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CASE STUDY

VULNERABILITY PROFILE

MARA WETLANDS

SUBCATCHMENT OVERVIEW

Located at the lower end of the Mara River in Tanzania, adjacent to Lake Victoria, the Mara Wetlands are riverine swampland dominated by papyrus, with a total area ranging from 390 km^2 to more than 500 km^2, depending on seasonal flooding. Home to a wide array of birds, terrestrial and semi-aquatic mammals, and fish, the wetlands are an important source of habitat for wildlife as well as natural resources for local communities [27].

The wetlands cover four districts of the Mara region – Butiama, Rorya, Tarime and a small portion of Serengeti – which are largely rural (90 percent) and experienced an average population increase of 28 percent between the 2002 and 2012 censuses. Twenty villages surround the wetlands, with a 2012 census population of almost 56,000. Approximately 83 percent of households engage in agriculture as their primary occupation and 98 percent of crops are rainfed [11]. As of 2012, 26.2 percent of the population was below the country's poverty line [12].

Projected increases in temperature, variability in rainfall, frequency and intensity of heavy rainfall events, and intensity and duration of heat waves and drought events, coupled with high levels of poverty and a reliance on rainfed agriculture, make the communities around the wetlands particularly vulnerable to climate change.

CLIMATE PROJECTIONS

- 1.77°C increase in temperatures by 2050
- 10.7–12.5% increase in precipitation by 2050
- Increase in heavy rain events
- Increase in duration of heat waves and dry spells

KEY SECTORS AND VULNERABILITIES

Subsistence crops
Reduced yields and quality
Crop loss from extreme events
Food insecurity

Cash crops
Reduced yield and quality
Crop loss from extreme events
Income losses

Livestock
Increased morbidity and mortality
Reduced productivity
Reduced water and pasture availability

Human health
Undernutrition
Increased risk of malaria
Increased risk of waterborne disease

Water resources
Reduced access to safe drinking water
Damage to water infrastructure

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CONTEXT

The case study is aimed at organizations — including the Sustainable Water Partnership, as well as national and local governments, international donors, NGOs and community organizations — developing water use plans, policies and interventions in the case study geography, or within the broader Mara basin. The case study was designed to provide a highly localized vulnerability profile and recommendations for interventions, as well as provide local context for the vulnerability assessment of the Mara River Basin.

The information presented in this case study is based on a review of the plans, assessments and data listed in key resources, and is informed by consultations with 28 community members representing the North Mara Water Users Association (WUA), held in Kwibuse, Tanzania on September 27, 2018. The participatory consultations included a series of exercises designed to understand local vulnerabilities to climate risks and identify the community's adaptive capacity to address these risks. The case study was designed to provide a highly localized vulnerability profile as well as provide local context for the vulnerability assessment of the Mara River Basin. Descriptions of the consultation exercises, along with community responses, are summarized in the case study but are also available in detail in Annex 4 of the USAID ATLAS project's assessment: *Vulnerability and Adaptation in the Mara River Basin*.

PRIORITY VULNERABILITIES AND KEY ACTIONS

WHAT MAKES THE COMMUNITIES OF THE MARA WETLANDS VULNERABLE?

High sustained population growth leading to land conversion. The four districts that surround the wetlands experienced rapid population growth over the past 15 years, averaging an annual growth rate of 2.5 percent, which translates to an increase of almost 28 percent between the 2002 and 2012 censuses [14]. The Mara region as a whole more than doubled in population over the past 30 years, to an estimated current population of over 2 million [12]. This growth in population taxes already scarce resources, which when coupled with a further push toward villagization, has led to the conversion of forest and wetlands to crop and pasture lands. Current estimates suggest that more than 100 km^2 of wetlands have been converted to agriculture [9].

High levels of poverty and food insecurity. The most recent 2011/2012 Household Budget Survey estimated the poverty rate (poverty head count, below the basic needs poverty line) in the region at 26.2 percent, which is just below the national average of 27.5 percent. However, this does mark a decline in the poverty rate from 50 percent in 2000-2001. Food insecurity is particularly pronounced between January and April, when harvested stocks are generally depleted.

Dependence on surface water and other unimproved sources for drinking water. Ninety percent of the population of the wetland's districts is considered rural; as a result, only 25 percent of the population has access to improved drinking water sources, and less than 10 percent to piped drinking water. Instead, the primary sources of drinking water are those that are susceptible to drought and contamination: 23 percent rely on unprotected springs as a primary source of drinking water, 21 percent rely on surface water from rivers and lakes, and 28 percent rely on unprotected wells [12].

Dependence on rainfall for agriculture. Agriculture is the dominant economic activity – almost 83 percent of the working-age population engages in agriculture as a primary occupation. The farms in the area are almost exclusively smallholder, are rainfed and grow a mix of subsistence and cash crops, making them highly vulnerable to the negative impacts of climate variability and change. Less than 2 percent of the planted area is under irrigation, and the water used for irrigation is drawn using hand buckets or is gravity fed from either the Mara River or Lake Victoria [11].

Deforestation and overgrazing. In addition to land conversion driven by a rapidly growing population, cooking fuel sources and livestock production methods contribute to degraded forests and grasslands. Almost 98 percent of the population uses firewood or charcoal as a primary fuel source for cooking, and many often turn to illegal logging and charcoal making during periods of crop loss [12]. During the 2017 drought that caused widespread crop failures, the North Mara WUA estimated that 70 percent of the community turned to illegal forest harvesting. Approximately 95 percent of ruminant livestock in the region are kept under traditional production systems, which depend on grazing and crop residues as the main feed source [15]. Overgrazing and clearing forested land for pasture increase soil erosion, particularly in areas with steep slopes such as those found in Tarime district. This clearing makes the area more susceptible to landslides, flooding, river siltation and soil nutrient loss, all of which will be exacerbated by climate variability and change.

No voice in or control over critical upstream activities. As a transboundary resource, the community and country have limited influence over the upstream portions of the Mara River in Kenya, where agricultural runoff, industry and increased forest clearing have increased siltation and pollution. Major potential dam projects in Kenya — including the 10-meter Norera dam on the Mara River (for irrigation), the 65-meter Amala High dam on the Amala River (for hydropower), and the 30- and 70-meter Nyangores River dams (for irrigation) — could further exacerbate the situation. As it stands, sediment deposition at the river's edge due to upstream activities has increased the wetland's area by pushing backflow toward the wetlands over the last 30 years. The image below shows the extent of the increase in the wetland's area between 1984 and 2016, during a period that typically does not experience flooding (January).

Change in area of the Mara Wetlands from January 1984 (left) to January 2016 (right)

Source: Google Earth

Note: Width of each map image is 64km. The maps show the change in the extent of the Mara wetlands, with the map on the right from 2016 showing a wetland area that has almost doubled in size compared to 1984.

COMMUNITY-IDENTIFIED VULNERABILITIES

Drought and disease (both human and animal) were priority risks identified during the consultations, seen as having significant impacts on crops, livestock, fisheries, and human health. Livestock was seen as the resource most at risk from climate change, ranked highly vulnerable to drought and disease, and moderately vulnerable to flooding and land use change.

CRITICAL ACTIONS

The two wetland WUAs (North Mara and South Mara) have yet to develop their subcatchment management plans (SCMPs) or WUA plans. The only two Mara River subcatchments in Tanzania that do have plans are Somoche and Tabora, both located in Serengeti district. Nevertheless, the *Mara Wetlands Integrated Management Plan 2018–2022* and the *Conservation Investment Plan for Mara Wetlands* form the guiding documents for the wetlands. Both plans are harmonized with the overall goals of the Lake Victoria Basin Commission's *Mara River Basin Transboundary Integrated Natural Resources Management Plan (2016–26).*
To address issues directly related to the impacts of climate variability and climate change as well as community identified vulnerabilities, the following management actions from the *Mara Wetlands Integrated Management Plan 2018–2022* are critical [10]:

- Promoting agroforestry to address soil erosion and land degradation, including providing key inputs, materials, training, and extension to enable on-farm agroforestry.
- Promoting sustainable production and management of livestock, including formulation and enforcement of by-laws regulating entry of cattle into ecologically sensitive areas, as well as support to farmers to access improved livestock breeds, employ reduced-impact feeding techniques, and benefit from new market opportunities.
- Establishing domestic water supply schemes, including formulating plans for enhancement of water supply and storage facilities at village and household levels, implementing water supply and storage upgrades, and establishing maintenance arrangements with local WUAs.
- Controlling soil erosion, including rehabilitating soils, implementing terracing along catchment slopes, and training extension workers on soil management technologies and techniques.

Additionally, other management actions from the management plan should be supported to increase the community's climate resilience, including:

- Enhancing communication and capacity among Mara River Basin stakeholders to support proper conservation and management of the wetland as a transboundary resource.
- Promoting the best climate change adaptation technologies in the Mara Wetlands, including climate-smart agriculture and improved cookstoves.
- Promoting ecosystem restoration and sustainable land management through tree-based business measures such as on-farm tree planting, community and institutional woodlots, and development of associated income-generating and value-adding opportunities (e.g., nurseries and seedling production, small-scale wood processing, and fruit and fodder production)
- Regulating water abstraction, including conducting an environmental flow assessment for the wetlands and using the results to develop abstraction regulations.
- Collating and improving data for the Mara Wetlands and adjacent areas, including regular biodiversity, social and demographic, and water level, quality and quantity surveys, along with repairing existing data stations and restarting regular data collection.

CLIMATE SUMMARY

The Mara River Basin in Tanzania ranges in elevation from almost 1,900 meters in Tarime near the Kenyan border, to 1,100 meters where the Mara River enters Lake Victoria. As a result, rainfall patterns differ throughout the basin. The northern zone covering upper Tarime and the northeastern portion of the Serengeti district has an average rainfall of 1,250 mm to 2,000 mm per year and two rainy seasons that are longer in length than in other portions of the basin: a "long" rainy season (known locally as *masika*) from February to June, and a "short" season (known locally as *vuli*) from September to January. The central zone where the wetlands lie receives annual rainfall of 900 mm to 1,300 mm, and the low-lying areas in southern Serengeti and Butiama districts have an annual rainfall of 500 mm to 800 mm [8]. Rainfall patterns in these two zones are also bimodal, with long rains between March and May and short rains between October and December, and the two seasons are separated by a typically dry season between June and August. Average monthly temperatures range between 13–30°C; the lowest average minimums occur in June and July, and the highest average maximums occur between September and October.

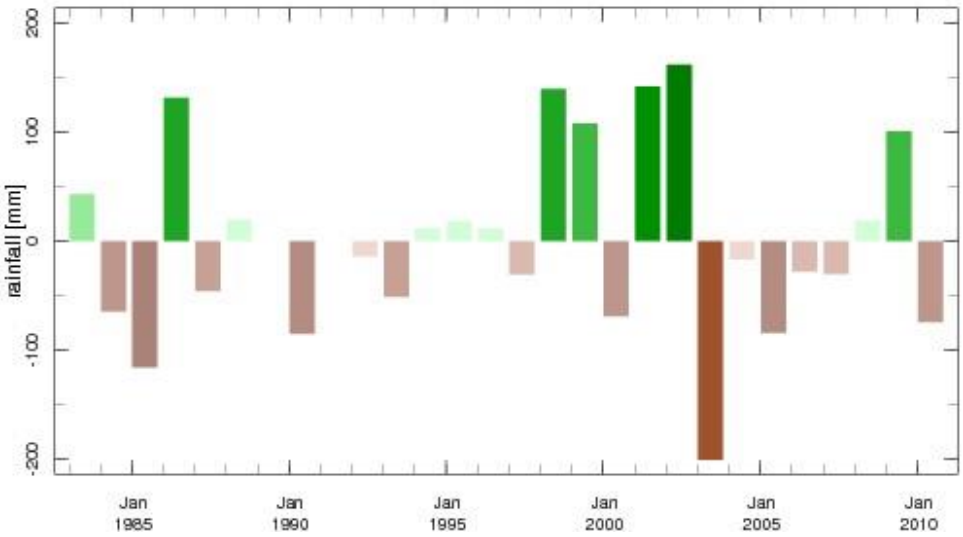
HISTORICAL CLIMATE

Historical climate trends include [20]:

- Increase of 0.9°C in the average maximum temperature at the Musoma station – from 28.0°C in 1961 to 28.9°C in 2014.
- Increase of 1.1°C in the average minimum temperature at the Musoma station – from 17°C in 1961 to just over 18°C in 2014.
- Little change in the trend for average annual precipitation, but rainfall is highly variable from year to year, with flooding events around the 2000s, and droughts in 2003, 2006, 2011 and 2017. The graph below provides a visual representation of the frequency and severity of rainfall variation over the past 30 years.

- Rainfall patterns drive seasonal and interannual water level fluctuations in Lake Victoria; the lake level usually rises from May to July and falls from August to December.
- The wetlands themselves tend to flood annually during the long rains from March to May, and the overall area of the wetlands more than doubled in the past 30 years.

Yearly seasonal rainfall anomalies for Mara Wetlands (1983–2011)



Source: Tanzania Meteorological Agency Map Room [18]

COMMUNITY EXPERIENCE WITH CLIMATE SHOCKS AND CHANGES

In discussions with the community, members of the North Mara WUA described a climate that was highly variable from year to year, with regular drought and flooding events. Two climate events in particular caused larger disruptions: the major flooding during the El Niño event of 1997–1998 and a significant drought in 2017. Two additional non-climate events, which were exacerbated in part by climate variability and change, increased the community's vulnerability: land use changes in the 2010s, and an increase in crop and livestock disease from 2014–2018.

El Niño event (1997–1998). This event caused widespread flooding throughout the East Africa region. The community noted that the event caused major changes in the course of the Mara River in Tanzania, including widening in certain places caused by logs washed down from upstream that blocked the course of the river.

Major drought event (2016–2017). According to FEWS NET, well-below-average September to December *vuli* rains in 2016 resulted in substantial crop loss of more than 50 percent for the season. This was followed by March to May *masika* rains in 2017 that were up to 40 percent below average, resulting in crop production 40 percent below the five-year average and a subsequent spike in food prices. The community dealt with local crop failure and livestock deaths primarily by turning to illegal logging and charcoal making – an estimated 70 percent of the population turned to these sources of income – as well as increasing fishing and small-scale mining operations.

Land use changes (2010–2018). Over the course of the past decade, the community noted that pasture land was either lost – largely due to expansion in wetlands area and in the width of the Mara River – or converted to crop land and human settlements due to a significant increase in population and *ugamaa* (villagization, a move from informal communal land use to formal village-based land use plans).

Increase in crop and livestock disease (2014–2018). In the past five years, the community observed a notable increase in crop diseases (primarily cassava mosaic and maize streak virus) as well as outbreaks of livestock disease during the dry season: Newcastle disease in chickens, foot-and-mouth disease in cloven-hoofed ruminants and *degedege* (convulsions) in sheep and goats.

FUTURE CLIMATE

Projected changes include [20]:

- Increase in average temperatures of 1.77°C across the Lake Victoria Basin zone by 2050, and an increase of 3.3–3.4°C by 2100. The largest increases are expected during the June–August dry season.
- Increase in average rainfall of 10.7–12.5 percent across the Lake Victoria Basin zone by 2050, and an increase of 18.2–23.3 percent by 2100. The two rainy seasons follow the same range of increase, but the June–August dry season is considerably more variable, with projected average rainfall by 2100 to be anywhere between -40.8 percent and +44.6 percent.
- Increased frequency and intensity of heavy rainfall events.
- Increased intensity and duration of heat waves and drought events.

SECTOR IMPACTS AND VULNERABILITIES

AGRICULTURE

The agriculture sector contributes approximately 29 percent to Tanzania's gross domestic product (GDP) and employs 75–80 percent of the working-age population [26]. Eighty percent of agricultural production is rainfed, characterized as low-input smallholder farms highly vulnerable to weather variability. Around the wetlands these figures are even higher: 83 percent of households engage in agriculture as their primary occupation, and less than 2 percent of the planted area is under irrigation. This reliance on rainfall, coupled with low technology, low-input farming techniques on small plots (generally between 1.0–1.5 hectares), makes the agriculture sector vulnerable to climate variability and reduces its resilience to climate change. Projected temperature rise, longer dry spells, and more frequent and intense rains will further put these communities at risk [22].

While use of irrigation, more advanced implements and use of inputs such as improved seeds, fertilizers, pesticides and herbicides is limited (one or more of these advanced practices or inputs are used on less than 10 percent of the total planted area), farmers do employ a number of coping strategies to reduce their risk, including: crop diversification, mixing crops with varying maturity periods (e.g., maize and beans), mixing in drought-tolerant crops (e.g., cassava and sorghum), crop rotation techniques and use of multiple planting periods [7].

Barriers to community uptake of adaptation actions (including those listed below) include: lack of capital to invest in new techniques and technologies; lack of access to improved inputs; lack of awareness of options and training on new techniques; and a low tolerance for risk. Any successful intervention will need to be designed to take these barriers into account.

Subsistence Crops

Maize is the dominant crop, representing approximately 50 percent of the planted area, followed by cassava (32 percent of the planted area), sorghum, beans, sweet potatoes, millet and rice. At the household level maize, cassava and sorghum are the three most important crops, with 0.6 hectares on average devoted to each household plot [11,12]. These districtwide statistics match with community perception; North Mara WUA members ranked the following in order as the most important subsistence crops: maize, cassava, kidney beans and sorghum.

Land preparation in the districts around the wetlands takes place from December through February. Crops are typically planted in the period between January and March or between September and November to coincide with the two annual rainy seasons. The primary harvest period is between June and August after the *masika* rains, with a secondary harvest between December and March after the *vuli* rains, although some household-level crops (e.g., cassava and potato) are harvested throughout the year.

Maize production under a changing climate is expected to decline countrywide in Tanzania, with an average predicted decline of 17 percent in the Lake Victoria Basin region (2,7,16,17,23). Maize is susceptible to both higher temperatures and drought, and does particularly poorly under a hot and dry scenario, with production decreases in the region projected at 10–37 percent [1]. The reliance of wetland communities on maize as both a food source and a source of income, coupled with projected higher temperatures, increased variability in rainfall and greater likelihood of longer, more intense droughts, puts these communities at significant risk in the future. Decline in yields is likely to have the most impact in Tarime district, which has almost double the planted area of maize as the next closest district.

The second most important subsistence crop around the wetlands, cassava, is considerably more drought-tolerant, and serves as a failsafe in the event of maize crop failure. However, cassava is susceptible to prolonged periods of drought, and yields are not likely to keep up with the increased population needs. In the districts around the wetlands, Butiama has the largest area planted with cassava.

Climate Stressors and Climate Risks AGRICULTURE – Subsistence Crops		
Stressors	**Risks**	**Illustrative Adaptation strategies**
Rising temperatures and evaporation rates	Reduced food yields due to heat stress	• Use of drought-tolerant or -resistant varieties of maize • Use of early-maturing crop varieties (e.g., maize, sorghum, sweet potato, beans) • Rainwater harvesting or irrigation
Increase in precipitation variability	Cropping pattern uncertainty	• Change in planting patterns, such as altering rotations or using intercropping • Increased use and availability of climate, weather and early warning information (e.g., Tanzania Meteorological Agency's monthly and seasonal outlooks)
	Reduced yields or quality of crops due to water stress	• Rainwater harvesting, irrigation and water storage • Crop diversification (from maize) to include more drought resistant crops (e.g., sorghum, millet, cowpea, pigeon pea)
Increased frequency and intensity of heavy rainfall	Damage to crops and land from heavy rainfall, flooding, erosion and waterlogging	• Improved soil management (limited tilling, composting, mulching, terracing, fertilizer application) • Adopting agroforestry techniques such as border planting, alley cropping or Sloping Agricultural Land Technology
	Increased pest and disease damage	• Use of pesticides, disease- or pest-resistant varieties, crop rotation or companion planting

Cash Crops

Although all cash crops grown represent less than 10 percent of the total planted area around the wetlands, they are an important source of income. These include primarily oilseeds (e.g., groundnut, sunflower, sesame) and cotton. North Mara WUA members ranked the following in order as the most important cash crops: sunflower, cotton, sesame and excess subsistence crops (including groundnut, which is primarily viewed as a subsistence crop).

The two main cash crops (sunflower and cotton) are sold raw and are processed outside of the community. The Tanzanian government is encouraging cultivation of sunflower seeds, and farmers in the area sell directly to a processing facility located in Namanga on the Tanzanian–Kenyan border. In the case of cotton, farmers form a relationship with the local cotton board, wherein the board provides all inputs, and farmers sell raw cotton to the board, less the cost of inputs.

Sunflowers are generally a hardy and fairly drought-resistant crop, but with projected changes in climate, while yields are not expected to decline, neither are they expected to significantly increase. Cotton farming is water-intensive and relies on rainfall. The projection of an overall increase in precipitation in the area would be beneficial for cotton and yields could increase. However, cotton may be more susceptible to pests (such as the cotton bollworm) that thrive in warmer temperatures and wetter conditions, and is highly susceptible to droughts, which are likely to increase in intensity and duration.

Climate Stressors and Climate Risks AGRICULTURE – Cash Crops		
Stressors	**Risks**	**Illustrative Adaptation strategies**
Rising temperatures and evaporation rates	Reduced yields due to heat stress	• Use of drought-tolerant or -resistant varieties (e.g., groundnuts) • Use of high-yield crop varieties (e.g., cotton) • Rainwater harvesting or irrigation
Increase in precipitation variability	Reduced cotton yields due to sporadic rain	• Rainwater harvesting, irrigation or water storage • Income diversification (from cash crops) to include tree-based business such as fruit trees, community and institutional woodlots, and seedling production • Increased use and availability of climate, weather and early warning information (e.g., Tanzania Meteorological Agency's monthly and seasonal outlooks)
Increased frequency and intensity of heavy rainfall	Damage to crops and land from heavy rainfall, flooding, erosion and waterlogging	• Improved soil management and fertility techniques (limited tilling, composting, mulching, terracing, fertilizer application) • Adopting agroforestry techniques such as border planting, alley cropping or Sloping Agricultural Land Technology
	Increased pest and disease damage	• Use of pesticides, disease- or pest-resistant varieties, crop rotation or companion planting

LIVESTOCK AND FISHERIES

Livestock fulfill a number of functions for communities around the wetlands, including as a source of income, and for consumption, ceremonies and dowry. Sixty-two percent of households keep livestock; cattle, goats, sheep and chickens are the primary livestock in terms of both percentages of animals kept and the community's ranking of their importance.

Cattle have the most economic and social importance –more than 2 million head of cattle are currently kept in the region. Ownership in the region is split between small-scale producers and large operations: one-third of households in the region have one to five cattle (small-scale producers), but approximately one-half of the cattle in the region are owned by less than 1 percent of households with large herds (200+ cattle). The area around the wetlands is almost exclusively small-scale producers that rely on grazing and crop residues for feed.
Tarime and Rorya districts raise primarily indigenous cattle, and account for less than 30 percent of the cattle in the region [11]. Larger concentrations of cattle, particularly dairy and beef cattle, are found in lower-lying areas south of the wetlands in Butiama and Bunda districts. The cattle population has increased dramatically at around 9 percent per year, up almost 1 million head from the official count of 1.1 million in 2003 [8]. Cattle are susceptible to climate variability, requiring large amounts of water and pasture land, and dairy cows in particular are susceptible to increasing temperatures. The communities around the wetlands cited multiple instances in the past 20 years where flooding or drought led to widespread cattle deaths.

Goat, sheep and chickens provide additional income as well as being food sources. Unlike cattle, all three tend to be kept on farm plots or near households, and are stall raised or allowed to graze locally. Although there are large populations of goats (more than 1 million), sheep (more than 500,000) and chickens (more than 2 million), virtually all are kept by small-scale producers with one to ten animals per household, and are indigenous breeds. All three tend to be more climate-resilient than cattle, in part because of lower input requirements, but also because the animals are better adapted to dry conditions and grazing on local fodder. Fish also provide a source of food and income for the population around the wetlands, and are almost exclusively obtained through small-scale capture fishery. Overfishing, siltation and conversion of wetland habitat have all increased pressure on wild fish stocks [9].

Climate Stressors and Climate Risks LIVESTOCK AND FISHERIES		
Stressors	**Risks**	**Illustrative Adaptation strategies**
Rising temperatures and evaporation rates	Heat stress in livestock, leading to reduced reproduction, growth rates and milk production; higher morbidity and mortality	• Use of improved breeds (such as indigenous breeds that are more resistant to diseases and high-yielding)
	Increase in water temperature for fisheries	• Use of cage culture in natural bodies of water or aquaculture
Increase in precipitation variability	Degraded pasture land	• Use of semi-intensive production (free-range combined with intensive systems) • Improved fodder production and grazing management (establishment, stocking rate, rotational grazing)
	Decreased water availability	• Implementation of small-scale dams and boreholes as alternative water sources
Increased frequency and intensity of heavy rainfall	Increase in vector-borne diseases	• Improved access to extension services • Increased use of dipping and spraying
	Losses from floods	• Increased use and availability of climate, weather and early warning information

HUMAN HEALTH

Nineteen percent of children under age five were classified as underweight in 1991, and that number declined to 12 percent in 2010 [25]. In the most recent Tanzania Demographic and Health Survey and Malaria Indicator Survey (DHS-MIS) from 2016, slightly more than 10 percent of children under age five were classified as malnourished according to weight-for-age in Mara region [21]. That can quickly change however, as seen during the 2016–2017 drought. As a result of only two poor harvests over a period of less than a year the region became classified as “stressed” by FEWS NET [6][1]. Increasing demand driven by population pressure, coupled with increased rainfall variability and projected decreases in maize production, could rapidly undo the progress of the past few decades.

1 Stressed: “Even with any humanitarian assistance at least one in five households in the area have the following or worse: Minimally adequate food consumption but are unable to afford some essential nonfood expenditures without engaging in irreversible coping strategies.” (Integrated Phase Classification v2.0)

The wetlands' climate is categorized as highly suitable for malaria transmission six to seven months out of the year [4]. In the 2016 DHS-MIS, 19 percent of children under age five tested positive for malaria in the region. Tarime in particular has a very high rate of endemicity, with a population-weighted mean prevalence four to seven times higher than neighboring Serengeti or Musoma districts. Based on the projected temperature and precipitation increases, it is thought that most of the region (excluding eastern Serengeti) could become suitable for malaria year-round by 2050 [25].

Waterborne illnesses are also prevalent, and the percentage of children under age five reporting diarrhea in the past year increased from 11 percent of total population in 1991 to almost 18 percent of total population in 2010 [21]. With a large percentage of the population dependent on unimproved drinking water sources, and with an average of 82 percent of the households around the wetlands using non-improved toilet facilities, that trend is likely to increase with warmer temperatures and increased risk of flooding. Cholera in particular is a concern as its prevalence is increased by warming temperatures and is spread by high rainfall events. In 2015 Tanzania experienced a cholera outbreak, and the Mara region was one of the four worst affected regions.

Climate Stressors and Climate Risks HUMAN HEALTH		
Stressors	**Risks**	**Illustrative Adaptation strategies**
Rising temperatures and evaporation rates	Increased mortality and morbidity related to heat stress	• Development of heat warning system • Improvements to design and ventilation of housing
	Increased risk of vector- and waterborne diseases, including malaria and cholera	• Use of prevention measures such as treated mosquito nets, ventilation, spraying and access to improved drinking water sources • Implementation of surveillance and predication programs to identify and respond to outbreaks (or potential outbreaks) of malaria and other infectious diseases
Increase in precipitation variability	Increased food insecurity and malnutrition from decreased agricultural productivity	• Promotion of diversified cropping systems and mixed agriculture • Projects on water harvesting and irrigation to enhance water access and availability
Increased frequency and intensity of heavy rainfall	Loss of life or displacement due to flooding or landslides	• Use of erosion control measures • Increased use and availability of climate, weather and early warning information
	Increased risk of vector- and waterborne diseases, including malaria and cholera	• Use of prevention measures such as treated mosquito nets, ventilation, spraying and access to improved drinking water sources • Implementation of surveillance and predication programs to identify and respond to outbreaks (or potential outbreaks) of malaria and other infectious diseases

WATER RESOURES

As mentioned in previous sections, despite proximity to the Mara River, Lake Victoria and even the wetlands themselves, communities around the wetlands underutilize water resources. Additionally, very few households around the wetlands have access to improved drinking water: access ranges from a low of 10 percent in Rorya to 41 percent in Serengeti. Most of those with access to improved drinking water draw it from a public tap or protected well or spring, and less than 10 percent of those with access to improved drinking receive it from water piped to their home or plot [5]. That leaves the majority of the population drawing their water from unimproved sources such as unprotected springs (Tarime), surface water from rivers and lakes (Rorya) or unprotected wells (Butiama).

In the four districts that border the wetlands, anywhere from 30–65 percent of the population relies on unprotected surface water from streams, rivers or the lake as a primary drinking water source, which greatly increases vulnerability to climate variability and change. Members of the North Mara WUA noted that a number of small local streams dried up in the past decade, and more extensive observations around the region noted a signification reduction in the past 10 years, with some local streams drying up completely and some becoming more seasonal. At the other end of the spectrum, an increase in the number of high rainfall events increases the likelihood of those water sources becoming contaminated by upstream mining (e.g., Mara North Gold Mine), agricultural farms and sewerage systems [24].

Climate Stressors and Climate Risks
WATER RESOURCES

Stressors	Risks	Illustrative Adaptation strategies
Rising temperatures and evaporation rates	Decreased soil moisture and infiltration rates	• Improved soil management techniques (composting, mulching, terracing) and water infiltration designs
Increase in precipitation variability	Reduced access to drinking water due to drying up of small streams and seasonal water decreases	• Projects to enhance access to water, including rainwater harvesting, new boreholes and rehabilitation of local streams
Increased frequency and intensity of heavy rainfall	Increased flooding from heavy rainfall events, threatening water infrastructure and quality	• Climate-proofed design and construction of water sources, such as wells, boreholes, reservoirs and water supply infrastructure
	Increase in pollution from farms and sewerage systems	• Climate-proofed design and construction of farms and sewerage systems to include buffer strips and maintenance of wetlands

INSTITUTIONAL STRUCTURE FOR WATER MANAGEMENT

NATIONAL FRAMEWORK

The Water Resources Management Act (WRMA) No. 11 of 2009 is the primary guiding document for water management in Tanzania, and is overseen by the Ministry of Water. Per the WRMA, water resources in Tanzania are managed at five levels, from national to local: (1) the National Water Board; (2) the nine Basin Water Boards (BWBs); (3) Catchment Water Committees; (4) district councils; and (5) WUAs. In practice, technical and economic powers in the water sector are delegated from the Ministry of Water to the nine BWBs, and rural water supply regulation is delegated to the 185 district councils. The actual provision of water and sanitation services in rural areas is then managed by Community-Owned Water Supply Organizations (COWSOs). Below is a summary table of roles and responsibilities at each level, extracted from the WRMA.

Structure and responsibilities of water management institutions in Tanzania

INSTITUTION	ROLES AND RESPONSBILITIES
Ministry of Water	• Formulating national policy and strategy • Regulating, coordinating, supervising, monitoring and evaluating the execution of the functions
National Water Board (NWB)	• Multisectoral coordination in integrated water resources planning and management • Resolving national and international water conflicts
Basin Water Board (BWB)	• Preparing basin water resources management plans • Developing guidelines and standards for water source structures • Monitoring, evaluating and approving construction and maintenance of water source structures • Approving, issuing, managing and revoking water use and discharge permits • Assessing and managing water resources data • Resolving intrabasin conflicts • Coordinating intersectoral water resources management at the basin level • Constituting WUAs
Catchment and Subcatchment Water Committees	• Coordinating and harmonizing catchment or subcatchment integrated water resources management plans • Resolving water resources conflicts in the catchment or subcatchment
Water Users Association (WUA)	• Managing, distributing and conserving water from a source used jointly by members of the association • Acquiring and operating any permits • Resolving conflicts between members of the association related to the joint use of water or a water resource • Collecting water user fees on behalf of the Basin Water Board • Representing the special interests and values arising from water used for public purposes, such as in an environmental or conservation area, or for purposes of managing groundwater control areas

WATER RESOURCE MANAGEMENT IN THE MARA WETLANDS

The Lake Victoria Basin Water Board (LVBWB) oversees water management in the region, including the Mara River and Wetlands. Under the LVBWB is a catchment committee (equivalent to the WRUA board in Kenya) for the wider Mara River Basin, which consists of 14 WUAs. Around the wetlands themselves two WUAs are responsible for water management: North Mara WUA and South Mara WUA. The North Mara WUA consists of eight villages in Tarime and Rorya districts, representing approximately 31,000 residents from the villages of Kembwi, Bisarwi, Surubu, Nyamerambaro, Nkerege, Marasibora, Kwibuse and Nyanchabakenye. The South Mara WUA consists of eight villages in Butiama district, representing approximately 29,000 residents from the villages of Kitasakwa, Ryamisanga, Buswahili, Kongoto, Wegero, Kwisaro, Kirumi and Bukabwa.

The World Wide Fund for Nature (WWF) has played a large role in the basin over the past 15 years, and both WUAs were formed in 2013 with its assistance. Each association has a constitution and four primary officers – Chairperson, Vice-chairperson, Secretary and Treasurer – who are each responsible for some aspect of planning and financial management.

Discussions with the North Mara WUA identified the following roles and responsibilities of its WUA:

- *Managing sources of water and conserving the environment*. The WUA manages water sources by establishing laws and has the power to fine offenders. The water sources under the North Mara WUA's purview are:
    - Mara River (portion of the river in Tarime and Rorya districts)
    - Springs
    - Dams
    - Natural and manmade wells
- *Solving conflicts over water use*. Village committees and village offices resolve conflicts, with more complicated or intractable conflicts referred to the courts. Common sources of conflict are:
    - Lack of awareness of environmental conservation measures
    - Lack of awareness of the existence of laws that govern the use of water sources
    - Illegal logging for domestic and business purposes along water sources
    - Drowning of cattle in water sources used for domestic purposes
- *Collecting fees.* The WUA collects fees from the eight villages on behalf of the LVBWB. Every water user contributes Tsh 2,000 (less than $1) per year and these fees are used to renovate water infrastructure.
- *Educating the community.* The WUA delivers educational messages to its members on topics such as the benefits of and methods for conserving water sources (e.g., planting trees) and proper livestock grazing.
- *Designing and implementing projects.* The WUA has worked with a number of international nongovernmental organizations (NGOs) (e.g., WWF, Birdlife International) to design and implement projects that improve water sources, such as a beekeeping project sponsored by WWF and community tree-planting events.

RELEVANT WATER AND NATURAL RESOURCE MANAGEMENT POLICIES AND PLANS

In addition to the WRMA, the following documents govern the management of water and natural resources in Tanzania:

- Water Supply and Sanitation Act No.12 of 2009
- National Water Policy 2002 (NAWAPO)
- National Water Sector Development Strategy (WSDS) 2006–2015
- National Climate Change Strategy (2012)
- National Forestry Policy (1998)
- National Environmental Policy (1997)
- National Environmental Action Plan (2012–2017)
- National Environment Management Act (2004)
- Mara River Basin Transboundary Integrated Natural Resources Plan 2016–2026 (LVBC 2016)
- Mara Wetlands Integrated Management Plan 2018–2022
- Conservation Investment Plan for Mara Wetlands

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25. USAID. 2017. Vulnerability, Impacts and Adaptation Assessment in the East Africa Region. Chapter 11: Impact of Climate Change on Health in East Africa – Future Scenarios
26. USAID. 2018. Climate Risk Profile – Tanzania
27. USAID. 2018. Fact Sheet: Valuing Ecosystem Services of Mara Wetlands, Tanzania