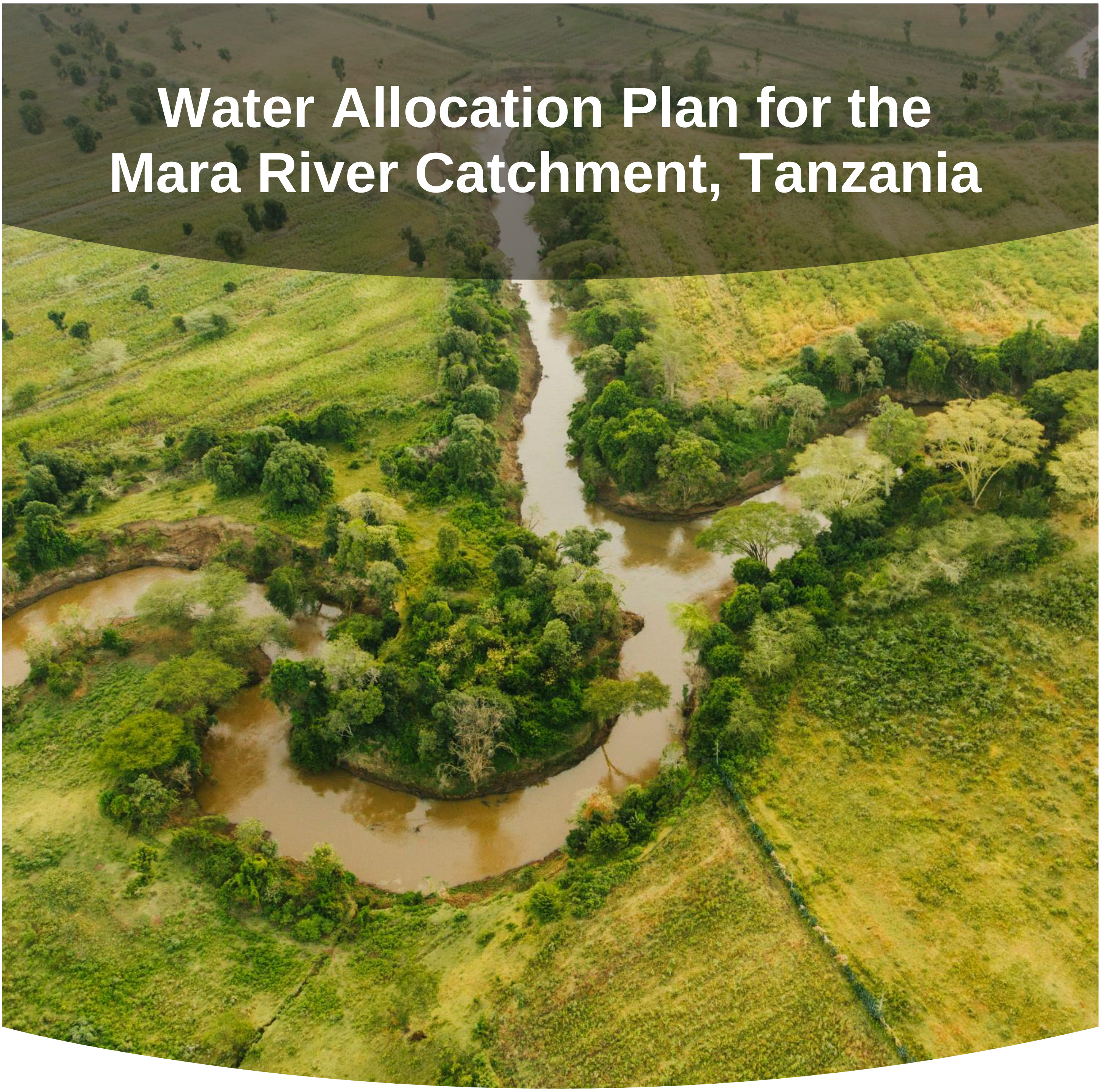
THE UNITED REPUBLIC OF TANZANIA

MINISTRY OF WATER

LAKE VICTORIA BASIN WATER BOARD

Water Allocation Plan for the Mara River Catchment, Tanzania



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Executive Summary

"Water allocation is the process of equitable sharing of available water resources; therefore, it reflects an important component in the management and development of the water resources. The process can have a significant bearing on the availability of the water resource to meet domestic needs, environmental reserve and social-economic development. The process is important to ensure water security and alleviation of water use conflicts" (As per the 2018 Draft Tanzania Guidelines for the Water Allocation Plan).

Based on the limited availability of long-term hydrometeorological data, as well as the lack of hydrogeological information within the Mara River Catchment (MRC), alternately referred to as the Mara River Basin (MRB), the focus of the current water resources allocation lies within the scope of an assessment of the available surface water resources in the catchment.

The Ministry seeks to streamline the water allocation process so that it supports its mandate to control and regulate the use of water resources. The increase in competing demands for the water resources in Mara River Catchment poses a huge challenge to the process of water allocation.

One key element is the requirement for the basin water board (BWB) to provide hydrological and/or hydrogeological assessment report(s) which document, among other things, the water demand by the user and whether the water source has sufficient unallocated water to support the intended application purpose. This requires specific guidelines to address the water allocation process.

With growing demands on limited water resources, expanding and refining water allocation systems has become a central governing concern in water management. This observation regarding development and administration of water allocation challenges led Kenya and Tanzania to sign a Memorandum of Understanding (MOU) for joint water resources management and conservation efforts of the transboundary Mara River Catchment. The MOU is intended to deal with the main threats to the catchment, including poor water quality, reduction of water levels/flows (quantity) and biodiversity degradation. Part of the memorandum included the establishment and strengthening of a Joint Cooperative Framework for sustainable water resources management of the catchment. The parties undertook to cooperate in the area of sustainable development, management and equitable utilization of water resources, including water allocation, water supply and sanitation, capacity building, data and information sharing, research and development. Therefore, the plan will consider current, medium and long-term demand.

This water allocation planning (WAP) sets out an analytical framework for water allocation regimes as a basis for examining how they function in a range of countries and how they can be improved. It highlights how water is a complex resource, with distinctive features as an economic good, often with a unique legal status. It identifies the key components of an allocation regime and the policy levers that can be used to improve their performance. Finally, the framework links the elements of allocation regimes with the policy objectives of economic efficiency, environmental sustainability, and social equity. Therefore, preparation of this water allocation plan is aimed at ensuring sustainable water availability, water security and avoids water related conflicts among various users.

Currently, water allocation is done based on Water Resources Management (water abstraction, use and discharge, environmental water requirements, rainwater harvesting) regulations. The allocation is done through provision of water use permits, which are given to a particular user on a demand-driven basis.

The process involves the assessment of the available water resources in terms of quantity and quality, allocate water requirement for domestic and environment, allocate water requirement for available permit holders downstream and then provide water from the remaining amount to the new user after consulting particular stakeholders who are likely to be affected. The validity of the permit is determined by the BWBs depending on the intended type of water use and the respective water use project period.

The main constraints are:

i. Apportioning reserve for ecological functions,

ii. Over-allocation,

iii. Over-abstraction, and

iv. Illegal abstraction.

Water availability in the basin was assessed and analysed into six sub-basins, namely Serengeti, Tobora, Somoche, Mara Mines, Tigithe and Mara Wetland. The average annual water availability in the full Tanzanian Mara River Basin is 2,947,104 m^3/day. Of this total, 76% (2,237,760 m^3/day) is generated on the Kenyan side of the basin. The available water generated in Tanzania amounts to 709,344 m^3/day, of which 261,792 m^3/day is available in the Serengeti sub-basin, 50,112 m^3/day is generated in the Tobora sub-basin, 91,584 m^3/day is generated in the Somoche sub-basin, 54,432 m^3/day is generated in the Mara Mines sub-basin, 50,976 m^3/day is generated in the Tigithe sub-basin, and 200,448 m^3/day is generated in the Mara Wetland sub-basin. Total average water availability varies from a low of 2,311,200 m^3/day in dry conditions to a high of 4,857,408 m^3/day in wet conditions.

The water allocation plan was prepared by referring legal requirements and water allocation guidelines. Other contributions were obtained from stakeholders and the task force team.

The total net available flow balance for allocation:

Year		2018		2023		2028		2038	
Net Flow Balance for allocation		Wet (m^3/day)	Dry (m^3/day)	Wet (m^3/day)	Dry (m^3/day)	Wet (m^3/day)	Dry (m^3/day)	Wet (m^3/day)	Dry (m^3/day)
1	Serengeti HU	1,502,413	747,882	1,501,759	747,214	1,501,002	746,438	1,499,050	744,418
2	Tobora HU	-1,636	-1,646	-1,819	-1,833	-2,208	-2,228	-2,956	-2,995
3	Somoche HU	22,626	-3,909	22,016	-4,242	20,758	-5,171	18,342	-6,732
4	Tigithe HU	22,924	-4,034	22,472	-4,290	21,473	-5,070	19,706	-6,325
5	Mara Mine HU	1,591,864	767,285	1,589,786	765,192	1,586,212	761,596	1,578,480	753,788
6	Mara Wetland HU	1,848,831	798,453	1,845,287	794,871	1,838,182	787,713	1,824,422	773,770

The following provides the rules governing water allocation within the Mara River Catchment and how water allocation can be done or not for catchment management planning.

– **Serengeti HU**: For the Serengeti sub-basin, all demands for water are expected to be met for both dry and wet conditions for both normal and flood flows. This is true for current water demand and for the future water demand in the projected years of 2023, 2028 and 2038. The percent of allocatable yield available for future permits is approximately 99% for normal flow and 100% for flood flow. This is approximately 70-75% of the available water under normal flow and 90-100% percent of the available water under flood flow.

– **Tobora HU:** The Tobora sub-basin generates a small amount of available flow that is less than the reserve threshold, meaning the flows in the Tobora sub-basin will be in reserve conditions more than 20% of the time. This indicates that all demands for additional domestic needs, livestock, tourism, wildlife and mining must come from flood flows. For flood flow, there is expected to be sufficient water to cover the environmental flow baseflow deficit and any future water permitting requests for both wet and dry conditions (at the moment, there is no irrigation and hence no flood flow demand in the Tobora sub-basin). During flood flow, 100% of the allocatable yield is available, which is approximately 63% of the available water.

- **Somoche HU:** Therefore people should be encouraged to find another source of water to account for this deficit. Under normal flow, the water balance in Somoche sub-basin yielded positive results during wet conditions for both present and future planning horizons, although there is a negative water balance for dry conditions for all planning horizons. The reserve (basic human needs and environmental flow) requirements is expected to be satisfied 100% of the time during wet conditions. For dry conditions, only basic human needs are expected to be fully met while the ecological component of the reserve requires flow levels in excess of Q80. About 85% percent of the allocatable yield is available for future permitting during wet conditions (which is approximately 30% of the available water in 2018, decreasing to 24% in 2038). During flood flow, there is sufficient water for allocation during both wet and dry conditions, including covering the deficit from the ecological component of the reserve as well as the implementation of the planned Nyamatita irrigation scheme. In 2018, 100% of the allocatable yield for flood flow is available for permitting in wet and dry conditions (approximately 90% of the available water in wet conditions and 64% in dry conditions), which drops to 97% for wet conditions and 75% for dry conditions in 2038 (approximately 90% of the available water in wet conditions and 45% in dry conditions).

- **Tigithe HU:** In the Tigithe sub-basin, there is expected to be sufficient water resources to meet the reserve and all demands in wet conditions for all planning horizons, while there is expected to be insufficient water resources to meet the reserve and demand in dry conditions under normal flows. The amount available for allocation in wet conditions ranges from 85% in 2018 to 76% in 2038. In dry conditions, basic human needs are met 100% of the time. Water for additional domestic needs, livestock, tourism, wildlife and mining in Tigithe sub-basin must be allocated from the flood flow. Under flood flow, 100% of the allocatable water is available for water permits since there is very little mechanized irrigation in the Tigithe sub-basin. In wet conditions, this is approximately 74% of the available flood flow. In dry conditions, the flood flow is first used to provide water for the ecological component of the reserve. Beyond that, 100% is available for allocation to water permits (which is approximately 80% of available water).

- **Mara Mine HU:** In Mara Mines sub-basin, there is sufficient water for all uses in both wet and dry conditions, under normal and flood flows, and for all planning horizons for the WAP. Under normal flow, 98-99% of the allocatable yield is available for future permits in wet conditions (which is approximately 71% of the available water) and 96-97% is available in dry conditions (which is approximately 70-71% of available water). Under flood flow, there is also sufficient water, with 100% of allocatable water available for permitting in 2018 (which is approximately 84% and 100% of flood flow water available, respectively). In the planning horizon, the Mara Valley Project is estimated to begin in part by 2028 and in full by 2038. Since this is an irrigation project, it will consume flood flow to fill the reservoir and the irrigation canals. This will decrease the percent of the allocatable yield to 98% and 94% for wet and dry conditions in 2028, and to 88% and 70% for wet and dry conditions in 2038. This represents approximately 82% and 94% of available flood flow water for wet and dry conditions in 2028 and approximately 74% and 70% of available flood flow water for wet and dry conditions in 2038.

- **Wetland HU:** In the Mara Wetland sub-basin, there are sufficient water resources to meet the reserve as well as all demands in wet and dry conditions, under normal and flood flow, and for the entire planning horizon. Under normal flow, the percent of allocatable yield available for permitting in wet conditions is between 98% in 2018 and 97% in 2038, which is approximately 70% and 69% of the total available water. For dry conditions, it is between 96% in 2018 and 94% in 2038, which is approximately 68% and 66% of the total available water. Under flood flow, 100% of allocatable yield is available for future permitting for both wet and dry conditions in 2018 (85% and 100% of available water, respectively). In 2038, this drops to 92% and 73% for wet and dry conditions (78% and 73% of available water, respectively).

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Acronyms

BWB	Basin Water Board
LU	Livestock unit
LVBWB	Lake Victoria Basin Water Board
MaMaSe	Mau Mara Serengeti
MOU	Memorandum of Understanding
MoW	Tanzanian Ministry of Water
MRB	Mara River Basin
MRC	Mara River Catchment
NAWAPO	Nation Water Policy
SENAPA	Serengeti National Park
WAP	Water Allocation Plan
WEAP	Water Evaluation and Planning Model
WRMA	Water Resources Management Act of 2009
WUA	Water Users Association
WRMA	Water Resources and Management Act

1 Introduction

Water allocation planning is a water management tool for determining the amount of water available in a river basin and deciding how it should be distributed between the environment and different water users. Water scarcity is increasing globally due factors such as changes in water availability and demand. Therefore, water allocation planning is becoming an important strategy not only for protecting aquatic ecosystems but also prioritizing different uses of water to ensure the sustainable development of the river basin. Further, the process is also important in addressing water use conflicts (2018 Draft Tanzania Guidelines for Water Allocation Planning). “Water allocation is the process of equitable sharing of ‘available’ water resources; therefore, it reflects an important component in the management and development of the water resources. The process can have a significant bearing on the availability of the water resource to meet domestic needs, environmental reserve needs and social-economic development.”

Water allocation relies on the water balance in a river basin, taking into account the available water from different sources (surface water, rainfall, groundwater and spring), and the amount that is required to maintain water-dependent ecosystems, and any international agreements or inter-basin transfers. The remaining water when these requirements have been met can be allocated to different users through a water permitting system established by the basin water authority.

Water allocation plans should be customized to suit the river basin context and generally should achieve the following objectives (Speed *et al.*, 2013)

- Equity: the fair use and prioritization of water between different user groups and geographical regions.
- Environmental protection: recognizing the importance of different water-dependent ecosystems and providing adequate water to maintain important processes.
- Development priorities: supporting and promoting economic and social development at the regional and national scale, including protecting existing uses.
- Balancing supply and demand: Structuring the supply of water so that it does not exceed the demand within the natural variability of the system, preventing water shortages.
- Efficient use of water: promoting water users to utilize the most efficient use of freshwater resources.

1.1 JUSTIFICATION FOR WATER ALLOCATION PLAN

The importance of the WAP in the Mara River Catchment is well-described in the national laws and the recent guidelines on WAP. In addition, the WAP has also adhered to international best practices and regional agreements on water management. The WAP for the Mara River Catchment has been developed following the Tanzania legal framework on water resources management, specifically the Water Policy of 2002, Water Resources Management Act (WRMA) of 2009, the Draft WAP Guideline of 2019, and the existing Memorandum of Understanding between Kenya and Tanzania for the management of the MRC. A water allocation plan is required of all basin water boards in Tanzania by the Tanzania legal and policy frameworks on water resources management; the key elements are identified as components of the Integrated Water Resources Management and Development plans (IWRM&D). The Ministry of Water (MoW) seeks to streamline the WAP process so that it supports its mandates to control and regulate the use of water resources.

The current trends of water resources uses in the basin pose significant challenges and risks in terms of allocating water to different sectors with competing demands. In Tanzania, the Lake Victoria Basin Water Board (LVBWB) is the government authority under the Ministry of Water responsible, for among others, water allocation planning for the Mara River. LVBWB is responsible for evaluating and approving Water User Permit applications while meeting the flow requirements of the reserve (basic human needs and environmental flows) and developing the basin in a sustainable manner. Furthermore, the LVBWB must have an understanding of the water available for allocation from different water sources in different sub-basins of the MRC to enhance water allocation decisions.

1.2 FRAMEWORK FOR WATER ALLOCATION PLAN

The WRMA of 2009 and the Draft WAP Guideline of 2019 specifies the essential elements to be included in integrated water resources management plans. These include (***inter alia***): water balance, requirements for the reserve, proposed options for forecasted demands, and implementation measures. The guideline describes the basis for water allocation, and further proposes the approaches for quantification of the water balance; namely, water availability, the reserve, and water demands. Two stages are defined for water allocation: a planning stage and a management stage. Quantification of the water balance is prioritized in the planning stage. The management stage emphasizes the allocation of water to specific users, primarily through the issuing of water permits. Guidelines are provided for allocation both when there are sufficient water resources to meet identified demands, and when there are insufficient water resources. In the case of insufficient water resources, prioritization of allocations is needed and additional measures such as reallocation, proportional allocation, or water demand management may be invoked.

Actions in the planning and management stages of water allocation should be aligned with the underlying principles of sustainable integrated water resources management and sustainable development. As specified in the guidelines, these principles are:

- The ***precautionary principle*** implies that decisions can or indeed must be made even where information is incomplete in relation to: taking preventive action in the face of uncertainty; shifting the burden of proof to the proponents of an activity; exploring a wide range of alternatives to potential harmful actions; and providing for public participation in decision-making.
- The ***polluter pays principle***, in which any person who pollutes the water in any river, stream or water cause or in any water body of surface water should be subjected to fines or imprisonment.
- The ***principle of ecosystem and integrity***: water for the environment to protect the ecosystems that underpin our water resources, both now and in the future, will attain second priority and will be reserved.
- The ***principle of public participation*** in development of policies, plans and processes for the management of water resources.
- The ***principle of international cooperation*** in management of environmental resources shared by two or more states; transboundary water resources management requires understanding and agreement among the riparian states.
- The ***principle of common*** but differentiated responsibilities.
- Freshwater is a ***finite*** and vulnerable resource that is essential to sustain life, development and the environment. This implies that the resources must be managed, conserved and allocated in a manner that serves the public and ecological interest. In addition, where resources are insufficient to meet all the demands, priority of allocation will need to be established.

2 Overview of the Mara River Catchment

The Mara River Catchment is an important hydrologic system that serves the bordering countries of Kenya and Tanzania and is also a valuable input to Lake Victoria, the world's second largest freshwater lake, which forms the headwaters of the White Nile River. The Mara River contributes approximately five (5) percent of the total amount of water that flows into Lake Victoria. However, despite its minimal contribution in terms of water volume into Lake Victoria, the Mara River is probably one of the most important rivers with regards to conservation, it supports both the Maasai Mara National Reserve in Kenya and Serengeti National Park (SENAPA) in Tanzania (Nile Basin Initiative, 2008). The catchment also contains of a variety of wildlife, significant livestock activity, agriculture with a high potential for irrigation, rapidly growing mining activities and a uniquely attractive tourism industry with significant economic value, all of which use freshwater resources.

The Mara River Catchment is currently experiencing severe degradation as a result of increased land use modification, habitat fragmentation and increasing demand on water resources by the catchment's inhabitants. Climate change is also altering the amount and timing of rainfall, contributing to extreme flooding or drought events (USAID, 2019). Current indications are that the river is highly vulnerable as it has been reported to have attained dangerously low levels during certain drought periods, causing extreme stress of larger animals such as hippos and crocodiles. The prevailing system of uncoordinated water resources management in the catchment cannot sustain the increasing water needs of the various water use sectors. Uncoordinated management has the potential to cause serious effects on the local socioeconomic development, ecological systems and national economies of both countries. This dangerous trend has been blamed on factors such as destruction of riverine and catchment forests, soil erosion and siltation, climate change and over abstraction. Each of these factors has contributed to low water levels, especially during the dry seasons.

The catchment's water resources management is therefore an issue of very high significance. It requires an effective strategy that involves all the conflicting water uses and interests within the catchment to match or balance the demand for water with its availability through an accepted, suitable water allocation arrangement.

2.1 LOCATION OF MARA RIVER CATCHMENT

The Mara River flows 395 km from its headwaters in the Mau Forest of Kenya to Lake Victoria, Tanzania (Figure 2-1). The Mara River Catchment is located roughly between longitudes 33° 47’ 11″ E and 35° 431’ 48″ E and latitudes 1° 21’ 29″ S and 1° 52’ 12″ S. It is approximately 13,504 km^2, with the upper 65% area in Kenya and the lower 35% in Tanzania. Originating from the Enapuyiapui Swamp in the Mau Escarpment in the highlands of Kenya and flowing into Lake Victoria in Tanzania, the elevation ranges from 2,932 meters at its source to 1,134 meters at the outflow. The whole Mara River Catchment has eight significant tributaries: the Amala, Nyangores, Talek, and Sand streams in Kenya, and the Borogonja, Somoche, Tobora, and Tigithe Streams in Tanzania.

The Mara River Catchment of Tanzania starts from the border with Kenya, before joining Borogonja Stream and channeling into the Mara River inside SENAPA. The Somoche River begins in the Serengeti District and flows into the Mara River in the town of Somoche. The Tobora River begins in the Serengeti District (near the town of Mugumu) and channels into the Mara River at the town of Nyansurura. The Tigithe River starts from the Nyamwaga Hills and streams into the Mara River downstream of North Mara Gold Mine. The lower catchment region in Tanzania includes parts of these districts: Tarime, Butiama, Rorya, and Serengeti.

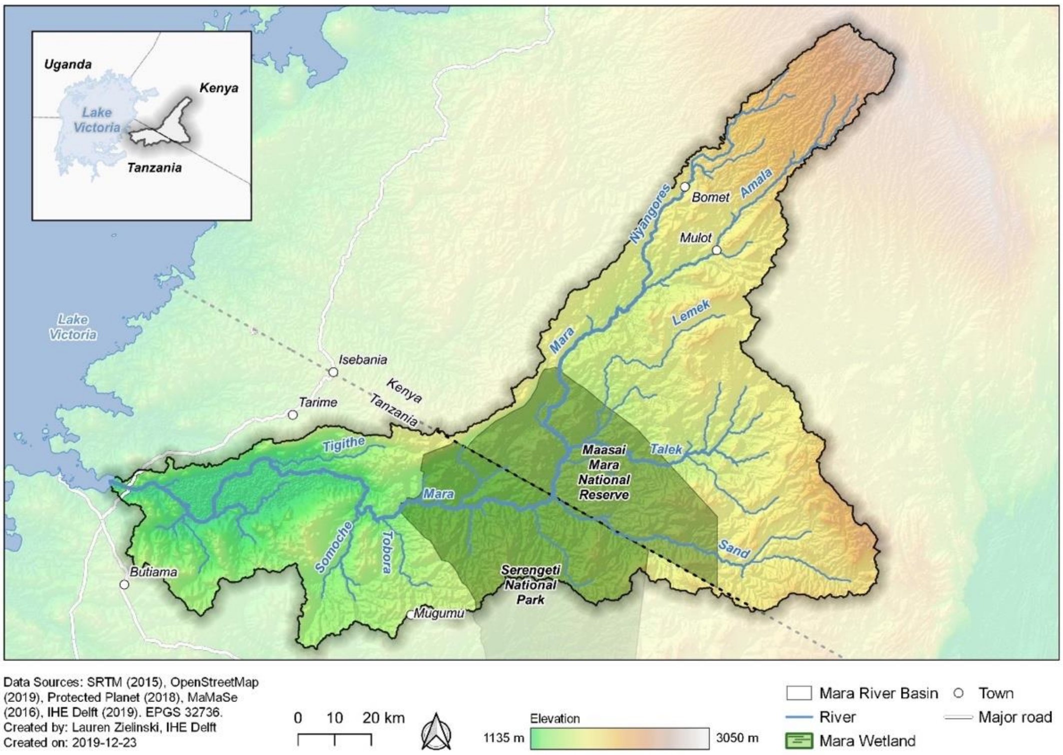

Figure 2-1: Map of the Mara River Catchment

2.2 ADMINISTRATIVE UNITS OF THE MARA RIVER CATCHMENT (MRC)

The MRC is located within the Lake Victoria Basin, which is one of nine basins in Tanzania and is managed by the LVBWB. The Lake Victoria Basin Water Board (LVBWB) was established in 2000 with the roles of water resource management, water resources protection and pollution control as stipulated in WRM Act Number 9 of 2009. The primary office for the LVBWB is located in Mwanza, with two sub-workplaces in Bukoba and Musoma. The Musoma sub-office is the primary location for board decisions and LVBWB activities associated with the MRC. Within the MRC, a Mara Catchment Committee and six Water User Associations (WUAs) have been established.

The MRC is additionally located in Mara Region in Tanzania and incorporates four districts. Serengeti District contains the biggest segment of the MRC (65%), followed by Butiama (16%), Tarime (15%) and Rorya Districts (4%) (see Table 2-1 and Figure 2-2). Each district has its own regional government staff, including a district water engineer and an environmental officer, while the Mara Region has its own administration authorities based in Musoma, including a territorial authoritative secretary and a zonal irrigation officer

Table 2-1: Area of districts inside the MRC

District Name	Total Area of District (km^2)	Area Inside Lower MRC (km^2)	% of District	% of Lower MRC
Butiama	2,168	812	37%	16%
Rorya	2,002	178	9%	4%
Serengeti	11,157	3,280	29%	65%
Tarime	1,534	776	51%	15%
Total	***16,861***	***5,046***	***-***	***100%***

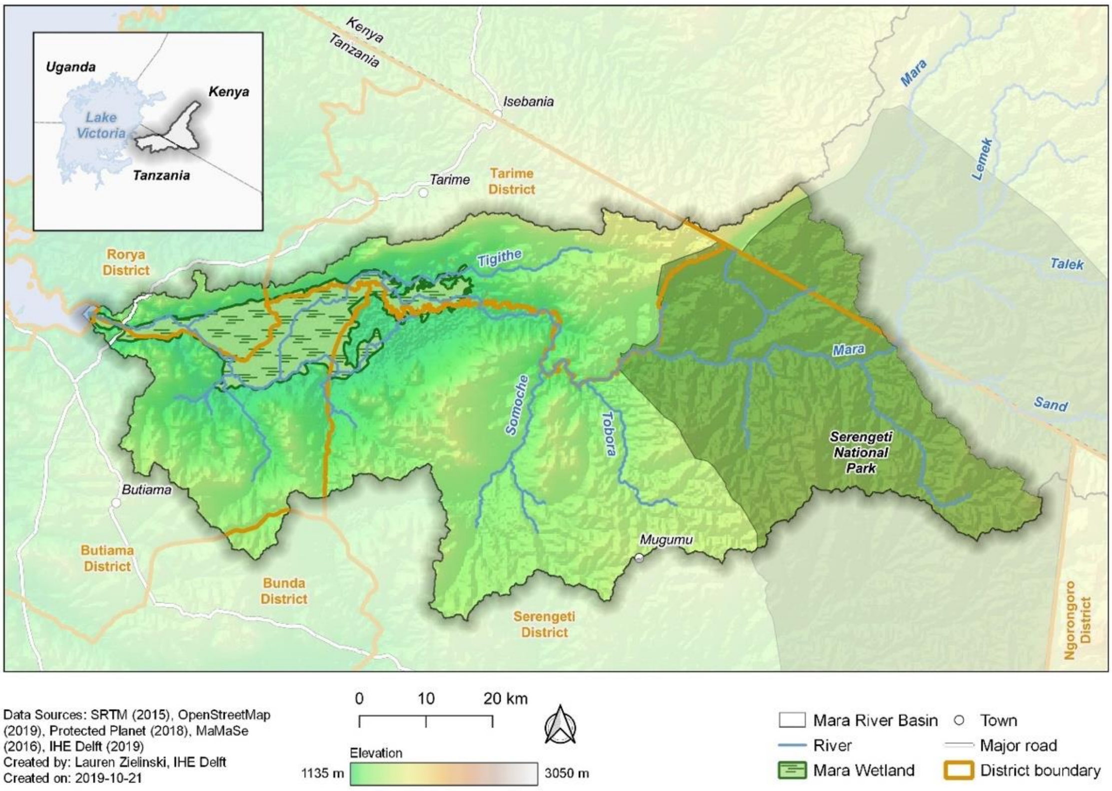

Figure 2-2: Districts within the MRC

2.3 CATCHMENT CHARACTERISTICS

The most recent census in Tanzania (2012) estimated that 1.28 million people live in the Mara River Catchment, with approximately 861,000 people in the Kenya sub-basin and 419,000 people in the Tanzania sub-basin (KNBS, 2010; NBS and OCGS, 2013). The residents of the Mara River Catchment rely primarily on agriculture and livestock production for income, as well as forest products, mining, and wildlife and tourism. The Mara River Catchment is also home to two important wetlands, the Enapuyiapui Swamp in Kenya and the Mara Wetlands in Tanzania.

2.3.1 TOPOGRAPHY

The Lower MRC lies between the altitudes of 1,101 m to 2,601 m above mean sea level. The area consists of high- and low-relief areas. The high-relief area in the Mara River Catchment is found in the north-eastern part of the catchment that mostly lies in Serengeti District. The main Mara River ends its journey into Lake Victoria at an altitude of 1,133 m above the mean sea level. The Lower MRC lies in the equatorial region with a range of different landforms, including high mountains and large inland lakes, making the climate highly variable.

2.3.2 PRECIPITATION

Yearly precipitation in the Lower MRC ranges between 680 mm and 1,336 mm. The northern and north-eastern part of the catchment receives the highest precipitation. The southern and western parts receive comparatively lower precipitation. Monthly precipitation data clearly demonstrate a bimodal regime with two precipitation seasons. Long rains occur from March to June and short rains from October to December, with dry seasons from July to September and January to February

About 57-65% of the total yearly precipitation falls during the time of the long rains. Monthly precipitation ranges from more than 100 mm during the long rains and more than 80 mm during the short rains to less than 40 mm during the dry periods.

The intra-yearly fluctuation of streams in the Lower MRC reflects the precipitation patterns in the catchment just as the dependence of streams from the upstream catchment because of the mainstem Mara River. The highest monthly flows occur in April and May; lowest flows are in August for the Somoche, and in October for the Mara and Serengeti.

2.3.3 TEMPERATURE

The average temperature of the Lower MRC is 23.2˚C. The temperature consistently ranges between a minimum of 16.8˚C in July to a maximum of 28.9˚C in October. During the year, the temperature variety is insignificant.

2.3.4 CLIMATE CHANGE

The Climate Change Variability and Adaptation Assessment (USAID, 2019) was done to evaluate the vulnerability of the MRC to climate variability and change and provide investment recommendations for donors, the government and the private sector to address the changing nature of risk across the catchment. Results indicate that weather and climatic conditions in the MRC are a product of both human-induced climate change and natural cyclical climate patterns. The climate of the catchment is changing; temperatures have risen by 1°C–1.5°C and rainfall is becoming more erratic. This is projected to continue to change, as outlined below.

Increasing Temperatures and Intensity and Duration of Heat Waves

Compared with period of 1985-2015, the average temperature of the MRC is expected to increase by 0.7°C-1.97°C by 2030 and 1.5°C-2.71°C by 2050, with the most warming during the months of the long rains (March to May). The catchment is also expected to see an increase in the duration of heat waves in Kenya (from 21 to 30 days) and in Tanzania (from 15 to 22 days). Increases in temperature and in the duration of heat waves can impact human populations, agriculture and livestock and ecosystems. Examples are as follows:

- Loss of crops or decreased yields caused by decreased soil moisture and infiltration rates.
- Increased poverty and food insecurity caused by loss of crops or decreased yields, loss of livestock, or loss of other sources of food and income.
- Declining wildlife populations due to heat stress and reduced water availability from increased evaporation, leading to both a loss of biodiversity and decreased revenue from tourism.

Continued Increase in the Frequency and Intensity of Rainfall and Drought Events

Extreme rainfall and drought events have impacted the catchment’s economy, environment and people. For example, the 1997–98 El Niño event led to widespread flooding throughout the East Africa region and caused major changes in the course of the Mara River. These events can have long-lasting impacts, such as:

- Increased poverty and food insecurity caused by loss of crops or decreased yields, loss of livestock or loss of other sources of food and income.
- Decreased water quality due to sedimentation from river bank erosion and deforestation, or excessive water abstractions.
- Water shortages caused by drought or poor planning and management of water resources, particularly within populations that rely primarily on surface water.

Increased Interseasonal Rainfall Variability

The length of time that soil temperature and soil moisture conditions are suitable for cash and subsistence crops is changing, with delayed starts and more frequent failure of the short rains, making for less-reliable growing seasons. This increased unreliability can have major impacts; for example:

- Increased poverty and food insecurity caused by loss of crops or decreased yields, loss of livestock or loss of other sources of food and income.
- Reduced access to drinking water due to drying up of small streams and seasonal water decreases.
- Changes in the suitability of certain crops, requiring either altered planting and harvesting schedules or outright substitution for a more suitable crop.

2.3.5 HYDROLOGY

The Mara River Catchment has four tributaries: Borogonja, Tobora, Somoche, and Tighite (Figure 2-3). The Borogonja Stream begins from Borogonja Spring in Serengeti National Park (SENAPA) and channels into Mara River inside the SENAPA. The Tobora River begins from Serengeti District (near the town of Mugumu) and channels into Mara River at the town of Nyansurura. The Somoche River begins in Serengeti District and flows into the Mara River at the town of Somoche, downstream of the confluence between the Tobora River and the Mara River. The Tigithe River starts from Nyamwaga Hills and flows into Mara Wetland downstream of North Mara Gold Mine.

These tributaries drain water throughout the year except on extreme drought event. The Borogonja Spring flows year-round. The Tobora River dries up occasionally, but not frequently. These four tributaries typically have very low flows during the dry season. While no groundwater studies have been conducted in the catchment, it is expected that groundwater and year-round springs contribute to the flow during dry periods.

A range of water bodies lie within the Mara River Catchment including springs, chaco dams, shallow wells and boreholes. Chaco dams, commonly referred to as water pans, are often small and/or shallow depressions in the local topography that collect rainwater which can be used for livestock or human use. There has been no groundwater survey of the Lower MRC, so it is not known where groundwater aquifers are located, nor the amount of water contained within them.

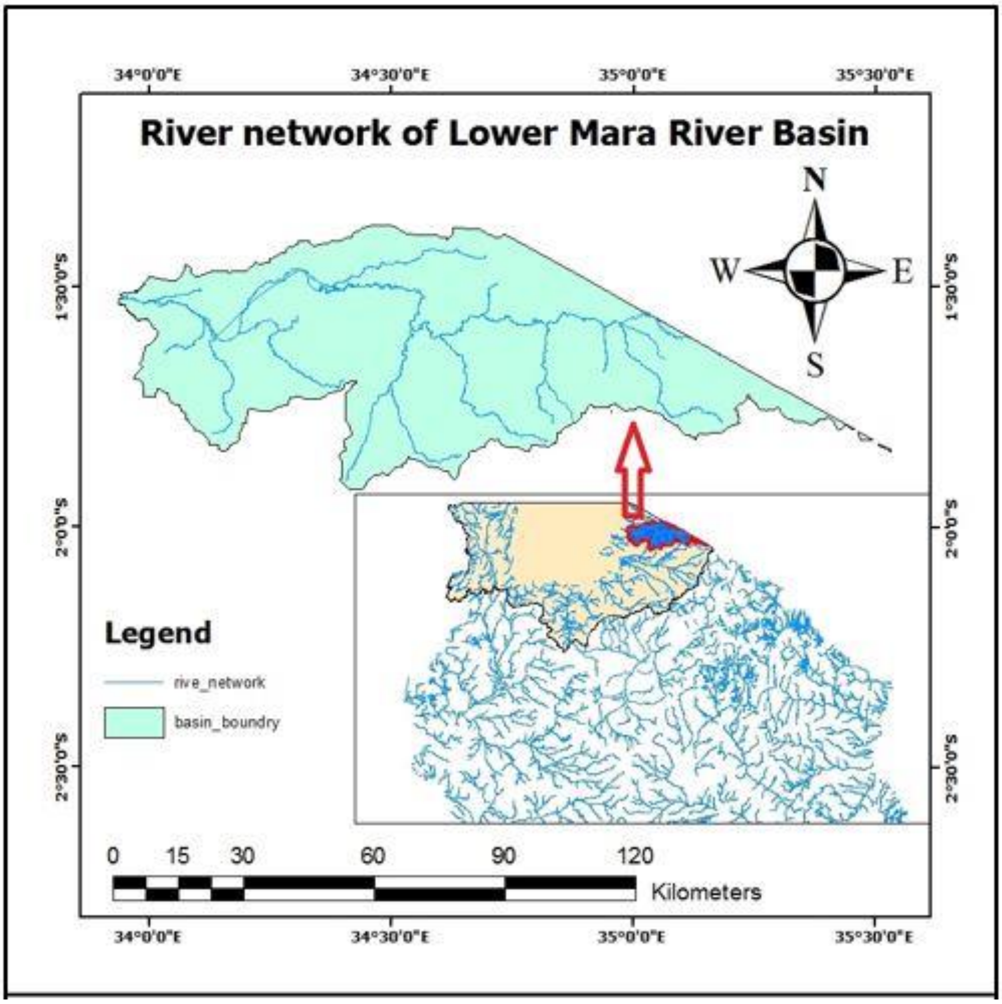

Figure 2-3: River network in Mara River Catchment

2.3.6 SOIL

The soil distribution in Lower MRC is not uniform (Figure 2-4). The Luvic Phaeozems soil type dominates the eastern part of the catchment all the way to border of Tanzania and Kenya. The Eutric Planosols soil type dominates the western and central parts of the catchment. Eutric Leptosols cover a small area in the central part of the catchment, and Eutric Fluvisols are found in the northwest part of the catchment. This classification system is according to Food and Agriculture Organization (FAO) of the United Nations. The Fluvisols soils are found typically on level topography that is flooded periodically by surface waters or rising groundwater, as in river floodplains and deltas and in coastal lowlands.

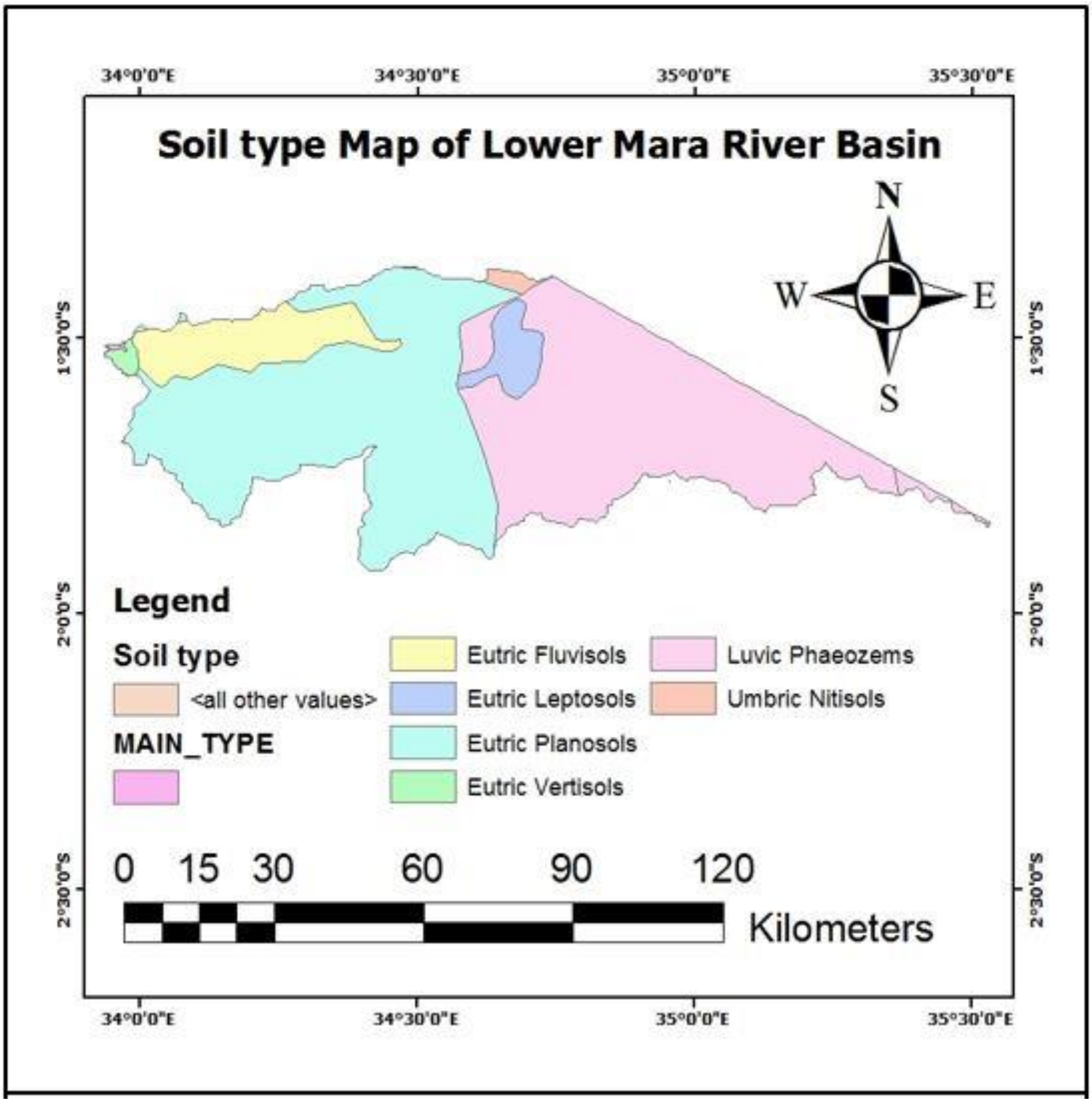

Figure 2-4: Soil distribution in Mara River Catchment

2.3.7 GEOLOGY

The geology of the Lower MRC is characterized with different rock types (Figure 2-5). In the southeast of the catchment, Nyanza belt dominates. From the southeast to western part of the catchment, the Tanzania craton extends all the way to northwest. The Tabular Bukoban rock type dominates the central part of the catchment, where it joins with the craton type in all directions. The rocks are exactly similar in type to rocks of the Ubendian belt system. They represent an ancient series of sediments, probably shale, sandstones and greywackes, which have been altered by regional metamorphism and magmatization to their present high grade. This thick formation consists almost entirely of coarse-to-medium grained, white, occasionally cream, pure quartzites and sandstones, with occasional bands of quartz pebbles. There are few horizons of shaly beds, which often show signs of shearing, and thin basal conglomerates are sometimes developed.

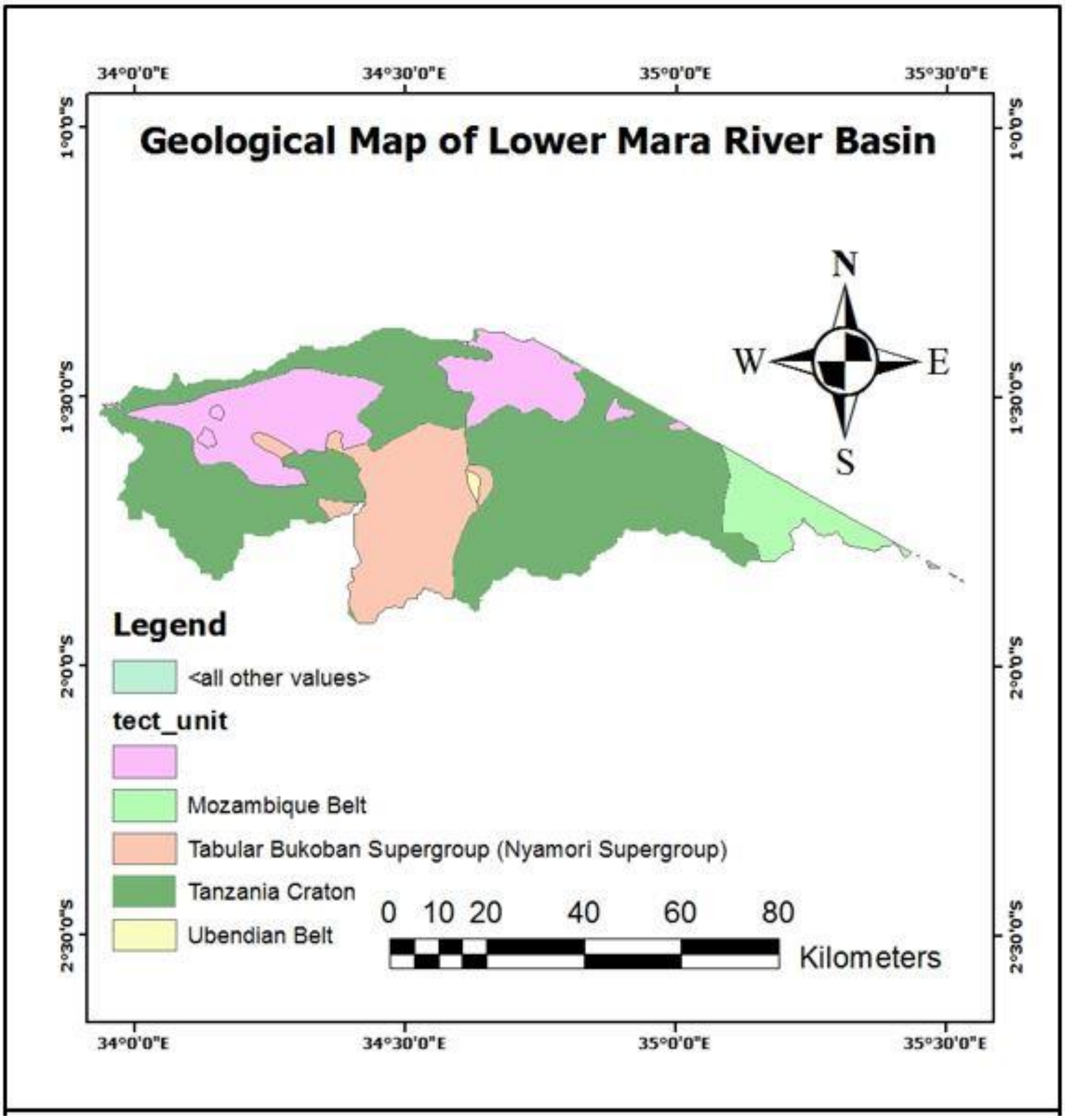

Figure 2-5: Geological map of the Mara River Catchment

2.3.8 LAND USE/LAND COVER

The catchment is characterized by bush lands and bare soils, cultivated land, grassland and forest (Figure 2-6). Permanent swamps cover a considerable part of the catchment. Woodlands also are extended to different parts of the catchment. The grassland, woodland and bushland dominate the whole catchment, while cultivated land and permanent swamp are found in small areas. Natural forest land is scattered throughout the catchment but mostly found in the Serengeti district.

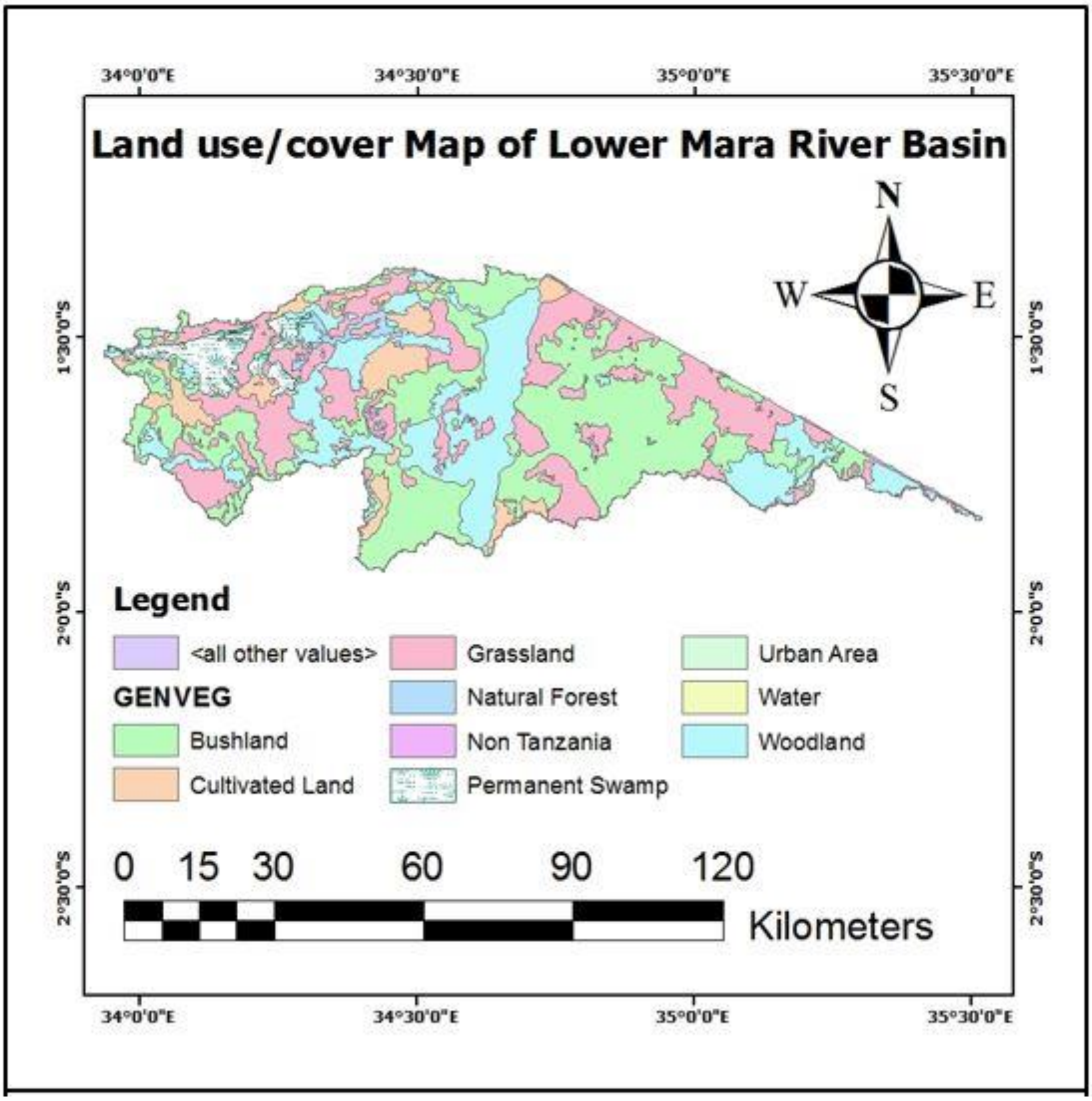

Figure 2-6: Map of land use/cover for Mara River Catchment

2.3.9 SOCIOECONOMIC CHARACTERISTICS AND TRENDS

The estimated total population of the MRC is estimated to be approximately 1.28 million. Estimates for the annual population growth rate of the Lower MRC vary from 2.5-3% based on source and geographic location within the catchment. The population is expected to grow rapidly, increasing pressure on land for agriculture and human settlement.

The rangelands that include the Serengeti National Park have lower population density due to their semiarid climate. Subsistence agriculture and livestock production are the dominant economic activities in the Lower MRC, with more than 60% of households engaging in smallholder subsistence farming as their primary occupation, followed by tourism and cash crop production. Other economic sectors in the catchment include mining, trade and industry, and forestry, each of which is overseen by a respective ministry. In and around SENAPA, tourism is the main economic activity, benefitting primarily those employed in the industry by large international lodge owners and some district governments operating lodges and/or parks, as well as pastoral herdsmen who conduct small- and medium-scale livestock rearing.

Around the Mara Wetland in the lower highlands, livestock and milk production (primarily beef and dairy cattle, goats and sheep) dominate as sources of income. Small-scale subsistence farming in this area includes sweet potatoes, maize, onions, beans, sorghum, and millet, with subsistence and additional income also coming from fishing and small-scale mining. There is one large-scale gold mine in the region called the North Mara Gold Mine. Crops and livestock are even more important in this area, with 83% of households engaging in agriculture as their primary occupation. More than 50% of households grow maize, which is intercropped with cotton as well as traditional crops more resilient to drier conditions such as cassava, sorghum, beans, sweet potatoes, millet and oilseeds. About 62% of households keep livestock, primarily cattle, goats, sheep and chickens. The trend indicates that crops and livestock continue to be the dominant economic activities in the Mara River Catchment. Tourism also continues to be a growth sector over the past decade, but with limited economic benefits to the catchment inhabitants.

3 Methodology

The approach adopted during preparation of the Lower Mara River Catchment Water Allocation Plan includes a review of different water acts and policies of Tanzania. Stakeholder engagement was conducted using workshops, meetings and public hearings to ensure that inputs of beneficiaries were captured in the WAP. Additionally, field assessments were conducted to understand water availability and water demand in the catchment. The preparation of the WAP involved various activities including stakeholder engagement, multiple water resources assessments, and a climate change vulnerability and adaptation assessment.

Literature review

Following the approach outlined in the draft Water Allocation Planning Guidelines for Tanzania in 2018, different assessments were carried out to determine the water balance. According to the draft, the water balance is defined as:

Water Balance = Available Water - (Reserve + Agreements/Transfers + Demand)

The water balance is calculated using assessments on the available water in the system (determined from historical hydrological records or modelled results), the environmental requirements (determined from the reserve, which is the amount of water that protects aquatic ecosystems and provides for basic human needs), participation in international agreements and/or interbasin transfers, and assessments of current and future allocations (including current use and expected demand). Having an accurate water balance is important to know since the remaining water in the water balance will be available for allocation now and into the future through existing permitting procedures. The preparation of the WAP involved multiple water resources assessments, and a climate change vulnerability and adaptation assessment.

The WAP was prepared in accordance with Section 13 (2) (g) of Water Resources Management Act (WRMA) No. 11 of 2009, which mandates the responsible Minister to formulate regulation, technical standards and guidelines for the purpose of implementing the Act. The process of water allocation has to adhere to the provisions of the Nation Water Policy (NAWAPO) of 2002, the National Water Sector Development Strategy (NWSDS) of 2006 and the WRMA of 2009, together with its regulations related to water allocation. The guidelines also reflect the requirements stipulated under Section 31 (3) of the WRMA.

Section 4.1.2 of the NAWAPO of 2002 sets criteria for the prioritization of water allocations to ensure domestic, environmental and social-economic water requirements, whereby the letter shall receive its share of the resource based on the availability. The criteria are also meant to enable various sectors to increase productivity and mitigate possible scarce conflicts. In addition, Part II Section 6 (2) (a-c) of the WRMA of 2009 provides for preference for water allocation as a supplement to the policy. Furthermore, the water allocation process considers the available water permits issued to a given source according to part VII of the WRMA of 2009.

Water allocation follows the Water Abstraction and Use (Section 43 Water Resource Management Act 2009 No. 11) and Discharge (section 67), Environmental Water Requirements, Rainwater Harvesting Regulations. The allocation is done through provision of water use permits, which are given to a particular user on a demand-driven basis.

The process involves the assessment of the available water resources in terms of quantity and quality, allocating water requirements for domestic and environment, allocating water requirements for available permit holders downstream, and then providing water from the remaining amount to the new user after consulting particular stakeholders who are likely to be affected. The validity of the permit is determined by the BWBs depending on the intended type of water use and the respective water use project period.

The literature review helped to provide baseline information on the existing legal frameworks and practices on water resources management and water allocation in Tanzania.

3.1 STAKEHOLDER ENGAGEMENT

Engagement of stakeholders at all levels was key to the successful preparation and implementation of the WAP. Stakeholders were involved by using a bottom-up approach whereby local community leaders and administrative leaders were kept aware of the proceedings and later became the awareness creators to the rest of the community members in the project area. All stakeholders were consulted and effectively involved in the assignment through provision of data, information and experienced challenges in relation to water resources management. Engagement of stakeholders aimed at providing an opportunity for them to express their interests, concerns and their contributions towards successful development and implementation of the plan.

In addition, stakeholders were brought together in a series of workshops to develop and evaluate different future scenarios and critical uncertainties faced by the water sector in the Lower MRC.

To achieve the preparations of the WAP various stakeholders' workshops were conducted as follows:

3.1.1 INCEPTION WORKSHOP FOR WAP GUIDELINE REVIEW

The Inception Workshop for WAP Guideline Review was held at Tarime where 64 stakeholders attended from 19 organizations, including local, regional and national stakeholders, project partners and support staff. The stakeholder organizations included 6 WUAs, LVBWB, MoW, Zonal Irrigation Office in Mwanza, SENAPA, Tanzanian universities and both local and national non-governmental organizations. Partner organizations that attended the event included IHE Delft, NBI-NELSAP, WWF-Tanzania, the Sustainable Water Partnership, USAID Kenya, and the Stockholm Environment Institute. Involvement of stakeholders at the inception phase, aimed at introducing the exercise which was about to be conducted. Their main role was to provide required data and information, provide innovative ideas and sharing experienced challenges related to water resources management in the Mara River Catchment.

3.1.2 RQO WORKSHOP

The Resource Quality Objective (RQO) workshop was held at Tarime where 39 stakeholders attended from 14 organizations from different administrative levels, project partners and support staff. The stakeholders included 6 WUAs, the LVBWB, the MoW, the Zonal Irrigation Office in Mwanza, SENAPA, Tanzanian universities, non-governmental organizations as well as partner organizations like IHE Delft, NBI-NELSAP, WWF-Tanzania, the Sustainable Water Partnership, USAID Kenya, and the Stockholm Environment Institute. The aim of the meeting was to assess the present resource quality with focus on the importance, pressures and trends, which was essential for environmental flow assessment. Participants of the workshop expressed their issues on how the water resources in the Lower MRC should be utilized and managed.

3.1.3 ROBUST DECISION SUPPORT PROBLEM FORMULATION WORKSHOP

The Robust Decision Support Problem Formulation Workshop took place in Mwanza in 2018 to establish the structural components of the scenarios to be analysed. These included the critical uncertainties, the metrics of success and the strategies that could be implemented to increase water security in the catchment. The stakeholders identified two critical uncertainties: climate change and upstream developments and/or diversions. The metrics of success included:

- Heathy ecosystems
- Equitable water use across the catchment
- Achieve water-related development potential
- Resilience to climate change

A set of strategies were also established which included combinations of expansion of small storage, introduction of alternative livelihoods, expanded irrigation, and better education and communication around water, sanitation and hygiene.

The Water Security Assessment Workshop was held on July 2019 at Ryans Bay Hotel in Mwanza city. A Water Evaluation and Planning (WEAP) model of the Mara was further developed based on the inputs from the prior workshop on Robust Decision Support Problem Formulation. The results of this model were shared to allow stakeholders to gain a deeper understanding of the vulnerabilities in the Tanzanian portion of the Mara, and the ability to enhance water security through the implementation of various strategies as noted in the prior workshop.

The stakeholders' engagement enabled the WAP preparation team to obtain stakeholders' views, which have been incorporated in the plan. Understanding stakeholders' requirements and how they are affected by implementation of various interventions for WRM, such as water use permitting, improved scenario analysis during WAP preparation. Further engagement meetings and workshops held included:

- Conducted Water Allocation Plan Inception Meeting in Tarime Tanzania in June 2018 with over 87 participants representing stakeholders and partners working in the Mara River Catchment.
- Conducted problem formulation and scenario development workshop for Tanzania.
- Environmental Flow Assessment (EFA) is completed. The low flow assessment was conducted in February 2019, and the high flow assessment was done in May 2019. The technical meeting to consolidate the EFA was conducted between 1-2 July 2019.
- The review of all technical reports by stakeholders (sector ministries, NGOs and LVBWB) was completed June 2019.
- The submission and review of WAP technical papers finalized on 15 July 2019.
- WAP writing commenced on 8 October 2019, with second stage completed on 1 November 2019.
- The Tanzania WAP Guideline has been approved by the Ministry and going through the final stages for adoption as a national document.

3.2 FIELD ASSESSMENT

3.2.1 ASSESSMENT BOUNDARIES

For all assessments, distinct sub-basins were delineated so that all the calculations in the separate assessment followed the same boundaries, allowing the water balance to be calculated for the same geographical areas. The MRC was divided into six sub-basins: Serengeti, Tobora, Somoche, Mara Mines, Tigithe, and Wetland (Figure 3-1). This was done to emphasize the differences between the mainstem Mara River, the tributaries, and the Mara Wetland. These six sub-basins are based on natural hydrological boundaries and were used in all the technical water resources assessments and the final water balances. Some sub-basins also align with boundaries of existing WUAs. Details for each water resources assessment are discussed in Sections 4.1 to 4.5.

All the technical water resources assessments considered the information gathered in a cumulative manner. This meant that the results for downstream sub-basins include the values of that sub-basin plus all of the sub-basins located upstream (including from Kenya, when appropriate). Specifically:

- The available water for each sub-basin considers the surface flow from that specific sub-basin plus all of the sub-basins upstream.

– the reserve takes into account the basic human needs and environmental needs of that sub-basin plus all areas upstream.

– and the water demand includes all the demands from that sub-basin and all sub-basins upstream.

The Serengeti sub-basin includes inputs from the Upper MRC in Kenya and the Serengeti sub-basin; the Mara Mines sub-basin includes inputs from the Upper MRC, Serengeti, Tobora, Somoche, and Mara Mines sub-basins; while the Wetland sub-basin includes inputs from the Upper MRC and all sub-basins (including those from the Wetland sub-basin). Based on the geography of the Lower MRC, Tobora, Somoche, and Tigithe are stand-alone sub-basins, and hence, are not cumulative.

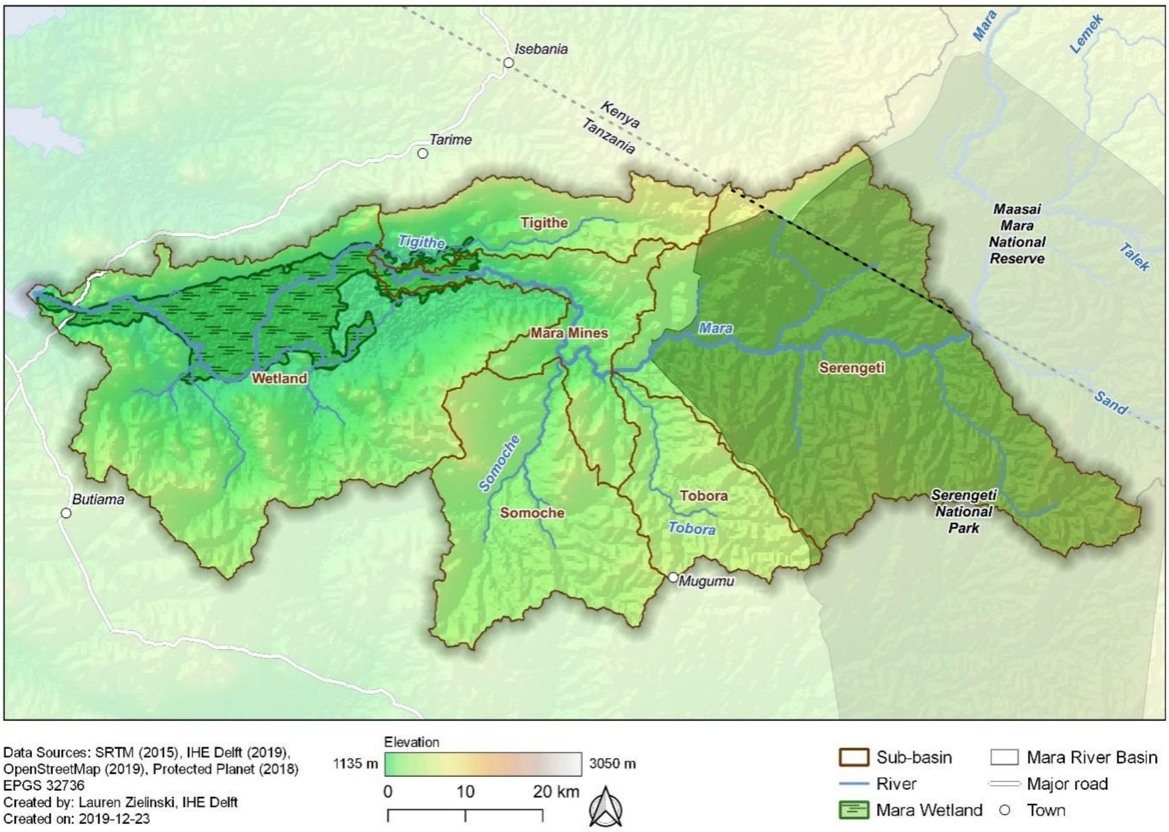

Figure 3-1: The 6 sub-basins used in the WAP: Serengeti, Tobora Somoche, Mara Mine, Tigithe and Wetland

3.2.2 WET AND DRY CONDITIONS

While all of the water resources assessments were completed on a monthly basis, this is not a time scale that is convenient for water allocation planning and implementation. It would be difficult and impractical to change management actions every month, creating challenges to notify and enforce changes in water use allowances or restrictions. An annual time scale is also not practical since hydrological conditions change significantly throughout the year, creating the potential to over-allocate water in the dry months and under-allocate water in the wet months. To alleviate this, the LVBWB will base management actions on the hydrological condition of the catchment. This was done to align management with the natural weather patterns of the area, so more water can be reliably allocated to water users in wet conditions and less water can be allocated in dry conditions to ensure the reserve is met. It is also intended to increase flexibility in order to properly manage naturally variable conditions. For example, a typical year may be two rainy periods and two dry periods, in which case the condition would be changed four times in one year. Some years, the long rains may never occur, leaving the option to maintain water allocation in a dry condition for many months. Alternatively, if there are heavy rains and the rivers remain high for additional months, then the catchment could remain in a wet condition for longer. Ultimately, the decision on the current condition and when to change the condition will be up to the LVBWB managers, but it cannot be changed more than four times in one water year.

The water balance for each sub-basin was then calculated using these wet and dry conditions. To determine wet and dry months for the water resources assessments, the average monthly flow was compared to the average annual flow for each sub-basin. If the monthly average flow was greater than the average annual flow, than it was considered a wet month; if the monthly average flow was less than the average annual flow, then it was considered a dry month. For each water resources assessment, the results for the wet and dry months were averaged together to find the values that were used in the water balance. Table 3-1 shows the wet months in blue and the dry months in yellow for each sub-basin.

Table 3-1: Wet and dry months for each sub-basin

Month	Serengeti	Tobora	Somoche	Tigithe	Mara Mines	Wetland
January						
February						
March						
April						
May						
June						
July						
August						
September						
October						
November						
December						

The intent of the WAP is to provide guidance on how to manage water allocation in a sustainable and equitable manner, while leaving enough flexibility for the LVBWB mangers to make situation-specific decisions. The WAP management divide the amount of water into six distinct hydrological situations: wet and dry conditions during flood flow, normal flow, and reserve flow. For each of these six situations, the WAP provide input on how to manage water resources in situations of sufficient water resources, insufficient water resources, and when the Mara River and its tributaries are in the reserve, which are based on the outcomes of the water balance and future scenario analysis.

4 Water Resources Assessments

To accurately assess the water balance in the Lower MRC, a series of assessments related to water resources was completed. These included a water resources availability assessment (SWP, 2019), a reserve assessment (URT, 2019), participation in international agreements and inter-basin transfers, an abstraction survey (SWP, 2019), and a water demand assessment (SWP, 2019). Each assessment was completed for the same six sub-basins and at a monthly time step. These results were then used to develop the water balance for each sub-basin. A summary of the methodology and results is included in Sections 4.1 to 4.5.

4.1 WATER RESOURCES AVAILABILITY ASSESSMENT

4.1.1 METHODOLOGY

Water availability in the MRC is mainly driven by precipitation falling within the boundary of the river catchment. Part of the precipitation seeps into the ground to recharge groundwater, while the rest develops into surface runoff which drains to the Mara River's tributaries and its mainstem. Based on the availability of long-term hydrometeorological data as well as the inadequacy of hydrogeological information within the MRC, the Water Resources Availability Assessment focuses on the available surface water resources in the Lower MRC. The assessment builds on earlier work carried out under the Mau Mara Serengeti (MaMaSe) Sustainable Water Initiative in the Kenyan part of the MRC, which was updated with new data and information collected during WAP-related activities in the Lower MRC in Tanzania.

Data used for this assessment includes topographic data and its derived information (e.g., flow direction, flow accumulation, catchment boundaries, catchment areas, and river networks) as well as location information of precipitation and hydrometric stations. The time series used for the analyses consists of long-term annual and monthly precipitation and discharge values, which were aggregated from daily records. Precipitation and discharge time series were a combination of outputs from the Water Resources Authority in Kenya and LVBWB databases and from data collected during the MaMaSe project.

The first step was to undertake catchment delineation where catchments and drainage networks were derived from the SRTM 90m Digital Elevation Database v4.1. Delineation of sub-basins within the entire MRC was carried out at two levels using the widely adopted Pfafstetter coding system. This is a recursive hierarchical subdivision of larger basins into smaller ones until the desired level of detail is reached.

For the precipitation input, a total of 25 stations in and around the MRC were selected. Of these stations, 16 are located inside the catchment and nine are located outside the catchment. Time series of daily precipitation were available, ranging from 15 to 49.5 years in length and with 0 to 40% of missing data. After a visual inspection and first correction of outliers, the daily time series were aggregated to monthly and annual time series. The consistency of the dataset was checked by double mass curve analyses. Monthly totals were only calculated if at least 25 daily observations for the month were available in the database. For the annual calculations, only years with a complete set of 12 months were used.

For the river discharge input, a total of 11 hydrometric (or river gauging) stations are available in the Mara River Catchment, of which seven are situated in the Kenyan part and four in the Tanzanian part of the catchment. Only five stations with long time series daily discharges were available, having a time series of daily discharge ranging from 2.7 to 59.5 years in length and with 15.5 to 75.1% of missing data. After a visual inspection and first correction of outliers, these daily time series were aggregated to monthly and annual time series. Monthly averages were only calculated if at least 25 daily observations for the month were available in the database. For the annual calculations, only years with a set of minimal ten available months were used.

The objectives of this assessment were to:

i. regionalize average monthly and average annual discharge data.
ii. estimate flow duration curves.
iii. setup long term water balances for the sub-catchments within the MRC.
iv. assess changes in the hydrometeorological time series data sets.

4.1.1 RESULTS

Water availability in the catchment was assessed and analysed into six sub-basins, namely Serengeti, Tobora, Somoche, Mara Mines, Tigithe, and Mara Wetland. The average annual water availability in the full Tanzanian Mara River Catchment is 2,947,104 m^3/day. Of this total, 76% is generated from the Kenyan side of the catchment. The available water generated in Tanzania amounts to 700,397 m^3/day, of which 2,499,506 m^3/day is available in the Serengeti sub-basin, 50,112 m^3/day is generated in the Tobora sub-basin, 91,584 m^3/day is generated in the Somoche sub-basin, 2,695,680 m^3/day is available in the Mara Mines sub-basin, 50,987 m^3/day is generated in the Tigithe sub-basin, and 2,947,104 m^3/day is available in the Mara Wetland sub-basin. Total average water availability varies from a low of 2,311,200 m^3/day in dry condition to a high of 4,857,408 m^3/day in wet condition.

The annual discharge (m^3/s) and magnitude (m^3/day) were determined for each sub-basin, as well as averaged values for both wet and dry conditions. This was completed for annual average flow, Q50, Q80, Q95, and flood flows (the summation of flows between Q1 and Q80) (Table 4-1). Detailed results can be found in Annex A.

Table 4-1: Flow statistics for the six sub-basins in the Mara River Catchment

Sub-basin		Discharge (m^3/s)			Magnitude (m^3/day)		
	Parameter	**Annual**	**Wet**	**Dry**	**Annual**	**Wet**	**Dry**
Serengeti	Average	28.93	42.29	22.26	2,499,506	3,653,856	1,923,264
	Q50	24.20	40.33	19.76	2,091,010	3,484,448	1,707,465
	Q80	13.58	24.35	11.50	1,173,135	2,103,584	993,281
	Q95	7.17	13.55	5.65	619,849	1,170,530	488,251
	Flood flow	27.21	39.29	20.13	2,350,947	3,395,033	1,739,001
Tobora	Average	0.58	1.12	0.31	50,112	96,768	26,784
	Q50	0.34	1.01	0.23	28,985	87,051	19,843
	Q80	0.08	0.47	0.05	6,842	40,752	4,235
	Q95	0.02	0.22	0.02	1,529	19,213	1,334
	Flood flow	0.57	1.07	0.32	49,343	92,512	27,581
Somoche	Average	1.06	2.08	0.55	91,584	179,712	47,520
	Q50	0.62	1.86	0.43	53,533	160,791	37,291
	Q80	0.16	0.89	0.11	14,250	77,075	9,324
	Q95	0.03	0.38	0.03	2,945	32,435	2,430
	Flood flow	1.05	1.96	0.58	90,425	169,399	49,773
Mara Mines	Average	31.20	45.82	23.89	2,695,680	3,958,848	2,064,096
	Q50	25.98	43.17	20.70	2,244,439	3,730,122	1,788,239
	Q80	14.71	25.74	12.43	1,270,858	2,223,846	1,073,642
	Q95	7.91	14.44	6.17	683,586	1,247,824	533,281
	Flood flow	29.29	42.73	21.75	2,530,937	3,692,057	1,879,479
Tigithe	Average	0.59	1.15	0.31	50,987	99,360	26,784
	Q50	0.38	1.04	0.27	32,608	89,780	22,952
	Q80	0.09	0.49	0.07	7,740	42,574	5,668
	Q95	0.01	0.22	0.01	1,204	18,742	1,042
	Flood flow	0.59	1.11	0.33	50,651	96,318	28,218

Table 4-1: Flow statistics for the six sub-basins in the Mara River Catchment

Sub-basin		Discharge (m^3/s)			Magnitude (m^3/day)		
	Parameter	**Annual**	**Wet**	**Dry**	**Annual**	**Wet**	**Dry**
Wetland	Average	34.11	56.22	26.75	2,947,104	4,857,408	2,311,200
	Q50	27.41	52.80	23.09	2,367,964	4,562,192	1,995,222
	Q80	16.34	30.49	13.65	1,411,766	2,634,658	1,179,018
	Q95	8.45	18.52	7.48	729,938	1,599,879	646,406
	Flood flow	31.88	52.07	24.28	2,754,562	4,498,531	2,097,929

4.2 RESERVE ASSESSMENT

4.2.1 METHODOLOGY

In the WRMA (2009), the reserve is defined as the *quantity and quality of water required for -*

(a) satisfying basic human needs by securing a basic water supply for people who are now or who shall in the reasonably for near future, be

(i) relying upon

(ii) taking water from; or

(ii) being supplied from the relevant water resources; and

(b) protecting aquatic ecosystems in order to secure ecologically sustainable development and use of the relevant water resources.

From this definition, the reserve consists of two parts. Part 1 is focused on meeting basic human needs, which can be considered a component of the domestic water demand. Part 2 is focused on protecting aquatic ecosystems, also known as environmental flows. The determination of the reserve was completed using the Nile Basin Initiative's Environmental Flows Framework. This framework was developed to ensure a standard process is followed for the increasing number of environmental flow assessments being conducted in the Nile Basin. This framework includes seven phases:

- Phase 1: Basin Scale Situation Assessment and Alignment Process
- Phase 2: Resource Quality Objectives Setting
- Phase 3: Hydrological Foundation
- Phase 4: Ecosystem Type Classification
- Phase 5: Assessment of Flow Alterations
- Phase 6: Flow-Ecological-Ecosystem Services Linkages
- Phase 7: E-Flows (Reserve) Setting and Monitoring

To determine the reserve requirements, these phases were carried out in partnership with the LVBWB, the MoW, and local stakeholders. Phases 1 through 5 were carried out using existing information, and provided inputs on how reserve recommendations should be developed and where in the catchment the reserve should be determined.

In Phase 6, three field campaigns were completed using a modified Building Block Methodology to capture the biophysical (hydrological and ecological) and social components of environmental flows in the Lower MRC (Figure 4-1). The biophysical field campaigns were completed in February and May of 2019, gathering data from seven study sites. This included two sites on the main stem Mara River (Kogatende and Mara Mines), three sites on important tributaries (Tobora, Somoche, and Tigithe), and two sites on the Mara Wetland (Bisarwi and Mara Wetland). Specific study sites were selected based on accessibility, diversity of physical habitats, presence of natural conditions, proximity to existing river gauging stations, safety, and alignment with previous environmental flow assessments. Field studies were conducted for hydrology, hydraulics, water quality, geomorphology, fish, macroinvertebrates, and riparian and wetland vegetation.

The social survey was conducted in early 2019 and included surveys of two villages within each sub-basin (excluding Serengeti and 4 villages within Tigithe), with 14 villages surveyed in total. The selection of the villages was based on accessibility, diversity of economic activities, proximity to the river or wetland, and population. The total number of participants in each village was about 40, which were selected using the village register with the assistance of the village leader. The selection was random but the gender and age of the participants were taken into consideration. During the Focus Group Discussions, each group had a different discussion theme, including general village profiles, social and economic issues, natural resources available and their environment, and biophysical analysis of water bodies.

The information collected in the field campaigns was then used to develop flow-ecology relationships during Phase 7. This provided an understanding of the connection between different volumes and timing of flow and the life cycle requirements of different species and ecosystem services important to local communities. Using these relationships, numerical flow requirements were developed for the ecological and social needs for specific indicators. Using a consensus approach, the most sensitive indicator was used for the final environmental flow requirements for baseflows, freshets (small events), and floods (large events). During Phase 7, the basic human need requirement was also determined. This part of the reserve was determined using population data from the Tanzanian census to determine the population within the Lower MRC. This number was then multiplied by the basic human needs requirement of 25 liters/person/day, as provided in the draft Water Allocation Planning Guidelines. The basic human needs and the environmental flows were combined to get a total reserve requirement for each sub-basin.

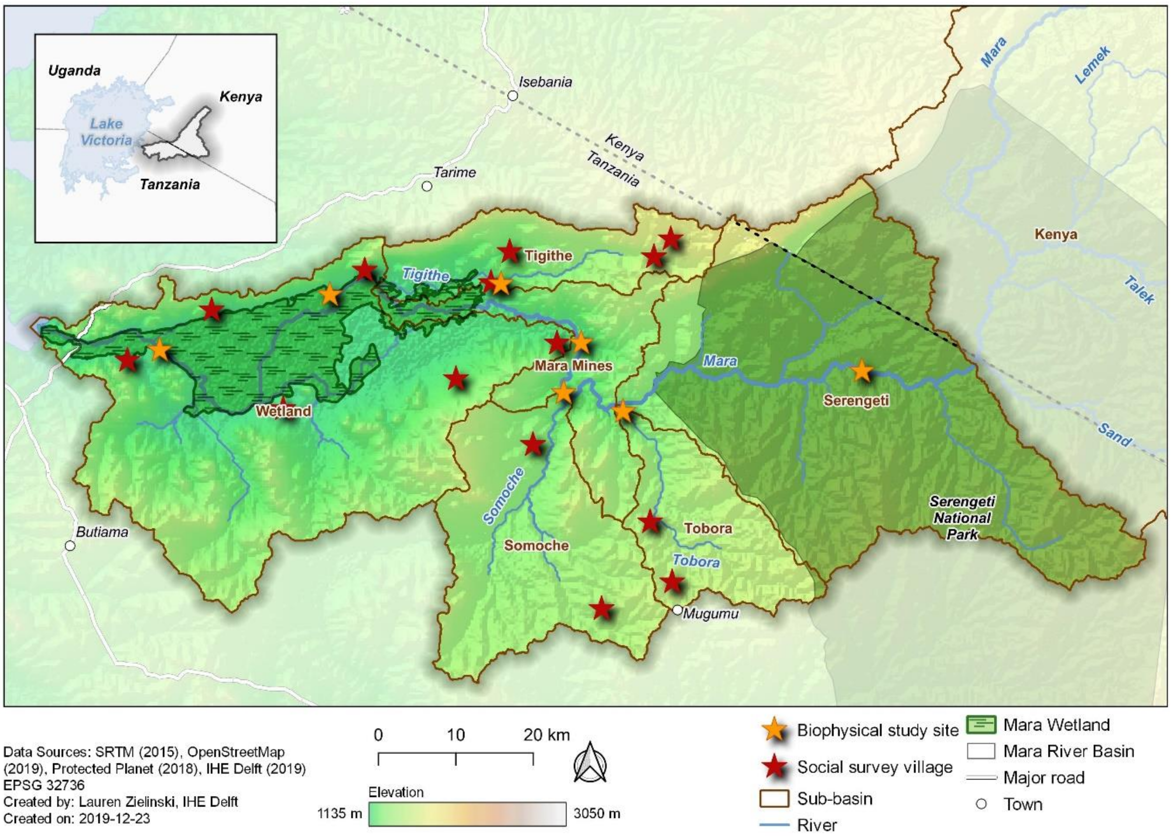

Figure 4-1: Map of the environmental flow study sites

4.2.2 RESULTS

The reserve assessment included an analysis to determine the flow required for basic human needs as well as environmental flow requirements in each study area. Since the sub-basins for the reserve assessment were slightly different than those used in the WAP, the final reserve values were reassessed using the WAP sub-basin boundaries. This involved recalculating the population and water requirements for basic human needs and then re-evaluating the environmental flow requirements. For the environmental flow requirements, the results of the reserve assessment most sites (Serengeti, Mara Mines, Tigithe, and Mara Wetland) needed to be "shifted" downstream to the outlet of the WAP sub-basin, which aligned these results with the results from the other water resources assessments. This involved estimating the additional flow contributed from the catchment between the existing reserve location and the location of the outlet of that sub-basin using the hydrological data from the Water Resources Availability Assessment. Other sites that are located at the outlet of the WAP sub-basin (Tobora and Somoche) could be directly included in the WAP results. Detailed results for both basic human needs and environmental flows can be found in Annex A.

The required basic human needs component of the reserve resulted in a required flow between 786 m^3/day (0.009 m^3/s) and 3,379 m^3/day (0.039 m^3/s) for the individual sub-basins. The cumulative requirements are 10,015 m^3/day (0.116 m^3/s) for the entire Lower MRC for 2018. The monthly values for basic human needs are expected to remain constant with population. As such, the requirements were the same for both wet and dry conditions. The requirements for basic human needs are also expected to grow as population in the catchment increases.

The final environmental flow requirements provided monthly flow values, which were then divided into wet and dry conditions. For wet conditions, the lowest environmental flow requirement for both baseflows and freshets & floods were selected from the "wet months" for each sub-basin. The same was done for the dry conditions. In general, the sites on the mainstem Mara River (Serengeti, Mara Mines, and Mara Wetland) had the largest requirements, while the tributaries (Tobora, Somoche, and Tigithe) had the smallest requirements. The wet condition also had greater baseflow requirements than the dry conditions. In addition, the wet condition has freshet and flood requirements while the dry condition does not. The environmental flow requirements are expected to stay the same through all planning horizons. All of the reserve requirements can be found in Table 4-2 and detailed tables in Annex A.

Table 4-2: Reserve flows for both wet and dry conditions (m³/day)

Year	2018		2023		2028		2038	
Condition	**Wet**	**Dry**	**Wet**	**Dry**	**Wet**	**Dry**	**Wet**	**Dry**
Serengeti								
Basic human needs	1,259	1,259	1,449	1,449	1,669	1,669	2,222	2,222
Eflows, baseflow	591,457	233,811	591,457	233,811	591,457	233,811	591,457	233,811
Eflows, freshets & floods	377,114	0	377,114	0	377,114	0	377,114	0
Total Reserve	**969,830**	**235,070**	**970,020**	**235,260**	**970,241**	**235,480**	**970,794**	**236,033**
Tobora								
Basic human needs	786	786	933	933	1,108	1,108	1,563	1,563
Eflows, baseflow	40,594	12,960	40,594	12,960	40,594	12,960	40,594	12,960
Eflows, freshets & floods	33,166	0	33,166	0	33,166	0	33,166	0
Total Reserve	**74,546**	**13,746**	**74,694**	**13,893**	**74,869**	**14,068**	**75,324**	**14,523**
Somoche								
Basic human needs	1,477	1,477	1,754	1,754	2,083	2,083	2,939	2,939
Eflows, baseflow	49,063	25,920	49,063	25,920	49,063	25,920	49,063	25,920
Eflows, freshets & floods	15,050	0	15,050	0	15,050	0	15,050	0
Total Reserve	**65,590**	**27,397**	**65,867**	**27,674**	**66,197**	**28,003**	**67,052**	**28,859**
Mara Mines								
Basic human needs	4,913	4,913	5,717	5,717	6,658	6,658	9,054	9,054
Eflows, baseflow	606,956	279,453	606,956	279,453	606,956	279,453	606,956	279,453
Eflows, freshets & floods	572,344	0	572,344	0	572,344	0	572,344	0
Total Reserve	**1,184,213**	**284,367**	**1,185,017**	**285,170**	**1,185,959**	**286,112**	**1,188,355**	**288,508**
Tigithe								
Basic human needs	1,722	1,722	1,920	1,920	2,141	2,141	2,661	2,661
Eflows, baseflow	13,897	8,640	13,897	8,640	13,897	8,640	13,897	8,640
Eflows, freshets & floods	24,805	0	24,805	0	24,805	0	24,805	0
Total Reserve	**40,425**	**10,362**	**40,623**	**10,560**	**40,843**	**10,781**	**41,364**	**11,301**
Wetland								

Table 4-2: Reserve flows for both wet and dry conditions (m^3/day)

Year	2018		2023		2028		2038	
Condition	**Wet**	**Dry**	**Wet**	**Dry**	**Wet**	**Dry**	**Wet**	**Dry**
Basic human needs	10,015	10,015	11,479	11,479	13,171	13,171	17,392	17,392
Eflows, baseflow	744,005	334,561	744,005	334,561	744,005	334,561	744,005	334,561
Eflows, freshets & floods	672,347	0	672,347	0	672,347	0	672,347	0
Total Reserve	**1,426,366**	**344,576**	**1,427,831**	**346,040**	**1,429,522**	**347,732**	**1,433,744**	**351,953**

4.3 INTERNATIONAL AGREEMENTS AND INTERBASIN TRANSFERS

Legal commitments made to other countries are of international importance and have a high priority in the water balance. In addition, any current or planned inter-basin transfers (where water from one basin is moved to another basin using constructed water infrastructure) could also have a large impact on the amount of water available for allocation and needs to be included in the water balance. Any international agreements or inter-basin transfers that may be included in this WAP need to be officially documented and approved by the LVBWB and MoW. In the Lower MRC, there are no such agreements in place nor are there plans in development for providing water for these purposes. As such, no additional abstractions have been included in this WAP for these purposes.

4.4 ABSTRACTION SURVEY

4.4.1 METHODOLOGY

To determine the current water use and help determine the current water demand, an abstraction survey was completed which collected abstraction information across the MRC. A team of more than 16 people was trained on mWater Surveyor application for the purpose of abstraction survey data collection: 12 people were full involved in abstraction data collection in Mara River Catchment, 2 people for data processing and analysis, and 2 people from IHE Delft were providing technical and financial assistance. During the exercise of water abstraction survey, community members were also part of the team in order to obtain the best information possible. The communities were represented by village leaders, WUAs leaders, and individuals who were using water resources. The abstraction survey covered the entire Lower MBR and was completed in 7 weeks.

The information targeted in the abstraction survey are as follows;

- Location of the source
- Quantity abstracted (Volume)
- The user of the source
- Water use permit
- Type of the source
- Type of use and
- Status of the source

4.4.2 RESULTS

A total of 499 water abstraction points was identified, of which only 308 points were functional. From the functional points, approximately 11,280 m^3/day are abstracted from various locations and sources throughout the MRC. These included:

– 42 functional abstraction points in Serengeti sub-basin (627 m^3/day)

– 32 functional abstraction points in Tobora sub-basin (900 m^3/day)

– 21 functional abstraction points in Somoche sub-basin (437 m^3/day)

– 56 functional abstraction points in Mara Mines sub-basin (2,763 m^3/day)

– 44 functional abstraction points in Tigithe sub-basin (2,210 m^3/day)

– 113 functional abstraction points in Mara Wetland sub-basin (4,344 m^3/day)

The source of water also varied across the MRC (Figure 4-2). Water sources and abstraction amounts included:

– 234 abstractions from boreholes, shallow wells, or springs (3,522 m^3/day)

– 38 abstractions from a river or stream (993 m^3/day)

– 35 abstractions from dams and/or water pans (6,765 m^3/day)

– 1 abstraction from rainwater harvesting (2 m^3/day)

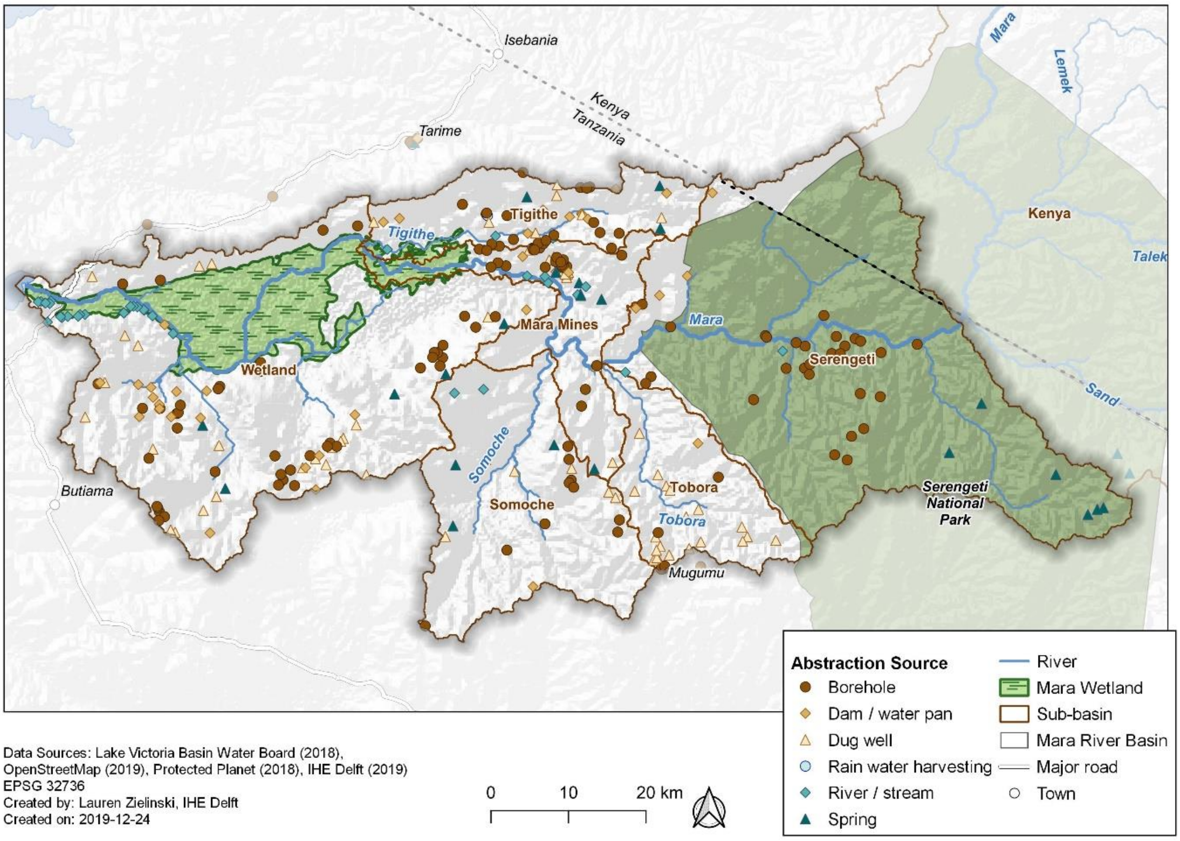

Figure 4-2: Water abstractions in the Lower MRC by source

The primary water use for the abstractions varied (Figure 4-3), and included:

– 170 abstractions for domestic or public supply (4,235 m^3/day)

– 41 abstractions for hotels (179 m^3/day)

– 33 abstractions for mining (2,404 m^3/day)

– 32 abstractions for livestock (3,623 m^3/day)

– 30 abstractions for irrigation (823 m^3/day)
– 2 abstractions for other uses (17 m^3/day)

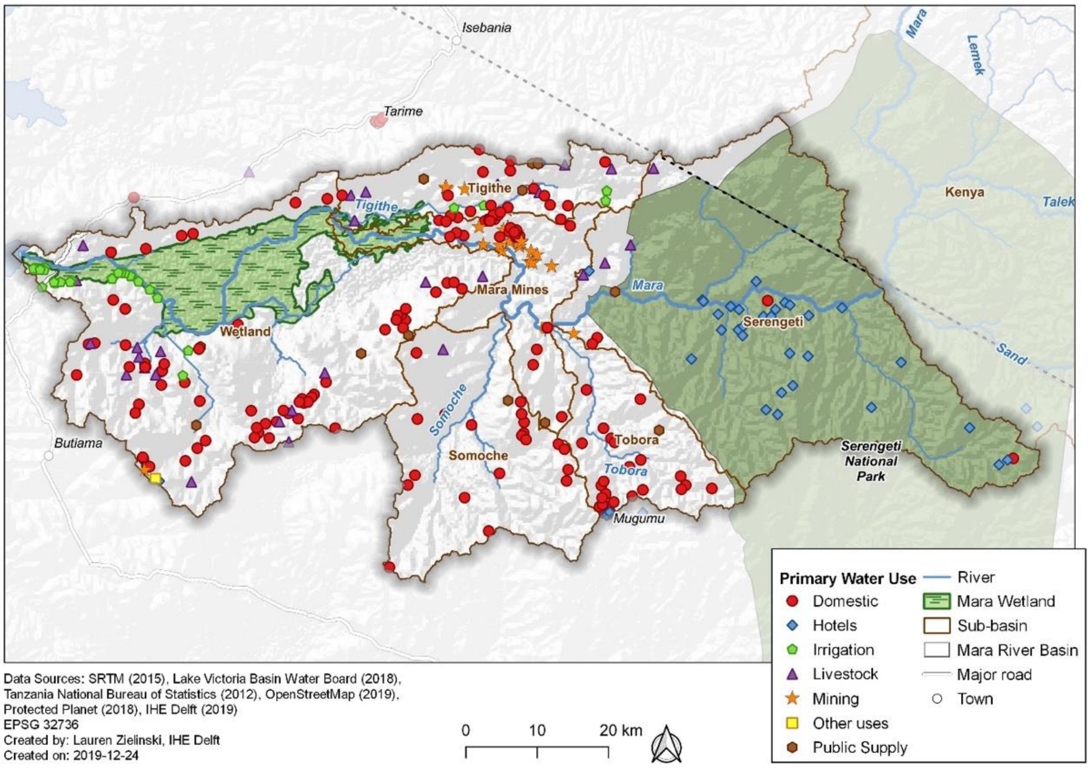

Figure 4-3: Water abstractions in the Lower MRC by primary water use

4.5 WATER DEMAND ASSESSMENT

4.5.1 METHODOLOGY

The water demand assessment analysed and estimated the current and future water demands over the entire catchment of the Lower MRC. The water demand assessment methodology was based on the draft Water Allocation Planning Guidelines for Tanzania. The targeted water demanding entities entailed human and economic activities in Tanzania for the next 5, 10, and 20 years (2023, 2028, and 2038, respectively). Demand was estimated for domestic use, livestock, irrigation, tourism, wildlife and mining, following the methodology in the draft WAP guidelines. Since there are no major industrial or commercial water users in the catchment, they were excluded from the assessment. To the greatest extent possible, the most local and most recent information available was used to estimate demand, including census data, livestock surveys, wildlife information, data from the abstraction survey, Ministry design manuals, feasibility studies and personal communication with members of local and national government agencies. The demands for each use were estimated for each of the six sub-basins in the Lower MRC for wet and dry conditions. An additional 20% was added to all sectors except for wildlife to account for losses through leakage and wastage as recommended in the draft guidelines.

4.5.2 RESULTS

For domestic water demand, a growth rate between 2 and 3.5 percent was used to calculate the increase in population for 5, 10 and 20 years. Using 30 liters/person/day, taken as the additional water requirement on top of the 25 liters/person/day water allocated for basic human needs in the reserve, water demand was estimated to be 12,018 m^3/day in 2018 and increasing to 20,870 m^3/day in 2038.

Livestock demand has been calculated using a 25 percent increase every 10 years, providing an estimated demand of 13,066 m^3/day in 2018 and 19,599 m^3/day in 2038.

There are few small-scale irrigators in the Lower MRC and two major irrigation schemes are planned for development and expansion: the Mara Valley Project and Nyamitita Irrigation Scheme. Estimates of maximum future daily water demand are 715 m^3/day in 2018 and 1,107 m^3/day in 2038 for small-scale irrigators, and 503,778 m^3/day for irrigation schemes.

The average daily water demand over the year for resident and migrating wildlife populations is estimated to be 6,744 m^3/day, but varies between 3,676 m^3/day and 11,039 m^3/day depending on the movement of the migrating wildlife.

Tourism is estimated to grow 7.24 percent annually, with an annual average daily water demand of 67 m3/day in 2018 and 272 m^3/day in 2038. Demand varies by month as it is closely linked with the great migration in the Serengeti ecosystem.

While the North Mara Gold Mine is not expected to use additional water in the future, artisanal mining is growing quickly. The water demand for mining is estimated to be 2,885 m^3/day in 2018 and grow up to 4,036 m^3/day in 2038.

Current and future water demand has been estimated for the districts in the project area as well as six sub-basin. Projections of total water demand among all users in the Tanzanian Mara River Catchment increase from 33,575 m^3/day in 2018 to 43,848 m^3/day, 142,486 m^3/day, and 554,340 m^3/day in 2023, 2028, and 2038, respectively. The current largest demand in the catchment is livestock, accounting for 39 percent of total demand, while the largest water demand in the catchment in 2038 is projected to be irrigation, accounting for 91 percent of total water demand.

4.5.2.1 Domestic Use

To calculate the per person water demand for domestic use, two categories of water use were considered: basic human needs (water needed for basic domestic activities, such as drinking, cooking, bathing, and washing) and additional domestic demand (anything that expected to be used above this value). Combining both of these amounts equals the total domestic demand.

Domestic demand = Basic human needs + Additional domestic demand

According to Chapter 4 of the Design Manual for Water Supply and Waste Water Disposal published by the Ministry of Water and Irrigation in the United Republic of Tanzania (MoWI, 2009), domestic demand is based on, if the area is rural or urban, the type of payment structure, and the consumer category (income level and type of access to domestic water, Table 4-3).

Table 4-3: Domestic water requirements (from MoWI, 2009)

Consumer Category	Rural Areas (liters/person/day)			Urban Areas (liters/person/day)			Remarks
	FR	M-UT	M-PBT	FR	M-UT	M-PBT	
Low income using kiosks or public taps	25	25	25	25	25	25	Most squatter areas, to be taken as the minimum
Low income multiple household with yard tap	50	45	40	50	45	40	Low income group housing, no inside installation and pit latrine
Low income, single household with yard tap	70	60	50	70	60	50	Low income group housing, no inside installation and pit latrine
Medium income household				130	110	90	Medium income group housing, with sewer or septic tank

Table 4-3: Domestic water requirements (from MoWI, 2009)

Consumer Category	Rural Areas (liters/person/day)			Urban Areas (liters/person/day)			Remarks
	FR	M-UT	M-PBT	FR	M-UT	M-PBT	
High income household				250	200	150	High income group housing, with sewer or septic tank

FR = flat rate; M-UT = metered with uniform tariff; M-PBT = metered with progressive block tariff

Currently, the study area is primary rural villages with access to water directly from surface water sources (rivers, streams, natural springs, etc.) or hand pumps with access to shallow groundwater, often for no charge or for a small fee from a village organization or authority. This definition fits the first consumer category (low income using kiosks or public taps) with a flat rate. The demand for this category is 25 liters/person/day.

The minimum value for any consumer category in Table 4-3 is 25 liters/person/day, which meets this international standard. It is also the recommended value from the draft Water Allocation Planning Guidelines for Tanzania. For these reasons, this value will be used as the basic human need requirement in the domestic demand equation above. Taking the full domestic demand of 50 liters/person/day and subtracting the basic human needs of 25 liters/person/day means that the additional domestic demand is 25 liters/person/day.

Domestic demand = Basic human needs + Additional domestic demand
50 liters/person/day = 25 liters/person/day + 25 liters/person/day
(Reserve assessment) (Demand assessment)

Only the additional domestic demand of 25 liters/person/day will be used in this analysis. An additional 20 percent was added to this value following the draft WAP guidelines for an additional domestic demand of 30 liters/person/day or 0.03 m^3/person/day.

To estimate domestic demand in the Lower MRC, the population of the study area was multiplied by the additional domestic demand of 30 liters/person/day. For population information, data from the 2012 Population Census was used (NBS, 2012).

A growth rate for each district was provided by the 2012 Census: 2.0 percent for Rorya District, 2.2 percent for Butiama and Tarime District, and 3.5 percent for Serengeti District. These growth rates were applied to the population in each district, calculating the estimated population for the WAP planning years (2018, 2023, 2028, and 2038). These values were then multiplied by 30 liters/person/day to calculate the additional domestic demand by sub-basin (Table 4-4 and Table 4-5). The current demand for domestic use is estimated to be around 12,000 m^3/day and increasing to almost 21,000 m^3/day at the outlet in the Mara Wetland.

Table 4-4: Projected domestic population in the Lower MRC by sub-basin

Sub-basin	2012	2018	2023	2028	2038
Serengeti	42,596	50,356	57,958	66,772	88,892
Tobora	25,566	31,428	37,324	44,330	62,534
Somoche	48,061	59,080	70,167	83,339	117,557
Mara Mines	47,813	55,661	63,231	71,894	93,185
Tigithe	60,453	68,887	76,805	85,632	106,449
Wetland	116,032	135,177	153,672	174,861	227,062
Grand Total	***340,521***	***400,589***	***459,157***	***526,828***	***695,679***

Source: NBS 2012

Table 4-5: Projected water demand for additional domestic use by sub-basin (m^3/day)

Sub-basin	2018	2023	2028	2038
Serengeti	1,511	1,739	2,003	2,667
Tobora	943	1,120	1,330	1,876
Somoche	1,772	2,105	2,500	3,527
Mara Mines*	5,896	6,860	7,990	10,865
Tigithe	2,067	2,304	2,569	3,193
Wetland*	12,018	13,775	15,805	20,870

4.5.2.2 Livestock

Livestock is an important economic and social activity in the Lower MRC and also an important water user. Many villages and wards conduct a livestock census of the cattle, goats, sheep, donkeys, and pigs that are owned by the residents either annually or every few years. To estimate the current population and water demand for livestock, the most recent livestock census data were collected from the district offices.

The livestock census data for the villages and wards ranged from 2015 to 2018. To standardize the analysis, all data were assumed to be from 2018. These data were analysed to provide an estimate of livestock population in each sub-basin within the Lower MRC (Table 4-6).

Table 4-6: Current livestock population by sub-basin

Livestock unit	*1*	*5*	*5*	*2*	*1*	
Sub-basin	**Cattle**	**Goats**	**Sheep**	**Donkeys**	**Pigs**	**Total**
Serengeti	34,571	4,191	2,530	299	40	41,631
Tobora	18,982	1,523	1,919	142	16	22,582
Somoche	60,907	4,600	5,052	505	161	71,225
Mara Mines	43,238	5,793	3,631	277	229	53,168
Tigithe	54,486	6,228	3,550	313	80	64,657
Wetland	160,368	10,283	10,442	1,103	84	182,280
Total	**372,552**	**32,618**	**27,124**	**2,638**	**610**	**435,542**

To estimate water demand from the livestock in the Lower MRC, values from the Design Manual for Water Supply and Waste Water Disposal were used (MoW, 2009). In the design manual, livestock water demand is calculated in livestock units (LUs). For the livestock considered in this study, 1 indigenous cow equals 1 LU (high grade dairy cows equal 2 or 3 LUs each, but it is assumed that all cows in the Lower MRC are indigenous cows), 5 goats or sheep equal 1 LU, 2 donkeys equal 1 LU, and 1 pig equals 1 LU. The number of livestock units in the Lower MRC can be found in Table 2-5.

The Design Manual for Water Supply and Waste Water Disposal recommends using a value of 25 liters/LU/day (0.025 m^3/LU/day) to estimate livestock water demand (MoW, 2009). An additional 20 percent was added to this value per the draft WAP guidelines for a daily demand value of 30 liters/LU/day or 0.03 m^3/LU/day. The current water demand was found to be 13,066 m^3/day at the outlet in the Mara Wetland (Table 4-7)

To estimate the water demand in the future, a growth rate of 25 percent in 10 years and 50 percent in 20 years was used for all livestock types (MoW, 2009). For 5-years, a growth rate of 12.5 percent was used. The current water demand is projected to increase to 19,600 m^3/day by 2038 at the outlet in the Mara Wetland (Table 4-7).

It is assumed that livestock will have the same water demand year-round, including wet and dry conditions.

Table 4-7: Projected water demand from livestock by sub-basin (m^3/day)

Sub-basin	2018	2023	2028	2038
Serengeti	1249	1,405	1,561	1,873
Tobora	677	677	847	1,016
Somoche	2,137	2,137	2,671	3,205
Mara Mines*	5,658	5,814	7,073	8,487
Tigithe	1,940	1,940	2,425	2,910
Wetland*	13,066	13,222	16,333	19,599

**cumulative sub-basin*

4.5.2.3 Irrigation

While there are many smallholder farms in the catchment, most rely on rainfall for their primary water source and plant their crops on a schedule related to annual rainfall patterns. However, there are some farmers that utilize small-scale irrigation, removing water directly from the river or wetland using petrol pumps. There are two types of irrigated agriculture present in the Lower MRC: small-scale and large-scale irrigation. From the 2018 abstraction survey, current water demand for small-scale irrigation was found to vary throughout the year, with the lowest demand of 340 m^3/day in February and the highest demand of 990 m^3/day in September, and an average annual demand of 596 m^3/day. During the abstraction survey, the agricultural water demand was determined in consultation with the farmers. They provided information on the type of crop, what months they water, and the size of their irrigated land. All of this information went into the estimation of the amount of water abstracted for each location.

There are no data or formal plans estimating the growth rate for small-scale irrigation, so the current demand was taken as a baseline for 2018 and growth was assumed to be the same as the growth in overall population. The projected water demand from small-scale irrigation was estimated to be 755 m^3/day in 2018 increasing to 940 m^3/day in 2038 in dry condition (Table 4-8). There was no irrigation found in Rorya District or Serengeti sub-basin, and this condition is expected to continue in the future.

Table 4-8: Projected water demand from small-scale irrigation by sub-basin (m^3/day)

Sub-basin	2018		2023		2028		2038	
	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry
Serengeti	0	0	0	0	0	0	0	0
Tobora	0	0	0	0	0	0	0	0
Somoche	0	6	0	7	0	9	0	12
Mara Mines*	12	0	15	0	17	0	24	0
Tigithe	12	45	13	51	15	56	18	70
Wetland*	597	755	665	842	742	940	922	1,169

**cumulative sub-basin*

Two large-scale irrigation schemes are planned in the Lower MRC: the Mara Valley Water Resources Development Project (Mara Valley Project) and the Nyamitita Irrigation Scheme. Information about the demand of the Mara Valley Project was taken from the consultant's design report from February 2018 (NBI, 2018), while information about the demand of the Nyamitita Irrigation Scheme came from the Zonal Irrigation Office in Mwanza.

The Mara Valley Project plans to develop 8,340 hectares of land, including 6,903 hectares of smallholder farming and commercial farming in three distinct areas referred to as Command Areas. Commercial farming will cultivate rice exclusively, while small-holder farming will be a mixture of rice, maize, and pulses. Two annual crops are expected in both commercial and small-holder operations. The project will be located along the southern margin of Mara Wetland. Water for the system will come from the planned Borenga Dam and reservoir, which is located in the Mara Mines sub-basin.

Once completed the Mara Valley Project is expected to have an annual average water demand of 497,088 m^3/day (72.01 m^3/day/hectare), with a maximum demand of 849,312 m^3/day (123.04 m^3/day/hectare) in August and a minimum demand of 107,309 m^3/day (15.55 m^3/day/hectare) in April.

Based on the planned construction and implementation schedule for the Mara Valley Project, regular irrigated agricultural production is not expected until 8 years into the project, when Command Area 1 (covering 1,314 hectares) is expected to begin. Assuming that the construction of Borenga Dam and the Mara Valley Project begins within the next 2 years, the demand for Command Area 1 is projected to appear by 2028. The remainder of the project demand is projected to appear by 2038. Limited information is available about the Nymatita Irrigation Scheme, but the demand is projected to be between 1,444 m^3/day and 11,430 m^3/day per month. It is expected to appear by 2023 and remain unchanged over the projection period (Table 4-9).

Table 4-9: Projected water demand from large-scale irrigation by sub-basin (m^3/day)

Sub-basin	2018		2023		2028		2038	
	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry
Serengeti	0	0	0	0	0	0	0	0
Tobora	0	0	0	0	0	0	0	0
Somoche	0	0	4,844	7,613	4,844	7,613	4,844	7,613
Mara Mines*	0	0	5,057	7,506	76,637	113,757	380,810	565,261
Tigithe	0	0	0	0	0	0	0	0
Wetland*	0	0	4,275	7,495	64,783	113,584	321,910	564,400

**cumulative sub-basin*

Water demand from all irrigation types for the next 5, 10, and 20 years is expected to reach a total demand of 322,832 m^3/day in wet conditions and 565,570 m^3/day in dry conditions by 2038 (Table 4-10). Note that the wet and dry months are different for each sub-basin, so the wet and dry averages were calculated for each sub-basin individually and do not sum together.

Table 4-10: Projected water demand from total irrigation by sub-basin (m^3/day)

Sub-basin	2018		2023		2028		2038	
	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry
Serengeti	0	0	0	0	0	0	0	0
Tobora	0	0	0	0	0	0	0	0
Somoche	0	6	4,844	7,620	4,844	7,621	4,844	7,625

Table 4-10: Projected water demand from total irrigation by sub-basin (m^3/day)

Sub-basin	2018		2023		2028		2038	
	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry
Mara Mines*	12	0	5,071	7,506	76,654	113,757	380,835	565,261
Tigithe	12	45	13	51	15	56	18	70
Wetland*	597	755	4,940	8,337	65,525	114,523	322,832	565,570

cumulative sub-basin

4.5.2.4 Tourism

Since the number of tourists and available hotel beds fluctuate with the migration, the demand for water from hotels will vary by month. While the exact number of beds available in the mobile camps is not available, it was assumed that when the mobile camps leave the Lower MRC during the low season, the number of available beds would be half of the total capacity (50% availability of beds). The current average daily water demand was estimated by month using 95 m^3/day as the demand for the high season (100% availability of beds, assuming all of those beds are filled) and 47 m^3/day as the demand for the low season (50% availability of beds, assuming all of those beds are filled). Using the growth rate of 7.24%, this method was then applied to find the average water demand for wet and dry conditions across the year for 2023, 2028, and 2038 (Table 4-11). Note that the wet and dry months are different for each sub-basin, so the wet and dry averages were calculated for each sub-basin individually and do not sum together.

Table 4-11: Projected water demand from tourism by sub-basin (m^3/day)

Sub-basin	2018		2023		2028		2038	
	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry
Serengeti	49	58	69	83	98	117	197	236
Tobora	5	7	6	11	9	15	19	30
Somoche	0	0	0	0	0	0	0	0
Mara Mines*	54	65	77	93	109	131	220	264
Tigithe	2	3	3	4	4	6	7	12
Wetland*	47	74	67	105	95	148	192	298

cumulative sub-basin

4.5.2.5 Wildlife

It is estimated that 1,300,000 wildebeest, 200,000 zebras, 350,000 gazelles, and 12,000 elands cross the Mara River each year between June and November (Hopcraft, 2010; Tanzania Tourism Board, 2012; Subalusky *et al.*, 2017). The wildebeest populations have been relatively constant since the 1970s, with around 1.3 million wildebeest within the migration (Mduma, Sinclair and Hilborn, 1999; Hopcraft, 2010). Due to this stability, it is assumed that population numbers will remain constant in the future. Each species in the migration has a different daily water demand, with wildebeest requiring 9 liters/day/animal, zebras requiring 12 liters/day/animal, gazelles requiring 1 liter/day/animal, and elands requiring 23 liters/day/animal (Toit, 2002; UNEP, 2002). The total daily water demand from the migrating populations was found to be 14,726 m^3/day. The additional 20 percent recommended by the draft WAP guidelines to account for losses for leakage and wastage was not applied to wildlife there is no infrastructure associated with this demand type. There is little available data on the populations of animals that live in the Lower MRC year-round. There are population numbers for the entire SENAPA for specific species from the Tanzanian Wildlife Research

Institute. To maintain conservative estimates, it was assumed that all populations provided were resident populations of the Lower MRC. The values for both migration and resident populations were combined to get a total water demand of 18,402 m^3/day (Table 4-12).

Table 4-12: Daily water demand for wildlife (m^3/day)

Animal Species	Daily water demand (m^3/day/animal)	Est. Population	Total Water Demand (m^3/day)
Wildebeest	0.009	1,300,000	11,700
Burchell's zebra	0.012	200,000	2,400
Thompson's gazelle	0.001	350,000	350
Eland	0.023	12,000	276
Migration Total	*0.045*	*1,862,000*	*14,726*
Buffalo	0.031	61,896	1,919
Elephant	0.150	7,535	1,130
Giraffe	0.040	5,246	210
Impala	0.0025	72,159	180
Hartebeest	0.055	7,204	40
Waterbuck	0.009	1,085	10
Warthog	0.0035	3,370	12
Topi	0.005	35,044	175
Resident Wildlife Total	*0.031*	*199,723*	*3,676*
Wildlife Total			***18,402***

Source: (Toit, 2002; UNEP, 2002; Hoffman, 2007; Hopcraft, 2010; Tanzania Tourism Board, 2012, TAWIRI pesonal communication)

It was estimated that only 50 percent of the wildlife population would be in the MRC at one time, during the months of the migration (July to November). Averages for the wet and dry conditions are presented in Table 4-13.

Table 4-13: Projected water demand from wildlife by sub-basin (m^3/day)

Sub-basin	2018		2023		2028		2038	
	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry
Serengeti	5,516	7,357	5,516	7,357	5,516	7,357	5,516	7,357
Tobora	0	0	0	0	0	0	0	0
Somoche	0	0	0	0	0	0	0	0
Mara Mines*	5,516	7,357	5,516	7,357	5,516	7,357	5,516	7,357
Tigithe	0	0	0	0	0	0	0	0
Wetland*	5,516	7,357	5,516	7,357	5,516	7,357	5,516	7,357

cumulative sub-basin

4.5.2.6 Mining

The total amount of water used from artisanal mining was found to be 125 m^3/day in 2018 (LVBWB, 2018), including the additional 20% for losses and leakage. For the North Mara Gold mine, the amount of water used (including the 20%) was estimated to be 2,760 m^3/day, although this value may fluctuate on a daily basis (Table 4-14). This value is expected to be the same for both wet and dry conditions.

Table 4-14: Projected water demand for both artisanal and large-scale mining by sub-basin (m^3/day)

Sub-basin	Artisanal				Large-Scale			
	2018	2023	2028	2038	2018	2023	2028	2038
Serengeti	12	21	38	122	0	0	0	0
Tobora	0	0	0	0	0	0	0	0
Somoche	0	0	0	0	0	0	0	0
Mara Mines*	96	171	305	972	2,760	2,760	2,760	2,760
Tigithe	18	32	57	182	0	0	0	0
Wetland*	125	224	400	1,276	2,760	2,760	2,760	2,760

**cumulative sub-basin*

4.5.2.7 Hydropower

The relatively gentle and undulating topography of the Mara Catchment is not optimal for large reservoirs and hydropower projects. There is, however, a plan for a small (3 MW) hydropower plant in association with Borenga Dam. Hydropower generation is scheduled to begin in the 9th year of the dam development project, which suggests it would not begin within the next 10 years, given there are no fixed plans to begin the construction project.

The main purpose of Borenga Dam is to supply water to the Mara Valley agricultural project, as described in Section 4.5.2.3. Hydropower production is second priority and the plant design is to make maximal use of water entering the reservoir in excess of irrigation demands. Based on hydrological analyses considering no upstream water use, the design discharge for the turbines is 25 m^3/s, with the potential of operating to a minimum discharge of 4 m^3/s. The average total estimated water use for hydropower is 1,563,110 m^3/d, which corresponds to the total water estimated to be available within the operating parameters of the hydropower turbines. This estimated water use amounts to approximately 50% of the total annual average water availability in the Mara Catchment (including inputs from Kenya) and close to 100% of available water during dry seasons.

Given that the strategy of hydropower development is to make maximal use of available water, it is not included as a specific demand to be set aside in this water allocation plan. If and when the Borenga Dam project is confirmed and initiated, the developers will need to reconsider the design of the hydropower component in light of this water allocation plan and in consultation with the Lake Victoria Basin Water Board.

5 Future Scenarios and Understanding Uncertainties

Effective water planning requires an understanding of current water demands and supplies, as well as recognition of the uncertainties around both in the future. For example on the supply side, climate change can affect both the wet and dry seasons, the frequency and duration of extreme events, and the water requirements with higher temperatures. On the demand side, there can be demographic, economic and political shifts that can be quite unpredictable. The challenge is to find the best path forward with the current knowledge at hand, obtain data that are crucial to know better going forward, and take actions – both in the form of policy and infrastructure development – that ensure the highest level of water security that is equitable and sustainable.

When two countries are involved, there are additional uncertainties that need to be factored in, as political commitments under a current administration may not be upheld by later administrations. It is important, as a responsible government, to understand the implications of political changes, as well as climatic and demographic. In this context, various types of upstream development in Kenya are considered in order for Tanzania to be as resilient as possible across the full range of deep uncertainties looking into the future.

The water balances in Section 6 assume historical hydrology, which is known from science is not be the case going forward. The signal from climate change relative to existing variability is likely not clear in the next 5 years, so the scenario analysis focused on the next 10 to 20 years and beyond.

Focusing on the critical uncertainty centered around climate change, there were 20 climate projections selected for evaluation (Figure 5-1). The change in temperature and precipitation are shown averaged over the catchment in 2028 and 2038 below relative to the historical, which is the dark blue dot at 19°C and approximately 1000 mm of annual precipitation. There is a clear shift both at 10 and 20 years into the future in increased temperatures. There is more scatter in the precipitation, with some drier projections, but the majority show wetter average annual precipitation. Seasonally, there is an emerging pattern of wetter wet seasons across virtually all climate projections, and to some extent drier dry seasons, as shown in Figure 5-2 (the historical average is shown as a black line).

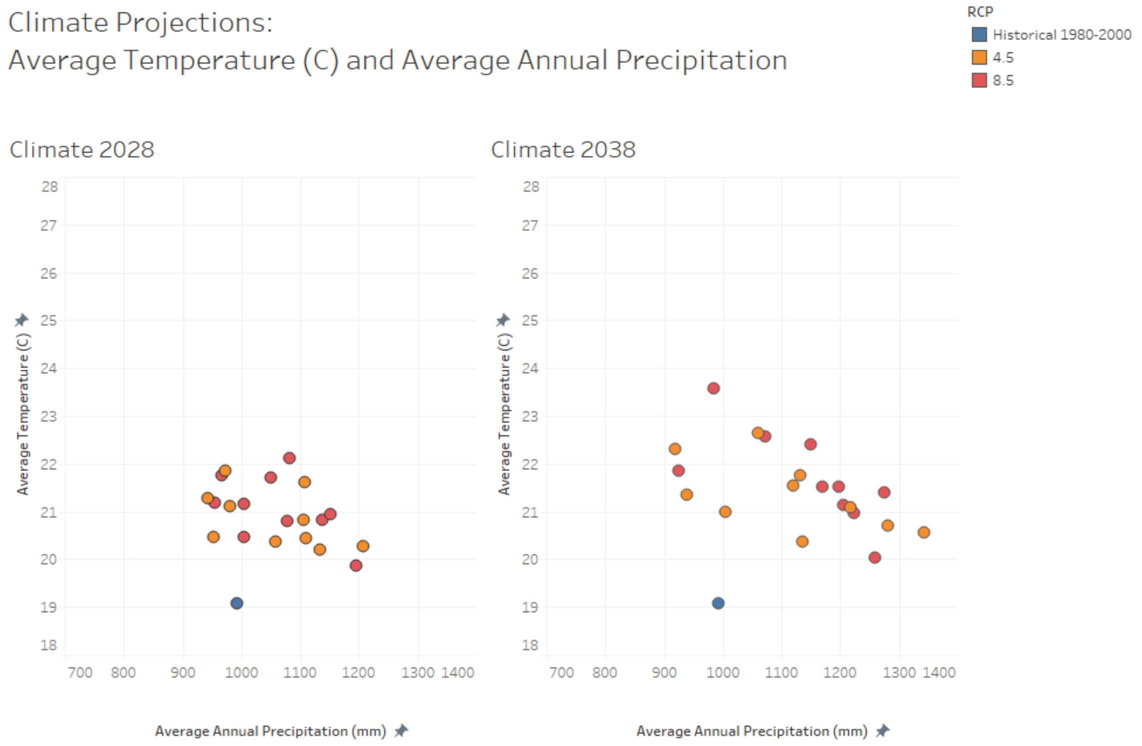

Figure 5-1: Climate projections for average temperature and average annual precipitation for 2028 and 2038

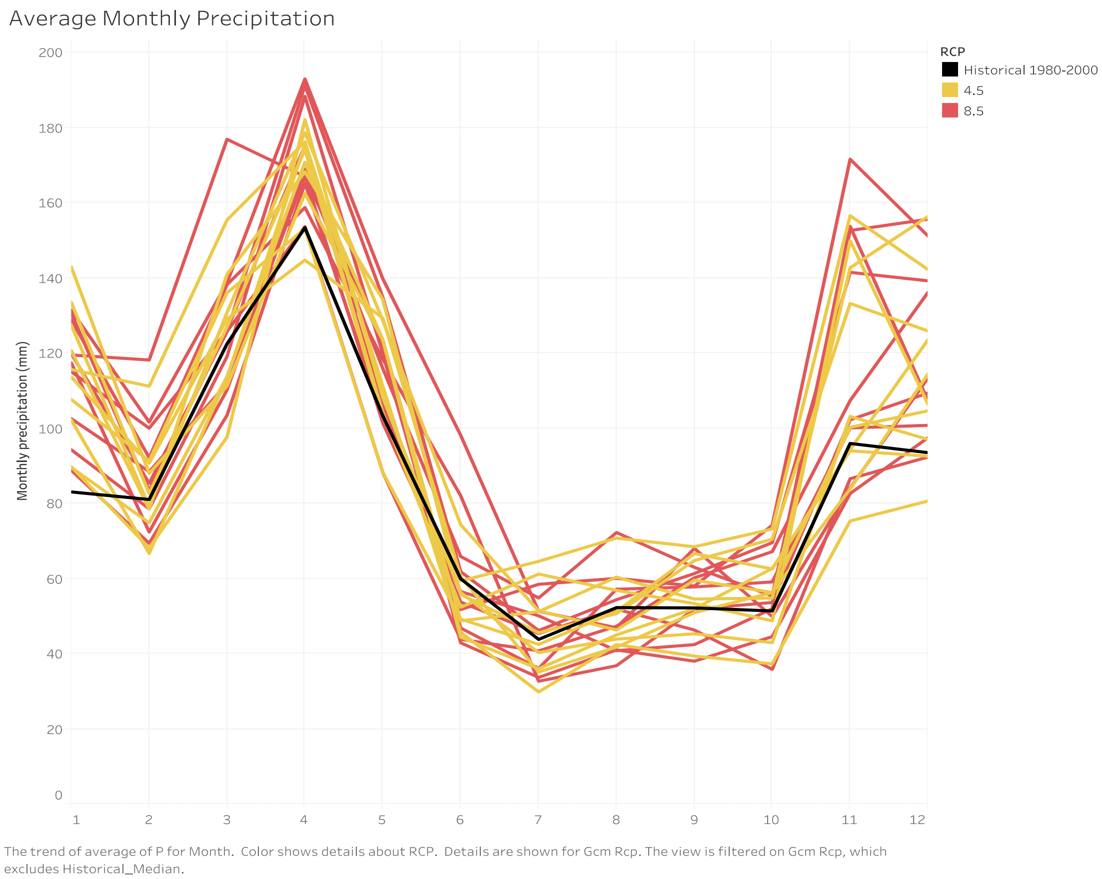

Figure 5-2: Climate projections for average monthly precipitation

Three scenarios emerged based on the inputs from stakeholders during the course of the workshops, with each scenario run with each of the 20 climate projections. All three x 20 scenarios assume the growth in demands as estimated in Section 4.5. The first scenario, referred to as Baseline, or Business As Usual, assumes implementation of expanded irrigation and a continued lack of enforcement around the reserve. The second scenario assumes the reserve flows are enforced. The third scenario is identical and includes upstream development in Kenya with enforcement of the reserve in both Kenya and Tanzania. More specifically, in 2025 agricultural expansion in Kenya in the model includes 1600 hectares of agriculture (average demand of 850 m^3/ha) taking water from the Nyangores River and 2170 ha of agriculture (average demand of 6258 m^3/ha) and an inter basin transfer of 2.6 m^3/s both taking water from the Amala River. It is assumed that with new upstream development in Kenya, Kenya will also enforce the reserve so that demands will not abstract water from the river when it is in the reserve.

These are summarized in the table below. All scenarios were simulated from 2020 to 2050.

Table 5-1: Future scenarios evaluated for the WAP

Baseline/Business as Usual	TZ Reserve Enforced	Upstream Development
Socio economic growth + Expanded irrigation in TZ	Baseline + Reserve Enforced in TZ	Baseline + Expanded Agriculture in KE + Reserve Enforced in KE + Reserve Enforced in TZ
20 climate Projections		

5.1 OUTCOMES FROM SCENARIOS AND EXAMINING UNCERTAINTIES

There are two distinct forms of uncertainty that Tanzania faces in planning for the Mara that are critical to address, but also to distinguish. The first form of uncertainty lies around inadequacy of data – this is something within the ability of the Lake Victoria Basin Water Board to address. The second form of uncertainty (deep uncertainty) lies around factors that Tanzania has little to virtually no control over – such as climate change, sudden political or ecological shifts, and decisions about upstream developments, diversions or dams.

Regarding data, perhaps the most critically missing point of reference is any stream gage data in any of the three tributaries which are Tobora, Somoche and Tigithe. It is not feasible to plausibly model the tributaries with any degree of confidence without these data. It is likely, given that most of the water withdrawals in the catchment are currently from within these tributaries, that the scenarios analysis done may be underestimating shortfalls. But it is impossible to know without better data.

With respect to deep uncertainty, as modeled in the Water Evaluation And Planning (WEAP) model around upstream developments and climate change, there are strategies that Tanzania can take to become more water secure. There are two fundamental actions – one policy and one more founded in infrastructure. One the policy side, establishing and enforcing the reserve is critical for ecosystems and humans. For infrastructure, storage is key, as long as the withdrawals are taken when the Mara River is not in the reserve.

Annual and monthly average flows in the Mara River at the border are presented for the three scenarios for the historical climate (1970-2005) in Figure 5-3. These results indicate the extent to which flows at the border could be expected to decrease as a result of upstream developments in Kenya. For this particular example, the average decrease in flow is roughly 50 million cubic meters per year, which equates to about a 10 percent reduction of flows as compared to scenarios without any additional upstream development. Figure 5-3 shows the results for one climate sequence, but across all climate projections, a reduction in flows is seen in scenarios with upstream development in Kenya, and monthly average flow decreases are notable particularly after April.

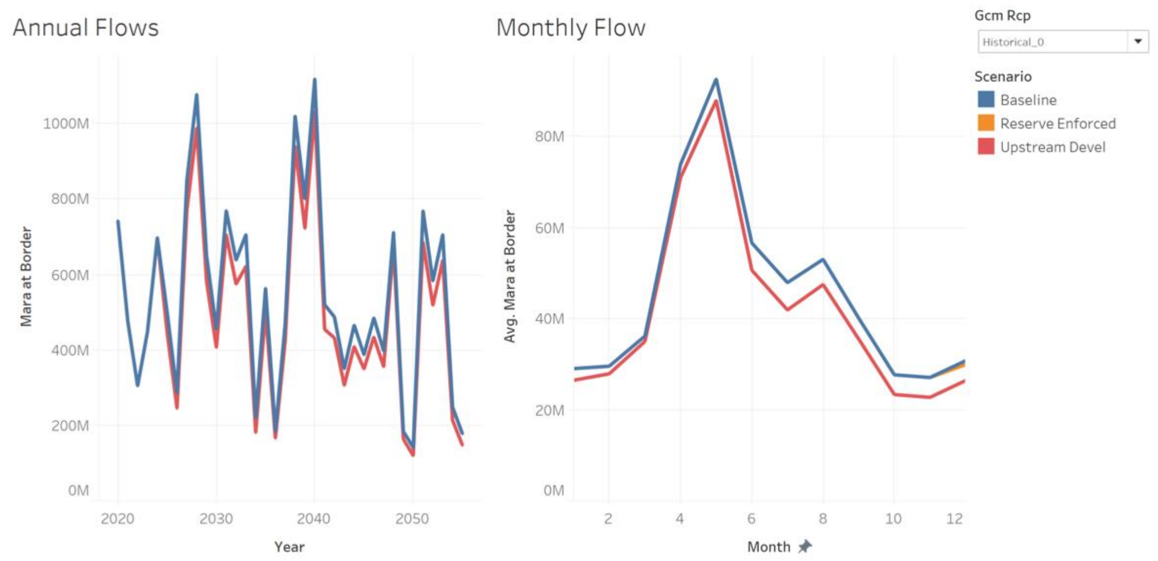

Figure 5-3. Mara River flows at the Border of Kenya and Tanzania

Figure 5-4 presents a vulnerability map for the reserve, which compares the percentage of years that experience 3 or more consecutive months during which the river is in the reserve, across all scenarios at the three key locations on the Mara River (each column represents one scenario, for each of the three key locations on the Mara River: Kogatende, Mara Mines and Bisarwi) across all climate projections (each row represents one projection). The map on the top shows the percentage of years within the period 2020-2030 that experience three or more consecutive months during which the river is in the reserve at those three locations and the bottom map shows this for thirty years out, 2041-2050. The greater the percentage of years that the river is in an extended reserve condition, the more red the cell is. Within each map, considerable variability across climate projections is evident (range of results within one column, across all rows). Comparing the maps from top, to bottom, as a period farther into the future is considered, indicates that almost all climate scenarios increase the percentage of years that will see at least three consecutive months in the reserve, overtime. This is to say that it is likely that overtime, due to climate change and increasing demands on water resources, the river will spend more time in reserve condition, when abstractions are limited to basic human needs.

Upstream development in Kenya would further increase the likelihood of long periods where the river is in reserve conditions. On the other hand, enforcing the reserve does not have a noticeable effect on decreasing periods where the river is in the reserve, nor does pursuing the expansion of irrigation. Enforcing the reserve does not generally affect the ability to meet demands due to the fact that during these times, the demands are quite small relative to the volumes of water required to keep river levels above the reserve.

Num.Fail Months: 3

Time Segments
- [x] 2020-2025
- [x] 2026-2030
- [ ] 2031-2040
- [ ] 2041-2050

0.000 1.000

	Kogatende			Mara Mines			Bisarwi		
	Baseline	Reserve Enforced	Upstream Devel	Baseline	Reserve Enforced	Upstream Devel	Baseline	Reserve Enforced	Upstream Devel
BCC-CSM1-1_4.5	9%	9%	18%	18%	18%	27%	9%	9%	18%
BCC-CSM1-1_8.5	9%	9%	18%	18%	18%	18%	9%	9%	18%
CanESM2_4.5	27%	27%	27%	27%	27%	27%	18%	18%	27%
CanESM2_8.5	9%	9%	9%	9%	9%	18%	9%	9%	9%
CNRM-CM5_4.5	45%	45%	45%	73%	64%	73%	36%	36%	45%
CNRM-CM5_8.5	27%	27%	27%	27%	27%	27%	27%	27%	27%
CSIRO-MK3-6-0_4.5	36%	36%	45%	45%	45%	45%	45%	45%	45%
CSIRO-MK3-6-0_8.5	27%	27%	27%	45%	45%	55%	36%	27%	36%
GISS-E2-H_4.5	45%	45%	55%	55%	55%	64%	45%	45%	55%
GISS-E2-H_8.5	64%	64%	73%	82%	82%	91%	55%	55%	64%
HadGEM2-ES_4.5	55%	55%	55%	73%	73%	82%	64%	55%	64%
HadGEM2-ES_8.5	27%	27%	36%	45%	45%	45%	27%	27%	36%
Historical_0	45%	45%	36%	45%	45%	45%	27%	27%	27%
MIROC-ESM_4.5	0%	0%	0%	0%	0%	9%	0%	0%	0%
MPI-ESM-LR_4.5	9%	9%	9%	9%	9%	9%	0%	0%	0%
MPI-ESM-LR_8.5	27%	27%	27%	27%	27%	27%	18%	18%	27%
MRI-CGCM3_4.5	36%	36%	36%	36%	36%	36%	36%	36%	36%
MRI-CGCM3_8.5	36%	36%	45%	55%	55%	55%	45%	45%	45%
NorESM1-M_4.5	45%	45%	45%	45%	45%	64%	45%	45%	45%
NorESM1-M_8.5	27%	27%	45%	64%	64%	73%	27%	27%	45%

Num.Fail Months: 3

Time Segments: 2020-2025 ☐ | 2026-2030 ☐ | 2031-2040 ☐ | 2041-2050 ☑

0.000 – 1.000

	Kogatende			Mara Mines			Bisarwi		
	Baseline	Reserve Enforced	Upstream Devel	Baseline	Reserve Enforced	Upstream Devel	Baseline	Reserve Enforced	Upstream Devel
BCC-CSM1-1_4.5	44%	44%	50%	69%	69%	69%	38%	31%	44%
BCC-CSM1-1_8.5	50%	50%	50%	56%	50%	56%	50%	44%	56%
CanESM2_4.5	6%	6%	19%	19%	19%	19%	6%	6%	6%
CanESM2_8.5	6%	6%	6%	6%	6%	6%	6%	6%	6%
CNRM-CM5_4.5	6%	6%	6%	13%	13%	13%	13%	6%	13%
CNRM-CM5_8.5	44%	44%	44%	44%	44%	50%	38%	38%	38%
CSIRO-MK3-6-0_4.5	31%	31%	50%	63%	63%	75%	19%	19%	31%
CSIRO-MK3-6-0_8.5	38%	38%	50%	50%	50%	63%	31%	31%	38%
GISS-E2-H_4.5	81%	81%	81%	81%	81%	94%	63%	63%	69%
GISS-E2-H_8.5	75%	75%	75%	75%	75%	81%	75%	75%	75%
HadGEM2-ES_4.5	69%	69%	69%	75%	75%	75%	38%	38%	50%
HadGEM2-ES_8.5	44%	44%	50%	63%	56%	63%	38%	38%	38%
Historical_0	38%	38%	38%	50%	50%	56%	31%	31%	38%
MIROC-ESM_4.5	0%	0%	6%	6%	6%	19%	0%	0%	0%
MPI-ESM-LR_4.5	6%	6%	6%	6%	6%	6%	0%	0%	0%
MPI-ESM-LR_8.5	13%	13%	19%	19%	19%	31%	13%	6%	13%
MRI-CGCM3_4.5	31%	31%	31%	44%	44%	50%	25%	25%	25%
MRI-CGCM3_8.5	31%	31%	31%	31%	31%	38%	19%	19%	19%
NorESM1-M_4.5	56%	56%	56%	56%	56%	63%	38%	38%	44%
NorESM1-M_8.5	44%	44%	44%	56%	56%	63%	50%	50%	50%

Figure 5-4. Vulnerability of reserve flows in 2020-2030 (top) and 2040-2050 (bottom). Percentages indicate the percentage of years that will have a period of three or more months that the Mara River is in the reserve. The top label indicates the three key locations assessed along the river, with one column per scenario. Each row represents one climate projection. Assessment of demands

A key conclusion, based on the available data, is that if there are upstream developments that go hand-in-hand with upstream enforcement of the reserve, Tanzania can meet its reserve, at least on the main stream of the Mara. This will not impact meeting the reserve on the tributaries, which have not been represented in WEAP due to inadequacy of gage data.

Several key messages are clear from the scenario analyses.

1. It is not possible to convincingly present results for the three tributaries, as there are no stream gage data to calibrate against. Given that the water balances in the tributaries show the most stress, it is essential to start monitoring stream flows in the tributaries as soon as possible.
2. There are patterns of unmet demands and extended consecutive months in the reserve across the various climate projections, particularly during the dry season.
3. The unmet demands and months in reserve increase in later decades.
4. It is clear that storage in some form is an essential strategy to address the shortfalls in human demands.
5. It is also clear that the reserve needs to be enforced in order to preserve ecosystem functioning.

6 Water Balance and Management Guidelines

6.1 WATER BALANCE

The water balance is a critical part of the water allocation planning process as it brings together the best available information to determine how much water is available for allocation. When used in integrated water resource planning, it is an important tool which helps to ensure effective use of available water without depleting or overutilizing water resources, which can be detrimental to the environment and people. To determine the water balance, information was gathered on water availability from river flows, the reserve (basic human needs and environmental flows), international agreements and inter-catchment transfers, and current and future water demand. The water balance is calculated for each of the six Mara sub-catchments used in the WAP (Figure 3-1).

The water balance equation is as follows:

Water Balance = Available Water - (Reserve + Agreements/Transfers + Demand)

As there are currently no international agreements or inter-catchment transfers in the Lower MRC, the water balance can be simplified to:

Water Balance = Available Water – (Reserve + Demand)

Because the reserve is protected under law and thus non-allocatable, it is useful for planning purposes to quantify the "allocable yield". This is the amount of water available for allocation to water users through Water Use Permits after the reserve has been met.

Allocatable Yield = Available Water – Reserve

If the value of allocatable yield is positive, this indicates that water is available for allocation to water users in the planning sub-catchment and from the relevant flow component. If the allocatable yield is a negative value, then the amount of water available for allocation to water users is zero. This means that all available water from the specific flow component in the sub-catchment is required for the reserve. Thus, the water balance may also be represented as:

Water Balance = Allocatable Yield – Demand

If the final water balance including demand is a positive value, this indicates that there are sufficient water resources in that flow component of the sub-catchment under wet or dry conditions. If the final water balance or the allocatable yield is negative, it indicates that there are insufficient water resources in that flow component of the sub-catchment under wet or dry conditions.

In order to account for the spatial and temporal variability of water availability, demands, and ecological characteristics of the Lower MRC, the water balance calculations are disaggregated according to planning sub-catchment, dry or wet conditions in the sub-catchment, and hydrological conditions of the river flow. The water balance is also calculated for the planning horizons of the WAP: present day, 5, 10, and 20 years in the future (2018, 2023, 2028, and 2038).

The requirement of distinguishing between "normal flow" and "flood flow" components of the river flow regime as specified in the draft Water Allocation Planning Guidelines for Tanzania. The normal flow is set as the flow value (m^3/day) that is expected to be exceeded in the river at least 80% of the time (also known as Q80). This represents the volume of water that is relatively reliable on a given day. The flood flow is composed of all flows in excess of Q80. This is generally a larger volume of water than is available in the normal flow, but it is less reliable on a given day.

In the water balance calculations below, the basic human need and base flow ecological component of the reserve are considered in the water balance of normal flow. Likewise, the demand for additional domestic needs, livestock, tourism, wildlife, and mining were also subtracted from normal flow. The flood ecological component of the reserve and the demand for irrigation (both small and large scale) were subtracted from flood flow. Reserve components were subtracted first from the two flow components to calculate the allocable yield. If the result is positive, the additional demands are subtracted from the allocable yield to arrive at a final water balance. If the result is negative, the deficit is carried over and subtracted from the flood flow. The water availability and values include all upstream catchments, including those located in Kenya. However, the demand from Kenya was not included in the demand values.

While the values presented below are based on the best currently available data, there are uncertainties associated with these values. In particular, water availability values during dry conditions in the tributaries (Tobora, Somoche, and Tigithe sub-catchments) are based only on rainfall-run off relationships regionalized from the mainstream Mara. This was necessary due to a total lack of flow or precipitation data from the tributaries. This method also fails to capture any groundwater or year-round spring contributions during low flows, which residents of the catchment suggested are important in the tributaries. Thus it is likely that water availability during dry conditions is particularly underrepresented in the water balance. When river gauging stations are installed in these sub-catchments, the hydrology and water availability analyses should be updated, along with the water balance. More details on this and other uncertainties can be found in the full water resources assessments.

6.2 MANAGEMENT GUIDELINES

Taking into consideration the water balance for each sub-catchment as well as the outcomes and key messages from the future scenarios, general management guidelines were developed. These are intended to guide the LVBWB when making permit approval decisions in specific sub-catchments, leaving specific permit approval details to the LVBWB decision makers and stakeholders.

Following the draft Water Allocation Planning Guidelines for Tanzania, the LVBWB will manage for two situations: sufficient resources (when there are enough water resources to meet the reserve and all demands) and insufficient resources (when there are not enough water resources to meet the reserve and all demands). Each of these situations requires a different approach to management and the conditions which should be used to inform the Water Use Permit approval process.

Sufficient Resources

- All current permits may remain valid and eligible new permit requests for all water sources may be approved.
- No requirement for prioritization of future allocations, all water uses get equal priority.
- Permits for agricultural irrigation should only abstract water from normal flows if there is positive net balance after all prioritized demands are met. Off-channel storage sufficient to meet 3 months of dry condition water demand is highly encouraged to provide water security to these users.
- Off-channel storage is encouraged for all water users to provide the water necessary to maintain activities through short-term extreme low flow (drought) periods.
    - The water from this storage can be collected by rainfall harvesting or from surface water sources. For rivers, the storage water can only be collected during flood flows. It is not recommended to use groundwater sources for storage water.
- Rainwater harvesting is encouraged year-round and for all water users.

Insufficient Resources

- Existing permits should be reviewed for potential termination or revision. No new permits allowable for water abstracted from rivers or streams as per section Na.49 of WRMA Na.11 of 2009.
- Water for additional domestic demand abstracted from groundwater or lakes has first priority.
- Requirements for prioritization of future allocation as per section 6 of WRMA Na.11 of 2009.
- All other abstractions from groundwater or lakes have second priority, which are to be determined by the LVBWB based on the best available data and the following considerations, as outlined in the WAP guidelines:
    - Existing lawful uses;
    - Efficient and public benefit;
    - Commitments or priorities set in the Catchment's Integrated Water Resources Management and Development Plan;
    - Potential impacts on other water users and the water resources;
    - The class and resource quality objectives;
    - Existing and future investments by the applicant;
    - Strategic importance of the application;
    - Quality of the water resource which may be required for the Reserve; and
    - Probable duration of the water use activity.

6.2.1 FLOW MANAGEMENT THRESHOLDS

Because water for specific demands may be abstracted only from specific river flow components, flow management thresholds are specified to determine the abstractions that are allowed at any given time. LVBWB will inform water users of river conditions relative to the thresholds in the implementation of this WAP. Two thresholds are determined: one defining the boundary between reserve conditions and normal flow, and a second defining the boundary between normal flow and flood flow (Figure 6-1). When river flow levels drop below the reserve flow threshold, water users are to stop all water abstractions other than those to meet basic human needs until river levels again rise above the reserve threshold. When flow levels are above the reserve threshold but below the normal flow threshold, irrigation water users are to stop water abstractions and revert to their storage until river levels again exceed the normal flow threshold and enter the range of flood flows. Thresholds differ between wet and dry conditions, but the restrictions on water users remain the same.

In Tobora, Somoche, and Tigithe sub-catchments, there are conditions in which the reserve threshold exceeds the threshold between normal and flood flows. In this situation all permitted abstractions (including irrigation) other than for basic human needs are to stop when river flows drop below the reserve threshold. Abstractions may resume when river levels recover.

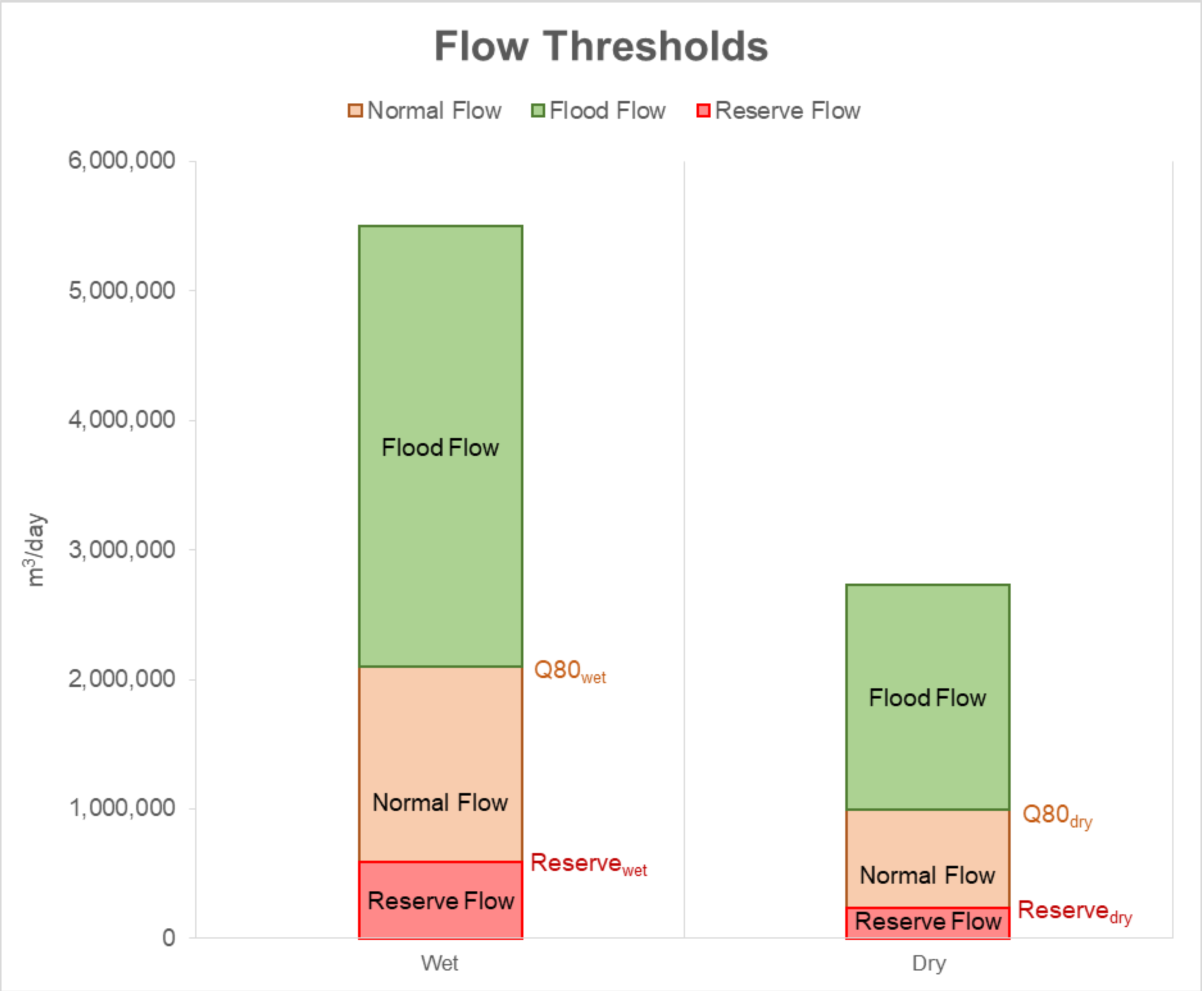

Figure 6-1: Flow management thresholds

Below are summaries of the water balance and the resulting management guidelines for each sub-catchment. Detailed tables with information on all aspects at a monthly, conditional, and annual scale can be found in Annex A.

6.3 SERENGETI SUB-CATCHMENT

The Serengeti sub-catchment is the most upstream sub-catchment in the Lower MRC. The outlet of the Serengeti sub-catchment is at the confluence of the Mara River and Tobora River, located just outside of SENAPA (Figure 6-2). The catchment includes all lands within the Lower MRC catchment that are located upstream of this point (including catchments located in Kenya), and all water balance calculations are cumulative. The water availability includes all hydrological inputs between the Mau Forest in Kenya and the sub-catchment outlet. The reserve requirements at this location consider the basic human needs for the estimated population living inside the sub-catchment as well as the ecological requirements for this reach of river. The water demand estimates are based on known and expected uses inside the Serengeti sub-catchment. For this version of the WAP, no information on water demand from Kenya was available. As this information becomes available through the Joint MOU and the Transboundary WAP between Kenya and Tanzania, it should be incorporated into future versions of this WAP for the Lower MRC.

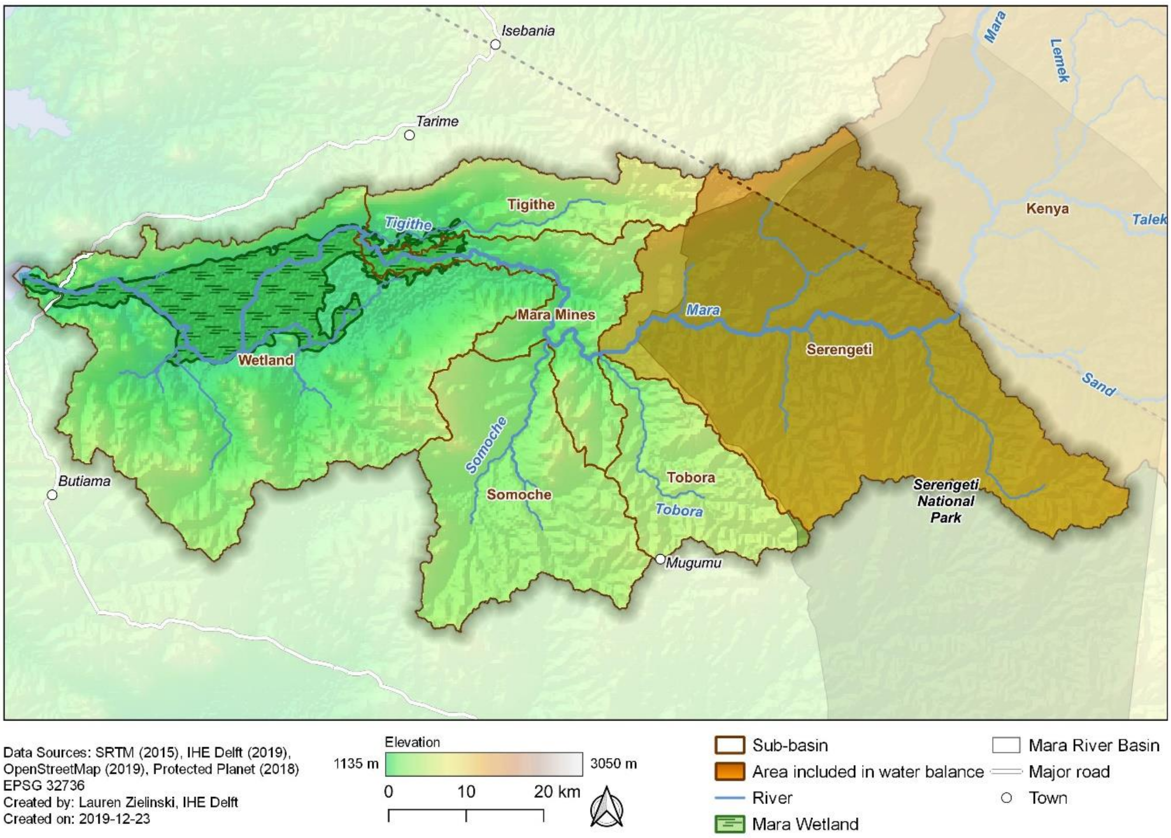

Figure 6-2: The Serengeti sub-catchment and its cumulative catchment

For the Serengeti sub-catchment, all demands for water are expected to be met for both dry and wet conditions for both normal and flood flows. This is true for current water demand and for the future water demand in the projected years of 2023, 2028, and 2038. The percent of allocable yield available for future permits is approximately 99% for normal flow and 100% for flood flow. This is approximately 70 - 75% of the available water under normal flow and 90 - 100% percent of the available water under flood flow.

Table 6-1: Water balance analysis for Serengeti sub-catchment (m^3/day)

Year		2018		2023		2028		2038	
Condition		**Wet**	**Dry**	**Wet**	**Dry**	**Wet**	**Dry**	**Wet**	**Dry**
Normal Flow									
Available Water	Normal flow	2,103,584	993,281	2,103,584	993,281	2,103,584	993,281	2,103,584	993,281
Reserve	BHN	1,259	1,259	1,449	1,449	1,669	1,669	2,222	2,222
	Eflows, baseflow	591,457	233,811	591,457	233,811	591,457	233,811	591,457	233,811
Net balance		1,510,867	758,211	1,510,677	758,021	1,510,457	757,801	1,509,904	757,248
Allocatable Yield		1,510,867	758,211	1,510,677	758,021	1,510,457	757,801	1,509,904	757,248
Demand	Normal flow	8,455	10,329	8,918	10,806	9,455	11,363	10,854	12,830
Water balance		**1,502,413**	**747,882**	**1,501,759**	**747,214**	**1,501,002**	**746,438**	**1,499,050**	**744,418**
% of allocatable yield consumed		1%	1%	1%	1%	1%	1%	1%	2%
% of allocatable yield remaining		99%	99%	99%	99%	99%	99%	99%	98%
Flood Flow									
Available Water	Flood flow	3,395,033	1,739,001	3,395,033	1,739,001	3,395,033	1,739,001	3,395,033	1,739,001
Reserve	Eflows, freshets and floods	377,114	0	377,114	0	377,114	0	377,114	0
	Deficit from eflows, baseflow	0	0	0	0	0	0	0	0
Net balance		3,017,919	1,739,001	3,017,919	1,739,001	3,017,919	1,739,001	3,017,919	1,739,001
Allocatable Yield		3,017,919	1,739,001	3,017,919	1,739,001	3,017,919	1,739,001	3,017,919	1,739,001
Demand	Flood flow	0	0	0	0	0	0	0	0
Water balance		**3,017,919**	**1,739,001**	**3,017,919**	**1,739,001**	**3,017,919**	**1,739,001**	**3,017,919**	**1,739,001**
% of allocatable yield consumed		0%	0%	0%	0%	0%	0%	0%	0%
% of allocatable yield remaining		100%	100%	100%	100%	100%	100%	100%	100%

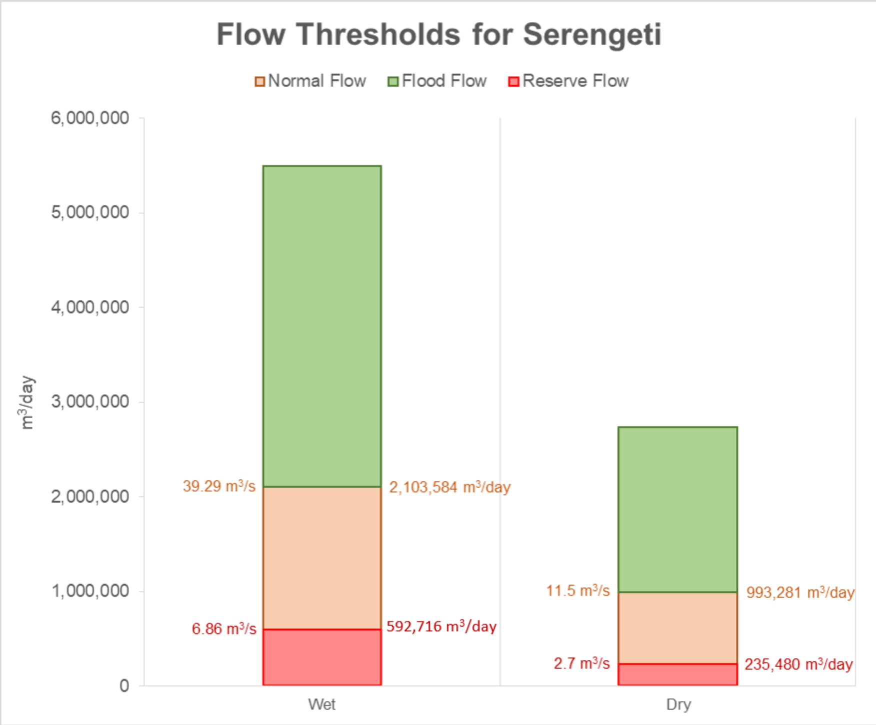

Figure 6-3: Flow thresholds for Serengeti sub-catchment

Table 6-2: Management Guidelines for Serengeti sub-catchment

	Wet Condition	Dry Condition
Flood Flow (Above Q80)	<u>Sufficient Resources</u> - No prioritization or restrictions on current or future abstractions - All water sources are available for abstraction - Abstractions for offline storage is allowed	<u>Sufficient Resources</u> - No prioritization or restrictions on current or future abstractions - All water sources are available for abstraction - Abstractions for offline storage is allowed
Normal Flow (Between Q80 and the reserve)	<u>Sufficient Resources</u> - Abstractions for irrigation are not allowed, abstractions for all other uses are allowed - All water sources are available for abstraction - Abstractions for offline storage are not allowed	<u>Sufficient Resources</u> - Abstractions for irrigation are not allowed, abstractions for all other uses are allowed - All water sources are available for abstraction - Abstractions for offline storage are not allowed
Reserve Flow (Below the reserve)	<u>Reserve Condition</u> - Water in the rivers and groundwater must be protected for environmental flows - Abstractions for basic human needs only - All other abstractions must stop	<u>Reserve Condition</u> - Water in the rivers and groundwater must be protected for environmental flows - Abstractions for basic human needs only - All other abstractions must stop

Table 6-2: Management Guidelines for Serengeti sub-catchment

	Wet Condition	Dry Condition
Other Considerations - Rainwater harvesting and increasing water efficiency is encouraged for all water users throughout the year - Offline storage is encouraged for all water users to increase water security during dry periods		

6.4 TOBORA SUB-CATCHMENT

The Tobora sub-catchment is located on the southern side of the Lower MRC and includes all the catchment areas where water flows into the Tobora River (Figure 6-4). The outlet of is located at the confluence of the Tobora and Mara Rivers. Since this catchment is not cumulative, the water availability, reserve, and demand values are based on analyses for this catchment only.

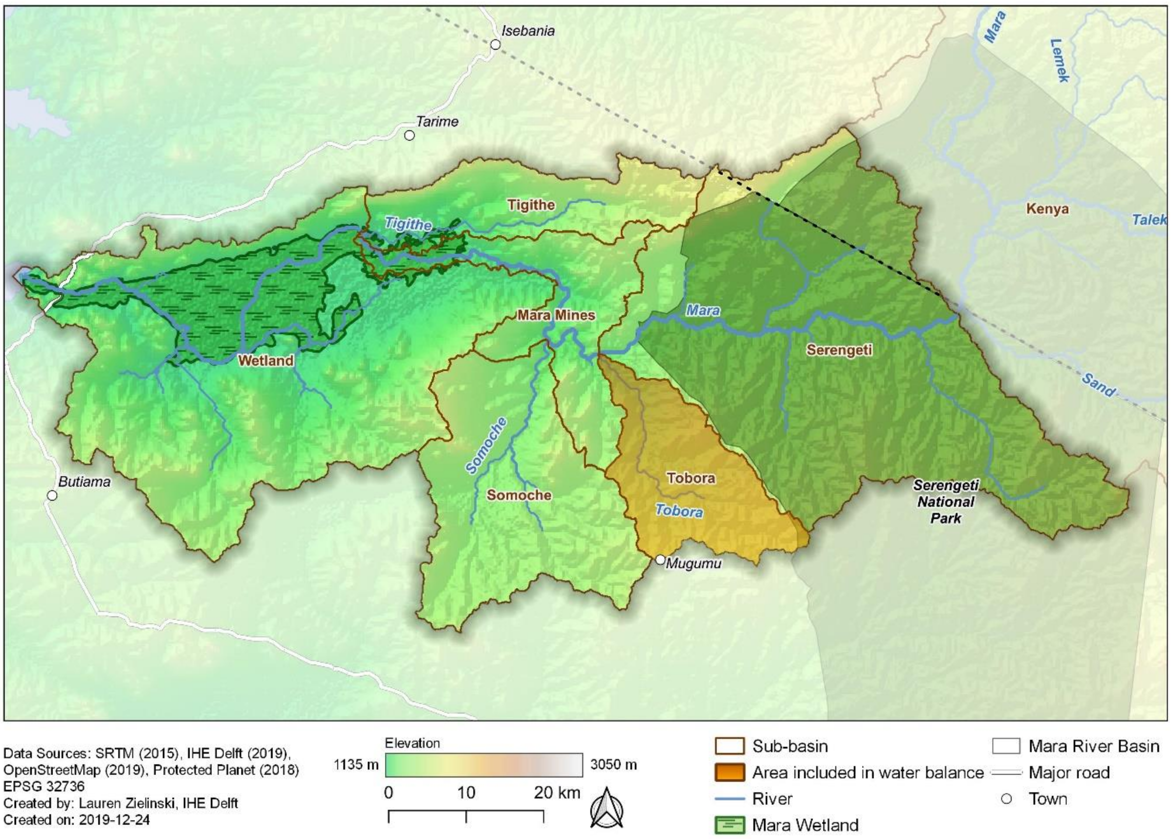

Figure 6-4: The Tobora sub-catchment

The Tobora sub-catchment generates a small amount of available flow that is less than the reserve threshold, meaning the flows in the Tobora sub-catchment will be in reserve conditions more than 20% of the time (Table 6-3). This indicates that all demands for additional domestic needs, livestock, tourism, wildlife, and mining must come from flood flows.

For flood flow, there is expected to be sufficient water to cover the environmental flow base flow deficit and any future water permitting requests for both wet and dry conditions (at the moment, there is no irrigation and hence no flood flow demand in the Tobora sub-catchment). During flood flow, 100% of the allocatable yield is available, which is approximately 63% of the available water.

Table 6-3: Water balance analysis for Tobora sub-catchment (m^3/day)

Year		**2018**		**2023**		**2028**		**2038**	
Condition		**Wet**	**Dry**	**Wet**	**Dry**	**Wet**	**Dry**	**Wet**	**Dry**
Normal Flow									
Available Water	Normal flow	40,752	4,235	40,752	4,235	40,752	4,235	40,752	4,235
Reserve	BHN	786	786	933	933	1,108	1,108	1,563	1,563
	Eflows, baseflow	40,594	12,960	40,594	12,960	40,594	12,960	40,594	12,960
Net balance		-628	-9,511	-775	-9,658	-951	-9,833	-1,406	-10,288
Allocatable Yield		0	0	0	0	0	0	0	0
Demand	Normal flow	1,636	1,646	1,819	1,833	2,208	2,228	2,956	2,995
Water balance		**-1,636**	**-1,646**	**-1,819**	**-1,833**	**-2,208**	**-2,228**	**-2,956**	**-2,995**
% of allocatable yield consumed		>100%	>100%	>100%	>100%	>100%	>100%	>100%	>100%
% of allocatable yield remaining		0%	0%	0%	0%	0%	0%	0%	0%
Flood Flow									
Available Water	Flood flow	92,512	27,581	92,512	27,581	92,512	27,581	92,512	27,581
Reserve	Eflows, freshets and floods	33,166	0	33,166	0	33,166	0	33,166	0
	Deficit from eflows, baseflow	-628	-9,511	-775	-9,658	-951	-9,833	-1,406	-10,288
Net balance		58,717	18,071	58,570	17,923	58,395	17,748	57,940	17,293
Allocatable Yield		58,717	18,071	58,570	17,923	58,395	17,748	57,940	17,293
Demand	Flood flow	0	0	0	0	0	0	0	0
Water balance		**58,717**	**18,071**	**58,570**	**17,923**	**58,395**	**17,748**	**57,940**	**17,293**
% of allocatable yield consumed		0%	0%	0%	0%	0%	0%	0%	0%
% of allocatable yield remaining		100%	100%	100%	100%	100%	100%	100%	100%

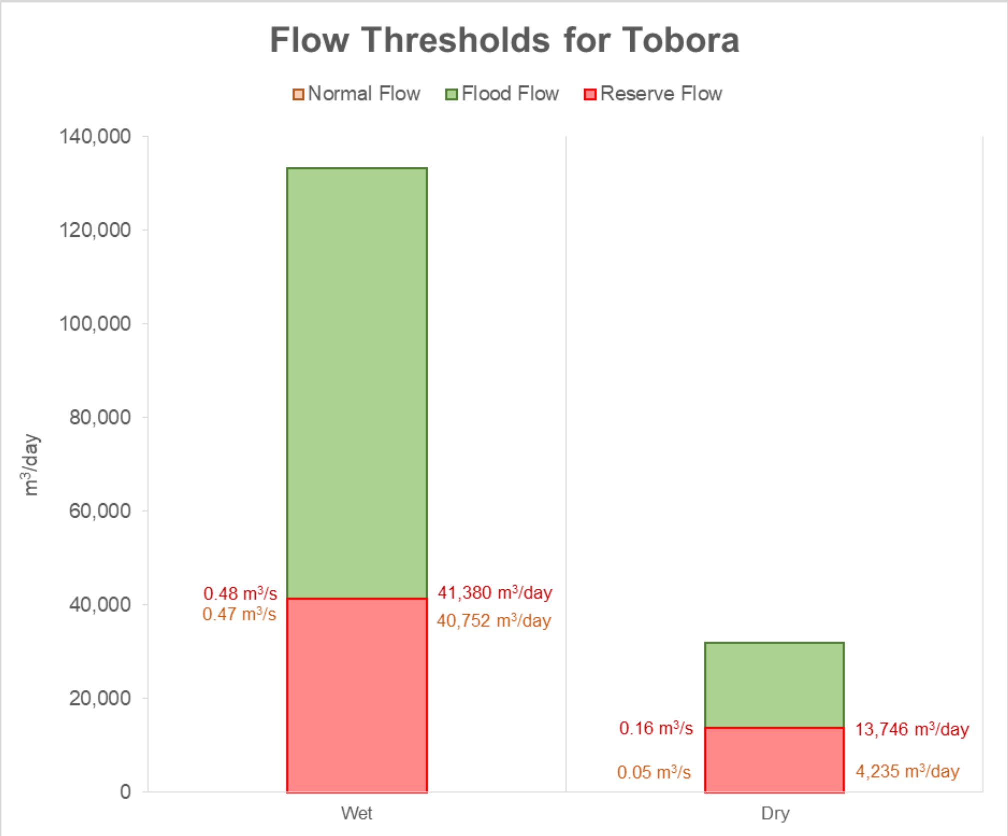

Figure 6-5: Flow thresholds for Tobora sub-catchment

Table 6-4: Management Guidelines for Tobora sub-catchment

	Wet Condition	Dry Condition
Flood Flow (Above Q80)	Sufficient Resources - No prioritization or restrictions on current or future abstractions - All water sources are available for abstraction - Abstractions for offline storage is allowed	Sufficient Resources - No prioritization or restrictions on current or future abstractions - All water sources are available for abstraction - Abstractions for irrigation is allowed - Abstractions for offline storage is allowed
Normal Flow (Between Q80 and the reserve)	Insufficient Resources - All abstractions from rivers and streams should stop - Abstractions from groundwater or lakes for additional domestic demand has first priority - All other abstractions from groundwater or lakes have second priority and should be approved based on LVBWB decisions and WAP guidelines	Insufficient Resources - All abstractions from rivers and streams should stop - Abstractions from groundwater or lakes for additional domestic demand has first priority - All other abstractions from groundwater or lakes have second priority and should be approved based on LVBWB decisions and WAP guidelines

Table 6-4: Management Guidelines for Tobora sub-catchment

	Wet Condition	Dry Condition
Reserve Flow (Below the reserve)	Reserve Condition - Water in the rivers and groundwater must be protected for environmental flows - Abstractions for basic human needs only - All other abstractions must stop	Reserve Condition - Water in the rivers and groundwater must be protected for environmental flows - Abstractions for basic human needs only - All other abstractions must stop
Other Considerations - Rainwater harvesting and increasing water efficiency is encouraged for all water users throughout the year - Offline storage is encouraged for all water users to increase water security during dry periods - Tobora sub-catchment is not suitable for significant groundwater abstractions for commercial use or irrigation purposes - In critical cases, intercatchment transfers may be considered		

6.5 SOMOCHE SUB-CATCHMENT

The Somoche sub-catchment is also located on the southern side of the Lower MRC, downstream of the Tobora River (Figure 6-6). The outlet of the catchment is at the confluence of the Somoche River and the Mara River, a few kilometres downstream from the Tobora confluence. The outlet is located at the confluence of the Tobora and Mara Rivers. Since this sub-catchment is not cumulative, the water availability, reserve, and demand values are based on analyses for this sub-catchment only.

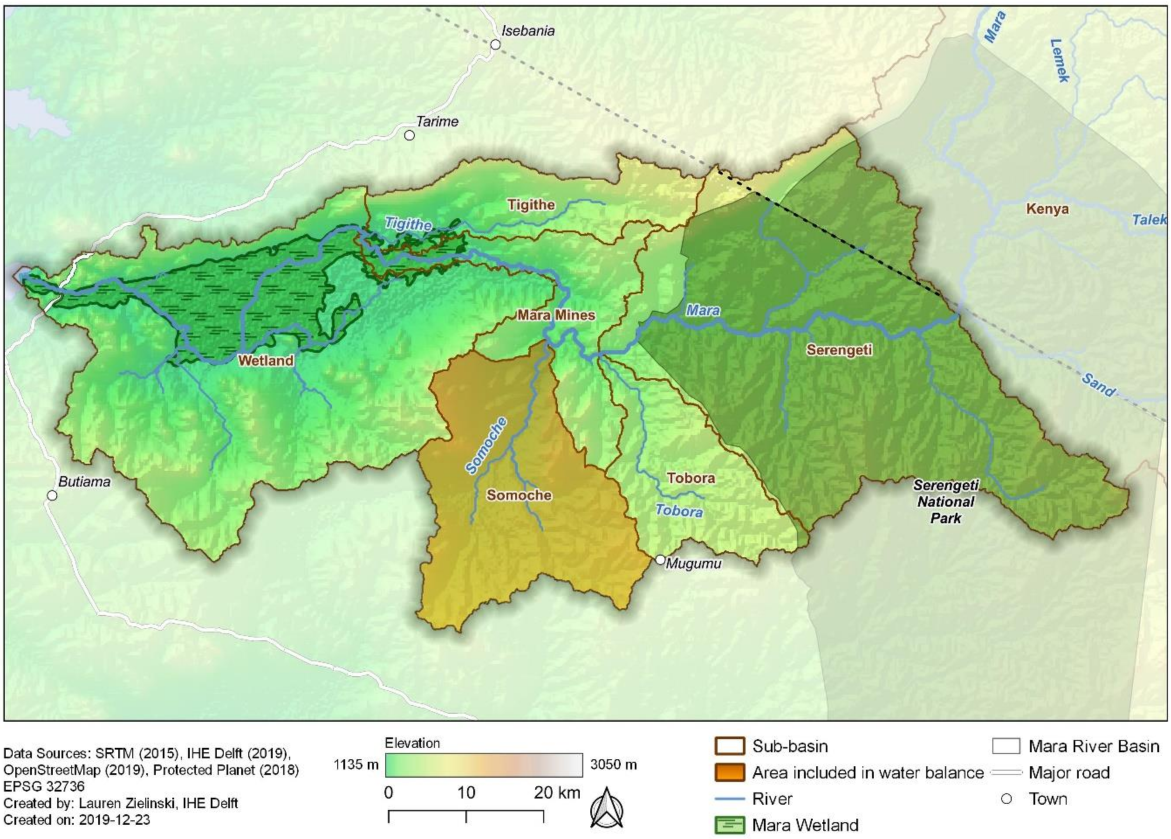

Figure 6-6: The Somoche sub-catchment

Under normal flow, the water balance in Somoche sub-catchment yielded positive results during wet condition for both present and future planning horizons, although there is a negative water balance for dry conditions for all planning horizons (Table 6-5). The reserve (catchment human needs and environmental flow) requirement is expected to be satisfied 100% of the time during wet conditions. For dry conditions, only basic human needs are expected to be fully met while the ecological component of the reserve requires flow levels in excess of Q80. About 85% percent of the allocatable yield is available for future permitting during wet conditions (which is approximately 30% of the available water in 2018 decreasing to 24% in 2038).

During flood flow, there is sufficient water for allocation during both wet and dry conditions, including covering the deficit from the ecological component of the reserve as well as the implementation of the planned Nyamatita irrigation scheme. In 2018, 100% of the allocatable yield for flood flow is available for permitting in wet and dry conditions (approximately 90% of the available water in wet conditions and 64% in dry conditions), which drops to 97% for wet conditions and 75% for dry conditions in 2038 (approximately 90% of the available water in wet conditions and 45% in dry conditions).

Table 6-5: Water balance analysis for Somoche sub-catchment (m^3/day)

Year		**2018**		**2023**		**2028**		**2038**	
Condition		**Wet**	**Dry**	**Wet**	**Dry**	**Wet**	**Dry**	**Wet**	**Dry**
Normal Flow									
Available Water	Normal flow	77,075	9,324	77,075	9,324	77,075	9,324	77,075	9,324
Reserve	BHN	1,477	1,477	1,754	1,754	2,083	2,083	2,939	2,939
	Eflows, baseflow	49,063	25,920	49,063	25,920	49,063	25,920	49,063	25,920
Net balance		26,535	-18,073	26,258	-18,351	25,929	-18,680	25,073	-19,535
Allocatable Yield		26,535	0	26,258	0	25,929	0	25,073	0
Demand	Normal flow	3,909	3,909	4,242	4,242	5,171	5,171	6,732	6,732
Water balance		**22,626**	**-3,909**	**22,016**	**-4,242**	**20,758**	**-5,171**	**18,342**	**-6,732**
% of allocatable yield consumed		15%	>100%	16%	>100%	20%	>100%	27%	>100%
% of allocatable yield remaining		85%	0%	84%	0%	80%	0%	73%	0%
Flood Flow									
Available Water	Flood flow	169,399	49,773	169,399	49,773	169,399	49,773	169,399	49,773
Reserve	Eflows, freshets and floods	15,050	0	15,050	0	15,050	0	15,050	0
	Deficit from eflows, baseflow	0	-18,073	0	-18,351	0	-18,680	0	-19,535
Net balance		154,349	31,700	154,349	31,423	154,349	31,093	154,349	30,238
Allocatable Yield		154,349	31,700	154,349	31,423	154,349	31,093	154,349	30,238
Demand	Flood flow	0	6	4,844	7,620	4,844	7,621	4,844	7,625
Water balance		**154,349**	**31,694**	**149,505**	**23,803**	**149,505**	**23,472**	**149,505**	**22,613**
% of allocatable yield consumed		0%	0%	3%	24%	3%	25%	3%	25%

Table 6-5: Water balance analysis for Somoche sub-catchment (m^3/day)

Year	2018		2023		2028		2038	
Condition	**Wet**	**Dry**	**Wet**	**Dry**	**Wet**	**Dry**	**Wet**	**Dry**
% of allocatable yield remaining	100%	100%	97%	76%	97%	75%	97%	75%

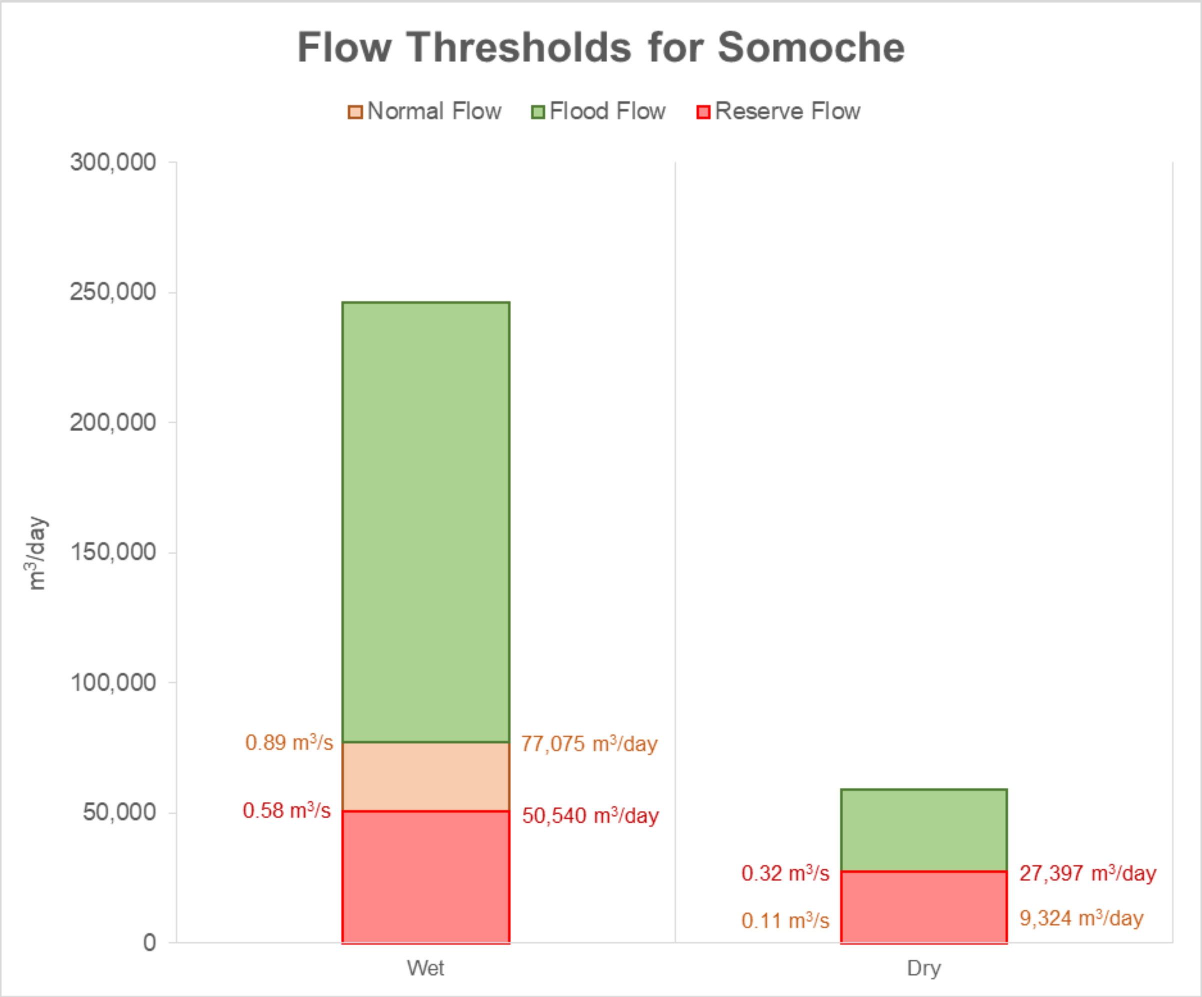

Figure 6-7: Flow thresholds for Somoche sub-catchment

Table 6-6: Management Guidelines for Somoche

	Wet Condition	Dry Condition
Flood Flow (Above Q80)	Sufficient Resources - No prioritization or restrictions on current or future abstractions - All water sources are available for abstraction - Abstractions for irrigation is allowed - Abstractions for offline storage are allowed	Sufficient Resources - No prioritization or restrictions on current or future abstractions - All water sources are available for abstraction - Abstractions for irrigation are allowed - Abstractions for offline storage is allowed
Normal Flow (Between Q80 and the reserve)	Sufficient Resources - Abstractions for irrigation are not allowed, abstractions for all other uses are allowed - All water sources are available for abstraction - Abstractions for offline storage are not allowed	Insufficient Resources - All abstractions from rivers and streams should stop - Abstractions from groundwater or lakes for additional domestic demand has first priority - All other abstractions from groundwater or lakes have second priority and should be approved based on LVBWB decisions and WAP guidelines
Reserve Flow (Below the reserve)	Reserve Condition - Water in the rivers and groundwater must be protected for environmental flows - Abstractions for basic human needs only - All other abstractions must stop	Reserve Condition - Water in the rivers and groundwater must be protected for environmental flows - Abstractions for basic human needs only - All other abstractions must stop
Other Considerations - Rainwater harvesting and increasing water efficiency is encouraged for all water users throughout the year - Offline storage is encouraged for all water users to increase water security during dry periods - In critical cases, intercatchment transfers may be considered		

6.6 MARA MINES SUB-CATCHMENT

The Mara Mines sub-catchment is located in the centre of the Lower MRC, beginning at the confluence of the Tobora and Mara Rivers and ending where the Mara River flows into the Mara Wetland (Figure 6-8). The water balance for this sub-catchment is cumulative, meaning it encompasses everything upstream of the outlet point except for demands in the Kenyan portion of the MRC. The water availability results include all flows from the mainstem Mara River, the Tobora River, and the Somoche River. The reserve includes the basic human needs for the Serengeti, Tobora, Somoche, and Mara Mines sub-catchments, and provides for the ecological needs of that reach of river. The demands include all demands in the upstream Tanzanian sub-catchments and the Mara Mines sub-catchment.

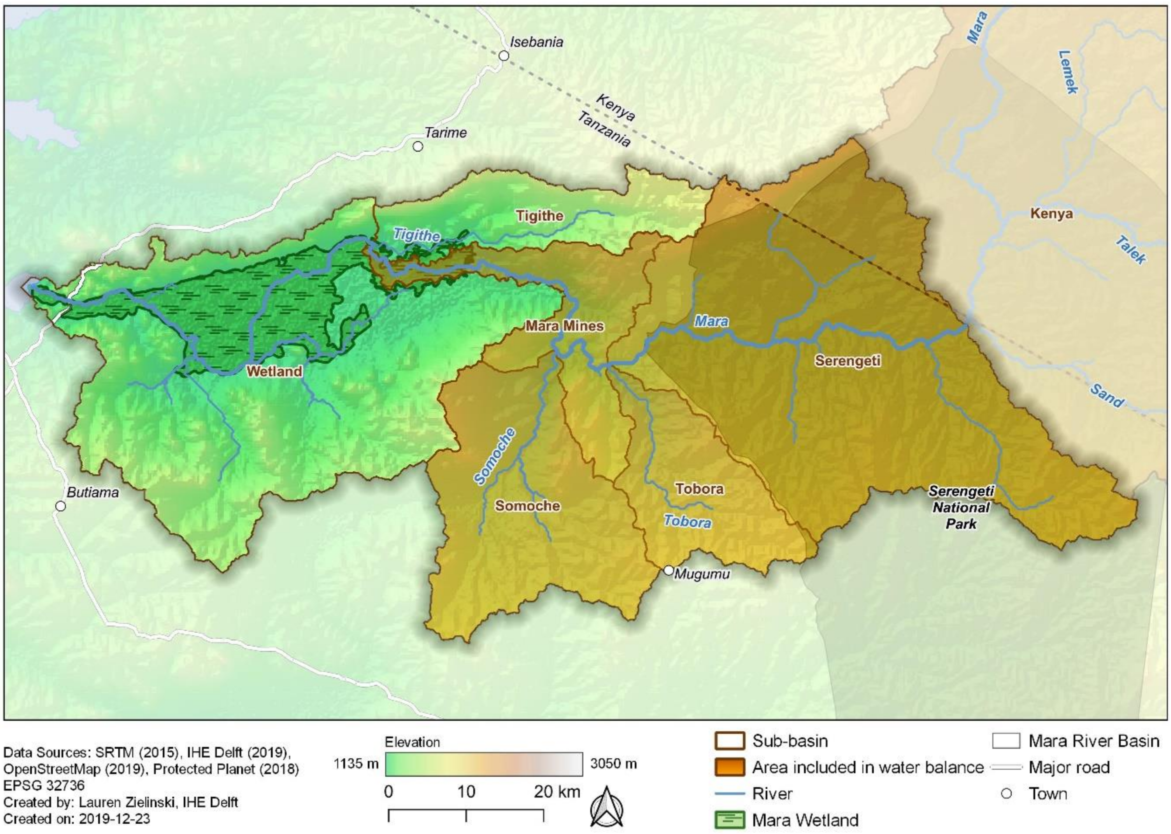

Figure 6-8: The Mara Mines sub-catchment and its cumulative catchment

In Mara Mines sub-catchment, there is sufficient water for all uses in both wet and dry conditions, under normal and flood flows, and for all planning horizons for the WAP (*Table 6-7*). Under normal flow, 98 – 99% of the allocatable yield is available for future permits in wet conditions (which is approximately 71% of the available water) and 96 – 97% is available in dry conditions (which is approximately 70 – 71% of available water). Under flood flow, there is also sufficient water, with 100% of allocatable water available for permitting in 2018 (which is approximately 84% and 100% of flood flow water available, respectively). In the planning horizon, the Mara Valley Project is estimated to begin in part by 2028 and in full by 2038. Since this is an irrigation project, it will consume flood flow to fill the reservoir and the irrigation canals. This will decrease the percent of the allocatable yield to 98% and 94% for wet and dry conditions in 2028, and to 88% and 70% for wet and dry conditions in 2038. This represents approximately 82% and 94% of available flood flow water for wet and dry conditions in 2028 and approximately 74% and 70% of available flood flow water for wet and dry conditions in 2038.

Table 6-7: Water balance analysis for Mara Mines sub-catchment (m^3/day)

Year		2018		2023		2028		2038	
Condition		**Wet**	**Dry**	**Wet**	**Dry**	**Wet**	**Dry**	**Wet**	**Dry**
Normal Flow									
Available Water	Normal flow	2,223,846	1,073,642	2,223,846	1,073,642	2,223,846	1,073,642	2,223,846	1,073,642
Reserve	BHN	4,913	4,913	5,717	5,717	6,658	6,658	9,054	9,054
	Eflows, baseflow	606,956	279,453	606,956	279,453	606,956	279,453	606,956	279,453
Net balance		1,611,976	789,276	1,611,173	788,472	1,610,231	787,531	1,607,835	785,135
Allocatable Yield		1,611,976	789,276	1,611,173	788,472	1,610,231	787,531	1,607,835	785,135
Demand	Normal flow	20,112	21,990	21,386	23,280	24,019	25,935	29,355	31,347
Water balance		**1,591,864**	**767,285**	**1,589,786**	**765,192**	**1,586,212**	**761,596**	**1,578,480**	**753,788**
% of allocatable yield consumed		1%	3%	1%	3%	1%	3%	2%	4%
% of allocatable yield remaining		99%	97%	99%	97%	99%	97%	98%	96%
Flood Flow									
Available Water	Flood flow	3,692,057	1,879,479	3,692,057	1,879,479	3,692,057	1,879,479	3,692,057	1,879,479
Reserve	Eflows, freshets and floods	572,344	0	572,344	0	572,344	0	572,344	0
	Deficit from eflows, baseflow	0	0	0	0	0	0	0	0
Net balance		3,692,057	1,879,479	3,119,713	1,879,479	3,119,713	1,879,479	3,119,713	1,879,479
Allocatable Yield		3,692,057	1,879,479	3,119,713	1,879,479	3,119,713	1,879,479	3,119,713	1,879,479
Demand	Flood flow	12	0	5,071	7,506	76,654	113,757	380,835	565,261
Water balance		**3,119,700**	**1,879,479**	**3,114,641**	**1,871,972**	**3,043,059**	**1,765,722**	**2,738,878**	**1,314,217**
% of allocatable yield consumed		0%	0%	0%	0%	2%	6%	12%	30%
% of allocatable yield remaining		100%	100%	100%	100%	98%	94%	88%	70%

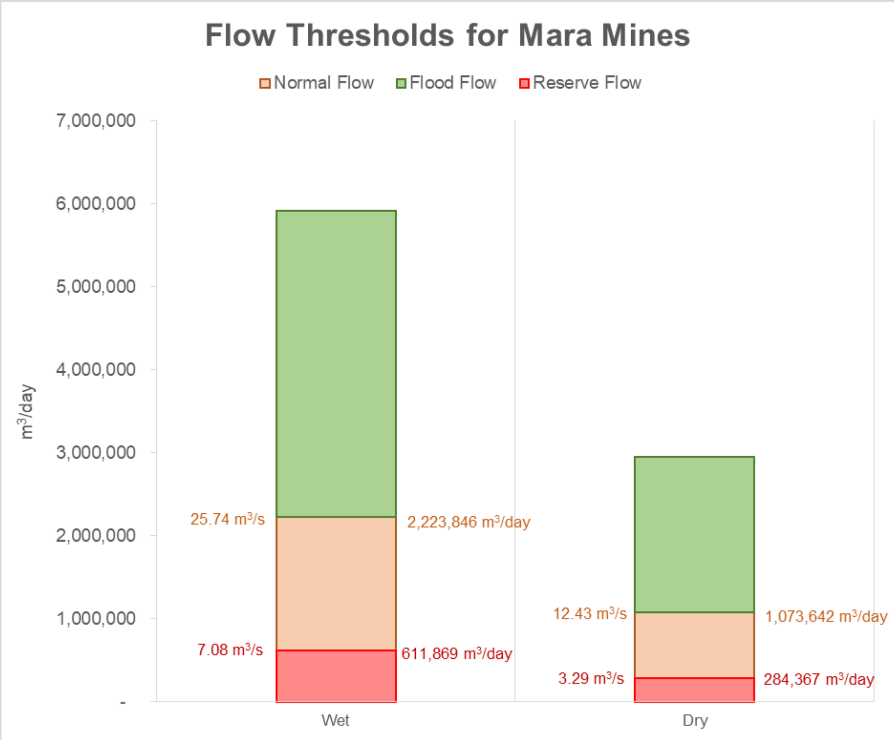

Figure 6-9: Flow thresholds for Mara Mines sub-catchment

Table 6-8: Management Guidelines for Mara Mines sub-catchment

	Wet Condition	Dry Condition
Flood Flow (Above Q80)	Sufficient Resources - No prioritization or restrictions on current or future abstractions - All water sources are available for abstraction - Abstractions for offline storage are allowed	Sufficient Resources - No prioritization or restrictions on current or future abstractions - All water sources are available for abstraction - Abstractions for offline storage are allowed
Normal Flow (Between Q80 and the reserve)	Sufficient Resources - Abstractions for irrigation are not allowed, abstractions for all other uses are allowed - All water sources are available for abstraction - Abstractions for offline storage are not allowed	Sufficient Resources - Abstractions for irrigation are not allowed, abstractions for all other uses are allowed - All water sources are available for abstraction - Abstractions for offline storage are not allowed
Reserve Flow (Below the reserve)	Reserve Condition - Water in the rivers and groundwater must be protected for environmental flows - Abstractions for basic human needs only - All other abstractions must stop	Reserve Condition - Water in the rivers and groundwater must be protected for environmental flows - Abstractions for basic human needs only - All other abstractions must stop
Other Considerations - Rainwater harvesting and increasing water efficiency is encouraged for all water users throughout the year - Offline storage is encouraged for all water users to increase water security during dry periods		

6.7 TIGITHE SUB-CATCHMENT

Tigithe sub-catchment is located in the northern side of the Lower MRC and flows directly into the Mara Wetland. Since this catchment is not cumulative, the water availability, reserve, and demand values are based on analyses for this catchment only.

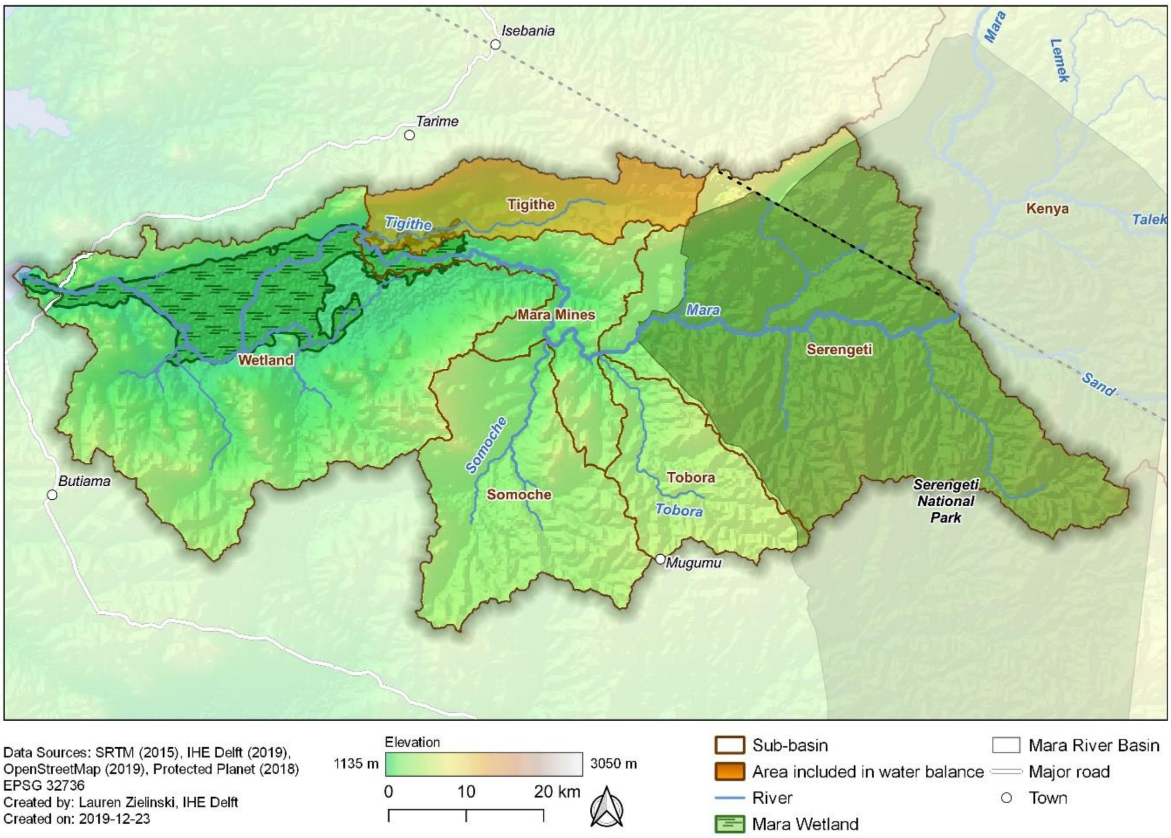

Figure 6-10: The Tigithe sub-catchment

In the Tigithe sub-catchment, there is expected to sufficient water resources to meet the reserve and all demands in wet conditions for all planning horizons, while there is expected to be insufficient water resources to meet the reserve and demand in dry conditions under normal flows (see Table 6.9). The amount available for allocation in wet conditions ranges from 85% in 2018 to 76% in 2038 (which is approximately 54 and 46% of available water, respectively). In dry conditions, basic human needs are met 100% of the time while the ecological component of the reserve is only expected to be met 34 - 45% of the time. This indicates that the water for additional domestic needs, livestock, tourism, wildlife, and mining in Tigithe sub-catchment must be allocated from the flood flow.

Under flood flow, 100% of the allocatable water is available for water permits since there is very little mechanized irrigation in the Tigithe sub-catchment. In wet conditions, this is approximately 74% of the available flood flow. In dry conditions, the flood flow is first used to provide water for the ecological component of the reserve. Beyond that, 100% is available for allocation to water permits (which is approximately 80% of available water).

Table 6-9: Water balance analysis for Tigithe sub-catchment (m^3/day)

Year		2018		2023		2028		2038	
Condition		**Wet**	**Dry**	**Wet**	**Dry**	**Wet**	**Dry**	**Wet**	**Dry**
Normal Flow									
Available Water	Normal flow	42,574	5,668	42,574	5,668	42,574	5,668	42,574	5,668
Reserve	BHN	1,722	1,722	1,920	1,920	2,141	2,141	2,661	2,661
	Eflows, baseflow	13,897	8,640	13,897	8,640	13,897	8,640	13,897	8,640
Net balance		26,954	-4,694	26,756	-4,892	26,535	-5,113	26,015	-5,633
Allocatable Yield		26,954	0	26,756	0	26,535	0	26,015	0
Demand	Normal flow	4,030	4,034	4,284	4,290	5,063	5,070	6,309	6,325
Net flow balance		**22,924**	**-4,034**	**22,472**	**-4,290**	**21,473**	**-5,070**	**19,706**	**-6,325**
% of allocatable yield consumed		15%	>100%	16%	>100%	19%	>100%	24%	>100%
% of allocatable yield remaining		85%	0%	84%	0%	81%	0%	76%	0%
Flood Flow									
Available Water	Flood flow	96,318	28,218	96,318	28,218	96,318	28,218	96,318	28,218
Reserve	Eflows, freshets and floods	24,805	0	24,805	0	24,805	0	24,805	0
	Deficit from eflows, baseflow	0	-4,694	0	-4,892	0	-5,113	0	-5,633
Water balance		71,513	23,523	71,513	23,325	71,513	23,105	71,513	22,584
Allocatable Yield		71,513	23,523	71,513	23,325	71,513	23,105	71,513	22,584
Demand	Flood flow	12	45	13	51	15	56	18	70
Net flow balance		**71,501**	**23,478**	**71,499**	**23,275**	**71,498**	**23,048**	**71,494**	**22,514**
% of allocatable yield consumed		0%	0%	0%	0%	0%	0%	0%	0%
% of allocatable yield remaining		100%	100%	100%	100%	100%	100%	100%	100%

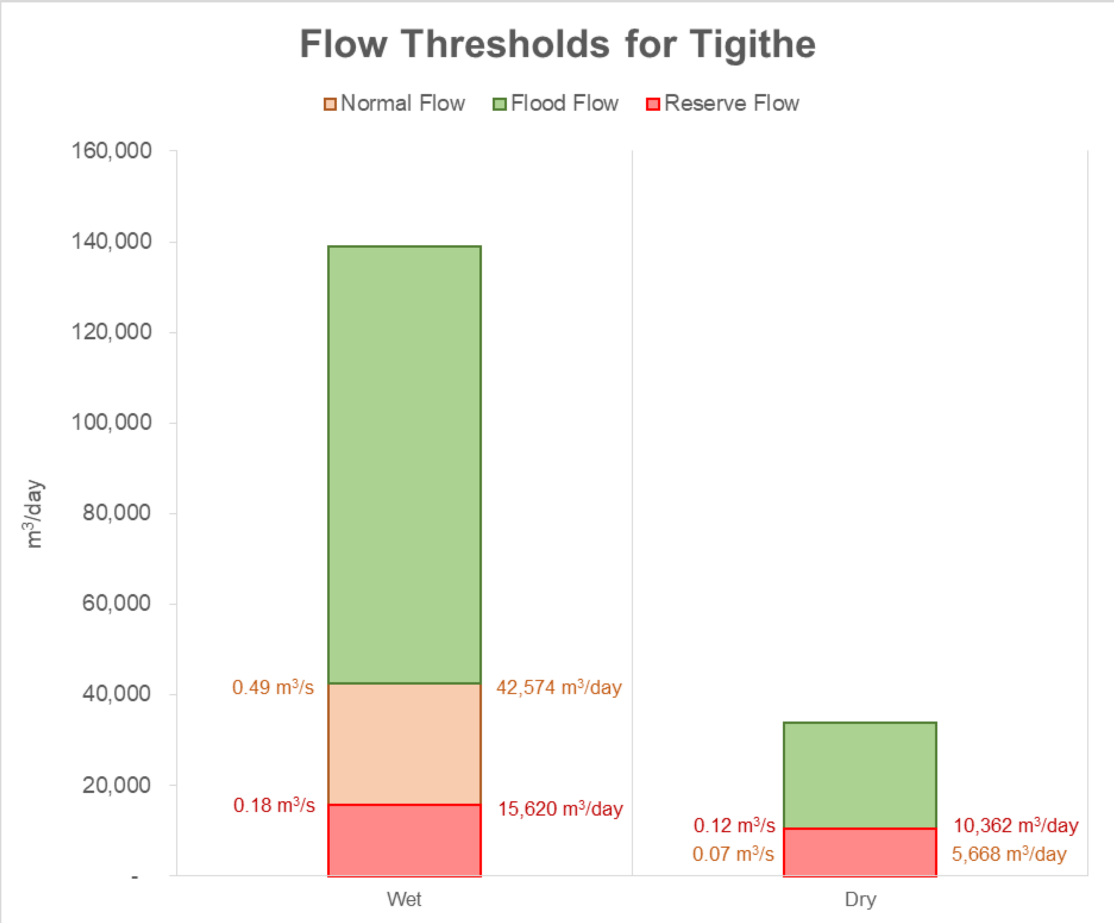

Figure 6-11: Flow thresholds for Tigithe sub-catchment

Table 6-10: Management Guidelines for Somoche sub-catchment

	Wet Condition	Dry Condition
Flood Flow (Above Q80)	Sufficient Resources - No prioritization or restrictions on current or future abstractions - All water sources are available for abstraction - Abstractions for offline storage are allowed	Sufficient Resources - No prioritization or restrictions on current or future abstractions - All water sources are available for abstraction - Abstractions for offline storage are allowed
Normal Flow (Between Q80 and the reserve)	Sufficient Resources - Abstractions for irrigation are not allowed, abstractions for all other uses are allowed - All water sources are available for abstraction - Abstractions for offline storage are not allowed	Insufficient Resources - All abstractions from rivers and streams should stop - Abstractions from groundwater or lakes for additional domestic demand has first priority - All other abstractions from groundwater or lakes have second priority and should be approved based on LVBWB decisions and WAP guidelines

Table 6-10: Management Guidelines for Somoche sub-catchment

	Wet Condition	**Dry Condition**
Reserve Flow (Below the reserve)	Reserve Condition - Water in the rivers and groundwater must be protected for environmental flows - Abstractions for basic human needs only - All other abstractions must stop	Reserve Condition - Water in the rivers and groundwater must be protected for environmental flows - Abstractions for basic human needs only - All other abstractions must stop
Other Considerations - Rainwater harvesting and increasing water efficiency is encouraged for all water users throughout the year - Offline storage is encouraged for all water users to increase water security during dry periods - In critical cases, intercatchment transfers may be considered		

6.8 MARA WETLAND SUB-CATCHMENT

The Mara Wetland sub-catchment is the most downstream sub-catchment and contains the Mara Wetland, which contains the outlet to the Mara River where it enters Lake Victoria (Figure 6-12). This sub-catchment accumulates all of the hydrological inputs, basic human needs requirements, and current and future demand of all the upstream sub-catchments (except in Kenya) as well as the Mara Wetland sub-catchment. The reserve is estimated to maintain the ecological function of the Mara Wetland.

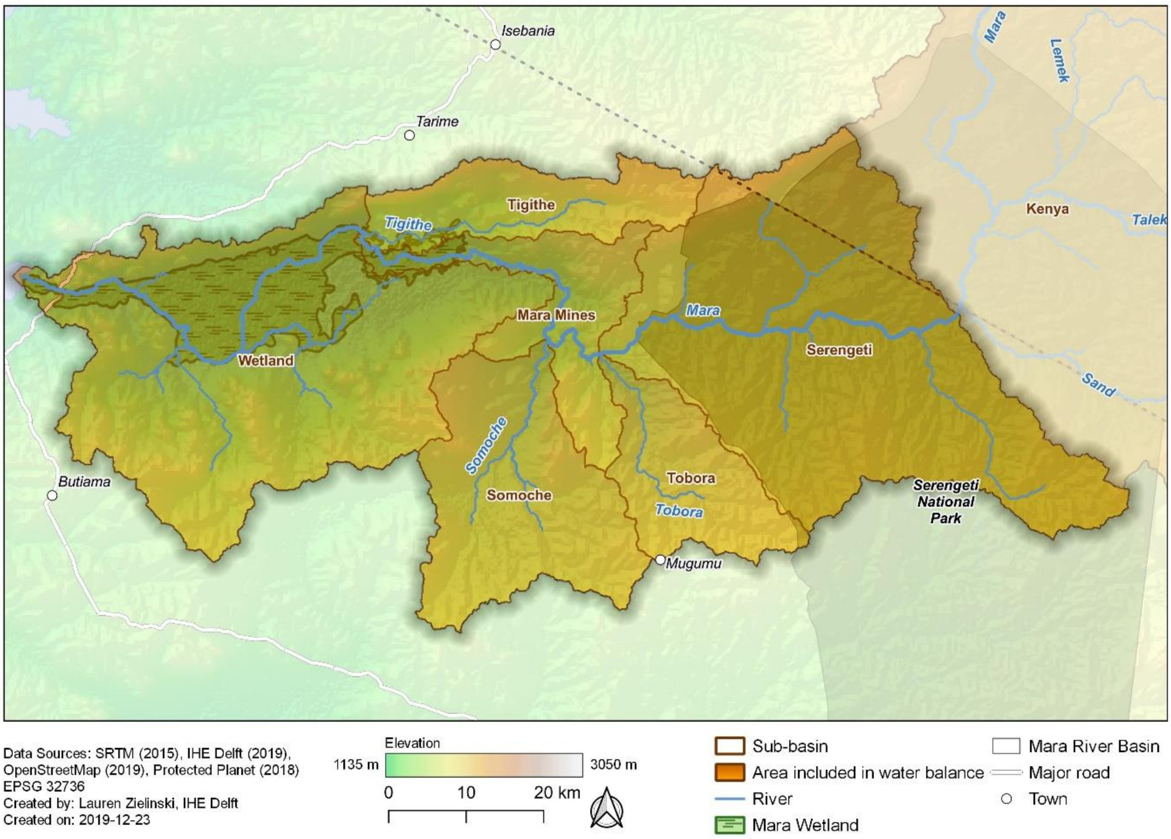

Figure 6-12: The Mara Wetland sub-catchment and its cumulative catchment

In the Mara Wetland sub-catchment, there are sufficient water resources to meet the reserve as well as all demands in wet and dry conditions, under normal and flood flow, and for the entire planning horizon. Under normal flow, the percent of allocable yield available for permitting in wet conditions is between 98% in 2018 and 97% in 2038, which is approximately 70% and 69% of the total available water. For dry conditions, it is between 96% in 2018 and 94% in 2038, which is approximately 68% and 66% of the total available water. Under flood flow, 100% of allocable yield is available for future permitting for both wet and dry conditions in 2018 (85% and 100% of available water, respectively). In 2038, this drops to 92% and 73% for wet and dry conditions (78% and 73% of available water, respectively).

Table 6-11: Water balance analysis for Mara Wetland sub-catchment (m^3/day)

Year		**2018**		**2023**		**2028**		**2038**	
Condition		**Wet**	**Dry**	**Wet**	**Dry**	**Wet**	**Dry**	**Wet**	**Dry**
Normal Flow									
Available Water	Normal flow	2,634,658	1,179,018	2,634,658	1,179,018	2,634,658	1,179,018	2,634,658	1,179,018
Reserve	BHN	10,015	10,015	11,479	11,479	13,171	13,171	17,392	17,392
	Eflows, baseflow	744,005	334,561	744,005	334,561	744,005	334,561	744,005	334,561
Net balance		1,880,638	834,442	1,879,174	832,977	1,877,482	831,286	1,873,261	827,064
Allocatable Yield		1,880,638	834,442	1,879,174	832,977	1,877,482	831,286	1,873,261	827,064
Demand	Normal flow	31,807	35,988	33,887	38,106	39,300	43,572	48,839	53,295
Water balance		**1,848,831**	**798,453**	**1,845,287**	**794,871**	**1,838,182**	**787,713**	**1,824,422**	**773,770**
% of allocatable yield consumed		2%	4%	2%	5%	2%	5%	3%	6%
% of allocatable yield remaining		98%	96%	98%	95%	98%	95%	97%	94%
Flood Flow									
Available Water	Flood flow	4,498,531	2,097,929	4,498,531	2,097,929	4,498,531	2,097,929	4,498,531	2,097,929
Reserve	Eflows, freshets and floods	672,347	0	672,347	0	672,347	0	672,347	0
	Deficit from eflows, baseflow	0	0	0	0	0	0	0	0
Net balance		3,826,184	2,097,929	3,826,184	2,097,929	3,826,184	2,097,929	3,826,184	2,097,929
Allocatable Yield		3,826,184	2,097,929	3,826,184	2,097,929	3,826,184	2,097,929	3,826,184	2,097,929
Demand	Flood flow	597	755	4,940	8,337	65,525	114,523	322,832	565,570
Water balance		**3,825,587**	**2,097,174**	**3,821,244**	**2,089,592**	**3,760,659**	**1,983,406**	**3,503,352**	**1,532,359**
% of allocatable yield consumed		0%	0%	0%	0%	2%	5%	8%	27%
% of allocatable yield remaining		100%	100%	100%	100%	98%	95%	92%	73%

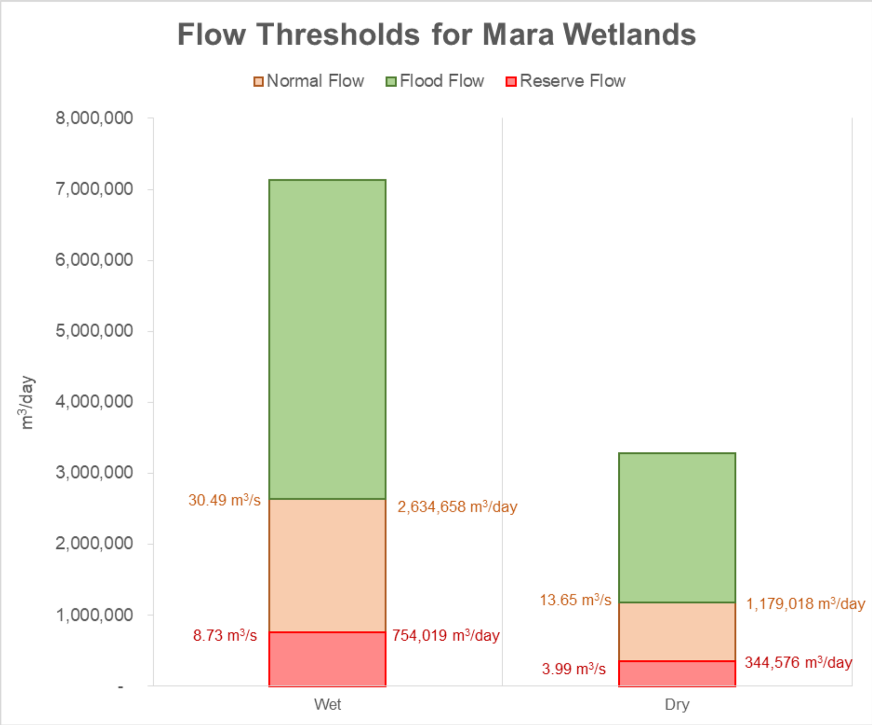

Figure 6-13: Flow thresholds for Mara Wetlands sub-catchment

Table 6-12: Management Guidelines for Mara Wetland sub-catchment

	Wet Condition	Dry Condition
Flood Flow (Above Q80)	Sufficient Resources - No prioritization or restrictions on current or future abstractions - All water sources are available for abstraction - Abstractions for offline storage are allowed	Sufficient Resources - No prioritization or restrictions on current or future abstractions - All water sources are available for abstraction - Abstractions for offline storage are allowed
Normal Flow (Between Q80 and the reserve)	Sufficient Resources - Abstractions for irrigation are not allowed, abstractions for all other uses are allowed - All water sources are available for abstraction - Abstractions for offline storage are not allowed	Sufficient Resources - Abstractions for irrigation are not allowed, abstractions for all other uses are allowed - All water sources are available for abstraction - Abstractions for offline storage are not allowed
Reserve Flow (Below the reserve)	Reserve Condition - Water in the rivers and groundwater must be protected for environmental flows - Abstractions for basic human needs only - All other abstractions must stop	Reserve Condition - Water in the rivers and groundwater must be protected for environmental flows - Abstractions for basic human needs only - All other abstractions must stop
Other Considerations - Rainwater harvesting and increasing water efficiency is encouraged for all water users throughout the year - Offline storage is encouraged for all water users to increase water security during dry periods		

7 Operationalization of the WAP

7.1 DETERMINATION OF WET AND DRY CONDITIONS

The LVBWB is responsible for making the official determination when the MRC is in a wet condition or a dry condition. The intent of changing between wet and dry conditions is to allow more water to be productively utilized during wet conditions while preventing over abstraction in the dry conditions. The LVBWB is only able to change this designation four times per year, which is intended to align with the two rainy seasons (March to May and October to December) and two dry seasons (June to September and January and February) in the MRC. However, the LVBWB can decide when to change this designation based on the current hydrological and climatic conditions and those expected in the near future. This decision should utilize information on current hydrological conditions, expected weather conditions in the upcoming weeks, local or regional climate information on the changing of the seasons, and information from stakeholders on the ground. When a decision is made to change between wet and dry conditions, the permit holders and stakeholders should be informed in a reasonable timeframe.

7.2 MONITORING AND EVALUATION

The most important aspect is to make the WAP operational; it is the installation, operation, and maintenance of a monitoring network and established evaluation procedures.

- The monitoring network needs to provide consistent information on the flow (either as flow directly measured in m^3/s or as a water depth in meters combined with a rating curve) at or very near to the outlets of each sub-basin. This information should be collected at least once per day and then transmitted to the LVBWB and stored in a local or national database. These monitoring networks should be established and maintained by the LVBWB. However due to high cost of establishing such networks, the Ministry of Water and other development partners can also support the basin to establish a monitoring network.
- Information on upcoming weather patterns and expected changes at local and regional climate should also be available to the LVBWB staff. This information is necessarily needed so that the LVBWB managers can determine when the catchment is in wet or dry conditions and when it should change to align with local rainfall patterns. The catchment can work closely with Tanzania Meteorological Authority.
- Regular monitoring on permit compliance should also be conducted by performing regular visits to Water Use Permit holders and ensuring they are not abstracting more than allowable amount of water allocated in their permit. If it is found that permit holders are not in compliance, then enforcement or necessary measure should be taken.
- There should be a monitoring team responsible for collecting, organizing, and sharing the data with decision makers at the LVBWB and MoW. The information should be summarized and shared on a regular basis (e.g., weekly) so that important decisions can be made regarding water resources management. Detailed reports should also be prepared annually on water levels and abstraction compliance to be submitted to the LVBWB, MoW and, later, at regional level through LVBC for management purpose.

7.3 INTEGRATION INTO PERMITTING PROCESS

The LVBWB is responsible for the review and approval of Water Use Permits in the Lower MRC. This is the primary way in which medium-to-large water abstractions occur in the catchment (often, small abstractions, such as those for basic human needs, livestock, and wildlife, are often not or cannot be permitted). When deciding upon the approval of a permit application, the decision committee should utilize the analysis and guidelines provided for each sub-basin in this document. The LVBWB and permit decision committee has the authority to decide the specific conditions to which each permit holder is accountable, which should align with the management guidelines provided. Ultimately, the decision to approve a permit and its specific terms and conditions are at the discretion of the LVBWB.

The LVBWB also has the authority to suspend or vary all or any water permits for a length of time (as deemed necessary) when a drought or natural disaster results in an insufficient amount of water to meet the needs of the reserve and all permit holders (WRMA, section 36). Weather forecasting is determined by Tanzania Meteorological Authority (TMA), in which the LVBWB and MoW uses such information from TMA to inform changes in abstractions during the given extreme situations.

7.4 ABSTRACTION DATABASE

When Water Use Permits are approved, they should be entered into an abstraction database. This database will help the LVBWB keep track of the number, amount, and locations of abstractions and should automatically compare the permitted abstractions against the water available for allocation (or the allocatable yield).

This database should store all information for the approved permit, including (but not limited to): permit holder name, address, and contact information; the amount of water allocated in permit, including any conditional requirements; the purpose or water use for the abstraction; the location of the abstraction, including sub-basin name; the start and end date of the permit; and information on any enforcement checks completed on that permit, including date, compliance/non-compliance, and any enforcement actions taken.

7.5 UPDATES TO THE WATER ALLOCATION PLAN

The WAP is intended to be a "living document". Therefore, it needs to be updated regularly to capture changes in water use in the Catchment as well as incorporate any updated and/or new data or analyses into the water balance. Regular updates also allow the LVBWB and MoW to incorporate any changes in water resources management techniques and/or priorities at the catchment or national level. To achieve this, it is recommended that this document be updated every 5 years, building upon the analysis provided in this initial WAP document. Suggested updates and changes should be developed by the LVBWB and then approved by the MoW through the appropriate processes used by the Government of Tanzania.

Regarding the next updates, efforts should be focused on collecting data and updating the analyses for the water availability assessment, which currently has the highest uncertainties and is the foundation of the water balance. In addition, as updated values become available for water demand (such as updated census numbers, wildlife population assessments, or current abstraction values), the analyses for future water demand should also be updated. The reserve values should also be regularly updated as new census data becomes available (to calculate basic human needs) and as more data becomes available on the hydrology and ecology of the different sub-basins.

8 Implementation Strategy

In order to implement the Mara River Catchment Water Allocation Plan (Mara WAP), the team has proposed several strategies which essentially aim at implementing actions mentioned in Mara WAP, with the ultimate goal of achieving the objectives of the WAP. The proposed strategies were identified based on the identified challenges during the preparation of Mara WAP, literature review, the team experience and stakeholders' consultations. The following six key result areas were identified to form the main framework of the Mara WAP and respective strategies and action plan:

i. Water Resources Management,
ii. Stakeholders engagement,
iii. Capacity Building,
iv. Demand Management, and
v. Mobilization of Financial Resources.
vi. Monitoring strategy

8.1 WATER RESOURCES MANAGEMENT

Water Resources Management includes management of surface water, groundwater, water quality, environment flow requirement, water resources monitoring stations, compliance monitoring, law enforcement, discharge/effluent monitoring and management of water use permits.

8.1.1 SURFACE WATER ASSESSMENT AND MONITORING

Surface Water data management (from collection to dissemination) should be done in the short term in order to obtain a clearer picture of water availability in the Mara River catchment. The implementation of the Mara WAP largely depends on accurate and timely available river flow data for efficient water allocation among users. Meteorological parameters are equally important as river flow values. Therefore, LVBWB has to invest in surface water data collection, analysis, storage and dissemination.

To achieve the above, the following should be considered:

i. Employ Gauge Readers,
ii. Review the location of the current water level monitoring stations and identify if more stations are required,
iii. Rehabilitate and construct Hydrometeorological network
iv. Data collection for Reviewing and preparing rating curves/equations for each water level monitoring station as required,
v. Revise the water balance values for each catchment,
vi. Establish the required database, data management and dissemination tools, and
vii. Prepare Water Resources Monitoring Plan.

8.1.2 GROUNDWATER ASSESSMENT AND MONITORING

Groundwater sources constitute 82.9% of abstraction points in the Mara River Catchment. As groundwater is a reliable and highly used source of domestic water in the Catchment, quantification of this resource in the short term is highly recommended as it will help in revising both water allocation and water balance in each catchment within the Mara River Catchment. To accomplish this, the LVBWB and donors are required to carry out the following:

i. Conduct detailed geological and hydrogeological study of the Mara River Catchment,
ii. Identify and characterize the available aquifers,
iii. Establish groundwater recharge and discharge areas,
iv. Quantify amount of both annual groundwater recharge and sustainable groundwater yield/abstraction for each aquifer/catchment,
v. Establish the groundwater – surface water interactions,
vi. Prepare groundwater monitoring plan, and establish groundwater monitoring stations,
vii. Establish groundwater data management system,
viii. Revise the water balance values for each catchment, and
ix. Establish the required database, management and dissemination tools.

8.1.3 MANAGEMENT OF WATER QUALITY

The quality of water is essential for any Water Allocation Plan since Basin authorities around the globe are not allocating water with poor quality to their users. Mining, Irrigation, Agriculture and Pastoralism are among major human activities available in Mara River Catchment. These activities are a major source of water pollution in the Catchment thus entailing water quality management in the Mara River Catchment.

The available information indicates that water quality monitoring is rarely done in the Mara River Catchment, despite confirmed point source pollution such as discharges from mine sites with heavy metal and low pH values that do not meet discharge standards.

To safeguard water quality in the Mara River Catchment the LVBWB is required to undertake the following steps:

i. Prepare water quality monitoring plan for the Mara River Catchment,
ii. Identify sources and types of water pollution in the Mara River Catchment,
iii. Review the water quality monitoring system by updating and extending the existing system in order to cover both surface and groundwater sources,
iv. Conduct regular discharge compliance monitoring,
v. Create awareness to stakeholders on water pollution issues,
vi. Establish environmental flow requirements for each river/stream in the Catchment,
vii. Conduct River Health Assessment in the Catchment,
viii. Undertake legal enforcement actions to polluters, and
ix. Engage the Kenyan authorities on the water quality management to minimize water pollution emanating from upstream neighbouring country.

8.2 STAKEHOLDER ENGAGEMENT

Both the National Water Policy and the Water Resources Management Act (2009) directs that water resources management should be participatory. The participation envisaged in the above legislations requires that all types of stakeholders be engaged at all levels of water resources management. Similarly, the Integrated Water Resources Management (IWRM) principles requires active stakeholders (especially women) involvement in water resources management.

The Participatory Water Resources Management process required for the implementation of the Mara WAP shall begin with the identification of stakeholders and the analysis of their expectations, rights and responsibilities and of the power dynamics between them. All participatory processes also have to involve the mobilization and sensitization of stakeholders. The process to be followed has to be legitimate and acceptable to all. It is necessary to ensure that all relevant stakeholders are part of the process and their positions and stakes are represented by designated representative accepted by them. The process should be culturally sensitive, socially, and politically appropriate. It must also be transparent in that all parties are aware of all steps in the process and are involved in decision-making as appropriate.

Stakeholder participation should be done at all stages of implementation of this plan and at all levels of water resources management in the Mara River Catchment. To undertake appropriate stakeholders' engagement during the implementation of the Mara WAP, the LVBWB should prepare a clear stakeholders engagement plan that should involve the following key activities:

8.2.1 STAKEHOLDER IDENTIFICATION

The primary aim of stakeholder identification is to document all stakeholders who could and should be involved in the implementation of the WAP process. This is essential to avoid unexpected and undesirable outcomes when stakeholders are not actors in the implementation of the Plan. Due to power relations in the Mara River Catchment, societies will give prominence to some stakeholders and their needs, often at the expense of women and marginalized groups such as people with disability. Processes of stakeholder identification are most complete and effective when they are based on the functions of the resource, instead of attempting to simply list the user groups and other stakeholders. In practice, taking each function of the water resources or the areas under management using the identified Key Result Areas will provide the best decisions and answers to critical issues. The responsibility for stakeholder identification rests primarily with LVBWB.

While stakeholder identification cannot be a fully participatory exercise, since its purpose is precisely to determine who should participate, there can be benefits to be gained from self-selection, i.e. involving some of the stakeholder groups, particularly LGAs in broadening the scope of participation by asking them to identify other stakeholders. In this way, stakeholder identification can become a mechanism to incorporate new participants progressively and to widen the circle of participation, with the aim of making it truly inclusive.

8.2.2 STAKEHOLDER ANALYSIS

The method selected for stakeholder analysis should be based on the specific intent and purpose of the water allocation issues being addressed. Some or a combination of the following typically asked questions will be used during the stakeholder analysis exercise to identify stakeholders' interests:

- What are the current and future interests of the various stakeholders in the use and management of the water resource; how do they use the water resource and what benefits do they derive?
- What are their past and current sources of power, rights and responsibilities, both formal and informal; what are the networks and institutions of which they are part?
- What are the social and environmental impacts, both positive and negative, of their past and current uses of and relationships with the water resource?
- How ready and willing are they to participate in and contribute to the water resources allocation, and what are the potential areas of agreement and shared interest upon which consensus and collaboration can be developed? Which ones do we recommend for the Mara River Catchment and why?

In most cases, it is beneficial to involve stakeholders in identification of stakeholder interests, thus making stakeholder analysis an instrument of negotiation and conflict management. A participatory stakeholder analysis exercise allows the various parties to hear and understand each other's interests and expectations. It has been established that considerable progress can be made in resolving conflicts when stakeholders agree to hear the views and expectations of others, and when they move from stating their individual positions to seeking an overview of the positions of all stakeholders. A participatory stakeholder analysis provides such an opportunity.

8.2.3 STRATEGIES AND MECHANISMS FOR STAKEHOLDER ENGAGEMENT

The following strategies can be implemented for stakeholder engagement in the Stakeholder Mobilization

Participatory water allocation planning and implementation require significant investments in the effective mobilization of all relevant stakeholders. Stakeholder mobilization guarantees that all potential participants in the process are informed of what is happening, are aware of the factors that prompted the process, recognize the legitimacy of the people and organizations that have taken the initiative, and are encouraged to become involved. To make this efficient and effective, mobilization of stakeholders will take place for small groups with common interests. This will help the stakeholders meeting be efficient and productive.

8.2.3.1 Facilitation

Stakeholder engagement in water allocation planning and implementation processes call for skillful and neutral facilitation. The role of facilitators is largely to assure that stakeholder participation is fair and equitable. During implementation of the plan, LVBWB will identify competent and experienced facilitators, preferably from within catchment boundaries, to carry out this assignment.

8.2.3.2 Creating equal opportunities for all

In any given situation, not all stakeholders will have the same opportunity and ability to participate. An individual's participation in planning processes is affected by a number of individual, social, and cultural factors that have little to do with the actual issues being addressed. These factors include: education, age, gender, social class, political affiliation and language. Efforts will be made to ensure that each special interest group have a chance to participate by separating them during group discussions: for example, the elderly, men, women, boy youths, girl youths, children, the disabled, farmers, livestock keepers, etc.

8.2.3.3 Sharing information

Stakeholders can only participate effectively in the plan implementation processes when they have the information needed to develop proposals and make decisions, hence sharing information is critical to ensure their active participation.

8.2.3.4 Sustaining Participation

Given the constant and often rapid pace of change, planning cannot end with the implementation of decisions, but must be an ongoing process. Responding to change requires flexible structures that involve all actors in management and decision-making. Incentives may be used to sustain participatory planning preferable in kind, that may include training, study visits, certification of people attended special workshops etc.

8.3 CAPACITY BUILDING

Capacity building is a permanent and continuous activity required for the good functioning of any organisation. The LVBWB should prepare a clear capacity development plan (CD-Plan) required for the effective and efficient implementation of the Mara WAP. The CD-Plan should consider but is not limited to the following:

8.3.1 INSTITUTION FRAMEWORK

The available Institution Framework in the Mara River Catchment is adequate. The available Water User Associations (WUAs) and the Catchment Committee are well-suited for the implementation of this Plan. WUA composition and spatial coverage should be reviewed to ensure all members are involved and the areas are of manageable size. Some of the WUAs, such as Tobora and Somoche, occupy larger areas that involve long travel distances during the implementation of their activities.

The available WUAs need to be capacitated on a regular basis as needs arise. This may include providing WUAs with the required working tools and offices for them to be effective, be known and be recognised at the local level. Training in water resources management, financial management and conflict resolution are among the important areas required by WUAs.

8.3.2 WORKING TEAM/STAFFING

The available staff in the Mara Catchment Committee is not adequate both in terms of the number required and type of professions. These staff also lack experience as most of them are relatively newly employed from school. The current staff ability to undertake hydrogeological, hydrological, water quality monitoring and technical information management system is inadequate and needs further improvement. There is a challenge for staff to generate accurate and complete water resources data because of non-operating monitoring stations and limited resources for the data collection, processing and storage.

The following capacity building are immediately required:

i. Water resources data management (including quality control).
ii. Procurement, installation, operation and maintenance of the required and the currently used water resources management software and databases.
iii. Hands-on training in hydrogeological, water quality, hydraulic and hydrological modelling (developing rating curves).
iv. International water laws, water diplomacy and customer care.
v. Report writing, preparation of concept note, proposals and financial mobilization.

vi. Water resources allocation and abstraction compliance monitoring.

Basic technical training should be offered to gauge readers on the value of consistent and careful data collection, storage, and its uses in understanding the behaviour of the Catchment. Staff in water laboratory should have competency in the following:

- Sample collection and field measurements.
- Laboratory analysis (physical, biological and chemical data).
- Data entry, data analysis and data dissemination.
- Customer care.

Some deficiencies in staff capacity can be solved by short-term training but the long-term solution lies in the recruitment of well-qualified technicians with graduate and post-graduate degrees. The LVBWB should encourage technical staff to enroll in advanced degrees by providing staff development opportunities and job security.

8.3.3 EQUIPMENT

The LVBWB should provide the necessary working tools and instruments to staff required for the implementation of the Plan. Gauge readers and WUAs should not be forgotten in this as they are the ones living with water users. Some of the required tools and instrument include measuring instruments, computers, software, internet, mobile phones and transport.

8.4 DEMAND MANAGEMENT

In general, the assessed flow values in the Mara River Catchment are sufficient to meet the current and future sectoral water demand. This is not true when negative water balances are manifested for individual sub-catchments due to both temporal and spatial variation of river flows. Therefore, demand management measures should be implemented together with the application of water allocation guidelines in areas and times of negative water balances. The following demand management measures can be implemented in the Mara River Catchment.

i. Conjunctive use of Surface and Groundwater, especially for sectors with high water demand such as Irrigation, Agriculture, Domestic Water Supply and Mining.

ii. Prioritization on permit issuance and on type of uses, this can involve setting abstraction thresholds per source and identification of key activities to be done and those that cannot be done in certain catchments. The identification of these activities should be done by involving stakeholders.

iii. Construction of water storage facilities.

iv. Rainwater harvesting.

v. Promoting efficient water use.

8.5 FINANCIAL STRATEGY

A clear financial strategy and implementable financing plan is required for the successful implementation of the Mara WAP. The financial resources mobilisation strategy and plan for the implementation of the Mara WAP should be prepared and implemented by the LVBWB. The objective of the financial resource mobilization is to ensure that resources are available for the implementation of the plan and its related activities. With increasing competition for scant grant resources, creating options for new, diverse and multiple funding is crucial. Financial resources mobilization does not take place in a vacuum; it needs resources. The LVBWB can capitalise in the interaction between the state, civil society organizations and business to gain a profound impact on raising awareness.

Financial resources mobilization requires development of an ethical framework for fundraising, ensuring transparency, developing trust, indication of commitment and having clear and convincing case for support. The Basin Water Board can maximize benefits accruing from environmental factors.

Several methods can be used for financial resources mobilization, which include:

- Grand project proposal writing: writing sound and competitive proposals for funding,
- Writing programs or activities for funding.
- Organizing events.
- Developing fundraising strategies.

The Basin can also access the following environmental funds, which exist in three general categories:

i. **Government environmental funds**

These include: comprehensive National Environmental Funds (NEFs), pollution abatement funds and forestry funds which are typically created by national law, controlled by government and financed primarily through public sources of revenue (domestic budget and ear-marked taxes).

ii. **Conservation trust funds**

These are generally registered as private legal entities, although they are established under a variety of different legal regimes, and have majority non-governmental boards or strong participation of civil society. They raise funds from different sources (donations, debt-for-nature swaps, user fees, government budget allocations or investment schemes) and focus primarily on financing conservation and sustainable development activities through grants.

iii. **Private sector funds**

These are private funds that provide equity and credit financing to private sector companies making environmental investments.

The following challenges to effective financial resources mobilisation should be considered:

i. **Lack of structured and coordinated information**

Information flow related to financial resources mobilisation lacks within and beyond the government. There are little efforts on resource mobilization strategies and targets. There is also a significant lack of information on who is responsible for resources mobilisation in general and for fundraising in particular. Information relating to donor profiles, processes, funding opportunities, predictability of funding needs to be readily available or easy to access.

ii. **Lack of Incentives and Empowerment**

Staff members require incentives to identify opportunities, design projects and articulate activities to donor audiences.

iii. **Lack of Donor and Partner Interaction Opportunities**

Mobilizing resources is intimately linked with two factors: (1) knowing about an opportunity that exists, and (2) getting the donor’s attention. The latter requires in most cases getting in front of the donor. Donor intelligence-gathering must be done for the effective financial resource mobilisation.

iv. **Emphasis on producing results and monitoring impact**

Donors are placing increasing importance on implementation, delivery, monitoring and evaluation of programmes, as well as documentation of impact. The Basin should in its proposals, reports and through inter-personal communication highlight the mechanisms and systems it has in place to ensure accountability, transparency and cost-effectiveness.

v. Capacity to articulate and effectively carryout financial resources mobilization

Capacity to articulate and effectively carryout financial resources mobilisation is inadequate and must be strengthened in the LVBWB.

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10 Annexes

Annex A: Hydrological statistics

Table A-1: Hydrological statistics for Serengeti sub-basin (m^3/s)

Statistics Serengeti	10	11	12	1	2	3	4	5	6	7	8	9	Filled	WET	DRY
Average	19.46	19.84	26.33	21.80	17.54	23.48	48.63	56.95	31.70	23.38	26.16	31.89	28.93	42.29	22.26
Min	3.68	4.11	0.76	2.05	1.32	5.53	10.22	14.22	6.90	2.80	7.65	8.30	0.76	6.90	0.76
Max	53.42	69.43	91.54	70.93	37.16	55.85	86.47	125.09	63.12	64.84	55.74	66.94	125.09	125.09	91.54
VALID	49	49	49	49	49	49	49	49	49	49	49	49	588		
MISSING	0	0	0	0	0	0	0	0	0	0	0	0	0		
%-MISSING	0	0	0	0	0	0	0	0	0	0	0	0	0		
STDEV	9.04	13.61	18.13	15.12	9.58	12.66	19.58	24.24	13.46	12.22	9.76	14.37	18.82	21.30	13.08
CV	0.46	0.69	0.69	0.69	0.55	0.54	0.40	0.43	0.42	0.52	0.37	0.45	0.65	0.50	0.59
Percentiles	**10**	**11**	**12**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**P7_ANN**		
0.1	52.68	68.72	90.72	70.25	37.03	55.76	86.46	124.35	62.97	64.28	55.19	66.70	115.59	121.94	84.64
0.2	51.94	68.00	89.91	69.58	36.91	55.68	86.44	123.60	62.83	63.71	54.64	66.46	107.78	118.81	77.91
0.5	49.73	65.85	87.48	67.56	36.53	55.43	86.41	121.37	62.40	62.02	52.99	65.75	100.04	109.47	65.42
1	46.03	62.26	83.42	64.18	35.90	55.02	86.35	117.65	61.69	59.19	50.25	64.56	87.13	102.94	59.12
2	38.64	55.08	75.30	57.44	34.64	54.18	86.22	110.20	60.25	53.54	44.76	62.17	80.88	94.21	53.95
5	36.12	44.77	60.78	49.64	33.71	44.16	84.32	101.66	58.00	43.80	42.55	59.40	66.39	82.58	43.99
10	30.11	38.04	51.67	42.68	31.30	43.06	77.89	87.52	49.99	40.92	39.76	52.70	55.52	69.91	37.34
15	27.91	33.26	43.13	40.20	29.13	36.41	70.25	75.92	45.39	37.47	35.72	48.48	46.88	62.13	33.37
20	26.42	30.15	32.53	33.91	28.14	32.69	67.34	72.39	42.46	34.05	33.62	43.36	42.53	59.98	30.76
30	21.09	21.76	28.65	26.56	21.79	28.76	58.17	67.50	38.56	25.18	30.76	37.70	34.02	53.02	26.67
40	19.75	17.98	25.84	21.44	17.11	24.89	52.94	60.67	35.19	22.20	28.56	30.76	28.87	44.53	22.12
50	17.77	16.00	22.13	17.12	15.30	23.53	46.59	55.84	30.42	20.64	26.55	28.55	24.20	40.33	19.76
60	15.76	14.11	20.40	13.99	13.23	17.69	44.01	55.18	28.66	20.08	22.30	25.06	20.36	34.47	16.67
70	14.47	11.98	18.58	12.26	11.76	13.33	40.32	43.57	24.78	17.30	20.67	24.32	17.61	29.23	13.61
80	12.79	9.68	16.14	9.60	9.81	11.95	34.47	38.27	20.40	15.40	18.33	20.25	13.58	24.35	11.50
85	12.43	8.84	12.71	9.35	7.17	11.20	29.01	35.88	19.11	12.77	17.91	19.13	11.95	21.96	9.84
90	10.43	5.88	9.91	8.21	5.73	9.34	25.18	25.13	17.96	10.84	15.73	15.86	9.77	18.94	8.07
95	7.90	5.32	5.78	5.37	3.88	7.32	16.73	21.40	14.32	9.83	12.78	10.16	7.17	13.55	5.65
98	6.40	4.80	3.03	2.76	2.12	7.01	11.37	18.37	10.70	9.08	8.23	9.26	4.62	9.49	2.82
99	5.04	4.46	2.74	2.40	1.72	6.27	10.80	16.29	8.80	5.94	7.94	8.78	2.82	8.00	2.19
99.5	4.36	4.29	2.59	2.23	1.52	5.90	10.51	15.26	7.85	4.37	7.79	8.54	2.18	7.01	1.65

99.8	3.96	4.18	2.51	2.12	1.40	5.68	10.34	14.63	7.28	3.43	7.71	8.40	1.44	6.95	1.08
99.9	3.82	4.15	2.48	2.09	1.36	5.61	10.28	14.42	7.09	3.12	7.68	8.35	1.09	6.92	0.92

Table A-2: Hydrological statistics for Tobora sub-basin (m^3/s)

Statistics Tobora	**10**	**11**	**12**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**Filled**	**WET**	**DRY**
Average	0.21	0.43	0.75	0.49	0.45	0.83	1.38	1.50	0.46	0.18	0.03	0.19	0.58	1.12	0.31
Min	0.00	0.01	0.01	0.02	0.00	0.09	0.15	0.11	0.00	0.00	0.00	0.00	0.00	0.01	0.00
Max	1.06	1.30	3.02	1.38	1.23	2.09	2.87	3.68	1.63	0.91	0.11	0.64	3.68	3.68	1.63
VALID	49	49	49	49	49	49	49	49	49	49	49	49	588		
MISSING	0	0	0	0	0	0	0	0	0	0	0	0	0		
%-MISSING	0	0	0	0	0	0	0	0	0	0	0	0	0		
STDEV	0.22	0.34	0.58	0.36	0.29	0.47	0.68	0.84	0.44	0.20	0.03	0.16	0.63	0.73	0.32
CV	1.04	0.78	0.77	0.72	0.64	0.56	0.49	0.56	0.95	1.14	0.77	0.83	1.09	0.65	1.05
Percentiles	**10**	**11**	**12**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**P7_ANN**		
0.1	1.05	1.30	2.97	1.37	1.22	2.07	2.86	3.67	1.63	0.90	0.11	0.64	3.53	3.63	1.60
0.2	1.04	1.30	2.93	1.36	1.21	2.06	2.85	3.66	1.62	0.89	0.11	0.64	3.36	3.58	1.58
0.5	1.01	1.30	2.79	1.35	1.19	2.01	2.83	3.62	1.61	0.87	0.11	0.64	3.02	3.43	1.44
1	0.95	1.29	2.55	1.32	1.15	1.94	2.79	3.56	1.60	0.82	0.10	0.64	2.71	3.08	1.35
2	0.85	1.29	2.07	1.26	1.07	1.78	2.71	3.44	1.57	0.74	0.10	0.63	2.39	2.82	1.24
5	0.68	1.19	1.79	1.22	0.98	1.61	2.50	2.98	1.40	0.61	0.09	0.54	1.85	2.45	1.00
10	0.56	0.95	1.51	1.00	0.84	1.54	2.40	2.63	1.21	0.42	0.07	0.37	1.45	2.20	0.80
15	0.31	0.84	1.29	0.91	0.79	1.42	2.25	2.35	0.91	0.34	0.06	0.31	1.21	1.81	0.65
20	0.27	0.64	1.19	0.87	0.68	1.23	1.95	2.27	0.77	0.30	0.06	0.28	0.95	1.65	0.55
30	0.21	0.56	0.84	0.66	0.57	0.95	1.76	1.98	0.60	0.20	0.04	0.23	0.72	1.44	0.39
40	0.17	0.43	0.75	0.49	0.43	0.87	1.49	1.55	0.43	0.15	0.03	0.21	0.51	1.21	0.30
50	0.15	0.33	0.70	0.38	0.39	0.79	1.30	1.35	0.31	0.09	0.03	0.16	0.34	1.01	0.23
60	0.11	0.25	0.59	0.34	0.31	0.67	1.16	1.28	0.25	0.07	0.02	0.12	0.25	0.83	0.15
70	0.08	0.23	0.43	0.25	0.29	0.46	0.94	1.14	0.16	0.06	0.02	0.09	0.16	0.69	0.09
80	0.07	0.17	0.28	0.20	0.25	0.40	0.79	0.84	0.11	0.03	0.01	0.04	0.08	0.47	0.05
85	0.06	0.13	0.25	0.15	0.15	0.39	0.68	0.61	0.08	0.02	0.01	0.04	0.05	0.39	0.04
90	0.05	0.10	0.21	0.13	0.09	0.33	0.64	0.45	0.04	0.01	0.01	0.03	0.03	0.30	0.03
95	0.04	0.06	0.12	0.10	0.04	0.28	0.42	0.28	0.02	0.01	0.00	0.01	0.02	0.22	0.02
98	0.00	0.05	0.09	0.04	0.03	0.16	0.22	0.26	0.00	0.00	0.00	0.00	0.00	0.11	0.00
99	0.00	0.03	0.08	0.03	0.01	0.13	0.19	0.26	0.00	0.00	0.00	0.00	0.00	0.08	0.00
99.5	0.00	0.02	0.07	0.03	0.01	0.11	0.17	0.26	0.00	0.00	0.00	0.00	0.00	0.05	0.00

Table A-3: Hydrological statistics for Somoche sub-basin (m^3/s)

Statistics Somoche	10	11	12	1	2	3	4	5	6	7	8	9	Filled	WET	DRY
Average	0.40	0.82	1.31	0.95	0.84	1.56	2.62	2.85	0.73	0.28	0.06	0.34	1.06	2.08	0.55
Min	0.01	0.08	0.02	0.05	0.00	0.33	0.34	0.21	0.00	0.00	0.00	0.00	0.00	0.02	0.00
Max	1.93	2.39	5.16	2.48	2.12	3.87	5.24	6.90	2.37	1.23	0.19	1.15	6.90	6.90	2.48
VALID	49	49	49	49	49	49	49	49	49	49	49	49	588		
MISSING	0	0	0	0	0	0	0	0	0	0	0	0	0		
%-MISSING	0	0	0	0	0	0	0	0	0	0	0	0	0		
STDEV	0.38	0.60	0.98	0.66	0.51	0.85	1.23	1.55	0.64	0.28	0.04	0.25	1.15	1.35	0.55
CV	0.95	0.74	0.75	0.70	0.60	0.54	0.47	0.54	0.88	1.00	0.72	0.75	1.09	0.65	1.00
Percentiles	**10**	**11**	**12**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**H2_ANN**		
0.1	1.91	2.38	5.07	2.47	2.11	3.83	5.22	6.87	2.37	1.22	0.19	1.14	6.61	6.80	2.44
0.2	1.89	2.38	4.98	2.47	2.10	3.80	5.21	6.85	2.37	1.21	0.19	1.13	6.29	6.71	2.41
0.5	1.82	2.36	4.71	2.45	2.07	3.69	5.17	6.79	2.37	1.17	0.18	1.10	5.27	6.45	2.37
1	1.72	2.33	4.27	2.43	2.02	3.52	5.10	6.67	2.37	1.11	0.17	1.06	4.96	5.44	2.36
2	1.51	2.28	3.37	2.37	1.91	3.16	4.95	6.45	2.36	0.99	0.16	0.97	4.50	4.93	2.23
5	1.12	2.15	3.06	2.33	1.70	3.02	4.58	5.57	2.18	0.88	0.15	0.86	3.43	4.39	1.80
10	1.00	1.76	2.54	1.87	1.50	2.85	4.41	4.82	1.78	0.62	0.12	0.64	2.63	3.93	1.38
15	0.59	1.49	2.21	1.72	1.39	2.64	4.14	4.33	1.35	0.53	0.11	0.50	2.21	3.37	1.14
20	0.49	1.22	2.07	1.59	1.25	2.25	4.03	4.04	1.16	0.49	0.10	0.48	1.81	3.07	1.01
30	0.43	1.02	1.44	1.21	1.08	1.76	3.28	3.64	0.92	0.36	0.08	0.41	1.25	2.55	0.73
40	0.32	0.84	1.32	0.99	0.84	1.62	2.72	3.22	0.77	0.23	0.06	0.35	0.91	2.26	0.54
50	0.29	0.62	1.17	0.73	0.75	1.53	2.41	2.67	0.52	0.20	0.05	0.30	0.62	1.86	0.43
60	0.23	0.48	1.07	0.68	0.60	1.26	2.23	2.50	0.43	0.13	0.05	0.21	0.46	1.56	0.28
70	0.20	0.44	0.77	0.55	0.55	0.90	1.99	2.20	0.28	0.10	0.04	0.17	0.29	1.32	0.19
80	0.16	0.38	0.53	0.39	0.46	0.74	1.55	1.68	0.22	0.08	0.02	0.14	0.16	0.89	0.11
85	0.15	0.27	0.49	0.34	0.29	0.72	1.41	1.14	0.16	0.06	0.02	0.10	0.11	0.72	0.08
90	0.13	0.18	0.36	0.25	0.20	0.59	1.21	0.85	0.14	0.02	0.01	0.07	0.07	0.59	0.06
95	0.08	0.16	0.20	0.20	0.09	0.57	0.99	0.61	0.07	0.01	0.01	0.04	0.03	0.38	0.03
98	0.01	0.09	0.16	0.08	0.04	0.51	0.40	0.55	0.03	0.00	0.00	0.02	0.01	0.20	0.01
99	0.01	0.09	0.13	0.06	0.02	0.42	0.37	0.52	0.01	0.00	0.00	0.01	0.00	0.12	0.00
99.5	0.01	0.09	0.12	0.06	0.01	0.37	0.36	0.50	0.01	0.00	0.00	0.00	0.00	0.07	0.00
99.8	0.01	0.08	0.11	0.05	0.00	0.35	0.35	0.49	0.00	0.00	0.00	0.00	0.00	0.04	0.00

Table A-4: Hydrological statistics for Mara Mines sub-basin (m^3/s)

Statistics Mara Mines	10	11	12	1	2	3	4	5	6	7	8	9	Filled	WET	DRY
Average	20.39	21.57	29.12	23.71	19.17	26.77	54.37	62.84	33.41	24.07	26.29	32.67	31.20	45.82	23.89
Min	3.70	4.31	0.81	2.22	1.45	6.81	11.07	16.68	6.97	3.14	7.72	8.44	0.81	6.97	0.81
Max	54.04	74.35	102.35	74.68	40.19	62.13	96.79	139.08	68.46	66.42	55.97	67.29	139.08	139.08	102.35
VALID	49	49	49	49	49	49	49	49	49	49	49	49	588		
MISSING	0	0	0	0	0	0	0	0	0	0	0	0	0		
%-MISSING	0	0	0	0	0	0	0	0	0	0	0	0	0		
STDEV	9.47	14.66	19.92	16.25	10.38	14.09	21.91	26.97	14.51	12.64	9.79	14.61	20.73	23.98	14.06
CV	0.46	0.68	0.68	0.69	0.54	0.53	0.40	0.43	0.43	0.53	0.37	0.45	0.66	0.52	0.59
Percentiles	**10**	**11**	**12**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**P7_ANN**		
0.1	53.39	73.62	101.35	74.05	40.08	62.10	96.72	138.29	68.29	65.90	55.41	67.09	129.00	135.73	93.85
0.2	52.74	72.88	100.35	73.42	39.97	62.06	96.66	137.50	68.13	65.38	54.85	66.89	120.12	132.42	85.58
0.5	50.80	70.69	97.35	71.53	39.64	61.96	96.46	135.13	67.65	63.82	53.18	66.30	111.50	122.51	68.47
1	47.56	67.03	92.36	68.37	39.08	61.79	96.13	131.18	66.84	61.21	50.39	65.31	97.51	112.43	63.96
2	41.09	59.71	82.36	62.07	37.97	61.44	95.48	123.29	65.22	56.01	44.82	63.33	89.27	104.51	57.59
5	38.46	48.68	66.42	53.52	36.88	50.11	93.41	111.57	60.51	45.45	42.69	60.88	72.99	90.26	49.73
10	33.01	41.05	56.22	46.94	34.23	47.72	86.82	94.95	52.04	42.10	39.89	54.05	61.37	78.70	39.96
15	29.82	36.45	48.09	43.14	31.44	40.00	80.64	82.04	49.21	38.66	35.95	49.55	50.46	69.40	36.34
20	27.21	32.68	37.53	37.16	30.46	36.37	75.92	80.33	45.78	34.44	33.82	44.10	44.86	64.88	33.43
30	21.85	24.38	31.72	29.41	23.01	33.24	65.26	74.81	41.32	26.26	30.90	38.47	36.39	57.37	28.43
40	20.71	19.93	30.16	23.35	18.95	28.53	58.58	68.01	36.24	22.98	28.74	31.93	30.60	48.99	24.32
50	18.53	17.36	24.81	18.56	16.89	26.45	51.66	62.97	31.60	21.23	26.63	28.92	25.98	43.17	20.70
60	16.47	15.23	22.66	15.37	14.53	20.61	48.62	59.74	29.54	20.38	22.36	26.05	21.50	37.02	17.79
70	15.53	12.87	19.82	13.28	12.73	16.01	44.91	45.67	25.77	18.19	20.82	25.08	18.39	30.18	14.80
80	13.32	10.57	17.62	10.81	10.99	14.02	38.85	43.16	21.25	15.57	18.35	20.69	14.71	25.74	12.43
85	12.63	9.60	14.10	10.27	8.30	13.26	31.99	39.47	19.67	13.00	17.95	19.81	13.06	22.77	10.91
90	10.86	6.87	11.66	8.86	6.45	10.70	29.15	26.48	18.31	11.06	15.83	15.99	10.93	19.67	8.77
95	8.34	6.11	6.15	5.79	4.02	8.69	18.09	22.67	14.52	10.06	12.80	10.61	7.91	14.44	6.17
98	6.94	5.17	3.41	2.86	2.21	8.14	13.58	20.54	10.71	9.24	8.35	9.65	4.98	10.01	3.15
99	5.32	4.74	3.04	2.54	1.83	7.48	12.33	19.86	8.84	6.19	8.04	9.04	3.11	8.11	2.27
99.5	4.51	4.52	2.86	2.38	1.64	7.14	11.70	19.52	7.91	4.67	7.88	8.74	2.27	7.07	1.80
99.8	4.03	4.40	2.75	2.29	1.52	6.94	11.33	19.32	7.34	3.75	7.79	8.56	1.58	7.01	1.17
99.9	3.87	4.35	2.71	2.25	1.49	6.87	11.20	19.25	7.16	3.45	7.76	8.50	1.18	6.99	0.99

Table A-5: Hydrological statistics for Tigithe sub-basin (m^3/s)

Statistics Tigithe	10	11	12	1	2	3	4	5	6	7	8	9	Filled	WET	DRY
Average	0.32	0.46	0.67	0.41	0.29	0.84	1.68	1.42	0.49	0.24	0.03	0.24	0.59	1.15	0.31
Min	0.01	0.00	0.01	0.02	0.00	0.12	0.21	0.09	0.00	0.00	0.00	0.00	0.00	0.01	0.00
Max	1.13	1.14	2.32	1.03	0.71	2.00	4.82	3.11	1.73	0.84	0.08	0.79	4.82	4.82	1.73
VALID	49	49	49	49	49	49	49	49	49	49	49	49	588		
MISSING	0	0	0	0	0	0	0	0	0	0	0	0	0		
%-MISSING	0	0	0	0	0	0	0	0	0	0	0	0	0		
STDEV	0.28	0.31	0.50	0.28	0.18	0.48	0.83	0.76	0.38	0.23	0.02	0.19	0.64	0.78	0.29
CV	0.88	0.67	0.76	0.68	0.61	0.57	0.50	0.53	0.77	0.96	0.81	0.80	1.09	0.67	0.93
Percentiles	**10**	**11**	**12**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**P7_ANN**		
0.1	1.13	1.14	2.30	1.03	0.71	2.00	4.76	3.10	1.71	0.84	0.08	0.78	4.07	4.57	1.57
0.2	1.13	1.14	2.27	1.03	0.71	2.00	4.70	3.10	1.69	0.84	0.08	0.78	3.46	4.32	1.41
0.5	1.12	1.14	2.21	1.03	0.71	1.99	4.53	3.08	1.64	0.84	0.08	0.76	3.01	3.58	1.25
1	1.10	1.14	2.10	1.02	0.71	1.98	4.23	3.06	1.54	0.84	0.08	0.73	2.71	3.14	1.14
2	1.07	1.13	1.88	1.00	0.71	1.97	3.64	3.01	1.35	0.83	0.08	0.67	2.39	2.91	1.03
5	0.93	1.04	1.54	0.96	0.55	1.93	2.74	2.80	1.18	0.73	0.07	0.63	2.04	2.48	0.91
10	0.74	0.91	1.35	0.86	0.51	1.46	2.46	2.47	0.98	0.58	0.07	0.52	1.46	2.13	0.77
15	0.63	0.83	1.21	0.80	0.51	1.30	2.37	2.14	0.89	0.45	0.07	0.49	1.15	2.04	0.63
20	0.53	0.76	1.05	0.64	0.47	1.12	2.18	2.09	0.79	0.39	0.06	0.41	0.96	1.89	0.54
30	0.40	0.59	0.90	0.53	0.31	0.98	2.09	1.86	0.62	0.31	0.04	0.29	0.70	1.47	0.42
40	0.31	0.52	0.67	0.43	0.29	0.84	2.00	1.59	0.48	0.25	0.03	0.23	0.51	1.23	0.35
50	0.24	0.42	0.55	0.36	0.25	0.78	1.66	1.44	0.41	0.19	0.02	0.18	0.38	1.04	0.27
60	0.17	0.30	0.49	0.27	0.21	0.67	1.41	1.19	0.36	0.13	0.02	0.16	0.27	0.85	0.20
70	0.14	0.27	0.41	0.24	0.19	0.58	1.27	0.99	0.29	0.07	0.01	0.10	0.18	0.70	0.13
80	0.09	0.22	0.27	0.17	0.15	0.44	1.11	0.80	0.18	0.04	0.01	0.08	0.09	0.49	0.07
85	0.08	0.16	0.22	0.16	0.13	0.34	0.86	0.68	0.13	0.01	0.01	0.07	0.07	0.43	0.04
90	0.06	0.09	0.13	0.10	0.07	0.34	0.74	0.46	0.10	0.00	0.00	0.05	0.03	0.34	0.02
95	0.04	0.06	0.09	0.07	0.03	0.25	0.55	0.38	0.04	0.00	0.00	0.03	0.01	0.22	0.01
98	0.01	0.04	0.07	0.03	0.00	0.12	0.42	0.30	0.01	0.00	0.00	0.02	0.00	0.09	0.00
99	0.01	0.02	0.06	0.03	0.00	0.12	0.31	0.26	0.01	0.00	0.00	0.01	0.00	0.08	0.00
99.5	0.01	0.01	0.06	0.02	0.00	0.12	0.26	0.24	0.00	0.00	0.00	0.00	0.00	0.05	0.00
99.8	0.01	0.00	0.06	0.02	0.00	0.12	0.23	0.23	0.00	0.00	0.00	0.00	0.00	0.03	0.00
99.9	0.01	0.00	0.06	0.02	0.00	0.12	0.22	0.22	0.00	0.00	0.00	0.00	0.00	0.02	0.00

Table A-6: Hydrological statistics for Mara Wetland sub-basin (m^3/s)

Statistics Mara Wetland	10	11	12	1	2	3	4	5	6	7	8	9	Filled	WET	DRY
Average	21.98	23.80	32.36	25.67	20.65	30.93	63.03	69.99	35.63	25.12	26.42	33.76	34.11	56.22	26.75
Min	3.73	4.52	0.86	2.39	1.59	7.76	12.08	17.12	7.04	4.34	7.79	8.59	0.86	7.04	0.86
Max	54.82	79.74	113.42	78.49	42.45	71.62	110.80	153.93	74.36	69.96	56.29	67.68	153.93	153.93	113.42
VALID	49	49	49	49	49	49	49	49	49	49	49	49	588		
MISSING	0	0	0	0	0	0	0	0	0	0	0	0	0		
%-MISSING	0	0	0	0	0	0	0	0	0	0	0	0	0		
STDEV	10.12	15.75	21.97	17.31	11.02	16.00	25.29	29.88	15.87	13.19	9.83	14.92	23.29	28.43	15.41
CV	0.46	0.66	0.68	0.67	0.53	0.52	0.40	0.43	0.45	0.53	0.37	0.44	0.68	0.51	0.58
Percentiles	**10**	**11**	**12**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**H1_ANN**		
0.1	54.30	78.99	112.23	77.90	42.39	71.47	110.72	153.09	74.25	69.34	55.72	67.59	143.24	151.27	102.02
0.2	53.79	78.24	111.04	77.30	42.33	71.32	110.63	152.25	74.13	68.73	55.15	67.50	133.65	148.61	90.94
0.5	52.24	76.00	107.46	75.53	42.16	70.86	110.38	149.74	73.80	66.88	53.44	67.23	122.86	140.64	74.33
1	49.66	72.26	101.51	72.57	41.87	70.09	109.96	145.55	73.23	63.81	50.59	66.77	111.14	130.24	69.60
2	44.51	64.79	89.59	66.65	41.29	68.56	109.11	137.18	72.11	57.66	44.88	65.86	98.55	122.88	63.44
5	42.22	53.73	72.84	56.57	38.69	58.33	108.04	123.51	65.40	47.47	42.88	62.24	81.40	108.04	55.86
10	35.99	43.89	61.98	51.15	36.71	54.98	102.38	103.77	55.55	44.07	39.96	56.04	66.82	92.25	44.80
15	32.02	40.42	56.76	44.58	33.95	45.37	93.46	91.90	52.25	39.71	36.22	51.25	56.65	86.81	40.37
20	30.07	35.80	42.04	40.53	32.09	43.06	87.85	88.96	48.12	35.05	33.89	45.73	48.44	78.44	36.80
30	24.64	26.24	36.74	32.03	25.23	37.62	75.38	84.52	44.03	27.06	30.99	39.36	39.33	70.66	31.38
40	22.34	22.88	33.04	25.70	20.15	33.52	65.29	76.51	38.36	24.33	28.89	33.63	32.62	60.31	27.35
50	20.37	19.59	27.53	19.71	18.26	30.07	58.70	72.36	32.57	22.02	26.70	30.52	27.41	52.80	23.09
60	17.65	16.98	25.34	16.35	16.27	23.12	56.72	64.80	31.52	20.88	22.42	26.98	23.18	46.80	20.18
70	16.93	14.43	22.25	14.87	13.57	18.38	52.63	55.31	27.61	19.63	21.08	25.80	19.70	38.05	17.23
80	13.98	12.85	19.32	11.98	12.13	15.95	47.11	47.28	23.57	15.77	18.36	22.46	16.34	30.49	13.65
85	13.27	10.89	17.31	11.03	9.39	15.37	38.53	45.20	20.64	13.76	17.99	20.74	13.92	26.09	12.29
90	12.15	8.80	13.90	9.80	6.96	12.53	32.80	29.31	19.22	11.91	15.94	16.43	12.06	23.28	10.00
95	8.73	6.35	6.53	6.36	4.25	11.43	21.90	25.43	14.74	10.29	12.80	11.86	8.45	18.52	7.48
98	7.98	5.57	3.81	2.96	2.22	8.91	16.15	23.69	10.71	9.34	8.56	9.75	5.46	12.00	3.80
99	5.85	5.04	3.38	2.67	1.91	8.33	14.12	23.19	8.88	6.84	8.18	9.17	3.63	8.94	2.54
99.5	4.79	4.78	3.16	2.53	1.75	8.05	13.10	22.94	7.96	5.59	7.99	8.88	2.39	7.12	2.00
99.8	4.15	4.63	3.03	2.45	1.65	7.87	12.49	22.80	7.41	4.84	7.87	8.70	1.71	7.07	1.32

Table 10-7: Flood statistics for the six sub-basins

Serengeti	**10**	**11**	**12**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**ANN**	**WET**	**DRY**
	FV [m^3]	FV [m^3]	FV [m^3]	FV [m^3]	FV [m^3]	FV [m^3]	FV [m^3]	FV [m^3]	FV [m^3]	FV [m^3]	FV [m^3]	FV [m^3]	FV [m^3]	FV [m^3]	FV [m^3]
	46,470,462	47,576,423	66,358,387	54,734,074	39,014,021	57,647,690	116,060,943	138,910,487	75,661,945	57,645,735	62,873,617	74,032,086	858,095,512	410,799,030	424,316,275
	FV [Mm^3]	FV [Mm^3]	FV [Mm^3]	FV [Mm^3]	FV [Mm^3]	FV [Mm^3]	FV [Mm^3]	FV [Mm^3]	FV [Mm^3]	FV [Mm^3]	FV [Mm^3]	FV [Mm^3]	FV [Mm^3]	FV [Mm^3]	FV [Mm^3]
	46.47	47.58	66.36	54.73	39.01	57.65	116.06	138.91	75.66	57.65	62.87	74.03	858.10	410.80	424.32
	FV [m^3/d]	FV [m^3/d]	FV [m^3/d]	FV [m^3/d]	FV [m^3/d]	FV [m^3/d]	FV [m^3/d]	FV [m^3/d]	FV [m^3/d]	FV [m^3/d]	FV [m^3/d]	FV [m^3/d]	FV [m^3/d]	FV [m^3/d]	FV [m^3/d]
	1,499,047	1,585,881	2,140,593	1,765,615	1,393,358	1,859,603	3,868,698	4,480,983	2,522,065	1,859,540	2,028,181	2,467,736	2,350,947	3,395,033	1,739,001
	FV [Mm^3/d]	FV [Mm^3/d]	FV [Mm^3/d]	FV [Mm^3/d]	FV [Mm^3/d]	FV [Mm^3/d]	FV [Mm^3/d]	FV [Mm^3/d]	FV [Mm^3/d]	FV [Mm^3/d]	FV [Mm^3/d]	FV [Mm^3/d]	FV [Mm^3/d]	FV [Mm^3/d]	FV [Mm^3/d]
	1.50	1.59	2.14	1.77	1.39	1.86	3.87	4.48	2.52	1.86	2.03	2.47	2.35	3.40	1.74
Tobora	**10**	**11**	**12**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**ANN**	**WET**	**DRY**
	FV [m^3]	FV [m^3]	FV [m^3]	FV [m^3]	FV [m^3]	FV [m^3]	FV [m^3]	FV [m^3]	FV [m^3]	FV [m^3]	FV [m^3]	FV [m^3]	FV [m^3]	FV [m^3]	FV [m^3]
	529,230	1,086,949	1,950,888	1,280,087	1,022,615	2,046,852	3,322,452	3,838,510	1,179,608	460,428	90,582	470,674	18,010,345	11,378,966	6,674,657
	FV [Mm^3]	FV [Mm^3]	FV [Mm^3]	FV [Mm^3]	FV [Mm^3]	FV [Mm^3]	FV [Mm^3]	FV [Mm^3]	FV [Mm^3]	FV [Mm^3]	FV [Mm^3]	FV [Mm^3]	FV [Mm^3]	FV [Mm^3]	FV [Mm^3]
	0.53	1.09	1.95	1.28	1.02	2.05	3.32	3.84	1.18	0.46	0.09	0.47	18.01	11.38	6.67
	FV [m^3/d]	FV [m^3/d]	FV [m^3/d]	FV [m^3/d]	FV [m^3/d]	FV [m^3/d]	FV [m^3/d]	FV [m^3/d]	FV [m^3/d]	FV [m^3/d]	FV [m^3/d]	FV [m^3/d]	FV [m^3/d]	FV [m^3/d]	FV [m^3/d]
	17,072	36,232	62,932	41,293	36,522	66,027	110,748	123,823	39,320	14,853	2,922	15,689	49,343	92,512	27,581
	FV [Mm^3/d]	FV [Mm^3/d]	FV [Mm^3/d]	FV [Mm^3/d]	FV [Mm^3/d]	FV [Mm^3/d]	FV [Mm^3/d]	FV [Mm^3/d]	FV [Mm^3/d]	FV [Mm^3/d]	FV [Mm^3/d]	FV [Mm^3/d]	FV [Mm^3/d]	FV [Mm^3/d]	FV [Mm^3/d]
	0.02	0.04	0.06	0.04	0.04	0.07	0.11	0.12	0.04	0.01	0.00	0.02	0.05	0.09	0.03
Somoche	**10**	**11**	**12**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**ANN**	**WET**	**DRY**
	FV [m^3]	FV [m^3]	FV [m^3]	FV [m^3]	FV [m^3]	FV [m^3]	FV [m^3]	FV [m^3]	FV [m^3]	FV [m^3]	FV [m^3]	FV [m^3]	FV [m^3]	FV [m^3]	FV [m^3]
	995,418	2,020,057	3,359,472	2,442,281	1,886,870	3,820,676	6,300,010	7,283,883	1,860,589	728,601	157,312	815,874	33,004,981	20,836,071	12,045,153
	FV [Mm^3]	FV [Mm^3]	FV [Mm^3]	FV [Mm^3]	FV [Mm^3]	FV [Mm^3]	FV [Mm^3]	FV [Mm^3]	FV [Mm^3]	FV [Mm^3]	FV [Mm^3]	FV [Mm^3]	FV [Mm^3]	FV [Mm^3]	FV [Mm^3]
	1.00	2.02	3.36	2.44	1.89	3.82	6.30	7.28	1.86	0.73	0.16	0.82	33.00	20.84	12.05
	FV [m^3/d]	FV [m^3/d]	FV [m^3/d]	FV [m^3/d]	FV [m^3/d]	FV [m^3/d]	FV [m^3/d]	FV [m^3/d]	FV [m^3/d]	FV [m^3/d]	FV [m^3/d]	FV [m^3/d]	FV [m^3/d]	FV [m^3/d]	FV [m^3/d]
	32,110	67,335	108,370	78,783	67,388	123,248	210,000	234,964	62,020	23,503	5,075	27,196	90,425	169,399	49,773
	FV [Mm^3/d]	FV [Mm^3/d]	FV [Mm^3/d]	FV [Mm^3/d]	FV [Mm^3/d]	FV [Mm^3/d]	FV [Mm^3/d]	FV [Mm^3/d]	FV [Mm^3/d]	FV [Mm^3/d]	FV [Mm^3/d]	FV [Mm^3/d]	FV [Mm^3/d]	FV [Mm^3/d]	FV [Mm^3/d]
	0.03	0.07	0.11	0.08	0.07	0.12	0.21	0.23	0.06	0.02	0.01	0.03	0.09	0.17	0.05
Mara Mines	**10**	**11**	**12**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**ANN**	**WET**	**DRY**
	FV [m^3]	FV [m^3]	FV [m^3]	FV [m^3]	FV [m^3]	FV [m^3]	FV [m^3]	FV [m^3]	FV [m^3]	FV [m^3]	FV [m^3]	FV [m^3]	FV [m^3]	FV [m^3]	FV [m^3]
	48,916,222	51,881,964	73,838,855	59,641,463	42,470,053	65,513,652	129,607,657	152,904,723	79,677,743	59,420,278	63,151,413	75,834,860	923,791,956	446,738,890	458,592,780
	FV [Mm^3]	FV [Mm^3]	FV [Mm^3]	FV [Mm^3]	FV [Mm^3]	FV [Mm^3]	FV [Mm^3]	FV [Mm^3]	FV [Mm^3]	FV [Mm^3]	FV [Mm^3]	FV [Mm^3]	FV [Mm^3]	FV [Mm^3]	FV [Mm^3]
	48.92	51.88	73.84	59.64	42.47	65.51	129.61	152.90	79.68	59.42	63.15	75.83	923.79	446.74	458.59
	FV [m^3/d]	FV [m^3/d]	FV [m^3/d]	FV [m^3/d]	FV [m^3/d]	FV [m^3/d]	FV [m^3/d]	FV [m^3/d]	FV [m^3/d]	FV [m^3/d]	FV [m^3/d]	FV [m^3/d]	FV [m^3/d]	FV [m^3/d]	FV [m^3/d]
	1,577,943	1,729,399	2,381,899	1,923,918	1,516,788	2,113,344	4,320,255	4,932,410	2,655,925	1,916,783	2,037,142	2,527,829	2,530,937	3,692,057	1,879,479
	FV [Mm^3/d]	FV [Mm^3/d]	FV [Mm^3/d]	FV [Mm^3/d]	FV [Mm^3/d]	FV [Mm^3/d]	FV [Mm^3/d]	FV [Mm^3/d]	FV [Mm^3/d]	FV [Mm^3/d]	FV [Mm^3/d]	FV [Mm^3/d]	FV [Mm^3/d]	FV [Mm^3/d]	FV [Mm^3/d]

Table 10-7: Flood statistics for the six sub-basins

	1.58	1.73	2.38	1.92	1.52	2.11	4.32	4.93	2.66	1.92	2.04	2.53	2.53	3.69	1.88
Tigithe	**10**	**11**	**12**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**ANN**	**WET**	**DRY**
	FV [m^3]	FV [m^3]	FV [m^3]	FV [m^3]	FV [m^3]	FV [m^3]	FV [m^3]	FV [m^3]	FV [m^3]	FV [m^3]	FV [m^3]	FV [m^3]	FV [m^3]	FV [m^3]	FV [m^3]
	845,613	1,155,752	1,748,775	1,061,834	642,652	2,077,787	4,023,465	3,622,598	1,234,496	633,476	79,578	600,335	18,487,788	11,847,075	6,828,642
	FV [Mm^3]	FV [Mm^3]	FV [Mm^3]	FV [Mm^3]	FV [Mm^3]	FV [Mm^3]	FV [Mm^3]	FV [Mm^3]	FV [Mm^3]	FV [Mm^3]	FV [Mm^3]	FV [Mm^3]	FV [Mm^3]	FV [Mm^3]	FV [Mm^3]
	0.85	1.16	1.75	1.06	0.64	2.08	4.02	3.62	1.23	0.63	0.08	0.60	18.49	11.85	6.83
	FV [m^3/d]	FV [m^3/d]	FV [m^3/d]	FV [m^3/d]	FV [m^3/d]	FV [m^3/d]	FV [m^3/d]	FV [m^3/d]	FV [m^3/d]	FV [m^3/d]	FV [m^3/d]	FV [m^3/d]	FV [m^3/d]	FV [m^3/d]	FV [m^3/d]
	27,278	38,525	56,412	34,253	22,952	67,025	134,116	116,858	41,150	20,435	2,567	20,011	50,651	96,318	28,218
	FV [Mm^3/d]	FV [Mm^3/d]	FV [Mm^3/d]	FV [Mm^3/d]	FV [Mm^3/d]	FV [Mm^3/d]	FV [Mm^3/d]	FV [Mm^3/d]	FV [Mm^3/d]	FV [Mm^3/d]	FV [Mm^3/d]	FV [Mm^3/d]	FV [Mm^3/d]	FV [Mm^3/d]	FV [Mm^3/d]
	0.03	0.04	0.06	0.03	0.02	0.07	0.13	0.12	0.04	0.02	0.00	0.02	0.05	0.10	0.03
Mara Wetland	**10**	**11**	**12**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**ANN**	**WET**	**DRY**
	FV [m^3]	FV [m^3]	FV [m^3]	FV [m^3]	FV [m^3]	FV [m^3]	FV [m^3]	FV [m^3]	FV [m^3]	FV [m^3]	FV [m^3]	FV [m^3]	FV [m^3]	FV [m^3]	FV [m^3]
	53,292,077	57,335,531	82,583,597	64,293,438	45,719,618	75,206,950	149,731,239	171,627,816	84,883,557	61,706,249	63,415,054	78,691,263	1,005,415,148	409,366,293	574,832,479
	FV [Mm^3]	FV [Mm^3]	FV [Mm^3]	FV [Mm^3]	FV [Mm^3]	FV [Mm^3]	FV [Mm^3]	FV [Mm^3]	FV [Mm^3]	FV [Mm^3]	FV [Mm^3]	FV [Mm^3]	FV [Mm^3]	FV [Mm^3]	FV [Mm^3]
	53.29	57.34	82.58	64.29	45.72	75.21	149.73	171.63	84.88	61.71	63.42	78.69	1005.42	409.37	574.83
	FV [m^3/d]	FV [m^3/d]	FV [m^3/d]	FV [m^3/d]	FV [m^3/d]	FV [m^3/d]	FV [m^3/d]	FV [m^3/d]	FV [m^3/d]	FV [m^3/d]	FV [m^3/d]	FV [m^3/d]	FV [m^3/d]	FV [m^3/d]	FV [m^3/d]
	1,719,099	1,911,184	2,663,987	2,073,982	1,632,844	2,426,031	4,991,041	5,536,381	2,829,452	1,990,524	2,045,647	2,623,042	2,754,562	4,498,531	2,097,929
	FV [Mm^3/d]	FV [Mm^3/d]	FV [Mm^3/d]	FV [Mm^3/d]	FV [Mm^3/d]	FV [Mm^3/d]	FV [Mm^3/d]	FV [Mm^3/d]	FV [Mm^3/d]	FV [Mm^3/d]	FV [Mm^3/d]	FV [Mm^3/d]	FV [Mm^3/d]	FV [Mm^3/d]	FV [Mm^3/d]
	1.72	1.91	2.66	2.07	1.63	2.43	4.99	5.54	2.83	1.99	2.05	2.62	2.75	4.50	2.10

Table A-8: Basic human need requirements for individual sub-basin

	2012		2018		2023		2028		2038	
	m^3/day	*m^3/s*	*m^3/day*	*m^3/s*	*m^3/day*	*m^3/s*	*m^3/day*	*m^3/s*	*m^3/day*	*m^3/s*
Serengeti	1,065	0.012	1,259	0.015	1,449	0.017	1,669	0.019	2,222	0.026
Tobora	639	0.007	786	0.009	933	0.011	1,108	0.013	1,563	0.018
Somoche	1,202	0.014	1,477	0.017	1,754	0.020	2,083	0.024	2,939	0.034
Mara Mines	1,195	0.014	1,392	0.016	1,581	0.018	1,797	0.021	2,330	0.027
Tigithe	1,511	0.017	1,722	0.020	1,920	0.022	2,141	0.025	2,661	0.031
Wetland	2,901	0.034	3,379	0.039	3,842	0.044	4,372	0.051	5,677	0.066
Grand Total	**8,513**	**0.099**	**10,015**	**0.116**	**11,479**	**0.133**	**13,171**	**0.152**	**17,392**	**0.201**

Table A10-9: Basic human need requirements for cumulative sub-basins

	2012		2018		2023		2028		2038	
	m^3/day	*m^3/s*	*m^3/day*	*m^3/s*	*m^3/day*	*m^3/s*	*m^3/day*	*m^3/s*	*m^3/day*	*m^3/s*
Serengeti	1,065	0.012	1,259	0.015	1,449	0.017	1,669	0.019	2,222	0.026
Tobora	639	0.007	786	0.009	933	0.011	1,108	0.013	1,563	0.018
Somoche	1,202	0.014	1,477	0.017	1,754	0.020	2,083	0.024	2,939	0.034
Mara Mines	4,101	0.047	4,913	0.057	5,717	0.066	6,658	0.077	9,054	0.105
Tigithe	1,511	0.017	1,722	0.020	1,920	0.022	2,141	0.025	2,661	0.031
Wetland	8,513	0.099	10,015	0.116	11,479	0.133	13,171	0.152	17,392	0.201

Table A-10: Reserve requirements for 2018 by sub-basin (m³/day)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual	Wet	Dry
Serengeti															
Basic human needs	1,259	1,259	1,259	1,259	1,259	1,259	1,259	1,259	1,259	1,259	1,259	1,259	1,259	1,259	1,259
Eflows, baseflow	301,253	292,623	428,166	342,720	233,811	350,889	956,951	1,169,054	591,457	404,161	495,086	628,627	516,233	591,457	233,811
Eflows, freshets/floods	0	389,685	377,114	0	0	0	389,685	3,771,142	0	0	0	0	410,636	377,114	0
Tobora															
Basic human needs	786	786	786	786	786	786	786	786	786	786	786	786	786	786	786
Eflows, baseflow	19,717	28,206	40,594	30,508	29,082	43,542	64,604	69,120	29,338	18,378	12,960	18,887	33,745	40,594	12,960
Eflows, freshets/floods	0	34,272	33,166	0	0	0	34,272	190,637	0	0	0	0	24,362	33,166	0
Somoche															
Basic human needs	1,477	1,477	1,477	1,477	1,477	1,477	1,477	1,477	1,477	1,477	1,477	1,477	1,477	1,477	1,477
Eflows, baseflow	32,215	39,991	49,063	42,398	40,361	53,691	73,317	77,760	38,325	29,993	25,920	31,104	44,511	49,063	25,920
Eflows, freshets/floods	0	15,552	15,050	0	0	0	15,552	271,463	0	0	0	0	26,468	15,050	0
Mara Mines															
Basic human needs	4,913	4,913	4,913	4,913	4,913	4,913	4,913	4,913	4,913	4,913	4,913	4,913	4,913	4,913	4,913
Eflows, baseflow	308,185	334,956	515,014	387,390	279,453	455,265	1,111,316	1,320,794	621,454	398,864	455,552	606,956	566,267	606,956	279,453
Eflows, freshets/floods	0	572,344	553,881	0	0	0	572,344	2,823,375	0	0	0	0	376,829	572,344	0
Tigithe															
Basic human needs	1,722	1,722	1,722	1,722	1,722	1,722	1,722	1,722	1,722	1,722	1,722	1,722	1,722	1,722	1,722
Eflows, baseflow	20,862	12,029	13,897	11,622	10,763	15,135	21,600	19,803	12,355	10,310	8,640	10,312	13,117	13,897	8,640
Eflows, freshets/floods	0	25,632	24,805	0	0	0	25,632	189,801	0	0	0	0	22,156	24,805	0
Wetland															
Basic human needs	10,015	10,015	10,015	10,015	10,015	10,015	10,015	10,015	10,015	10,015	10,015	10,015	10,015	10,015	10,015
Eflows, baseflow	368,959	401,009	616,574	463,783	334,561	545,043	1,330,467	1,581,254	744,005	477,520	545,387	726,647	677,934	744,005	334,561
Eflows, freshets/floods	0	672,347	650,659	0	0	0	672,347	3,316,690	0	0	0	0	442,670	672,347	0

Table A-11: Reserve requirements for 2023 by sub-basin (m³/day)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual	Wet	Dry
Serengeti															
Basic human needs	1,449	1,449	1,449	1,449	1,449	1,449	1,449	1,449	1,449	1,449	1,449	1,449	1,449	1,449	1,449
Eflows, baseflow	301,253	292,623	428,166	342,720	233,811	350,889	956,951	1,169,054	591,457	404,161	495,086	628,627	516,233	591,457	233,811
Eflows, freshets/floods	0	389,685	377,114	0	0	0	389,685	3,771,142	0	0	0	0	410,636	377,114	0
Tobora															
Basic human needs	933	933	933	933	933	933	933	933	933	933	933	933	933	933	933
Eflows, baseflow	19,717	28,206	40,594	30,508	29,082	43,542	64,604	69,120	29,338	18,378	12,960	18,887	33,745	40,594	12,960
Eflows, freshets/floods	0	34,272	33,166	0	0	0	34,272	190,637	0	0	0	0	24,362	33,166	0
Somoche															
Basic human needs	1,754	1,754	1,754	1,754	1,754	1,754	1,754	1,754	1,754	1,754	1,754	1,754	1,754	1,754	1,754
Eflows, baseflow	32,215	39,991	49,063	42,398	40,361	53,691	73,317	77,760	38,325	29,993	25,920	31,104	44,511	49,063	25,920
Eflows, freshets/floods	0	15,552	15,050	0	0	0	15,552	271,463	0	0	0	0	26,468	15,050	0
Mara Mines															
Basic human needs	5,717	5,717	5,717	5,717	5,717	5,717	5,717	5,717	5,717	5,717	5,717	5,717	5,717	5,717	5,717
Eflows, baseflow	308,185	334,956	515,014	387,390	279,453	455,265	1,111,316	1,320,794	621,454	398,864	455,552	606,956	566,267	606,956	279,453
Eflows, freshets/floods	0	572,344	553,881	0	0	0	572,344	2,823,375	0	0	0	0	376,829	572,344	0
Tigithe															
Basic human needs	1,920	1,920	1,920	1,920	1,920	1,920	1,920	1,920	1,920	1,920	1,920	1,920	1,920	1,920	1,920
Eflows, baseflow	20,862	12,029	13,897	11,622	10,763	15,135	21,600	19,803	12,355	10,310	8,640	10,312	13,117	13,897	8,640
Eflows, freshets/floods	0	25,632	24,805	0	0	0	25,632	189,801	0	0	0	0	22,156	24,805	0
Wetland															
Basic human needs	11,479	11,479	11,479	11,479	11,479	11,479	11,479	11,479	11,479	11,479	11,479	11,479	11,479	11,479	11,479
Eflows, baseflow	368,959	401,009	616,574	463,783	334,561	545,043	1,330,467	1,581,254	744,005	477,520	545,387	726,647	677,934	744,005	334,561
Eflows, freshets/floods	0	672,347	650,659	0	0	0	672,347	3,316,690	0	0	0	0	442,670	672,347	0

Table A-12: Reserve requirements for 2028 by sub-basin (m^3/day)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual	Wet	Dry
Serengeti															
Basic human needs	1,669	1,669	1,669	1,669	1,669	1,669	1,669	1,669	1,669	1,669	1,669	1,669	1,669	1,669	1,669
Eflows, baseflow	301,253	292,623	428,166	342,720	233,811	350,889	956,951	1,169,054	591,457	404,161	495,086	628,627	516,233	591,457	233,811
Eflows, freshets/floods	0	389,685	377,114	0	0	0	389,685	3,771,142	0	0	0	0	410,636	377,114	0
Tobora															
Basic human needs	1,108	1,108	1,108	1,108	1,108	1,108	1,108	1,108	1,108	1,108	1,108	1,108	1,108	1,108	1,108
Eflows, baseflow	19,717	28,206	40,594	30,508	29,082	43,542	64,604	69,120	29,338	18,378	12,960	18,887	33,745	40,594	12,960
Eflows, freshets/floods	0	34,272	33,166	0	0	0	34,272	190,637	0	0	0	0	24,362	33,166	0
Somoche															
Basic human needs	2,083	2,083	2,083	2,083	2,083	2,083	2,083	2,083	2,083	2,083	2,083	2,083	2,083	2,083	2,083
Eflows, baseflow	32,215	39,991	49,063	42,398	40,361	53,691	73,317	77,760	38,325	29,993	25,920	31,104	44,511	49,063	25,920
Eflows, freshets/floods	0	15,552	15,050	0	0	0	15,552	271,463	0	0	0	0	26,468	15,050	0
Mara Mines															
Basic human needs	6,658	6,658	6,658	6,658	6,658	6,658	6,658	6,658	6,658	6,658	6,658	6,658	6,658	6,658	6,658
Eflows, baseflow	308,185	334,956	515,014	387,390	279,453	455,265	1,111,316	1,320,794	621,454	398,864	455,552	606,956	566,267	606,956	279,453
Eflows, freshets/floods	0	572,344	553,881	0	0	0	572,344	2,823,375	0	0	0	0	376,829	572,344	0
Tigithe															
Basic human needs	2,141	2,141	2,141	2,141	2,141	2,141	2,141	2,141	2,141	2,141	2,141	2,141	2,141	2,141	2,141
Eflows, baseflow	20,862	12,029	13,897	11,622	10,763	15,135	21,600	19,803	12,355	10,310	8,640	10,312	13,117	13,897	8,640
Eflows, freshets/floods	0	25,632	24,805	0	0	0	25,632	189,801	0	0	0	0	22,156	24,805	0
Wetland															
Basic human needs	13,171	13,171	13,171	13,171	13,171	13,171	13,171	13,171	13,171	13,171	13,171	13,171	13,171	13,171	13,171
Eflows, baseflow	368,959	401,009	616,574	463,783	334,561	545,043	1,330,467	1,581,254	744,005	477,520	545,387	726,647	677,934	744,005	334,561
Eflows, freshets/floods	0	672,347	650,659	0	0	0	672,347	3,316,690	0	0	0	0	442,670	672,347	0

Table A-13: Reserve requirements for 2038 by sub-basin (m^3/day)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual	Wet	Dry
Serengeti															
Basic human needs	2,222	2,222	2,222	2,222	2,222	2,222	2,222	2,222	2,222	2,222	2,222	2,222	2,222	2,222	2,222
Eflows, baseflow	301,253	292,623	428,166	342,720	233,811	350,889	956,951	1,169,054	591,457	404,161	495,086	628,627	516,233	591,457	233,811
Eflows, freshets/floods	0	389,685	377,114	0	0	0	389,685	3,771,142	0	0	0	0	410,636	377,114	0
Tobora															
Basic human needs	1,563	1,563	1,563	1,563	1,563	1,563	1,563	1,563	1,563	1,563	1,563	1,563	1,563	1,563	1,563
Eflows, baseflow	19,717	28,206	40,594	30,508	29,082	43,542	64,604	69,120	29,338	18,378	12,960	18,887	33,745	40,594	12,960
Eflows, freshets/floods	0	34,272	33,166	0	0	0	34,272	190,637	0	0	0	0	24,362	33,166	0
Somoche															
Basic human needs	2,939	2,939	2,939	2,939	2,939	2,939	2,939	2,939	2,939	2,939	2,939	2,939	2,939	2,939	2,939
Eflows, baseflow	32,215	39,991	49,063	42,398	40,361	53,691	73,317	77,760	38,325	29,993	25,920	31,104	44,511	49,063	25,920
Eflows, freshets/floods	0	15,552	15,050	0	0	0	15,552	271,463	0	0	0	0	26,468	15,050	0
Mara Mines															
Basic human needs	9,054	9,054	9,054	9,054	9,054	9,054	9,054	9,054	9,054	9,054	9,054	9,054	9,054	9,054	9,054
Eflows, baseflow	308,185	334,956	515,014	387,390	279,453	455,265	1,111,316	1,320,794	621,454	398,864	455,552	606,956	566,267	606,956	279,453
Eflows, freshets/floods	0	572,344	553,881	0	0	0	572,344	2,823,375	0	0	0	0	376,829	572,344	0
Tigithe															
Basic human needs	2,661	2,661	2,661	2,661	2,661	2,661	2,661	2,661	2,661	2,661	2,661	2,661	2,661	2,661	2,661
Eflows, baseflow	20,862	12,029	13,897	11,622	10,763	15,135	21,600	19,803	12,355	10,310	8,640	10,312	13,117	13,897	8,640
Eflows, freshets/floods	0	25,632	24,805	0	0	0	25,632	189,801	0	0	0	0	22,156	24,805	0
Wetland															
Basic human needs	17,392	17,392	17,392	17,392	17,392	17,392	17,392	17,392	17,392	17,392	17,392	17,392	17,392	17,392	17,392
Eflows, baseflow	368,959	401,009	616,574	463,783	334,561	545,043	1,330,467	1,581,254	744,005	477,520	545,387	726,647	677,934	744,005	334,561
Eflows, freshets/floods	0	672,347	650,659	0	0	0	672,347	3,316,690	0	0	0	0	442,670	672,347	0

Annex B: Photos

Figure B-1: E-Flow setting workshop held in Mwanza on July, 2019

Figure B-2: A team of different Experts collecting data for WAP development

Figure B-3: A team of Hydrologist conducting low flow measurements at Mara mine