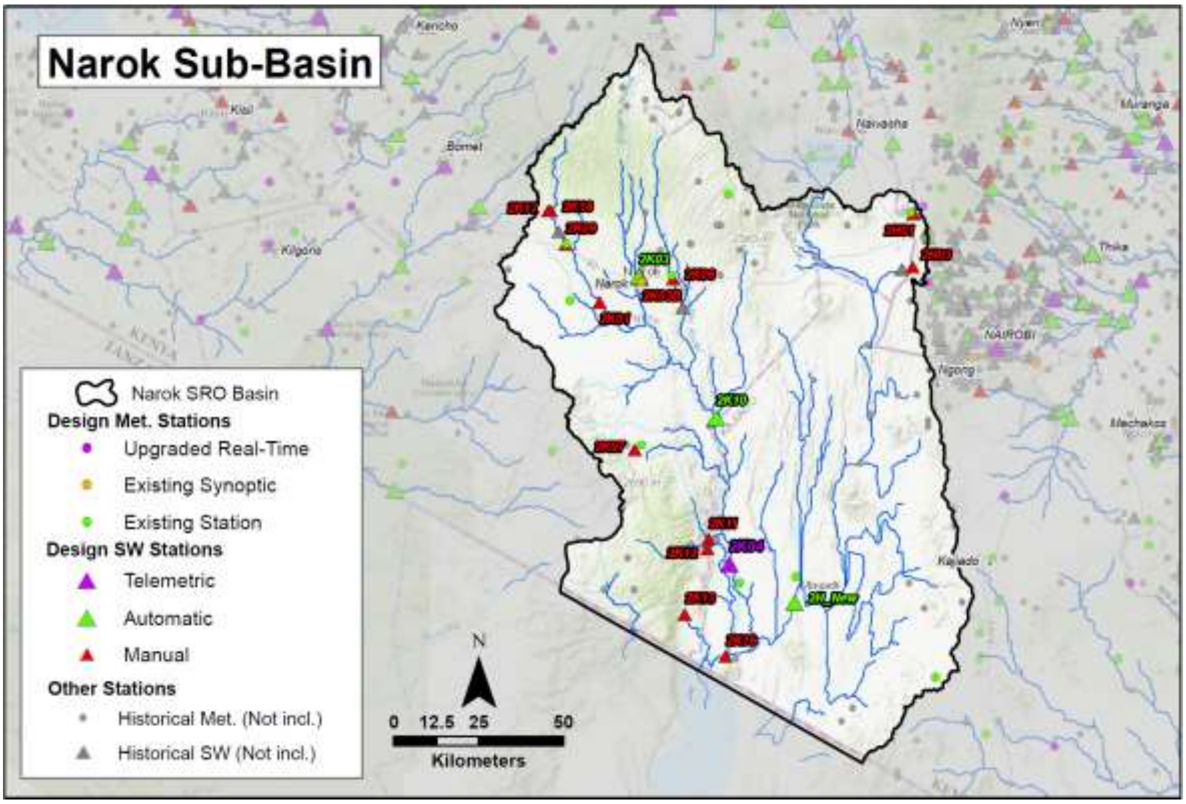


Figure 6-18: Narok sub-region: Proposed flow and met monitoring network

6.8.3.2 Monitoring of dam and lake levels

The same approach was used to design a lake level monitoring network for the RV Basin. The result is a water body monitoring network design consisting of 7 stations (Table 6-22). These stations are included in Figure 6-14 to Figure 6-18.

Table 6-23: Proposed lake monitoring network for the RV Basin

Water body	Sub-Regional Office	Existing station type	Proposed station type
Lake Turkana	Lodwar	Manual	Automatic
Lake Baringo	Kabarnet	Manual	Automatic
Emsos	Kabarnet	Manual	Manual
Lake Elementaita	Naivasha	Manual	Automatic
Lake Nakuru	Naivasha	Manual	Automatic
Lake Naivasha	Naivasha	Manual	Automatic
Lake Magadi	Narok	None	Automatic

6.8.3.3 Meteorological monitoring

The approach towards the design of a meteorological network for the RV Basin entailed an assessment of the historical meteorological network in the Basin against specific criteria. The result is a meteorological network design for the RV basin consisting of 49 stations: 13 in Kabarnet, 5 in Kapenguria, 10 in Lodwar, 11 in Naivasha and 10 in Narok. All of these stations already exist and need to be upgraded or repaired. Figure 6-14 to Figure 6-18 also display the proposed meteorological network for the RV 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 RV 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 RV Basin

RV Basin	Current stations (2018)	Proposed stations to be retained	Proposed stations to be discontinued	Proposed new stations	Total
Surface water	43	40	3	9	49
Effluent stations	21	21	0	7	28
Ground water	39	30	9	0	30

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 RV basin

RV Basin	Proposed baseline monitoring stations	Proposed first priority stations
Surface water	5	16
Effluent stations	-	10
Ground water	-	8

Surface Water

The proposed surface water station water quality network for the RV 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 RV 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.

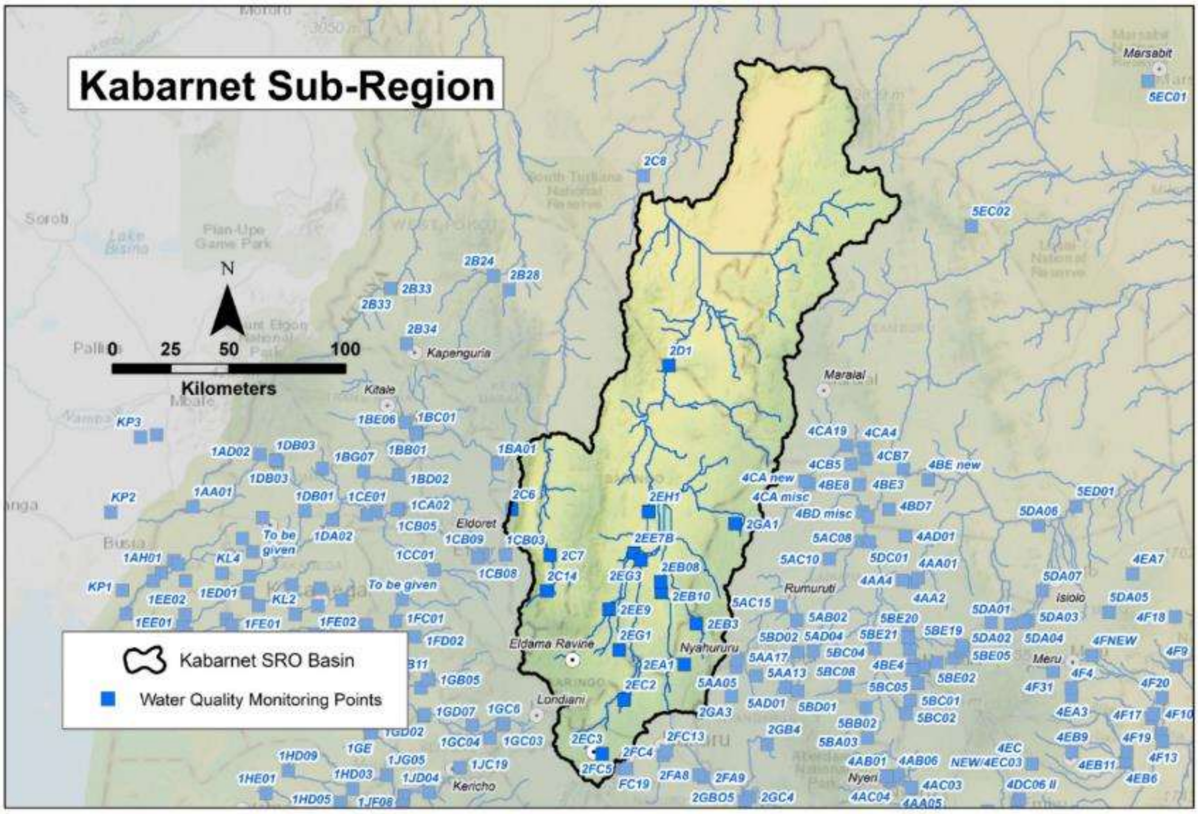


Figure 6-19: Kabarnet sub-region: Proposed surface water quality monitoring points

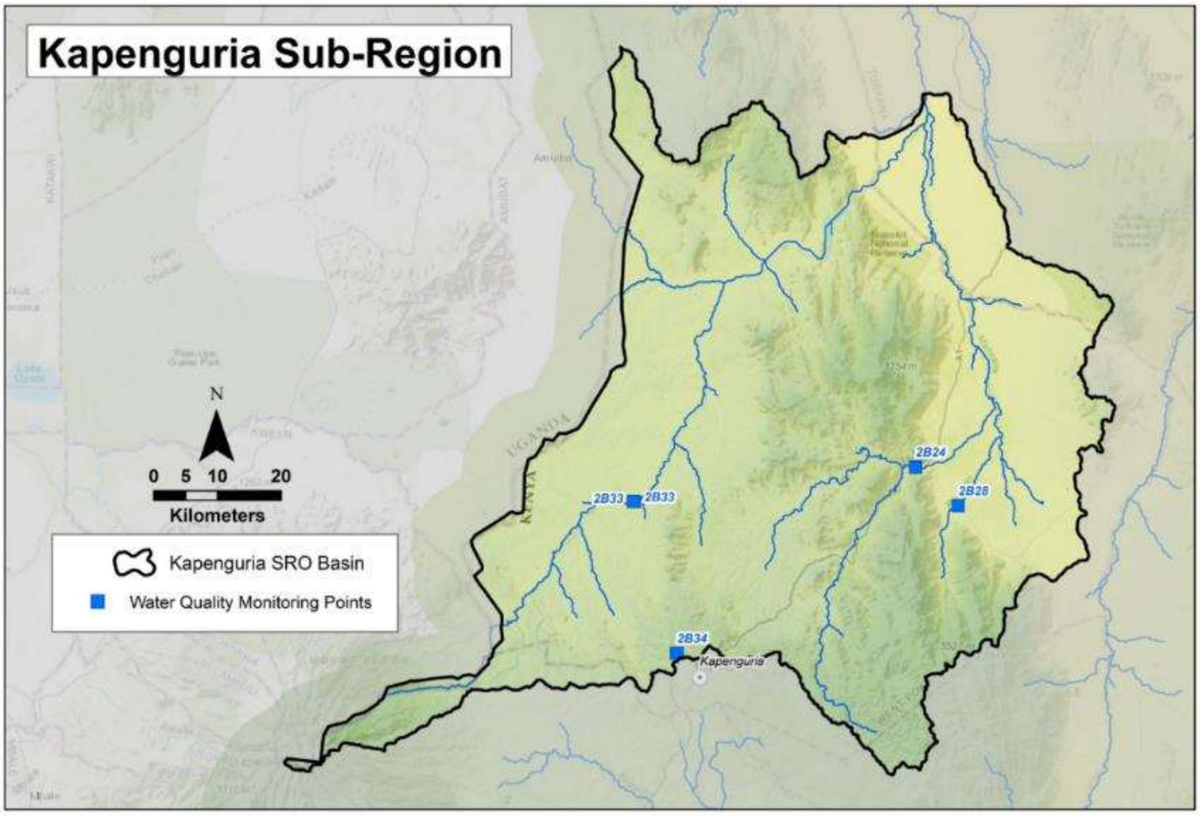


Figure 6-20: Kapenguria: Proposed surface water quality monitoring points

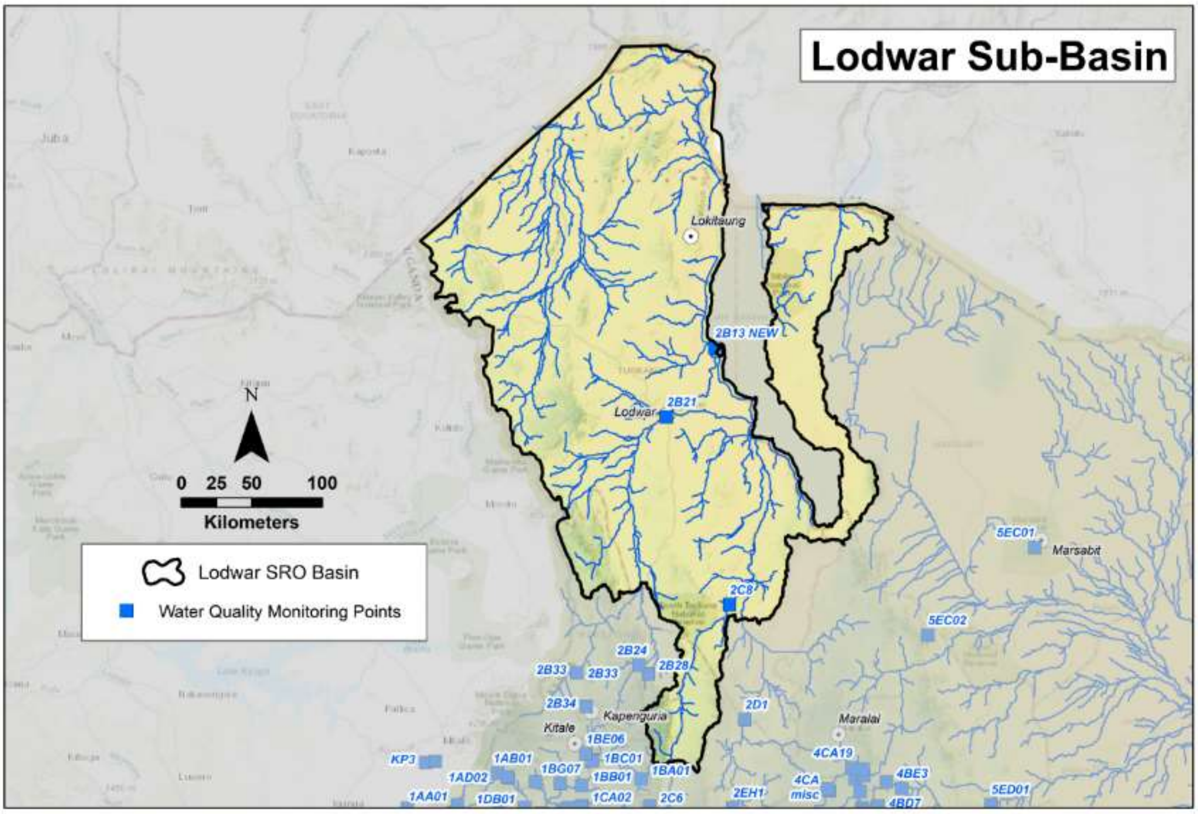


Figure 6-21: Lodwar sub-region: Proposed surface water quality monitoring points

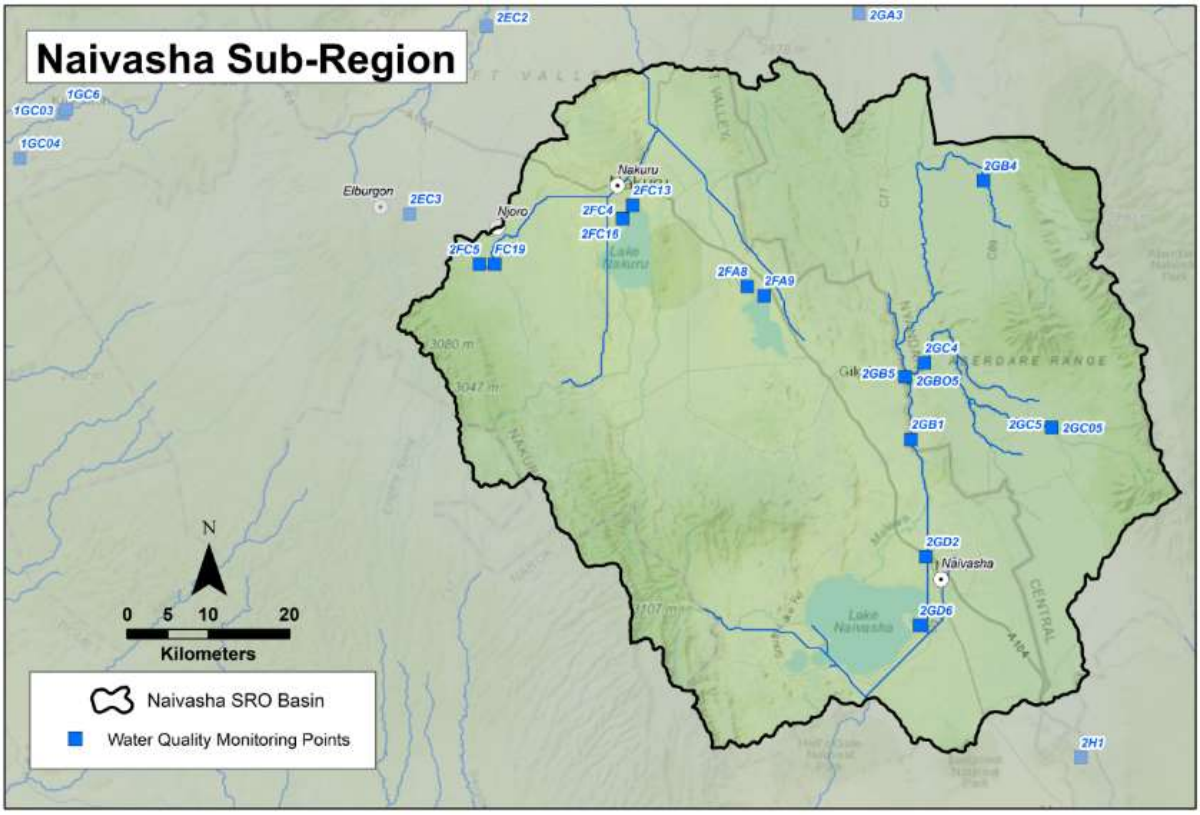


Figure 6-22: Naivasha sub-region: Proposed surface water quality monitoring points

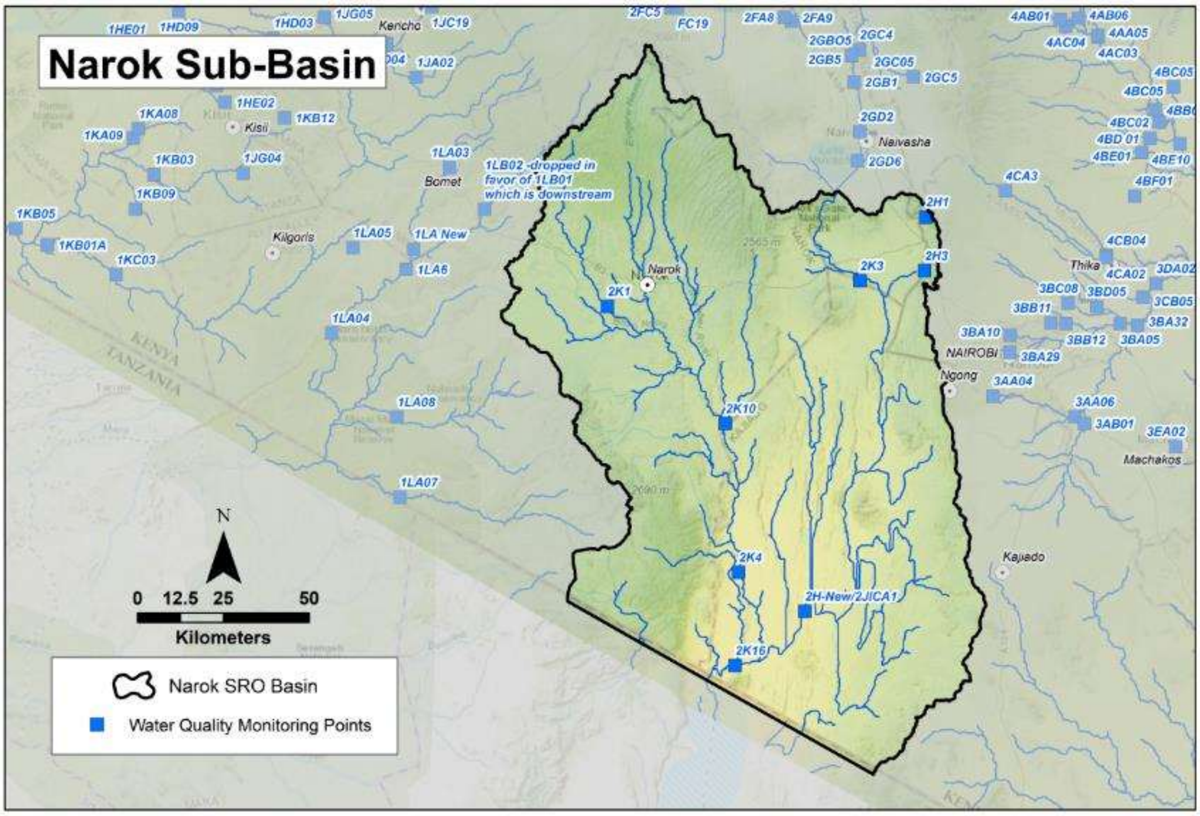


Figure 6-23: Narok sub-region: Proposed surface water quality monitoring points

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 based on past polluting history of the source. Most of the sources within the RV 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.

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 water quality changes could occur as a consequence of over-abstraction.

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.

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.

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 inadequate equipment currently, 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.

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.

Laboratory Equipment

The current level of instrumentation in water quality laboratories is poor. All 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, laboratory 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, one FEWS has been proposed in the RV Basin for the Perkerra River. The proposed FEWS is shown below and comprises 2 telemetric stream flow gauging stations and 5 full telemetric meteorological Automatic Weather Stations for the RV River flood prone areas. Details of the proposed stream flow and meteorological telemetric monitoring stations to inform the FEWS are listed in Table 6-27 and Table 6-28, and shown on Figure 6-24.

Table 6-27: RV FEWS – Proposed telemetric stream flow gauging stations

ID	River	WRA SRO	Lat	Long	Operational status	Existing station type	Proposed station type
2EE07B	Perkerra	Kabarnet	0.459	35.970	Operational	Telemetric	Telemetric
2EE09	Perkerra	Kabarnet	0.242	35.874	Non-operational	Manual	Telemetric

Table 6-28: RV FEWS – Proposed telemetric meteorological stations

ID	Station name	County	Lat	Long	Existing type	Proposed type
8935007	Eldama Ravine District Office	Baringo	0.050	35.72	Manual	Telemetric
8935091	Tenges Divisional Agricultural Office	Baringo	0.317	35.80	Manual	Telemetric
8935145	Torongo Primary School	Baringo	0.117	35.60	Manual	Telemetric
8935200	Kimose Agricultural Holding Ground	Baringo	0.250	35.88	Manual	Telemetric
9035311	Kiptuget Forest Station	Baringo	-0.100	35.70	Manual	Telemetric

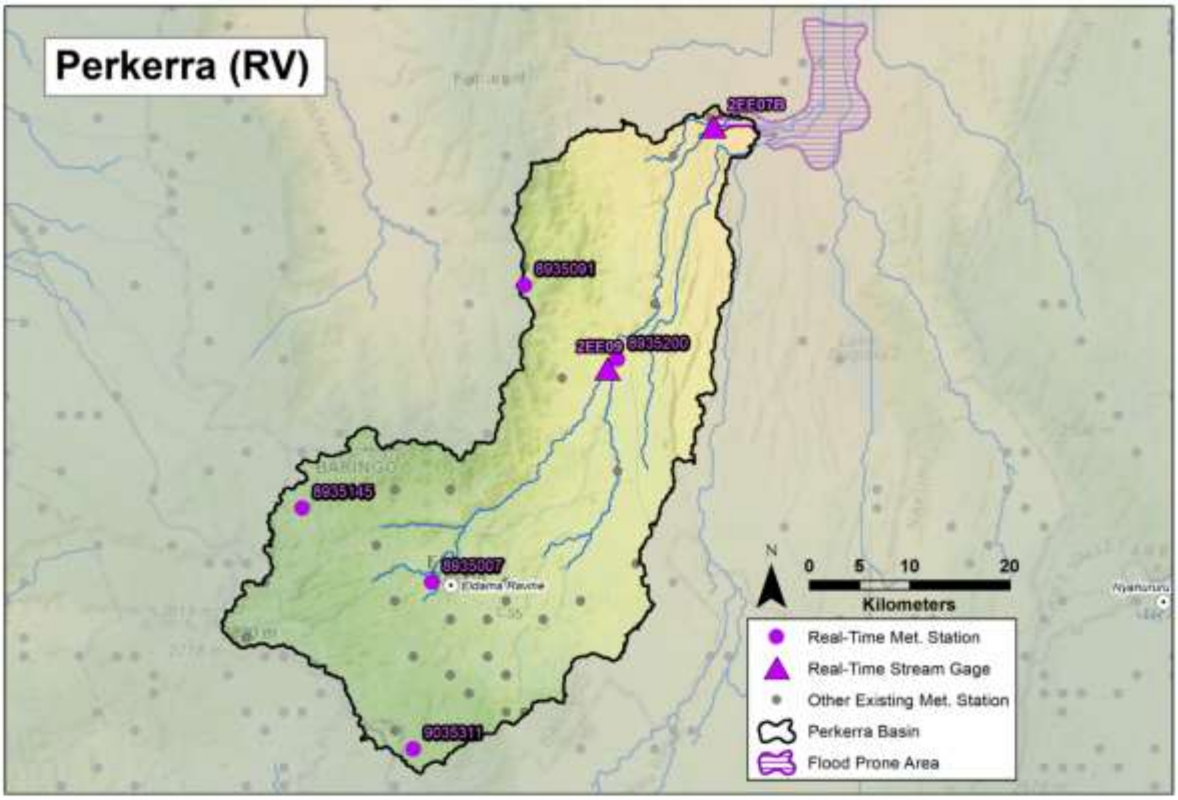


Figure 6-24: Proposed Perkerra flood early warning hydromet network

6.8.4 Strategy

In order to comprehensively and systematically address the hydrometeorological monitoring issues and challenges in the RV 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 RV 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 RV 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 RV 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.		
7.1.4	Water quality monitoring: Surface water and groundwater	
Under this Consultancy, the current water quality monitoring network in the RV 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 RV 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 with regard to 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 RV 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 need's assessment in relation to data requirements e.g. for operational, monitoring of compliance, water balance or other purposes.		

7	Key Strategic Area:	Hydrometeorological Monitoring
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 regarding 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 RV Basin to improve water availability and assurance of supply for current and projected future water use in the basin, 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. The approach entailed an evaluation of the need for and the capacity of large-scale water resources development interventions such as dams and transfers, 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. The proposed schemes 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 mean annual precipitation across the RV Basin varies from less than 300 mm in some areas in the north to as high as 1 200 mm in some of the central areas. Towards the south of the basin, the mean annual precipitation reduces again to less than 800 mm. The mean annual precipitation across the basin is about 510 mm. Due to the topographical and climate variability across the basin, surface water distribution in the basin varies greatly (both temporally and spatially) and many areas often lack sufficient access to surface water.

Existing large-scale water resources developments in the RV Basin include four large dams and some large-scale irrigation schemes. Turkwel Dam (1 641 MCM) on the upper Turkwel River is used for hydropower generation and irrigation supply. The dam is the third largest hydroelectric power plant in

Kenya, having an installed capacity of 106 MW. Chemususu Dam (11 MCM) on an upper tributary of the Perkerra River supplies water for domestic use and irrigation. Kirandich Dam (4.5 MCM), close to Kabernet Town, is used for domestic water supply. Chemeron Yatoi Dam (2.3 MCM) is used for local water supply but has lost a lot of storage due to sedimentation. The Chemususu, Kirandich and Chemeron dams are all located in the central part of the RV Basin in the Lake Baringo catchment. In addition to the dams, there are two river intake structures in the basin used to divert water for domestic supply: Turasha Intake Weir on the Turasha River, a tributary of the Malewa River (in the Lake Naivasha catchment), and the Narok Intake Weir on an upper tributary of the Ewaso Ng'iro South River.

Three large-scale irrigation schemes exist in the basin with a total area of about 2 600 ha. The Perkerra Scheme is located about 100 km north of Nakuru close to Marigat. The scheme gets it water from the Perkerra River and Chemususu Dam. Other schemes include the Katilu Scheme along the Turkwel River downstream of Turkwel Dam and the Wei-Wei Irrigation Scheme, a run-of-river scheme in the upper Turkwel River catchment

Construction on various large dams in the RV Basin is about to start, is underway, or has started but are currently on hold due to contractual, financial and/or other issues. These dams include the Muruny-Siyoi Dam in West Pokot as part of the Kapenguria Water Supply Project and the Arror multipurpose dam on upper tributaries of the Kerio River in Elgiyo Marakwet County, which will be used for hydropower generation and to supply water for about 3 000 ha of irrigation. The Lowaat Dam on the Kerio River and the Radat Dam on the Perkerra River in Turkana and Baringo counties respectively, will also be used for irrigation supply.

Most of the water currently consumed in the RV Basin is for irrigation and domestic and industrial use. Water is mainly sourced directly from groundwater, rivers, lakes, small dams and pans, with some towns and irrigation schemes being supplied from larger dams. Supply reliability in most parts of the basin is reasonable. However, frequent shortages are experienced during the dry season due to lack of storage, often exacerbated by the late start of the wet season. Non-consumptive use in the basin is linked to the generation of hydropower at Turkwel Dam.

The total current water requirement (2018) in the basin equates to 481 MCM/a.

Table 6-30: Current (2018) water demands in the RV Basin

Sector	Total (MCM/a)
Irrigation	**204**
- Small scale / Private	164
- Large-scale	40
Domestic and Industrial	**192**
- Urban centres	39
- Basin-wide	153
Livestock	**80**
Other	**5**
Total	**481**

6.9.3 Water resources development potential

The current (2018) total water demand in the RV Basin (481 MCM/a) constitutes about 13% of the total water resources available for use.

The results of the surface water resources analysis which was undertaken for this Consultancy, estimated the total natural surface runoff in the RV Basin as 2 682 MCM/a, equivalent to an average runoff coefficient of 4%. The current surface water demand in the Basin was estimated at 283 MCM/a, which is about 10% of the surface water available in rivers - taking into consideration the ecological reserve (Q95), calculated as 251 MCM/a. The current groundwater use in the RV Basin was estimated at 198 MCM/a, which is about 50% of the estimated sustainable groundwater yield (398 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

Key considerations for estimating future water requirements in the RV Basin relate to the plans for significant irrigation and hydropower expansion in the basin, the water requirements linked to oil production in Turkana County, meeting the expected growth in and improving the reliability of future domestic and industrial water demands, water requirements associated with the proposed Turkana Resort City as part of LAPSSET, and environmental flow requirements. 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 30% of the population in the basin is currently supplied by WSPs.

The scenario analyses undertaken as part of this Consultancy took into account the proposed developments and projected (to 2040) growth in water demands across the basin. The analysis highlighted the water use benefits of improving irrigation efficiencies for both small-scale and large-scale irrigation in the RV Basin. Similarly, water demand management should be implemented in all urban areas to improve water use efficiencies. The future water requirements as presented below therefore incorporate a 20% reduction in urban water requirements, as well as improved irrigation efficiencies and a reduction in some of the proposed large-scale irrigation areas. Furthermore, estimates of future water requirements were aimed at reducing the impact of consumptive use on lake inflows under future development, by limiting the total future water use in the basin to 60% of the total water resources available, mainly by capping irrigation development.

The sustainable development scenario for the RV Basin (Scenario 3A) estimated the total future (2040) water requirement from the Basin at 1 784 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 expansion of small-scale irrigation, the LAPSSET and Tullow Oil developments and for improving water supply to an increasing 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 RV Basin

Sector	MCM/a
Irrigation	**920**
Domestic and Industrial	**708**
- Urban centres	211
- Basin-wide	497
Livestock	**146**
Other	**10**
Total	**1 784**

6.9.5 Proposed water resources development plan

6.9.5.1 Overview

The essence of the proposed water resources development plan for the Rift Valley Basin, up to 2040, is to expand irrigation in the basin in line with water availability, especially in the Turkwel, Kerio, Perkerra and Ewaso Ng'iro South catchments as well as next to Lake Turkana; to ensure a reliable supply of water to meet the expected growth in urban water demands; to increase hydropower production in the basin; to implement the identified schemes which will export water from the Lake Victoria South Basin 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. 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 should be implemented for both small and large-scale irrigation and for urban centres.

The following specific interventions are proposed:

- Construction of two multipurpose dams in the Kerio River catchment viz. Embobut and Arror dams which will provide water for large scale irrigation, hydropower, flood control and water supply in general.
- Construction of the Upper Narok multipurpose dam in the upper Ewaso Ng'iro South River catchment. This dam will provide water for urban users as well as large scale irrigation and flood control.
- Construction of the Lowaat and Radat dams on the lower Kerio and Perkerra rivers respectively, to mainly supply water for large-scale irrigation development.
- Construction of the Waseges Dam on the Waseges River to support irrigation development in the lake Bagoria catchment.
- Construction of Malewa Dam on the Malewa River to improve water supply to Naivasha Town and Gilgil.
- Construction of Siyoi Muruny Dam for local water supply as part of the Kapenguria Water Supply Project.
- Implementation of the Ewaso Ng'iro Multipurpose Project which includes three cascading dams along the Ewaso Ng'iro South River viz. Oletukat Olenkululu, Leshota and Oldorko dams and the installation of hydropower capacity of 180 MW. This project also entails the construction of Amala Dam on the Amala River, an upper tributary of the Mara River in Lake Victoria South Basin, from where water will be diverted via a tunnel to the upper Ewaso Ng'iro South River, as well as the development of about 15 000 ha of irrigation in the Ewaso Ng'iro South Valley.
- The construction of Itare Dam on the Itare River, an upper tributary of the Sondu River in Lake Victoria South Basin, to supply water to the RV Basin via an inter-basin transfer (tunnel). This water will augment the supply to Nakuru Town and address water shortages in Molo, Njoro and Rongai along the way.
- Implementation of the Todonyang-Omo Irrigation Scheme along the north-western shore of Lake Turkana, using water from the Omo River.
- The expansion of large-scale irrigation along the Turkwel River downstream of Turkwel Dam.
- The expansion of irrigation along the Perkerra River, Kerio River and Ewaso Ng'iro South River using the storage provided by the new dams to be constructed.
- Re-allocating water from the existing Turkwel Dam to meet the expected water demands for oil production in Turkana County as well as the anticipated water requirements linked to the development of Eliye Springs Resort as part of LAPSSET, on the western shore of Lake Turkana
- Prioritising environmental water requirements of lakes in water allocation.
- Addressing transboundary issues in the Lake Turkana catchment through an integrated catchment management plan with Ethiopia.
- 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.

- Implementation and enforcement of the Q95 flow downstream of proposed dams and large-scale irrigation schemes to maintain the ecological health of the rivers.

Note: Although a number of independent, international studies have been commissioned by various institutions in an attempt to evaluate and quantify the possible hydrological impact of the Gibe Hydropower Schemes and proposed large scale irrigation on the hydrological characteristics of Lake Turkana, it is imperative that a joint transboundary study involving Ethiopia and Kenya be initiated with the intent to ultimately reach a mutually beneficial Agreement with regard to the development and management of the Turkana Basin based on international law and best practice.

Table 6-32 below summarises the proposed water resources developments and interventions in the RV Basin with a planning horizon of 2040, while Figure 6-25 displays the locations of the existing and proposed large-scale water resources developments.

Table 6-32: Water resources development plan for the RV Basin

Item	2018	2040	Comment
Storage: Large dams (MCM)	1 659	3 335	- 4 existing large dams - 4 new dams to supply growing urban centres - includes transfers - 3 new multipurpose dams for large scale irrigation, hydropower and/or flood control - 3 new dams specifically for hydropower - includes transfers - 3 new dams specifically for large-scale irrigation
Storage: Small dams / pans (MCM)	12	73	To supply towns and local domestic and livestock demands and improve assurance of supply for small-scale and private irrigation
Groundwater use (MCM/a)	198	351	As conjunctive use with surface water storage, or as the only water source in areas where surface water is not available.
Irrigation area (ha)	11 075	65 000	The increase in irrigation area is mainly due to new proposed large-scale schemes along the main rivers as well as additional small-scale irrigation
Hydropower (MW)	106	391	Hydropower to be installed at 5 new dams.

6.9.5.2 Arror Multipurpose Dam Project

The Arror Dam in Elgiyo Marakwet County will entail a 70 MCM dam on the Arror River, a perennial tributary of the Kerio River. The dam will have an installed hydropower capacity of 60 MW and will provide water for a new irrigation scheme (2 000 ha) in the Kerio Plains downstream of the Arror River and Kerio River confluence.

6.9.5.3 Embobut Multipurpose Dam Project

The Embobut Dam will be located in West Pokot County on the perennial Embobut tributary of the Kerio River and a storage capacity of 40 MCM is envisioned. The dam will allow the irrigation of up to 1 000 ha along the Kerio River downstream and will have installed hydropower of 45 MW.

6.9.5.4 Upper Narok Multipurpose Dam Project

The Upper Narok Dam (10 MCM) in the upstream part of the Ewaso Ng'iro South catchment, upstream of Narok Town, will ensure that the future water demand of Narok Town is met at an acceptable assurance of supply, will provide flood control and provide water for about 2 000 ha of irrigation.

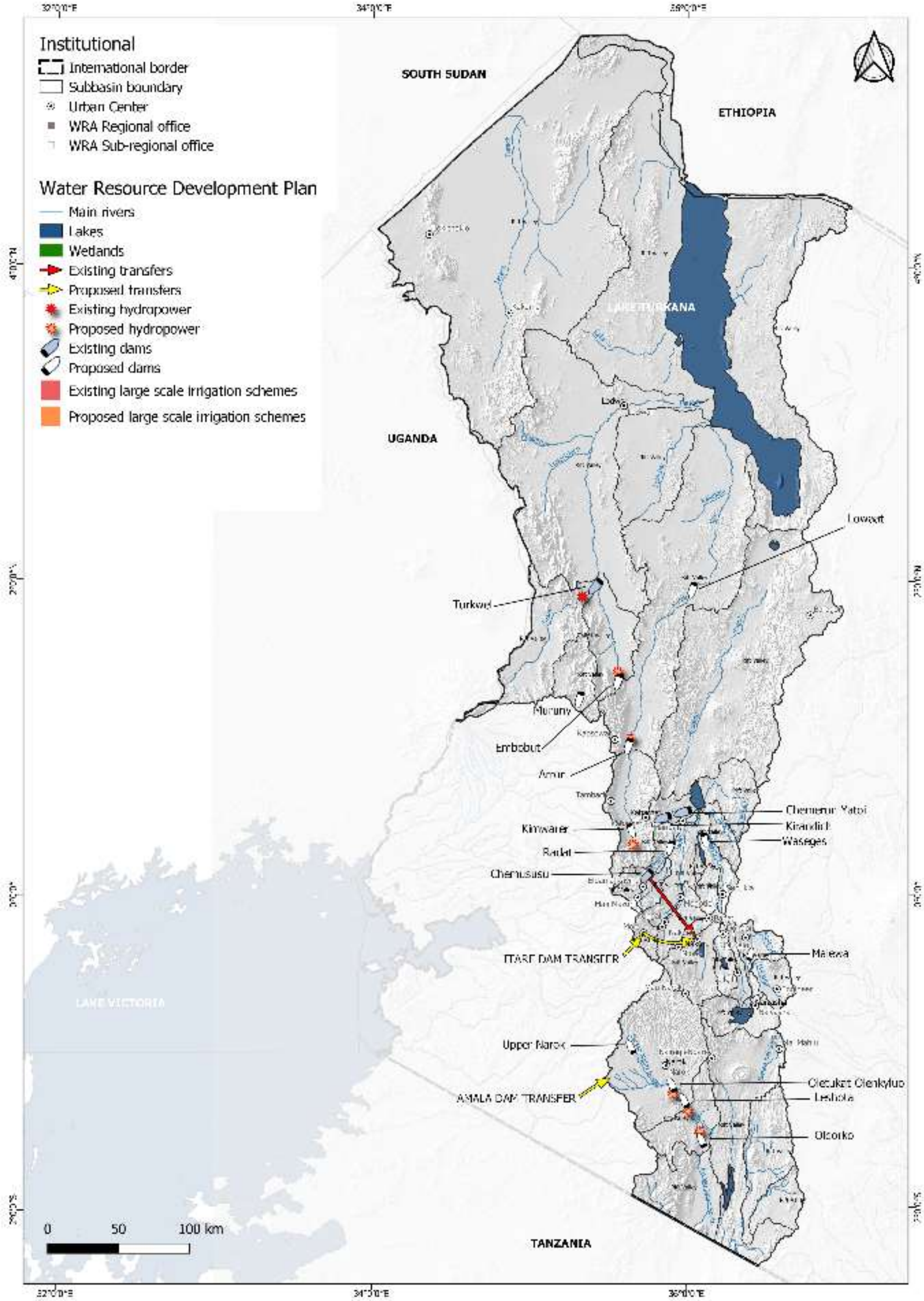


Figure 6-25: Proposed developments, dams and transfer schemes in the RV Basin

6.9.5.5 Tullow Oil

Since 2012, there has been ongoing oil exploration in Kenya and, following a full appraisal of the exploration data, Tullow Oil recently initiated the first stage of the South Lokichar basin development in Turkana County. The lifetime for the economically viable production of oil from the fields in Turkana County is estimated at 25 years. It is expected that by 2022 around 60 000 to 80 000 barrels of oil per day will be delivered to Lamu via pipeline from Lokichar. At about 600 litres of water required per barrel of oil produced, the water requirement for producing 80 000 barrels of oil per day equates to about 17 MCM/a. The water is used to pressurise oil wells. From discussions with Tullow Oil (E Johana, personal communication, July 2019), Tullow Oil recently completed a water resources analysis for the oil fields in Turkana County and concluded that the existing Turkwel Dam provided the most reliable source of water of adequate quality. As part of the water resources assessment which informed this Bain Plan, a future demand of 17 MCM/a was imposed on Turkwel Dam.

6.9.5.6 LAPSSET

Since 2009, the Government of Kenya has expressed plans to undertake a multipurpose transport and communication corridor known as the ‘Lamu Port-South Sudan-Ethiopia Transport (LAPSSET) Corridor. LAPSSET will consist of a standard gauge railway line, a port, a super highway, a regional international airport, ultra-modern tourist resorts, an oil pipeline, and a fibre-optic cable constructed to link Lamu to Juba and Addis Ababa. One of the proposed resort cities will be based in the RV Basin at Kalokol in Turkana County along the banks of Lake Turkana. Allowance was made in the water resources simulations to supply the future water demand of this resort city from Turkwel Dam. Figure 6-26 display the key development nodes of the proposed LAPSSET project.

6.9.5.7 Inter-basin transfers

Two inter-basin transfers to transfer surplus water from the LVS Basin to the RV 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 RV 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. 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 into the RV Basin is 123 MCM/a.

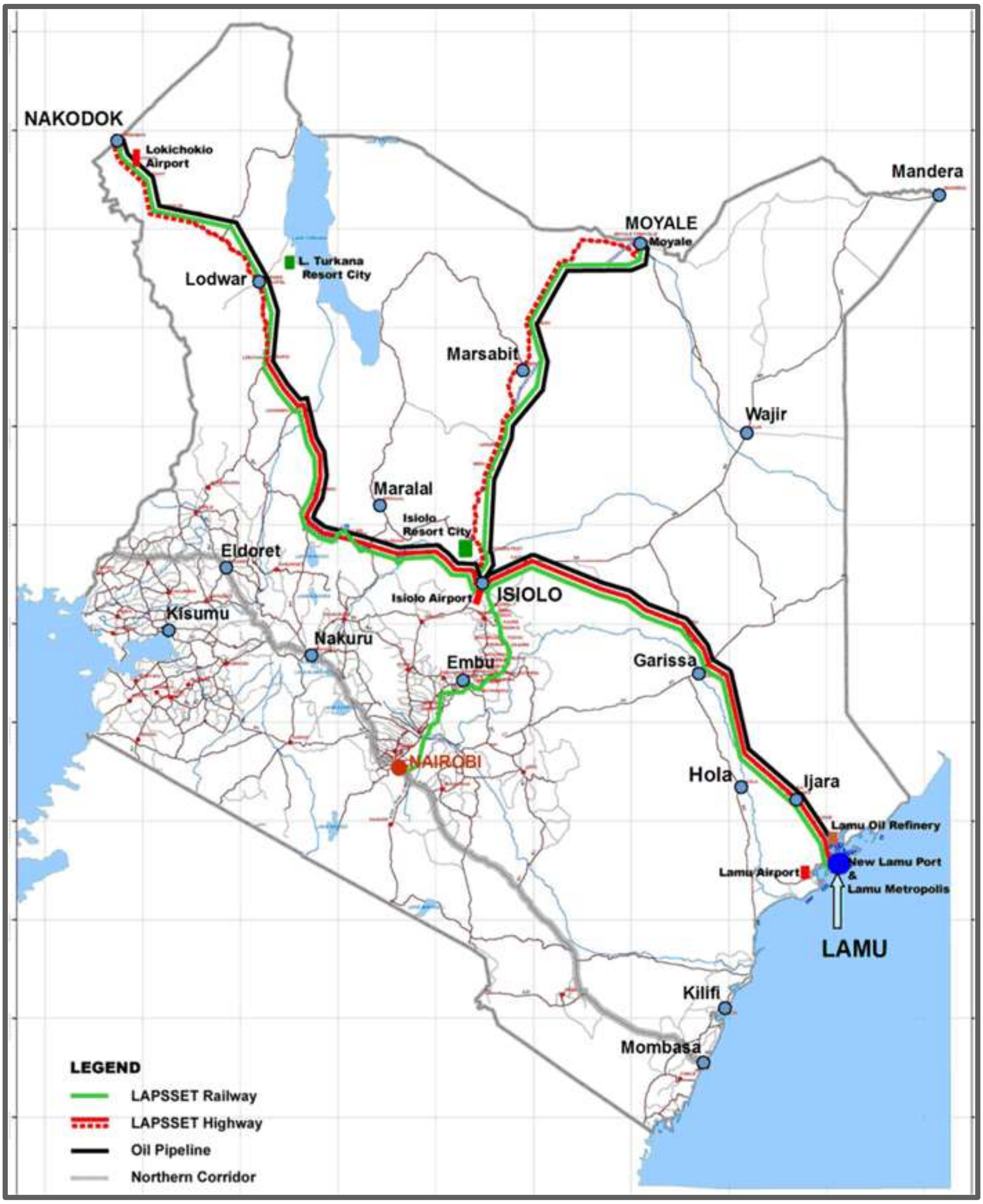


Figure 6-26: The proposed LAPSSET development

6.9.5.8 Large-scale Irrigation development

Irrigation developments in the RV Basin to be implemented by 2040 include various new and extensions to existing schemes.

The irrigation areas presented below represent reduced areas in order to limit the impact of consumptive use on lake inflows under future development, i.e. total future water use in the basin was capped at 60% of the total water resources available, mainly by capping irrigation development. As a result, it is also proposed to reduce the storage volumes of some of the large dams linked to large scale irrigation development.

An additional 5 000 ha will be developed by expanding the existing Perkerra Irrigation Scheme in Baringo County. This will be achieved through the construction of Radat Dam along the middle Perkerra River.

The existing irrigation downstream of Turkwel Dam will be expanded to 4 000 ha as combined small-scale irrigation schemes, while an additional 6 000 ha of irrigated sugar cane will be developed on the Turkana-Pokot border.

The new Todonyang-Omo Irrigation Scheme (2 000 ha) will be situated in Kenya just south of the Ethiopian border along the north-western shoreline of Lake Turkana. This scheme will draw water from the Omo River just upstream of Lake Turkana.

There is significant irrigation potential in the Ewaso Ng'iro South catchment and the intention is to use the improved regulation provided by the Lower Ewaso Ng'iro hydropower cascade scheme to irrigate 15 000 ha in the Ewaso Ng'iro South valley. Furthermore, the new Upper Narok Dam will allow 2 000 ha to be developed in the vicinity of Narok.

Similarly, it is proposed to develop a total of almost 13 000 ha of large-scale irrigation along the Kerio River upstream of Lake Turkana. This will include the construction of three dams and the development of separate schemes viz Arror Dam (2 000 ha), Embobut Dam (1 000 ha), and Lowaat Dam (10 000 ha).

Finally, the new Waseges Dam on the Waseges River upstream of Lake Bagoria will be used to irrigate 470 ha.

Table 6-33 summarises the proposed large-scale irrigation developments to be implemented by 2040.

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Table 6-33: Proposed large scale irrigation developments in the RV Basin

Scheme name	County	Area (ha)	Water Source
Arror Dam	Elgiyo Marakwet	2 000	Arror Dam (70 MCM)
Turkwel Dam Irrigation (replaces present day Turkwell irrigation.)	Turkana	4 000	Turkwel Dam (Existing)
Turkwel Dam Sugar	Turkana	6 000	Turkwel Dam (Existing)
Upper Narok Dam	Narok	2 000	Upper Narok Dam (10 MCM)
Oldorko Scheme (Lower Ewaso Ng'iro Scheme)	Narok	15 000	Ewaso Ng'iro South Development incl. Amala Transfer and Oletukat, Leshota and Oldorko Dams
Embobut Dam	Narok	1 000	Embobut Dam (40 MCM)
Waseges Dam	Baringo	470	Waseges Dam (5 MCM)
Todonyang-Omo	Turkana	2 000	Omo R (Ethiopia)
Lowaat Dam	Turkana	10 000	Lowaat Dam (383 MCM)
Perkerra (incl. portion supplied from Radat Dam)	Baringo	5 000	Radat Dam (135 MCM) and Perkerra River

6.9.5.9 Hydropower development

The Ewaso Ng'iro Project along the Ewaso Ng'iro South River is one of Kenya's Vision 2030 flagship projects. It includes three cascading dams along the Ewaso Ng'iro South River as well as a diversion from the Amala River, an upper tributary of the Mara River in the Lake Victoria South Basin, from where water will be transferred to the RV Basin via a 3.8 km tunnel with a design capacity of 82 MCM/a. The cascade dams include Oletukat (406 MCM storage; 25 MW), Leshota (247 MCM storage; 56 MW) and Oldorko (95 MCM storage; 99 MW).

Additional new hydropower installations in the RV Basin include 60 MW at Arror Dam and 45 MW at Embobut Dam. All of these dams are located along the upper Kerio River and will be used as multi-purpose dams

6.9.5.10 Water supply to urban centres

Many of the proposed dams listed above will also serve to improve existing and to meet the future expected growth in domestic and industrial demands (in addition to water for hydropower and irrigation). These dams include Upper Narok Dam which will supply Narok Town. The new Malewa Dam (73 MCM) along the Malewa River upstream of Lake Naivasha will supply Gilgil, parts of Nakuru County and Naivasha Town and could potentially also be used to augment supply to Nakuru Town until the Itare Dam transfer is operational. It is imperative that significant minimum flow (environmental) releases for Lake Naivasha are incorporated in the operating rules of Malewa Dam. Siyoi Muruny Dam (17 MCM storage) in West Pokot County will be used for local water supply as part of the Kapenguria Water Supply Project.

6.9.5.11 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 be carefully managed as they are prone to contamination.

6.9.5.12 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 RV Basin, which will be required to meet 2040 demands, amount to 61 MCM, while the total volume of additional groundwater development which will be required was estimated at 153 MCM/a.

The table below 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 requirements and groundwater development to meet 2040 demands

Sub-basin	Groundwater (MCM/a)	Surface Water Storage (MCM)	Sub-basin	Groundwater (MCM/a)	Surface Water Storage (MCM)	Sub-basin	Groundwater (MCM/a)	Surface Water Storage (MCM)
2AA	2.5	0.0	**2EC**	2.1	2.4	**2GA**	0.0	0.0
2AB	3.6	0.0	**2ED**	2.3	0.0	**2GB**	0.0	0.0
2BA	2.4	0.8	**2EE**	4.6	0.0	**2GC**	5.2	0.0
2BB	7.1	12.7	**2EF**	2.8	0.0	**2GD**	0.5	2.8
2BC	5.9	11.3	**2EG1**	6.6	0.0	**2H-1**	1.1	0.0
2BD	13.3	2.6	**2EG2**	3.7	16.8	**2H-2**	0.0	0.0

Sub-basin	Groundwater (MCM/a)	Surface Water Storage (MCM)	Sub-basin	Groundwater (MCM/a)	Surface Water Storage (MCM)	Sub-basin	Groundwater (MCM/a)	Surface Water Storage (MCM)
2CA	0.1	0.3	**2EH**	0.6	0.0	**2H-3**	1.3	0.0
2CB	22.8	0.0	**2EJ**	1.6	0.0	**2J**	25.1	0.0
2CC	4.7	10.0	**2EK**	0.4	0.0	**2KA**	15.9	0.0
2D	8.1	0.0	**2FA**	0.6	0.0	**2KB**	5.4	0.0
2EA	0.6	0.5	**2FB**	0.0	0.0	**2KC**	2.1	0.0
2EB	0.6	0.4	**2FC**	0.0	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

				Arror Scheme	Embobut Scheme	Todonyang-Omo Scheme	Lowaat Scheme	Malewa Scheme	Siyoi-Muruny Scheme	Radat Scheme	Turkwel Irrigation Scheme	Upper Narok Scheme	Waseges Scheme	Amala Scheme	Itare Scheme
				Arror Dam (70MCM) Arror Irrigation (2000ha) Hydropower (60MW) Flood control	Embobut Dam (40MCM) Embobut Irrigation (1000ha) Hydropower (45MW)	Gibe I-V Dams (Ethiopia) Todonyang-Omo Irrigation (2000ha)	Lowaat Dam (383MCM) Lowaat Irrigation (10000ha)	Malewa Dam (72.7MCM) Nakuru, Gilgil & Naivasha supply	Siyoi-Muruny Dam (17MCM) West Pokot County supply	Radat Dam (135MCM) Perkerra Irrigation (5000ha)	Turkwel Dam (Existing) Turkwel Irrigation (6000ha)	Upper Narok Dam (10MCM) Upper Narok Irrigation (2000ha) Narok supply Flood control	Waseges Dam (5MCM) Waseges Irrigation (470ha)	Amala Dam (175MCM) Amala transfer (82MCM) Oletukat-Olenkuluo Dam (406MCM) & Hydropower (25MW) Leshota Dam (247MCM) & Hydropower (56MW) Oldorko Dam (95MCM) & Hydropower (99MW) Oldorko Irrigation (15000ha) Flood control	Itare Dam (20MCM) Itare transfer (41MCM) Nakuru & Litein (LVS) supply
ENVIRONMENT	Footprint areas	Environmentally sensitive areas	Area (km2)	1.3	0.8	0.0	7.1	0.0	0.0	18.1	0.0	0.0	0.4	4.6	1.0
		Carbon emissions dams	tons	1052	660	0	15534	7906	3606	3700	0	368	177	29151	3840
		Carbon emissions LIR	tons	11650	7767	0	55005	0	0	42360	305895	6403	1660	1128037	0
	Downstream areas	Floodplain area inundated	% change from baseline	-16.67	-98.24	-9.56	-34.64	-7.86	-4.65	-69.75	-50.39	-0.18	-59.06	-26.24	-42.90
		Ecological stress	Index (-5 to 0)	-1.00	-5.00	-5.00	-4.00	-1.00	-2.00	-5.00	-5.00	-2.00	-4.00	-5.00	-3.00
		Wet duration	% change from baseline	-17.16	-88.04	-24.10	-80.45	-4.00	-5.11	-35.21	-64.00	-5.11	-8.27	17.39	-57.70
	Water quality	Phytoplankton growth potential	Average growth potential %	55.74	47.50	0.00	95.37	90.92	65.11	-19.35	0.00	11.89	24.74	72.53	45.35
		Aquatic macrophytes growth potential	Index (-5 to 0)	0.00	-2.00	0.00	-1.00	0.00	0.00	-2.00	-5.00	-1.00	-3.00	-5.00	0.00
SOCIAL	Water availabilit	Riparian users	% change from baseline	-13.29	-97.23	-79.16	-54.66	0.46	-17.90	63.40	-95.93	-34.44	0.00	-84.14	-31.37
	Community heal	Malaria endemicity	Malaria endemicity (km2)	1.12	0.74	1.90	6.22	0.10	0.14	6.45	11.81	0.62	0.25	10.71	0.19
	Food security and livelihoods	Formal irrigation schemes	Area (km2)	20.0	10.0	20.0	100.0	0.0	0.0	50.0	60.0	20.0	4.7	150.0	0.0
		Impact on recession agriculture	% change from baseline	-16.67	-98.24	-9.56	-34.64	-7.86	-4.65	-69.75	-50.39	-0.18	-59.06	-26.24	-42.90
		Fish production (dams/lakes)	Tons/annum	11.39	6.93	0.00	168.64	36.40	17.50	82.08	0.00	15.29	7.86	323.93	15.39
		Change in fish productivity	% change from baseline	-17.16	-88.04	-24.10	-80.45	-4.00	-5.11	-35.21	-64.00	-5.11	-8.27	17.39	-57.70
		Loss of productive land	Area (km2)	0.86	0.57	0.86	4.75	0.81	0.31	8.12	21.34	2.08	1.39	21.76	0.56
		Loss of natural resources	Area (km2)	1.28	0.85	0.00	7.11	0.01	0.00	18.11	0.00	0.00	0.36	4.61	1.03
	Displacement	Physical displacement	Number people	310	205	937	1719	444	90	6359	9018	393	692	6485	243
ECONOMIC	Energy	Avg energy	GWh/annum	149.47	128.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	609.80	0.00
	Food production	Crop production (formal irrigation)	Ton/annum	9120	4420	9800	44500	0	0	22000	52800	8400	2068	71250	0
		Fish production (dams/lakes)	Ton/annum	11.39	6.93	0.00	168.64	36.40	17.50	82.08	0.00	15.29	7.86	323.93	15.39
	Employment	Employment formal irrigation	Number people	7500.00	5000.00	25000.00	35410.00	0.00	0.00	27700.00	62500.00	5000.00	1175.00	37500.00	0.00
		Employment hydropower	Number people	373.67	320.40	0.00	179.05	0.00	0.00	0.00	0.00	0.00	0.00	1524.49	0.00
	Sediment	Volume of dam silted	Index (-5 to 0)	-5.00	-5.00	0.00	-5.00	-3.00	-5.00	-2.00	0.00	-5.00	-5.00	-3.55	-3.00
	Financial	BCR	Ratio	0.89	2.83	0.37	0.30	3.16	2.37	0.33	0.96	2.42	0.28	2.16	1.28
	Flood control	Flood control potential	Ratio (Dam capacity/MAR)	1.07	1.08	0.00	0.70	0.44	0.87	1.26	0.00	0.07	0.09	0.83	0.26
	Water productiv	Water productivity formal irrigation	Million USD/MCM	0.03	0.03	0.09	0.03	0.00	0.00	0.00	0.12	0.06	0.05	0.04	0.00
		Water productivity hydropower	Million USD/MCM	0.27	0.41	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.00
QUALITATIVE	Preparedness for implementation		5 Ready for implementation, 0 Not started	3	0	0	0	2	0	1	0	0	0	0	5
	Public perception/buy-in		5 Full public support, -5 Very contentious	-4	0	-2	0	-3	0	0	0	0	0	-3	-1
	Scale of impact		5 Basin wide and beyond, 1 Very local	2	2	2	1	3	1	2	2	2	1	4	4
	Transboundary and trans-county implications		5 Beneficial, -5 Detrimental	1	2	2	0	1	0	0	0	0	0	3	3
	Potential downstream environmental impact		5 Beneficial, -5 Detrimental	-2	-1	-4	-1	-3	0	-2	-1	0	-1	-4	-1
	Fatal flaw		0 None, -5 Flawed	-2	0	-3	0	-2	0	-3	-1	0	0	-3	-2

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	**Itare Scheme**	*Itare Dam (20MCM)*
		Itare transfer (41MCM)
		Nakuru & Litein (LVS) supply
2	**Turkwel Irrigation Scheme**	*Turkwel Dam (Existing)*
		Turkwel Irrigation (10 000ha)
3	**Upper Narok Scheme**	*Upper Narok Dam (10MCM)*
		Upper Narok Irrigation (2000ha)
		Narok supply
		Flood control
4	**Embobut Scheme**	*Embobut Dam (40MCM)*
		Embobut Irrigation (1000 ha)
		Hydropower (45MW)
5	**Siyoi-Muruny Scheme**	*Siyoi-Muruny Dam (17MCM)*
		West Pokot County supply
6	**Arror Scheme**	*Arror Dam (70MCM)*
		Arror Irrigation (2000 ha)
		Hydropower (60MW)
		Flood control
7	**Malewa Scheme**	*Malewa Dam (72.7MCM)*
		Nakuru, Gilgil & Naivasha supply
8	**Todonyang-Omo Scheme**	*Gibe I-V Dams (Ethiopia)*
		Todonyang-Omo Irrigation (2000 ha)
9	**Amala Scheme**	*Amala Dam (175MCM)*
		Amala transfer (82MCM)
		Oletukat-Olenkuluo Dam (406MCM) & Hydropower (25MW)
		Leshota Dam (247MCM) & Hydropower (56MW)
		Oldorko Dam (95MCM) & Hydropower (99MW)
		Oldorko Irrigation (15000ha)
		Flood control
10	**Waseges Scheme**	*Waseges Dam (5MCM)*
		Waseges Irrigation (470ha)
11	**Lowaat Scheme**	*Lowaat Dam (383MCM)*
		Lowaat Irrigation (10000ha)
12	**Radat Scheme**	*Radat Dam (135MCM)*
		Perkerra Irrigation (5000ha)

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 6-39) 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: RV Basin Water Resources Development Investment Plan

Proposed Infrastructure Development - Water Resources, Hydropower & Large-Scale Irrigation							Expenditure (USD Million)																					
Scheme		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	**53**	**350**																					
Arror	70 MCM; 60 MW	42		●		●	28	189	63	63	63																		
Upper Narok	10 MCM	9	●			●	6	38								6	19	19											
Embobut	40 MCM; 45 MW	26		●		●	18	123													18	62	62						
Inter-basin Transfers							**118**	**787**																					
Itare Dam (LVS) / Transfer to Rift Valley Basin	20 MCM; 41 MCM/a	13	●				45	301	100	100	100																		
Amala Dam (LVS) / Transfer to Rift Valley Basi	175 MCM; 82 MCM/a	68		●			73	486										36	36	162	162	162							
Hydropower							**153**	**1017**																					
Ewaso Ng'iro South (LENSDEP): Oletukat	406 MCM; 25 MW	-		●			86	573																		43	43	287	287
Ewaso Ng'iro South (LENSDEP): Leshota	247 MCM; 56 MW	-		●			40	269															20	20	135	135			
Ewaso Ng'iro South (LENSDEP): Oldorka	95 MCM; 99 MW	-		●		●	26	175											13	13	88	88							
Dams - water supply (domestic)							**27**	**177**																					
Malewa	73 MCM	28	●				22	146				11	11	49	49	49													
Siyoi-Muruny	17 MCM	9.6	●				5	31		5	10	10	10																
Dams - large scale irrigation							**80**	**534**																					
Lowaat	383 MCM	226				●	58	386									29	29	129	129	129								
Radat	135 MCM	81				●	19	127							10	10	42	42	42										
Waseges	5 MCM	3.1				●	3	21			3	11	11																
Small dams / pans & Boreholes							**33**	**221**																					
Dams and pans	61 MCM	-	●				22	148	11	11	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
Groundwater (Boreholes)	153 MCM/a	-	●				11	73	5	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Large Scale Irrigation Schemes (excl. dams)							**133**	**886**																					
Arror	2 000 ha	-				●	6	39		6	13	13	13																
Expand Turkwel Dam	Expand by 4 000 ha	-				●	9	59	4	4	20	20	20																
Turkwel Sugar	6 000 ha	-				●	18	118		9	9	39	39	39															
Upper Narok	2 000 ha	-				●	6	39										6	39										
Lower Ewaso Ng'iro South	15 000 ha	-				●	44	296												22	22	49	49	49	49	49	49		
Embobut	1 000 ha	-				●	3	20														3	10	10					
Waseges	470 ha	-				●	1	4				1	2	2															
Todonyang-Omo	2 000 ha	-				●	6	39							3	3	13	13	13										
Lowaat	10 000 ha	-				●	30	197										15	15	66	66	66							
Perkerra	Expand by 5 000 ha	-				●	11	74							6	6	25	25	25										
								O&M Cost	4	8	14	16	19	21	23	24	27	30	37	46	57	68	71	73	78	83	84	92	99
								Total Annual Cost (USD Million)	**188**	**212**	**244**	**133**	**137**	**123**	**101**	**108**	**167**	**227**	**361**	**449**	**553**	**509**	**224**	**164**	**273**	**321**	**188**	**390**	**397**

6.9.7 Strategy

In order to comprehensively and systematically address the water resources development challenges in the RV 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 with regard to 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 take into account 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 and to improve the reliability of supply, will require significant storage of water during the wet seasons – specifically as part of the water supply to urban centres and for the large-scale irrigation schemes being planned. The proposed 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	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		
8.3.4	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.		
8.3.4	Inter-basin transfers	
The Itare Dam and Amala Dam transfers into the RV Basin (from the LVS Basin) should be implemented in		

8. Key Strategic Area		Water resources development
accordance with the LVS Basin Plan.		
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	
Many of the proposed large dams in the RV Basin will be used for hydropower generation.		
8.5.2	Small-scale hydropower development	
The upper catchment areas in the RV Basin offer opportunities for small-scale hydropower development and this should be investigated in more detail.		
8.6	**Theme:**	**Water for agriculture**
8.6.1	Large scale irrigation development: Develop new / expand existing irrigation schemes. Limit to max sustainable areas	
Significant large-scale irrigation development can be accommodated in the RV Basin, provided that large dams are implemented. The potential environmental impact of these schemes on the downstream lakes need to be investigated in more detail.		
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 improved due to the significant socio-economic benefits associated with this. Water supply should be improved and/or expanded by means of storage (small dams) 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.		
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 dams, especially at dams situated close to major cities.		
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.		
8.8.2	Reuse	
Re-use is not considered to be an option for water supply in the basin at this stage.		
8.8.3	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.		
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 Basin to inform		

8. Key Strategic Area	Water resources development
decisions 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 RV 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 RV 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 RV 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 RV 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 RV 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 RV 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 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 RV 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 RV Basin is aligned with the overall vision for the Basin and focusses on ensuring *a model and sustainable basin providing equitable, adequate and high-quality water and ecological services for socio-economic development by 2040.* The aim of the Plan is focused upon the incremental strengthening of the institutional frameworks to enable improved water resource governance within the RV 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		

9	Key Strategic Area:	Strengthen the Institutional Frameworks
regulatory approaches utilised by the WRA. This will include a number of 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	
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		

9	Key Strategic Area:	Strengthen the Institutional Frameworks
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 RV Basin, together with the need to support 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	Key Strategic Area:	Strengthen the enabling environment to support institutions
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.

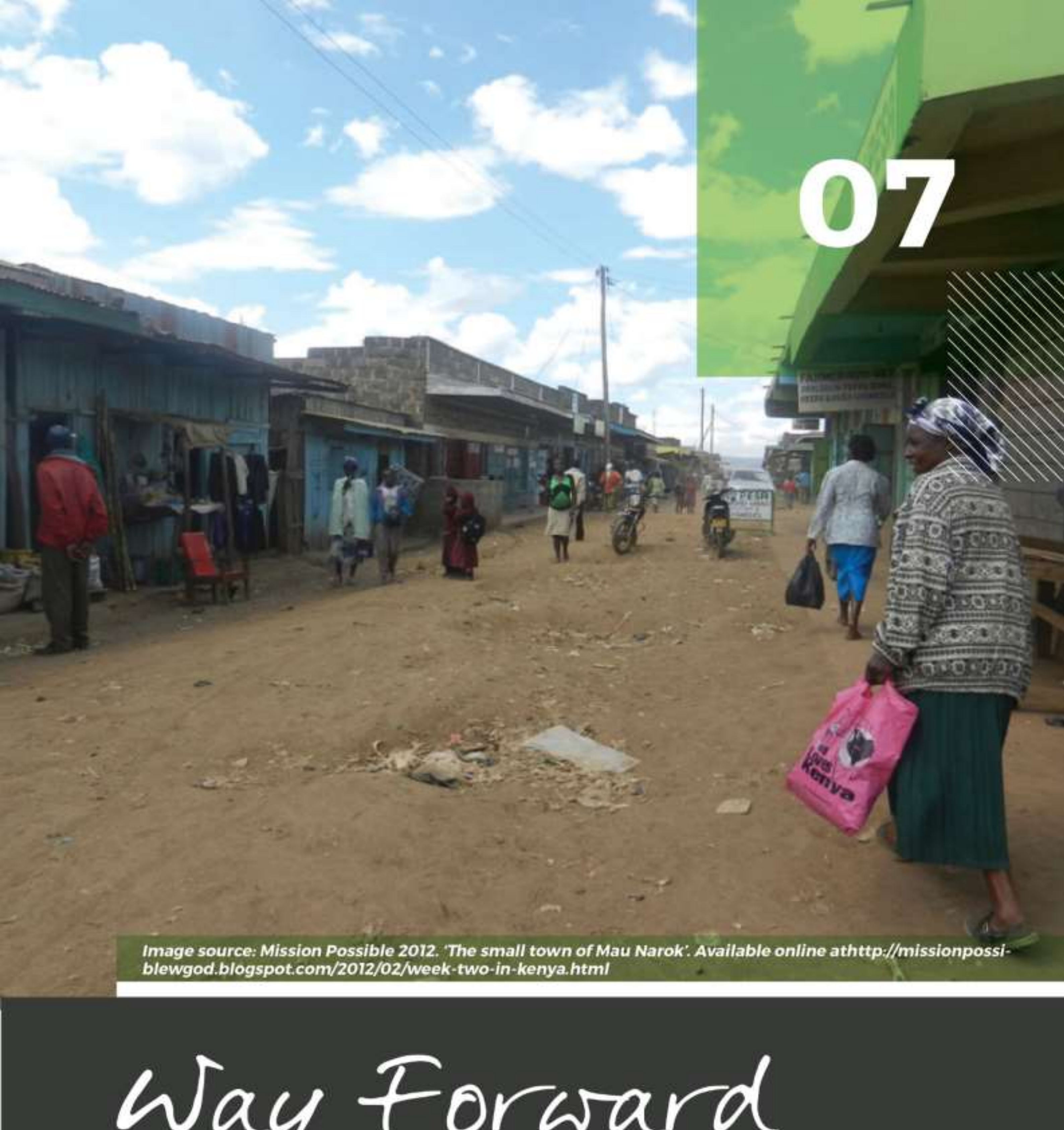

Image source: Mission Possible 2012. 'The small town of Mau Narok'. Available online athttp://missionpossiblewgod.blogspot.com/2012/02/week-two-in-kenya.html

07

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 Monitoring and Evaluation (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 RV Basin relate to the successful implementation of large-scale water resources and related infrastructure to support socio-economic development in the basin through improving water availability and assurance of supply for current and projected future water use in the basin, while taking into consideration environmental sustainability. Environmental sustainability is especially important in the RV Basin, where all the major rivers discharge into lakes which are internationally recognised for their ecological importance, while they also offer significant socio-economic value.

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. Whilst the analyses confirmed that the proposed developments, with a planning horizon of 2040, are feasible from a water balance and assurance of supply perspective, a key recommendation is that specialist studies are required to determine the environmental flow requirements of the lakes and to assess mitigation measures with regard to upstream developments.

The essence of the proposed water resources development plan for the RV Basin, up to 2040, is to expand irrigation in the basin in line with water availability, especially in the Turkwel, Kerio, Perkerra and Ewaso Ng’iro South catchments as well as next to Lake Turkana; to ensure a reliable supply of water to meet the expected growth in urban water demands; to increase hydropower production in the basin; to implement the identified schemes which will export water from the Lake Victoria South Basin to the RV 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. 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 should be implemented 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 RV Basin and unlock the value of water as it relates to socio-economic development, ten key strategic areas were formulated for the RV 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 RV Basin Plan provide various synergies with the SDGs. Furthermore, it is important to note that the successful implementation of the RV 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 RV 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.

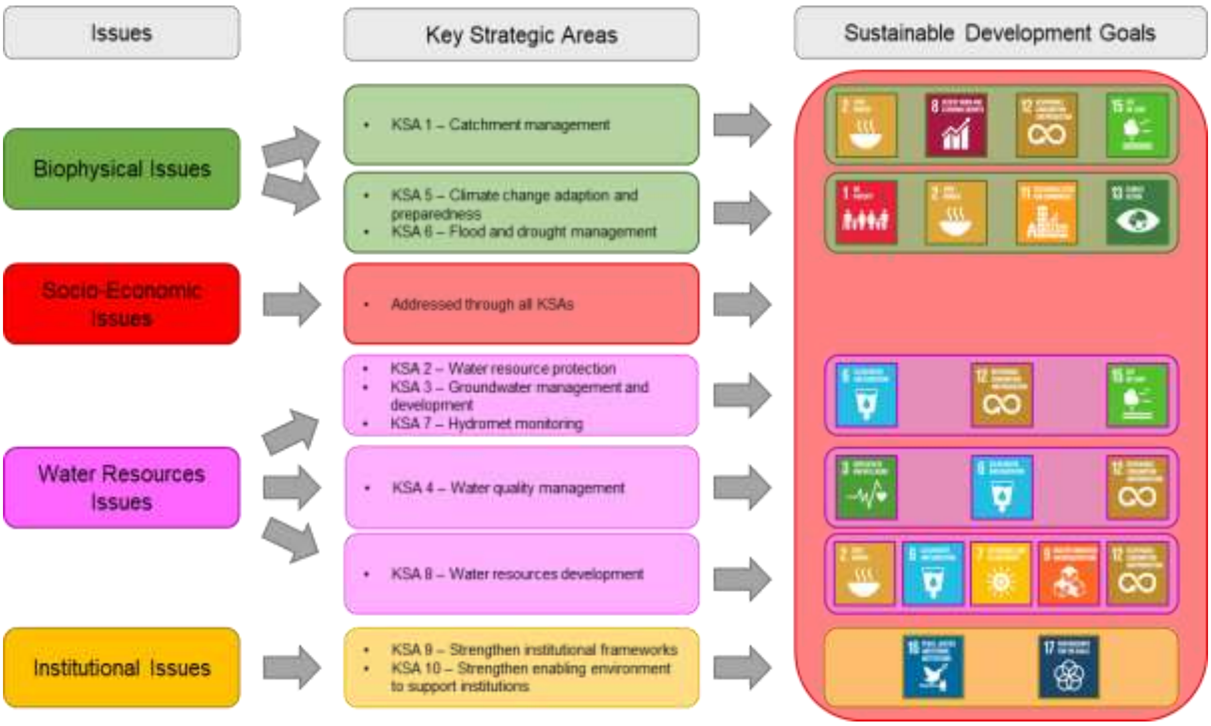

Figure 7-1: Integration of the SDGs into the RV Basin Plan

7.3.2 Linkages with other plans

This RV Basin Plan provides a vision and framework for the development and management of the water and related land resources of the RV Basin. Essentially it reinforces the RV 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 CIDPs are linked and synchronised with the overall basin planning initiatives. Relevant Regional Development Authorities (KVDA and ENSDA) as well as the Water Works Development Agencies (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 RV to be coordinated, key institutions linked to implementation need to be strengthened, 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 in Figure 7-2 and provide a roadmap to take the implementation of the Basin Plan forward. The following four sub chapters deal with each of these steps.

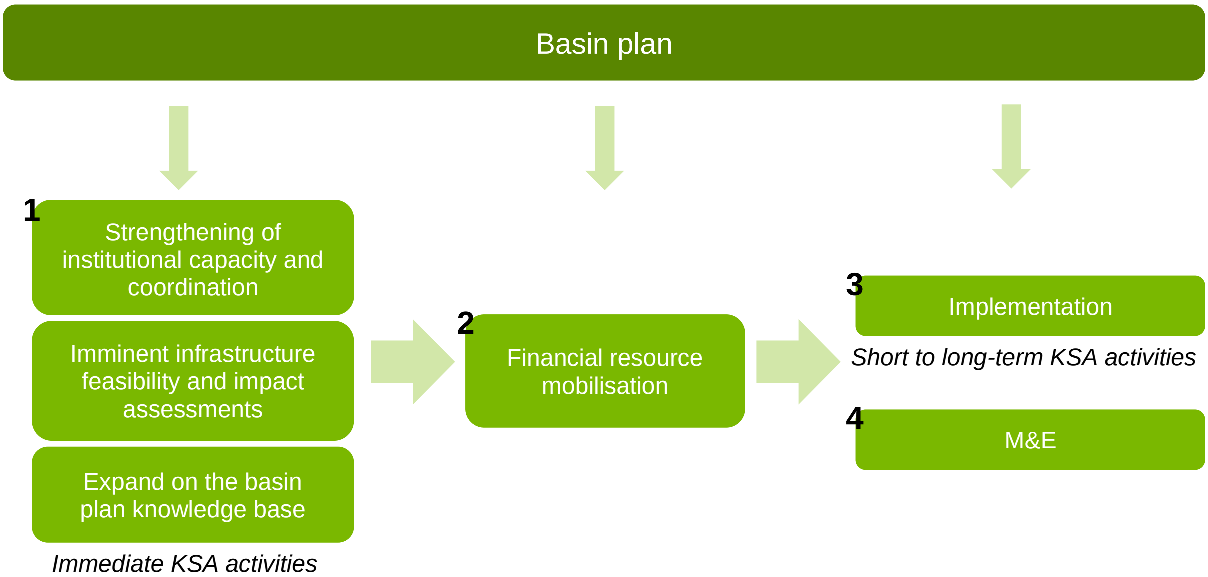

Figure 7-2: Roadmap for implementation of the Basin Plan

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 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 (refer to Table 7-1).

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 RV basin, feasibility and impact studies should begin immediately for projects which have been identified for imminent implementation. 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 the three areas describes during the previous section. 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 and developing strong knowledge bases, finances will be more easily mobilised for future activities. These immediate activities are also relatively cheap in comparison to the total budget of each KSA, as is shown in Table 7-2.

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 RV Basin (conducted prior to Reserve and RQO determination) - Determine the Reserve for prioritised water resources in the RV Basin (note Reserve required for RQOs) - Determine the Resource Quality Objectives for prioritised water resources in the RV Basin		
KSA 3 Groundwater management		**15 %**
- Implement aquifer mapping and groundwater modelling across the RV 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 - Develop groundwater allocation plan for strategic aquifers: Lotikipi Basin and Napuu - Undertake groundwater balance to determine sustainable yield available - For each aquifer in the basin, develop Allocation Plan and disaggregate to sub-basins		

KSA	Priority activities (immediate)	% of total KSA budget
- Implement groundwater abstraction schemes in accordance with groundwater development planning		
KSA 4 Water quality management		**2 %**
- Implement national water quality monitoring programme in the RV 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 RV 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 RV Basin. - Embed water quality management activities related to domestic water use, crop and livestock production in SCMPs		
KSA 5 Climate change adaptation and preparedness		**12 %**
- 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 - Assess potential social impacts: flooding; droughts; human conflict; migration; vulnerable groups; ocean acidification; agriculture; food production - Assess potential social impacts: flooding; droughts; human conflict; migration; vulnerable groups; ocean acidification; agriculture; food production - 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 RV Basin Flood Response Forum (FRF) under the auspices of the KMD to integrate all flood-relevant resource mobilisations and related interventions in the RV Basin. - Establish a Secretariat for the RV Basin FRF with accommodation in the WRA Regional Office. - Develop appropriate SOPs for the RV Basin FRF. - Organisational alignment/ collaboration: The RV Basin Flood Response Forum (FRF) will expand organisational capacity in the RV 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 RV Basin Drought Response Forum with accommodation in the Offices of one of the drought-prone counties. - The NDMA issues regular Drought Early Warning Bulletins for ASAL counties. In the RV Basin, Bulletins are issued for the Baringo, West Pokot, Samburu, Laikipia, Turkana and Marsabit counties. - Organisational alignment/ collaboration: RV Basin Drought Response Forum 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 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.		

KSA	Priority activities (immediate)	% of total KSA budget
- 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 Siyoi-Muruny and Arror 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 - Phased design and construction of identified small dams / pans: 61 MCM total storage - Implement one inter-basin water transfer: Itare Dam (LVS Basin) to RV Basin - Implement two large scale irrigation schemes: Development of Turkwel Sugar and expansion of Turkwel Dam		
KSA 9 Strengthen the Institutional Frameworks		**41 %**
- 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 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		

KSA	Priority activities (immediate)	% of total KSA budget
- 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.

Section 7.4.1 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. Section 7.4.1 also outlined the important role that good scientific studies and feasibility and impact assessments play for leveraging financing.

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 facilities, 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 RV 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 individual activities are provided (summarised in Table 7-3) with possible funding sources per activity identified
- corresponding CMS Strategic Actions are linked to each activity as applicable

7.4.4 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 RV Basin Plan and achievements should be done based on 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	6.5	32.6	29.0	21.2	**89**
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	16.0	30.4	22.6	40.3	**109**
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	4.1	25.6	71.9	95.8	**197**
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	11.0	10.7	7.1	**33**

Key Strategic Areas and Themes		Budget (USD Million)				
		2020-2022	2022-2025	2025-2030	2030-2040	Total
KSA 6	**Flood and drought management** - Flood management - Drought management	6.4	35.2	3.9	6.8	**52**
KSA 7	**Hydromet monitoring** - Improved monitoring network - Improved information management	1.0	13.1	5.8	6.0	**29**
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	255	403	939	2439	**4 036**
KSA 9	**Strengthen Institutional frameworks** - Promote improved and sustainable catchment management - Guidelines, codes of practice and manuals	5.3	2.6	2.9	2.0	**13**
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		**301**	**563**	**1 095**	**2 626**	**4 585**

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 an 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: Magical Kenya 'Rift Valley, Kenya'. Available online at http://www.magicalkenya.com/places-to-visit/highlands-and-valleys/rift-valley/

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 (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 RV 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 to ensure successful implementation. However, 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 RV 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 RV Basin.

9 References

Agriculture and Food Authority. (2017). *2017/18 – 2021/22 Strategic Plan*.

Akinyi, O. M. (2013). *Factors Influencing the use of Deflouridated Water in Nakuru Town: A Case Study of Catholic Diocese of Nakuru Water Quality Program*. University of Nairobi.

Allen, D. J., & Darling, W. G. (1992). *Geothermics and hydrogeology of the Kenya Rift Valley between Lake Baringo and Lake Turkana - British Geological Survey Research Report SD/92/1*.

Allen, D. J., Darling, W. G., & Burgess, W. G. (1989). *Geothermics and hydrogeology of the southern part of the Kenya Rift Valley with emphasis on the Magadi-Nakuru area: Research Report SD/89/1*.

Allen, R. G., Pereira, L. S., Raes, D., & Smith, M. (1998). *Crop evapotranspiration —guidelines for computing crop water requirements. FAO Irrigation and drainage paper 56*.

Asala, L. (2017). *Site Suitability Mapping of Water Harvesting Structures using GIS and Remote Sensing - Case Study: Machakos County*. University of Nairobi.

Baker, B. H. (1958). *Geology of the Magadi Area: Report No. 42*.

Baker, B. H. (1963). *Geology of the south area of Magadi: Report No. 61*.

Baumann, P., Ernst, E., & Woods, L. (2017). Surface Geophysical Exploration for Groundwater at the Kakuma Refugee Camp in Turkana County, Kenya. *CSEG Recorder*.

Becht, R., Mwango, F., & Muno, F. A. (2006). Groundwater links between Kenyan rift valley lakes. *Proceedings of the 11th World Lakes Conference*, 7–14.

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*.

Colvin, C., Cave, L., & Saayman, I. (2004). *A Functional Approach to Setting Resource Quality Objectives for Groundwater Report No. 1235/1/04*.

Commission on Revenue Allocation. (2013). *Kenya County Fact Sheets*.

County Government of Baringo. (2018). *Second County Integrated Development Plan 2018-2022*.

County Government of Elgeyo Marakwet. (2018). *County Integrated Development Plan (CIDP) 2018-2022*.

County Government of Kajiado. (2018). *County Integrated Development Plan 2018-2022*.

County Government of Kiambu. (2018). *County Integrated Development Plan 2018-2022*.

County Government of Laikipia. (2018). *Second County Integrated Development Plan*.

County Government of Marsabit. (2018). *Second Integrated Development Plan 2018-2022*.

County Government of Nakuru. (2018). *Nakuru County Integrated Development Plan 2018-2022*.

County Government of Narok. (2018). *County Integrated Development 2018-2023*.

County Government of Nyandarua. (2018). *Second Integrated Development Plan 2018 - 2022*.

County Government of Samburu. (2018). *Second County Integrated Development Plan 2018 - 2022*.

County Government of Turkana. (2018). *County Integrated Development Plan, 2018-23*.

County Government of West Pokot. (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)*.

Davies, R. (2017). *Kenya – Deadly Floods in Mombasa After 235mm of Rain, Thousands Displaced in Taveta*. Flood List. http://floodlist.com/africa/kenya-mombasa-may-2017

Department for International Development. (2001). *Water Resources and Utilisation Assessment Main Report (Final)*.

Department of Water Affairs. (2007). *Development of the water resource classification system: overview and 7-step classification procedure*.

Department of Water Affairs. (2011). *Procedures to develop and implement Resource Quality Objectives*.

Development Initiatives. (2017). *Assessment of Kenya's preparedness to disasters caused by natural hazards: floods, drought and disease outbreak*.

Diocese of Lodwar. (n.d.). *Phase Two of the Turkana Water Project Final Report - Diocese of Lodwar, Lodwar, Kenya (late 1980s)*.

Dulo, S., & Odira, M. (2018). *Network Analysis of Lodwar's Piped Water Infrastructure - Presentation* *at the REACH Turkana Stakeholder Meeting on Climate Resilience, Water Services and Poverty in Kenya, Thursday 15 February, 2018, The Cradle, Lodwar Town, Kenya*.

Dunkley, P. N., Smith, M., Allen, D. J., & Darling, W. G. (1993). *The geothermal activity and geology of the northern sector of the Kenya Rift Valley - British Geological Survey Research Report SC/93/1*.

East African Community. (2018). *Protocol on Environment and Natural Resources Management*. https://www.eac.int/environment/natural-resources-management/protocol-on-environment-and-natural-resource-management. Arusha, August 2018

Eugster, H. P. (1970). Chemistry and Origin of the Brines of Lake Magadi, Kenya. *Mineralogical Society of America*, *Spec. Pap.*(3), 213–235.

Fabreau, G. E., Bauman, P., Coakley, A. L., Johnston, K., Kennel, K. A., Gifford, J. L., Sadrzadeh, H. M. H., Whitford, G. M., Whyte, M. P., & Kline, G. A. (2019). Skeletal fluorosis in a resettled refugee from Kakuma refugee camp. *The Lancet*, *393*(10168), 223–225. https://doi.org/10.1016/S0140-6736(18)32842-3

Foster, S. S. D. (2000). *Sustainable Groundwater Exploitation for Agriculture: Current Issues and Recent Initiatives in the Developing World* (A, No. 6).

Gathura, G. (2015, September 20). Scientists warn El Nino to be worse than 1997/98. *The Standard*. https://www.standardmedia.co.ke/article/2000176966/scientists-warn-el-nino-to-be-worse-than-1997-98

Geothermal Development Company (GDC). (2019). *Annual Report and Financial Statements for the year ended 30 June 2018*.

Gevera, P., & Mouri, H. (2018). Natural occurrence of potentially harmful fluoride contamination in groundwater: an example from Nakuru County, the Kenyan Rift Valley. *Environmental Earth Sciences*, *77*, 19.

GIBB Africa Ltd. (2004). *Study of the Merti Aquifer - Technical Report Issue 2.0*.

Gicheruh, C. M. N. (2015). *Hydrogeological and Geophysical Investigation - Kalobeyei New Refugee Camp Water Project, Kalobeyei Location, Turkana West District, Turkana County, Kenya*.

Gitahi, S. M., Harper, D. M., Muchiri, S. M., Tole, M. P., & Ng'ang'a, R. N. (2002). Organochlorine and organophosphorus pesticide concentrations in water, sediment, and selected organisms in Lake Naivasha (Kenya). *Hydrobiologia*, *488*(1), 123–128. https://doi.org/10.1023/A:1023386732731

Gitiligini Ltd. (2010). *Hydrochemistry and Hydrogeology of the Ewaso Kedong Spring*.

Global Water Partnership. (2006). *Policy Brief 4: How IWRM Will Contribute to Achieving the MDGs*.

Government of Kenya. (1988). *Geological map of Longonot Volcano, the Greater Olkaria and Eburru Volcanic Complexes, and Adjacent Areas*.

The Fisheries Act, Pub. L. No. Cap. 378 of 1989 (1989).

Government of Kenya. (1999). *Sessional Paper No. 1 of 1999 on National Policy on Water Resources Management and Development*.

The Environmental Management and Co-ordination Act, Pub. L. No. Cap. 387 (1999).

The Water Act, Pub. L. No. Cap. 372 (2002).

Government of Kenya. (2003). *Economic Recovery Strategy for Wealth and Employment Creation 2003-2007*.

The Forests Act, Pub. L. No. Cap. 385 (2005).

Environmental Management and Co-ordination (Water Quality) Regulations, (2006).

The Energy Act, Pub. L. No. Cap. 314 (2006).

Government of Kenya. (2006). *The National Water Resources Management Strategy*.

Government of Kenya. (2007a). *Kenya Vision 2030*.

Government of Kenya. (2007b). *The Water Resources Management Rules*.

Government of Kenya. (2009). *Interim Report on Irrigation and Drainage Master Plan, 2009*.

Government of Kenya. (2010a). *Agricultural Sector Development Strategy 2010-2020*.

The Constitution of Kenya, (2010).

Government of Kenya. (2010b). *The National Climate Change Response Strategy*.

Government of Kenya. (2012). *Government of Kenya Adaptation Technical Analysis Report*.

The Water Resources Management (Amendment) Rules, (2012).

Government of Kenya. (2013a). *National Environment Policy*. Ministry of Environment, Water and Natural Resources. www.environment.go.ke

The Agriculture, Fisheries and Food Authority Act, Pub. L. No. 13 of 2013 (2013).

The Crops Act, Pub. L. No. 16 of 2013 (2013).

The Irrigation Act, (2013).

Government of Kenya. (2013b). *The National Climate Change Action Plan 2013-2017*.

The Natural Resources (Benefit Sharing) Bill, 587 (2014) (testimony of Government of Kenya).

Government of Kenya. (2015). *National Energy and Petroleum Policy - Final*. Government of Kenya.
Government of Kenya. (2016). *Kenya National Adaptation Plan 2015-2030*.
The Climate Change Act, Pub. L. No. 43 of 2016 (2016).
The Forest Conservation and Management Act, Pub. L. No. 34 of 2016 (2016).
The Water Act, Pub. L. No. 43 of 2016 (2016).
Government of Kenya. (2017a). *Ending Drought Emergencies in Kenya - Progress Report*.
Government of Kenya. (2017b). *Sector Plan for Environment, Water and Sanitation 2018-2022 (Draft of 13th of June 2017)*.
Government of Kenya. (2018). *The National Climate Change Action Plan 2018-2022*.
The Natural Resources (Benefit Sharing) Bill, 561 (2018) (testimony of Government of Kenya).
The Irrigation Act, Pub. L. No. 14 of 2019 (2019).
The National Disaster Management Authority Bill, 75 (2019) (testimony of Government of Kenya).
Government of Kenya, Royal Danish Embassy, & Norwegian Embassy. (2010). *In Search of Protection and Livelihoods - Socio-economic and Environmental Impacts of Dadaab Refugee Camps on Host Communities*.
Hackman, B. D., Ridgway, J., & Bundle, C. C. (1988). *Geology of the Baringo-Laikipia Area (1: 250,000) - Report No. 104, Geological Survey of Kenya, Nairobi*.
Harper, D. M., Childress, R. B., Harper, M. M., Boar, R. R., Hickley, P., Mills, S. C., Otieno, N., Drane, T., Vareschi, E., Nasirwa, O., Mwatha, W. E., Darlington, J. P. E. C., & Escuté-Gasulla, X. (2003). Aquatic biodiversity and saline lakes: Lake Bogoria National Reserve, Kenya. *Hydrobiologia*, *500*(1), 259–276. https://doi.org/10.1023/A:1024722821407
Huho, J. M., Mashara, J. N., & Musyimi, P. K. (2016). Profiling Disaster in Kenya and their Causes. *Academic Research International*, *7*(1), 290–305.
ILEC, UNEP-DHI, UNESCO-IHP, UNESCO-IOC, & UNEP. (2015). *Water System Information Sheets: Eastern & Southern Africa*.
Indeje, M., Semazzi, F. H. M., Xie, L., & Ogallo, L. J. (2001). Mechanistic Model Simulations of the East African Climate Using NCAR Regional Climate Model: Influence of Large-Scale Orography on the Turkana Low-Level Jet. *Journal of Climate*, *14*(12), 2710–2724. https://doi.org/10.1175/1520-0442(2001)014<2710:MMSOTE>2.0.CO;2
Institute of Economic Affairs. (2015). *Situational Analysis of Energy Industry, Policy and Strategy for Kenya*.
Institute of Hydrology. (1985). Groundwater conditions in Baringo District, Kenya. *Institute of Hydrology*, 26.
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*.
International Groundwater Resources Assessment Centre. (2013). *Review of the Report Advanced Survey of Groundwater Resources of Northern and Central Turkana County, Kenya*.
Jones, A., Breuning-Madsen, H., Brossard, M., Dampha, A., Deckers, J., Dewitte, O., Gallali, T., Hallett, S., Jones, R., Kilasara, M., Le Roux, P., Micheli, E., Montanarella, L., Spaargaren, O., Lamourdia, T., Van Ranst, E., Yemefack, M., & Zougmore, R. (2013). *Soil Atlas of Africa*.
Kenya Bureau of Standards. (2007). *Drinking Water – Specification, Part 1: The Requirements for Drinking Water (KS 459-1:2007)*.
Kenya Bureau of Standards. (2010). *Excess Fluoride in Water in Kenya - Report of the Consultative Committee on Excess Fluoride in Water*.
Kenya National Bureau of Statistics. (2009). *The 2009 Kenya Population and Housing Census*.
Kenya National Bureau of Statistics. (2019). *2019 Kenya Population and Housing Census Volume I: Population by County and Sub-County*. https://www.knbs.or.ke/?wpdmpro=2019-kenya-population-and-housing-census-volume-i-population-by-county-and-sub-county
Key, R. M., & Ridgway, J. (1987). *Geology of the Maralal Area (Reconnaissance, 1: 250,000) - Report No. 105*.
Kirianki, P. R., Muchiri, E., & Potgieter, N. (2018). Physico-chemical quality of drinking water in the Njoro sub-county in Kenya. *Journal of Water, Sanitation and Hygiene for Development*, *8*(3), 497–507. https://doi.org/10.2166/washdev.2018.001
Kiruki, S., Limo, M., Eliud, N., Nyaga, M., & Paul, O. (2011). Bacteriological quality and diarrhoeagenic pathogens on River Njoro and Nakuru Municipal water, Kenya. *Int J Biotechnol Mol Biol*, *2*.
Kusek, J. Z., & Rist, R. C. (2004). *A Handbook for Development Practitioners: Ten Steps to a Results-Based Monitoring and Evaluation System*.

Lane, I. M. (1995). *A Preliminary Assessment of the Hydrogeology and Hydrochemistry of the Merti Aquifer (North Eastern Province, Kenya: and Lower Juba, Somalia)*. University College, London.
Levine, S., & Pavanello, S. (2012). *Rules of the Range - Natural resources management in Kenya-Ethiopia border areas: HPG Policy Brief 45*.
McCall, G. J. H. (1958). *Geology of the Gwasi Area - Report No. 45*.
McCall, G. J. H. (1967). *Geology of the Nakuru-Thomson's Falls Area (1:125,000). Report 78*.
Met Office. (2011). *Climate: Observations, projections and impacts - Kenya*.
Ministry of Energy. (2004). *Sessional Paper No.4 of 2004 on Energy*.
Ministry of Energy and Regional Development. (1987). *Geological Map of Kenya (1: 1,000,000 scale)*.
Ministry of Environment and Natural Resources. (2014). *The Forest Policy*.
Ministry of Lands and Physical Planning. (2017). *Sessional Paper No. 1 of 2017 on National Land Use Policy*.
Ministry of Water and Irrigation. (2005). *Practice Manual for Water Supply Services in Kenya*.
Ministry of Water and Irrigation. (2009). *Draft National Policy on Trans-Boundary Waters*.
Ministry of Water and Irrigation. (2012). *National Water Quality Management Strategy (NWQMS) (2012 – 2016)*.
Ministry of Water and Irrigation. (2013). *The National Policy Groundwater Resources Development and Management - Final*.
Ministry of Water Development. (1991). *Samburu District Water Development Study 1993 – 2013: Part 1 Water Demand and Water Resources, Water Resources Assessment Project (WRAP)*.
Mogaka, H., Gichere, S., Davis, R., & Hirji, R. (2005). *Climate Variability and Water Resources Degradation in Kenya. Improving Water Resources Development and Management* (Working Paper No. 69).
Mohammedjemal, A. (2006). *Assessment of artificial groundwater recharge using greenhouse runoff (north east Naivasha, Kenya)*. International Institute for Geo-Information Science and Earth Observation.
Mumma, A., Lane, M., Kairu, E., Tuinhof, A., & Hirji, R. (2011). Kenya Groundwater Governance Case Study. In *Water Papers* (Vol. 71726). 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 A. Tuinhof & J. P. Heederik (Eds.), *Management of aquifer recharge and subsurface storage: making better use of our largest reservoir* (Internatio). Utrecht: Netherlands National Committee for the IAH.
Mwangi, K., & Mutua, F. (2015). Modeling Kenya's Vulnerability to Climate Change – A Multifactor Approach. *International Journal of Science and Research*, *3*(9).
National Environment and Management Authority. (2007). *National Sand Harvesting Guidelines 2007*.
Nguta, C. M., Osawa, W. O., Onyari, J. M., & Onyiego, K. B. (2010). Levels of Selected Heavy Metals and Fluoride in Water around Fluorspar Factory in Kerio Valley: Kenya. *Kenya Journal Science of Technology and Innovation*, *1*, 12–21.
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. https://doi.org/10.1016/J.EJRH.2018.03.004
OCHA. (2013). *Eastern Africa: Floods Update (as of 17 May 2013)*.
OCHA. (2018). *Flash Update #6 - Floods in Kenya*.
Ochieng, J. O., & Kagasi, J. (1988). *Geology of the Loiyangalani Area (Reconnaissance, 1: 250,000) - Report No. 107*.
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. https://doi.org/10.1023/A:1014207832471
Olago, D. (2018). Constraints and solutions for groundwater development, supply and governance in urban areas in Kenya. *Hydrogeology Journal*, 1–20. https://doi.org/10.1007/s10040-018-1895-y
Olago, D., Opere, A., & Barongo, J. (2009). Holocene palaeohydrology, groundwater and climate change in the lake basins of the Central Kenya Rift. *Hydrological Sciences Journal*, *54*(4), 655–664. https://doi.org/10.1623/hysj.54.4.765
Olaka, L., Wilke, F., Olago, D., Odada, E., Mulch, A., & Musolff, A. (2016). Groundwater fluoride enrichment in an active rift setting: Central Kenya Rift case study. *Science of The Total Environment*, *545–546*, 641–653. https://doi.org/10.1016/j.scitotenv.2015.11.161
Omwoyo, A., Muthama, N., Opere, A., & Onwonga, R. (2017). Simulating streamflow in response to climate change in the Upper Ewaso Ngiro Catchment, Kenya. *Journal of Climate Change and*

Sustainability, *1*(2), 12–29. https://doi.org/10.20987/jccs.1.02.2017
Oord, A. (2017). *Hydrology and hydrogeology of Sponge City Kajiado, Kenya*.
Opere, A. (2013). Chapter 21 - Floods in Kenya. In Paolo Paron, D. O. Olago, & C. T. Omuto (Eds.), *Kenya: A Natural Outlook* (Vol. 16, pp. 315–330). Elsevier. https://doi.org/https://doi.org/10.1016/B978-0-444-59559-1.00021-9
Paron, P, Olago, D. O., & Omuto, C. T. (2013). Kenya: A Natural Outlook. In J. F. Shroder (Ed.), *Geo-Environmental Resources and Hazards* (Volume 16). Elsevier.
Pickford, M., & Senut, B. (2001). Pickford, M. & Senut, B. The geological and faunal context of Late Miocene hominid remains from Lukeino, Kenya. C.R. Acad. Sci. Paris 332, 145-152. *Comptes Rendus de l'Académie Des Sciences - Series IIA - Earth and Planetary Science*, *332*, 145–152. https://doi.org/10.1016/S1251-8050(01)01528-2
Regional Centre for Mapping of Resources for Development. (2018). *Mapping for Sustainable Development*. https://www.rcmrd.org/
Reliefweb. (2013). *Kenya: Floods - March 2013*. https://reliefweb.int/disaster/fl-2013-000038-ken
Reliefweb. (2018). *Kenya: Drought - 2014-2018*. 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. https://doi.org/10.7343/as-2018-328
Rift Valley Water Services Board. (2016). *Environmental and Social Impact Assessment for Olkalau Town Sewerage Project*.
Saunders, J., Menezes, A., Aguilar-Manjarrez, J., & Matere, J. (2017). *Atlas of aquaculture potential in coastal Kenya*.
Schwartz, H., Shaabani, S., & Walther, D. (1991). *Range Management Handbook of Kenya*. Republic of Kenya, Ministry of Livestock Development, Range Management Division.
Sottas, J. (2013). *Hydrogeological Study of the Aquifer System of Kakuma, Kenya*. Universite de Neuchatel.
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*.
The World Bank. (2008). *Toolkit for monitoring and evaluation of agricultural water management projects*.
Thompson, A. O., & Dodson, R. G. (1963). *Geology of the Naivasha Area: Report No. 55*.
Tullow Oil Kenya. (2019). *Ustawi Newsletter Jan-June 2019, Issue 2*.
UN. (2015). *Sustainable Development Goals*. Sustainable Development Goals Knowledge Platform. https://sustainabledevelopment.un.org/sdgs
UNDP. (2011). *Human Development Report 2011 - Sustainability and Equity: A Better Future for All*.
UNHCR. (n.d.). *Kakuma Camp and Kalobeyei Settlement Visitor's Guide*.
Wafula, P. (2010, July 16). Lack of investment in water sector leaves Kenyan towns parched. *Business Daily*. https://www.businessdailyafrica.com/news/539546-958756-pssc71/index.html
Wambu, E. W., & Muthaki, G. K. (2011). High Fluoride Water in the Gilgil Area of Nakuru County, Kenya. *Fluoride: Research Report*, *44*(1), 37–41.
Wangati, F. J., & Said, M. Y. (1997). *National Land Degradation Assessment and Mapping in Kenya*.
Water and Sanitation for the Urban Poor. (2011). *Business models for delegated management of local water services: experience from Naivasha (Kenya)*.
Water Resources Authority. (2018a). *Code of Practice for Borehole Construction*.
Water Resources Authority. (2018b). *Code of Practice for the Pumping Test of Boreholes*.
Water Resources Authority. (2018c). *Code of Practice for the Siting of Boreholes*.
Water Resources Authority. (2018d). *Exploratory BH4 Lokichar Drilling Supervision Report*.
Water Resources Authority. (2018e). *Exploratory BH4 Loperot (Kaesomalit) Drilling Supervision Report*.
Water Resources Authority. (2018f). *Water Resources Situation Report, July 2017 to June 2018*.
Water Resources Authority. (2019a). *Guidelines for the Development of Water Allocation Plans in Kenya (Draft)*.
Water Resources Authority. (2019b). *Hydrogeological Mapping of Turkana Aquifers; Technical Aquifer Mapping Report, Turkana (Draft)*.
Water Resources Authority. (2019c). *National Groundwater Potential Report IR2 VOLUME 4A*.
Water Resources Management Authority. (1992). *The Study on the National Water Master Plan*.
Water Resources Management Authority. (2006). *Groundwater Protection – Proposal for a National Policy*.
Water Resources Management Authority. (2007a). *Guidelines for Artificial Groundwater Recharge*

(Draft).

Water Resources Management Authority. (2007b). *Permit database - Database used in determining allocation thresholds for Athi catchment groundwater permit applications*.

Water Resources Management Authority. (2007c). *Water Resources Allocation Thresholds for Classification of Permits - First Edition*.

Water Resources Management Authority. (2010). *Preliminary Water Allocation Plan of the Nairobi Aquifer Suite, and Long Term Water Resources Management Strategy*.

Water Resources Management Authority. (2013). *The National Water Master Plan 2030*.

Water Resources Management Authority. (2015a). *Annual Water Resources Situation Report 2014-2015*.

Water Resources Management Authority. (2015b). *Rift Valley Catchment Area Catchment Management Strategy (CMS) (2015-2022)*.

Water Resources Management Authority. (2016). *National Water Resources Situation Report for FY2015/2016*.

Water Services Regulatory Board. (2018). *Impact Report Issue No. 11/2019 - A Performance Review of Kenya's Water Services Sector - 2017/18*.

Wescott, W. A., Morley, C. K., & Karanja, F. M. (1993). Geology of the "Turkana Grits" in the Lariu range and Mt. Porr areas, southern Lake Turkana, Northwestern Kenya. *Journal of African Earth Sciences (and the Middle East)*, *16*(4), 425–435. https://doi.org/10.1016/0899-5362(93)90101-U

Wiesmann, U., Kiteme, B., & Mwangi, Z. (2016). *Socio-Economic Atlas of Kenya: Depicting the National Population Census by County and Sub-Location*.

Xiong, J., Thenkabail, P. S., Tilton, J. C., Gumma, M. K., Teluguntla, P., Congalton, R. G., Yadav, K., Dungan, J., Oliphant, A. J., Poehnelt, J., Smith, C., & Massey, R. (2017). NASA Making Earth System Data Records for Use in Research Environments (MEaSUREs) Global Food Security-support Analysis Data (GFSAD) @ 30-m Africa: Cropland Extent Product (GFSAD30AFCE). In *NASA EOSDIS Land Processes DAAC*. https://doi.org/10.5067/MEaSUREs/GFSAD/GFSAD30AFCE.001

10 Annexures

Annexure A: Analytical tools

Annexure B: Data at sub-basin level

Annexure C: Stakeholder information

Annexure D: Basin Planning: Policies, legislation and institutions

Annexure E: Implementation Plans

Annexure F: Costing

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A1: Erosion risk

Erosion risk in the Rift Valley (RV) 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 RV Basin was developed, which calculates the mean annual gross soil erosion at a cell level as the product of six factors:

$$A = R_i \times K_i \times L_i \times S_i \times C_i \times P_i \qquad (1)$$

where:

subscript $i = i^{th}$ cell

A_i = the average annual soil loss per unit area within the cell ($t \cdot ha^{-1} \cdot yr^{-1}$)

R_i = rainfall-runoff erosivity factor ($MJ \cdot mm \cdot ha^{-1} \cdot h^{-1} \cdot yr^{-1}$)

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, rainfall erosivity is low to moderate in most of the Basin.

Soil erodibility

A second key driver of erosion relates to soil characteristics. The geology of the Basin is made up of Quaternary sediments, Tertiary and Quaternary volcanics and Basement rocks. The formation of this geology is characterised by volcanic activity, brittle faulting and large half graben systems filled with river and lake sediments. This is linked to the soil erodibility that is found across most of the Basin.

Topography

There are steeper slopes associated with the hills and mountain footridges across the Basin, with gentler slopes in valleys and plains.

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 an important control over vegetation growth. Most of the dense vegetation cover occurs on hilltops and has a low cover factor (i.e. high vegetation cover). The lower Basin has a high cover factor (i.e. limited vegetation cover).

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)

	Factor	Input / Reference Data	Data type (Extent)	Resolution (arc-seconds)	Parameters used / derived
	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

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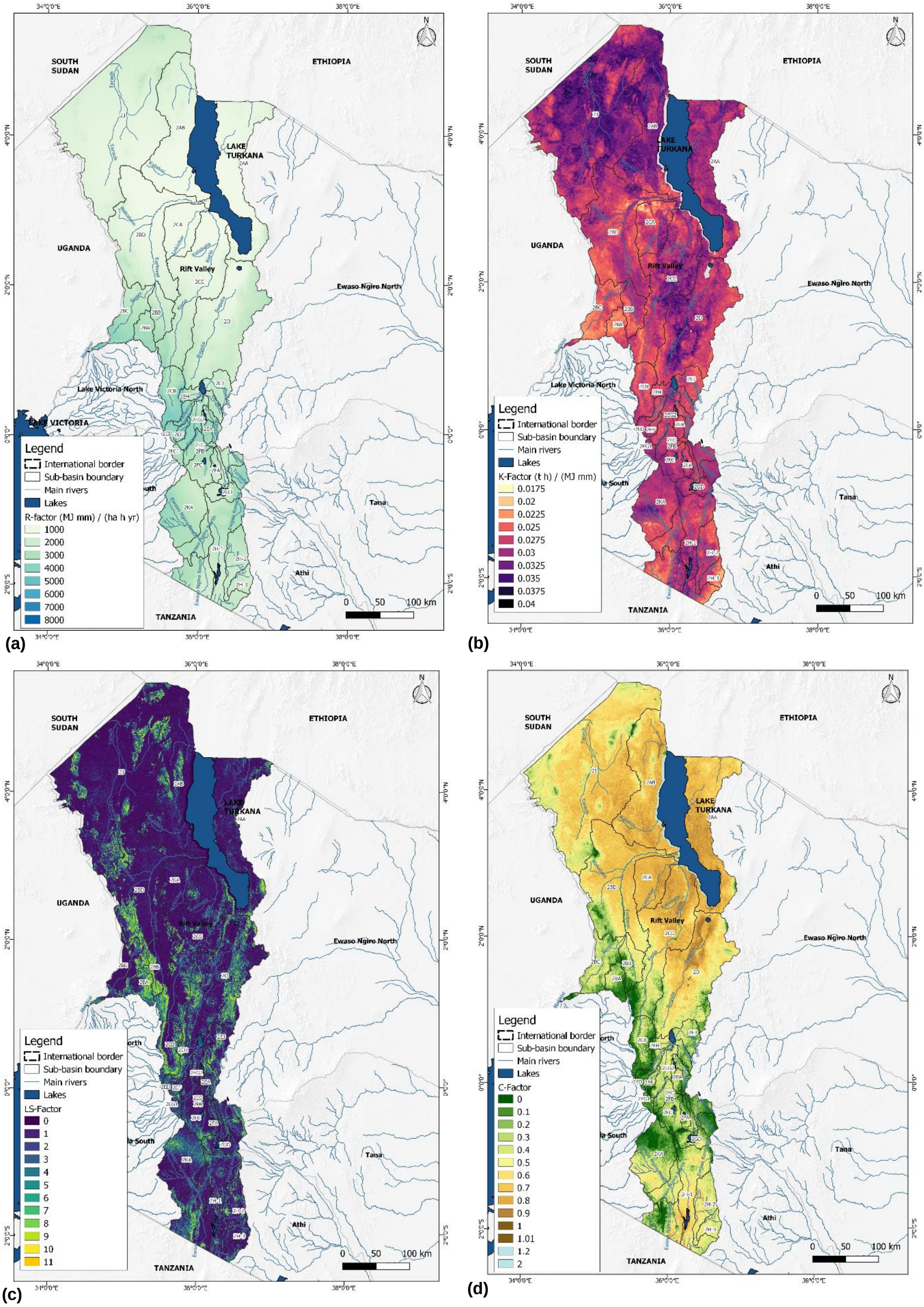

Figure A1-1: RUSLE factor maps for Rift Valley Basin (a) rainfall-runoff erosivity, (b) soil erodibility, (c) slope length and slope steepness, (d) cover management factor

Potential and estimated soil loss

Applying the RUSLE-based soil erosion risk assessment tool to the RV 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.

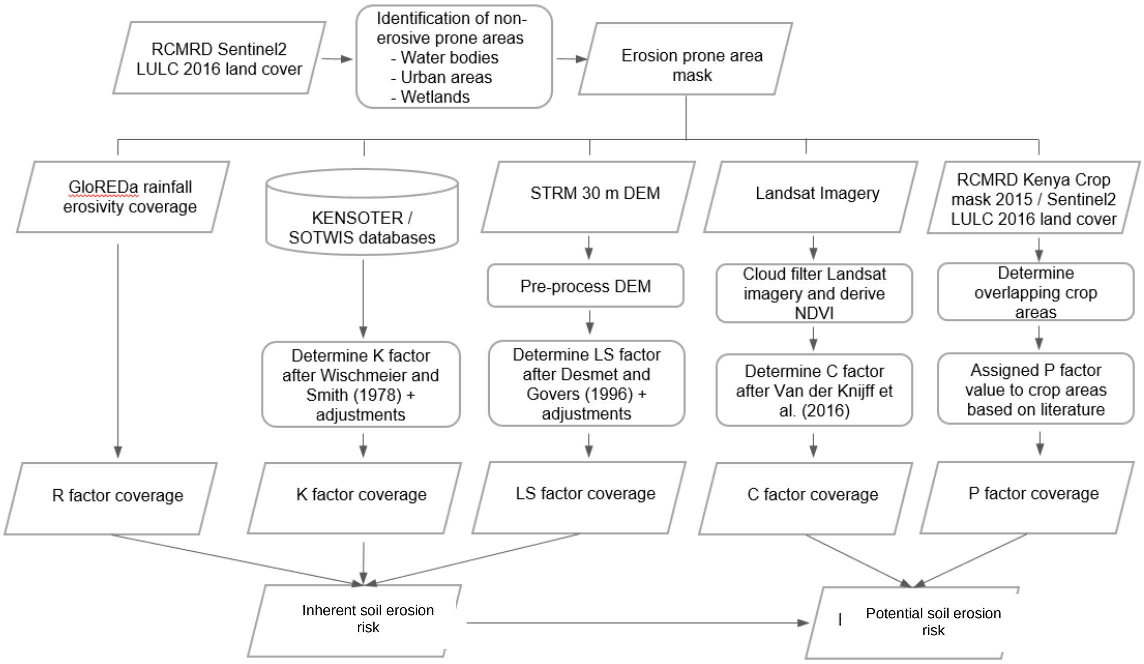

Figure A1-2: Modelling flow chart for soil erosion risk in Kenya

When comparing the potential soil erosion risk to the estimated soil erosion risk it is apparent that vegetation cover in on hilltops and ridges provides significant protection from soil erosion (Figure A1-3, Figure A1-4, Table A1-2). The upper Basin has a high potential for erosion considering the inherent soil and slope characteristics, and high rainfall erosivity. The lower Basin has a lower potential for erosion due to the reduced slopes and rainfall erosivity. Vegetation cover provides a greater influence on erosion rates in the upper Basin.

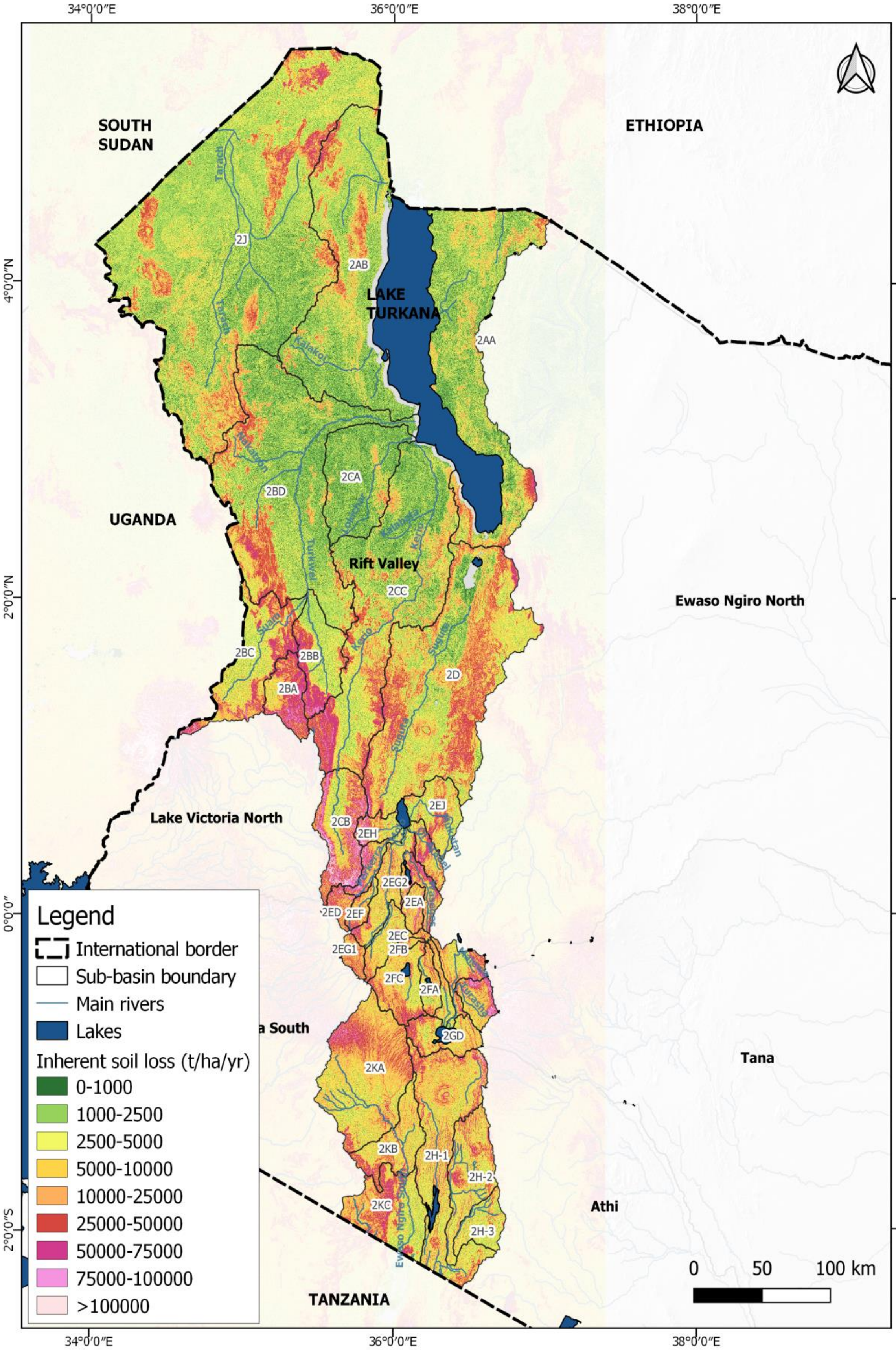

Figure A1-3: RV Inherent Soil Erosion Risk

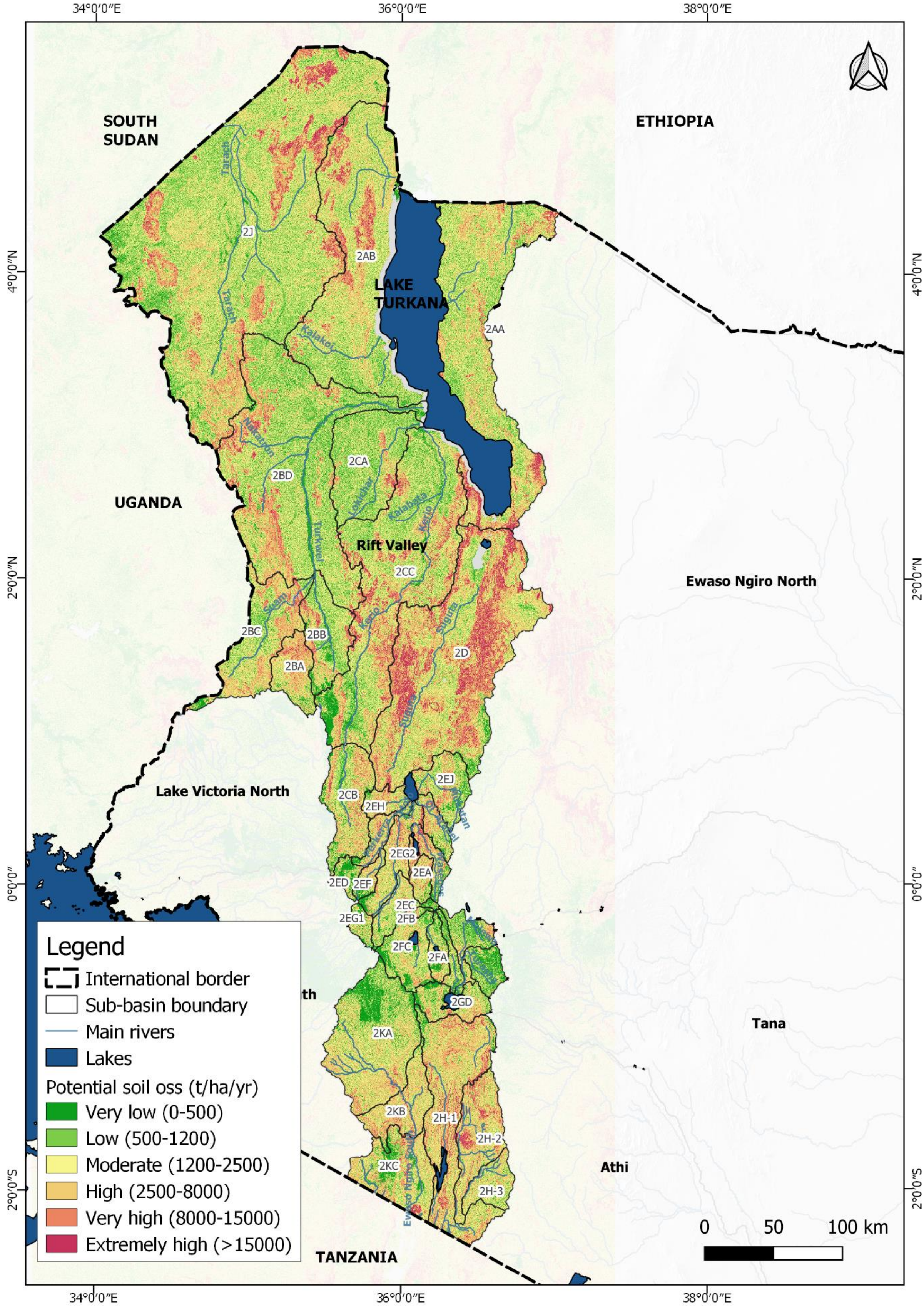

Figure A1-4: RV Basin Potential Soil Erosion Risk

Table A1-2: Rift Valley Basin mean factors, inherent soil loss and potential soil loss

Sub-basin	Mean R	Mean K	Mean LS	Mean inherent soil loss (t/ha/yr)	Mean C	Mean potential soil loss (t/ha/yr)	Erosion Risk
2AA	1128.90	0.03	1.40	5010	0.75	3351	High
2AB	1227.72	0.03	1.25	5349	0.78	3276	High
2BA	3168.67	0.02	4.63	35979	0.19	4640	High
2BB	2275.62	0.03	2.65	17656	0.33	2860	High
2BC	2921.63	0.02	2.37	16748	0.31	3459	High
2BD	1288.40	0.03	1.67	6725	0.59	2793	High
2CA	960.46	0.03	0.93	2449	0.77	1881	Moderate
2CB	3552.10	0.03	3.37	34099	0.19	3569	High
2CC	1552.73	0.03	1.81	9457	0.61	3613	High
2D	1819.08	0.03	2.50	13623	0.58	6691	High
2EA	3533.72	0.03	1.97	18686	0.31	4293	High
2EB	2996.56	0.03	3.21	25507	0.26	5341	High
2EC	3318.58	0.03	1.16	10616	0.26	2202	Moderate
2ED	3784.15	0.03	2.98	32151	0.07	1845	Moderate
2EE	3518.48	0.03	3.38	34282	0.26	4697	High
2EF	3815.13	0.03	1.84	18674	0.22	3011	High
2EG1	3120.12	0.03	2.16	20009	0.11	1986	Moderate
2EG2	3265.28	0.03	1.65	14376	0.37	4278	High
2EH	2971.56	0.03	2.81	25706	0.35	4491	High
2EJ	2262.18	0.03	1.96	11608	0.34	3077	High
2EK	2609.22	0.03	2.97	21015	0.27	3999	High
2FA	2371.03	0.03	1.79	11827	0.25	2378	High
2FB	3275.23	0.03	1.81	16057	0.23	3691	High
2FC	2678.42	0.03	1.99	14861	0.22	2230	Moderate
2GA	2200.36	0.03	1.60	10241	0.23	1741	Moderate
2GB	2485.67	0.03	2.26	16881	0.16	2011	Moderate
2GC	3329.32	0.03	2.56	24777	0.08	1217	Moderate
2GD	2497.97	0.03	2.21	15526	0.26	2826	High
2H-1	2526.26	0.03	1.87	13087	0.46	5187	High
2H-2	2386.17	0.03	1.96	12723	0.49	5607	High
2H-3	2133.51	0.03	1.27	6687	0.44	2725	High
2J	1522.06	0.03	1.27	5951	0.59	3001	High
2KA	2872.90	0.03	1.94	15004	0.26	2432	Moderate
2KB	2744.89	0.03	1.90	13770	0.39	4324	High
2KC	2467.72	0.03	2.53	16894	0.35	3580	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 Basin, to the Basin outlets indicates that there are various landforms which are linked to deposition zones, acting as sediment “traps” or buffer zones. These landforms such as lakes, 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 A1-4. The estimates were validated based on previous studies in the basin (Bancy *et al*., 2000; Dunne, 1979).

Table A1-3: Physiographic catchment characteristics contributing to sediment dynamics of RV Basin

Factor	Basin
Basin area (km^2)	130, 452
Annual Rainfall (mm)	510
Elevation (masl)	375-3000
Climate	Arid in the North, Semi-Arid Land (ASAL) in the South, Wet and dry in the central area.
Topography	Varies from low-lying in around Lake Turkana and mountainous areas of Aberdare ranges.
Vegetation	Forests on hill-slopes and cropland/rangeland on plains.
Land-use	Mainly rain-fed agriculture and rangeland, potential erosion around the bare ground around Lake Turkana
Connectivity (upper)	The Basin is narrow with numerous lakes on the Rift Valley floor and wetlands. The middle section on the Aberdare ranges landforms are mainly mountain ranges. The wetland around the lakes from major sediment traps with the seasonal riverbeds in the North of the basin.

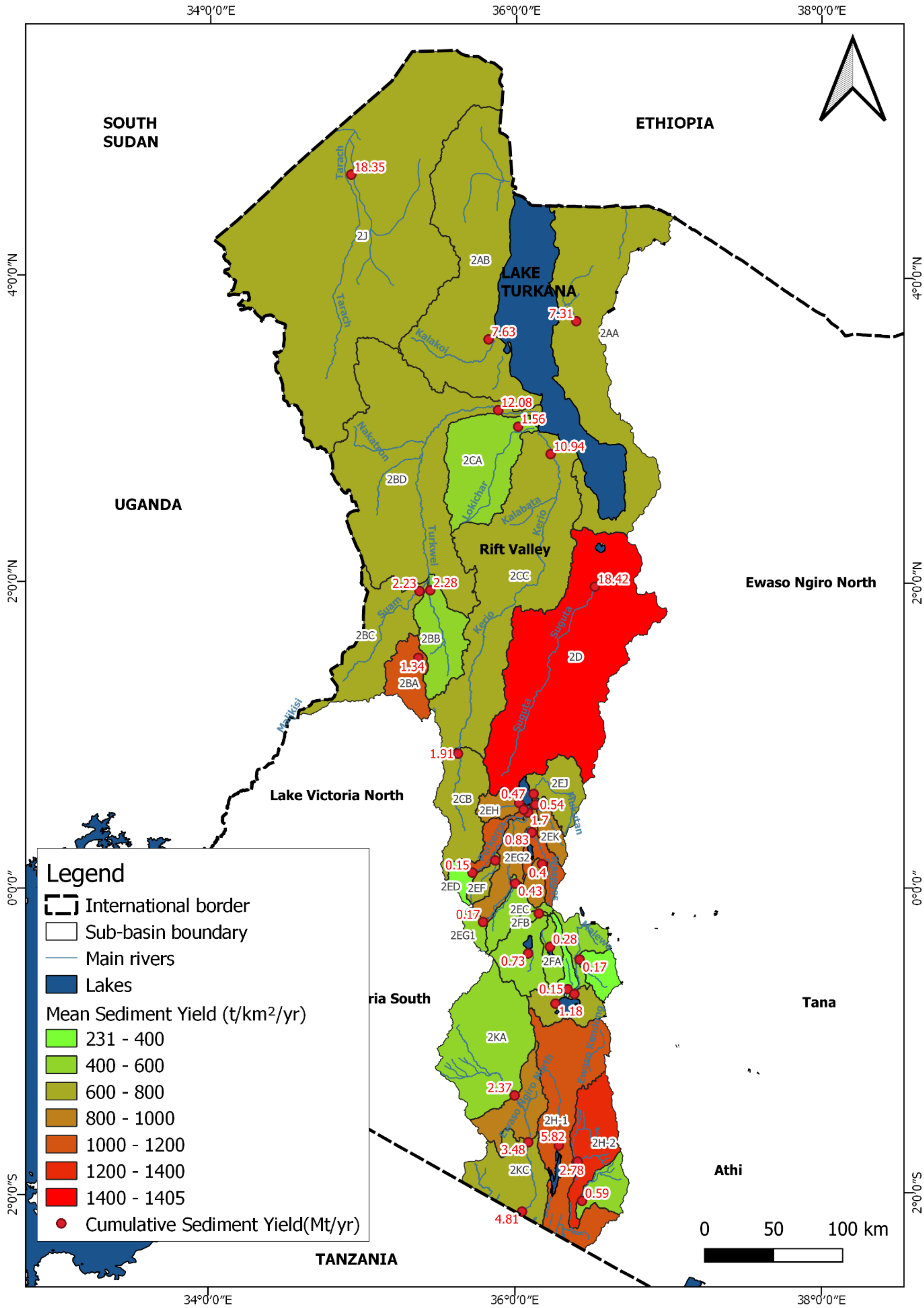

Figure A1-4: RV Basin - Cumulative sediment loads

Table A1-4 summarises the estimated soil loss and sediment yield in the RV Basin.

Table A1-4: Long term average soil loss estimates per sub-basin in the RV Basin

Sub-Basin	Area (km^2)	Potential soil loss (t/km2/yr)	Incremental sediment yield (t/km2/yr)	Cumulative sediment load (Mt/yr)
2AA	9917	3351	737.22	7.31
2AB	11085	3276	687.96	7.63
2BA	1316	4640	1020.80	1.34
2BB	2116	2860	572.00	2.28
2BC	3396	3459	657.21	2.23
2BD	13036	2793	614.46	12.08
2CA	3780	1881	413.82	1.56
2CB	2434	3569	785.18	1.91
2CC	11596	3613	794.86	10.94
2D	13108	6691	1405.11	18.42
2EA	428	4293	944.46	0.40
2EB	709	5341	1175.02	0.83
2EC	880	2202	484.44	0.43
2ED	420	1845	350.55	0.15
2EE	593	4697	1033.34	0.94
2EF	387	3011	662.42	0.26
2EG1	389	1986	436.92	0.17
2EG2	1298	4278	941.16	1.70
2EH	554	4491	853.29	0.47
2EJ	1399	3077	676.94	0.95
2EK	609	3999	879.78	0.54
2FA	543	2378	523.16	0.28
2FB	140	3691	812.02	0.11
2FC	1484	2230	490.60	0.73
2GA	402	1741	383.02	0.15
2GB	931	2011	442.42	0.50
2GC	745	1217	231.23	0.17
2GD	1051	2826	621.72	1.18
2H-1	5104	5187	1141.14	5.82
2H-2	2257	5607	1233.54	2.78
2H-3	988	2725	599.50	0.59
2J	27798	3001	660.22	18.35
2KA	5130	2432	462.08	2.37
2KB	1663	4324	951.28	3.48
2KC	2578	3580	787.60	4.81

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 RV 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.

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% to 12%) in mean annual precipitation (MAP) increasing to the north of the RV Basin by 2050, with the average MAP across the basin increasing from 510 mm to 562 mm by 2050 under RCP 4.5.

Day and night temperatures in the basin are expected to increase by up to 1.24°C and 1.46°C respectively by 2050 (RCP 4.5).

To assess the expected impacts on more localised precipitation in the RV Basin as result of climate change, four sub-basins were selected for detailed analyses namely: 2BD and 2CC in the North, and 2EG2 and 2KC in the South. The sub-basins and river nodes are illustrated in Figure A2-1.

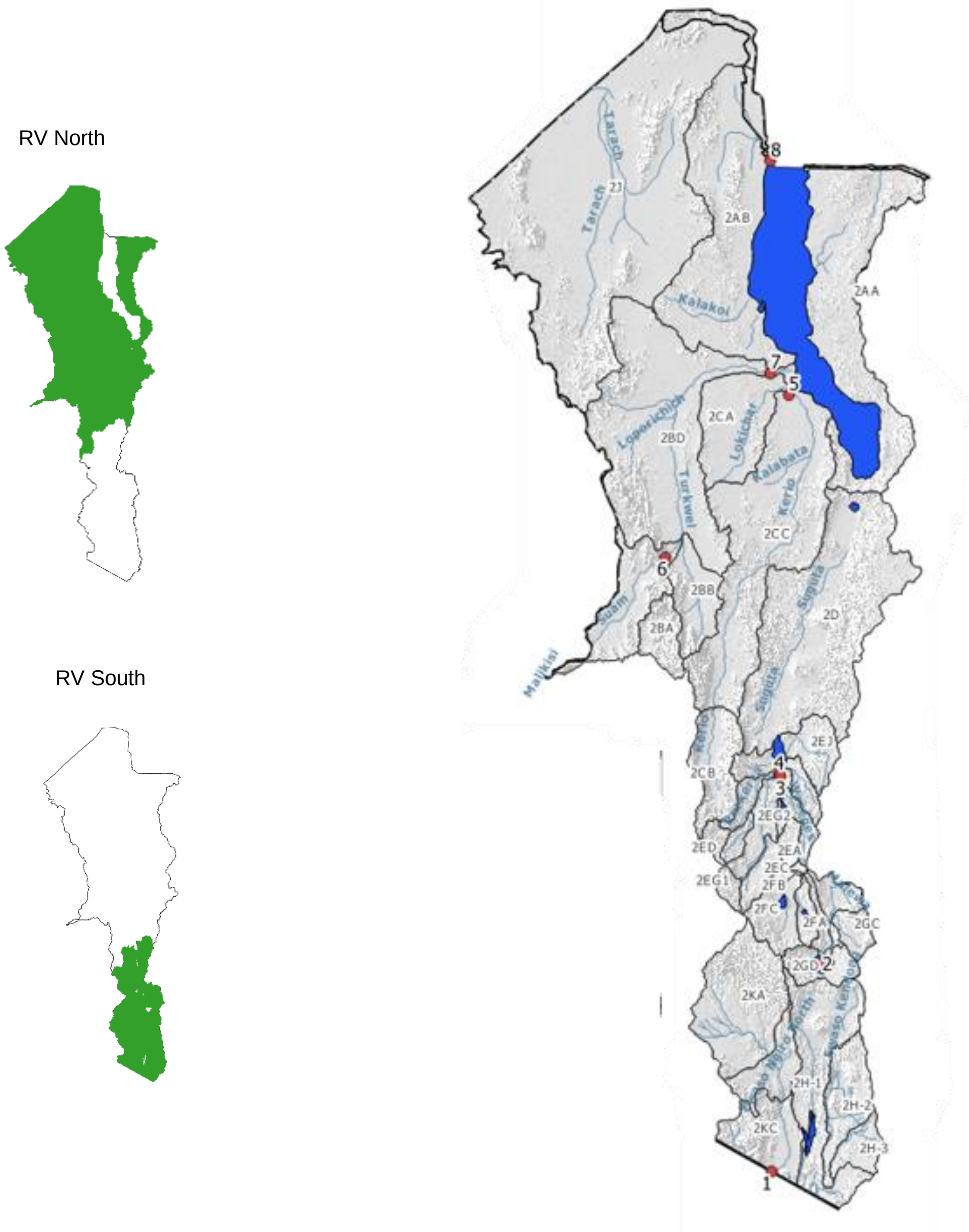

Figure A2-1: RV Basin with sub-basins and river nodes

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).

The RV Basin precipitation is governed by the distinctly different climate regions within the RV Basin, namely: arid region in the North, humid region in the centre and semi-arid region in the South. The precipitation is marked by two rainy seasons, the 'long' rainy season from April to May and the 'short' rainy season from October to December. Figure A2-2 indicates a high percentage increase in future precipitation in all four sub-basins (especially the Northern sub-basins 2CC and 2BD) in February before the start of the 'long' rainy season and a decrease in May at the end of the 'long' rainy season. This suggests that the 'long' rainy season will start earlier in February and not in March with an increased intensity. Furthermore, a smaller relative increase in precipitation is experienced during the 'short' rainy season with an increase in the precipitation in September and a decrease in precipitation in November and December, suggesting that the 'short' rainy season will also shift earlier and increase in intensity. It is important to note that although the percentage change in precipitation is quite high during the dry months of Jan and Feb, actual rainfall depths are low (Figure A2-3 to Figure A2-6). During the dry season from June to October, an overall decreasing precipitation trend is observed, especially in May and June, suggesting that the dry season will shift earlier. The precipitation decreases during May and June but increases in the dry months during July to August.

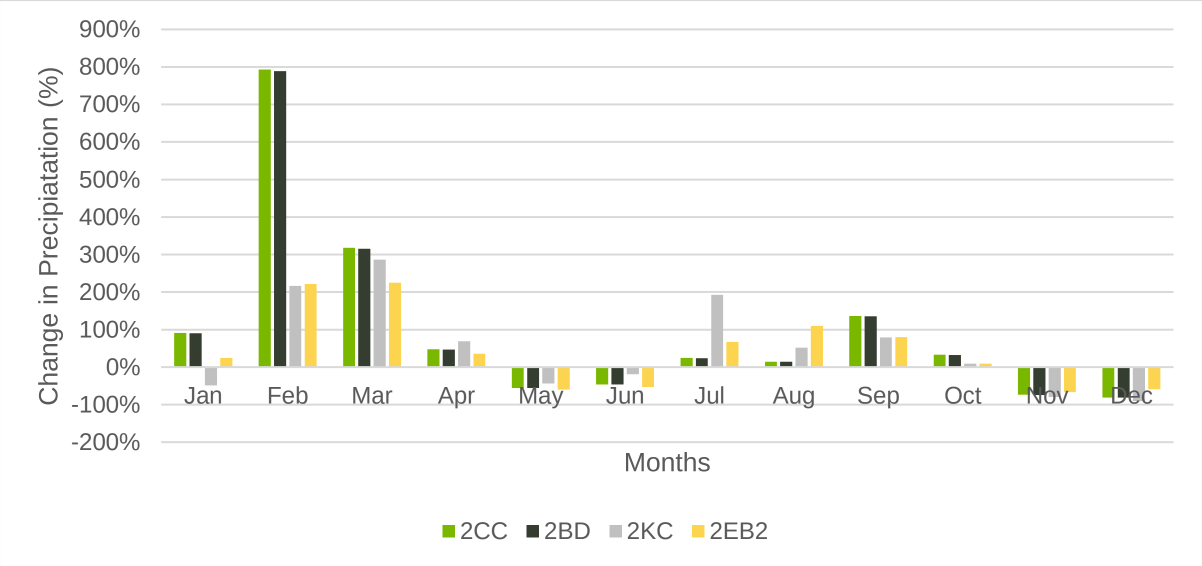

Figure A2-2: Percentage change in monthly precipitation for the period 2040 to 2060 compared to 1980 to 2000 in four sub-basins

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 September to November. The significant percentage increase in precipitation during the dry months of February 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. The rainy seasons also appear to shift almost a month earlier. The precipitation during the dry season (shifted to start in May) decreases.

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 March accompanied by a significant increase in the range of precipitation depths, suggesting that March precipitation will become more variable (see Figure A2-6a) as an example). Similarly, the figures show an increase in mean precipitation for August, September, October under climate change. Furthermore, during these months, the future range (variability) of precipitation depths will also increase. This suggests higher precipitation variability during the long and short rainy seasons, as well as more intense precipitation events.

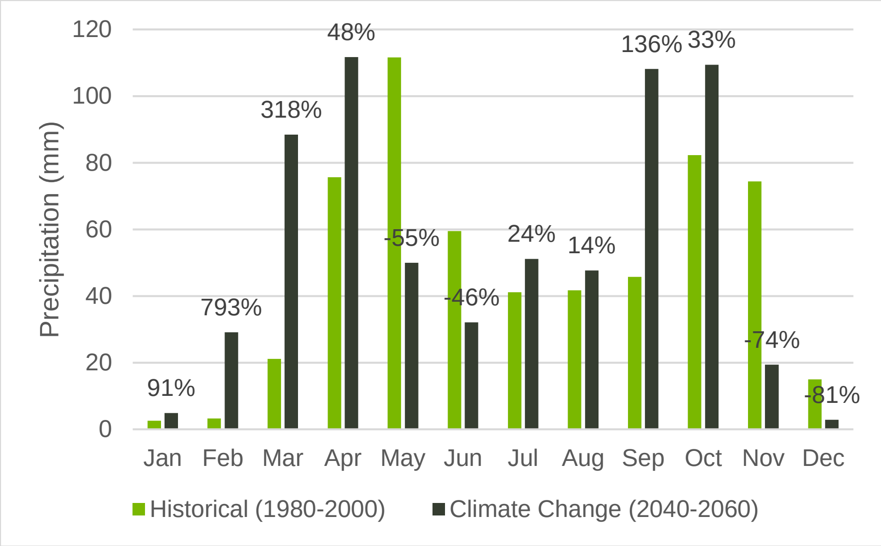

Figure A2-3: Percentage change - monthly avg. precipitation sub-basin 2CC

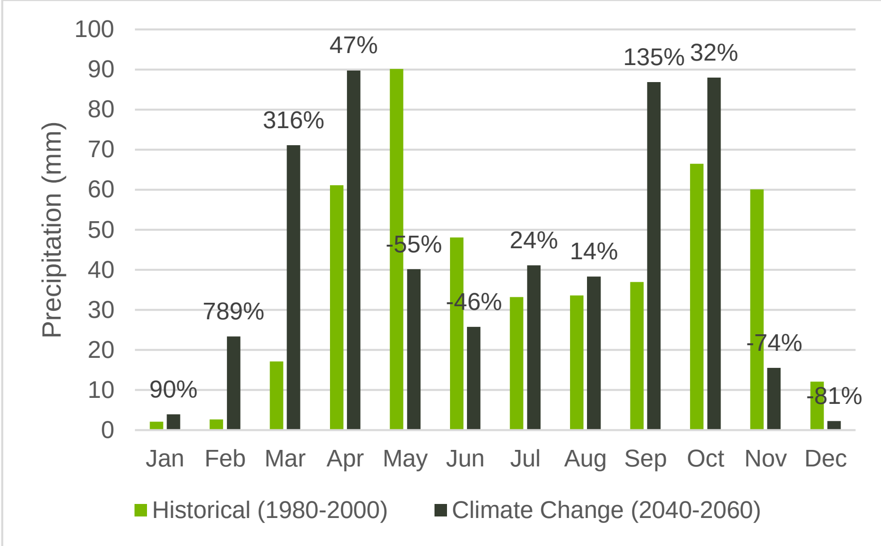

Figure A2-4: Percentage change - monthly avg. precipitation sub-basin 2BD

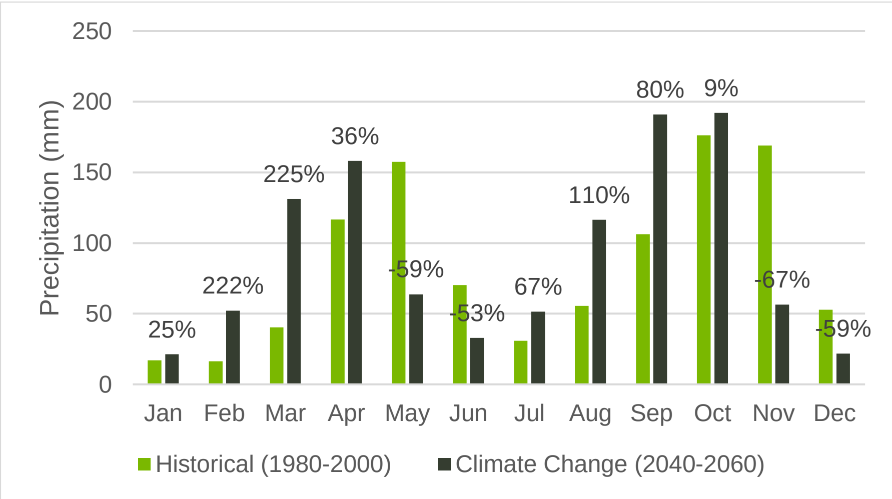

Figure A2-5: Percentage change - monthly avg. precipitation sub-basin 2EB2

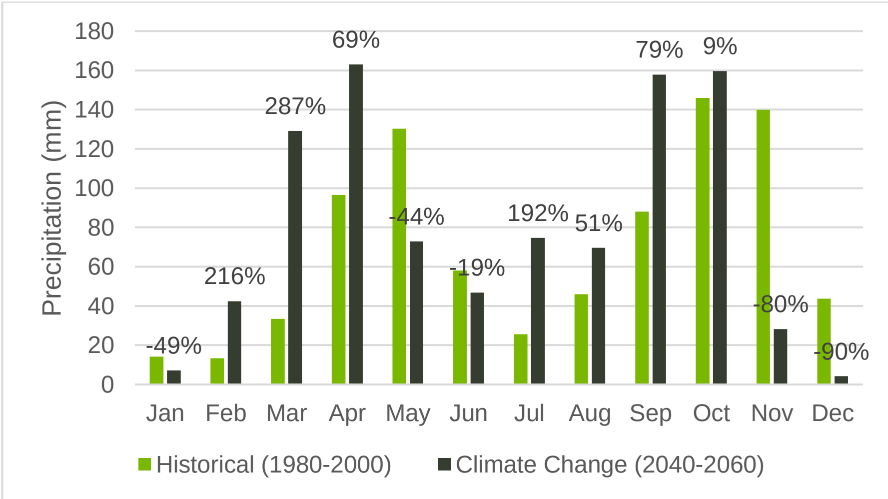

Figure A2-6: Percentage change - monthly avg. precipitation sub-basin 41EF

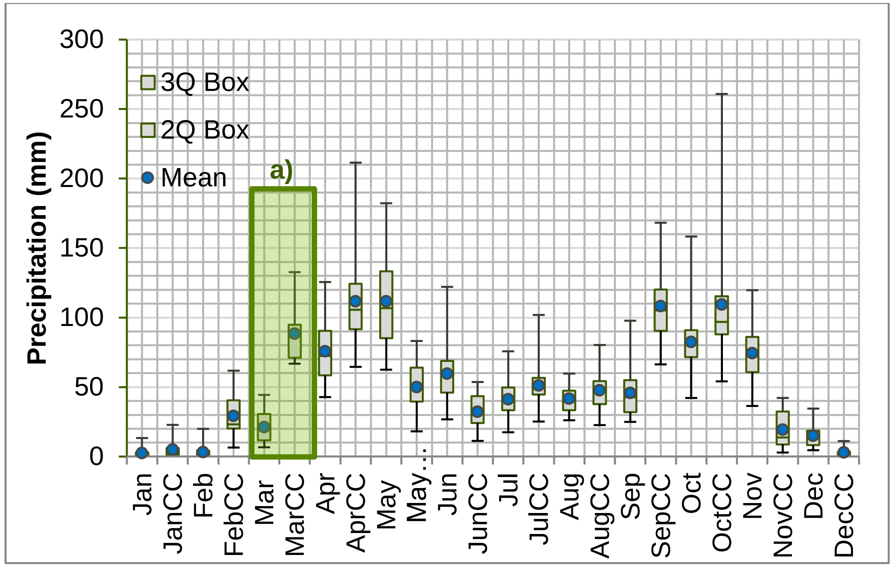

Figure A2-7: Precipitation box-plots for sub-basin 2CC

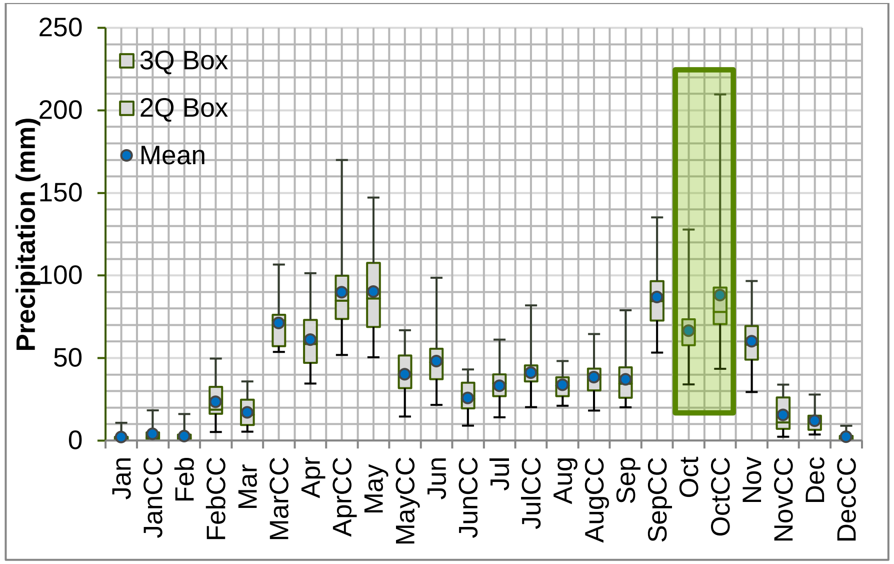

Figure A2-8: Precipitation box-plots for sub-basin 2BD

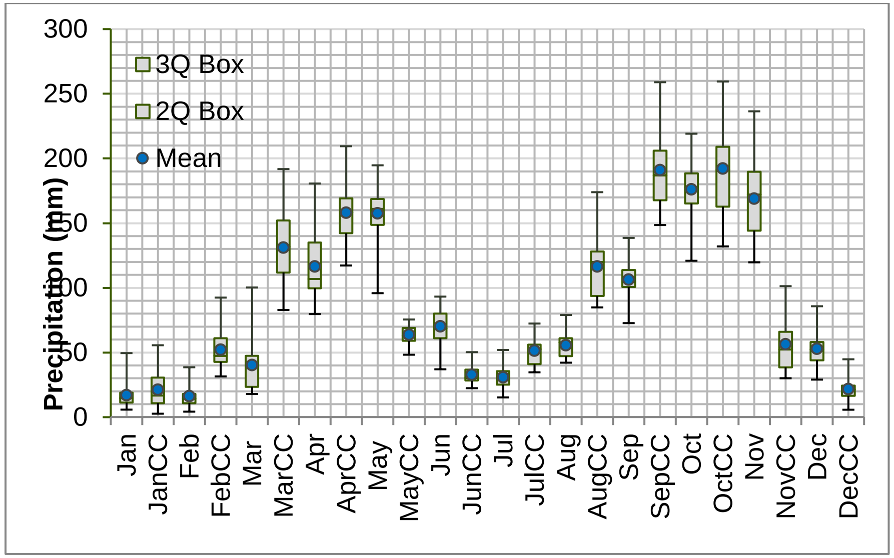

Figure A2-9: Precipitation box-plots for sub-basin 2EG2

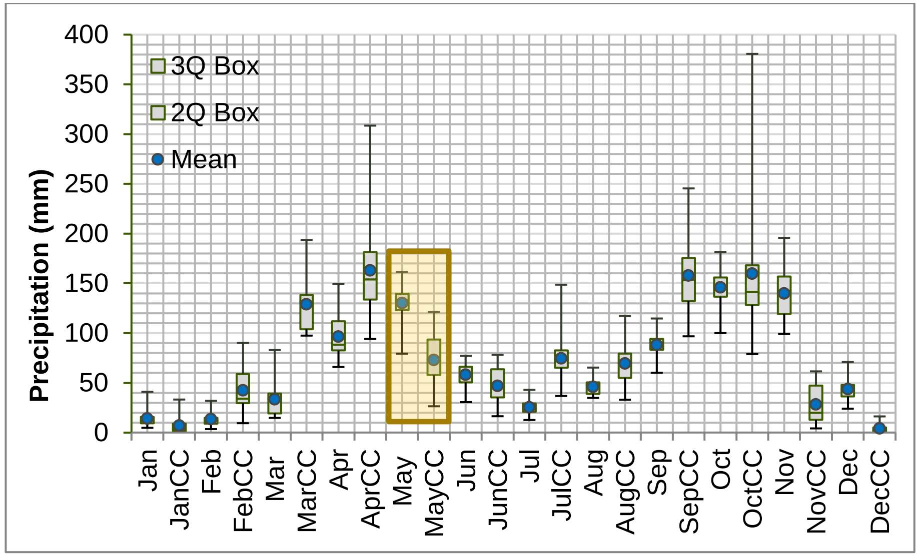

Figure A2-10: Precipitation box-plots for sub-basin 1EF

Stream Flow

Projected sub-basin precipitation and temperature changes under climate change scenario RCP 4.5 were superimposed on the hydrological model of the RV 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 by between 1% to 10% by 2050 The total surface water runoff from the RV Basin is projected to decrease with 2.9% by 2050 under RCP 4.5.

To assess the expected impacts on stream flow in the RV Basin as result of climate change, four river nodes were selected: Node 5 and Node 7 in the Northern regions; and Node 1 and Node 3 in the Southern regions. The river nodes within the RV 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 is expected to increase during November and December through to March. However, the flow also decreases during April through to October. Although rainfall is expected to increase in the ‘short’ rainy season and shift to start in September, the runoff decreases significantly in the RV South, the temperature increase causes greater evapotranspiration and evaporation losses within the RV basin causing an overall decrease in flow. The flow decreases in the dry season.

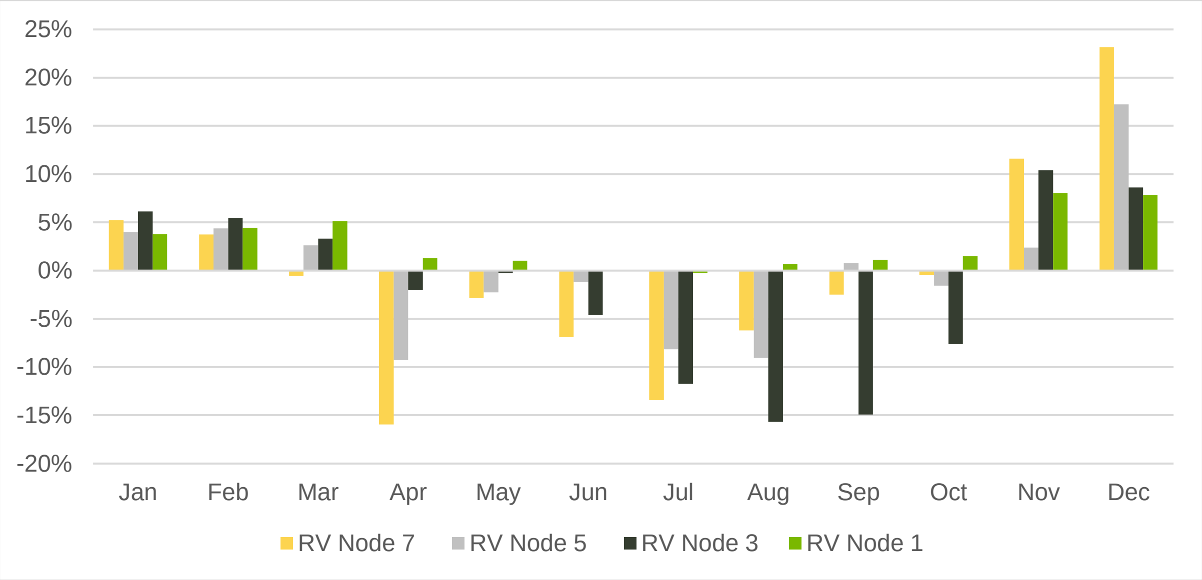

Figure A2-11: Percentage change between historical naturalised flow and naturalised flow with climate change

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 1 (Figure A2-16), high flows with a low exceedance probability (less than 20%) are expected to experience a decrease while lower flows associated with high exceedance probabilities (greater than 80%) are expected to experience a slight increase; suggesting that the rivers will have significantly decreased flows but slightly higher low flows in the dry season. Furthermore, the decrease in average monthly flow results in a decrease in magnitude of all instantaneous flows. Node 5, node 7 and node 3 portray general decreased magnitudes in flow peaks in the high flows, suggesting that there are transfer, evaporation and infiltration losses within the sub-basins due to increased temperatures.

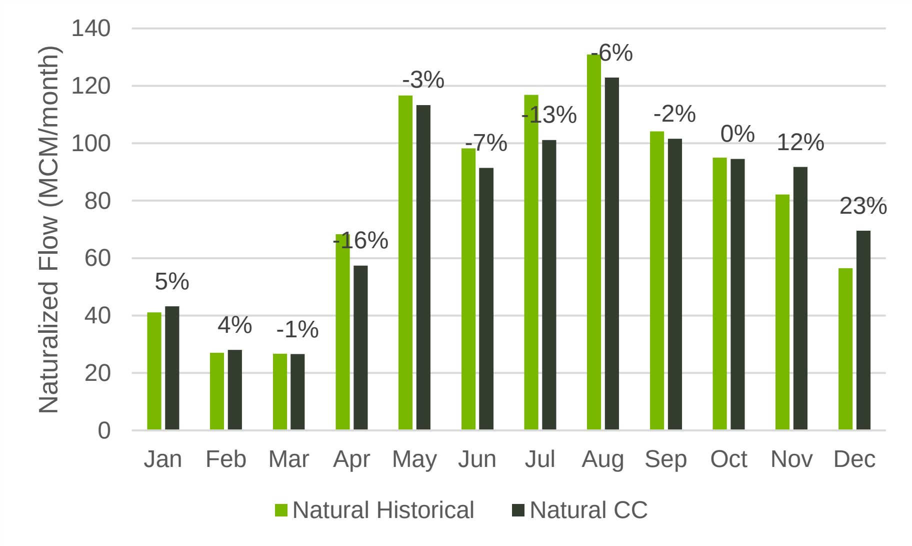

Figure A2-12: Monthly average flows and percentage change under current and future climate conditions - RV Node 7

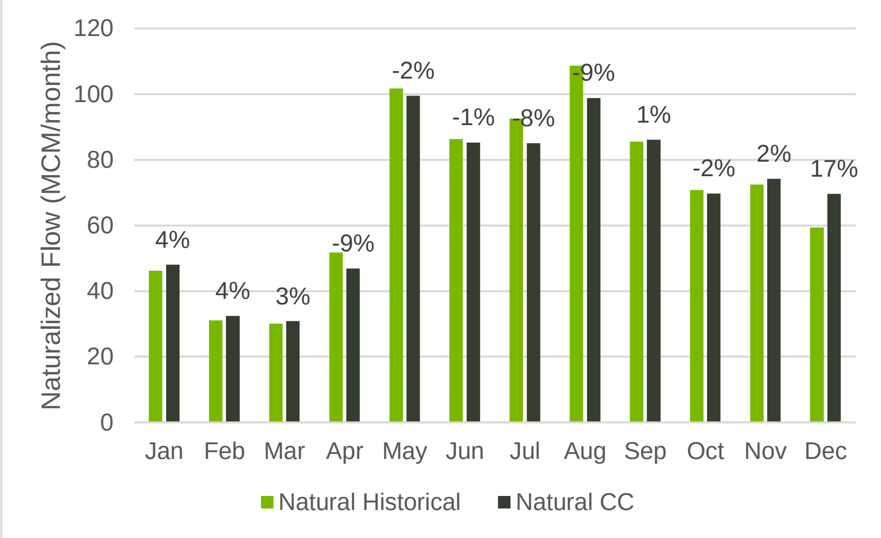

Figure A2-13: Monthly average flows and percentage change under current and future climate conditions – RV Node 5

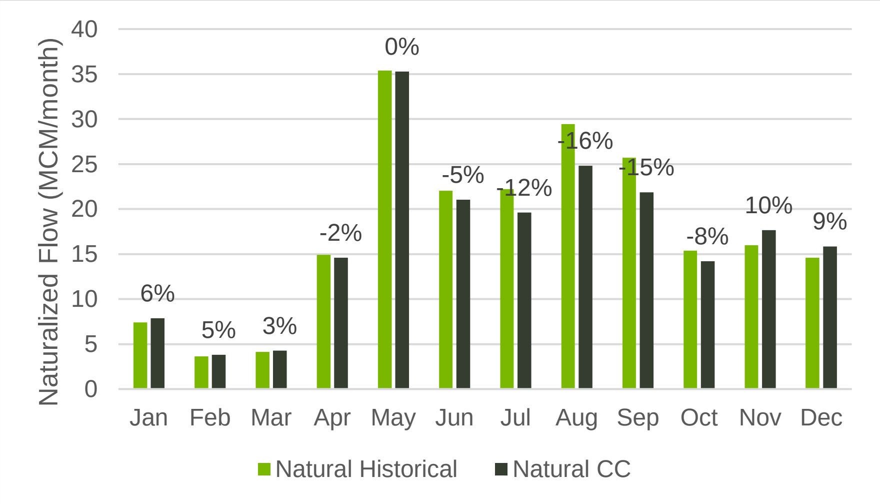

Figure A2-14: Monthly average flows and percentage change under current and future climate conditions – RV Node 3

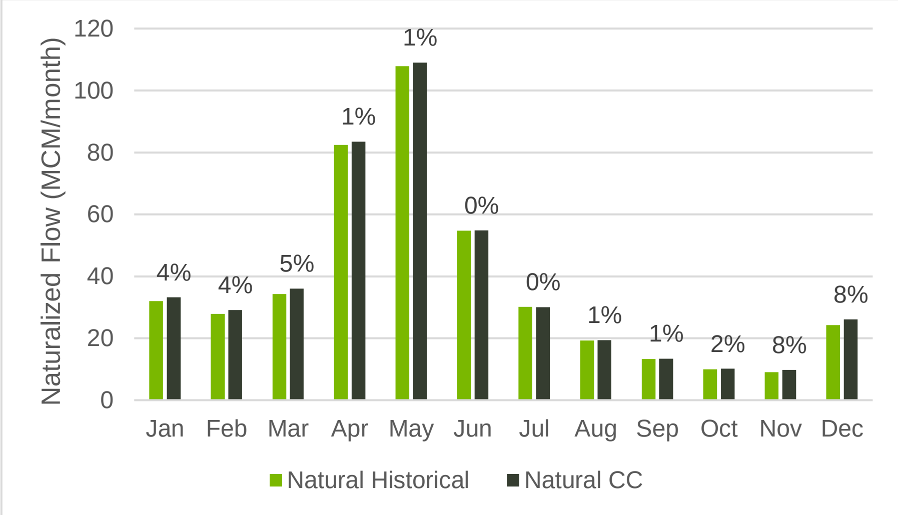

Figure A2-15: Monthly average flows and percentage change under current and future climate conditions – RV Node 1

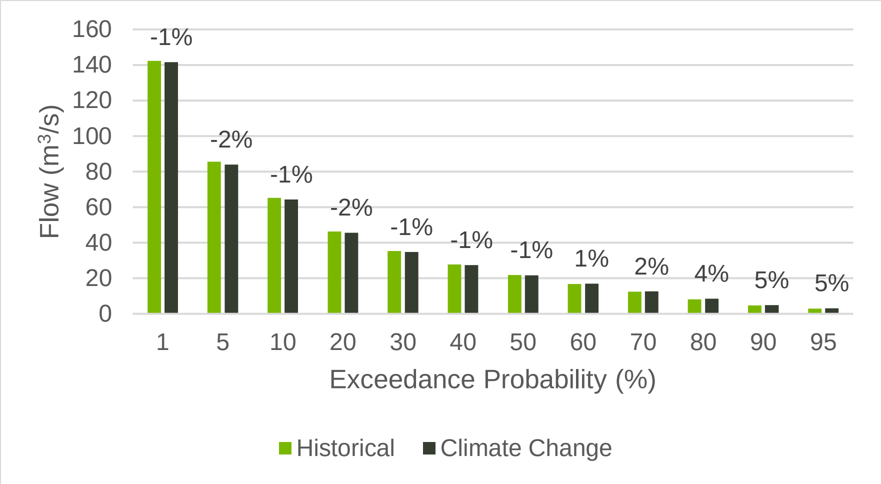

Figure A2-16: Monthly flow exceedance and percentage change under current and future climate conditions – RV Node 7

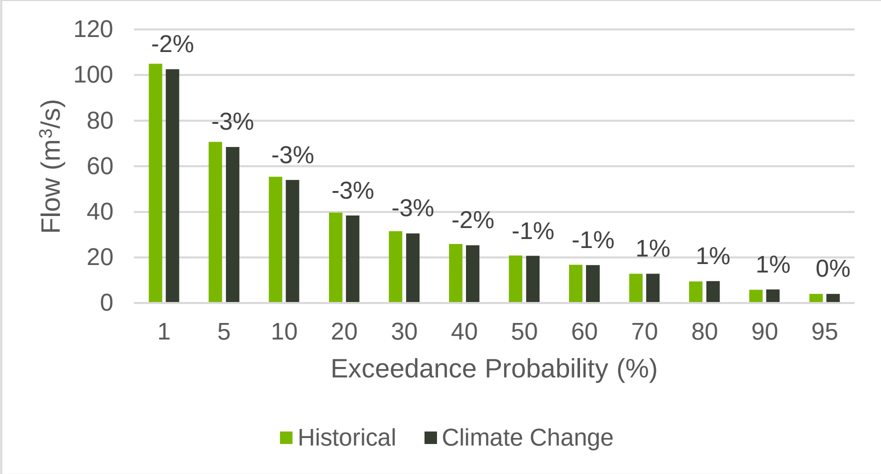

Figure A2-17: Monthly flow exceedance and percentage change under current and future climate conditions – RV Node 5

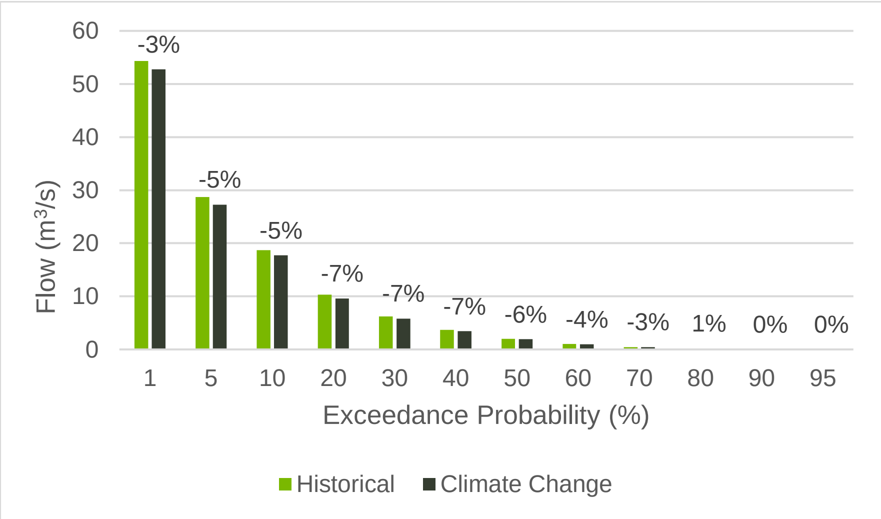

Figure A2-18: Monthly flow exceedance and percentage change under current and future climate conditions – RV Node 3

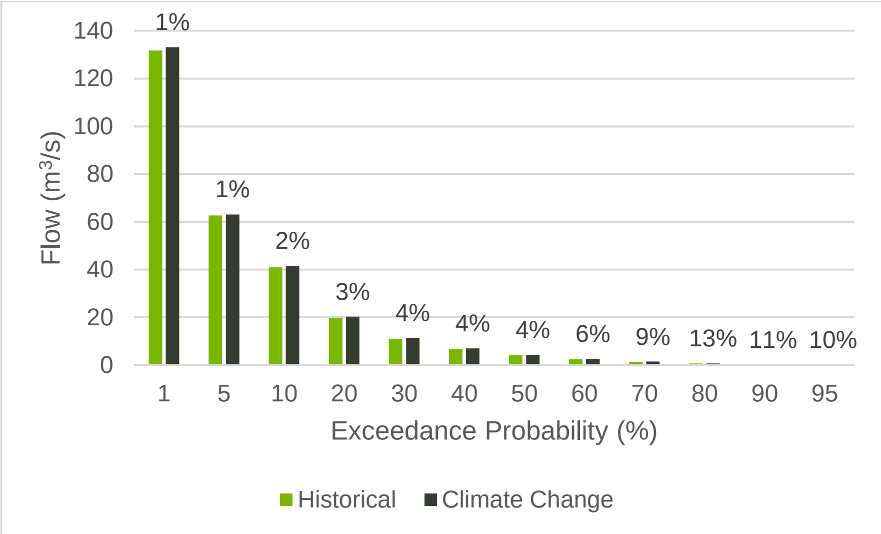

Figure A2-19: Monthly flow exceedance and percentage change under current and future climate conditions – RV Node 1

A3: Surface water resources modelling

The main objectives of the surface water resources analysis for the Rift Valley 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 71 rainfall stations in the Rift Valley Basin, with data availability ranging from 1926 up to mostly the late 1980s. Of these, 30 stations with good quality records were selected based on criteria such as record period (longer than 15 years), stationarity and extent of missing data. 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.

In order to extend the gap-filled WRA point rainfall data beyond 1989, the Climate Hazard Group InfraRed Precipitation with Stations (CHIRPS) dataset (Funk et al., 2015) was used to extend the rainfall records at the selected WRA stations from January 1989 to January 2017. The CHIRPS dataset offers a relatively high resolution compared to other station and satellite blended precipitation datasets. CHIRPS is a 30+ year quasi-global rainfall dataset, spanning 50°S - 50°N (and all longitudes). It 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), is freely available and has 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 to support effective hydrologic forecasts and trend analyses in south-eastern Ethiopia (Funk et al., 2015). CHIRPS daily precipitation data (January 1989 - January 2017) were extracted for those 0.05° grid cells corresponding to the selected WRA rainfall stations locations. The extracted CHIRPS records were then used to extend the gap-filled observed rainfall records providing point rainfall time series for the period from January 1990 to January 2017.

Due to the relatively few rainfall stations in parts of the Rift Valley Basin, inconsistent record quality, 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 gridded rainfall dataset (see Figure A3-3).

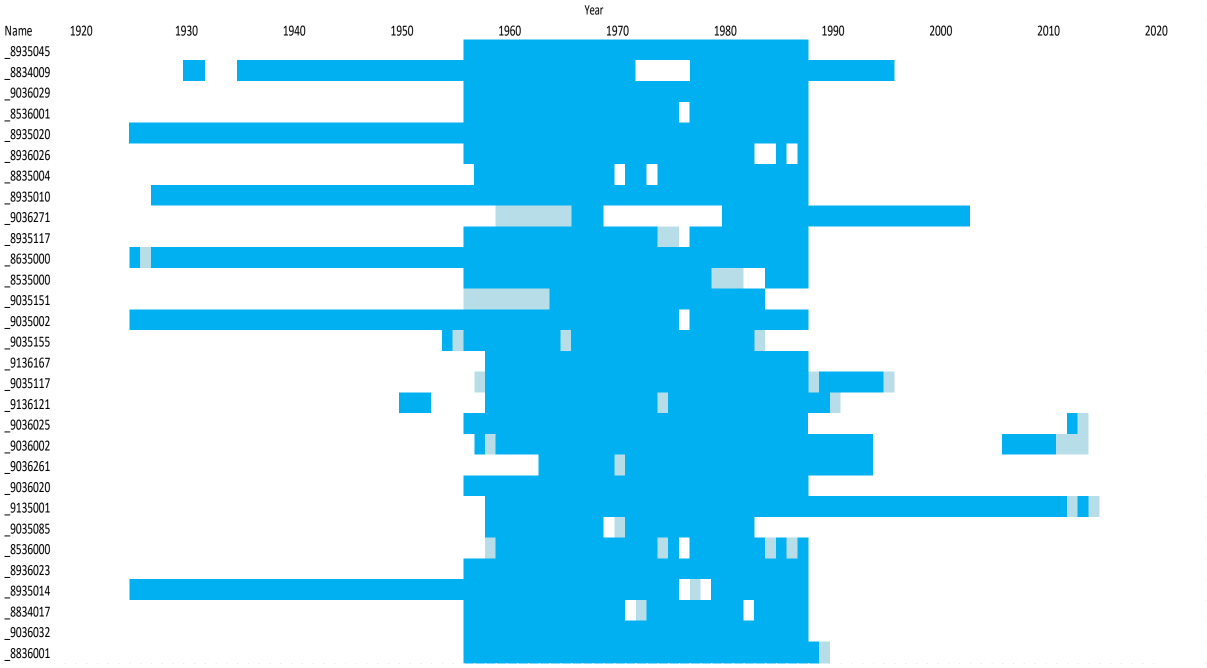

Figure A3-1: Data availability at selected rainfall stations

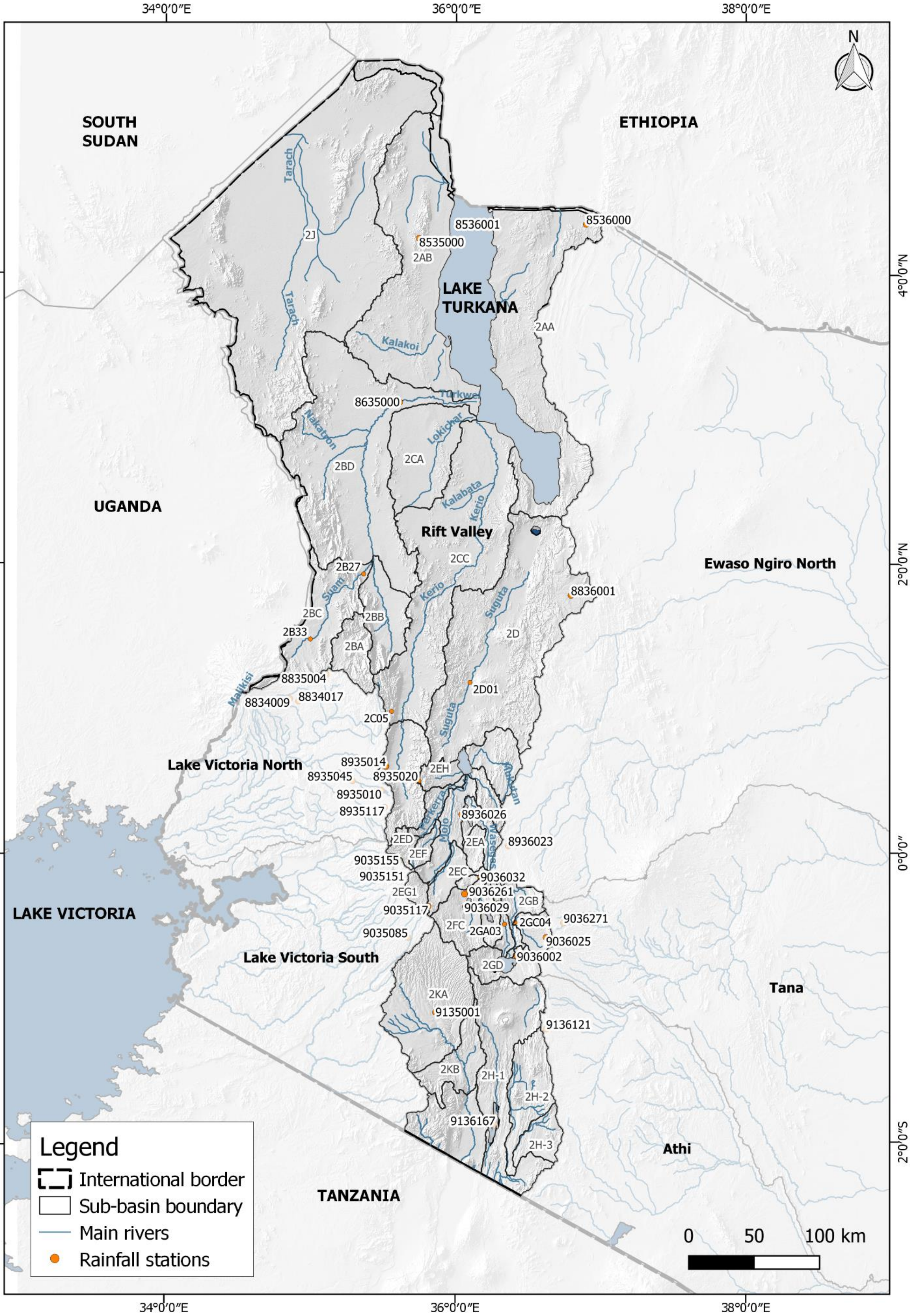

Figure A3-2: Location of selected rainfall stations

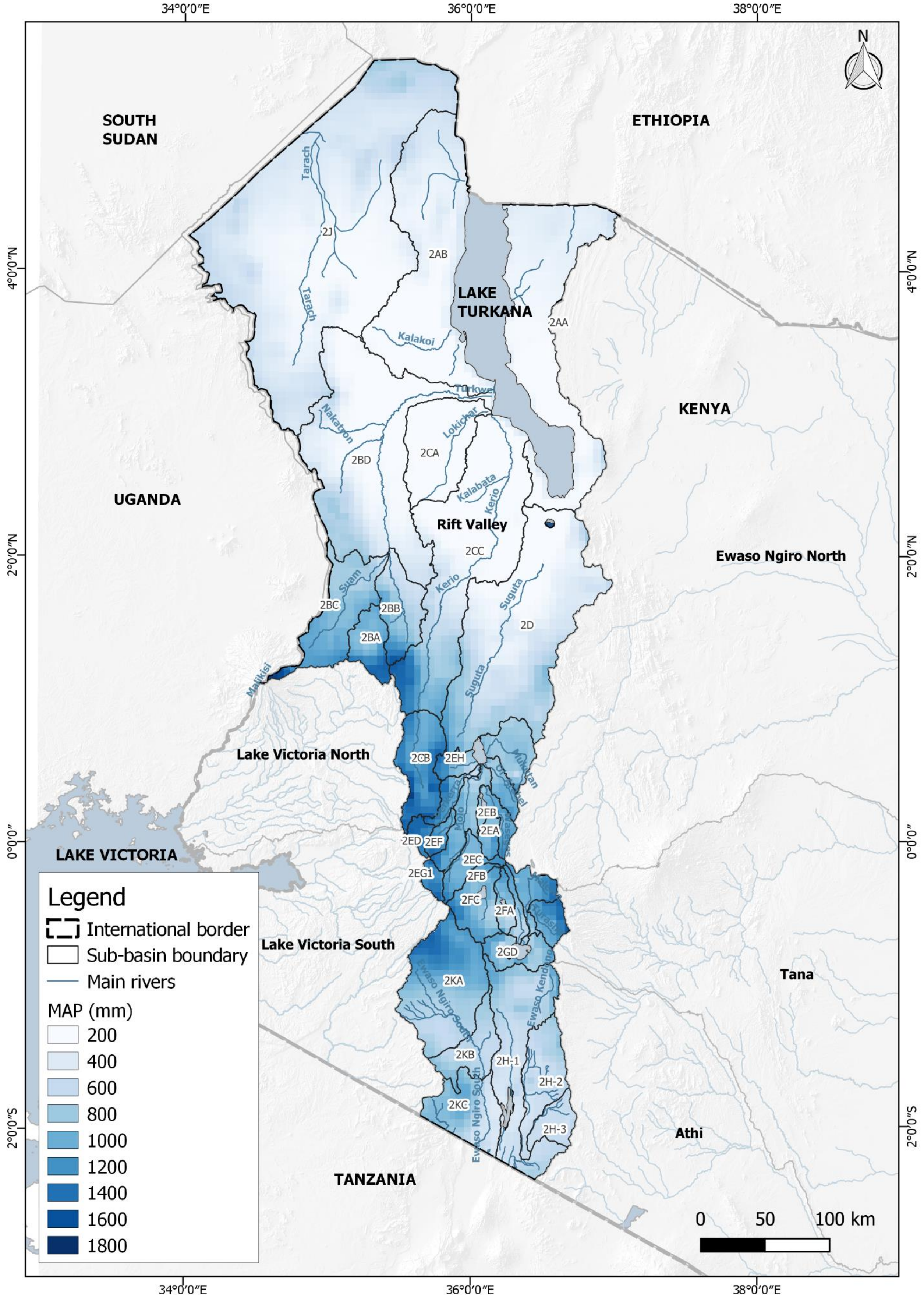

Figure A3-3: Mean Annual Precipitation

Streamflow data

In total, the Rift Valley Basin has historical daily water level records of varying quality and completeness for approximately 47 streamflow stations. Data availability at these stations, as sourced from WRA, is shown in Figure A3-4. Record periods at these stations vary between 2 to more than 70 years, however some stations are characterised by significant periods of missing data. A review of the available discharge records based on station location, records length, and data quality was undertaken. 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 9 stations were selected as listed in Table A3-1, for possible calibration and validation of the rainfall-runoff model. Their locations within the basin are indicated in Figure A3-5.

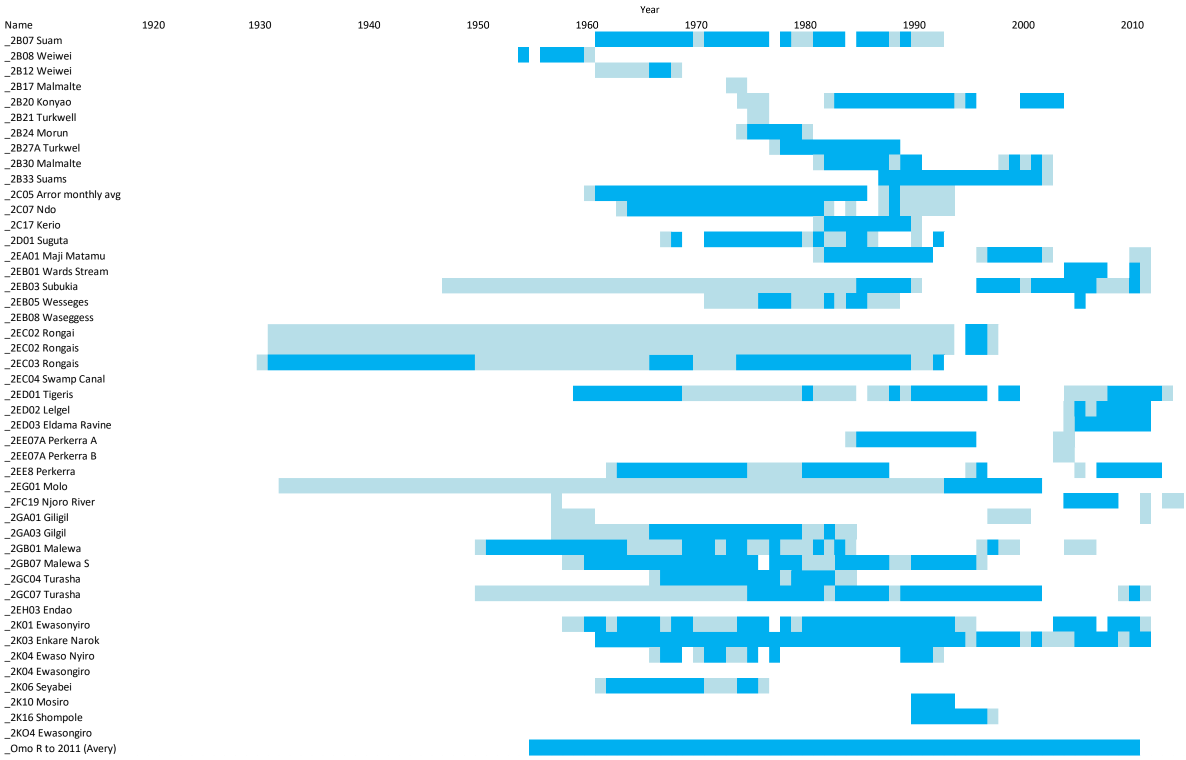

Figure A3-4: Data availability at river gauging stations

Table A3-1: Selected streamflow gauges for model calibration and validation

Station ID	Name	Longitude (°)	Latitude (°)	Catchment Area (km^2)
2B33	Suams	35.01065	1.478986	1 346
2C05	Arror (monthly averages)	35.56867	0.979751	184
2EB03	Subukia	36.21111	0.186111	329
2D01	Suguta	36.10671	1.180649	3 578
2EG01	Molo	35.96483	-0.02416	613
2GA03	Gilgil	36.34444	-0.49167	136
2GC04	Turasha	36.41667	-0.47917	745
2K01	Ewasonyiro	35.75778	-1.15056	688
2ED01	Tigeri	35.69111	0.102778	127

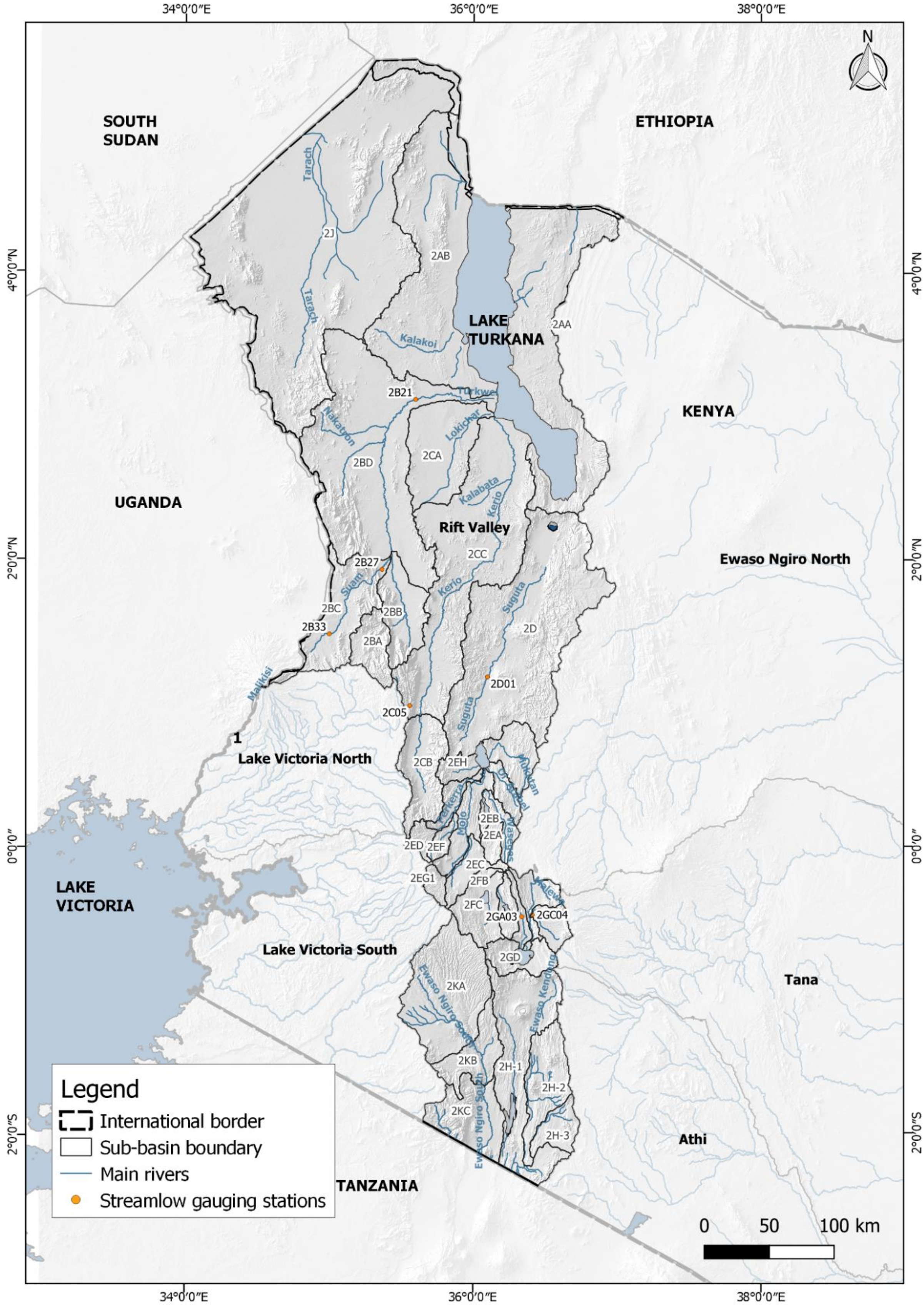

Figure A3-5: Locations of selected streamflow gauging stations

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. However, it was evident that stations are plagued with data availability and data quality issues.

Observed evaporation data were thus considered insufficient and not representative of the whole basin for water resources modelling purposes. Gridded temperature data from the US National Oceanic and Atmospheric Administration (NOAA) were 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. (FAO, 1986), from which a Mean Annual Potential Evapotranspiration map was developed for the Rift Valley Basin as shown in Figure A3-6. The temperature-derived ETo values were validated with observed and published evaporation data.

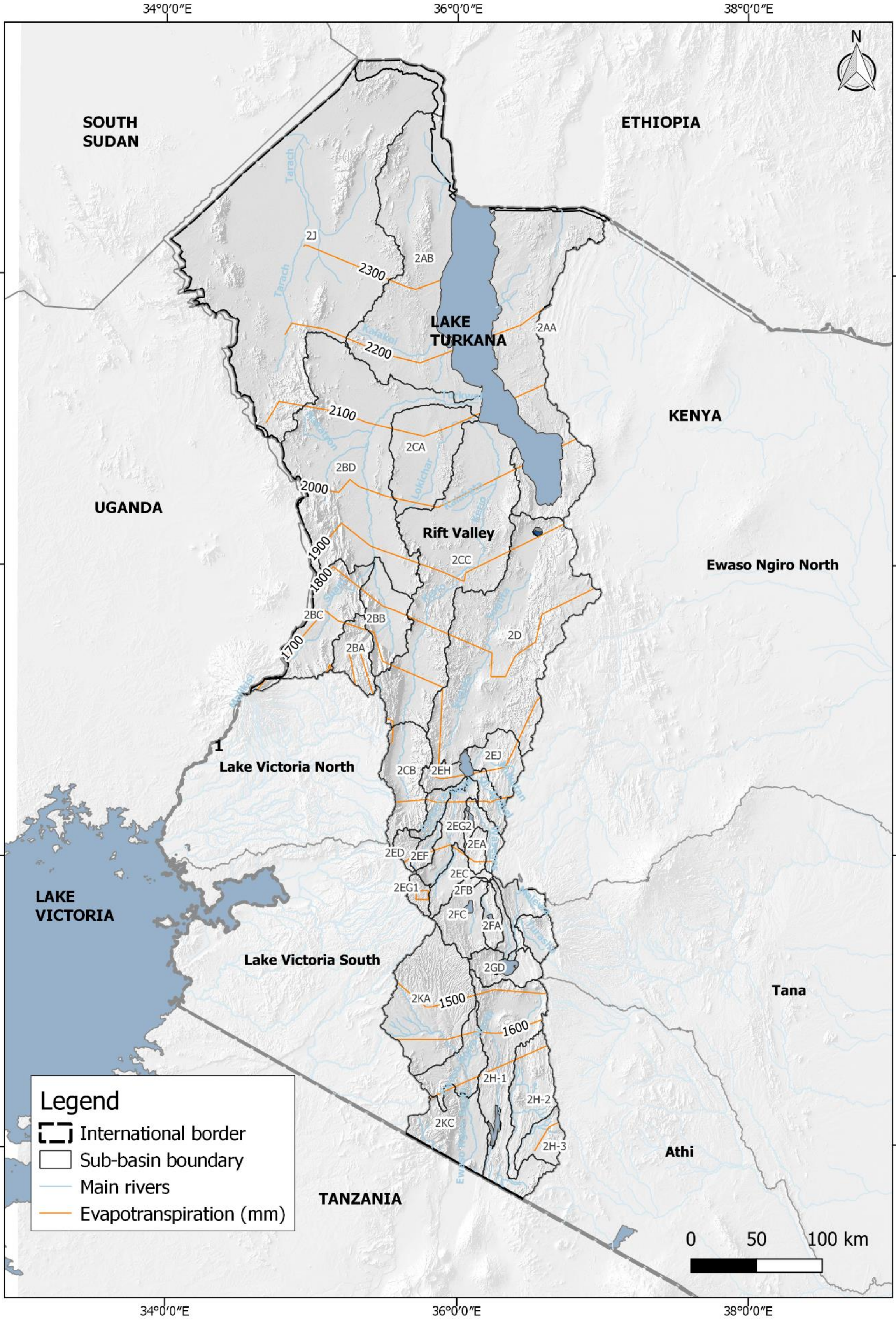

Figure A3-6: Potential mean annual evapotranspiration (mm) in the Rift Valley Basin

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 Rift Valley 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 to evaluate the historical (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 January 1960 to 1 January 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 Rift Valley 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. 2AA, 2AB…), streamflow gauging stations, existing and proposed dams, tributary confluences, river diversion or abstraction points and proposed water resources development schemes. Figure A3-7 presents an overview of the Rift Valley Basin containing the delineated model sub-catchments. In total, 94 sub-catchments were modelled.

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.

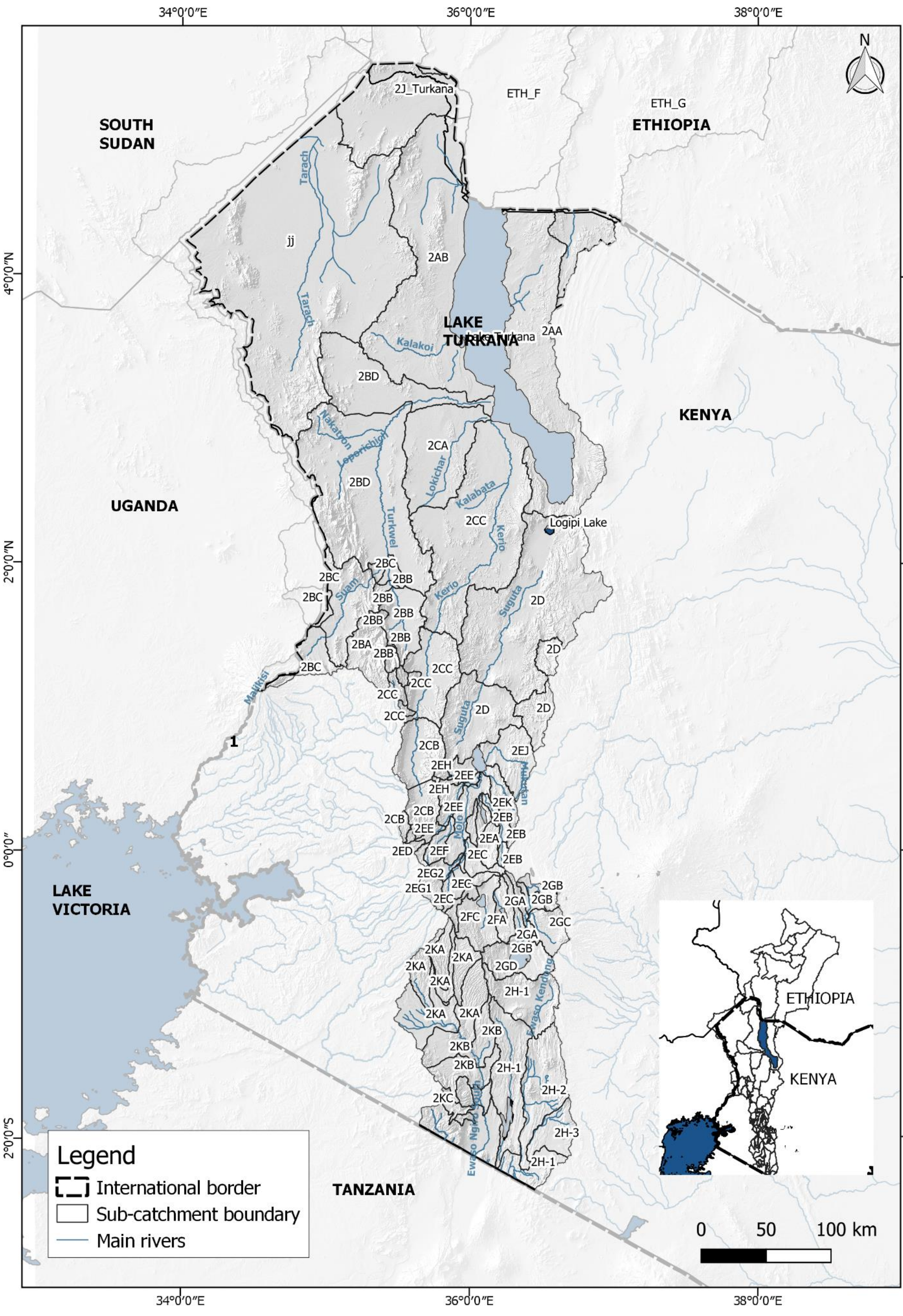

Figure A3-7: Delineated model sub-catchments in the Rift Valley Basin

The point rainfall data at the 30 rainfall stations across the Basin were converted from units of millimetres per day to % MAP per day for the simulation period. 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 sub-basin. The conversion of rainfall units from % MAP to mm was achieved though multiplication with the sub-basin MAPs extracted from the CHIRPS-based MAP coverage.

Areal averaged monthly ETo values for each model sub-catchment were calculated and assigned. An example of calculated daily ETo values for sub-basins in the Lake Turkana catchment area is shown in Figure A3-8.

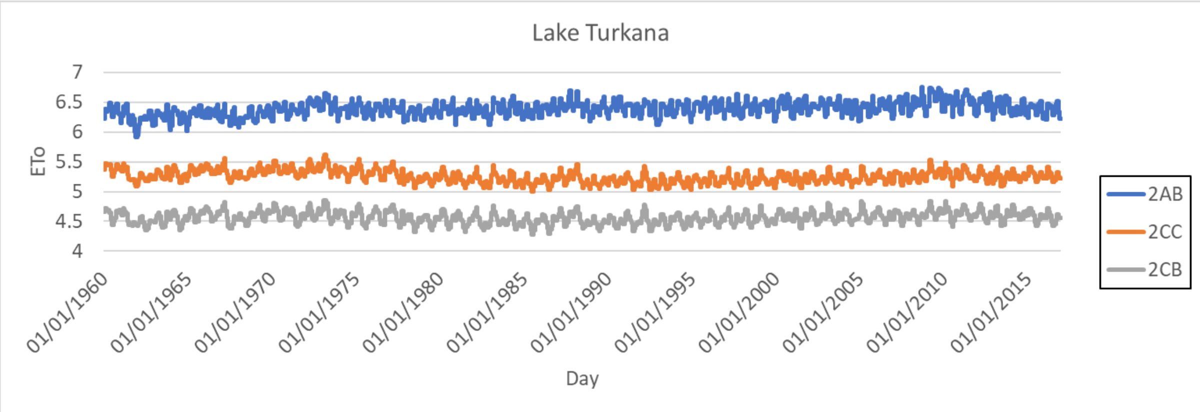

Figure A3-8: Typical reference ETo values in the Rift Valley Basin (mm/day)

Model Calibration

The calibration of the NAM rainfall-runoff model in the Rift Valley Basin was dependent on the availability of concurrent and good quality historical precipitation and streamflow data. On this basis, eight flow gauging stations were eventually selected as calibration and/or validation locations. All of the calibration and validation 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 and validation periods, from the WRA database, were added to downstream observed streamflow records at the station sites in order to ‘naturalise’ the observed flow records before calibration and validation. 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 A3-9 to Figure A3-14.

Table A3-3: Calibrated NAM model parameters

	Gauge ID					
Parameter	**2B33**	**2D01**	**2GC04**	**2K01**	**2EB03**	**2ED01**
Ss0	0	0	0	0	0	0
U0/UMAX	0	0	0	0	0	0
L0/LMAX	0	0	0	0	0	0
QOF	0	0	0	0	0	0
QIF_0	0	0	0	0	0	0
QBF_0	0	0	0	0	0	0
CAREA	1	1	1	1	1	1
LMAX	130	150	330	325	275	330
UMAX	4	15	9	25	20	9
CSNOW	0	0	0	0	0	0
CQOF	0.5	0.3	0.3	0.3	0.5	0.3
CQIF	0.1	0.1	0.1	0.2	0.2	0.1
TIF	0.1	0.2	0.4	0.15	0.5	0.4
TOF	0.1	0.2	0.5	0.15	0.5	0.5
TG	0.3	0.15	0.41	0.1	0.5	0.41
CKOF1	1	1	1	1	1	1
CKOF2	1	1	1	1	1	1
CKIF	42	42	30	15	15	15
CKBF	62.5	30	100	100	30	60

Table A3-4: Calibration performance metrics

Station number	Catchment Area (km^2)	Calibration Period	Observed MAR (Mm^3)	Simulated MAR (Mm^3)	Coefficient of Determination (r^2)	Water Balance Error (WBL)	Nash-Sutcliffe efficiency (NSE)
2B33	1 346	1991 – 1999	386.5	362.6	0.602	-6.2%	-0.083
2D01	3 578	1978 – 1987	148.5	154.9	0.528	+4.3%	-0.111
2EB03	329	1986 – 1991	26.9	13.7	0.504	-49.1%	0.131
2ED01	127	1961 – 1970	45.9	44.8	0.675	-2.3%	0.424
2GC04	745	1970 – 1978	69.9	71.4	0.388	+2.1%	-0.591
2K01	688	1984 - 1989	76.3	75.5	0.749	-0.01%	0.498

Calibration Results: 2B33 - Catchment Area: 1346 km²

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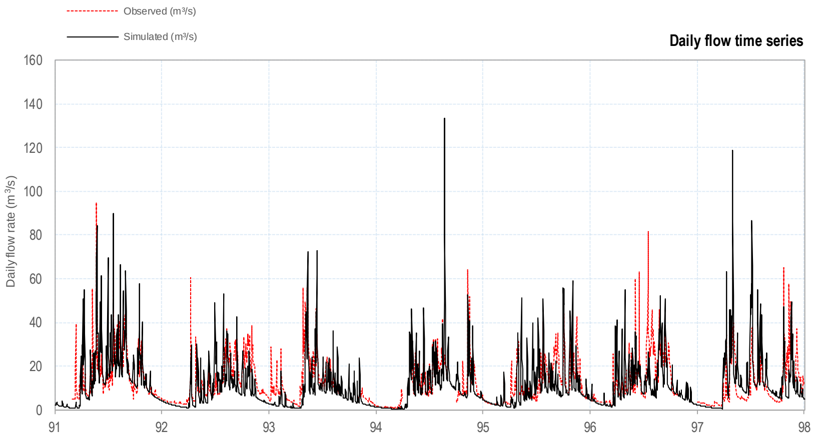
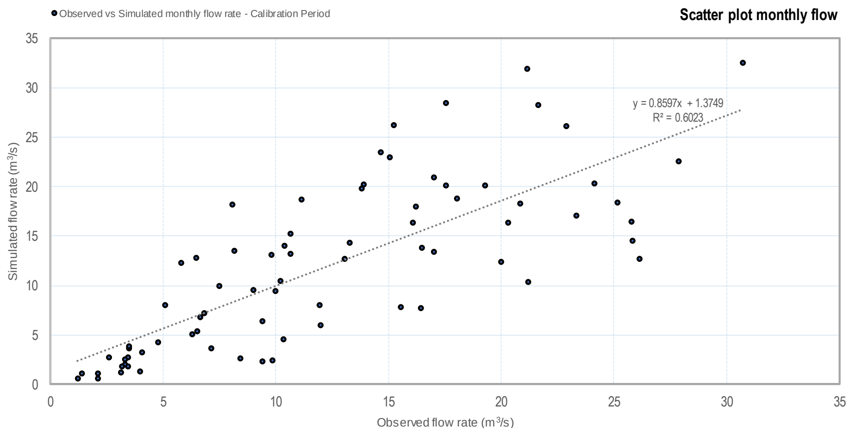
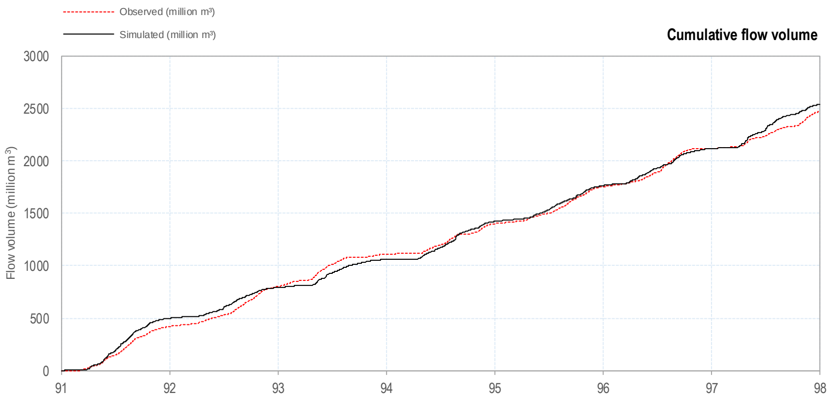
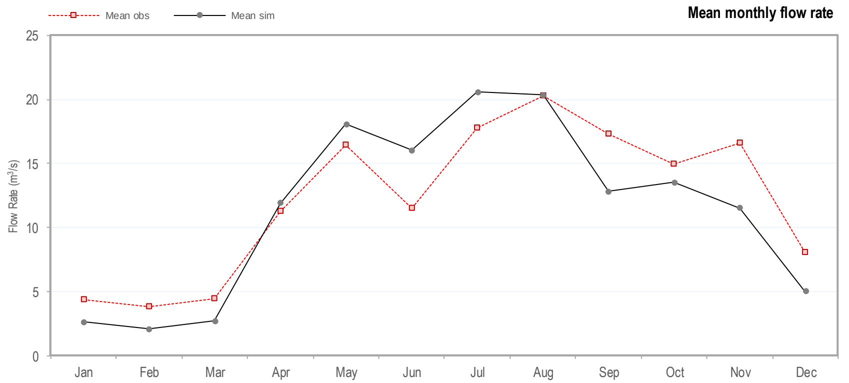








Performance Metrics

Node no. N394|Net flow to node

Node no. N394|Net flow to node

Coeff. of Determination (r^2) 0.602

Nash-Sutcliffe Coeff. of Efficiency -0.083

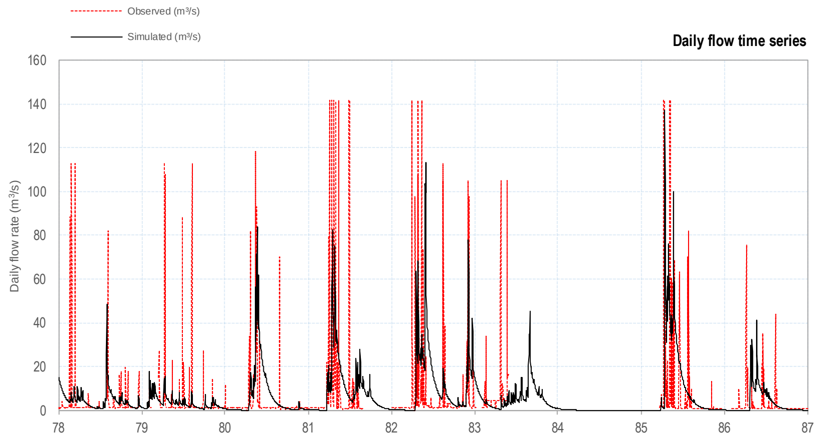
	Observed	Simulated	% Difference	Target %		Observed
Mean Annual Runoff (MAR) Jan- Dec [Mm³]	386.5	362.6	-6.6%	± 4%	Unit runoff [mm]	287.2
Annual Standard Deviation [Mm³]	15.1	78.3	80.7%	± 6%	MAP [mm]	1229
Seasonal Index	21.61	24.37	11.3%	± 8%	Runoff %	23%

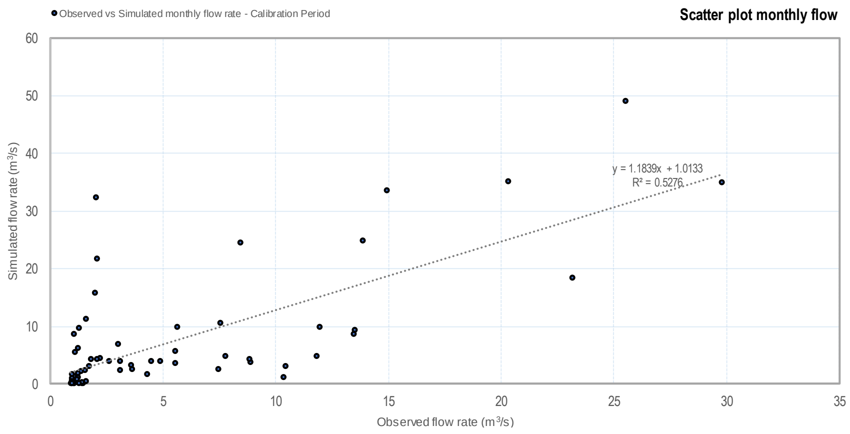
Average monthly flow rate [m³/s]

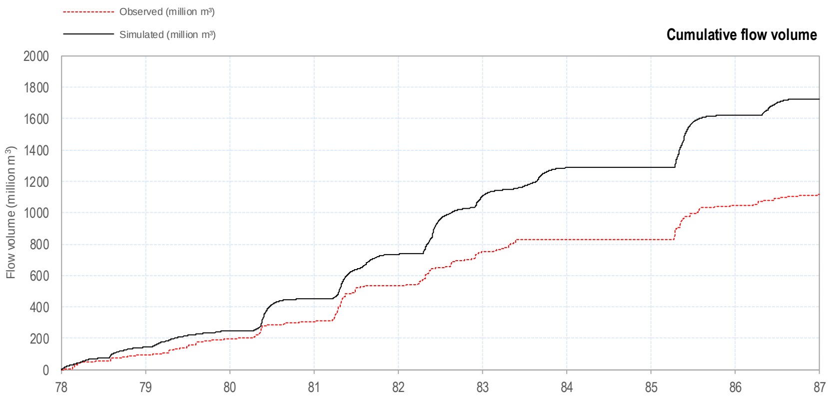
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average
Observed	4.4	3.8	4.5	11.3	16.5	11.5	17.8	20.3	17.3	15.0	16.6	8.1	12.2
Simulated	2.6	2.1	2.7	11.9	18.1	16.0	20.6	20.3	12.8	13.5	11.5	5.0	11.5
% difference	-66.2%	-82.8%	-64.6%	5.4%	9.0%	28.0%	13.8%	0.1%	-35.0%	-10.8%	-44.3%	-60.7%	-6.6%

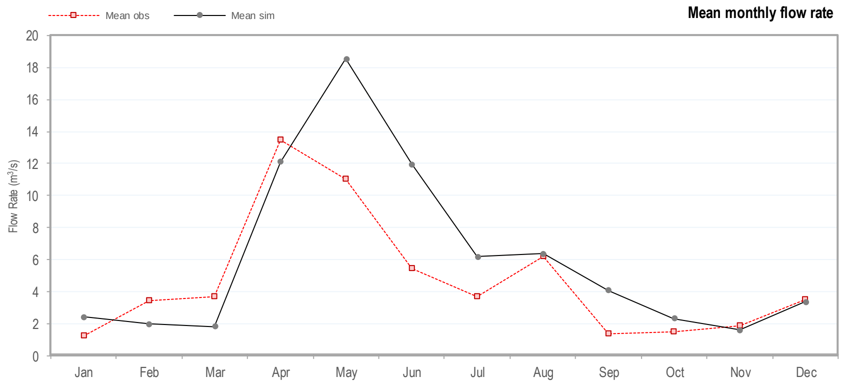
Figure A3-9: Calibration plot for streamflow gauge 2B33

Calibration Results: 2D01 - Catchment Area: 3578 km³ 4/6/2019 8:31AM









Performance Metrics

Node no. N394|Net flow to node

Node no. N394|Net flow to node

Coeff. of Determination (r^2) 0.528

Nash-Sutcliffe Coeff. of Efficiency -0.111

	Observed	Simulated	% Difference	Target %
Mean Annual Runoff (MAR) Jan- Dec [Mm³]	148.5	154.9	4.1%	± 4%
Annual Standard Deviation [Mm³]	Insufficient	138.7	Insufficient	± 6%
Seasonal Index	49.60	34.23	-44.9%	± 8%

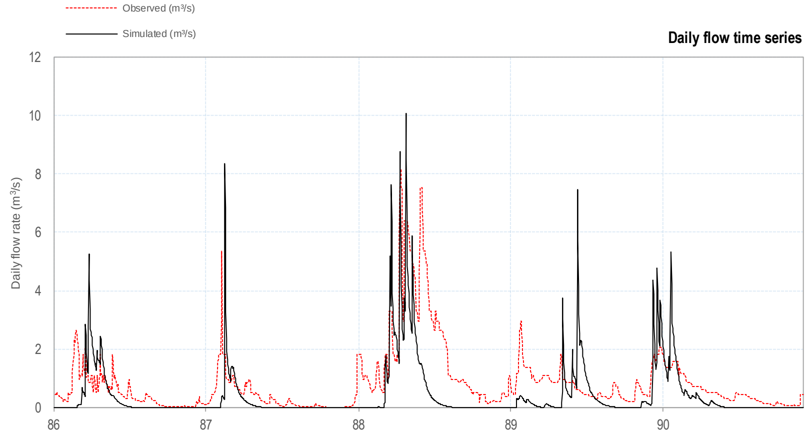
	Observed
Unit runoff [mm]	41.5
MAP [mm]	725
Runoff %	6%

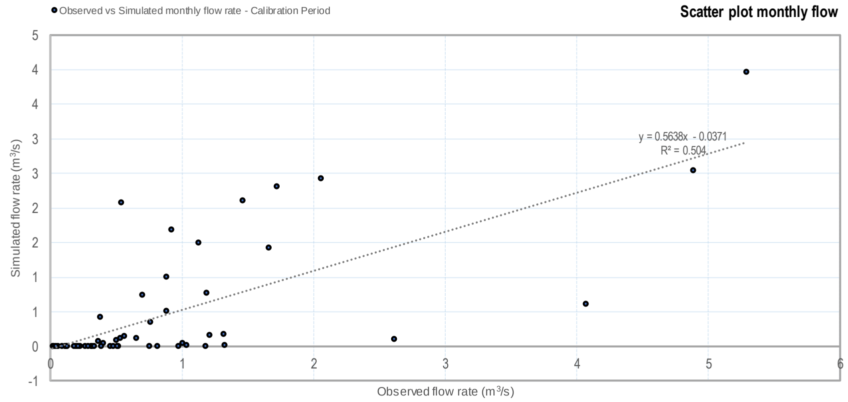
Average monthly flow rate [m³/s]

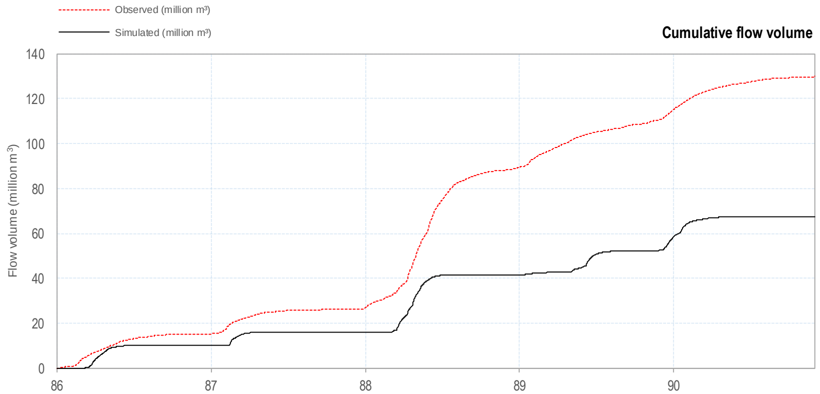
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average
Observed	1.3	3.4	3.7	13.5	11.0	5.5	3.7	6.2	1.4	1.5	1.9	3.5	4.7
Simulated	2.4	2.0	1.8	12.1	18.5	12.0	6.2	6.4	4.1	2.3	1.6	3.4	4.9
% difference	48.0%	-73.7%	-103.9%	-11.5%	40.6%	54.4%	40.0%	3.1%	66.8%	36.5%	-16.2%	-5.1%	4.2%

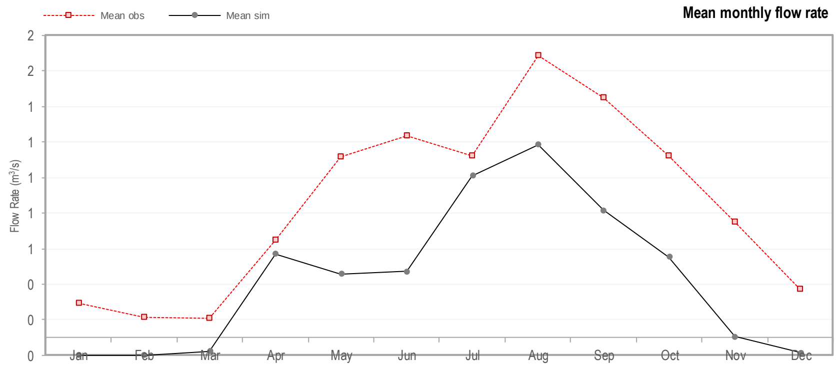
Figure A3-10: Calibration plot for streamflow gauge 2D01

Calibration Results: 2EB03 - Catchment Area: 329 km³ 4/6/2019 9:10 AM









Performance Metrics

Node no. N394|Net flow to node

Coeff. of Determination (r^2) 0.504

Nash-Sutcliffe Coeff. of Efficiency 0.131

	Observed	Simulated	% Difference	Target %
Mean Annual Runoff (MAR) Jan- Dec [Mm³]	26.9	13.7	-95.9%	± 4%
Annual Standard Deviation [Mm³]	6.3	#DIV/0!	#DIV/0!	± 6%
Seasonal Index	26.21	38.90	32.6%	± 8%

	Observed
Unit runoff [mm]	81.7
MAP [mm]	1068
Runoff %	8%

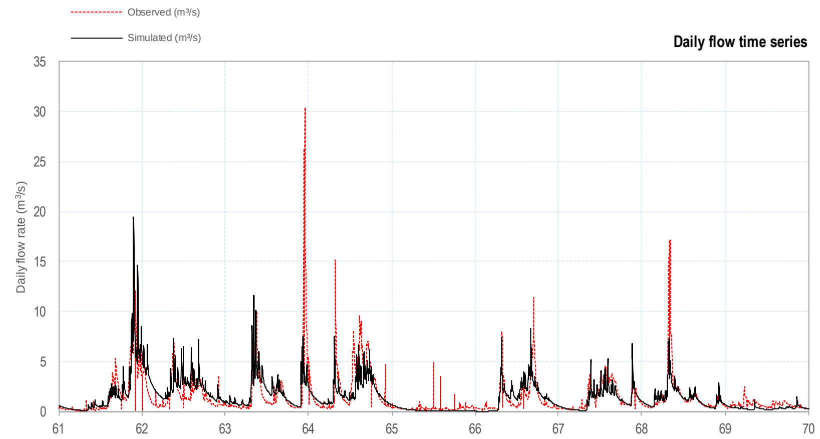
Node no. N394|Net flow to node

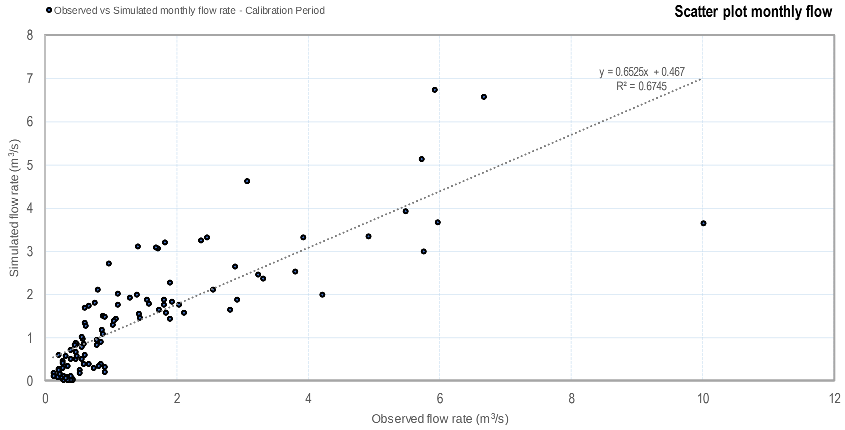
Average monthly flow rate [m³/s]

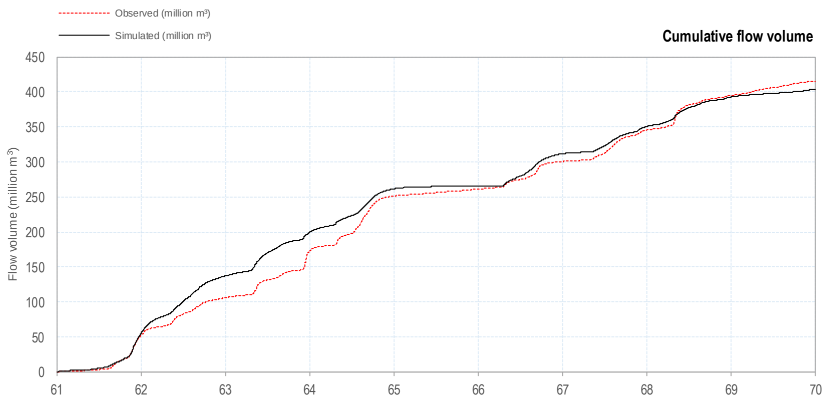
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average
Observed	0.3	0.2	0.2	0.6	1.1	1.2	1.1	1.7	1.5	1.1	0.7	0.4	0.9
Simulated	0.0	0.0	0.0	0.6	0.5	0.5	1.0	1.2	0.8	0.6	0.1	0.0	#DIV/0!
% difference	-98150.8%	#DIV/0!	-829.8%	-13.4%	-144.1%	-162.1%	-11.2%	-42.2%	-77.6%	-102.4%	-615.7%	-2320.6%	#DIV/0!

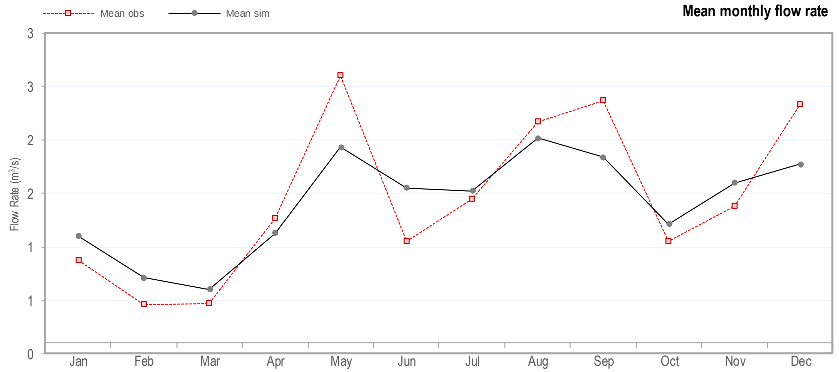
Figure A3-11: Calibration plot for streamflow gauge 2EB03

Calibration Results: 2ED01 - Catchment Area: 127 km³ 4/6/2019 9:15 AM









Performance Metrics

Node no. N394|Net flow to node

Coeff. of Determination (r^2) 0.675

Nash-Sutcliffe Coeff. of Efficiency 0.424

	Observed	Simulated	% Difference	Target %
Mean Annual Runoff (MAR) Jan- Dec [Mm³]	45.9	44.8	-2.5%	± 4%
Annual Standard Deviation [Mm³]	21.3	24.9	14.5%	± 6%
Seasonal Index	16.01	12.72	-25.9%	± 8%

	Observed
Unit runoff [mm]	361.8
MAP [mm]	1390
Runoff %	26%

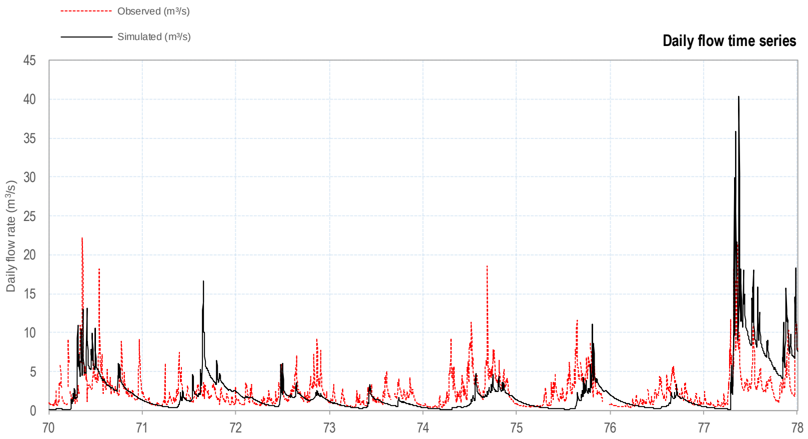
Node no. N394|Net flow to node

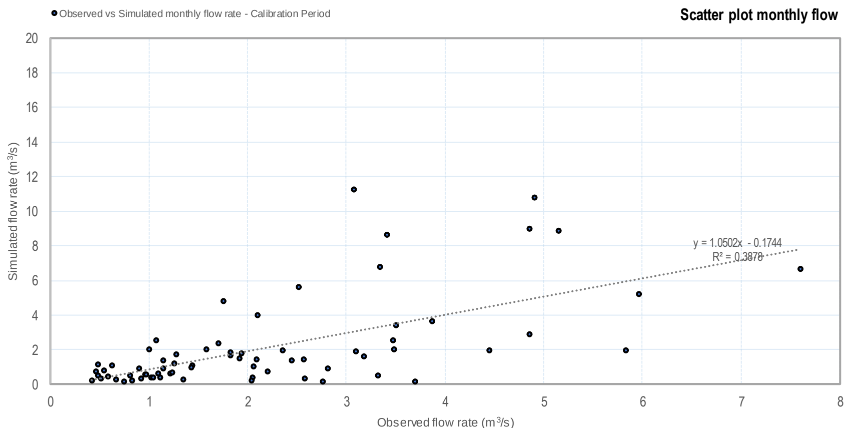
Average monthly flow rate [m³/s]

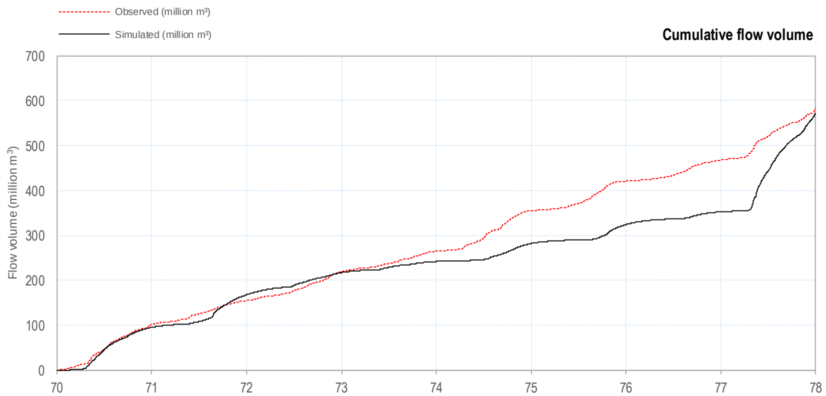
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average
Observed	0.9	0.5	0.5	1.3	2.6	1.1	1.4	2.2	2.4	1.0	1.4	2.3	1.5
Simulated	1.1	0.7	0.6	1.1	1.9	1.6	1.5	2.0	1.8	1.2	1.6	1.8	1.4
% difference	20.9%	36.0%	22.9%	-12.8%	-34.8%	32.0%	5.3%	-7.6%	-29.0%	13.8%	13.4%	-31.2%	-2.5%

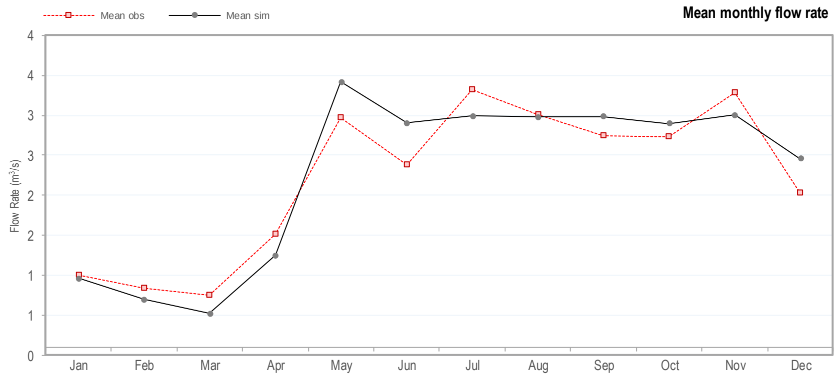
Figure A3-12: Calibration plot for streamflow gauge 2ED01

Calibration Results: 2G004 - Catchment Area: 745 km³ 4/6/2019 9:27 AM









Performance Metrics

Node no. N394|Net flow to node

Coeff. of Determination (r^2) 0.388

Nash-Sutcliffe Coeff. of Efficiency -0.591

	Observed	Simulated	% Difference	Target %
Mean Annual Runoff (MAR) Jan- Dec [Mm³]	69.9	71.4	2.1%	± 4%
Annual Standard Deviation [Mm³]	Insufficient	63.9	Insufficient	± 6%
Seasonal Index	17.40	20.95	16.9%	± 8%

	Observed
Unit runoff [mm]	93.8
MAP [mm]	1173
Runoff %	8%

Node no. N394|Net flow to node

Average monthly flow rate [m³/s]

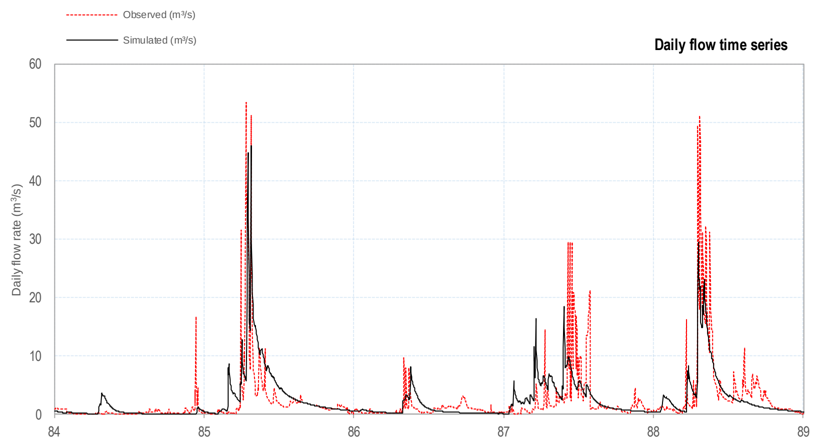
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average
Observed	1.0	0.8	0.7	1.5	3.0	2.4	3.3	3.0	2.7	2.7	3.3	2.0	2.2
Simulated	1.0	0.7	0.5	1.3	3.4	2.9	3.0	3.0	3.0	2.9	3.0	2.5	2.3
% difference	-4.5%	-21.0%	-44.0%	-21.0%	13.1%	18.2%	-10.9%	-0.9%	7.8%	5.6%	-9.1%	17.7%	2.1%

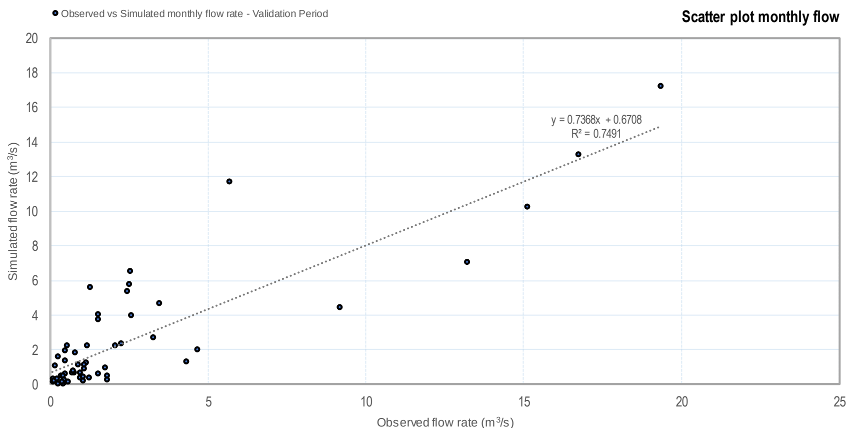
Figure A3-13: Calibration plot for streamflow gauge 2GC04

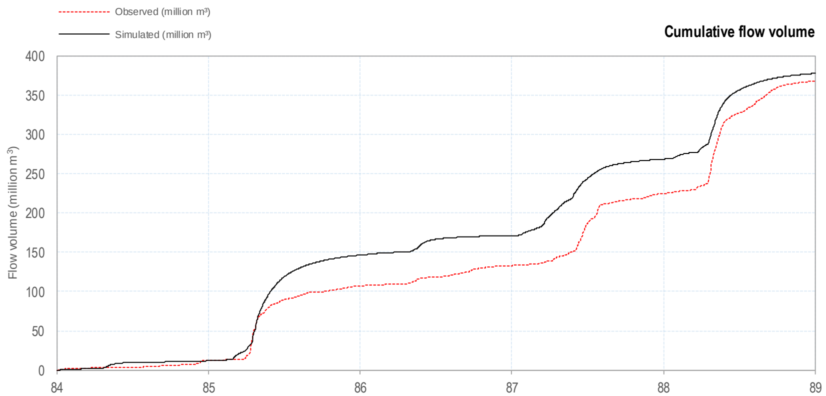
Calibration Results: 2K01 -

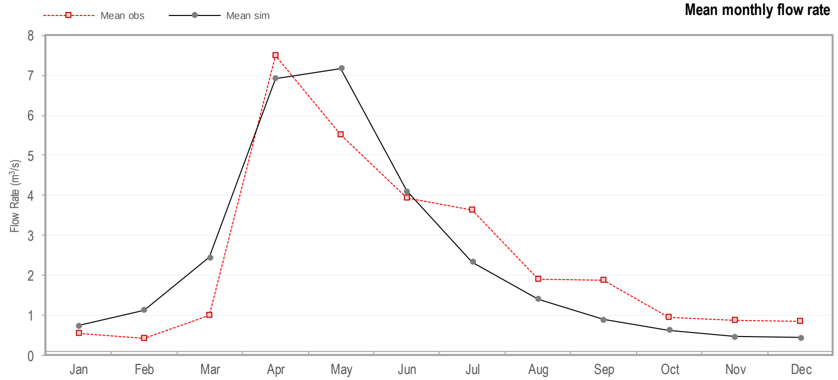
Catchment Area: 688 km³

4/6/2019 9:54 AM









Performance Metrics

Node no. N394|Net flow to node

Coeff. of Determination (r^2) 0.749

Nash-Sutcliffe Coeff. of Efficiency 0.498

	Observed	Simulated	% Difference	Target %
Mean Annual Runoff (MAR) Jan- Dec [Mm³]	76.3	75.5	-1.1%	± 4%
Annual Standard Deviation [Mm³]	58.4	54.0	-8.3%	± 6%
Seasonal Index	37.27	38.61	3.5%	± 8%

	Observed
Unit runoff [mm]	111.0
MAP [mm]	933
Runoff %	12%

Node no. N394|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	0.6	0.4	1.0	7.5	5.5	3.9	3.6	1.9	1.9	1.0	0.9	0.9	2.4
Simulated	0.7	1.1	2.4	6.9	7.2	4.1	2.3	1.4	0.9	0.6	0.5	0.4	2.4
% difference	25.2%	62.2%	59.0%	-8.0%	23.2%	4.1%	-56.2%	-35.6%	-111.2%	-49.5%	-88.0%	-94.7%	-1.1%

Figure A3-14: Calibration plot for streamflow gauge 2K01

Model Validation

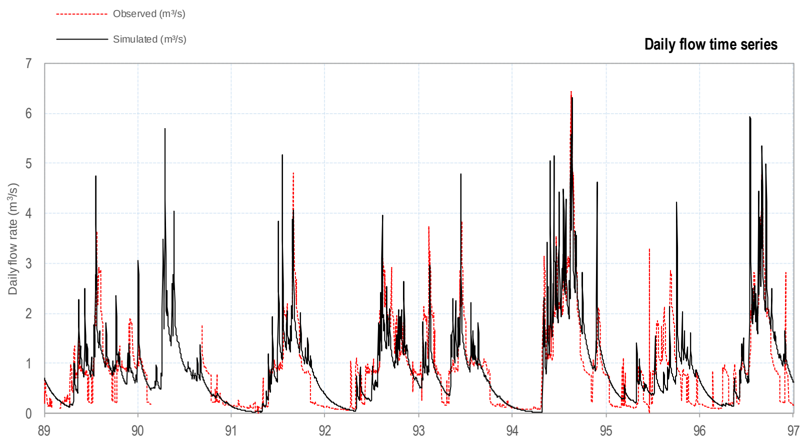
The calibrated NAM rainfall-runoff model was validated by comparing observed and simulated flows at three other flow gauging stations representative of the upper and middle parts of the basin respectively. Validation metrics are presented in Table A3-5. A visual comparison of observed vs. simulated flows confirmed a reasonable fit between simulated and observed flows, with emphasis on flow recession curves and low flows during the dry seasons, as shown in Figure A3-15 and Figure A3-17 below.

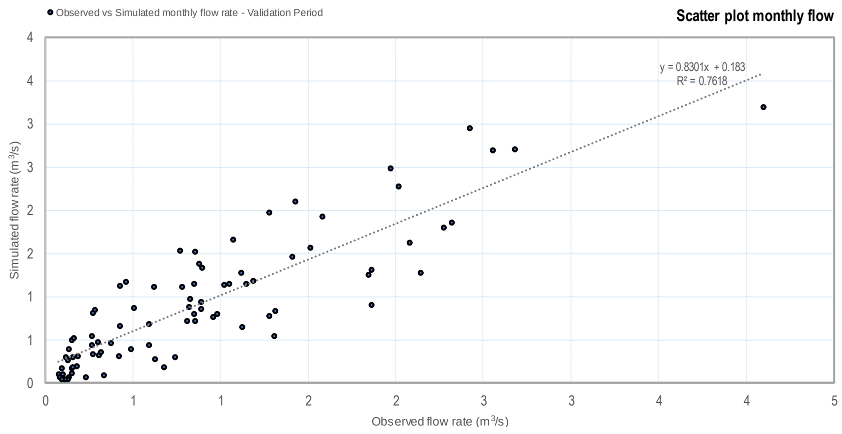
In general, taking into account the relatively limited observed rainfall and flow data availability as well as data quality issues e.g. missing and exceeded data at many flow gauging stations, the calibration and validation results were deemed acceptable for the purposes of water resources assessment and planning. Except for one station, all calibration and validation simulated flows are within 10% of the observed MARs, while all Nash-Sutcliffe Efficiency values are larger than zero.

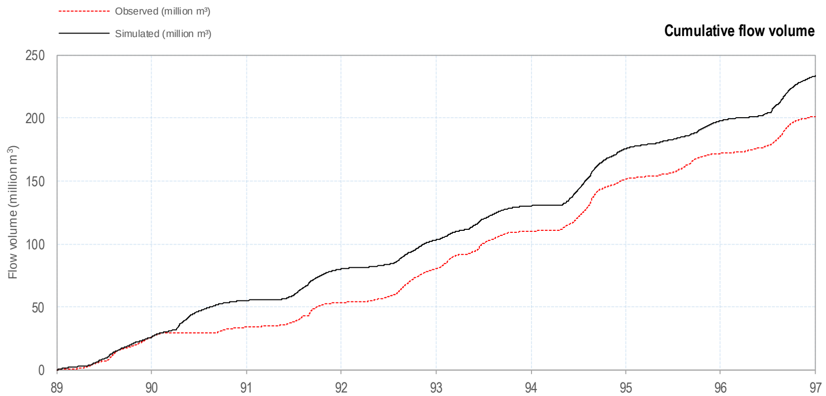
Table A3-5: Validation performance metrics

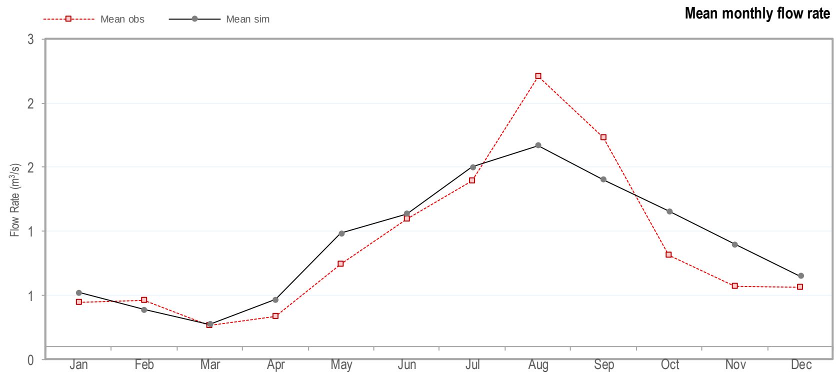
Station number	Catchment Area (km^2)	Validation Period	Observed MAR (Mm^3)	Simulated MAR (Mm^3)	Coefficient of Determination (r^2)	Water Balance Error (WBL)	Nash-Sutcliffe efficiency (NSE)
2ED01	127	1989 – 1997	28.0	29.2	0.762	+4.2%	0.518
2GC04	745	1980 – 1983	-	94.7	0.474	-	-0.187
2K01	688	1966 – 1968	-	82.3	0.874	-	0.374

Calibration Results: 2ED01 - Catchment Area: 127 km³ 4/6/2019 9:15 AM









Node no. N394|Net flow to node

Node no. N394|Net flow to node

Performance Metrics

Coeff. of Determination (r^2)	0.762
Nash-Sutcliffe Coeff. of Efficiency	0.518

	Observed	Simulated	% Difference	Target %
Mean Annual Runoff (MAR) Jan- Dec [Mm³]	28.0	29.2	4.1%	± 4%
Annual Standard Deviation [Mm³]	7.5	7.8	2.8%	± 6%
Seasonal Index	27.02	21.29	-26.9%	± 8%

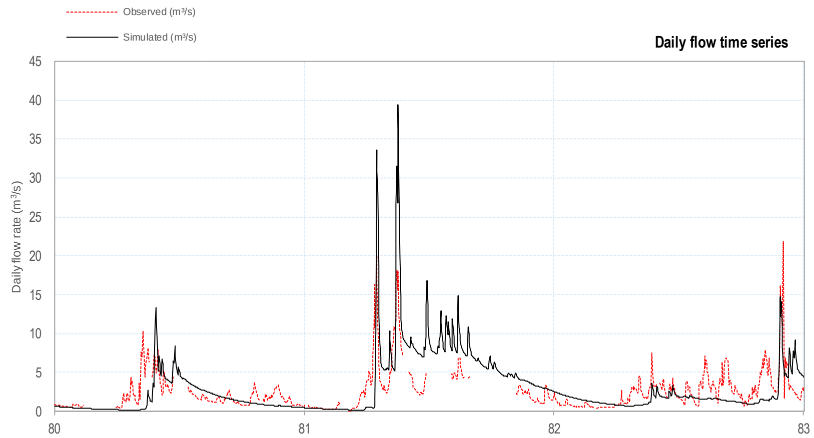
	Observed
Unit runoff [mm]	220.3
MAP [mm]	1390
Runoff %	16%

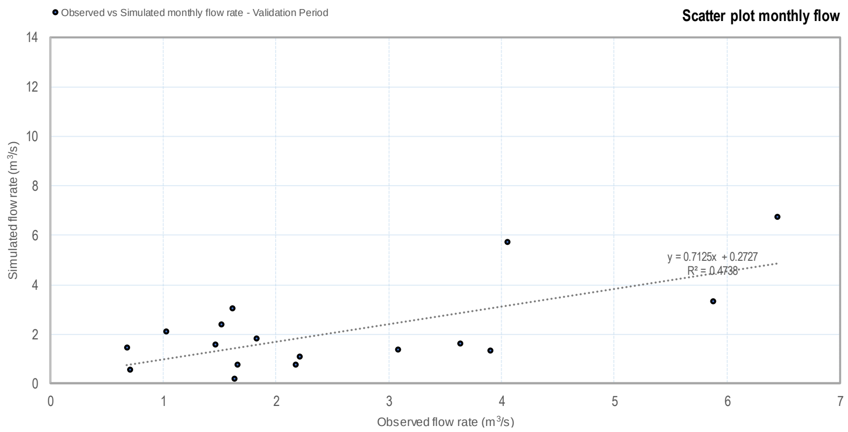
Average monthly flow rate [m³/s]

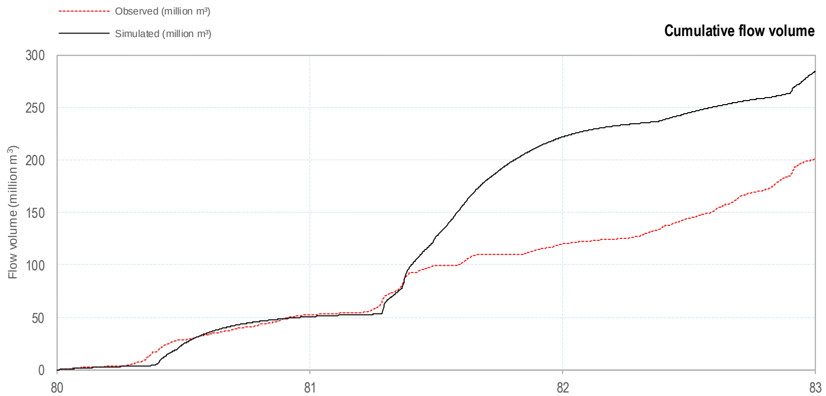
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average
Observed	0.4	0.5	0.3	0.3	0.7	1.1	1.4	2.2	1.7	0.8	0.6	0.6	0.9
Simulated	0.5	0.4	0.3	0.5	1.0	1.1	1.5	1.7	1.4	1.2	0.9	0.7	0.9
% difference	14.8%	-17.5%	2.4%	28.2%	24.1%	3.6%	7.4%	-32.4%	-23.6%	29.7%	36.0%	13.1%	4.1%

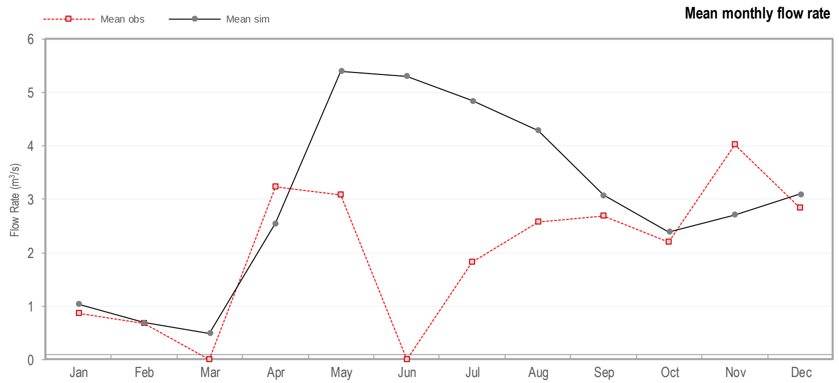
Figure A3-15: Gauge 2ED01 validation (1989 – 1997)

Calibration Results: 2G004 - Catchment Area: 745 km³ 4/6/2019 9:27 AM









Performance Metrics

Node no. N394|Net flow to node

Coeff. of Determination (r^2)	0.474
Nash-Sutcliffe Coeff. of Efficiency	-0.187

	Observed	Simulated	% Difference	Target %
Mean Annual Runoff (MAR) Jan- Dec [Mm³]	Insufficient	94.7	#VALUE!	± 4%
Annual Standard Deviation [Mm³]	Insufficient	66.5	Insufficient	± 6%
Seasonal Index	Insufficient	22.39	#VALUE!	± 8%

	Observed
Unit runoff [mm]	#VALUE!
MAP [mm]	1173
Runoff %	#VALUE!

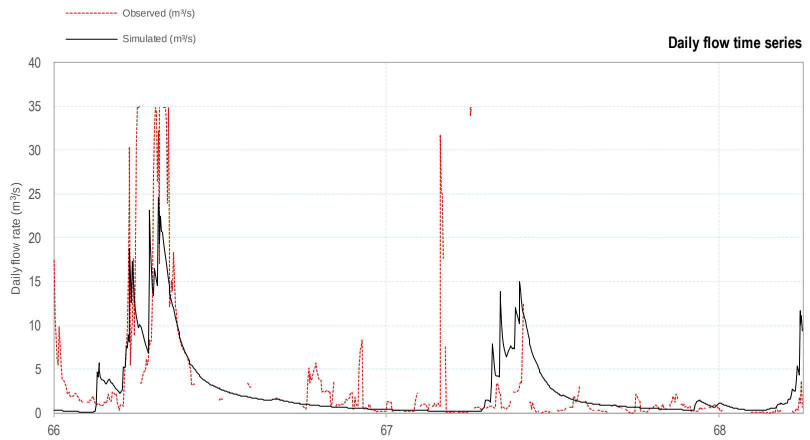
Node no. N394|Net flow to node

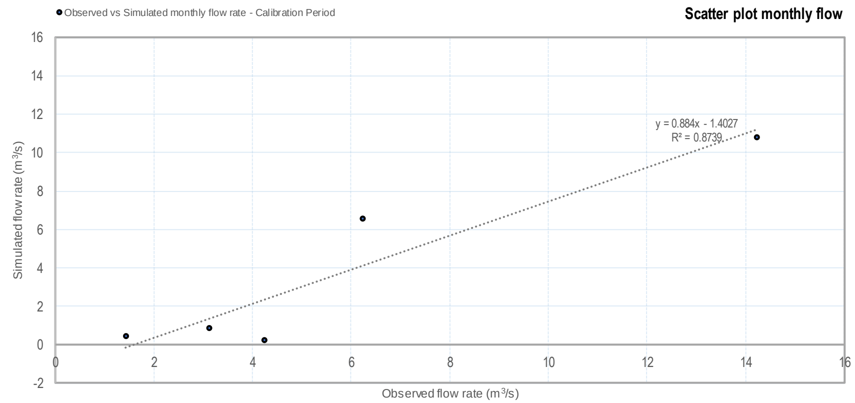
Average monthly flow rate [m³/s]

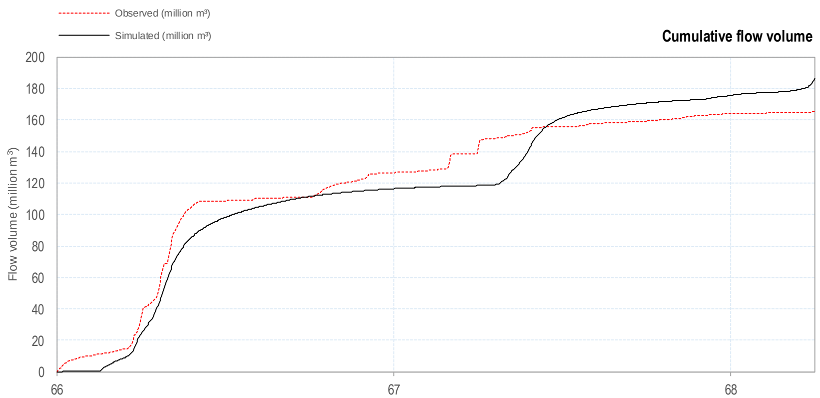
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average
Observed	0.9	0.7	#DIV/0!	3.2	3.1	#DIV/0!	1.8	2.6	2.7	2.2	4.0	2.8	#DIV/0!
Simulated	1.0	0.7	0.5	2.6	5.4	5.3	4.8	4.3	3.1	2.4	2.7	3.1	3.0
% difference	16.9%	1.7%	#DIV/0!	-27.0%	43.0%	#DIV/0!	62.4%	40.1%	12.9%	7.7%	-48.4%	8.5%	#DIV/0!

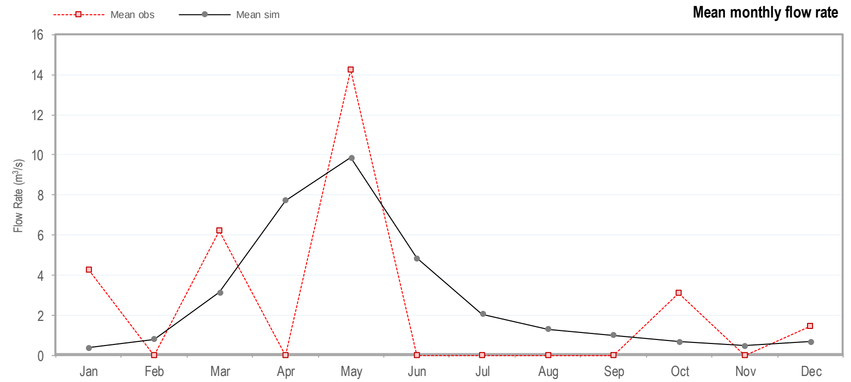
Figure A3-16: Gauge 2GC04 validation (1980 – 1983)

Calibration Results: 2K01 - Catchment Area: 688 km³ 4/6/2019 9:54 AM









Performance Metrics

Node no. N394|Net flow to node

Coeff. of Determination (r^2) 0.874

Nash-Sutcliffe Coeff. of Efficiency 0.374

	Observed	Simulated	% Difference	Target %
Mean Annual Runoff (MAR) Jan- Dec [Mm³]	Insufficient	82.3	#VALUE!	± 4%
Annual Standard Deviation [Mm³]	Insufficient	#DIV/0!	Insufficient	± 6%
Seasonal Index	Insufficient	44.03	#VALUE!	± 8%

	Observed
Unit runoff [mm]	119.6
MAP [mm]	933
Runoff %	13%

Node no. N394|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	4.2	#DIV/0!	6.2	#DIV/0!	14.2	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	3.1	#DIV/0!	1.4	#DIV/0!
Simulated	0.4	0.8	3.1	7.7	9.9	4.8	2.1	1.3	1.0	0.7	0.5	0.7	#DIV/0!
% difference	-992.7%	#DIV/0!	-98.3%	#DIV/0!	-44.3%	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	-354.8%	#DIV/0!	-108.2%	#DIV/0!

Figure A3-17: Gauge 2K01 validation: mean monthly flow rate (1966 – 1968)

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 some uncalibrated catchments, transition (weighted) parameters based on surrounding calibration catchment parameters were assigned. Table A3-6 presents the parameter data set assigned to each model sub-catchment, while Table A3-7 presents the values for each parameter data set.

Table A3-6: NAM model parameter data set assigned to model sub-catchments

Sub-basin	Parameter Data Set	Model sub-catchment
2AA	2D01	2AA
2AB		2AB
2BA	2ED01	2BA
2BB	Transition	2BB_us2B8
		2BB_us2B12
		2BB_usWeiWei_ab
		2BB_usEmbobut
	2ED01	2BB_US2B30
		2BB_US2B17
		2BB
2BC	2B33	2BC_a
	Transition	2BC_b_us2B20
		2BC_b_usTwel
	2ED01	2BC_b
2BD	2D01	2BD_b
	2ED01	2BD_a
2CA		2CA
2CB		2CB_a_usKimware
		2CB_a
		2CB_b
2CC	Transition	2CC_a_us2C05
		2CC_a_us2C18
		2CC_a_usEmb_Dam
		2CC_a_us2C12
	2ED01	2CC_a
		2CC_b
2D	2D01	2D_b
		2D_a
		2D_d
		2D_c
2EA	2EB03	2EA
2EB		2EB_a_us2EB01
		2EB_a
		2EB_b_us2EB05
		2EB_b

Sub-basin	**Parameter Data Set**	**Model sub-catchment**
2EC	2ED01	2EC_b
		2EC_a_usEC03
		2EC_a_USEC04
		2EC_a
2ED	2ED01	2ED_usChem
		2ED_us2ED01
		2ED_us2ED02
		2ED_usED03
		2ED
2EE	2D01	2EE
	2ED01	2EE_usAram
		2EE_usRatat
		2EE_usE07A
2EF		2EF
2EG1	Transition	2EG1
2EG2	2D01	2EG2_b_usEG08
		2EG2_b
	Transition	2EG2_a
2EH	2ED01	2EH_usKrandich
		2EH_usEH03b
		2EH_usChemeron
		2EH
2EJ	2EB03	2EJ
2EK	2EB03	2EK
2FA	2EG01	2FA
2FB	2EB03	2FB
2FC	Transition	2FC_us2FC16
		2FC
2GA	Transition	2GA_us2GA03
		2GA_us2GA01
	2GC04	2GA
2GB		2GB_a
		2GB_b_usMalewa
		2GB_b_us2GB01
		2GB_b
2GC		2GC
2GD		2GD
2H-1	2K01	2H_1_a
		2H_1_bMgadi
		2H_1_b
2H-2		2H_2
2H-3		2H_3
2J		2J_Tur
2KA		2KA_us2K01
		2KA_usUNarok

Sub-basin	Parameter Data Set	Model sub-catchment
		2KA_usNarokWeir
		2KA_us2K03
		2KA_us2K06
		2KA_usOletukat
		2KA
2KB		2KB_usLeshota
		2KB_usOldorko
		2KB
2KC		2KC_EntasopiaR
		2KC_US2EK04
		2KC_Sampu
		2KC_Olibotot
		2KC_ExclSampu
jj	2D01	jj

Table A3-7: NAM model parameters assigned to each data set

	Gauge ID												
Parameter	**2B33**	**2C05**	**2D01**	**2EA01**	**2EB03**	**2ED01**	**2EG01**	**2GA03**	**2GB07**	**2GC04**	**2K01**	**2ED01_Adj**	**Prev_2KC01**
Ss0	0	0	0	0	0	0	0	0	0	0	0	0	0
U0/UMAX	0	0	0	0	0	0	0	0	0	0	0	0	0
L0/LMAX	0	0	0	0	0	0	0	0	0	0	0	0	0
QOF	0	0	0	0	0	0	0	0	0	0	0	0	0
QIF_0	0	0	0	0	0	0	0	0	0	0	0	0	0
QBF_0	0	0	0	0	0	0	0	0	0	0	0	0	0
AREA	1346.195	184.0545	2714.613	93	209.6222	126.9965	612.5368	136.0222	368.7676	745.3667	688.382	126.9965	688.382
CAREA	1	1	1	1	1	1	1	1	1	1	1	1	1
LMAX	130	150	150	275	275	300	200	330	130	280	350	350	325
UMAX	4	12	13	20	15	11	9	2	5	30	40	40	25
CSNOW	0	0	0	0	0	0	0	0	0	0	0	0	0
CQOF	0.5	0.7	0.3	0.5	0.5	0.25	0.3	0.1	0.9	0.3	0.2	0.25	0.3
CQIF	0.1	0.1	0.1	0.2	0.2	0.05	0.05	0.01	0.1	0.1	0.1	0.05	0.2
TIF	0.1	0.2	0.2	0.5	0.5	0.4	0.45	0.4	0.4	0.4	0.5	0.4	0.15
TOF	0.1	0.2	0.2	0.5	0.5	0.6	0.45	0.5	0.4	0.5	0.5	0.6	0.15
TG	0.3	0.1	0.15	0.5	0.4	0.05	0.45	0.5	0.5	0.41	0.5	0.05	0.1
CKOF1	1	1	1	1	1	1	1	1	1	1	1	1	1
CKOF2	1	1	1	1	1	1	1	1	1	1	1	1	1
CKIF	41.66667	41.66667	41.66667	15	15	15	15	5	30	30	15	15	15
CKBF	62.5	180	30	30	30	60	30	30	100	100	100	60	100

A Natural MIKE HYDRO Basin model of the Rift Valley Basin was configured. The Natural model represents the pristine state of the basin before any man-made influences, i.e. no water users and no water-resources infrastructure. Figure A3-18 displays the Natural model configuration for the Rift Valley Basin. A relatively high spatial resolution was adopted for model construction in terms of number of model sub-catchments.

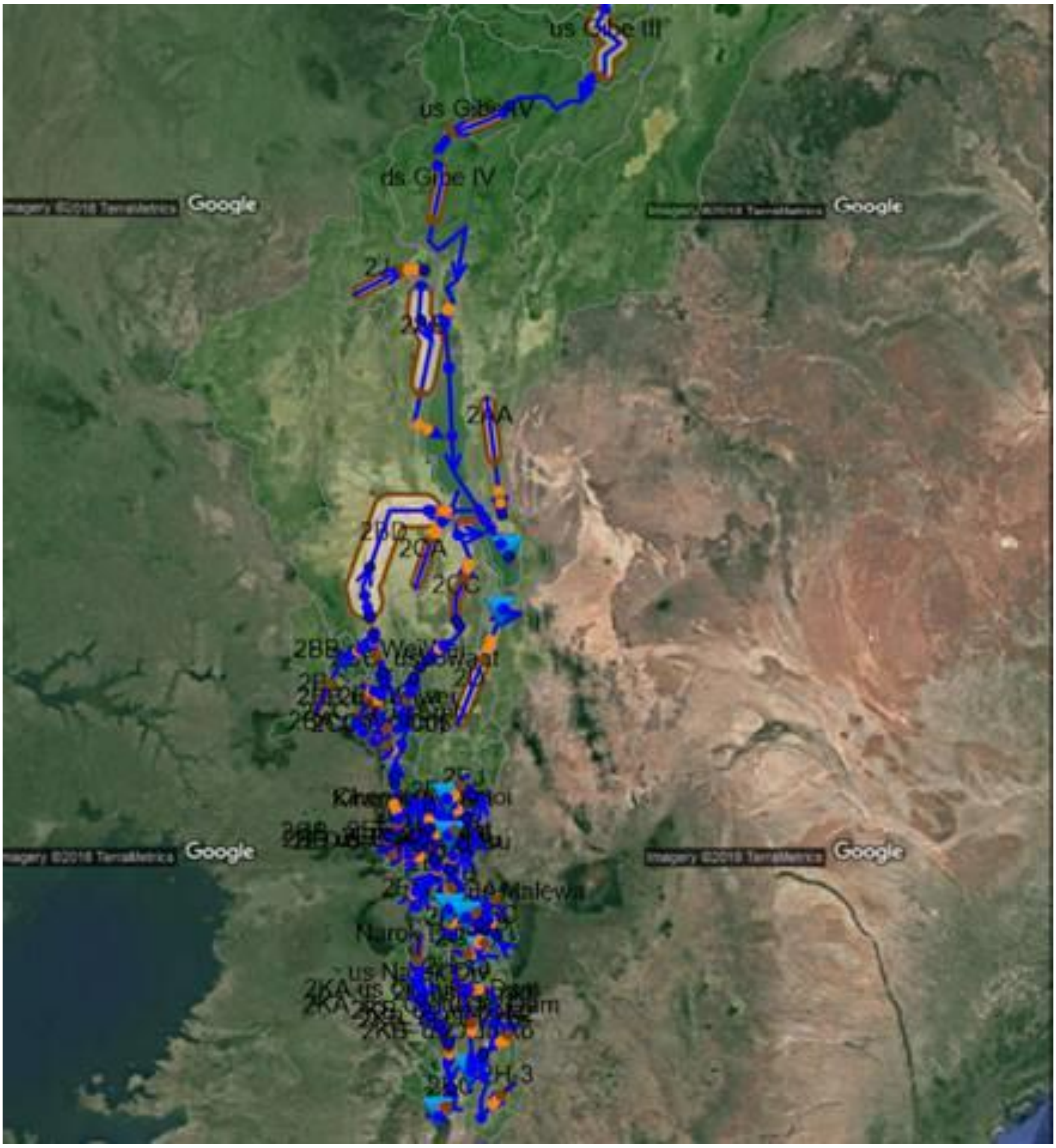


Figure A3-18: Rift Valley Basin Natural model configuration in MIKE HYDRO Basin

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".

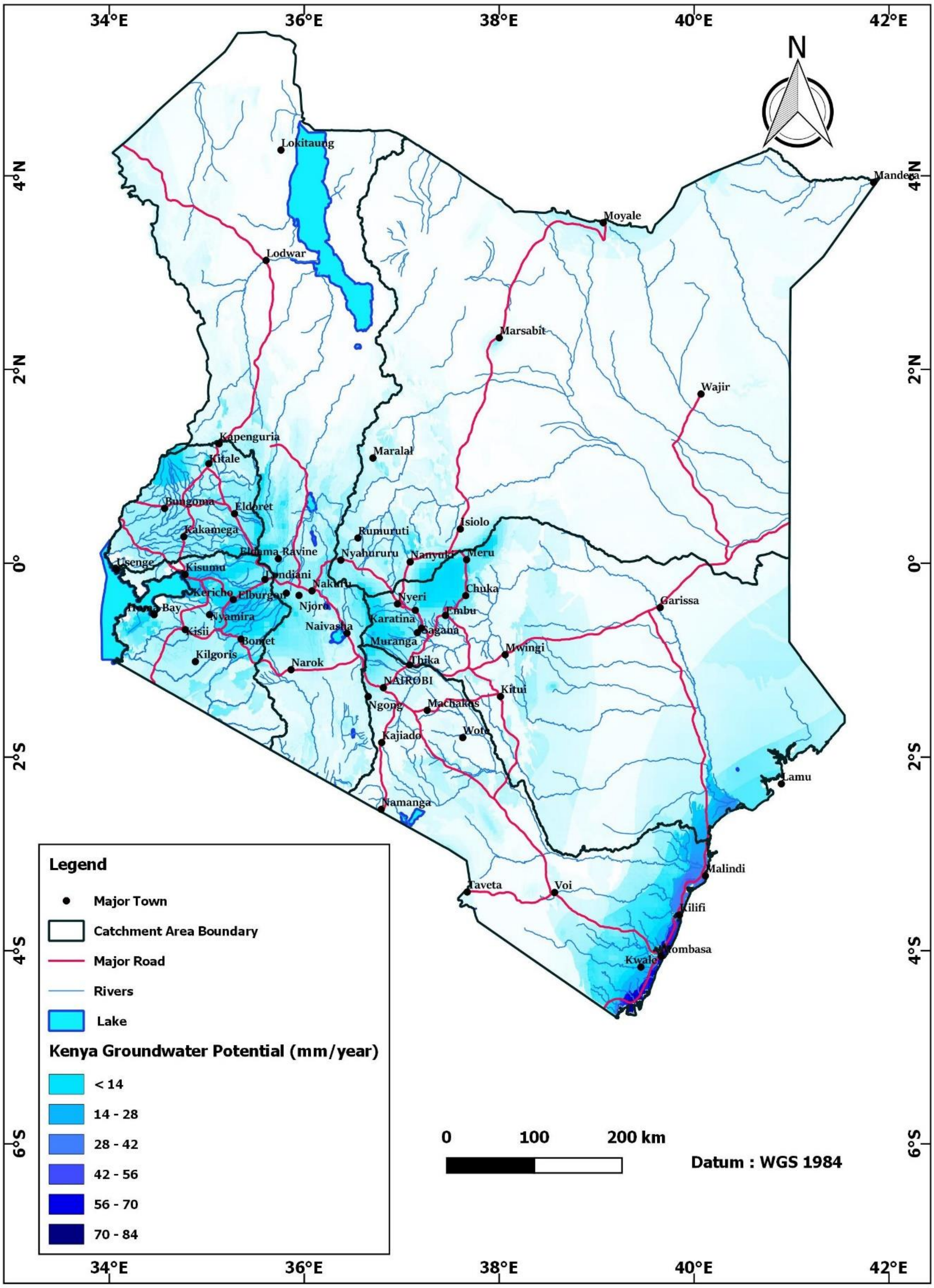


Figure A4 -1: Groundwater Potential in mm/year

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 RV Basin delineated the Basin into 35 sub-basins with two main components: ; the rivers, lakes and wetlands in the Lake Turkana Ecoregion, and; the rivers, lakes and wetlands situated in the Southern-Eastern Rift Ecoregion. 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 and Figure A5-2 indicates the locations of the representative nodes as well as the ecological condition of 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 Basin.

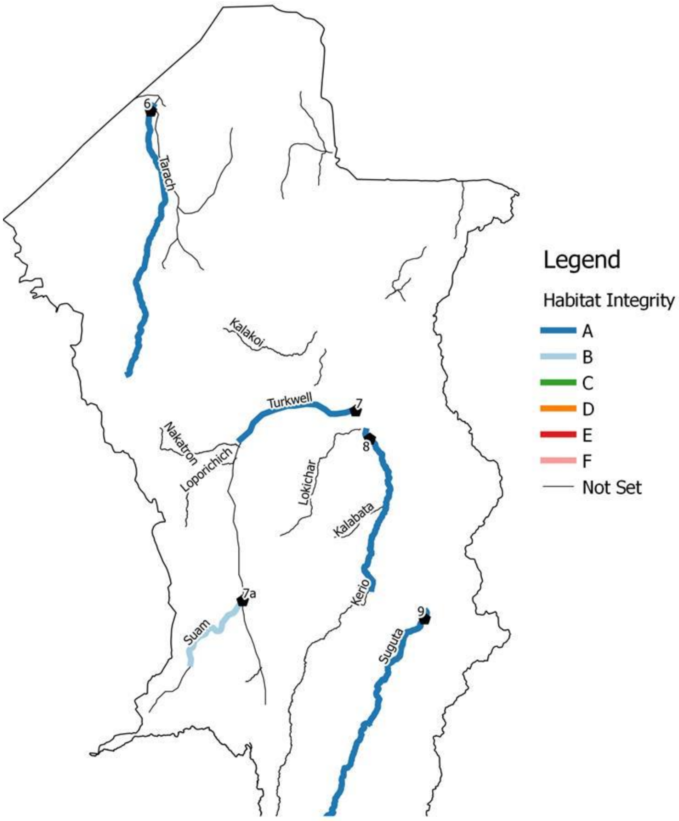


Figure A5-1: Ecological condition of five representative reaches in the northern region of the RV Basin

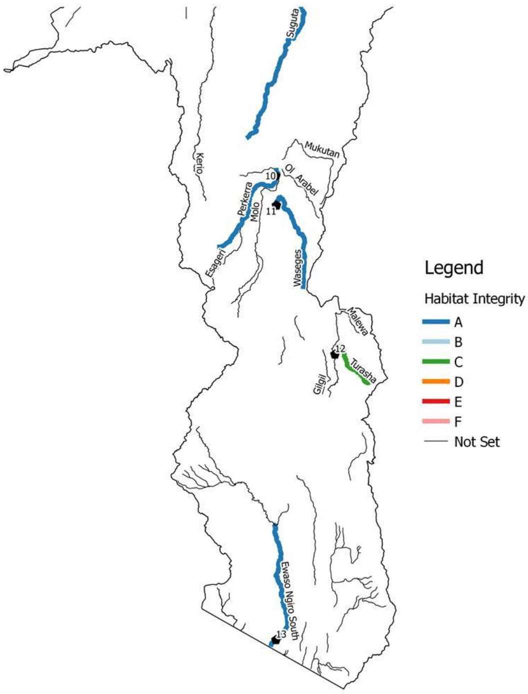


Figure A5-2: Ecological condition of five representative reaches in the southern region of the RV Basin

Table A5-2: Main hydro-geomorphological characteristics and 2018 ecological condition of representative nodes in the RV Basin

Node		River	Description	Ecological condition	Zone	Rosgen (1994)	x coord.	y coord..
Number	Code							
13	6	Tarach	u/s floodplain wetland	A (100%)	Tarach River	F	34.8959	4.872
14	7a	Suam	d/s Turkwell dam and gorge	B (87.6%)	Turkwel River	F	35.4332	2.0085
15	7	Turkwell	d/s Nakatron and u/s Lodwar Rivers	A (100%)		DA	36.0943	3.1194
16	8	Keiro	d/s Kalabata River	A (100%)	Keiro River	E	36.1766	2.9533
17	9	Suguta	u/s Lake Logipi	A (100%)	Suguta River	DA	36.4969	1.9027
18	10	Perkerra	d/s Masam dam	A (96.7%)	Lake Baringo	F	36.0718	0.5153
19	11	Weseges	d/s planned Weseges dam	A (92.3%)		F	36.0749	0.3487
20	12	Turasha	d/s Turasha dam	C (63.0%)	Lake Naivasha	F	36.405	-0.4912
21	13	Elwaso Ngiro South	d/s Leshota and Eldorko HPP site	A (100%)	Elwaso Ngiro South	E	36.0723	2.1008

The Holding EFlows, as a percentage of natural flows, for all sub-basins in the RV 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 RV Basin

Longitudinal zone	Sub-basins	HI		Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Tarach River	2J	9 - 14	A	66.3	100.0	100.0	66.3	66.3	66.3	100.0	100.0	66.3	66.3	66.3	66.3
			B	53.0	88.5	88.5	53.0	53.0	53.0	88.5	88.5	53.0	53.0	53.0	53.0
			C	35.3	59.0	59.0	35.3	35.3	35.3	59.0	59.0	35.3	35.3	35.3	35.3
			D	22.1	38.9	38.9	22.1	22.1	22.1	38.9	38.9	22.1	22.1	22.1	22.1
Lake Turkana	2AA, 2AB, 2CA	n/a													
Turkwel River	2BA, 2BB	n/a													
	2BC	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
	2BD	9 - 14	A	66.3	100.0	100.0	66.3	66.3	66.3	100.0	100.0	66.3	66.3	66.3	66.3
			B	53.0	88.5	88.5	53.0	53.0	53.0	88.5	88.5	53.0	53.0	53.0	53.0
			C	35.3	59.0	59.0	35.3	35.3	35.3	59.0	59.0	35.3	35.3	35.3	35.3
			D	22.1	38.9	38.9	22.1	22.1	22.1	38.9	38.9	22.1	22.1	22.1	22.1
Keiro River	2CB	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
	2CC	n/a													
Suguta River	2D	9 - 14	A	66.3	100.0	100.0	66.3	66.3	66.3	100.0	100.0	66.3	66.3	66.3	66.3
			B	53.0	88.5	88.5	53.0	53.0	53.0	88.5	88.5	53.0	53.0	53.0	53.0
			C	35.3	59.0	59.0	35.3	35.3	35.3	59.0	59.0	35.3	35.3	35.3	35.3
			D	22.1	38.9	38.9	22.1	22.1	22.1	38.9	38.9	22.1	22.1	22.1	22.1
Lake Baringo	2EA, 2EC, 2ED, 2EH, 2FB	n/a													
	2EB, 2EG1,	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

	2EG2, 2EF, 2EE, 2EJ, 2EK		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
Lake Nkuru	2FA, 2FC	n/a													
Lake Naivasha	2GA, 2GB, 2GC	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
	2GD	n/a													
Lake Magadi	2H-1, 2H-2, 2H-3	n/a													
Ewaso Ngiro South	2KA, 2KB, 2KC	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	km2

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 = x1.59 (0.13) (0.99x)
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	km2

Source Data
Planned large scale irrigation (km2)

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 (km2)

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	km2
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	km2

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)
$y = 1.4493x2 + 3.0897x -0.6197$
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 (km2)

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 (km2) 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.

Figure A7-1: Aggregation of Macro-Economic Sectors for the Hydro-Economic Analysis

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

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.

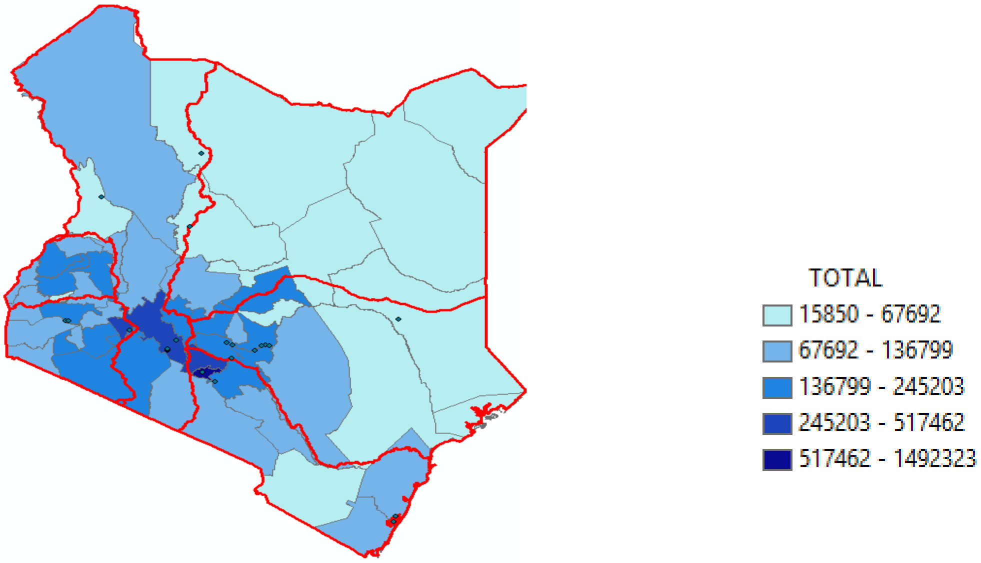


Figure A7-2: TOTAL GVA by County (KSH Millions)

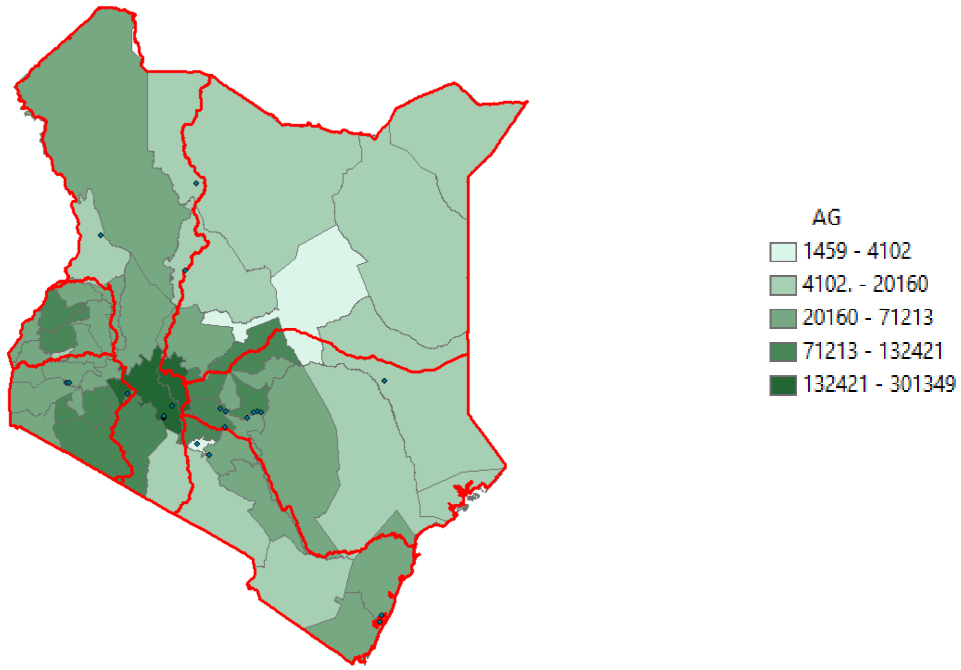


Figure A7-3: Agricultural GVA by County (KSH Millions)

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.

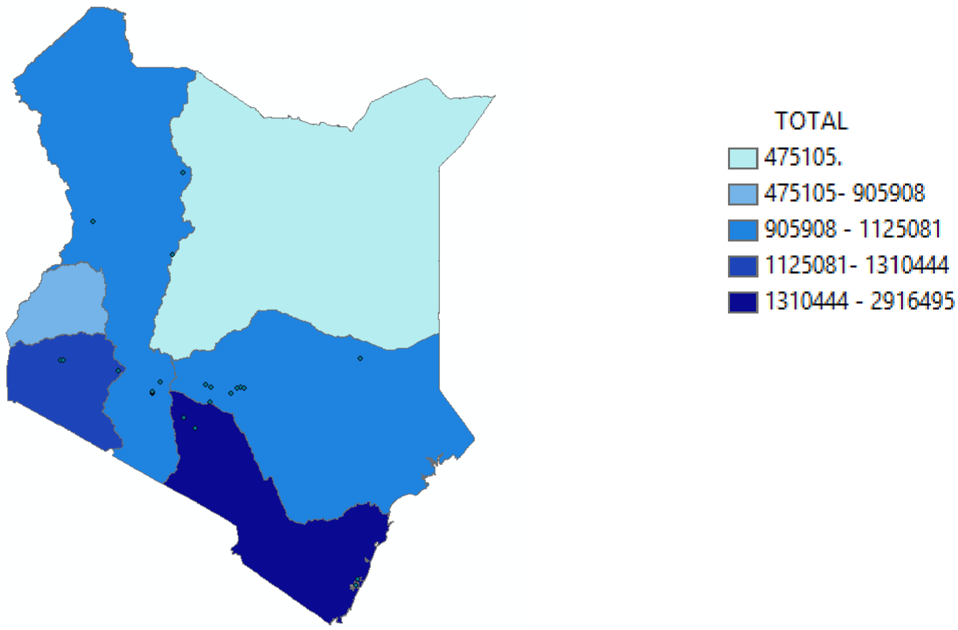


Figure A7-4: TOTAL GVA by River Basin'

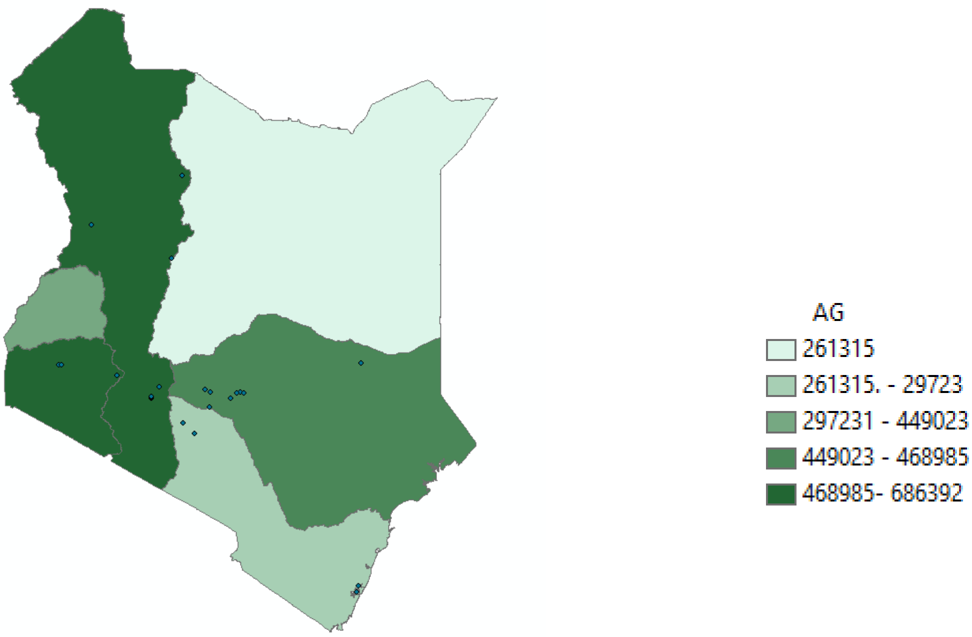


Figure A7-5: Agricultural GVA by River Basin

Table A7-3. TOTAL GVA by County

		BASIN					
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	NYANDARUA		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, whjch were used, along with the locations of proposed hydropower stations, to assess energy benefits.

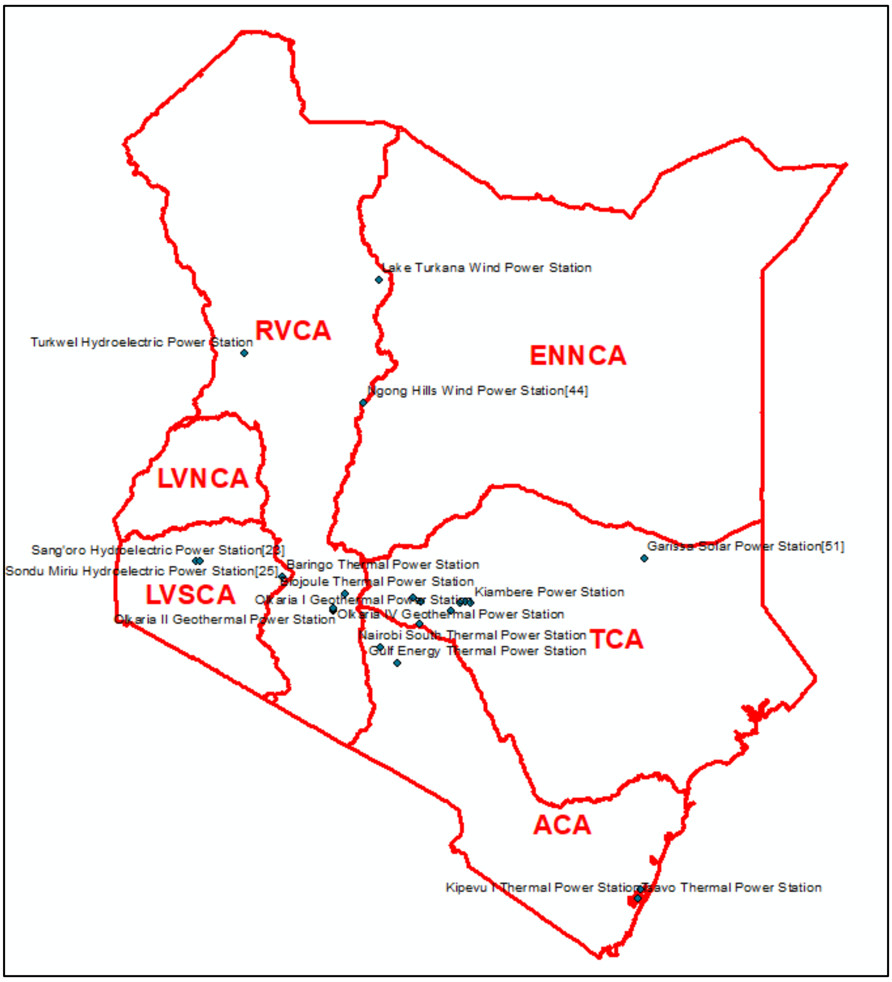


Figure A7-6: Electric Generation Stations in relation to river basins

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 MAR (1)	Groundwater sustainable yield	Total		Irrigation	Domestic / Industrial	Livestock	Wildlife & Fisheries	Total	(MCM/a)	%
2AA	10690	255	0.0	10.8	10.8	0.0	0.0	0.6	1.5	0.2	2.2	8.6	80%
2AB	13041	255	135.7	10.1	145.8	0.0	10.9	1.7	2.9	0.2	15.7	130.2	89%
2BA	1534	1012	46.9	5.4	52.3	29.2	3.8	2.1	1.6	0.2	7.6	15.5	30%
2BB	2466	728	108.9	8.5	117.4	9.0	5.4	1.5	2.4	0.2	9.4	99.0	84%
2BC	6979	845	156.7	15.2	171.9	57.8	12.6	5.1	5.0	0.2	22.9	91.2	53%
2BD	15894	296	532.9	17.5	550.4	0.0	24.9	4.2	8.6	0.2	37.9	512.6	93%
2CA	4407	118	45.1	2.3	47.4	0.0	3.6	0.6	2.1	0.2	6.4	40.9	86%
2CB	2837	1143	85.4	29.6	115.0	96.1	6.9	7.6	1.9	0.2	16.5	2.5	2%
2CC	13517	363	288.2	19.3	307.4	5.6	23.2	4.6	9.4	0.2	37.4	264.5	86%
2D	15293	419	264.6	32.0	296.6	2.1	21.3	3.2	8.6	0.2	33.2	261.2	88%
2EA	499	910	10.0	3.5	13.4	0.0	0.8	6.0	0.4	0.2	7.3	6.1	46%
2EB	826	913	20.1	6.4	26.5	0.0	1.6	5.3	0.5	0.2	7.5	18.9	72%
2EC	1026	942	14.6	1.8	16.4	0.0	1.2	13.1	1.0	0.2	15.4	1.1	7%
2ED	489	1273	12.9	6.7	19.6	16.3	1.0	1.6	0.4	0.2	3.1	0.2	1%
2EE	691	999	222.5	5.0	227.6	8.3	10.4	0.8	0.3	0.2	11.6	207.6	91%
2EF	451	1078	13.4	4.8	18.2	0.0	1.1	0.6	0.4	0.2	2.2	16.0	88%
2EG1	453	1181	10.4	11.1	21.5	0.0	0.8	6.2	0.5	0.2	7.6	13.9	64%
2EG2	1513	818	0.0	6.4	6.4	0.0	0.0	5.5	0.9	0.2	6.5	0.0	0%
2EH	646	845	27.1	4.0	31.0	6.8	2.2	2.2	0.1	0.2	4.6	19.6	63%
2EJ	1631	750	53.6	9.5	63.1	0.0	4.3	1.3	1.3	0.2	7.0	56.0	89%
2EK	710	856	23.1	4.3	27.4	0.0	1.9	0.6	0.3	0.2	2.9	24.5	89%
2FA	658	787	11.8	3.3	15.1	0.0	0.9	3.2	0.5	0.2	4.7	10.3	69%
2FB	163	985	2.3	1.0	3.3	0.0	0.2	2.0	0.1	0.2	2.4	0.9	27%
2FC	1777	900	26.5	11.5	37.9	0.0	2.1	41.4	1.7	0.2	45.4	0.0	0%
2GA	468	782	8.4	2.3	10.7	0.0	0.7	5.1	0.4	0.2	6.3	4.4	41%
2GB	1085	959	163.1	9.5	172.6	14.3	13.1	11.1	1.2	0.2	25.6	132.6	77%
2GC	869	1074	8.9	8.8	17.7	2.6	0.7	4.2	1.1	0.2	6.2	8.8	50%
2GD	1225	804	295.0	7.9	302.9	0.0	23.7	14.0	3.0	0.2	40.9	261.9	86%
2H-1	5950	342	151.8	11.1	162.9	0.0	12.2	13.4	3.4	0.2	29.2	133.8	82%
2H-2	2631	560	78.7	11.1	89.8	0.0	6.3	6.0	1.1	0.2	13.7	76.1	85%
2H-3	1151	524	0.0	11.1	11.1	0.0	0.0	0.5	0.4	0.2	1.0	10.2	91%
2J	8927	650	0.0	51.9	51.9	0.2	0.0	5.3	7.7	0.2	13.1	38.6	74%
2KA	5981	854	12.4	36.2	48.6	2.1	1.0	6.8	6.2	0.2	14.2	32.3	67%
2KB	1938	640	17.5	7.5	25.0	0.0	1.4	1.7	1.7	0.2	5.0	20.1	80%
2KC	3006	662	50.8	9.9	60.7	0.0	4.1	2.8	1.7	0.2	8.8	51.9	86%
Total	**131423**	**-**	**2899**	**397**	**3297**	**251**	**204**	**192**	**80**	**5**	**481**	**-**	**-**

Note (1): Excludes losses

B2: Future (2040) water demands per sub-basin

Subbasin	Future demand (MCM/a)				
	Irrigation	**Domestic / Industrial**	**Livestock**	**Wildlife & Fisheries**	**Total**
2AA	0.0	3.0	1.7	0.3	5.0
2AB	12.6	4.8	3.3	0.3	21.0
2BA	32.4	3.8	3.7	0.3	40.1
2BB	127.1	3.8	5.2	0.3	136.4
2BC	198.2	11.2	11.8	0.3	221.6
2BD	26.0	19.2	14.2	0.3	59.7
2CA	4.2	1.9	2.6	0.3	8.9
2CB	14.8	51.8	3.8	0.3	70.6
2CC	104.7	11.3	12.8	0.3	129.1
2D	24.4	8.6	10.2	0.3	43.5
2EA	0.9	5.9	0.8	0.3	7.9
2EB	1.9	5.7	1.5	0.3	9.3
2EC	1.4	13.6	3.1	0.3	18.3
2ED	4.6	7.0	0.8	0.3	12.6
2EE	76.1	1.9	0.3	0.3	78.5
2EF	3.0	3.0	0.8	0.3	7.0
2EG1	1.0	23.2	1.5	0.3	26.0
2EG2	180.7	7.9	2.2	0.3	191.1
2EH	2.5	2.8	0.1	0.3	5.6
2EJ	4.9	2.0	1.9	0.3	9.1
2EK	2.1	1.0	0.3	0.3	3.7
2FA	1.1	1.7	1.5	0.3	4.6
2FB	0.2	1.9	0.1	0.3	2.5
2FC	2.5	254.8	4.4	0.3	262.0
2GA	0.8	36.5	0.8	0.3	38.3
2GB	15.2	81.3	3.0	0.3	99.7
2GC	0.8	8.5	2.3	0.3	11.8
2GD	40.8	54.5	7.2	0.3	102.8
2H-1	13.9	9.0	8.1	0.3	31.3
2H-2	7.2	2.6	2.3	0.3	12.3
2H-3	0.0	1.5	0.8	0.3	2.5
2J	0.0	34.0	9.0	0.3	43.3
2KA	1.1	25.5	14.8	0.3	41.7
2KB	8.9	1.7	4.4	0.3	15.2
2KC	4.7	1.3	4.4	0.3	10.7
Total	**920.4**	**708.1**	**145.6**	**9.5**	**1783.6**

#	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	Karura, off Kiambu Road, Opposite CID HQ, Nairobi	020-2014663 020-2689882	info@kenyaforest service.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
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1	Willis Memo	ATCM-RVCA Nakuru		willismemo9@gmail.com
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4	Walter K. Tanui	SRM Kabernet		waltertanui@gmail.com
5	Kimeu Musau	SRM Narok		kimeumus@yahoo.com
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7	Samuel Njihia	Ag. ATCM Lodwar		samuelnjihia@yahoo.com

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2	South Rift Regional Office	Cornel Omondi 1st Floor, Oltalet Mall Narok		cornelakwiri@yahoo.com narok@watertowers.go.ke
Kenya Forest Services				
1	Mau Conservancy	Nakuru Town, Opposite Pyrithrum Road, Nakuru		hocmau@kenyaforestservice.org
2	North Rift Conservancy	Eldoret		hocnorthrift@kenyaforestservice.org
Water Services Board (now Water Works Development Agency)				
1	Rift Valley Water Works Development Agency	CEO, Eng. Hosea Wendot Rachael Makhoha Maji Plaza, Prisons Rd. off Eldama Ravine Highway Nakuru		info@rvwsb.go.ke www.http://rvwsb.go.ke
Rift Valley development authorities				
1	Kerio Valley Development Authority	KVDA Plaza, Oloo Street Eldoret	0532063361 0532063362 0532063363	info@kvda.go.ke http://www.kvda.go.ke
2	Ewaso Ng'iro South Development Authority	Peter Bwogero		bwogero@gmail.com
Kenya Red Cross				
1	South Rift Regional Office	Next to Mama Ngina Primary, Opposite AIC, Shabab Estate, Nakuru	0202079832	www.kenyaredcross.org
County Government and Agencies[1]				
Baringo County				
1	Baringo County Government	Headquarters, off Hospital Road, Kabernet		info@baringo.go.ke
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4	Chief Officer, Environment	John C. Kidogo		johhkidogo1@yahoo.com
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6	Director of Environment NEMA	Josiah Nyandoro 2nd Floor, Wing B Kabernet		Triplejoe@yahoo.com baringo@nema.go.ke

[1] The National Drought Management Authority (NDMA) has posted County Drought Coordinators in 23 ASAL counties in Kenya, including Isiolo, Laikipia, Marsabit, Meru, Nyeri and Samburu counties. The contact information for these offices is currently unavailable, but is being sought through NDMA's Head Office in Nairobi.

7	National Drought Management Authority	Bethwel Wafula Baringo County Disaster Coordinator		cdc.baringo@ndma.go.ke bethwel.wafula@ndma.go.ke
8	Kenya Forest Service	Ecosystem Conservator Baringo, Eldamaravin Town, Kabarnet		zmbaringo@kenyaforestservice.org
Elgeyo-Marakwet County				
1	County Government	Head Office Elgeyo Marakwet County Building, Iten	0534142277	info@elgeyomaarakwet.go.ke emcounty2013@gmail.com https://elgeyomarakwet.go.ke
2	County Environment Officer NEMA	Duncan Osale		dosale@nema.go.ke
3	Kenya Forest Service	Ecosystem Conservator Elgeyo-Marakwet, Iten		zmmarakwet@kenyaforestservice.or
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2	County Executive Committee: Energy, Water, Environment, Energy and Natural Resources	Eng. Festus Ng'eno		info.env@nakuru.go.ke/ Festus.Ngeno@nakuru.go.ke
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4	Deputy Director of Environment	Grace Karanja		neemah.karanja2009@gmail.com
5	Director of Environment NEMA	Antony Saisi		asaisia@yahoo.com cdekisumu@nema.go.ke
6	County Environment Officer NEMA	Daisy Maina PC's Building, Block B, 2nd Floor, Room 12, Moi Rd., Nakuru		dmaina@nema.go.ke nakuru@nema.go.ke
7	County Irrigation Officer	Eng. John N. Kagunda		kagunda3333@gmail.com
8	Kenya Forest Service	Ecosystem Conservator Elbagon Town, near Timsales, Nakuru		zmnakuru@kenyaforestservice.org
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1	County Executive Committee: Environment, Water, Energy and Natural Resources	Job Kiyiapi		kiyiapijob41@gmail.com
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8	Kenya Forest Service	Ecosystem Conservator Narok		zmnarok@kenyaforestservice.org
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2	Chief Officer: Water Services, Environment and Mineral Resources	Moses Napeyok Natome		moses.natome@turkana.go.ke
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4	Chief Superintendent - Water	Kenneth Omondi		kennethomondi2005@yahoo.com
5	County Director of Environment	Nadio Clement		nadioetaboclement@gmail.com
6	Director of Environment NEMA	Jilani Chiro Chigulu NEMA Turkana, Lodwar Post Office Building, next to Orange Shop, Lodwar		chugulu2000@yahoo.com
7	County Environment Officer NEMA	Robert Asembo		turkana@nema.go.ke
8	NDMA	Abdulkadir Jillo County Disaster Coordinator Dennis N. Mosioma CDIO		cdc.turkana@ndma.go.ke abdulkadir.jillo@ndma.go.ke dennis.mosioma@ndma.go.ke
9	Kenya Forest Service	Ecosystem Conservator Turkana Lodwar Town		zmturkana@kenyaforestserVIce.org
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4	Director, Environment	Kibet S. Parklea		ksparklea@gmail.com
5	County Director of Environment NEMA	Cliff Barkatch In Statistics Office Kapenguria		westpokot@nema.go.ke
6	County Environment Officer NEMA	Brian Otiende		bryoa@yahoo.com

7	Kenya Forest Service	Ecosystem Conservator Kapenguria		zmwestpokot@kenyaforestservice.org
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NGOs				
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2	WWF	Mvuli Park, Mvuli Rd., off Raphta Rd. Westlands, Nairobi		Info@wwfkenya.org
3	WWK Kenya (Naivasha)	Caroline Njiru		cnjiru@wwfkenya.org
4	Kenya Red Cross	Nairobi South C Red Cross Road Off Popo Road, Nairobi	0203950000 0207030370	info@redcross.or.ke http://www.redcross.or.ke
5	World Vision (Narok County)	Geoffrey Nyango		jeffnyango@gmail.com
6	Oxfam	The Atrium, Chaka Road Kilimani, Nairobi	0202820000 0202920000	hecainfo@oxfam.org.uk https://kenya.oxfam.org
Private Sector/WSPs				
1	Lodwar Water and Sanitation Company	Joseph Aleper Managing Director In Lodwar Handicraft Bldg., Mikela Street, Lodwar	05421003	lowassco.water@yahoo.com
2	Narok Water and Sewerage Services Company	Managing Director next to County Commissioners Office Narok	0202400732/ 33	narokwater@yahoo.com
3	Kapenguria Water and Sewerage Services Company	Managing Director Makutano Booster Station, Kitale-Lodwar Road, Kapenguria		kewasco@yahoo.com
4	Iten Tambach Water and Sanitation Company	Paul Yator, Managing Director At Iten Treatment Works, Behind Post Office, Iten		itenwater@yahoo.com
5	Nakuru Water and Sanitation Services Company	The Managing Director Government Rd. Nawassco Plaza, Nakuru	0512212269	info@nakuruwater.co.ke www.nakuruwater.co.ke
6	Nakuru Rural Water and Sanitation Company	Head Office Stanley Mathenge Rd, Industrial Area, Nakuru		info@naruwasco.co.ke www.naruwasco.co.ke
7	Naivasha Water and Sewerage Company	Head Office Jonka Building, 1st floor Prisons	0502020979	naivashawater@gmail.com

		Road/Biashara Street junction		
8	Eldama Ravine Water & Sewerage Company	KCB Building, 18th Floor Market Road Eldama Ravine		erawasco2007@yahoo.co.uk
9	Tullow Kenya	Johana Ekwam		johana.ekwam@tullowoil.com
10	Nakuru Chamber of Commerce and Industry	Lucy Wagura		luciee03@yahoo.com
11	Longonot Farms	Moi South Lake Road Naivasha	0202130235	---------------
12	Finlays Horticulture (K) Ltd., Flamingo and Kingfisher Farms	Lorraine Odhiambo Moi South Lake Rd. Naivasha	0502020418	info@dudutech.com http://www.flamingoholdings.co.ke
13	Kenya Farmer's Association	Oppst. Tanga House Narok		----------------
Academic and Research Institutions				
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2	Masai Mara University	Joshua Kuria		joshkuria2010@gmail.com
Development Partners				
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2	African Development Bank	Gabriel Negatu, Director Serge N'Guessan, Deputy Director Khushee Tower Longonot Road, Upper Hill	020712925/ 020712926/ 0202712928	g.negatu@afdb.org s.nguessan@afdb.org
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4	FAO	Block P, Level 3 United Nations Complex UN Avenue, Gigiri	0207625920	Fao-ke@fao.org
5	European Union	Union House Ragati Road, Nairobi	0202802000	Delegation-Kenya@eeas.europa.eu https://eeas.europa.eu/delegations/kenya
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D1. Environmental management

D1.1. Framework

To ensure quality of attention to environmental and social factors that affect the sustainable utilisation of water and allied resources in the RV 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 RV Basin Plan. This framework needs to be understood if the RV 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.

D1.1.1. National institutions

National institutions in Kenya who are involved with biodiversity and ecosystems management are listed below.

Table D1-1: 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.

D1.1.2. 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 RV 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 development 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 RV 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 D1-2: 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 RV 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 RV Basin Plan

The SEA for the RV 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 RV Basin Plan in terms of the legislated requirements for SEA are:

1. In the context of the RV 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 RV 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 RV 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 RV 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 RV 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.

D1.1.3. 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.

D2. Catchment Management

D2.1. Legal and institutional environment

D2.1.1. 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.

D2.1.2. 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.

D2.1.3. 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.

D3. Water resources protection

D3.1. Legal and institutional environment

D3.1.1. 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.

D3.1.2. 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.

D3.1.3. 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.

D4. Groundwater management

D4.1. Legal and institutional environment

D4.1.1. 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).**

D5. Climate change adaptation

D5.1. Legal and institutional environment

D5.1.1. 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**

D5.1.2. 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.

D5.1.3. 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.

D6. Flood and drought management

D6.1. Legislative and institutional environment

D6.1.1. 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**.

D6.1.2. 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.

D6.1.3. 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).

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. MoWSI, 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	0.88	-	-	-	0.88	MoWSI WSTF
Strategic Theme 1.2:	**Sustainable water and land use and management practices**											Strategic theme 1.2 total:	**6**	
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	0.88	-	-	-	0.88	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	-	0.88	-	-	0.88	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	1.75	-	-	-	1.75	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	-	-	0.88	-	0.88	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	0.88	-	-	-	0.88	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	-	-	0.88	-	0.88	MoWSI MoALF CG
Strategic Theme 1.3:		**Natural resources management for the protection and sustainable use of natural resources**											Strategic theme 1.3 total:	**54**	
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	-	2.63	2.63	-	5.25	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	-	0.88	0.88	1.75	3.50	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		-	-	0.35	-	0.35	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		-	-	0.35	-	0.35	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:	**26**	
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	-	0.9	0.9	1.8	3.6	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 groundwater 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
ii	Develop groundwater allocation plan for strategic aquifers: Lotikipi Basin and Napuu	Groundwater allocation plan successfully completed		Immediate to short-term	WRA MoWSI	BWRC	CG	WRUA	0.05	0.05	-	-	0.1	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	-	-	0.14	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.	RV 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:	**87**	
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 RV 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	11	18	18	37	84	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	-	0.05	-	-	0.05	MoWSI
Ii	Acquire necessary equipment and accessories for groundwater 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	-	0.42	0.42	-	0.84	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 RV Basin groundwater Vulnerability	Groundwater vulnerability assessed	LA25	Short-term	WRA				-	0.1	-	-	0.1	WRA
iii	Assess which RV Basin aquifers or parts of aquifers require formal protection.	Groundwater conservation areas (GCAs) identified		Short-term	WRA				-	0.05	-	-	0.05	WRA
iv	Assess which RV Basin aquifers contain important GDEs	Groundwater dependent ecosystems (GDEs) identified		Short-term	WRA				-	0.05	-	-	0.05	WRA
v	Develop an RV Basin groundwater Protection Plan	RV Basin groundwater Protection Plan	LY08	Short-term	WRA MoWSI NEMA MoICNG		CG WRUA	WSP Private sector (industry, agric.,	-	0.2	-	-	0.2	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	
									mining)						
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 RV Basin's polluted aquifers.		RV 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:	**10**	
Theme priority:	**Critical**													
4.1.1	**Implement routine surface and groundwater quality monitoring**													
i	Implement national water quality monitoring programme in the RV 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 RV 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	-	1.25	1.25	2.5	5	WRA NEMA
4.1.4	**Upgrade water quality testing laboratories**													
i	Upgrade central and regional laboratories in the RV 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

Strategy		Activities	Target/Indicators (M&E)	CMS Strategic Action	Implementation horizon	Key role players: National	Basin	Local	Other	Budget (USD Million): 2020 - 2022	2020 - 2022	2025 - 2030	2030 - 2040	Total cost	Funding source
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**														
		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 RV Basin stored in Mike Info.	Historical data captured & quality controlled; Data from laboratories captured on time & quality controlled		Immediate	WRA NEMA				0.25	-	-	-	0.25	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 RV 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				-	0.25	0.25	0.5	1	WRA
Strategic Theme 4.2:	**Promote sound water quality management governance in the RV 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 RV 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 RV 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		0.5	-	-	-	0.5	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:	**186**	
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 RV 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 such as Ngong, Ongata Rongai, Ruiru, Kiambu and Nairobi by installing sewers or septic tanks to contain domestic wastes, by 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**													

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**	
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
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	-	0.5	0.5	-	1	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 RV 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 RV 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:	**21**	
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		-	-	0.23	0.47	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		-	1	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		-	0.5	-	-	0.5	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:		**16**	
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 along the Molo River and its tributaries, the upper Ewaso Ng'iro South River, lower Kerio River, lower Turkwel River, flash-flood-prone streams out of the Mau Forest, flash-flood-/mudslide-prone zones in Narok, Baringo and West Pokot counties and the immediate lake environments of the six lakes (Baringo, Bogoria, Nakuru, Naivasha, Solai and Elementaita). 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	RV Basin FRF; WRA RO	CG		-	1.5	-	-	1.5	MoWSI WRA
ii	Review proposals in recent studies on resolving stormwater drainage problems and related infrastructure failures in Narok, Nakuru, Motogio and Lodwar Towns.	Record of successful assessments.	WA45 WA46	Short-term	WRA	RV Basin FRF	CG		-	1.5	-	-	1.5	MoWSI
iii	Systematise the above information in a Flood Risk Register for the RV Basin.	Flood Risk Register	WA47	Medium-term	WRA	RV 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 *RV Basin Flood Response Forum (FRF)* under the auspices of the KMD to integrate all flood-relevant resource mobilisations and related interventions in the RV Basin.	Establishment of the RV 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 *RV Basin FRF* with accommodation in the WRA Regional Office.	Establishment of Secretariat; Records of meetings		Immediate	KMD; NDMU; NDOC	WRA RO	WRUA		0.5	-	-	-	0.5	KMD WRA
iii	Develop appropriate SOPs (standard operating procedures) for the *RV 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	RV 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	Develop an IFMP for the Molo River catchment.	IFMP completed.	WA51	Short-term	WRA	RV Basin FRF	CG		-	0.1	-	-	0.1	WRA
ii	Develop an IFMP for the Upper Ewaso Ng'iro South and Ewaso Narok River catchments.	IFMP completed.	WA51	Short-term	WRA	RV Basin FRF	CG		-	0.1	-	-	0.1	WRA
iii	Develop an IFMP for the Turkwel River catchment.	IFMP completed.	WA51	Short to medium-term	WRA	RV Basin FRF	CG		-	0.05	0.05	-	0.1	WRA
iv	Develop an IFMP for the Kerio River catchment.	IFMP completed.	WA51	Short to medium-term	WRA	RV Basin FRF	CG		-	0.05	0.05	-	0.1	WRA
v	Develop an IFMP for the immediate environment of six lakes - Baringo, Bogoria, Nakuru, Naivasha, Solai & Elementaita.	IFMP completed.	WA51	Medium to long-term	WRA	RV Basin FRF	CG		-	-	0.2	-	0.2	WRA
6.1.5	**Implement flood management measures**													
i	The *RV Basin FRF* will prioritise the Implementation Schedules of each of the above five 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 RV 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	RV 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 *RV 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	RV 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 *RV Basin Flood Response Forum (FRF)* will expand organisational capacity in the RV 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 RV Basin FRF; Partnership & Collaboration working agreement	WA52	Immediate	KMD; NDMU; NDOC	RV 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 RV 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	RV 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 *RV 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	RV Basin FRF	Flood-prone county DRM Committees; WRUA; Village DRMC		-	0.9	0.9	1.8	3.6	KMD
Strategic Theme 6.2:	**Drought management**											Strategic theme 6.2 total:	**36**	
Theme priority:	**Very Important**													
6.2.1	**Formalise institutional roles and partnership collaborations**													
i	Establish a Secretariat for the *RV 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 *RV 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 RV 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	RV Basin Drought Response			-	7	-	-	7	NDMA
6.2.3	**Improve drought preparedness**													
i	The *RV 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 RV Basin Drought Response mandate.		Short-term	NDMA; NDMU; NDOC; KMD	RV 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	RV 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 RV Basin must be reviewed and deliberated by the collaboration partnership participants in the *RV Basin Drought Response strategy*. In the case of an adverse severity assessment, the *RV 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 RV Basin.	Successful collaboration by RV Basin Drought Response participants in drought severity assessments and resulting mobilisations and interventions.		Short-term	NDMA	RV 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. In the RV Basin, Bulletins are issued for the Baringo, West Pokot, Samburu, Laikipia, Turkana and Marsabit counties.	Number of additional drought-prone RV counties issuing Drought Early Warning Bulletins		Immediate	NDMA	RV Basin Drought Response	CG		0.3	-	-	-	0.3		NDMA
ii	SOP responses based on the Bulletins' early warning findings and alerts will be an integrating force in the RV 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 across the six drought-prone counties in the RV Basin.	Successful implementation of SOPs on sub-county and local community scales.		Short-term	NDMA	RV Basin Drought Response	Drought-prone county DRM Committees; WRA SRO; WRUA; Village DRMC	International Relief Aid agencies; Kenya Red Cross Society; NGO	-	6	-	-	6		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 *RV Basin Drought Response Strategy*.	Continuity in the use of FEWS NET monthly reports and maps.		Short-term	NDMA; Kenya Food Security Steering Group	RV 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 RV 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	RV 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: RV Basin Drought Response Strategy* will expand organisational capacity in the RV 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 RV Basin Drought Response.		Immediate	NDMA	RV 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 RV Basin Drought Response, participants at prioritising resource mobilisations, logistical planning and communicating technical and logistical information.	WA54 WA56	Short-term	NDMA	RV 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:	**27**	
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 the Perkerra River 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
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		Immediate to long-term	WRA WASREB		WWDA	WSP Private sector	1	1	1	1	4	WRA

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 7.2:		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:		**12**	
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	-	3.4	3	-	6.4	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				-	1.05	1.05	-	2.1	WRA
8.1.5	**Water allocation**													
i	Set Resource Quality Objectives (RQOs) for surface water and groundwater in the RV 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				-	0.4	-	-	0.4	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				-	2.3	-	-	2.3	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:		**6**	
Theme priority:	**Critical**													
8.2.1	**Updated planning for bulk water resources development**													
i	Update Central RV Basin Master Planning – Nakuru, Naivasha, Eldama Ravine, Kabarnet: Optimise large-scale, integrated bulk water supply systems supplying the above towns: 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	-	0.67	-	-	0.67	WSC MoWSI
iii	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 RV Basin indicating detailed timelines, phasing and budgets	WA74	Short-term	WRA MoWSI NWHSA	WWDA	CG		-	5.6	-	-	5.6	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:	**3 627**	
Theme priority:	**Very important**													
8.3.1	**Implement large dams: complete relevant feasibility and impact studies and plans; design and construct**													
i	Arror Dam (70 MCM)	Dam construction completed and successful commissioning	WA74	Medium to long-term	NWHSA MoWSI	WWDA	CG		126	63			217	MoWSI
ii	Siyoi-Muruny (17 MCM)			Immediate to short-term	NWHSA MoWSI	WWDA	CG		5	30	-	-	35	MoWSI
iii	Malewa Dam (73 MCM)			Short to medium-term	NWHSA MoWSI	WWDA	CG		-	71	98	-	169	MoWSI
iv	Upper Narok Dam (10 MCM)			Medium-term	NWHSA MoWSI	WWDA	CG		-	-	44	-	44	MoWSI
v	Oletukat-Olenkuluo Dam (406 MCM)			Long-term	NWHSA MoWSI	WWDA	CG		-	-	-	659	659	MoWSI
vi	Leshota Dam (247 MCM)			Long-term	NWHSA MoWSI	WWDA	CG		-	-	-	309	309	MoWSI
vii	Oldorko Dam (95 MCM)			Medium to long-term	NWHSA MoWSI	WWDA	CG		-	-	13	188	201	MoWSI
viii	Embobut (40 MCM)			Long-term	NWHSA MoWSI	WWDA	CG		-	-	-	141	141	MoWSI
ix	Waseges Dam (5 MCM)			Short-term	NWHSA MoWSI	WWDA	CG		-	29	-	-	29	MoWSI
x	Lowaat Dam (537 MCM)			Medium to long-term	NWHSA MoWSI	WWDA	CG		-	-	187	257	490	MoWSI
xi	Radat Dam (267 MCM)			Medium-term	NWHSA MoWSI	WWDA	CG		-	-	146	-	262	MoWSI
8.3.2	**Maintenance of existing dams**													
i	Dredging of existing dams	Number of dams dredged		Short-term	NWHSA MoWSI	WWDA	CG		-	1	-	-	1	MoWSI
8.3.3	**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
ii	Phased design and construction of identified small dams / pans	Number new dams constructed in accordance with international best practice	WA74	Immediate to long-term	NWHSA MoWSI	WWDA	CG WURA		22	37	37	74	170	MoWSI
8.3.4	**Provide other types of storage**													
i	Sand dams	Number of sand dams	WA74	Short to long-term	NWHSA MoWSI	WWDA	CG		-	9	14	14	32	MoWSI
ii	Artificial recharge	Successful implementation and operation of AR schemes	WA74	Short to long-term	NWHSA MoWSI	WWDA	CG		-	3.5	3	3	6.5	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**	
8.3.5	**Inter-basin transfers**													
i	Itare Dam (LVS Basin) and transfer to RV Basin	Transfer volume (supply volume)	WA74	Immediate to short -term	MoWSI	WWDA	CG		200	100	-	-	300	MoWSI
ii	Amala Dam (LVS Basin) and transfer to RV Basin			Medium to long-term	MoWSI	WWDA	CG		-	-	73	486	559	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	Install hydropower at Arror Dam (60 MW)	Cost included under Strategy 8.3.1												
ii	Install hydropower at Embobut Dam (45 MW)													
iii	Install hydropower at Oletukat Dam (36 MW)													
iv	Install hydropower at Leshota Dam (54 MW)													
v	Install hydropower at Oldorka Dam (90 MW)													
8.5.2	**Small-scale hydropower development**													
i	Investigate possibility of retrofitting existing dams with hydroelectric power generation capabilities.	Number of retrofitted dams	WA74	Short-term	KENGEN MoE				-	0.5	-	-	0.5	KENGEN, MoEn
ii	Assess potential for the development of small-scale hydropower plants, especially in the upper RV Basin.	Small-scale hydropower generation and supply	WA74	Short to long-term	KENGEN MoE				-	0.5	0.5	0.5	1.5	KENGEN, MoEn
Strategic Theme 8.6:	**Water for agriculture**											Strategic theme 8.6 total:	**1 862**	
Theme priority:	**Critical**													
8.6.1	**Large scale irrigation development: Develop new / expand existing irrigation schemes. Limit to max sustainable areas**													
i	Arror 2 000 ha	Irrigation area		Medium-term	WRA MoWSI MoALF NIB	WWDA	CG		6	39		-	45	MoWSI
ii	Expand Turkwel Dam Expand by 4 000 ha	Irrigation area		Immediate to short-term	WRA MoWSI MoALF NIB	WWDA	CG		8	60	-	-	68	MoWSI
iii	Turkwel Sugar 6 000 ha	Irrigation area		Immediate to short-term	WRA MoWSI MoALF NIB	WWDA	CG		9	127	-	-	136	MoWSI
iv	Upper Narok 2 000 ha	Irrigation area		Medium-term	WRA MoWSI MoALF NIB	WWDA	CG		-	-	45	-	45	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	Lower Ewaso Ng'iro South 15 000 ha	Irrigation area		Long-term	WRA MoWSI MoALF NIB	WWDA	CG		-	-	-	340	340	MoWSI
vi	Embobut 1 000 ha	Irrigation area		Long-term	WRA MoWSI MoALF NIB	WWDA	CG		-	-	-	23	23	MoWSI
vii	Waseges 470 ha	Irrigation area		Short-term	WRA MoWSI MoALF NIB	WWDA	CG		-	5	-	-	5	MoWSI
ix	Todonyang-Omo 2 000 ha	Irrigation area		Medium-term	WRA MoWSI MoALF NIB	WWDA	CG		-	-	45	-	45	MoWSI
x	Lowaat 10 000 ha	Irrigation area		Medium to long-term	WRA MoWSI MoALF NIB	WWDA	CG		-	-	30	198	318	MoWSI
xi	Perkerra Expand by 5 000 ha	Irrigation area		Medium-term	WRA MoWSI MoALF NIB	WWDA	CG		-	-	85	-	170	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		-	0.3	0.3	0.4	1	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		-	0.7	0.5	0.5	1.7	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

Strategy	Activities	Target/Indicators (M&E)	CMS Strategic Action	Implementation horizon	Key role players: National	Basin	Local	Other	Budget (USD Million): 2020-2022	2022-2025	2025-2030	2030-2040	Total cost	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**													
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
Strategic Theme 8.8:	**Non-conventional water resources**											Strategic theme 8.8 total:	**22**	
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	-	10	10	-	20	WRA
8.8.2	**Reuse**													
ii	Not considered as an option in RV at this stage													
8.8.2	**Water Conservation and Demand Management**													
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:	**2**	
Theme priority:	**Important**													
8.9.1	**Optimise system operating rules**													
i	Evaluate and improve operation of existing and future integrated bulk water supply systems to Nakuru and Naivasha to maximise yield. Develop curtailment rules.	Optimised system operating rules - multipurpose dams, user priority classification, conjunctive use, curtailment rules; Number of operating rules registered with NEMA		Medium-term	WRA MoWSI	WWDA	WRUA		-	-	0.85	-	0.85	MoWSI
ii	Develop and implement operating rules for proposed multipurpose dams			Short to medium-term	WRA MoWSI	WWDA	WRUA		-	0.1	0.1	-	0.2	MoWSI
iii	Evaluate and improve operation of existing stand-alone dams supplying individual towns and/or small-scale irrigation. Develop curtailment rules. Consider conjunctive use.			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

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		
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:		**8**	
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				0.7	-	-	-	0.7	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			0.4	0.4	-	-	0.8	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			-	-	0.79	-	0.79	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				0.7	-	-	-	0.7	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

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	
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.

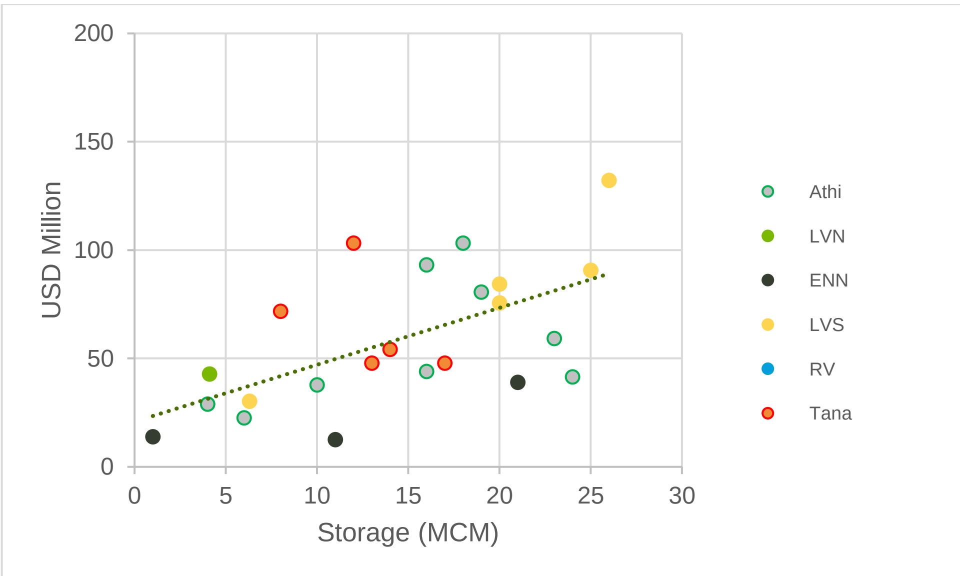

Figure F-1: Cost curve for dams smaller than 30 MCM

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.