Technical Annex

Water Demand Assessment

Lower Mara River Basin, Tanzania

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Executive Summary

This water demand assessment was developed for the Water Allocation Plan for the Mara River Basin being carried out by the Sustainable Water Partnership under the United States Agency for International Development. This technical annex presents the outcomes of analyses to estimate future water demand from human and economic activities in the Tanzanian Mara River Basin over the next 5, 10, and 20 years. Information reported here will be combined with data presented separately on water resource availability and the reserve to calculate the water balance to be included in the Mara Water Allocation Plan.

The water demand assessment methodology was based on the draft water allocation planning guidelines for Tanzania. Demand values were calculated based on population growth rates, guidelines from the Ministry of Water 2009 Design Manual for Water Supply and Waste Water Disposal, data provided by Tanzanian authorities, input from stakeholders, and standard international practice. An additional 20 percent was added to all sectors except for wildlife to account for losses through leakage and wastage as recommended in the draft guidelines.

- 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 MRB 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 192 m^3/day in 2018 and 776 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 3 hydrological units. Projections of total water demand among all users in the Tanzanian Mara River Basin increase from 35,502 m^3/day in 2018 to 45,792 m^3/day, 144,460 m^3/day, and 556,427 m^3/day in 2023, 2028, and 2038, respectively. The current largest demand in the basin is livestock, accounting for 39 percent of total demand, while the largest water demand in the basin in 2038 is projected to be irrigation, accounting for 91 percent of total water demand.

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Acronyms

GIS	geographic information system
HU	hydrological unit
km^2	square kilometer
LVBWB	Lake Victoria Basin Water Board
LU	livestock unit
Lower MRB	Mara River Basin in Tanzania
m^3/day	cubic meters per day
SENAPA	Serengeti National Park
SWP	Sustainable Water Partnership
WAP	Water Allocation Plan

1. INTRODUCTION

The Sustainable Water Partnership (SWP) aims to support the improvement of water resources management in the Mara River Basin. One of its tasks is to develop a Water Allocation Plan (WAP) for the entire river basin. The WAP will define the amount of water provided to different water users in the basin, as well as the priority of categories of water user, to ensure the equitable sharing of freshwater resources and to support the proper management of these resources during times of scarce water supply.

As part of the WAP process in the Lower Mara River Basin in Tanzania (Lower MRB), information on future water demand is required. For this effort, IHE Delft Institute for Water Education worked in collaboration with the Lake Victoria Basin Water Board (LVBWB) and other partners to collect information about the current and future demands of the major water users in the Lower MRB. This study was carried out concurrently with a water availability assessment and a reserve assessment in the Lower MRB. These three of these studies will be combined with parallel efforts in the Upper MRB in Kenya to assess how water can be allocated sustainably and equitably for all water users in the entire transboundary river basin.

This report is intended as a technical annex to the WAP for the Lower MRB, describing how the demand values were determined for the WAP process. For a full description of the Lower MRB characteristics and the application of these values into the WAP, please refer to the full WAP document.

2. APPROACH

The demand assessment was carried out according to the draft guidelines for water allocation planning developed by the Tanzanian Ministry of Water (URT, 2018). These draft WAP guidelines provide guidance to basin water boards on various aspects of water allocation planning, including how to assess water demand in a river basin. The guidelines provide information on what sectors to include and specifics on daily water demand for different types of users within each sector. It aligns with Tanzanian water legislation, including the National Water Policy of 2002 and the Water Resource Management Act of 2009. It also aligns with other guidelines and management plans related to water at the national level, including the draft Environmental Water Requirements Assessment Guidelines and the National Water Sector Development Strategy. In addition, adheres to the design values provided in the Design Manual for Water Supply and Waste Water Disposal published by the Ministry of Water and Irrigation (2009).

The draft WAP guidelines suggest assessing water demand for a variety of sectors, including domestic use, agriculture, livestock, industry and commercial, mining, energy, fisheries and aquaculture, wildlife and tourism, and navigation. Not all of these sectors are active in the Lower MRB. As such, analysis on domestic use, livestock, small- and large-scale irrigation, wildlife, tourism, and small- and large-scale mining were assessed. It also recommends including an additional 20 percent allowance for water losses through leakage and wastage. This allowance was added for the sectors that may use pipes or other infrastructure to move water, such as domestic use, small-scale agriculture, and mining. For other sectors, this may not be appropriate since there are either no infrastructure (like wildlife) or the losses are already accounted for in the referenced studies (like large-scale irrigation infrastructure). Whether or not the 20 percent is applied is included in the description for each sector.

Water demand was assessed for all current major water uses (2018) in units of cubic meters per day (m^3/day) for planning periods of 5, 10, and 20 years into the future (2023, 2028, and 2038, respectively). Water demand estimates were based on calculations using data from population censuses, outputs from the abstraction survey completed by the LVBWB in the Lower MRB, information gathered from documents sent by district officials, publically available data, and published reports. To the greatest extent possible, data used in the demand estimates were as local as possible, using data directly from the Lower MRB as the preferred source and utilizing regional, national, and/or worldwide data depending on the resources available.

This report examines the water demand in the Lower MRB, which is different than the actual use of water. Demand is a value that is reasonably expected to be consumed by a specific type of water user for a specified period of time and is the standard value used for planning purposes. Actual use is the water that is physically consumed by a specific water user in a specified period of time. For example, domestic water demand for one particular type of water user is 50 liters/day. The actual use may be higher or lower than that value depending on the activities and habits of that specific water user. The actual use will also vary day-to-day, making it very difficult to accurately plan for the needs of that water user. Instead, demand values are used for planning

purposes, which act more like an “average use” for a particular sector and can be multiplied by the number of water users to reach a demand value over a geographical area.

For some sectors, the Tanzanian government has developed water demand values that should be applied to all water users of that type, such as domestic use, livestock, and tourism. These values were used when provided. For other sectors, the water demand very much depends on the usage patterns for individual water user types, such as irrigation, wildlife, and mining. When national demand values were not available, current water use data from the Lower MRB abstraction report was used. This current water use data is used as proxy for demand since there are no national or international demand values for these sectors. When these values were not available, published scientific papers or reports were used to estimate demand values.

The water demand does not differentiate between different sources of water in the Lower MRB (i.e., flowing water in rivers, surface runoff gathered in pool or pans, shallow groundwater wells, deep groundwater boreholes, etc.). From a hydrological perspective, water balance calculations are completed on a catchment scale, where the requirements for the reserve and the demand are subtracted from the available water (calculated in the water availability report). The available water already considers the amount of water available from different sources (like runoff from rain, surface flow from upstream, and any shallow subsurface flow into river channels) and any natural processes that would remove water from the system (like evapotranspiration). As such, the water available in each catchment can be thought of as one source of water, and as such, it is not necessary to differentiate the sources for the demand.

The demand projections are estimates based on best available knowledge, and when necessary, professional judgement of IHE Delft and the LVBWB. In general, any assumptions made were intended to be conservative in nature, erring on the side of demanding more water rather than less water in an effort to minimize underestimation of demand. The assumptions made for each sector are described in the corresponding section of the document. In addition, the demand values provided should not be considered exact numbers and are approximations to assist with planning efforts.

This document is intended to be a “living” document and updated regularly. The input values in this report should be updated at the same time as the WAP, which is typically every 5 years, incorporating new datasets and research as they become available.

2.1. PLANNING UNITS

Future water demands were calculated for two different planning units within the Lower MRB. First, demand values were calculated for the four districts in the basin: Butiama, Rorya, Serengeti, and Tarime Districts (Figure 2-1). No district is located entirely within the Lower MRB, so only a percentage of each district is included in the study area (Table 2-1). Tarime District has the highest percentage of its district in the study area (51 percent) and Rorya District has the lowest percentage (9 percent). When looking at the land inside of the study area, Serengeti District occupies the most area (65 percent) while Rorya District occupies the least area (4 percent). There is a small portion of Bunda District that is located within the study area. This area accounts for less than one percent of the total study area and total population. Since this district has not been involved in WAP activities and its impact on the outcome is negligible, it has been omitted from the demand analysis.

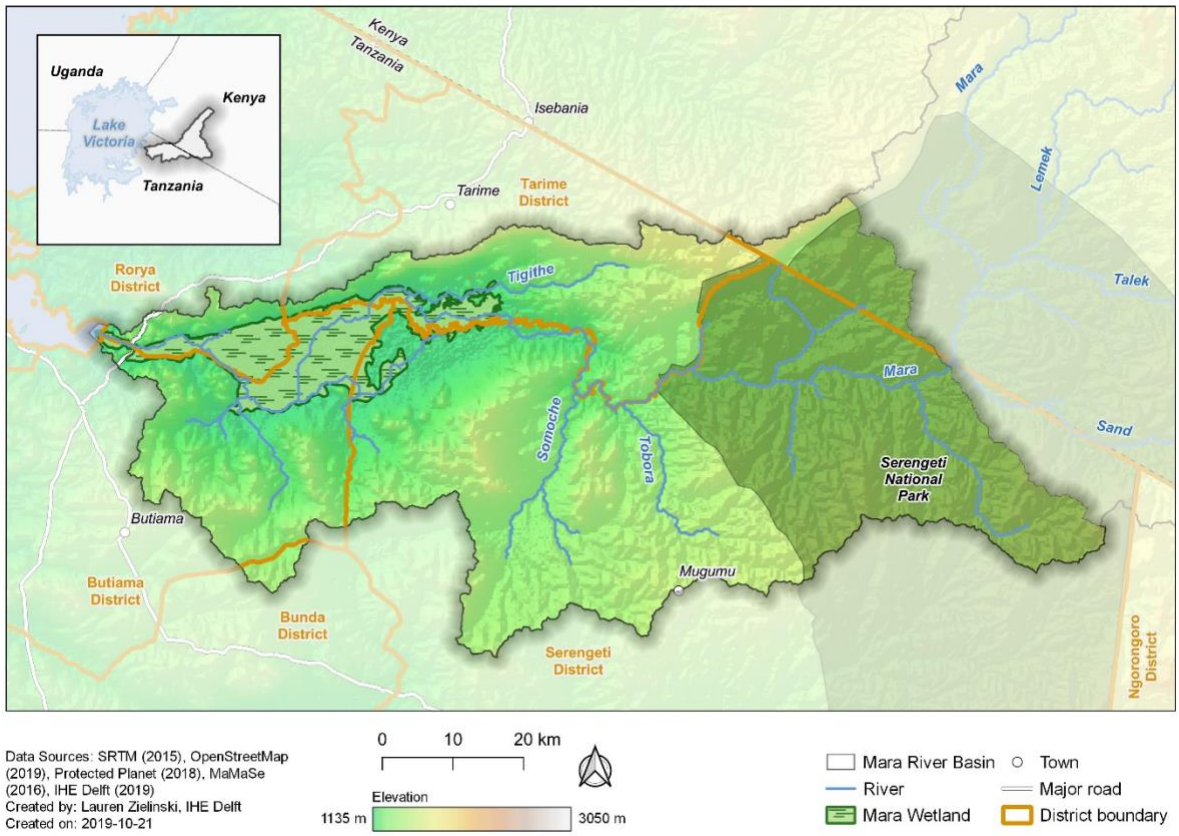


Figure 2-1: Map of the districts within the Lower MRB

Second, demand was calculated by the major hydrological units (HUs). The HUs include the Serengeti HU, Somoche HU, and Mara HU (Figure 2-2). There is a small portion of the Sand HU that lies in Lower MRB. However, the demand for this HU was previously assessed by the water demand assessment in the Upper MRB in Kenya. To prevent double counting, this HU was excluded from the analysis.

Table 2-1: Analysis of districts located within the Lower MRB

District	Total Area of District (km²)	Area Inside Study Area (km²)	% of District	% of Study Area
Butiama	2,168.03	812.44	37%	16%
Rorya	2,002.01	178.36	9%	4%
Serengeti	11,157.26	3,280.18	29%	65%
Tarime	1,534.58	775.89	51%	15%
Total	*16,861.88*	*5,046.87*	-	*100%*

By conducting the demand analyses by HU, it aligns the water demand with the other hydrological parameters calculated in the water availability assessment and the reserve assessment, which will be used to calculate the water balance for the Lower MRB WAP.

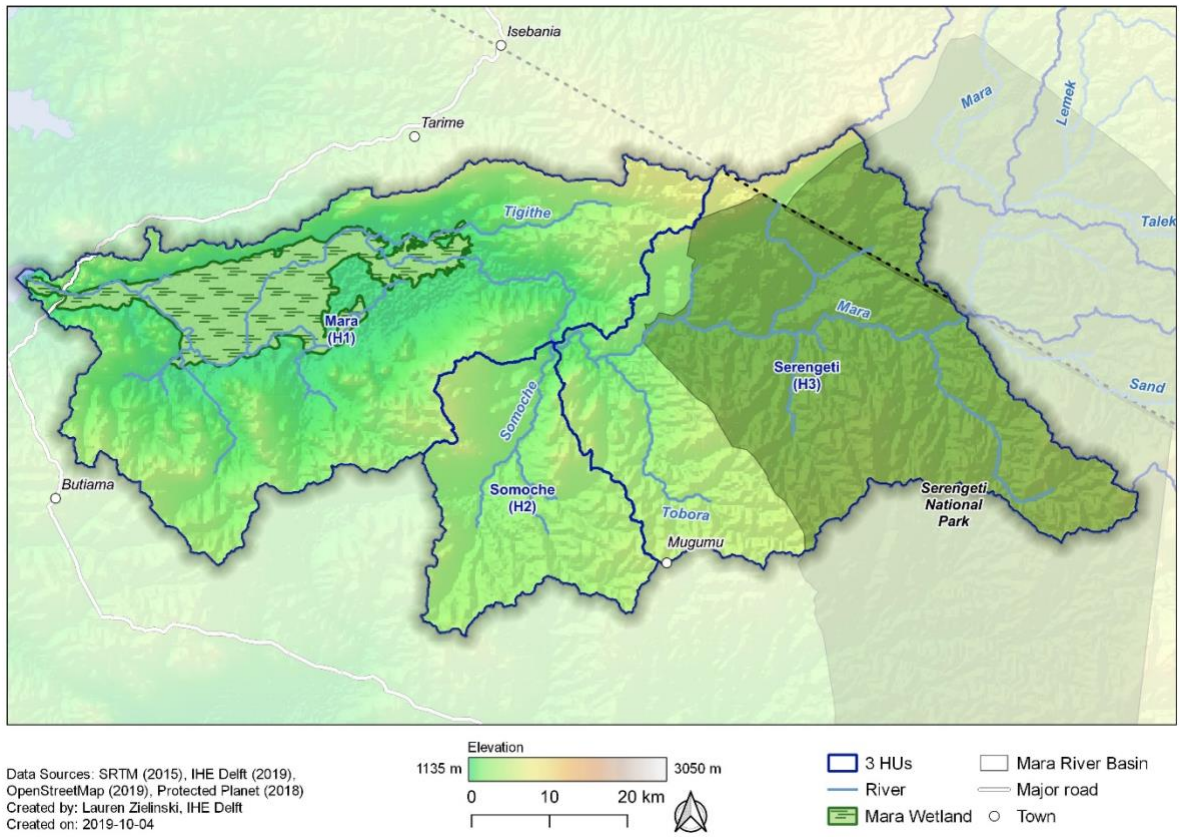
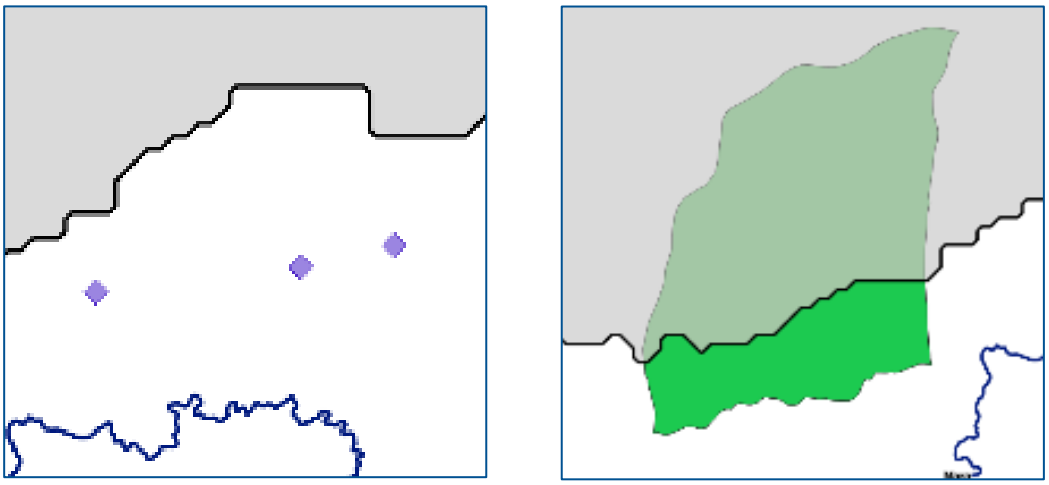


Figure 2-2: Map of the hydrological units within the Lower MRB

2.2. DATA ANALYSIS USING GIS

District and wards are political units (whose boundaries are determined by people) while HUs are physical units (whose boundaries are determined by physical characteristics in the landscape). For data sets where demand can be determined at specific geographic points (i.e., irrigation, tourism, wildlife, and mining), the total demands were summed for the data points located within each district or HU (Figure 2 3a). For spatial data sets where demand is spread out over a geographical area (i.e., population and livestock), additional analyses were conducted using GIS (a geographic information system) to provide an estimate of the demand located within the study area. For example, the smallest unit for which population data is provided is at the ward level. So each ward has a single population value for the entire area. If the entire ward is completely contained inside an HU, then 100 percent of the population can be counted towards that specific HU. However, if a ward boundary is split between two HUs or lies partially outside of the HU, then the full population cannot be attributed to that HU. Since we do not have data for units smaller than a ward, it was assumed that the population was equally distributed across the ward. The percentage of the ward located inside the HU was then calculated and applied to the total population to estimate how many people live inside the HU (e.g., if 30 percent of the ward is located inside an HU, then it was assumed that 30 percent of the population is also located inside the HU, Figure 2 3b).



(a) Geographic points
= 1 m3/day
Total in HU = 3 m3/day

(b) Geographic areas
Ward = 1,000 people
= 30% inside HU
Total in HU = 300 people

Figure 2-3: Examples of how different geographic datasets were analyzed

3. OVERVIEW OF WATER USE IN THE LOWER MRB

The Lower MRB includes the catchment located downstream of the Kenya/Tanzania border, which is about 5,000 km2 in size. When the Mara River enters Tanzania, it runs through Serengeti National Park (SENAPA), which is a savannah ecosystem in a very natural condition with little development or infrastructure. The world's largest overland migration goes through the Lower MRB and into SENAPA and the Maasai Mara National Reserve in Kenya for a few months a year. It is estimated that 2 million animals move through the area over a period of a few months. In the Lower MRB, the main economic driver of this area is tourism around the migration inside SENAPA. There are permanent hotels and mobile tent camps to provide accommodation and meals for the tourists. Outside of the park, the land use is dominated by small villages where rain-fed agriculture and livestock grazing are the main economic activities. Domestic water typically comes from rivers and streams, natural springs, and shallow groundwater wells. Livestock are watered at any location where surface water is available, including the Mara River and its tributaries, the Mara Wetland, natural depressions, and constructed water pans. The North Mara Gold Mine, a large open pit gold mine, is located in the north central part of the catchment. This mine uses a substantial amount of water, but much of this is from the rainwater collection in the large open mining pits. Surrounding the North Mara Gold Mine are small artisanal mining operations run by local companies or cooperatives, which pump out groundwater from their small mining shafts. Some of this is used for processing activities, but most is returned to the system by infiltration through the soil. Raidfed agriculture is grown during the two rainy seasons in the catchment, but there is some small-scale irrigation taking water directly from surface water sources. This occurs more frequently near the downstream end of the Mara Wetland as the soils there are better for growing crops and the water is easier to access. Aside from North Mara Gold Mine, there is are no other large commercial or industrial abstractors. Currently, there is no large scale water infrastructure in the Lower MRB, such as hydropower dams or reservoirs. There are proposals to build medium- and large-scale infrastructure for irrigation projects in the central part of the basin, but no plans for construction have been finalized.

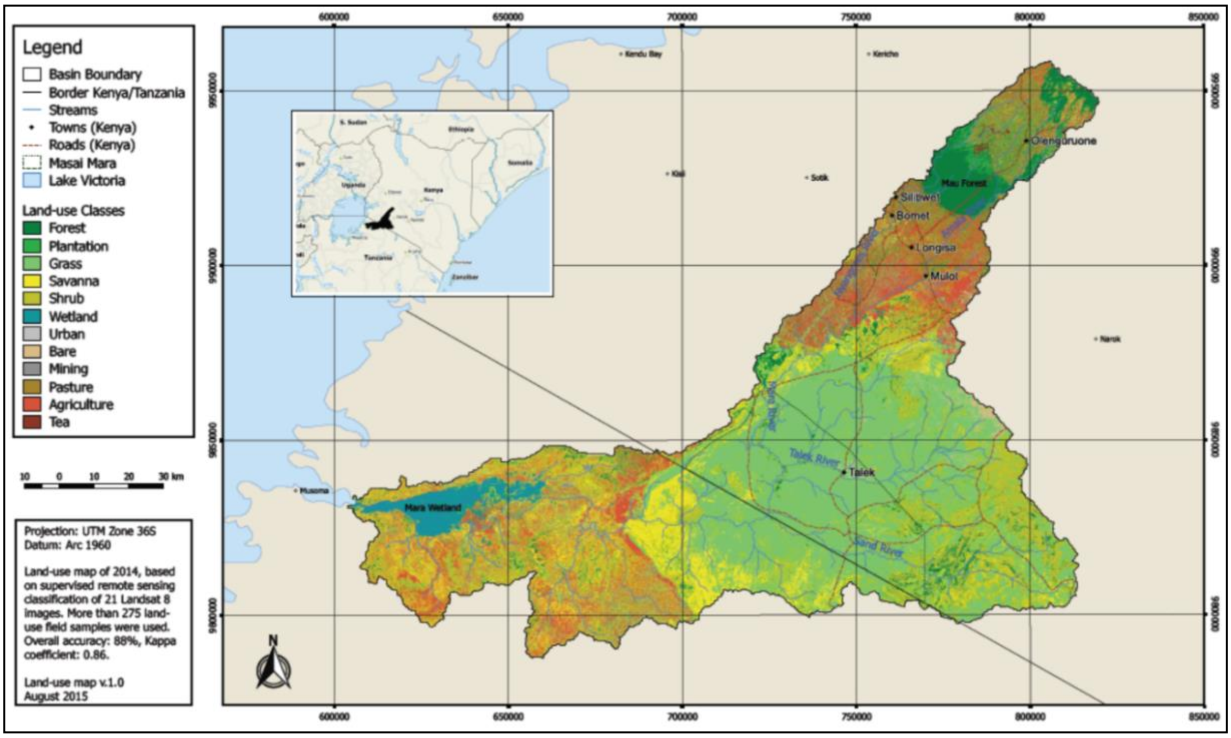


Figure 3-1: Land use map of the Mara River Basin (MaMaSe, 2019)

4. RESULTS

4.1. 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 1).

Table 4-1: 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
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. During a stakeholder engagement workshop in November 2018, stakeholders decided that the basin is expected to develop over the next two decades and would likely move to the next consumer category (low income multiple household with yard tap, flat rate). The demand for this category is 50 liters/person/day. This value will be used for the domestic demand in the equation above.

Access to safe and clean water is considered a human right by the United Nations (United Nations, 2010) and this right is often met when water for basic human needs is provided. Globally, it is agreed that water for basic human needs should be no less than 20 to 25 liters/person/day (Gleick, 1996; Jensen, Villumsen and Petersen, 2014). The minimum value for any consumer category in Table 4 1 is 25 liters/person/day, which meets this international standard. It is also the recommended value from the draft WAP guidelines for Tanzania. For these reason, this value will be used as the basic human needs 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.

As part of the WAP process, the reserve will also be determined and included in the development of future water allocation scenarios. The reserve is defined in the Water Resources Management Act of 2009 (URT, 2009) as water 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
   iii) being supplied from the relevant water resources; and
b) *to protect aquatic ecosystem in order to secure ecologically sustainable development and use of the relevant water resources.*

Since the water for basic human needs could be included in both the reserve and domestic demand, care needs to be taken that this amount is not double counted. Following the definition of the reserve, the amount of 25 liters/person/day will be included in the reserve analysis and not in the demand analysis. As such, 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.

Domestic demand = Basic human needs + Additional domestic demand

50 liters/person/day** = 25 liters/person/day + **25 liters/person/day
(Reserve assessment) *Demand assessment)*

To estimate domestic demand in the Lower MRB, 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 census is completed every 10 years by the Tanzanian Bureau of Statistics. 2012 is the latest year that data were collected with the smallest unit of enumeration being at the ward level. The census data at the ward level were processed using GIS (see Section 2.2) to provide an estimate for the population located within the Lower MRB by district and by HU for 2012 (Figure 4 1). The GIS population analysis results can be found in Section 7.1.

To estimate growth the growth into the future, the following population project equation was used:

$$P_f = P_p * (1 + i)^n \ z$$

$P_f = future\ population \ | \ P_p = present\ popuation \ | \ i = growth\ rate \ | \ n = number\ of\ years$

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 Districts, 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; Table 4 2 and Table 4 3). These values were then multiplied by 30 liters/person/day to calculate the additional domestic demand by district and by HU (Table 4 4 and Table 4 5). The current demand for domestic use is estimated to be around 12,000 m3/day and increasing to over 20,000 m3/day.

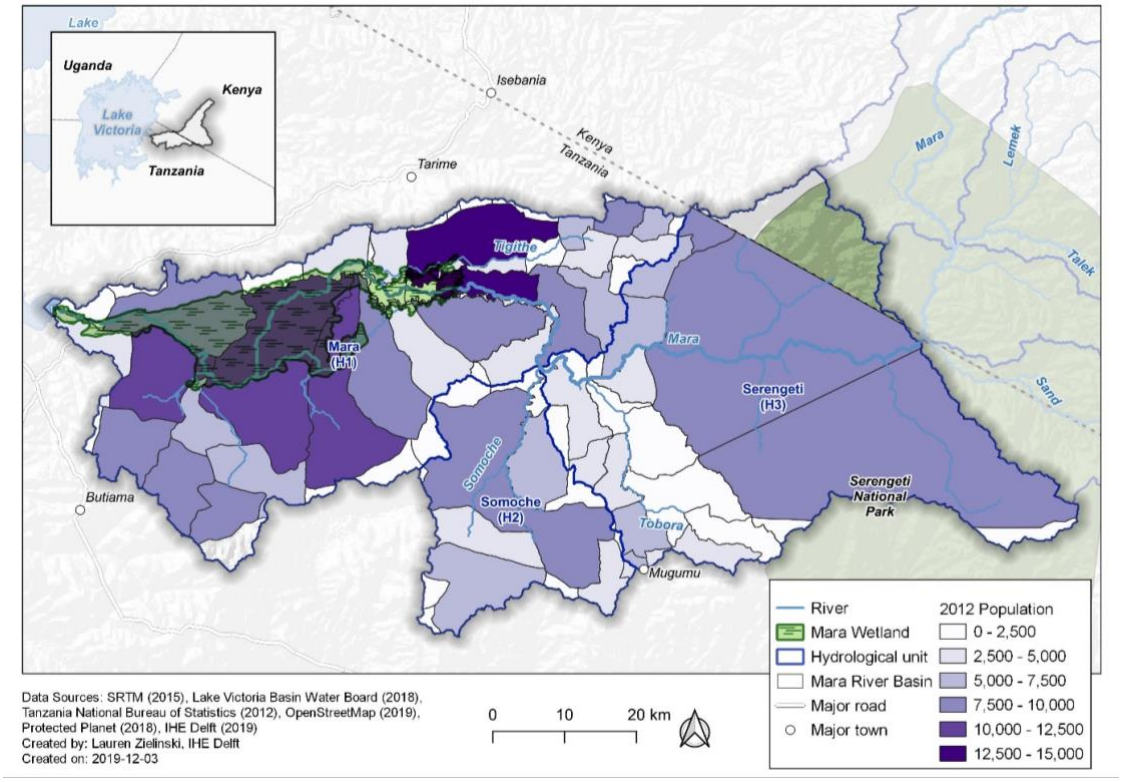


Figure 4-1: Population by ward in 2012 (NBS 2012)

Table 4-2: Projected domestic population in the Lower MRB by District

District	2012	2018	2023	2028	2038
Butiama	62,957	71,740	79,984	89,178	110,859
Rorya	11,529	12,983	14,335	15,826	19,293
Serengeti	141,695	174,180	206,867	245,697	346,582
Tarime	124,340	141,686	157,971	176,127	218,945
Total	*340,521*	*400,589*	*459,157*	*526,828*	*695,679*

Source: NBS 2012

Table 4-3: Projected domestic population in the Lower MRB by HU

HU	2012	2018	2023	2028	2038
Serengeti	78,877	94,796	110,590	129,119	176,419
Somoche	48,061	59,080	70,167	83,339	117,557
Mara	213,583	246,713	278,400	314,370	401,703
Total	*340,521*	*400,589*	*459,157*	*526,828*	*695,679*

Source: NBS 2012

Table 4-4: Projected water demand from domestic use by district (m^3/day)

District	2012	2018	2023	2028	2038
Butiama	1,889	2,152	2,400	2,675	3,326
Rorya	346	389	430	475	579
Serengeti	4,251	5,225	6,206	7,371	10,397
Tarime	3,730	4,251	4,739	5,284	6,568
Total	*10,216*	*12,018*	*13,775*	*15,805*	*20,870*

Table 4-5: Projected water demand from domestic use by HU (m^3/day)

HU	2012	2018	2023	2028	2038
Serengeti	2,366	2,844	3,318	3,874	5,293
Somoche	1,442	1,772	2,105	2,500	3,527
Mara	6,407	7,401	8,352	9,431	12,051
Total	*10,216*	*12,018*	*13,775*	*15,805*	*20,870*

4.2. LIVESTOCK

Livestock is an important economic and social activity in the Lower MRB 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 determine the current population of livestock, the most recent livestock census data were collected from the district offices (Table 4 6, Table 4 7, and Figure 4 2; livestock population by ward can be found in Section 7.2). The livestock census data for the villages and wards ranged from 2015 to 2018. To standardize the analysis, all data was assumed to be from 2018. The livestock census information provided data for the entire ward. Using GIS analysis, this data were analyzed to provide an estimate for the number of livestock located within the Lower MRB based on how much of the ward is located inside the study area (see Section 2.2).

Table 4-6: Current livestock population by district

District	Cattle	Goats	Sheep	Donkeys	Pigs	Total
Butiama	75,587	22,399	22,760	1,328	0	*122,074*
Rorya	7,041	2,906	2,746	65	0	*12,758*
Serengeti	175,578	63,367	66,609	2,373	284	*308,211*
Tarime	114,346	74,421	43,511	1,509	326	*234,113*
Total	*372,552*	*163,093*	*135,626*	*5,275*	*610*	*677,156*

Table 4-7: Current livestock population by HU

HU	Cattle	Goats	Sheep	Donkeys	Pigs	Total
Serengeti	63,689	33,858	27,774	1,101	77	*126,499*
Somoche	60,907	23,002	25,261	1,009	161	*110,340*
Mara	247,956	106,233	82,591	3,165	372	*440,317*
Total	*372,552*	*163,093*	*135,626*	*5,275*	*610*	*677,156*

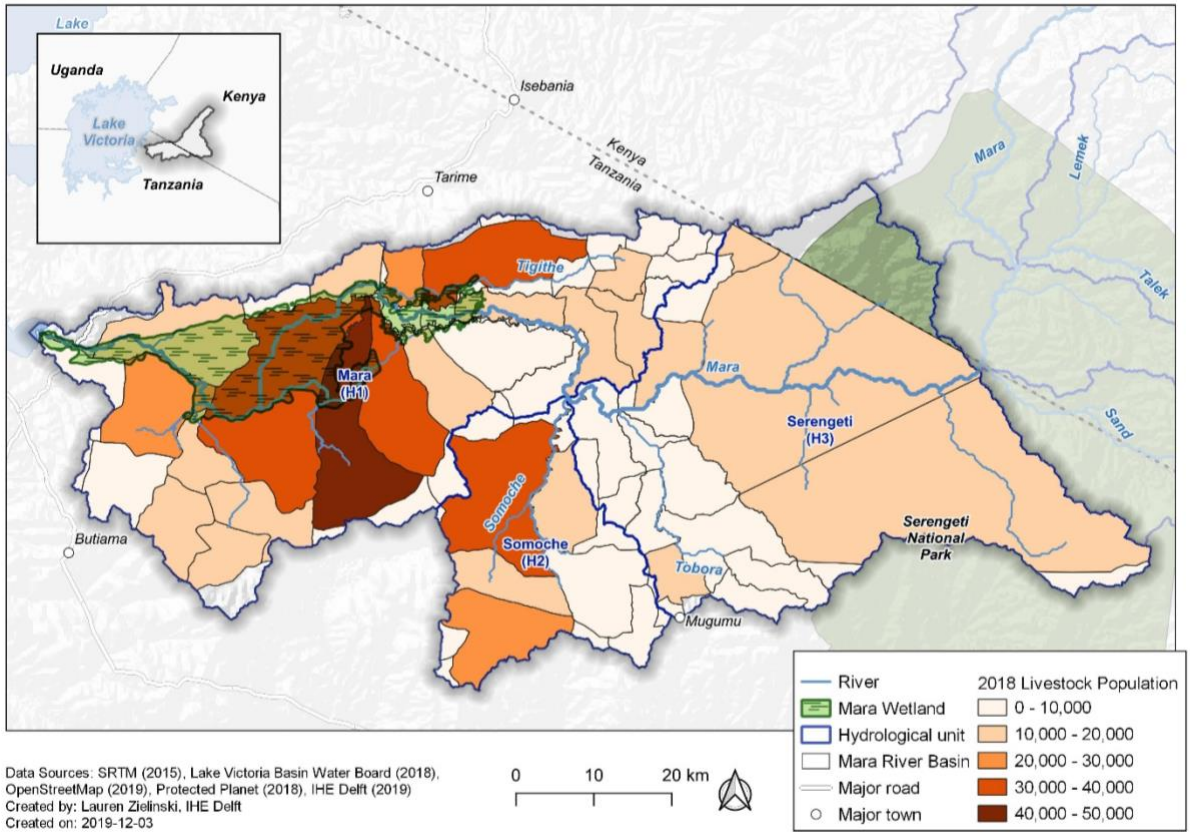


Figure 4-2: Livestock populations by ward in 2018 in the Lower MRB

To estimate the water demand from livestock, values from the Design Manual for Water Supply and Waste Water Disposal were used (MoWI, 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 MRB 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 MRB can be found in Table 4-8 and Table 4-9.

Table 4-8: Current livestock units by district

District	Cattle	Goats	Sheep	Donkeys	Pigs	Total
Butiama	75,587	4,480	4,552	664	0	*85,283*
Rorya	7,041	581	549	33	0	*8,204*
Serengeti	175,578	12,673	13,322	1,187	284	*203,044*
Tarime	114,346	14,884	8,702	755	326	*139,013*
Total	*372,552*	*32,618*	*27,125*	*2,638*	*610*	*435,543*

Table 4-9: Current livestock units by HU

HU	Cattle	Goats	Sheep	Donkeys	Pigs	Total
Serengeti	63,689	6,772	5,555	551	77	*76,644*
Somoche	60,907	4,600	5,052	505	161	*71,225*
Mara	247,956	21,247	16,518	1,583	372	*287,676*
Total	*372,552*	*32,619*	*27,125*	*2,638*	*610*	*435,544*

The Design Manual for Water Supply and Waste Water Disposal recommends using a value of 25 liters/LU/day (0.025 m3/LU/day) to estimate livestock water demand (MoWI, 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 m3/LU/day. The current water demand was found to be about 13,100 m3/day (Table 4 10 and Table 4 11).

Table 4-10: Current water demand from livestock by district (m^3/day)

District	Cattle	Goats	Sheep	Donkeys	Pigs	Total
Butiama	2,268	134	137	20	0	*2,558*
Rorya	211	17	16	1	0	*246*
Serengeti	5,267	380	400	36	9	*6,091*
Tarime	3,430	447	261	23	10	*4,170*
Total	*11,177*	*979*	*814*	*79*	*18*	*13,066*

Table 4-11: Current water demand from livestock by HU (m^3/day)

HU	Cattle	Goats	Sheep	Donkeys	Pigs	Total
Serengeti	1,911	203	167	17	2	*2,299*
Somoche	1,827	138	152	15	5	*2,137*
Mara	7,439	637	496	47	11	*8,630*
Total	*11,177*	*979*	*814*	*79*	*18*	*13,066*

To calculate 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 (MoWI, 2009). For a 5 year time period, a growth rate of 12.5 percent was used. (An analysis of the carrying capacity of the landscape was not completed as is recommended in MoWI 2009. As such, the carrying capacity of the Lower MRB may be lower than these projected values.) The current water demand is projected to increase to approximately 19,600 m3/day by 2038 (Table 4 12 and Table 4 13). It is assumed that livestock will have the same water demand year-round.

Table 4-12: Projected water demand from livestock by district (m^3/day)

District	2018	2023	2028	2038
Butiama	2,558	2,878	3,198	3,838
Rorya	246	277	308	369
Serengeti	6,091	6,853	7,614	9,137
Tarime	4,170	4,692	5,213	6,256
Total	*13,066*	*14,700*	*16,333*	*19,599*

Table 4-13: Projected water demand from livestock by HU (m3/day)

HU	2018	2023	2028	2038
Serengeti	2,299	2,587	2,874	3,449
Somoche	2,137	2,404	2,671	3,205
Mara	8,630	9,709	10,788	12,945
Total	*13,066*	*14,700*	*16,333*	*19,599*

4.3. IRRIGATION

There are two types of irrigated agriculture present in the Lower MRB: small-scale and large-scale irrigation. While there are many small holder farms in the basin, 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. From the 2018 abstraction survey, current water demand for small-scale irrigation was found to vary throughout the year, with the lowest demand of 339 m3/day in February and the highest demand of 1,060 m3/day in September, and an average annual demand of 715 m3/day (LVBWB 2018, Table 4 14 and Table 4 15). These values include the additional 20 percent to account for water losses. They are also organized by the start and end of the water year in Tanzania (October to September).

When completing 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 area 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 715 m3/day in 2018 increasing to 1,110 m3/day in 2038 (Table 4 16 and Table 4 17). There was no irrigation found in Rorya District or Serengeti HU, and this condition is expected to continue in the future.

Table 4-14: Monthly water demand from small-scale irrigation by district (m3/day)

Month	Butiama	Rorya	Serengeti	Tarime	Grand Total
October	967	0	0	0	967
November	878	0	0	0	878
December	655	0	0	47	702
January	603	0	0	72	675
February	339	0	0	72	411
March	464	0	0	0	464
April	550	0	0	0	550
May	602	0	0	0	602
June	637	0	0	0	637
July	619	0	0	73	692
August	751	0	0	73	824
September	1,060	0	49	73	1,182
Annual Average	*677*	*0*	*4*	*34*	*715*

Table 4-15: Monthly water demand from small-scale irrigation by HU (m3/day)

Month	Serengeti	Somoche	Wetland	Grand Total
October	0	0	967	967
November	0	0	878	878
December	0	0	702	702
January	0	0	675	675
February	0	0	411	411

Month	Serengeti	Somoche	Wetland	Grand Total
March	0	0	464	464
April	0	0	550	550
May	0	0	602	602
June	0	0	637	637
July	0	0	692	692
August	0	0	824	824
September	0	49	1,133	1,182
Annual Average	*0*	*4*	*711*	*715*

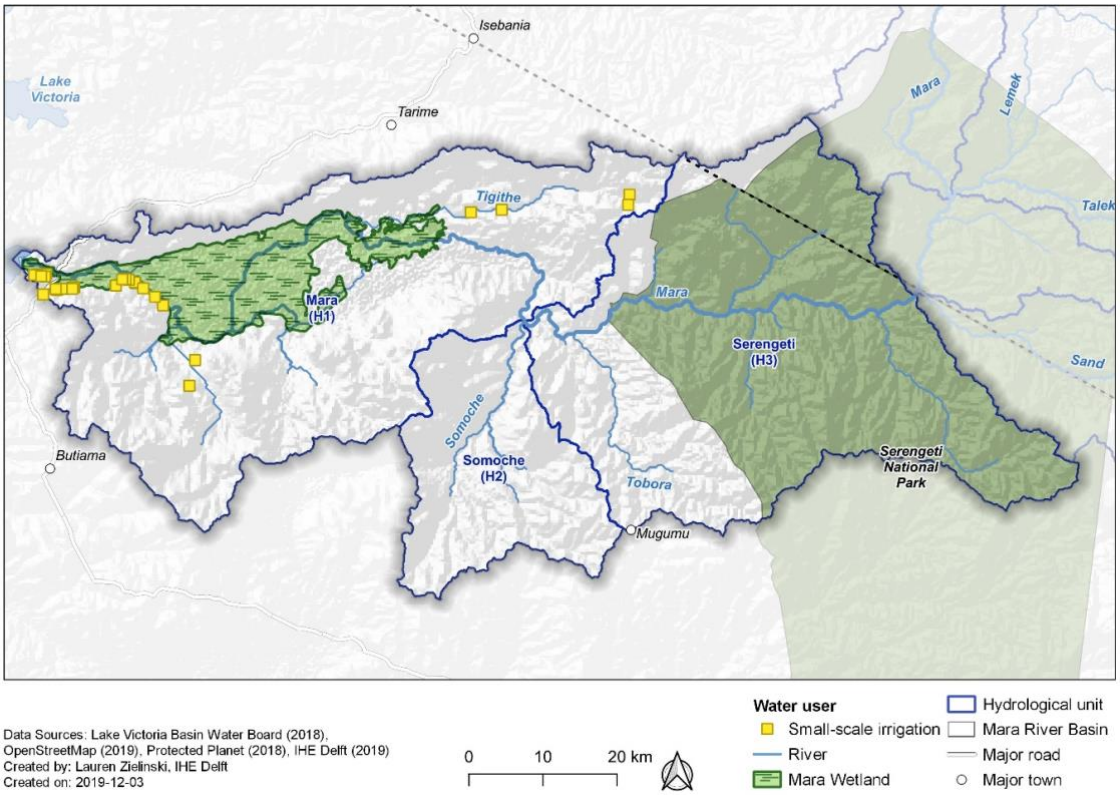


Figure 4-3: Small-scale irrigation locations in the Lower MRB

Table 4-16: Projected water demand from small-scale irrigation by district (m3/day)

District	2018	2023	2028	2038
Butiama	677	755	777	1,047
Rorya	0	0	0	0
Serengeti	4	5	6	8
Tarime	34	38	42	53
Total	*715*	*798*	*825*	*1,107*

Table 4-17: Projected water demand from small-scale irrigation by HU (m3/day)

HU	2018	2023	2028	2038
Serengeti	0	0	0	0
Somoche	4	5	6	8
Mara	711	793	884	1,099
Total	*715*	*798*	*890*	*1,107*

Two large-scale irrigation schemes are planned in the Lower MRB: 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 (Eng. E. Kombe, personal communication, Oct 2018).

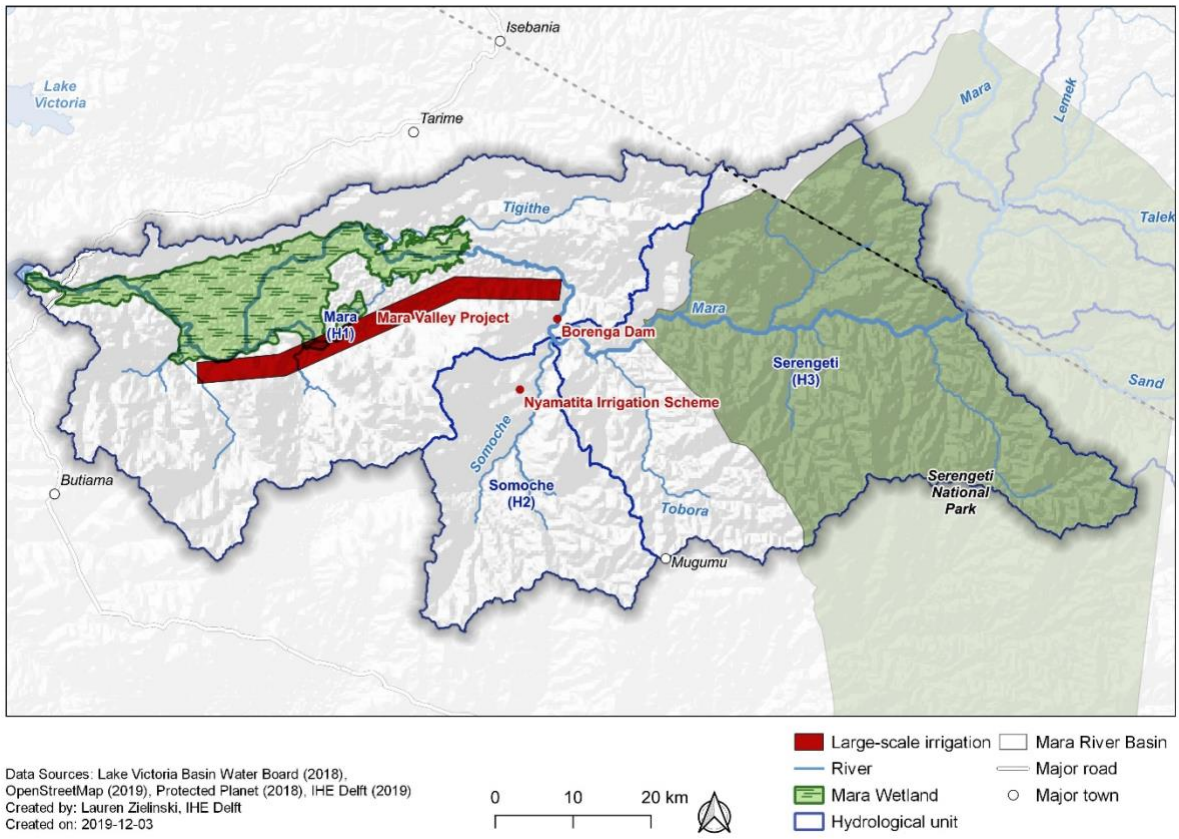


Figure 4-4: Approximate locations of large-scale irrigation schemes in the Lower MRB

The Mara Valley Project plans to develop 8,340 hectares of land, including 6,903 hectares of small-holder 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 in Serengeti and Butiama Districts (for this assessment, it was assumed that the irrigation demand would be split evenly between the two districts) and the Mara HU. Water for the system will come from the planned Borenga Dam and reservoir. The dam is to be 20 meters high and form a reservoir with a storage volume of 18.3 million cubic meters. The dam will include a hydropower plant with an installed capacity of 3.0 megawatts, and will also supply water for domestic use, livestock, and aquiculture. The project is to be developed over a 12-year period, with regular irrigated agricultural production occurring in three command areas at different times: Command Area 1 will begin 8 years after the project is initiated, Command Area 2 will begin 10 years after, and Command Area 3 will begin 12 years after. 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 (Table 4-18).

Limited information is available about the Nyamitita Irrigation Scheme. The project is located in the Somoche HU in Serengeti District, about 41 km from the district headquarters in Mugumu. Water will be taken from the Nyamitita River and conveyed through a canal system, irrigating 30 blocks and covering a total area of 92.9 hectares. No information was available about the planned crops or the cropping pattern. Furthermore, the only information available about water demand was a "peak scheme water requirement" of 2.47 liters/second/hectare. This information is insufficient to quantify demand over the course of a year. For the purposes of this demand

assessment, the monthly demand per hectare for the Mara Valley Project was applied to the 92.9 hectares of the Nyamitita Irrigation Scheme to estimate the water demand for that project (Table 4-18), resulting in an average annual demand of 6,690 m3/day. Since losses were incorporated into the detailed design report, the additional 20 percent to account for losses as recommended in the draft WAP guidelines were not applied to the demand values for either large-scale irrigation scheme.

Table 4-18: Monthly water demand from Mara Valley Project and Nyamitita Irrigation Scheme (m3/day)

Month	Monthly demand (m3/day/hectare)	Mara Valley Project		Nyamitita Irrigation Scheme (92.9 hectares)
		Command Area 1 (1,314 hectares)	All Command Areas (6,903 hectares)	
October	87.74	115,377	605,664	8,151
November	69.30	91,133	478,397	6,438
December	96.58	126,997	666,662	8,972
January	96.63	127,063	667,008	8,977
February	69.83	91,824	482,026	6,487
March	41.14	54,101	283,997	3,822
April	15.55	20,442	107,309	1,444
May	55.31	72,732	381,802	5,138
June	67.19	88,352	463,795	6,242
July	62.14	81,719	428,976	5,773
August	123.04	161,791	849,312	11,430
September	79.69	104,794	550,109	7,403
Average	*72.01*	*94,694*	*497,088*	*6,690*

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 (Table 4-19). The demand for the Nyamitita Irrigation Scheme is projected to appear by 2023 and remain unchanged over the projection period.

Table 4-19: Projected water demand from large-scale irrigation schemes (m3/day)

Year	2018	2023	2028	2038
Mara Valley Project	0	0	94,694	497,088
Nyamatita Irrigation Scheme	0	6,690	6,690	6,690
Total	*0*	*6,690*	*101,383*	*503,778*

The projection for small-scale and large-scale irrigation were combined to estimate the growth in water demand from irrigation for the next 5, 10, and 20 years (Table 4-20 and

Table 4-21), reaching a total demand of 504,885 m3/day by 2038.

Table 4-20: Projected water demand from total irrigation by district (m3/day)

District	2018	2023	2028	2038
Butiama	677	755	48,189	249,591
Rorya	0	0	0	0
Serengeti	4	6,695	54,042	255,242
Tarime	34	38	42	53
Total	*715*	*7,488*	*102,274*	*504,885*

Table 4-21: Projected water demand from total irrigation by HU (m3/day)

HU	2018	2023	2028	2038
Serengeti	0	0	0	0
Somoche	4	6,695	6,696	6,698
Mara	711	793	95,578	498,187
Total	*715*	*7,488*	*102,274*	*504,885*

4.4. TOURISM

Tourism plays a large part in the local economy of the Lower MRB, particularly around SENAPA. According to data collected during the abstraction survey (LVBWB, 2018), the majority of tourist hotels in the Lower MRB are located inside the park (Figure 4-5). Some of these hotels have a permanent location but most are mobile or tent camps that follow the great migration across the Serengeti landscape. As such, it was assumed that the demand for water would be greater during the months when the migration passes through the Lower MRB (July through November). Since the abstraction survey was conducted in September and October of 2018, it was also assumed that the majority of the mobile camps were located inside the Lower MRB at that time and that information collected represents the conditions during the high season for tourism (100 percent availability of beds).

Current demand for water from tourism was estimated using the number of hotel beds and multiplying by 200 liters/bed/day, which is the value provided for medium class urban hotel in the Design Manual for Water Supply and Waste Water Disposal (MoWI, 2009). Following the direction of the draft WAP guidelines, an additional 20 percent was added to account for losses which resulted in a demand value of 240 liters/bed/day or 0.24 m3/bed/day. The current number and location of hotel beds in the Lower MRB were provided from data collected during the abstraction survey (LVBWB, 2018). At full capacity, the water demand for all hotels is approximately 271 m3/day in the Lower MRB (Table 4 26 and Table 4 27).

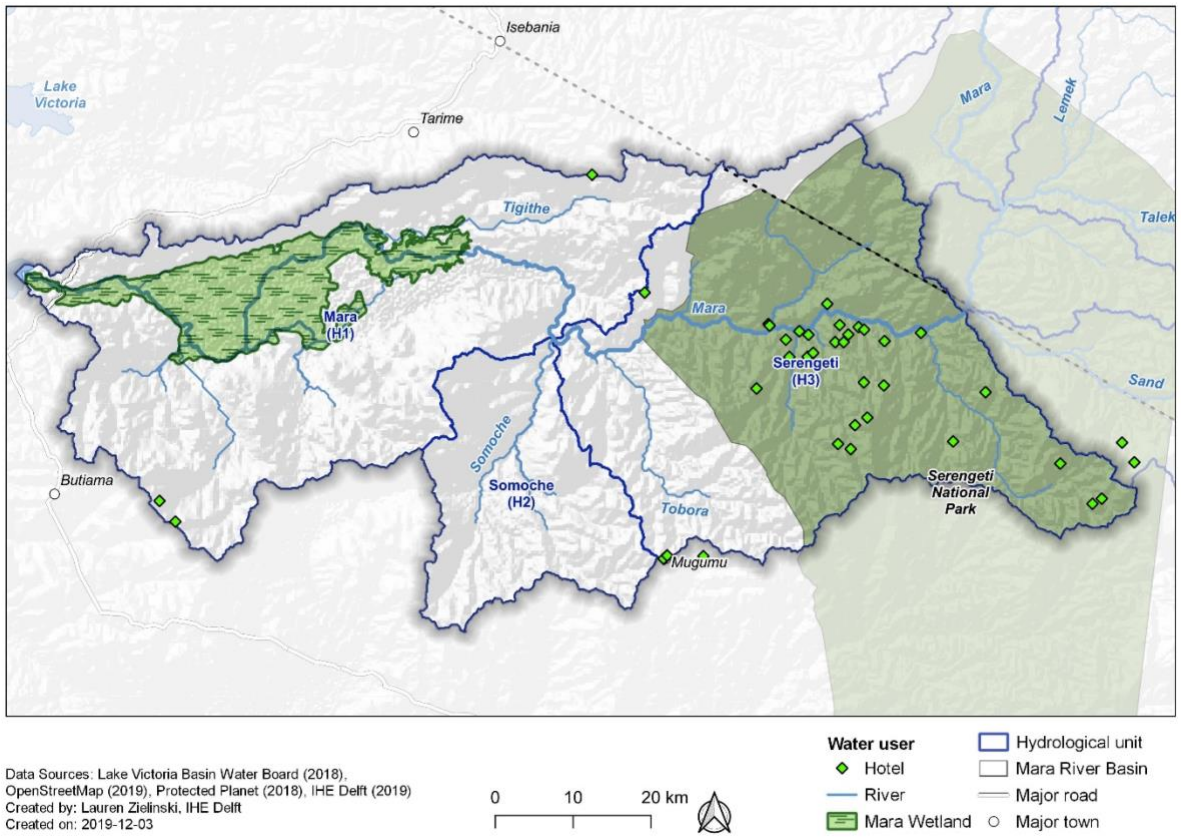


Figure 4-5: Location of hotels in the Lower MRB from the 2018 abstraction survey

Table 4-22: Current water demand from tourism by district (m^3/day)

District	No. of Hotels	No. of Hotel Rooms	No. of Hotel Beds	Water Demand
Butiama	2	50	50	12
Rorya	0	0	0	0
Serengeti	34	548	1,000	240
Tarime	5	49	78	19
Total	*41*	*647*	*1,128*	*271*

Table 4-23: Current water demand from tourism by HU (m^3/day)

HU	No. of Hotels	No. of Hotel Rooms	No. of Hotel Beds	Water Demand
Serengeti	38	577	1,036	249
Somoche	0	0	0	0
Mara	3	70	92	22
Total	*41*	*647*	*1,128*	*271*

It was assumed that the majority of the tourism (and therefore all the hotels in the region) were linked to tourists visiting SENAPA. Since the projected growth of the number of hotel beds in the next 20 years is unknown, the future water demand was linked to visitor days in SENAPA. Analyzing visitor data between 2001/2002 and 2018/2019, the average annual growth in the number of tourists was approximately 7.24 percent (although the change in visitor days between years could vary greatly in the positive or negative direction between years). An annual growth rate of 7.24 percent was then applied to the current water demand from hotels.

Table 4-24: Estimation of growth rate in tourism using historical visitor days for SENAPA

Year	Actual		Estimated 1.07 percent Annual Growth	
	Visitor Days	Percent Change	Visitor Days	Percent Change
2001/2	138,781		138,781	7.24
2002/3	160,571	16%	148,829	7.24
2003/4	156,131	-3%	159,604	7.24
2004/5	232,124	49%	171,159	7.24
2005/6	271,044	17%	183,551	7.24
2006/7	273,795	1%	196,840	7.24
2007/8	288,185	5%	211,092	7.24
2008/9	241,618	-16%	226,375	7.24
2009/10	272,072	13%	242,764	7.24
2010/11	515,870	90%	260,340	7.24
2011/12	347,553	-33%	279,189	7.24
2012/13	341,017	-2%	299,402	7.24
2013/14	388,105	14%	321,079	7.24
2014/15	372,917	-4%	344,325	7.24
2015/16	391,675	5%	369,254	7.24
2016/17	355,815	-9%	395,988	7.24
2017/18	400,457	13%	424,658	7.24
2018/19	455,575	14%	455,403	7.24

Source: SENAPA personal communication

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 MRB during the low season, the number of available beds would be half of the total capacity (50 percent availability of beds). Monthly visitor numbers for SENAPA were

not available, but it was assumed that the number of visitors doubles in the peak months for the migration (July to November). This was confirmed by the WAP technical team. The current average daily water demand was calculated by month using 271 m3/day as the demand for the high season (100 percent availability of beds, assuming all of those beds are filled) and 136 m3/day as the demand for the low season (50 percent availability of beds, assuming all of those beds are filled). These values were then averaged over the year to provide an average daily demand of 192 m3/day across the year (Table 4 25). Using the growth rate of 7.24 percent, this method was then applied to find the average daily water demand across the year for 2023, 2028, and 2038, with demand reaching 779 m3/day by 2038 (Table 4 26, Table 4 27).

Table 4-25: Projected water demand by month from tourism for the Lower MRB (m^3/day)

Month	Hotel Capacity	2018	2023	2028	2038
October	Peak season (100% capacity)	271	382	544	1091
November	Peak season (100% capacity)	271	382	544	1091
December	Low season (50% capacity)	136	194	275	556
January	Low season (50% capacity)	136	194	275	556
February	Low season (50% capacity)	136	194	275	556
March	Low season (50% capacity)	136	194	275	556
April	Low season (50% capacity)	136	194	275	556
May	Low season (50% capacity)	136	194	275	556
June	Low season (50% capacity)	136	194	275	556
July	Peak season (100% capacity)	271	382	544	1091
August	Peak season (100% capacity)	271	382	544	1091
September	Peak season (100% capacity)	271	382	544	1091
Average daily water demand (m^3/day)		**192**	**272**	**387**	**779**

Table 4-26: Projected water demand from tourism by district (m^3/day)

District	2018	2023	2028	2038
Butiama	9	12	17	34
Rorya	0	0	0	0
Serengeti	170	241	342	688
Tarime	13	19	27	54
Total	**192**	**272**	**386**	**776**

Table 4-27: Projected water demand from tourism by HU (m^3/day)

HU	2018	2023	2028	2038
Serengeti	176	250	354	713
Somoche	0	0	0	0
Mara	16	22	31	63
Total	**192**	**272**	**386**	**776**

4.5. WILDLIFE

Since the Mara River is the only perennial water source in the region, it is a critical water source for wildlife. This includes supplying water to the great migration of approximately 2 million animals as well as the resident wildlife that live in the Lower MRB year-round. For this analysis, the demand for the animals in the migration and the animals that live in the region year-round were calculated separately and then combined for total wildlife demand.

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 approximately 14,700 m3/day (Table 4-28). The additional 20 percent recommended by the draft WAP guidelines to account for losses for leakage and wastage was not applied to wildlife since there is no infrastructure associated with this demand type.

There is little available data on the populations of animals that live in the Lower MRB 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 the entire populations provided were resident populations of the Lower MRB. The values for both migration and resident populations were combined to get a total water demand of 18,402 m3/day (Table 4-28).

Table 4-28: 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)

Since the migration is always moving, it is important to estimate water demand in the Lower MRB by month. Based on the known annual migration patterns, wildlife enter the Mara River Basin in early June and stay within the northern part of SENAPA and the Maasai Mara National Reserve in Kenya until about November. After this, the migration moves to the eastern and southern parts of SENAPA (Hopcraft, 2010; Subalusky *et al.*, 2017) (Figure 4-6). It was assumed that the full migrating population would never be in the Lower MRB all at once. It is estimated that 50 percent would be in the Lower MRB at one time during the months of June through November as they migrate into the Lower MRB from Grumeti Game Reserve, out of the Lower MRB to the Maasai Mara National Reserve in Kenya, and then through the eastern side of the Lower MRB on their way south to Ngorongoro Conservation Area (Figure 4-6).

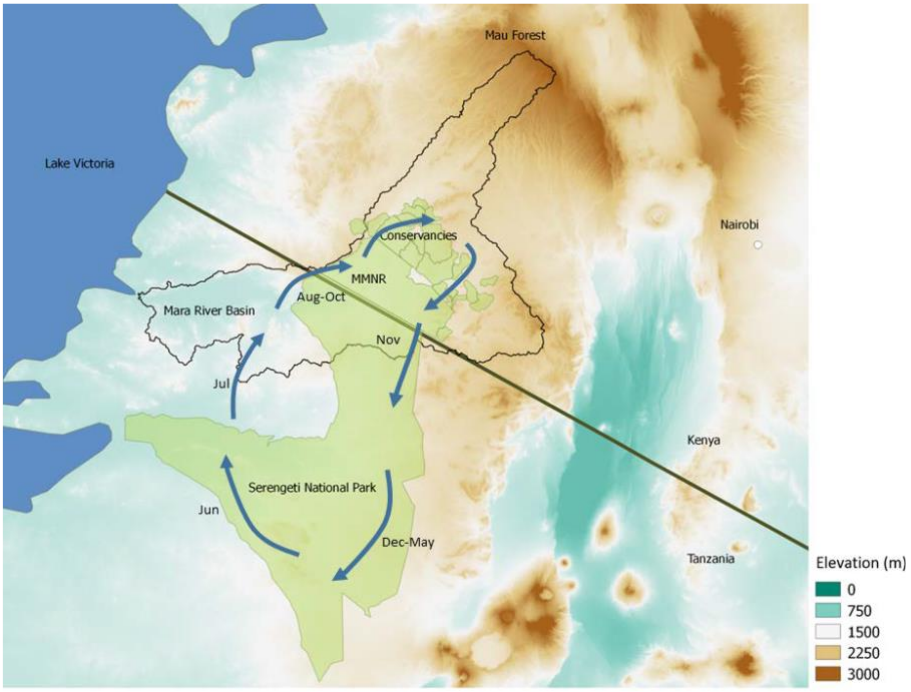


Figure 4-6: Migration pattern in the Serengeti (WWF-Kenya, 2019)

Using the estimated total water demand, the known migration patterns, and an approximation of the migrating population within the Lower MRB by month, the monthly and yearly average water demand for migrating wildlife was calculated to be 7,363 m3/day during the months of the migration, 0 m3/day during the months outside of the migration, and 3,068 m3/day when averaged over the whole year (Table 4-29). When the resident population demand is added for each month, the annual daily water demand increases to 11,039 m3/day during the months of the migration, 3,676 m3/day during the months outside of the migration, and 6,744 m3/day averaged across the year (Table 4-30).

Table 4-29: Projected water demand by month from the migration in the Lower MRB (m^3/day)

Month	Approx. Location of Migration	Approx. % in Lower MRB	2018	2023	2028	2038
October	Maasai Mara & Northeastern Serengeti	50	7,363	7,363	7,363	7,363
November	Northeastern & Southeastern Serengeti	50	7,363	7,363	7,363	7,363
December	Southeastern Serengeti	0	0	0	0	0
January	Southern Serengeti	0	0	0	0	0
February	Southern Serengeti	0	0	0	0	0
March	Southern Serengeti	0	0	0	0	0
April	Western Serengeti	0	0	0	0	0
May	Western Serengeti	0	0	0	0	0
June	Northwestern Serengeti	0	0	0	0	0
July	Northern Serengeti	50	7,363	7,363	7,363	7,363
August	Northern Serengeti & Maasai Mara	50	7,363	7,363	7,363	7,363
September	Northern Serengeti & Maasai Mara	50	7,363	7,363	7,363	7,363
Average daily water demand (m^3/day)			*3,068*	*3,068*	*3,068*	*3,068*

Source: (Hopcraft, 2010; Tanzania Tourism Board, 2012; Subalusky et al., 2017)

Table 4-30: Projected water demand by month from all wildlife (migration and residence populations) in the Lower MRB (m^3/day)

Month	Approx. Location of Migration	Resident Pop. Demand	2018	2023	2028	2038
October	Maasai Mara & Northeastern Serengeti	3,676	11,039	11,039	11,039	11,039
November	Northeastern & Southeastern Serengeti	3,676	11,039	11,039	11,039	11,039
December	Southeastern Serengeti	3,676	3,676	3,676	3,676	3,676
January	Southern Serengeti	3,676	3,676	3,676	3,676	3,676
February	Southern Serengeti	3,676	3,676	3,676	3,676	3,676
March	Southern Serengeti	3,676	3,676	3,676	3,676	3,676
April	Western Serengeti	3,676	3,676	3,676	3,676	3,676
May	Western Serengeti	3,676	3,676	3,676	3,676	3,676
June	Northwestern Serengeti	3,676	3,676	3,676	3,676	3,676
July	Northern Serengeti	3,676	11,039	11,039	11,039	11,039
August	Northern Serengeti & Maasai Mara	3,676	11,039	11,039	11,039	11,039
September	Northern Serengeti & Maasai Mara	3,676	11,039	11,039	11,039	11,039
Average daily water demand (m^3/day)			*6,744*	*6,744*	*6,744*	*6,744*

Source: Subalusky et al. 2017; Hopcraft 2010, TAWIRI personal communication

While wildlife are not limited to the human-created boundaries, most animals stay within the protected areas of the game reserves and national parks in the area. For this analysis, it was assumed that the vast majority of the animals in the migration remain within or very close to these boundaries and that the water demand from wildlife would be entirely within Serengeti District and the Serengeti HU.

Table 4-31: Projected water demand from wildlife by district (m^3/day)

District	2018	2023	2028	2038
Butiama	0	0	0	0
Rorya	0	0	0	0
Serengeti	6,744	6,744	6,744	6,744
Tarime	0	0	0	0
Total	*6,744*	*6,744*	*6,744*	*6,744*

Table 4-32: Projected water demand from wildlife by HU (m^3/day)

HU	2018	2023	2028	2038
Serengeti	6,744	6,744	6,744	6,744
Somoche	0	0	0	0
Mara	0	0	0	0
Total	*6,744*	*6,744*	*6,744*	*6,744*

4.6. MINING

Water demand for mining is based on the volume of abstractions intended for either extracting, processing, or sedimentation of gold ore. During the abstraction survey in 2018, 33 mining operations were found to be extracting water – 32 small-scale (artisanal) mining operations and 1 large-scale mining opeation, the North Mara Gold Mine (LVBWB 2018, Figure 4-7). Almost all of these operations were in the north central part of the study area, with a few operations in other parts of the Lower MRB.

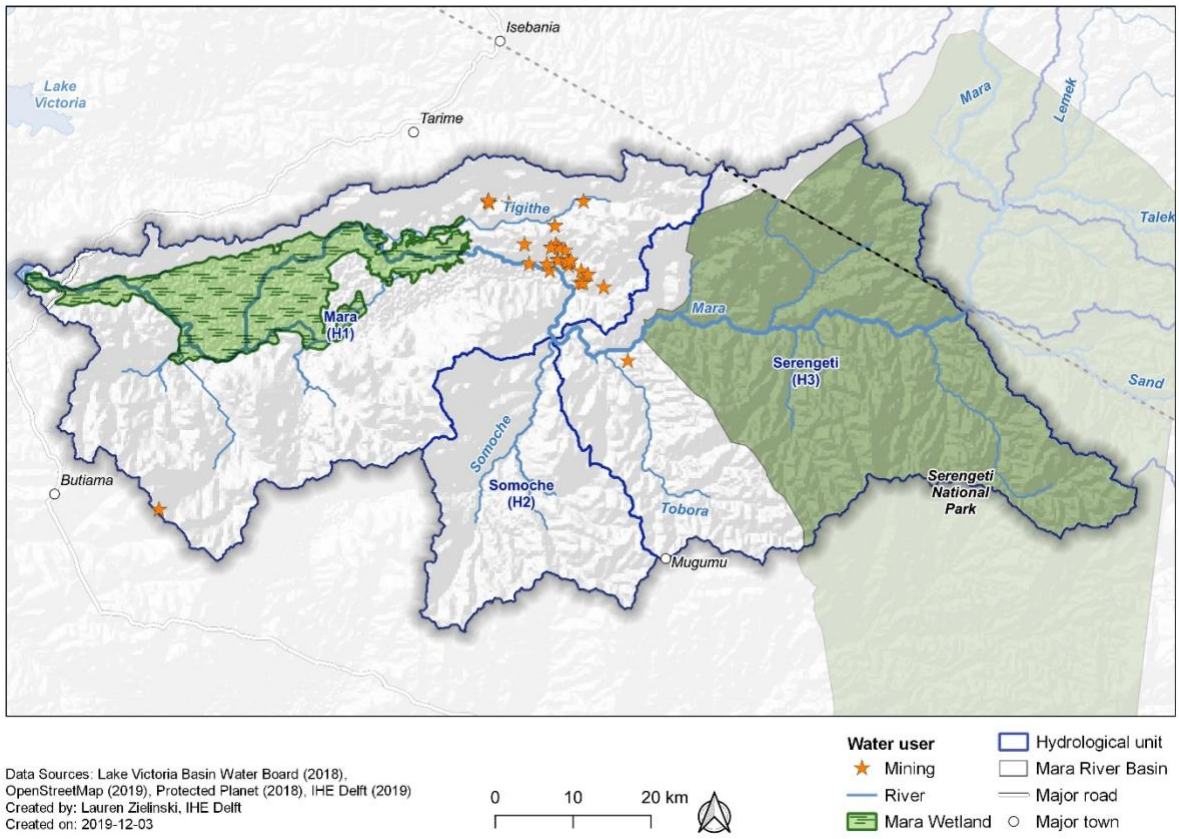


Figure 4-7: Location of mining operations in the Lower MRB from the 2018 abstraction survey

The artisanal mining operations often pump groundwater out of their mining shafts so the miners can then gather the raw ore. However, much of this is pumped to the surface and is not being consumed. As such, it was assumed that this water remains available in the hydrological system. They consume relatively small amounts of water for processing the gold ore, adding a variety of chemicals to help leach out the gold from the rock. Due to the expensive cost of these chemicals, the water/chemical combination is almost never flushed out and water is added only when the levels become too low due to small amounts of water leaving during processing or evaporation.

The North Mara Gold Mine is a very large open pit mining operation that is owned by an international mining company. They mine and process ore on a large scale using advanced processing techniques. While the North Mara Gold does not abstract water from the Mara River, it does collect a large quantity of rainwater in open pits which is used for processing activities. This amount of water is being consumed during this process and prevents this water from being used by other water users downstream. As such, this amount of collected rainwater is included as a water demand.

The total amount of water used from artisanal mining was found to be 104 m3/day in 2018 (LVBWB, 2018). An additional 20 percent was added to this value (following the draft WAP guidelines for Tanzania) for a demand of 125 m3/day. For the North Mara Gold mine, the amount of water used was estimted to be 2,300 m3/day, although this value may fluctuate on a daily basis. Again, 20 percent was added to this value for a daily demand of 2,760 m3/day for large-scale mining Table 4-33 and Table 4-34).

Table 4-33: Current water demand from mining by district (m3/day)

District	Artisanal		Large-Scale		Total	
	Number of Mines	Water Demand	Number of Mines	Water Demand	Number of Mines	Water Demand
Butiama	1	12	0	0	1	12
Rorya	0	0	0	0	0	0
Serengeti	1	12	0	0	1	12
Tarime	30	101	1	2,760	31	2,861
Total	*32*	*125*	*1*	*2,760*	*33*	*2,885*

Table 4-34: Current water demand from mining by HU (m3/day)

HU	Artisanal		Large-Scale		Total	
	Number of Mines	Water Demand	Number of Mines	Water Demand	Number of Mines	Water Demand
Serengeti	1	12	0	0	1	12
Somoche	0	0	0	0	0	0
Mara	31	113	1	2,760	32	2,873
Total	*32*	*125*	*1*	*2,760*	*33*	*2,885*

Based on conversations with the managers at North Mara Gold Mine during the abstraction survey, there were no plans for expansion. As such, the future water demand for North Mara Mine was assumed to be constant. However, artisnal mining in Tanzania is growing rapidly, with an annual growth of about 12.3 percent for Primary Mining Licenses across the country between 2010 and 2016 (although the year to year fluctuation can be very high in the positive or negative direction, Table 4-35). To try to get a better understanding of the conditions in the Mara Region, an information request was made with the Mara Regional Miners Association. While this organization is active in representing the local artisenal miners at events and workshops, they do not collect data on the number of active miners in the region (personal comm. John Ngawambala, LVBWB). Nationally, the small-scale mining unit within the State Mining Corporation under the Ministry of Minerals is responsible for collecting such data. However, the most recent information was collected in 2012 and does not provide any growth projections (Mutagwaba et al., 2018). Due to the lack of local information, the growth in Primary Mining Licenses will be used as a proxy for the growth of artisenal miners in the Lower MRB (Table 4-35).

Table 4-35: Number of Primary Mining Licenses approved in Tanzania between 2010 and 2016

Year	Primary Mining License	Percent Change
2010	5,086	
2011	3,965	-22.0
2012	8,648	118.1
2013	9,829	13.7
2014	4,733	-51.8
2015	6,413	35.5
2016	5,171	-19.4
Average	***6,264***	***12.3***

Source: Mutagwaba et al. 2018

Applying a growth rate of 12.3 percent to the water demand for artisanal mining operations in the Lower MRB and keeping the demand the same for the North Mara Gold Mine, it was found that the water demand would increase to around 4,036 m3/day by 2038 (Table 4-36 and Table 4-37).

Table 4-36: Projected water demand from mining by district (m^3/day)

District	2018	2023	2028	2038
Artisanal Mining				
Butiama	12	21	38	122
Rorya	0	0	0	0
Serengeti	12	21	38	122
Tarime	101	181	323	1,032
Total	*125*	*224*	*400*	*1,276*
Large-Scale Mining				
Butiama	0	0	0	0
Rorya	0	0	0	0
Serengeti	0	0	0	0
Tarime	2,760	2,760	2,760	2,760
Total	*2,760*	*2,760*	*2,760*	*2,760*
Total				
Butiama	12	21	38	122
Rorya	0	0	0	0
Serengeti	12	21	38	122
Tarime	2,861	2,941	3,083	3,792
Total	*2,885*	*2,984*	*3,160*	*4,036*

Table 4-37: Projected water demand from mining by HU (m^3/day)

HU	2018	2023	2028	2038
Artisanal Mining				
Serengeti	12	21	38	122
Somoche	0	0	0	0
Mara	113	203	362	1,154
Total	*125*	*224*	*400*	*1,276*
Large-Scale Mining				
Serengeti	0	0	0	0
Somoche	0	0	0	0
Mara	2,760	2,760	2,760	2,760
Total	*2,760*	*2,760*	*2,760*	*2,760*
Total				
Serengeti	12	21	38	122
Somoche	0	0	0	0
Mara	2,873	2,963	3,122	3,914
Total	*2,885*	*2,984*	*3,160*	*4,036*

4.7. 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. PROJECTED TOTAL WATER DEMAND

Over the next 20 years, the demand for water is expected to increase, with steady growth in some sectors and dramatic growth in others. Water for livestock and additional domestic use are currently the largest demands in the Lower MRB (39 percent and 36 percent, respectively) and are expected to steadily increase into the future. However, it is clear that the planned large-scale irrigation projects are projected to have the largest demands in the basin, accounting for 91 percent of the demand in the Lower MRB by 2038. Geographically, the demand is greatest in Serengeti District and the Mara HU due to the locations of the planned irrigation schemes. The location of the Mara Valley Project is near the downstream end of the Mara River before it reaches the Mara Wetland, which means care will need to be taken upstream if adequate flows are to be provided to that project. Aggregated values for districts, HUs, and for the entire Lower MRB can be found in Sections 5.1, 5.2, and 5.3.

Aside from the large-scale irrigations schemes and the North Mara Gold Mine, most sectors do not have a point source of abstraction for their water demand. Rather, it is dispersed around the Lower MRB and utilizes different water sources (surface water, shallow groundwater, rainwater collection, etc.). This may have the advantage that one single water source may not become overly depleted, but it does make it more difficult to determine where the abstractions are taking place within the basin.

Demand also fluctuates by month, most notably for irrigation due to the natural wet and dry seasons, for wildlife due to the movement of the migration, and for tourism which is based around the migration pattern. Monthly demand patterns are important to consider since water stress (where the availability of water cannot meet the demand) often occurs during the dry season(s) and has already been experienced in the Mara River Basin. Monthly values for the HUs are provided in Section 7.3.

5.1. DEMAND BY DISTRICT

Table 5-1: Projected total water demand in Butiama District for 2018 (m^3/day)

Butiama District	Current Demand	5 Years	10 Years	20 Years
	2018	2023	2028	2038
Domestic	2,152	2,400	2,675	3,326
Livestock	2,558	2,878	3,198	3,838
Irrigation	677	755	48,189	249,591
Tourism	8	11	16	32
Wildlife	0	0	0	0
Mining	12	21	38	122
Total	*5,408*	*6,065*	*54,116*	*256,908*

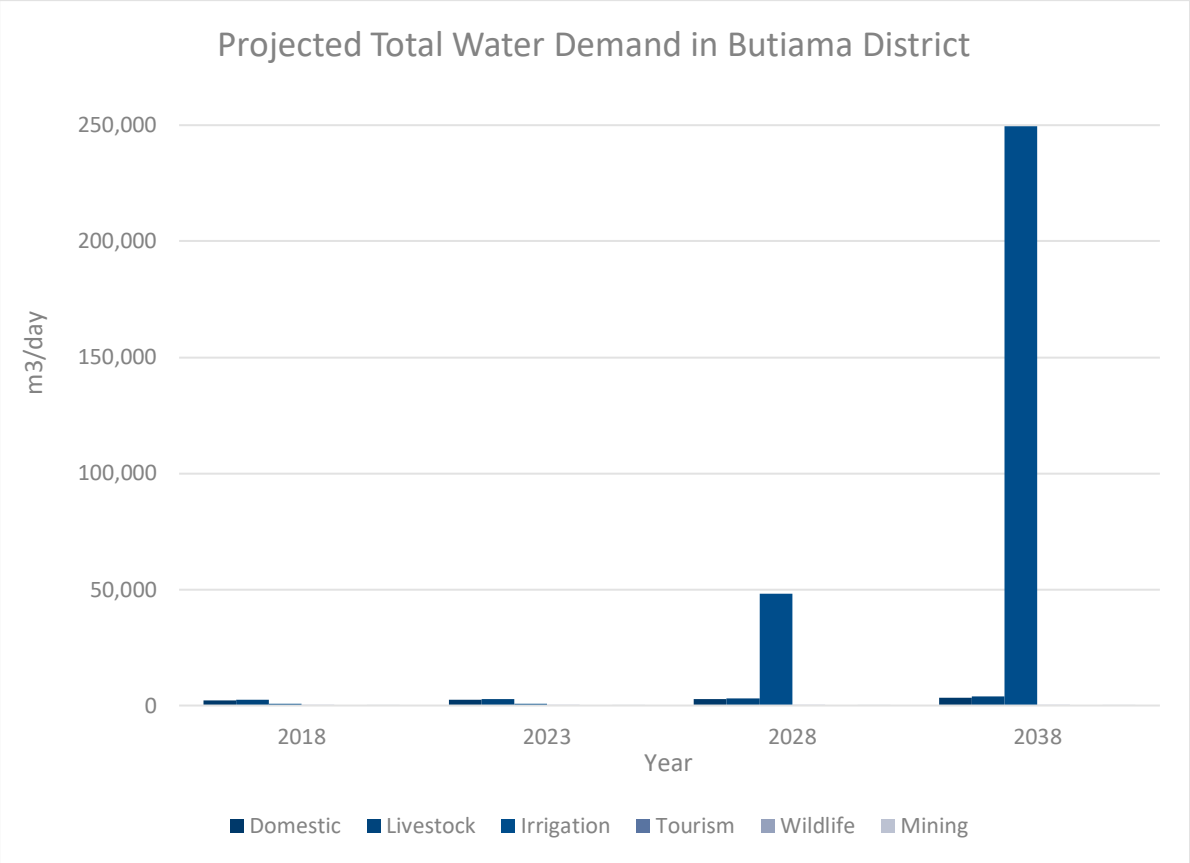


Figure 5-1: Projected total water demand in Butiama District

Table 5-2: Projected total water demand in Rorya District (m_3/day)

Rorya District	Current Demand	5 Years	10 Years	20 Years
	2018	2023	2028	2038
Domestic	389	430	475	579
Livestock	246	277	308	369
Irrigation	0	0	0	0
Tourism	0	0	0	0
Wildlife	0	0	0	0
Mining	0	0	0	0
Total	*636*	*707*	*782*	*948*

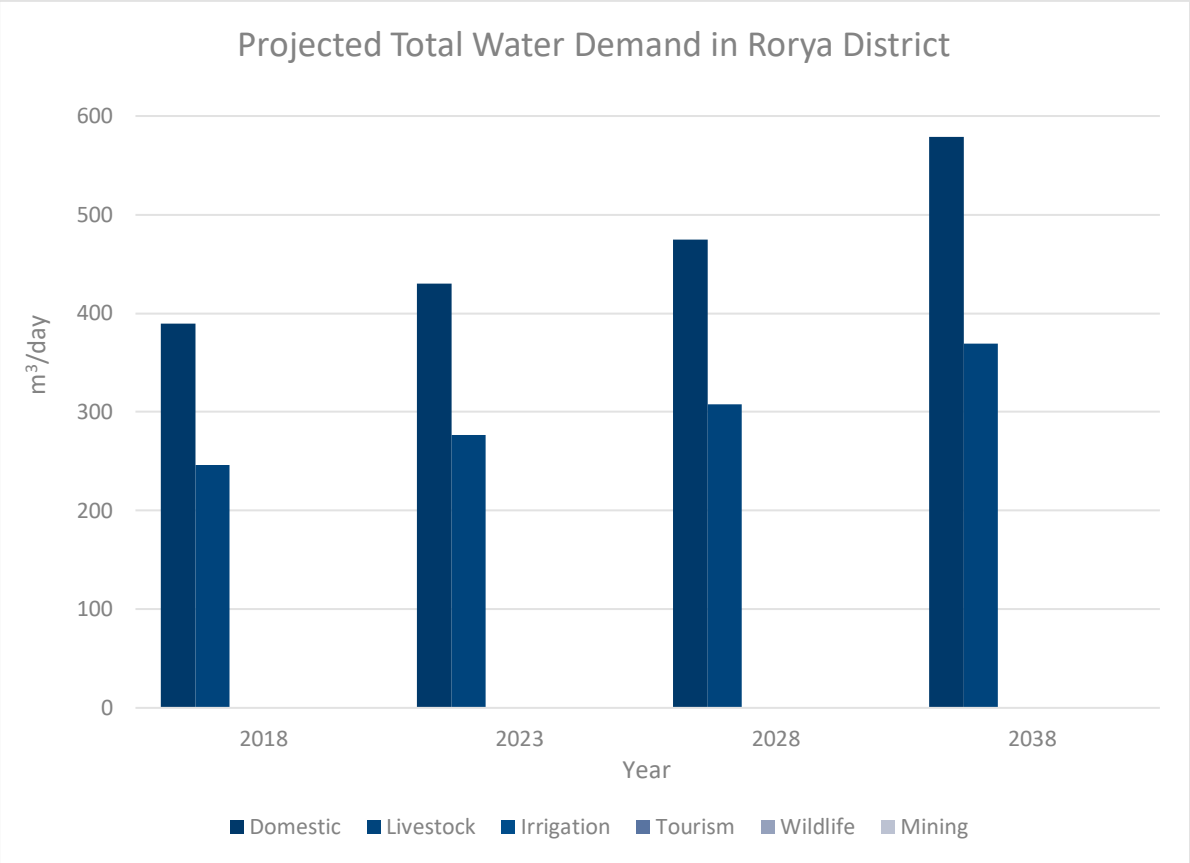


Figure 5-2: Projected total water demand in Rorya District

Table 5-3: Projected total water demand in Serengeti District (m_3/day)

Serengeti District	Current Demand	5 Years	10 Years	20 Years
	2018	**2023**	**2028**	**2038**
Domestic	5,225	6,206	7,371	10,397
Livestock	6,091	6,853	7,614	9,137
Irrigation	4	6,695	54,042	255,242
Tourism	60	84	120	241
Wildlife	6,744	6,744	6,744	6,744
Mining	12	21	38	122
Total	*18,137*	*26,603*	*75,930*	*281,883*

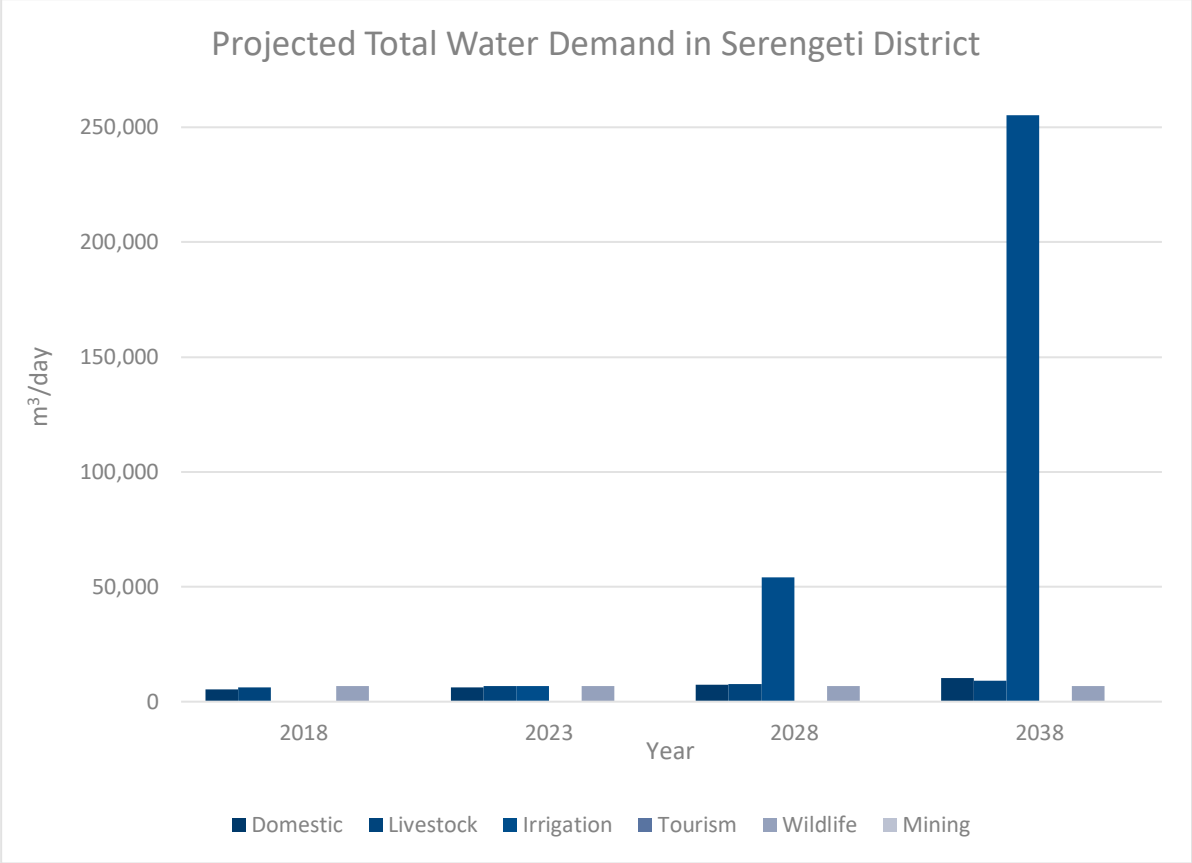


Figure 5-3: Projected total water demand in Serengeti District

Table 5-4: Projected total water demand in Tarime District (m3/day)

Tarime District	Current Demand	5 Years	10 Years	20 Years
	2018	2023	2028	2038
Domestic	4,251	4,739	5,284	6,568
Livestock	4,170	4,692	5,213	6,256
Irrigation	34	38	42	53
Tourism	5	7	9	19
Wildlife	0	0	0	0
Mining	2,861	2,941	3,083	3,792
Total	*11,322*	*12,417*	*13,632*	*16,687*

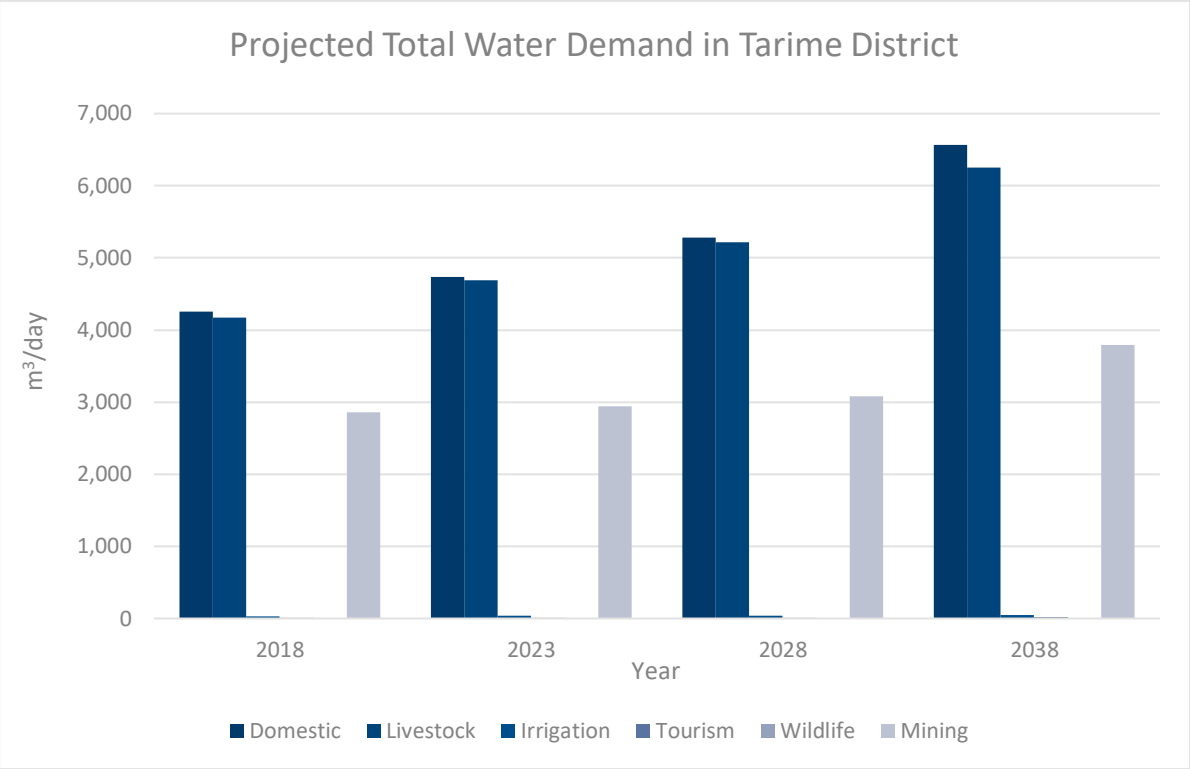


Figure 5-4: Projected total water demand in Tarime District

5.2. DEMAND BY HYDROLOGICAL UNIT

Table 5-5: Projected total water demand in Serengeti HU (m3/day)

Serengeti HU	Current Demand	5 Years	10 Years	20 Years
	2018	2023	2028	2038
Domestic	2,844	3,318	3,874	5,293
Livestock	2,299	2,587	2,874	3,449
Irrigation	0	0	0	0
Tourism	178	252	358	720
Wildlife	6,744	6,744	6,744	6,744
Mining	12	21	38	122
Total	*12,077*	*12,922*	*13,888*	*16,328*

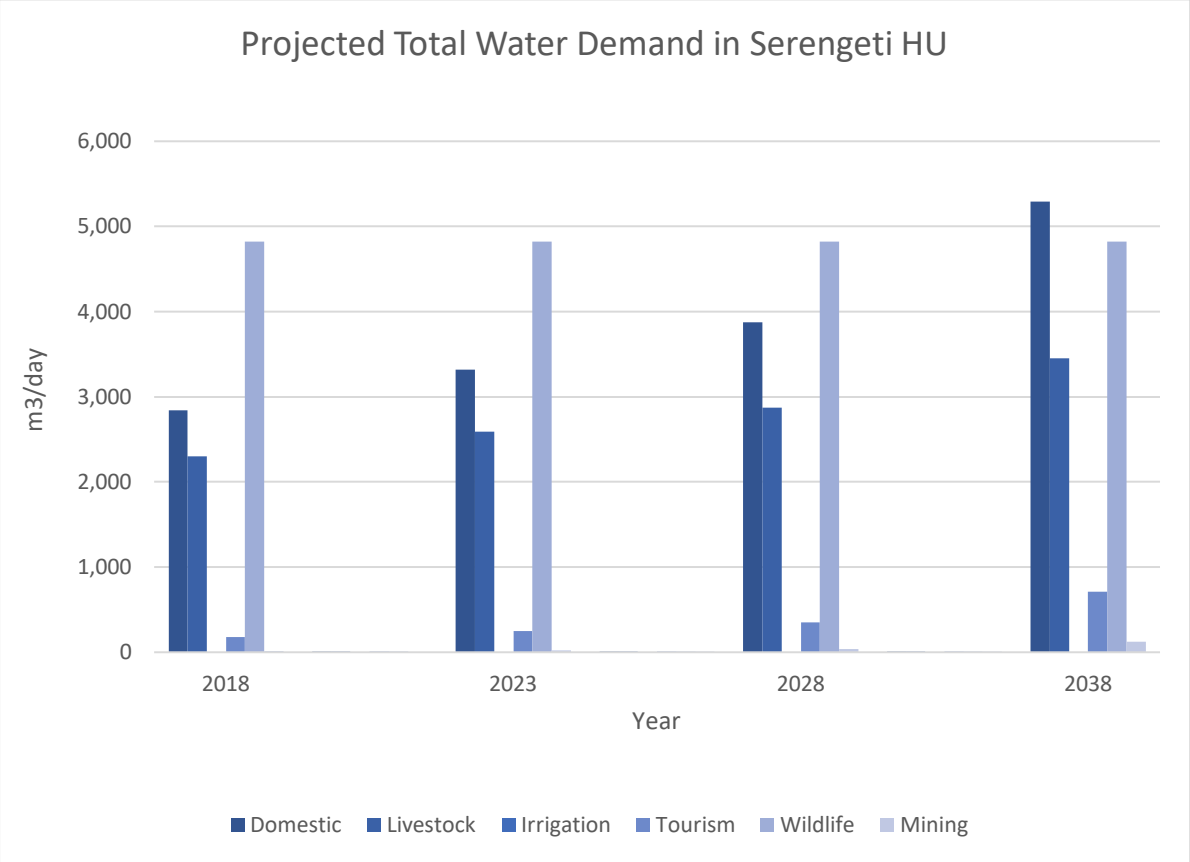


Figure 5-5: Projected total water demand in Serengeti HU

Table 5-6: Projected total water demand by month in Serengeti HU (m3/day)

Month	Current Demand	5 Years	10 Years	20 Years
	2018	2023	2028	2038
October	8,956	9,777	10,712	13,041
November	8,956	9,777	10,712	13,041
December	8,956	9,777	10,712	13,041
January	8,956	9,777	10,712	13,041
February	8,956	9,777	10,712	13,041
March	8,956	9,777	10,712	13,041
April	16,443	17,316	18,325	20,905
May	16,443	17,316	18,325	20,905
June	16,443	17,316	18,325	20,905
July	16,443	17,316	18,325	20,905
August	16,443	17,316	18,325	20,905
September	8,956	9,777	10,712	13,041
Average daily water demand	*12,075*	*12,918*	*13,884*	*16,318*

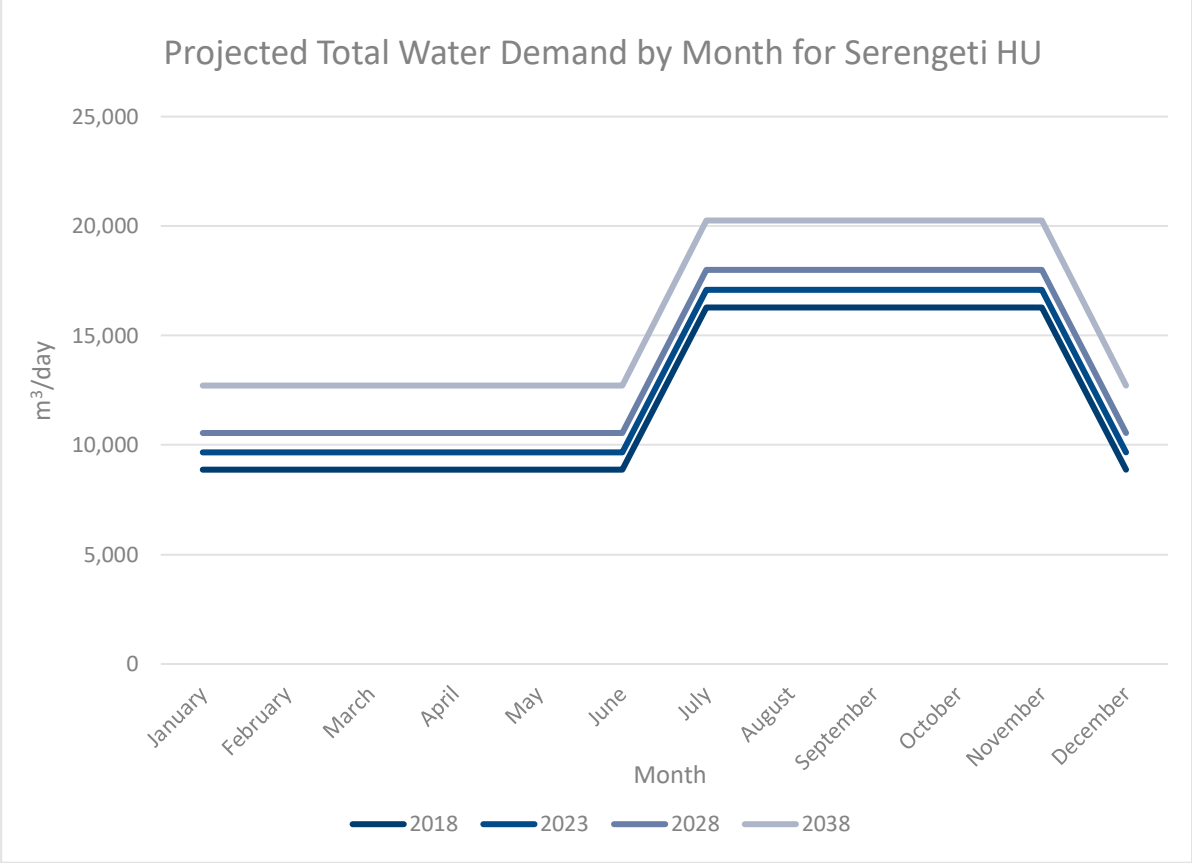


Figure 5-6: Projected total water demand by month in Serengeti HU

Table 5-7: Projected total water demand in Somoche HU (m3/day)

Somoche HU	Current Demand	5 Years	10 Years	20 Years
	2018	2023	2028	2038
Domestic	1,772	2,105	2,500	3,527
Livestock	2,137	2,404	2,671	3,205
Irrigation	4	6,695	6,696	6,698
Tourism	0	0	0	0
Wildlife	0	0	0	0
Mining	0	0	0	0
Total	*3,913*	*11,204*	*11,867*	*13,430*

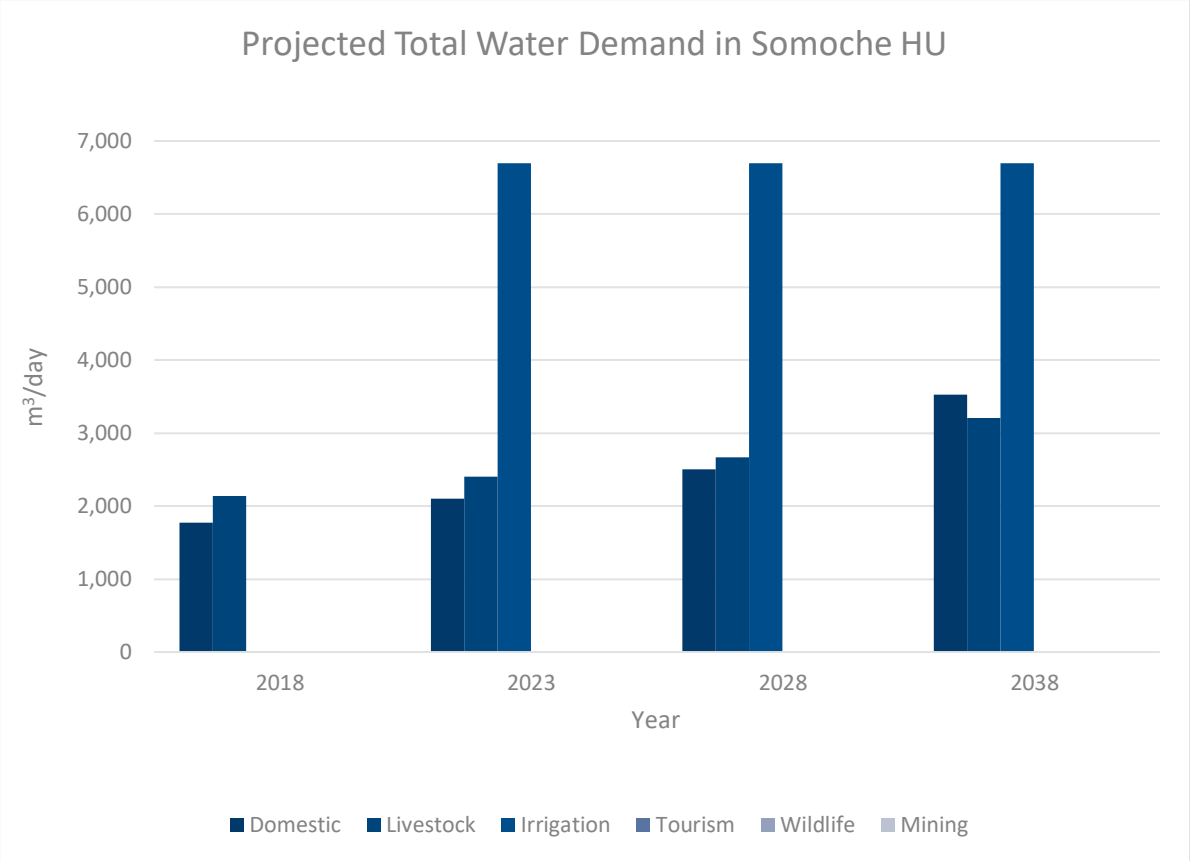


Figure 5-7: Projected total water demand in Somoche HU

Table 5-8: Projected total water demand by month in Somoche HU (m3/day)

Month	Current Demand	5 Years	10 Years	20 Years
	2018	2023	2028	2038
October	3,909	12,660	13,322	14,883
November	3,909	10,947	11,609	13,170
December	3,909	13,481	14,143	15,704
January	3,909	13,485	14,148	15,708
February	3,909	10,996	11,658	13,219
March	3,909	8,331	8,993	10,554
April	3,909	5,953	6,615	8,176
May	3,909	9,647	10,309	11,870
June	3,909	10,751	11,413	12,974
July	3,909	10,282	10,944	12,505
August	3,909	15,939	16,601	18,162
September	3,958	11,971	12,644	14,233
Average daily water demand	*3,913*	*11,204*	*11,867*	*13,430*

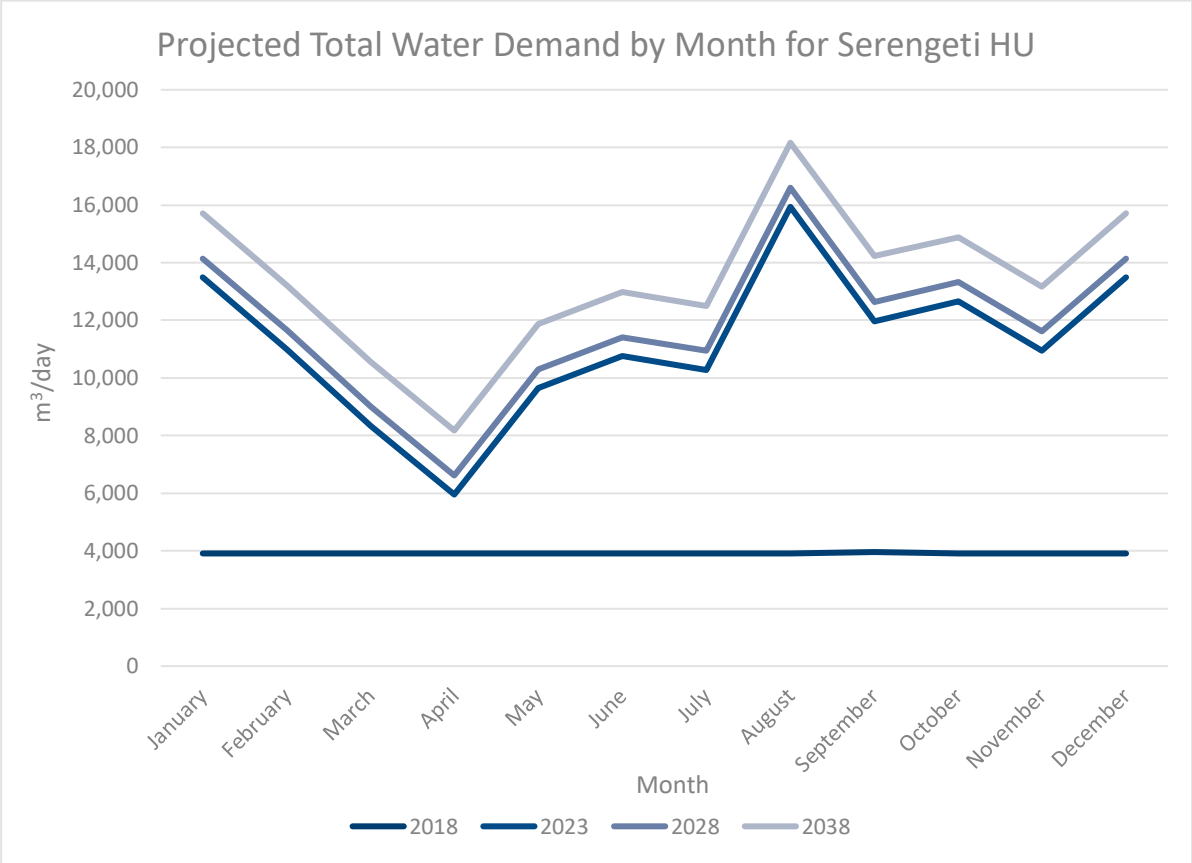


Figure 5-8: Projected total water demand by month in Somoche HU

Table 5-9: Projected total water demand in Mara HU (m3/day)

Mara HU	Current Demand	5 Years	10 Years	20 Years
	2018	2023	2028	2038
Domestic	7,401	8,352	9,431	12,051
Livestock	8,630	9,709	10,788	12,945
Irrigation	711	793	95,578	498,187
Tourism	16	22	31	63
Wildlife	0	0	0	0
Mining	2,873	2,963	3,122	3,914
Total	*19,632*	*21,839*	*118,950*	*527,161*

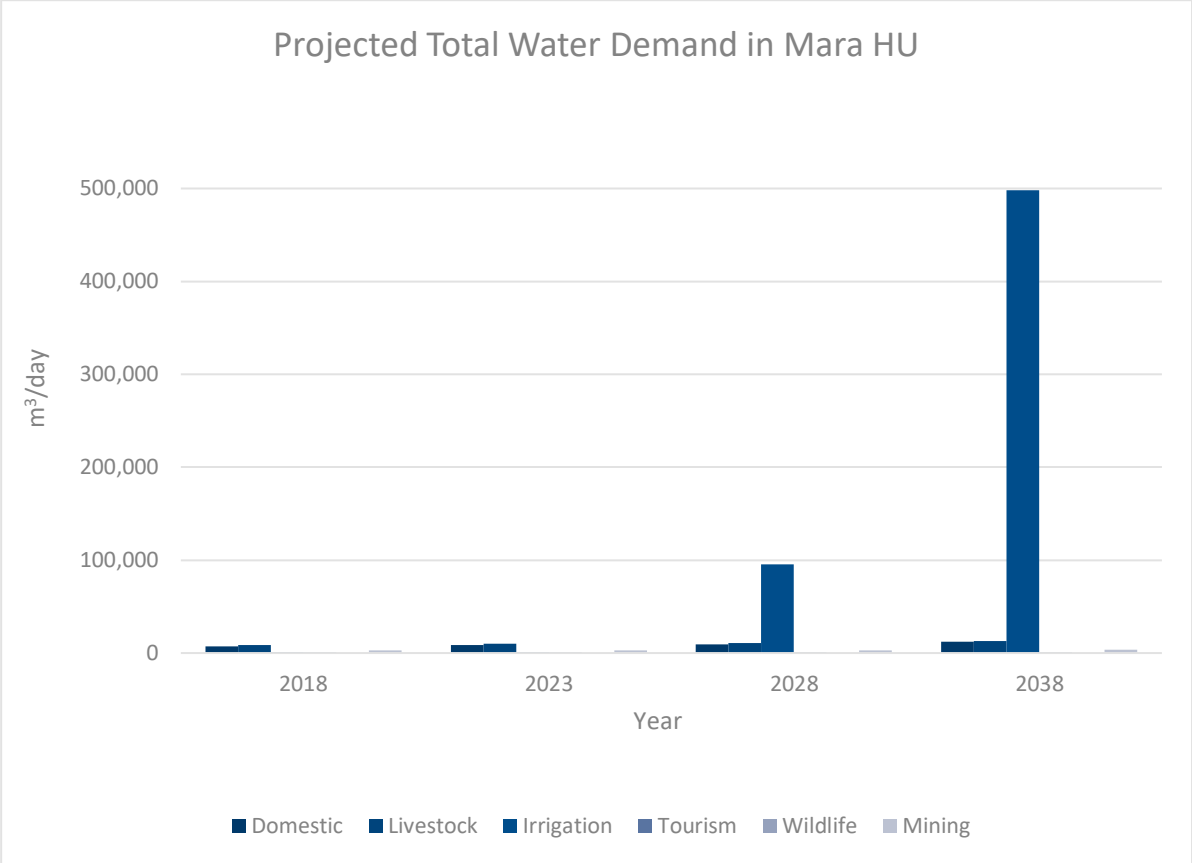


Figure 5-9: Projected total water demand in Mara HU

Table 5-10: Projected total water demand by month in Mara HU (m3/day)

Month	Current Demand	5 Years	10 Years	20 Years
	2018	2023	2028	2038
October	19,591	21,792	151,265	697,006
November	19,327	21,497	115,698	511,616
December	19,380	21,556	78,040	313,668
January	19,467	21,653	44,489	137,114
February	19,518	21,711	96,843	411,687
March	19,553	21,750	112,507	493,735
April	19,619	21,826	105,963	459,044
May	19,751	21,973	186,200	879,584
June	20,060	22,318	129,588	580,859
July	19,894	22,133	139,965	636,158
August	19,805	22,034	115,610	508,753
September	19,618	21,822	151,233	696,702
Average daily water demand	*19,632*	*21,839*	*118,950*	*527,160*

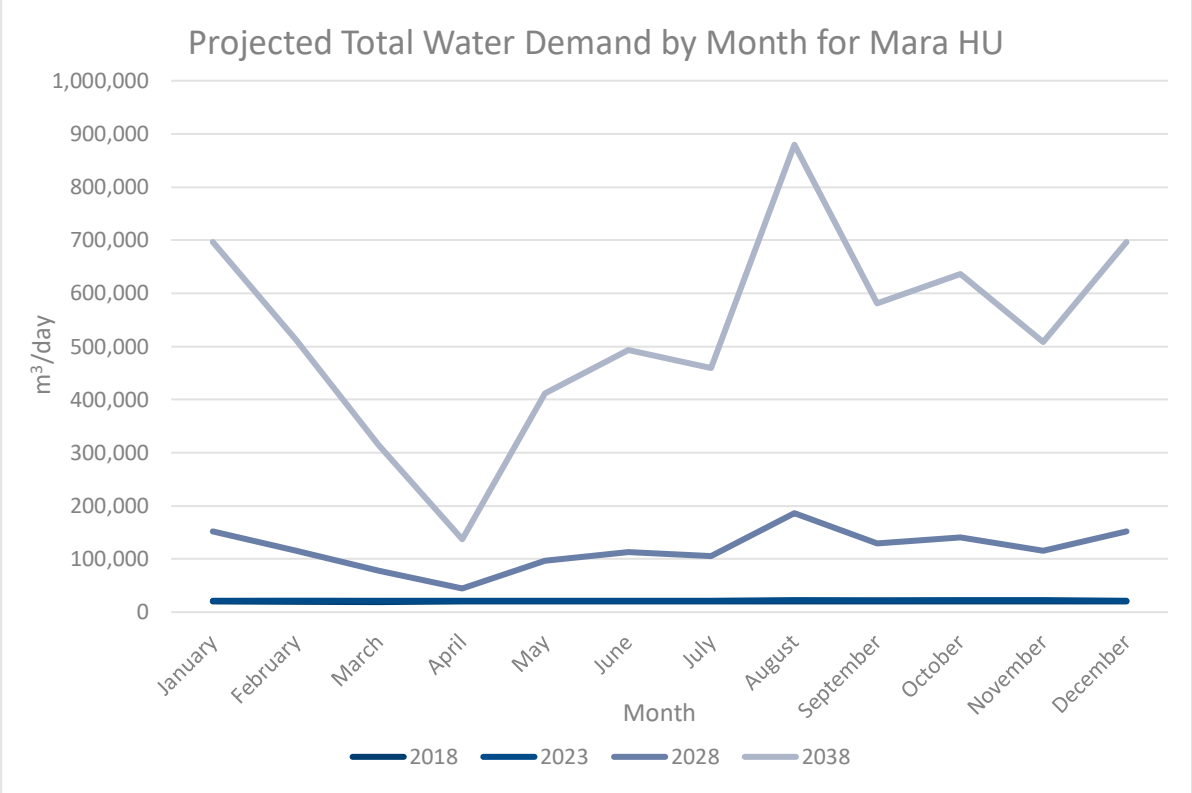


Figure 5-10: Projected total water demand by month in Mara HU

5.3. DEMAND FOR THE LOWER MRB TOTAL

Table 5-11: Projected total water demand in the Lower MRB by district (m3/day)

District	Current Demand		5 Years		10 Years		20 Years	
	2018		2023		2028		2038	
Butiama	5,408	15.2%	6,065	13.2%	54,116	37.5%	256,908	46.2%
Rorya	636	1.8%	707	1.5%	782	0.5%	948	0.2%
Serengeti	18,137	51.1%	26,603	58.1%	75,930	52.6%	281,883	50.7%
Tarime	11,322	31.9%	12,417	27.1%	13,632	9.4%	16,687	3.0%
Total	*35,502*	*100%*	*45,792*	*100%*	*144,460*	*100%*	*556,427*	*100%*

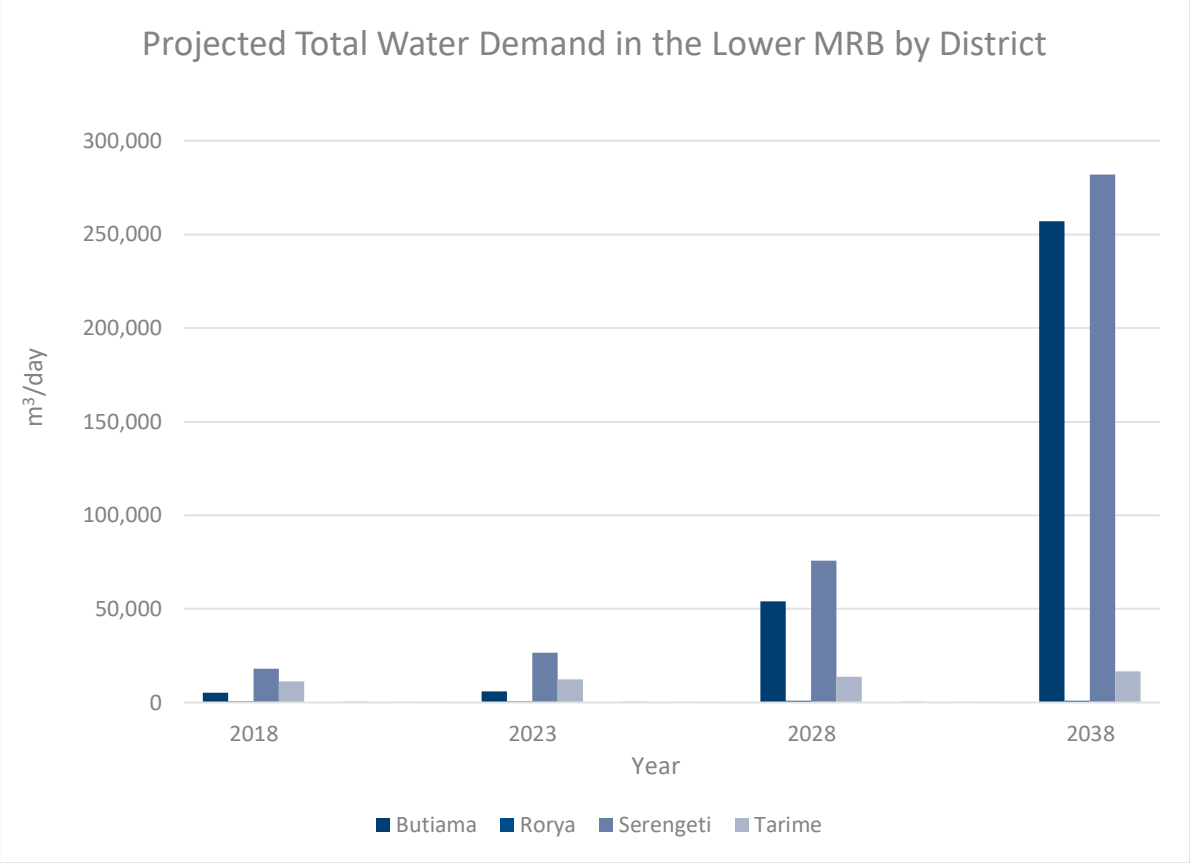


Figure 5-11: Projected total water demand in the Lower MRB by district

Table 5-12: Projected total water demand in the Lower MRB by HU (m3/day)

HU	Current Demand		5Years		10 Years		20 Years	
	2018		2023		2028		2038	
Serengeti	10,154	30.1%	10,999	25.0%	11,963	8.4%	14,400	2.6%
Somoche	3,913	11.6%	11,204	25.4%	11,867	8.3%	13,430	2.4%
Mara	19,632	58.3%	21,839	49.6%	118,950	83.3%	527,161	95.0%
Total	*33,700*	*100%*	*44,041*	*100%*	*142,779*	*100%*	*554,990*	*100%*

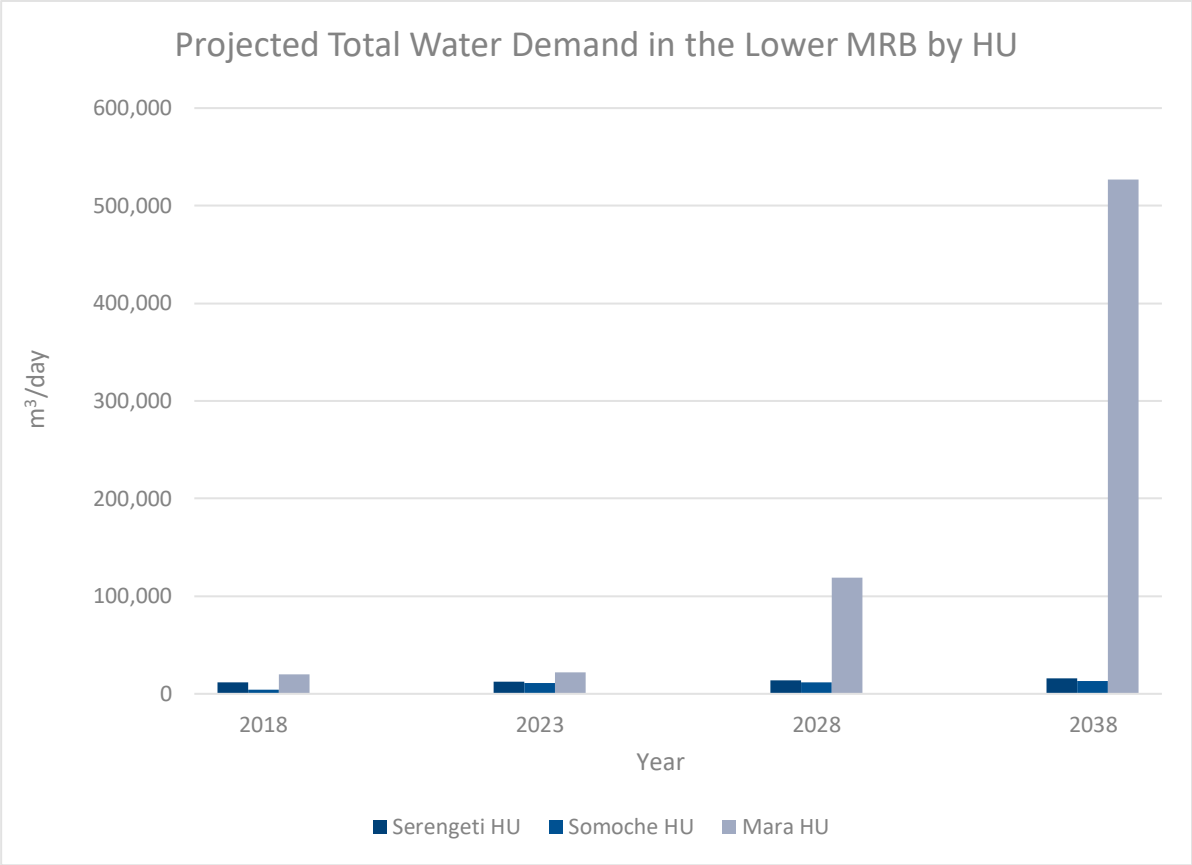


Figure 5-12: Projected total water demand in the Lower MRB by HU

Table 5-13: Projected total water demand in the Lower MRB by sector (m3/day)

Sector	Current Demand		5Years		10 Years		20 Years	
	2018		2023		2028		2038	
Domestic	12,018	35.7%	13,775	31.3%	15,805	11.1%	20,870	3.8%
Livestock	13,066	38.8%	14,700	33.4%	16,333	11.4%	19,599	3.5%
Irrigation	715	2.1%	7,488	17.0%	102,274	71.6%	504,885	91.0%
Tourism	192	0.6%	272	0.6%	386	0.3%	776	0.1%
Wildlife	4,823	14.3%	4,823	11.0%	4,823	3.4%	4,823	0.9%
Mining	2,885	8.6%	2,984	6.8%	3,160	2.2%	4,036	0.7%
Total	*33,700*	*100%*	*44,041*	*100%*	*142,780*	*100%*	*554,990*	*100%*

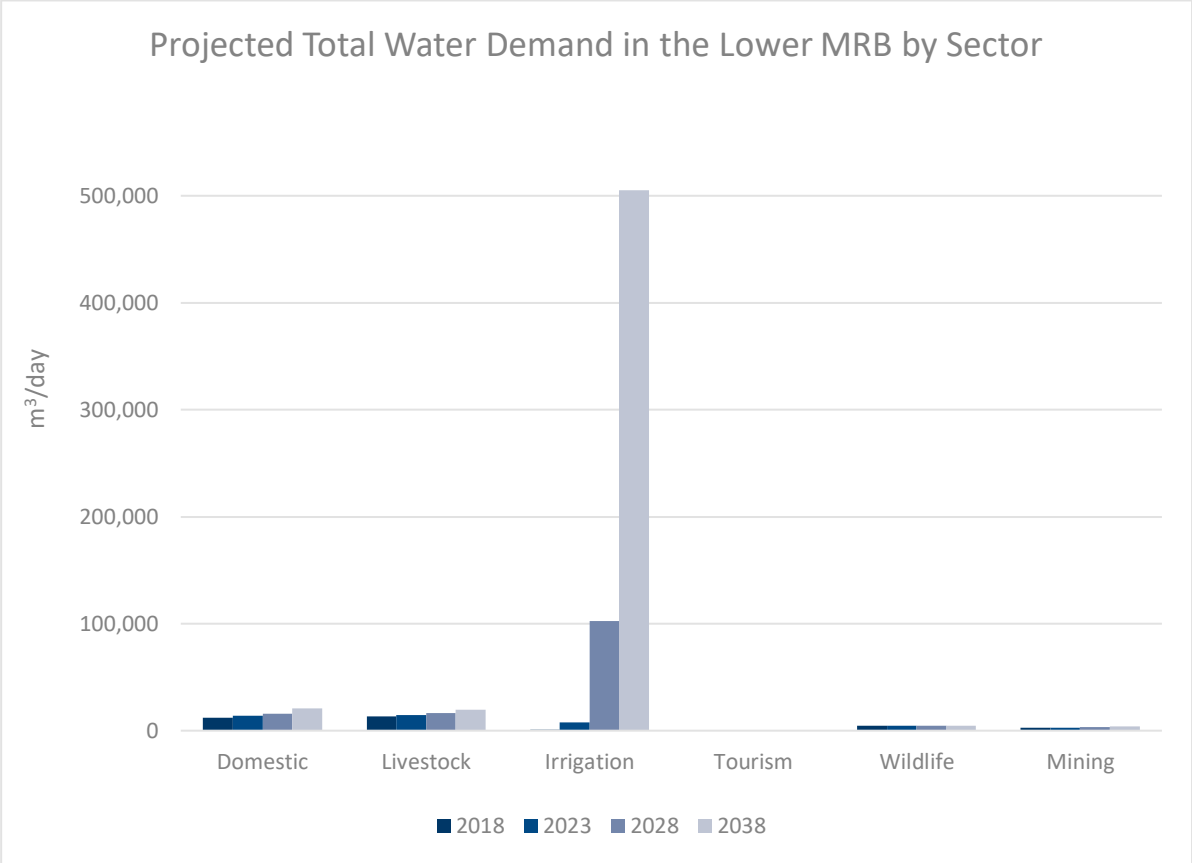


Figure 5-13: Projected total water demand in the Lower MRB by sector

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7. ANNEXES

7.1. POPULATION IN THE LOWER MRB

Region	District	Ward	HU	Total Ward Area (km^2)	Ward Area in HU (km^2)	Ward Area in HU (%)	Population in Ward (2012)	Est. Population in HU (2012)
Mara	Butiama	Buhemba	Mara	87.37	75.55	86.47	9,326	8,064
Mara	Butiama	Bukabwa	Mara	133.58	43.78	32.77	11,002	3,605
Mara	Butiama	Buswahili	Mara	305.48	305.48	100.00	11,576	11,576
Mara	Butiama	Butuguri	Mara	61.1	6.52	10.67	9,006	961
Mara	Butiama	Bwiregi	Mara	118.88	118.76	99.90	10,275	10,264
Mara	Butiama	Mirwa	Mara	86.23	56.2	65.17	13,722	8,943
Mara	Butiama	Muriaza	Mara	109.51	81.47	74.40	10,203	7,591
Mara	Butiama	Nyamimange	Mara	48.89	48.89	100.00	5,203	5,203
Mara	Butiama	Sirorisimba	Mara	91.05	75.51	82.93	8,220	6,817
Mara	Rorya	Kisumwa	Mara	217.19	147.66	67.99	12,447	8,463
Mara	Rorya	Komuge	Mara	135.08	20.61	15.26	13,651	2,083
Mara	Rorya	Rabour	Mara	116.13	9.57	8.24	11,259	928
Mara	Serengeti	Busawe	Mara	104.92	84.86	80.88	5,532	4,474
Mara	Serengeti	Busawe	Somoche	104.92	20.06	19.12	5,532	1,058
Mara	Serengeti	Geitasamo	Somoche	40.28	2.74	6.80	5,520	375
Mara	Serengeti	Geitasamo	Serengeti	40.28	37.54	93.20	5,520	5,145
Mara	Serengeti	Kebanchabancha	Somoche	93.79	75.13	80.10	8,241	6,601
Mara	Serengeti	Kebanchabancha	Serengeti	93.79	18.65	19.88	8,241	1,638
Mara	Serengeti	Kenyamonta	Mara	189.01	187.92	99.42	11,336	11,270
Mara	Serengeti	Kisaka	Mara	166.77	156.65	93.93	12,534	11,773
Mara	Serengeti	Kisaka	Somoche	166.77	10.12	6.07	12,534	761
Mara	Serengeti	Kisangura	Serengeti	90.21	35.78	39.66	8,506	3,373
Mara	Serengeti	Kyambahi	Somoche	196.57	7.79	3.96	7,022	278

Region	District	Ward	HU	Total Ward Area (km2)	Ward Area in HU (km2)	Ward Area in HU (%)	Population in Ward (2012)	Est. Population in HU (2012)
Mara	Serengeti	Machochwe	Serengeti	699.12	699.12	100.00	9,871	9,871
Mara	Serengeti	Magange	Mara	113.17	30.04	26.54	7,262	1,927
Mara	Serengeti	Majimoto	Mara	136.97	136.97	100.00	8,536	8,536
Mara	Serengeti	Mbalibali	Serengeti	990.58	767.74	77.50	11,390	8,827
Mara	Serengeti	Mosongo	Somoche	202.62	113.95	56.24	11,618	6,534
Mara	Serengeti	Mugumu	Somoche	10.25	3.33	32.49	10,226	3,322
Mara	Serengeti	Mugumu	Serengeti	10.25	5.66	55.22	10,226	5,647
Mara	Serengeti	Nyamatare	Somoche	83.76	70.08	83.67	5,476	4,582
Mara	Serengeti	Nyambureti	Somoche	149.76	11.29	7.54	14,158	1,068
Mara	Serengeti	Nyamoko	Somoche	105.64	105.59	99.95	8,237	8,233
Mara	Serengeti	Nyamoko	Serengeti	105.64	0.04	0.04	8,237	3
Mara	Serengeti	Nyansurura	Mara	135.38	0.3	0.22	10,129	22
Mara	Serengeti	Nyansurura	Somoche	135.38	10.07	7.44	10,129	754
Mara	Serengeti	Nyansurura	Serengeti	135.38	125.01	92.34	10,129	9,353
Mara	Serengeti	Rigicha	Somoche	85.4	4.4	5.15	9,465	487
Mara	Serengeti	Ring'wani	Mara	223.43	23.14	10.36	8,785	910
Mara	Serengeti	Ring'wani	Somoche	223.43	189.36	84.75	8,785	7,445
Mara	Serengeti	Rung'abure	Somoche	79.24	19.42	24.51	9,698	2,377
Mara	Serengeti	Rung'abure	Serengeti	79.24	59.82	75.49	9,698	7,321
Mara	Serengeti	Sedeco	Serengeti	1485	86.63	5.83	11,436	667
Mara	Serengeti	Stendi Kuu	Serengeti	11.91	4.71	39.55	6,625	2,620
Mara	Serengeti	Uwanja wa Ndege	Somoche	63.46	36	56.73	6,309	3,579
Mara	Serengeti	Uwanja wa Ndege	Serengeti	63.46	0.09	0.14	6,309	9
Mara	Tarime	Binagi	Mara	28.2	5.33	18.90	9,443	1,785
Mara	Tarime	Gorong'a	Mara	77.13	39.58	51.32	11,062	5,677
Mara	Tarime	Gorong'a	Serengeti	77.13	37.55	48.68	11,062	5,385
Mara	Tarime	Itiryo	Mara	27.97	17.58	62.85	9,972	6,267

Region	District	Ward	HU	Total Ward Area (km^2)	Ward Area in HU (km^2)	Ward Area in HU (%)	Population in Ward (2012)	Est. Population in HU (2012)
Mara	Tarime	Kemambo	Mara	108.88	87.53	80.39	13,338	10,722
Mara	Tarime	Kemambo	Serengeti	108.88	21.35	19.61	13,338	2,616
Mara	Tarime	Kentare	Mara	27.73	2.23	8.04	9,475	762
Mara	Tarime	Kibasuka	Mara	144.96	144.96	100.00	15,137	15,137
Mara	Tarime	Kiore	Mara	86.44	54.88	63.49	8,020	5,092
Mara	Tarime	Komaswa	Mara	78.88	22.34	28.32	6,860	1,943
Mara	Tarime	Manga	Mara	79.65	49.49	62.13	7,249	4,504
Mara	Tarime	Matongo	Mara	67.03	67.03	100.00	19,176	19,176
Mara	Tarime	Muriba	Mara	31.23	25.36	81.20	10,861	8,819
Mara	Tarime	Nyamwaga	Mara	46.72	18.82	40.28	13,917	5,606
Mara	Tarime	Nyanungu	Mara	30.03	3.14	10.46	11,272	1,179
Mara	Tarime	Nyanungu	Serengeti	30.03	24.89	82.88	11,272	9,342
Mara	Tarime	Nyarero	Mara	44.09	8.67	19.66	12,331	2,424
Mara	Tarime	Nyarokoba	Mara	138.6	81.28	58.64	15,670	9,189
Mara	Tarime	Nyarokoba	Serengeti	138.6	57.32	41.36	15,670	6,481
Mara	Tarime	Turwa	Mara	75.75	5	6.60	27,238	1,798

7.2. LIVESTOCK IN THE LOWER MRB

Region	District	Ward	HU	Ward Area in HU (%)	Cattle (2018)	Goats (2018)	Sheep (2018)	Donkeys (2018)	Pigs (2018)	Cattle in HU	Goats in HU	Sheep in HU	Donkeys in HU	Pigs in HU
Mara	Butiama	Buhemba	Mara	86.47	8,099	2,800	1,793	420	0	7,003	2,421	1,550	363	0
Mara	Butiama	Bukabwa	Mara	32.77	7,053	3,045	1,279	4	0	2,311	998	419	1	0
Mara	Butiama	Buswahili	Mara	100.00	22,913	6,114	5,911	225	0	22,913	6,114	5,911	225	0
Mara	Butiama	Butuguri	Mara	10.67	3,933	1,018	414	26	0	420	109	44	3	0
Mara	Butiama	Bwiregi	Mara	99.90	13,020	4,293	5,131	72	0	13,007	4,289	5,126	72	0
Mara	Butiama	Mirwa	Mara	65.17	11,441	2,496	2,318	414	0	7,456	1,627	1,511	270	0
Mara	Butiama	Muriaza	Mara	74.40	7,990	3,273	1,594	289	0	5,945	2,435	1,186	215	0
Mara	Butiama	Nyamimange	Mara	100.00	6,997	2,080	4,057	43	0	6,997	2,080	4,057	43	0
Mara	Butiama	Sirorisimba	Mara	82.93	11,554	2,815	3,578	163	0	9,582	2,334	2,967	135	0
Mara	Rorya	Kisumwa	Mara	67.99	10,354	4,273	4,038	95	0	7,040	2,905	2,745	65	0
Mara	Rorya	Komuge	Mara	15.26										
Mara	Rorya	Rabour	Mara	8.24										
Mara	Serengeti	Busawe	Mara	80.88	8,636	2,888	2,066	84	1	6,985	2,336	1,671	68	1
Mara	Serengeti	Busawe	Somoche	19.12	8,636	2,888	2,066	84	1	1,651	552	395	16	0
Mara	Serengeti	Geitasamo	Somoche	6.80	6,052	2,320	2,937	67	2	412	158	200	5	0
Mara	Serengeti	Geitasamo	Serengeti	93.20	6,052	2,320	2,937	67	2	5,640	2,162	2,737	62	2
Mara	Serengeti	Kebanchabancha	Somoche	80.10	7,153	2,960	3,069	314	6	5,730	2,371	2,458	252	5
Mara	Serengeti	Kebanchabancha	Serengeti	19.88	7,153	2,960	3,069	314	6	1,422	588	610	62	1
Mara	Serengeti	Kenyamonta	Mara	99.42	28,176	7,696	8,190	191	9	28,013	7,651	8,142	190	9
Mara	Serengeti	Kisaka	Mara	93.93	6,881	2,064	2,283	73	0	6,463	1,939	2,144	69	0
Mara	Serengeti	Kisaka	Somoche	6.07	6,881	2,064	2,283	73	0	418	125	139	4	0
Mara	Serengeti	Kisangura	Serengeti	39.66	11,117	4,222	6,438	54	9	4,409	1,674	2,553	21	4
Mara	Serengeti	Kyambahi	Somoche	3.96	1,697	607	961	14	1	67	24	38	1	0
Mara	Serengeti	Machochwe	Serengeti	100.00	6,568	2,929	1,706	152	10	6,568	2,929	1,706	152	10
Mara	Serengeti	Magange	Mara	26.54	16,320	5,968	8,134	109	31	4,331	1,584	2,159	29	8
Mara	Serengeti	Majimoto	Mara	100.00	19,970	6,489	5,380	137	52	19,970	6,489	5,380	137	52

Region	District	Ward	HU	Ward Area in HU (%)	Cattle (2018)	Goats (2018)	Sheep (2018)	Donkeys (2018)	Pigs (2018)	Cattle in HU	Goats in HU	Sheep in HU	Donkeys in HU	Pigs in HU
Mara	Serengeti	Mbalibali	Serengeti	77.50	13,188	5,422	5,431	236	22	10,221	4,202	4,209	183	17
Mara	Serengeti	Mosongo	Somoche	56.24	18,274	8,198	8,929	399	132	10,277	4,611	5,022	224	74
Mara	Serengeti	Mugumu	Somoche	32.49	726	154	290	0	0	236	50	94	0	0
Mara	Serengeti	Mugumu	Serengeti	55.22	726	154	290	0	0	401	85	160	0	0
Mara	Serengeti	Nyamatare	Somoche	83.67	10,931	4,067	5,166	85	70	9,146	3,403	4,322	71	59
Mara	Serengeti	Nyambureti	Somoche	7.540	2,672	1,001	980	9	52	201	75	74	1	4
Mara	Serengeti	Nyamoko	Somoche	99.95	3,737	1,448	1,513	56	0	3,735	1,447	1,512	56	0
Mara	Serengeti	Nyamoko	Serengeti	0.04	3,737	1,448	1,513	56	0	1	1	1	0	0
Mara	Serengeti	Nyansurura	Mara	0.22	11,186	5,150	5,603	156	6	25	11	12	0	0
Mara	Serengeti	Nyansurura	Somoche	7.44	11,186	5,150	5,603	156	6	832	383	417	12	0
Mara	Serengeti	Nyansurura	Serengeti	92.34	11,186	5,150	5,603	156	6	10,329	4,756	5,174	144	6
Mara	Serengeti	Rigicha	Somoche	5.15	2,732	574	819	4	5	141	30	42	0	0
Mara	Serengeti	Ring'wani	Mara	10.36	25,208	8,361	8,469	267	16	2,612	866	877	28	2
Mara	Serengeti	Ring'wani	Somoche	84.75	25,208	8,361	8,469	267	16	21,364	7,086	7,177	226	14
Mara	Serengeti	Rung'abure	Somoche	24.51	8,851	3,761	4,782	276	10	2,169	922	1,172	68	2
Mara	Serengeti	Rung'abure	Serengeti	75.49	8,851	3,761	4,782	276	10	6,682	2,839	3,610	208	8
Mara	Serengeti	Sedeco	Serengeti	5.83	5,512	2,068	2,338	66	18	321	121	136	4	1
Mara	Serengeti	Stendi Kuu	Serengeti	39.55										
Mara	Serengeti	Uwanja wa Ndege	Somoche	56.73	6,074	2,454	3,153	108	6	3,446	1,392	1,789	61	3
Mara	Serengeti	Uwanja wa Ndege	Serengeti	0.14	6,074	2,454	3,153	108	6	9	3	4	0	0
Mara	Tarime	Binagi	Mara	18.90	4,260	1,244	147	361	15	805	235	28	68	3
Mara	Tarime	Gorong'a	Mara	51.32	3,802	2,748	3,899	92	14	1,951	1,410	2,001	47	7
Mara	Tarime	Gorong'a	Serengeti	48.68	3,802	2,748	3,899	92	14	1,851	1,338	1,898	45	7
Mara	Tarime	Itiryo	Mara	62.85	3,675	963	781	7	2	2,310	605	491	4	1
Mara	Tarime	Kemambo	Mara	80.39	8,981	9,986	7,872	59	107	7,220	8,028	6,328	47	86
Mara	Tarime	Kemambo	Serengeti	19.61	8,981	9,986	7,872	59	107	1,761	1,958	1,544	12	21
Mara	Tarime	Kentare	Mara	8.04										

Region	District	Ward	HU	Ward Area in HU (%)	Cattle (2018)	Goats (2018)	Sheep (2018)	Donkeys (2018)	Pigs (2018)	Cattle in HU	Goats in HU	Sheep in HU	Donkeys in HU	Pigs in HU
Mara	Tarime	Kibasuka	Mara	100.00	25,964	8,922	6,705	337	0	25,964	8,922	6,705	337	0
Mara	Tarime	Kiore	Mara	63.49	23,546	19,163	12,610	120	0	14,949	12,167	8,006	76	0
Mara	Tarime	Komaswa	Mara	28.32	12,682	1,952	2,050	0	30	3,592	553	581	0	8
Mara	Tarime	Manga	Mara	62.13	12,494	7,691	10,152	521	0	7,763	4,778	6,307	324	0
Mara	Tarime	Matongo	Mara	100.00	13,592	7,314	2,167	256	185	13,592	7,314	2,167	256	185
Mara	Tarime	Muriba	Mara	81.20	4,272	4,366	1,156	26	0	3,469	3,545	939	21	0
Mara	Tarime	Nyamwaga	Mara	40.28	5,673	3,420	567	83	21	2,285	1,378	228	33	8
Mara	Tarime	Nyanungu	Mara	10.46	5,430	4,129	1,567	210	0	568	432	164	22	0
Mara	Tarime	Nyanungu	Serengeti	82.88	5,430	4,129	1,567	210	0	4,500	3,422	1,299	174	0
Mara	Tarime	Nyarero	Mara	19.66										
Mara	Tarime	Nyarokoba	Mara	58.64	22,000	18,300	5,000	40	0	12,901	10,731	2,932	23	0
Mara	Tarime	Nyarokoba	Serengeti	41.36	22,000	18,300	5,000	40	0	9,099	7,569	2,068	17	0
Mara	Tarime	Turwa	Mara	6.60										

7.3. PROJECTED WATER DEMAND BY MONTH

Table 7-1: Projected 2018 monthly water demand for Serengeti HU (m3/day)

Month	Domestic Demand	Livestock	Irrigation		Tourism	Wildlife	Mining		*Total*
			Small-scale	Large-scale			Small-scale	Large-scale	
October	2,844	2,299	0	0	87	11,039	12	0	16,281
November	2,844	2,299	0	0	87	11,039	12	0	16,281
December	2,844	2,299	0	0	44	3,676	12	0	8,875
January	2,844	2,299	0	0	44	3,676	12	0	8,875
February	2,844	2,299	0	0	44	3,676	12	0	8,875
March	2,844	2,299	0	0	44	3,676	12	0	8,875
April	2,844	2,299	0	0	44	3,676	12	0	8,875
May	2,844	2,299	0	0	44	3,676	12	0	8,875
June	2,844	2,299	0	0	44	3,676	12	0	8,875
July	2,844	2,299	0	0	87	11,039	12	0	16,281
August	2,844	2,299	0	0	87	11,039	12	0	16,281
September	2,844	2,299	0	0	87	11,039	12	0	16,281
Average	*2,844*	*2,299*	*0*	*0*	*62*	*6,744*	*12*	*0*	*11,961*

Table 7-2: Projected 2023 monthly water demand for Serengeti HU (m3/day)

Month	Domestic Demand	Livestock	Irrigation		Tourism	Wildlife	Mining		*Total*
			Small-scale	Large-scale			Small-scale	Large-scale	
October	3,318	2,587	0	0	123	11,039	21	0	17,088
November	3,318	2,587	0	0	123	11,039	21	0	17,088
December	3,318	2,587	0	0	62	3,676	21	0	9,664
January	3,318	2,587	0	0	62	3,676	21	0	9,664
February	3,318	2,587	0	0	62	3,676	21	0	9,664
March	3,318	2,587	0	0	62	3,676	21	0	9,664
April	3,318	2,587	0	0	62	3,676	21	0	9,664
May	3,318	2,587	0	0	62	3,676	21	0	9,664
June	3,318	2,587	0	0	62	3,676	21	0	9,664
July	3,318	2,587	0	0	123	11,039	21	0	17,088
August	3,318	2,587	0	0	123	11,039	21	0	17,088
September	3,318	2,587	0	0	123	11,039	21	0	17,088
Average	*3,318*	*2,587*	*0*	*0*	*87*	*6,744*	*21*	*0*	*12,757*

Table 7-3: Projected 2028 monthly water demand for Serengeti HU (m3/day)

Month	Domestic Demand	Livestock	Irrigation		Tourism	Wildlife	Mining		*Total*
			Small-scale	Large-scale			Small-scale	Large-scale	
October	3,874	2,874	0	0	175	11,039	38	0	18,000
November	3,874	2,874	0	0	175	11,039	38	0	18,000
December	3,874	2,874	0	0	88	3,676	38	0	10,550
January	3,874	2,874	0	0	88	3,676	38	0	10,550
February	3,874	2,874	0	0	88	3,676	38	0	10,550
March	3,874	2,874	0	0	88	3,676	38	0	10,550
April	3,874	2,874	0	0	88	3,676	38	0	10,550
May	3,874	2,874	0	0	88	3,676	38	0	10,550
June	3,874	2,874	0	0	88	3,676	38	0	10,550
July	3,874	2,874	0	0	175	11,039	38	0	18,000
August	3,874	2,874	0	0	175	11,039	38	0	18,000
September	3,874	2,874	0	0	175	11,039	38	0	18,000
Average	*3,874*	*2,874*	*0*	*0*	*124*	*6,744*	*38*	*0*	*13,654*

Table 7-4: Projected 2038 monthly water demand for Serengeti HU (m3/day)

Month	Domestic Demand	Livestock	Irrigation		Tourism	Wildlife	Mining		*Total*
			Small-scale	Large-scale			Small-scale	Large-scale	
October	5,293	3,449	0	0	352	11,039	122	0	20,255
November	5,293	3,449	0	0	352	11,039	122	0	20,255
December	5,293	3,449	0	0	176	3,676	122	0	12,716
January	5,293	3,449	0	0	176	3,676	122	0	12,716
February	5,293	3,449	0	0	176	3,676	122	0	12,716
March	5,293	3,449	0	0	176	3,676	122	0	12,716
April	5,293	3,449	0	0	176	3,676	122	0	12,716
May	5,293	3,449	0	0	176	3,676	122	0	12,716
June	5,293	3,449	0	0	176	3,676	122	0	12,716
July	5,293	3,449	0	0	352	11,039	122	0	20,255
August	5,293	3,449	0	0	352	11,039	122	0	20,255
September	5,293	3,449	0	0	352	11,039	122	0	20,255
Average	*5,293*	*3,449*	*0*	*0*	*249*	*6,744*	*122*	*0*	*15,857*

Table 7-5: Projected 2018 monthly water demand for Somoche HU (m^3/day)

Month	Domestic Demand	Livestock	Irrigation		Tourism	Wildlife	Mining		*Total*
			Small-scale	Large-scale			Small-scale	Large-scale	
October	1,772	2,137	0	0	0	0	0	0	3,909
November	1,772	2,137	0	0	0	0	0	0	3,909
December	1,772	2,137	0	0	0	0	0	0	3,909
January	1,772	2,137	0	0	0	0	0	0	3,909
February	1,772	2,137	0	0	0	0	0	0	3,909
March	1,772	2,137	0	0	0	0	0	0	3,909
April	1,772	2,137	0	0	0	0	0	0	3,909
May	1,772	2,137	0	0	0	0	0	0	3,909
June	1,772	2,137	0	0	0	0	0	0	3,909
July	1,772	2,137	0	0	0	0	0	0	3,909
August	1,772	2,137	0	0	0	0	0	0	3,909
September	1,772	2,137	49	0	0	0	0	0	3,958
Average	*1,772*	*2,137*	*4*	*0*	*0*	*0*	*0*	*0*	*3,913*

Table 7-6: Projected 2023 monthly water demand by Somoche HU (m^3/day)

Month	Domestic Demand	Livestock	Irrigation		Tourism	Wildlife	Mining		*Total*
			Small-scale	Large-scale			Small-scale	Large-scale	
October	2,105	2,404	0	8,151	0	0	0	0	12,660
November	2,105	2,404	0	6,438	0	0	0	0	10,947
December	2,105	2,404	0	8,972	0	0	0	0	13,481
January	2,105	2,404	0	8,977	0	0	0	0	13,485
February	2,105	2,404	0	6,487	0	0	0	0	10,996
March	2,105	2,404	0	3,822	0	0	0	0	8,331
April	2,105	2,404	0	1,444	0	0	0	0	5,953
May	2,105	2,404	0	5,138	0	0	0	0	9,647
June	2,105	2,404	0	6,242	0	0	0	0	10,751
July	2,105	2,404	0	5,773	0	0	0	0	10,282
August	2,105	2,404	0	11,430	0	0	0	0	15,939
September	2,105	2,404	58	7,403	0	0	0	0	11,971
Average	*2,105*	*2,404*	*5*	*6,690*	*0*	*0*	*0*	*0*	*11,204*

Table 7-7: Projected 2028 monthly water demand for Somoche HU (m3/day)

Month	Domestic Demand	Livestock	Irrigation		Tourism	Wildlife	Mining		*Total*
			Small-scale	Large-scale			Small-scale	Large-scale	
October	2,500	2,671	0	8,151	0	0	0	0	13,322
November	2,500	2,671	0	6,438	0	0	0	0	11,609
December	2,500	2,671	0	8,972	0	0	0	0	14,143
January	2,500	2,671	0	8,977	0	0	0	0	14,148
February	2,500	2,671	0	6,487	0	0	0	0	11,658
March	2,500	2,671	0	3,822	0	0	0	0	8,993
April	2,500	2,671	0	1,444	0	0	0	0	6,615
May	2,500	2,671	0	5,138	0	0	0	0	10,309
June	2,500	2,671	0	6,242	0	0	0	0	11,413
July	2,500	2,671	0	5,773	0	0	0	0	10,944
August	2,500	2,671	0	11,430	0	0	0	0	16,601
September	2,500	2,671	69	7,403	0	0	0	0	12,644
Average	*2,500*	*2,671*	*6*	*6,690*	*0*	*0*	*0*	*0*	*11,867*

Table 7-8: Projected 2038 monthly water demand for Somoche HU

Month	Domestic Demand	Livestock	Irrigation		Tourism	Wildlife	Mining		*Total*
			Small-scale	Large-scale			Small-scale	Large-scale	
October	3,527	3,205	0	8,151	0	0	0	0	14,883
November	3,527	3,205	0	6,438	0	0	0	0	13,170
December	3,527	3,205	0	8,972	0	0	0	0	15,704
January	3,527	3,205	0	8,977	0	0	0	0	15,708
February	3,527	3,205	0	6,487	0	0	0	0	13,219
March	3,527	3,205	0	3,822	0	0	0	0	10,554
April	3,527	3,205	0	1,444	0	0	0	0	8,176
May	3,527	3,205	0	5,138	0	0	0	0	11,870
June	3,527	3,205	0	6,242	0	0	0	0	12,974
July	3,527	3,205	0	5,773	0	0	0	0	12,505
August	3,527	3,205	0	11,430	0	0	0	0	18,162
September	3,527	3,205	98	7,403	0	0	0	0	14,233
Average	*3,527*	*3,205*	*8*	*6,690*	*0*	*0*	*0*	*0*	*13,430*

Table 7-9: Projected 2018 monthly water demand for Mara HU (m^3/day)

Month	Domestic Demand	Livestock	Irrigation		Tourism	Wildlife	Mining		*Total*
			Small-scale	Large-scale			Small-scale	Large-scale	
October	7,401	8,630	967	0	8	0	113	2,760	19,880
November	7,401	8,630	878	0	8	0	113	2,760	19,791
December	7,401	8,630	702	0	4	0	113	2,760	19,611
January	7,401	8,630	675	0	4	0	113	2,760	19,584
February	7,401	8,630	411	0	4	0	113	2,760	19,320
March	7,401	8,630	464	0	4	0	113	2,760	19,373
April	7,401	8,630	550	0	4	0	113	2,760	19,459
May	7,401	8,630	602	0	4	0	113	2,760	19,511
June	7,401	8,630	637	0	4	0	113	2,760	19,546
July	7,401	8,630	692	0	8	0	113	2,760	19,604
August	7,401	8,630	824	0	8	0	113	2,760	19,737
September	7,401	8,630	1,133	0	8	0	113	2,760	20,046
Average	*7,401*	*8,630*	*711*	*0*	*5*	*0*	*113*	*2,760*	*19,622*

Table 7-10: Projected 2023 monthly water demand for Mara HU (m^3/day)

Month	Domestic Demand	Livestock	Irrigation		Tourism	Wildlife	Mining		*Total*
			Small-scale	Large-scale			Small-scale	Large-scale	
October	8,352	9,709	1,079	0	11	0	203	2,760	22,113
November	8,352	9,709	979	0	11	0	203	2,760	22,014
December	8,352	9,709	783	0	5	0	203	2,760	21,811
January	8,352	9,709	753	0	5	0	203	2,760	21,781
February	8,352	9,709	458	0	5	0	203	2,760	21,486
March	8,352	9,709	517	0	5	0	203	2,760	21,545
April	8,352	9,709	614	0	5	0	203	2,760	21,642
May	8,352	9,709	672	0	5	0	203	2,760	21,700
June	8,352	9,709	711	0	5	0	203	2,760	21,739
July	8,352	9,709	771	0	11	0	203	2,760	21,806
August	8,352	9,709	919	0	11	0	203	2,760	21,953
September	8,352	9,709	1,264	0	11	0	203	2,760	22,298
Average	*8,352*	*9,709*	*793*	*0*	*7*	*0*	*203*	*2,760*	*21,824*

Table 7-11: Projected 2028 monthly water demand for Mara HU (m^3/day)

Month	Domestic Demand	Livestock	Irrigation		Tourism	Wildlife	Mining		*Total*
			Small-scale	Large-scale			Small-scale	Large-scale	
October	9,431	10,788	1,203	115,377	16	0	362	2,760	139,936
November	9,431	10,788	1,092	91,133	16	0	362	2,760	115,582
December	9,431	10,788	873	126,997	8	0	362	2,760	151,219
January	9,431	10,788	839	127,063	8	0	362	2,760	151,251
February	9,431	10,788	511	91,824	8	0	362	2,760	115,684
March	9,431	10,788	576	54,101	8	0	362	2,760	78,026
April	9,431	10,788	684	20,442	8	0	362	2,760	44,475
May	9,431	10,788	749	72,732	8	0	362	2,760	96,829
June	9,431	10,788	792	88,352	8	0	362	2,760	112,492
July	9,431	10,788	860	81,719	16	0	362	2,760	105,935
August	9,431	10,788	1,024	161,791	16	0	362	2,760	186,172
September	9,431	10,788	1,409	104,794	16	0	362	2,760	129,559
Average	*9,431*	*10,788*	*884*	*94,694*	*11*	*0*	*362*	*2,760*	*118,930*

Table 7-12: Projected 2038 monthly water demand for Mara HU (m^3/day)

Month	Domestic Demand	Livestock	Irrigation		Tourism	Wildlife	Mining		*Total*
			Small-scale	Large-scale			Small-scale	Large-scale	
October	12,051	12,945	1,495	605,664	31	0	1,154	2,760	636,100
November	12,051	12,945	1,357	478,397	31	0	1,154	2,760	508,695
December	12,051	12,945	1,085	666,662	16	0	1,154	2,760	696,674
January	12,051	12,945	1,043	667,008	16	0	1,154	2,760	696,978
February	12,051	12,945	635	482,026	16	0	1,154	2,760	511,587
March	12,051	12,945	717	283,997	16	0	1,154	2,760	313,640
April	12,051	12,945	851	107,309	16	0	1,154	2,760	137,086
May	12,051	12,945	931	381,802	16	0	1,154	2,760	411,659
June	12,051	12,945	985	463,795	16	0	1,154	2,760	493,706
July	12,051	12,945	1,069	428,976	31	0	1,154	2,760	458,986
August	12,051	12,945	1,273	849,312	31	0	1,154	2,760	879,526
September	12,051	12,945	1,751	550,109	31	0	1,154	2,760	580,801
Average	*12,051*	*12,945*	*1,099*	*497,088*	*22*	*0*	*1,154*	*2,760*	*527,120*