UPPER TANA-NAIROBI WATER FUND

STRATEGIC PLAN
2022–2026

Published by:
UTNWF Trust 2021

Prepared by: WaterFund Upper Tana-Nairobi

LIST OF ACRONYMS

AMCOW	African Ministers Council on Water
ASAL	Arid and Semiarid Lands
AWWDA	Athi Water Works Development Agency
BoM	Board of Management
BoT	Board of Trustees
CAC	Counties Advisory Committee
CARITAS	Congregations Around Richmond to Assure Shelter
CBO	Community-Based Organization
CEA	County Extension Assistant
CIAT	International Center for Tropical Agriculture
CIDPs	County Integrated Development Plans
CSR	Corporate Social Responsibility
CMS	Cubic Meters per Second
DHIS2	District Health Information System (version 2)
EIA	Environment Impact Assessment
EMCA	Environmental Management and Coordination Act
ESIA	Environment and Social Impact Assessment
ESIMP	Environment and Social Impact Management Plan
EX-ACT	Ex-Ante Carbon Balance Tool
FM	Financial Management
GDP	Gross Domestic Product
GEF	Global Environment Authority
GHG	Greenhouse Gas
GoK	Government of Kenya
HRM	Human Resources Management
ICRAF	International Centre for Research in Agroforestry
ICT	Information and Communication Technology
IFAD	International Fund for Agriculture Development
IOD	Indian Ocean Dipole
IPS	Industrial Promotion Services
JKUAT	Jomo Kenyatta University of Agriculture and Technology
KenGen	Kenya Electricity Generating Company
KeRRA	Kenya Rural Roads Authority
KFS	Kenya Forest Service
KM	Knowledge Management
Ksh	Kenya Shilling
KWS	Kenya Wildlife Service
LDSF	Land Degradation Surveillance Framework
M&E	Monitoring and Evaluation
MDG	Millennium Development Goal
MoA	Ministry of Agriculture
MoE & F	Ministry of Environment and Forestry
MoWS & I	Ministry of Water, Sanitation, and Irrigation
MTEF	Medium-Term Expenditure Framework

NCCAP	National Climate Change Action Plan 2018–2022
NCWSC	Nairobi City Water and Sewerage Company
NDEKA	Ndakaini Environmental Conservation Association
NEMA	National Environment Management Authority
NGO	Nongovernmental Organization
NIA	National Irrigation Authority
NMK	National Museums of Kenya
PESTEL	Political Economic, Socio, Environmental, and Legal
PESTLEG	Political, Environmental, Social, Technological, Legal, and Governance
PMU	Project Management Unit
PPP	Public-Private Partnership
PSC	Project Steering Committee
RFQ	Request for Quotation
SACDEP	Sustainable Community Development Program
SCMP	Subcatchment Management Plan
SDG	Sustainable Development Goal
SLM	Sustainable Land Management
SMEs	Small and Medium Enterprises
SMS	Short Message Service
SP	Strategic Plan
SSP	Shared Socioeconomic Pathway
SWLM	Sustainable Water and Land Management
SWOT	Strengths, Weaknesses, Opportunities, and Threats
TARDA	Tana and Athi Rivers Development Authority
TNC	The Nature Conservancy
TSS	Total Suspended Solids
UN	United Nations
USD	United States Dollar
UTNWF	Upper Tana-Nairobi Water Fund
WASREB	Water Services Regulatory Board
WF	Water Fund
WRA	Water Resources Authority
WRUA	Water Resource Users Association
WSTF	Water Sector Trust Fund

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PRESIDENT’S FOREWORD

On behalf of the Board of Trustees and Management of the Upper Tana-Nairobi Water Fund (UTNWF) Trust, I am pleased to present the Trust’s Strategic Plan for the period 2022–2026. This plan is a result of synthesis and integration of accomplishments and lessons learned over the last five years as they relate to the mandate of the Trust as envisaged in the incorporation Trust deed. This plan is a statement of intent about how the Trust, operating independently as of 2022, will continue to support the long-term conservation, protection, and maintenance of the Upper Tana watershed and thereby improve Nairobi’s water security and optimal functioning of Seven Forks hydropower generation plants along the Tana River. It also indicates the efforts that will be undertaken “to mobilize and efficiently deploy resources for sustainable and innovative conservation in the Upper Tana, resulting in improved livelihoods and safeguarded river water quality and quantity.” Equally, the strategic plan establishes specific goals aimed at achieving the Trust’s vision and mission of ensuring a well-conserved and managed watershed for sustained better life in the region and beyond.

The Trust brings together public and private sectors to work together in partnership and deliver collaborative solutions throughout the Upper Tana watershed for one of the greatest challenges to our future: source water protection. The Upper Tana watershed supports 95% of the water supply for Nairobi City and generates 65% of the nation’s hydropower. The plan also identifies and assesses the Trust’s strengths, weaknesses, threats, and opportunities, as well as identifies specific five-year strategic objectives that will be achieved through a series of strategic initiatives and detailed tasks to help us realize our vision and achieve the Trust’s strategic goals. During the strategic planning process, the Trust refined its vision to align with the aspirations espoused in the Trust deed, the 2015 UTNWF business case, the country’s development agenda, and the world’s desire to achieve the United Nation’s Sustainable Development Goals. The Trust’s four strategic focus areas that will drive it in realizing its vision are customer focus, financial plausibility, sound internal processes, and sustained organizational capacity. Successful implementation of the strategic plan will depend on the leadership, senior management and all staff fully embracing it and committing themselves to its attainment. I therefore call on all of us to work together to effectively conserve the source water areas and to sustain water supply security to Nairobi while at the same time ensuring sustainable livelihoods of the millions of communities living in Upper Tana and beyond so that this plan can be realized. I am confident that we shall effectively tackle any issues that may arise and thus make a visible contribution to the broader environmental and human development and to our prosperity.

As a trust, we are fully committed to implementing the clearly articulated goals in this plan. We commit to working with all stakeholders to continually develop appropriate policies and review the Trust’s work and operations to ensure smooth, successful implementation of this plan. I commend all those who gave their invaluable input, and more specifically the Board of Management and staff of the Trust who worked tirelessly to produce the UTNWF Strategic Plan.

Eddy Njoroge, E.B.S. C.B.S.
President, UTNWF Board of Trustees

CHAIRMAN'S PREAMBLE

I am pleased to present the Strategic Plan of the UTNWF for the period 2022–2026. This strategic plan is the culmination of an all-inclusive consultative process that involved our Board of Management, Trustees, staff, and other stakeholders. The plan incorporates lessons learned over the past five years, reviews past challenges, present new ones, and outlines the future for the Trust. The plan articulates a comprehensive road map for the next five years and outlines the Trust's short- and medium-term strategies. I urge staff to study and internalize the plan so that we can deliver on the targets set out therein. Going forward, our trust and individual performance commitments, as well as resource allocation, shall be based on this plan. To our stakeholders, this plan will serve as a yardstick for evaluating our performance as a trust and how responsive we are toward environmental, social, human, conservation, and development needs.

In developing this plan, the Trust considered several important factors to ensure that it is anchored on the prevailing government policies, national development plans, and the law. The most notable was that the UTNWF has attained maturity stage, according to the water fund development cycle. This follows a successful incubation phase managed by The Nature Conservancy (TNC). This plan refreshes the Trust's priorities and strategic objectives to fully meet the business case goals and targets, and provides the building blocks for the Trust's organizational, financial, and operational sustainability. This plan considers both the internal and external environment that the Trust operates in. It also incorporates contributions from diverse stakeholders and the lessons learned in the past to develop three strategic focus areas. Successful implementation of this plan calls for prudent leadership to enhance efficiency, effectiveness, and greater client orientation. Through this process, the Trust has identified a set of values that provide the cultural foundation required to align ourselves to the new strategy.

I am happy that given the consultative process we went through in developing this strategic plan, there is common understanding, common ownership, and common commitment to its implementation. As the chairman, I commit the BoT and by extension the BoM and CAC to remain the custodians and drivers of the implementation process, keeping the directors and key staff focused on the intended results to provide an enabling environment for success. On behalf of the Trust, I wish to express my gratitude to all those who participated or supported us as we developed this strategic plan. It was an exacting but nevertheless fruitful process. I have every confidence that we will deliver on this plan and thus make a positive contribution to source water protection, community livelihoods, clean water supply, and the economy of this country.

Hon. Joshua Irungu
Interim Chairman, Board of Trustees, UTNWF Trust

EXECUTIVE SUMMARY

The Upper Tana-Nairobi Water Fund Trust is registered as a public charitable trust in Kenya with the following ***Mission:*** To secure the long-term conservation, protection, and maintenance of the Upper Tana watershed and the benefits it provides for people and nature by advancing nature-based solutions to water security. The UTNWF's ***Vision*** is "a well-conserved and managed Upper Tana watershed that sustains healthy livelihoods and ecosystem functions in the region and beyond, with the ***Goal*** to support the long-term conservation, protection, and maintenance of the Upper Tana watershed and thereby improve Nairobi's water security and optimal functioning of hydropower facilities along the Tana River.

The purpose and objective of this Five-Year Plan is to

- **Create Clarity** — Establishing a framework for documenting and evolving important strategic choices made by UTNWF leadership.
- **Provide Focus** — Allowing for more effective goal setting and purpose-based leadership by the UTNWF.
- **Develop a Shared Road Map** — Driving measurable progress toward impact and systemic change.

The Upper Tana watershed is among the most important in Kenya for water supplies, agricultural production, and biodiversity conservation. The watershed supports 95% of the water supply for Nairobi City and generates 65% of the nation's hydropower. Over the next five years and beyond, the goals of the UTNWF will be to significantly increase its investments to improve water quality and quantity in the Upper Tana watershed, enhance food security, protect freshwater and terrestrial biodiversity, and improve human well-being of local communities. This will be achieved by implementing four strategic objectives: enhancing the climate change resilience of biodiversity and ecosystem function in the Upper Tana; improving socioeconomic conditions for local and regional communities; increasing water supply and quality with enhanced resilience to climate change; and establishing effective policies, knowledge sharing systems, and sufficient funding to sustain water and land conservation activities in the Upper Tana. Achieving these objectives will include increasing the capacity and accountability to UTNWF stakeholders; establishing robust data collection and sharing systems as part of monitoring, evaluation, and adaptive management; improving policies and investments of local governments and partners; strengthening UTNWF institutional capacity; and securing an operating endowment that can sustain the work of the UTNWF indefinitely.

The Trust is set up as a public-private partnership working collaboratively throughout the Upper Tana watershed on solutions for one of the greatest challenges to our future: source water protection. The Trust is an incorporated charitable trust in Kenya, governed by a board of trustees (BoT), board of management (BoM), and a county advisory committee (CAC), all of which oversee the work of staff and are led by a full-time executive director. In addition, over the first five years of operation, the Trust has established robust partnerships with local nongovernmental organizations (NGOs), government agencies, and research institutions to assist with and guide the implementation of watershed management. The Trust is now in a transition phase and will operate independently as of September 2021. The Trust has developed the necessary management systems, human resources, financial management, and operational systems necessary to operate as an independent entity. The strategic plan, therefore, will guide the Trust by clarifying its strategic objectives and priorities over the next five years, and by providing a road map for implementation and monitoring to ensure the Trust remains focused on delivering outcomes for the Upper Tana watershed and downstream water users. The plan will also provide the foundations for Trust leadership, key partners, staff, and stakeholders to measure progress and adjust programs as necessary to focus and consolidate the work of the Trust for the next five years.

Emmanuel Rurema
Interim Executive Director, UTNWF Trust

Introduction

Tana River Watershed and Regional Context

The Tana River is perhaps Kenya's most important river. It is the country's largest river — stretching almost 1,000 km from the edge of the Great Rift Valley to the fertile delta where it meets the Indian Ocean. A healthy Tana River is a significant contributor to Kenya's diversity and sustainability (Figure 1).

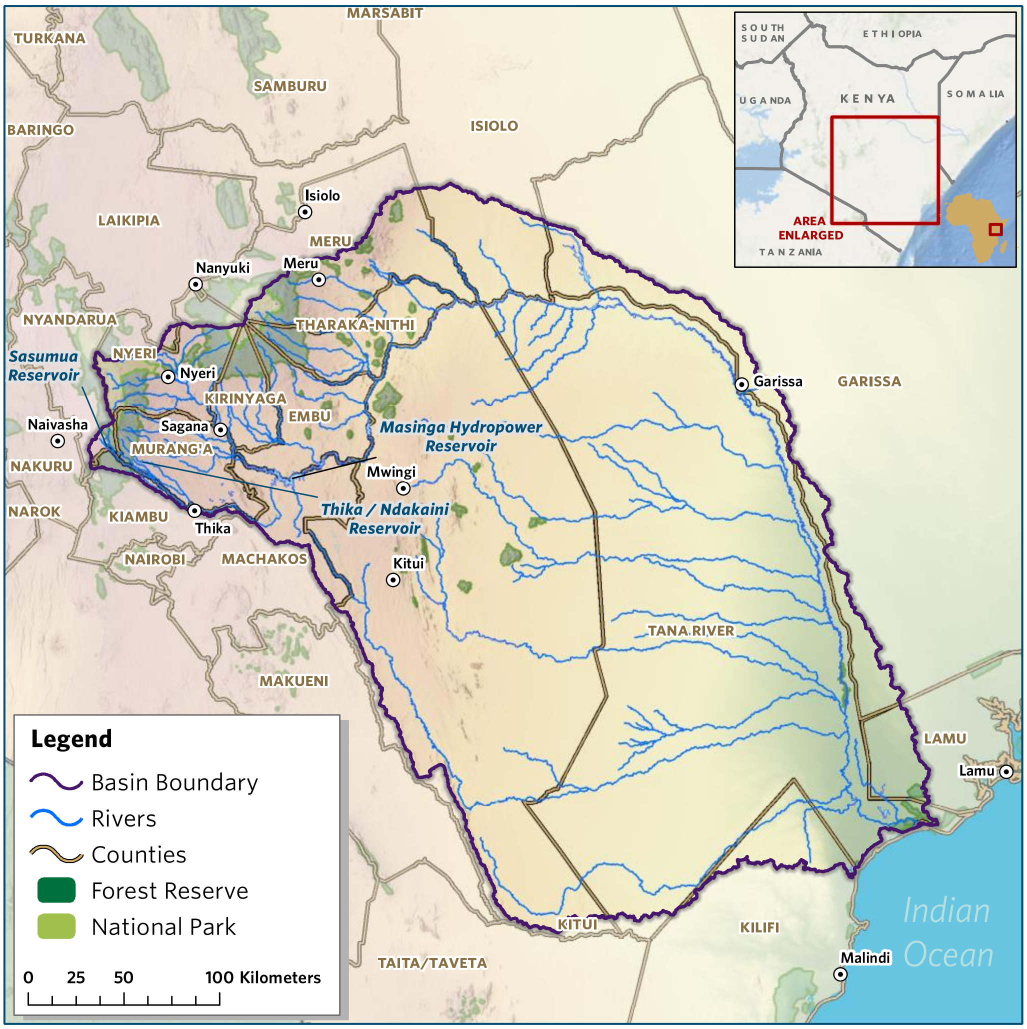

Figure 1: Tana River watershed.

The Tana sustains important aquatic biodiversity, provides water to key national parks, generates half of the total hydropower in the country,[1] and supplies 95% of Nairobi's wealth and water for a population of over 6 million people.[2] The water from the Tana is also the basis for Kenya's most

[1] Vogl et al. (2016). Valuing investments in sustainable land management in the Upper Tana River basin, Kenya.
[2] 2019 Kenya Population and Housing Census. Volume 1.

productive agricultural area, driving agricultural activities that feed millions of Kenyans, and supporting over 300,000 smallholder farms along its course.

The Upper Tana basin is also among the most important for the people of Nairobi and Kenya for several reasons. The Upper Tana covers approximately 17,000 km^2 (the equivalent of 3 million football fields), including three catchments and two of Kenya's most important sources of water — Mount Kenya and the Aberdare Range (Figure 2).

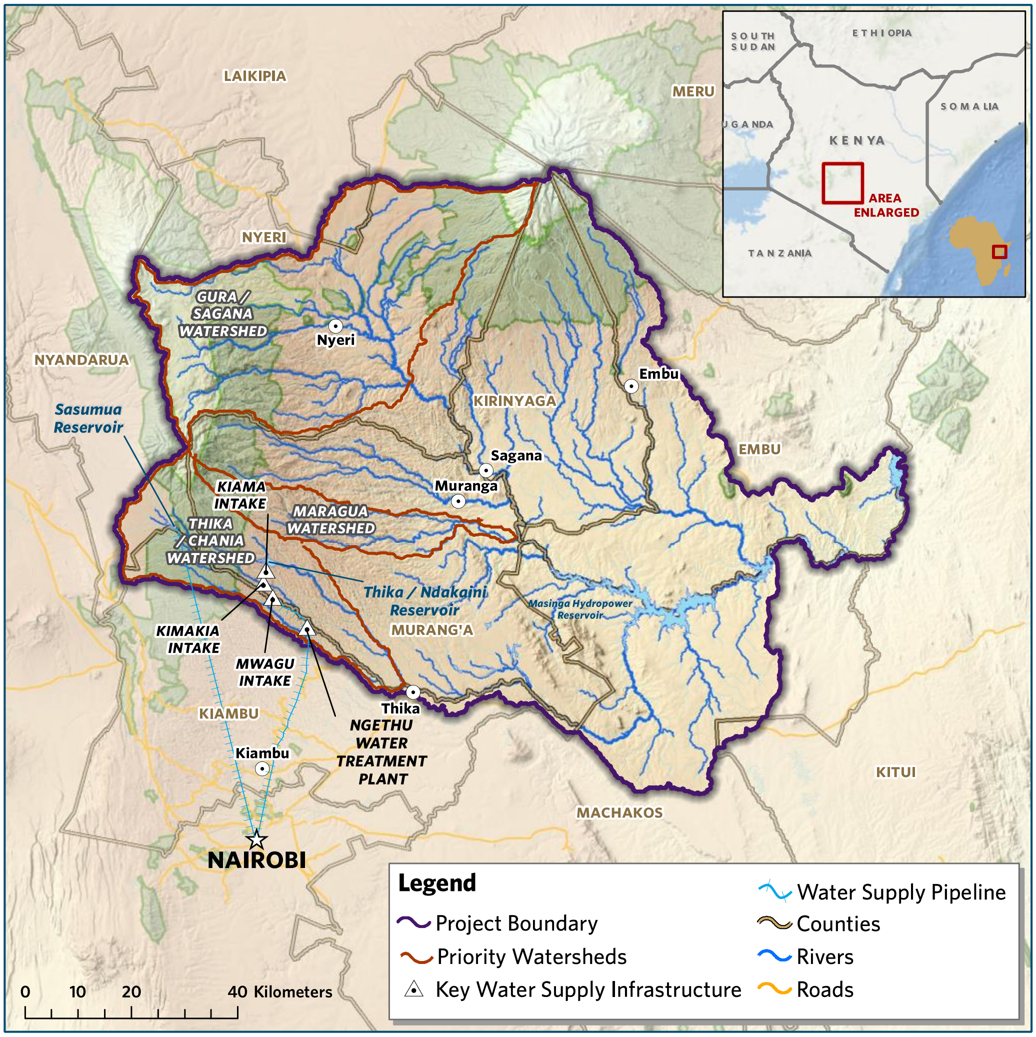

Figure 2: UTNWF project area.

The Upper Tana supports over 5 million people in the counties of Kirinyaga, Murang'a, Nyeri, Nyandarua, Laikipia, Kiambu, Embu, and Machakos.

Agriculture is the backbone of Kenya's economy, contributing approximately 25% of the gross domestic product and employing 75% of the national labor force. The Upper Tana is no exception; thousands of smallholder farmers produce diverse crops in this watershed, including coffee, tea, macadamia nuts, avocados, Asian vegetables, potatoes, rice, citrus fruits, mangoes, arrowroots, maize, and beans. These crops are grown both for their importance for subsistence of local people and as cash crops. Given that approximately 80% of the Kenyan population lives in rural areas and makes a living directly or indirectly from agriculture, improving agricultural management and the resilience of farming communities in the Upper Tana through protection of clean water supplies will not only be important for these local communities, but also be an important contribution to Kenya's wealth and resilience.

The Upper Tana is also a crucial energy resource because it drains directly into the Seven Forks hydroelectric generation systems, with reservoirs at Masinga and Kamburu. The Seven Forks system generates 65% of Kenya's hydropower, which is a significant portion of the energy for Kenya overall. This is becoming increasingly important for Kenya's sustainable development. Biomass energy currently provides over 80% of Kenya's national energy needs, and demand for wood fuel already exceeds sustainable supplies, compromising both people's access to energy and the forested ecosystems from where this wood is collected. Thus, maintaining or even increasing the energy production of the Seven Forks dams will be essential for the region and the country in the coming decades. Also, developing and demonstrating improved watershed management and conservation to protect water supplies and energy production will provide a vital demonstration of how to improve energy and water sustainability that can be a model for Africa and the world.

It's not only people that depend on a healthy Upper Tana. This region is home to a rich diversity of plants and animals. The forests in these important but fragile mountain ecosystems are key sources of food, cover, and water, and they serve as migration routes and habitat connectors for a variety of wildlife. Several different kinds of forest characterize the watershed, each hosting a diversity of species. These forests are complemented by the river ecosystems, wetlands, and grasslands that create a mosaic of habitats providing the resources that hundreds of different kinds of wildlife depend on for their survival. Both Mount Kenya and the Aberdares are protected within a national park. They share many ecological affinities with each other and the surrounding, unprotected landscapes. Collectively, these watersheds support most of the country's surviving Afro-montane forest and Afro-alpine moorland, the latter an otherworldly landscape of open moorland studded with bizarre, giant forms of heather, lobelia, and groundsel. The two mountains host an outstandingly varied fauna, including the big five (lion, leopard, elephant, rhinoceros, and cape buffalo), alongside more localized forest species such as Sykes' monkey, the black-and-white colobus, Harvey's red duiker, mountain antelope, and the giant forest hog. The Aberdare Range is also one of the few places in Africa where melanistic (all black) leopard sightings are common, and its forests support one of only two remaining wild populations of the mountain bongo, a large, beautifully marked critically endangered forest antelope that is now effectively endemic to Kenya, having become extinct elsewhere.

The health and survival of this wild diversity will depend on maintaining sustainable land and water management in the basin. The importance of these diverse ecosystems to people cannot be understated. They deliver valuable ecosystem services that inhabitants of the Tana basin and beyond depend on. The forests help control water pollution, reduce erosion, mitigate floods, and increase groundwater recharge. They also attract wildlife tourism — an important economic driver in Kenya that depends on rich biological diversity. Tourism accounts for 10% of Kenya's GDP and 9% of total formal employment. The Tana basin overall contains several protected areas, including four national parks and eight game reserves. Mount Kenya National Park is listed as a UNESCO World Heritage site and alone receives over 15,000 visitors per year. The long-term health and beauty of Mount Kenya National Park and the other protected areas will depend on the health of water and land surrounding them. Thus, enhancing the health and resilience of the Upper Tana and surrounding regions has the potential to both enhance the region's importance for biodiversity and increase tourism and associated economic development to provide alternative sources of income and livelihood for residents.

The region's biodiversity provides even more direct ecosystem services for local communities than tourism does. Most directly, the water and soils of the basin are the lifeblood of productive agriculture in one of Kenya's most important agricultural regions. Degradation of either of these precious resources over time will lead to a collapse of the agricultural economy and the livelihoods of millions of people in the region. Also, most Kenyans living in rural areas depend on medicinal plants for treating various ailments. With increasing exploitation of medicinal plants, demand for their sustainable management and utilization is rising. Protecting endangered plant and animal species and securing water resources from adverse impacts of pollution are crucial to enhancing and maintaining these natural resources.

Water Security Challenges and Consequences

The vegetation in the Upper Tana watershed plays a critical role in maintaining water quality and quantity, providing areas where runoff water is stored and sediment is naturally filtered. However, several factors— the conversion of forests to agriculture and unsustainable agricultural management practices chief among them—have contributed to the degradation of the river and surrounding lands, threatening the benefits of a healthy and diverse watershed.

Since the 1970s, most of the unprotected forests and woodlands — including those on steep hillsides, along rivers, and wetlands — have been converted to agriculture so that now most of the landscape is covered in herbaceous (33.24%) and shrub (14.68%) crops like tea, coffee, and corn. Along with this conversion has come increased demand for irrigation water from a growing number of river diversions that reduce available river flows that sustain downstream users and hydropower generation. Rain-fed smallholder agriculture now uses 36% of the available water, and irrigated agriculture uses an additional 4%. Hydropower generation depends on 33% of the available water in the watershed; however, this use is nonconsumptive since the water is returned to the river after being used for power generation (Figure 3).

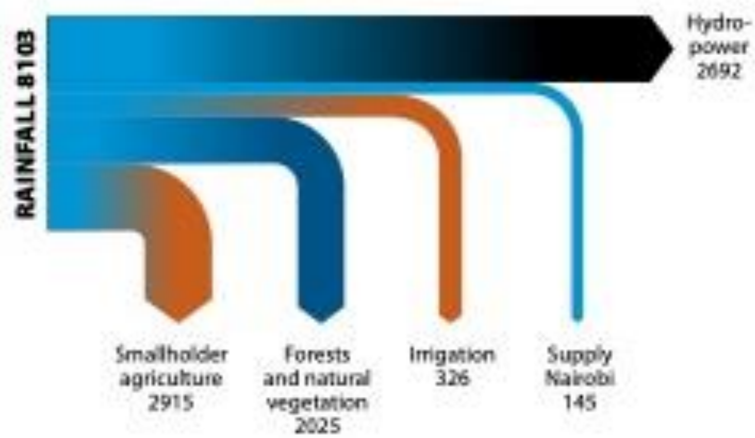

Figure 3: Annual water use by those who depend on the water supply of the Upper Tana River basin above Masinga Dam (WRMA, 2011).

This rapidly increasing demand is severely reducing dry season river flow, not only because of diversions, but also because the Upper Tana's dry season flows depend on groundwater. The conversion of natural wetlands that once stored runoff water and recharged groundwater supplies to agriculture is reducing groundwater availability, further reducing dry season flows. Increasing demand and decreasing water supply in the river is consequently increasing local conflicts among different water users in and downstream from the watershed.

In addition to reduced river flows, water quality is declining. Unsustainable farming practices are causing widespread soil erosion, degrading farmland productivity and — combined with increasing competition for space — forcing farmers onto steeper and steeper slopes, where erosion is an even larger problem. Increased sedimentation is reducing water quality for both residents and downstream users, with important social and economic implications. Increased sediment in the river reduces the quality of drinking water available to people and increases maintenance and water treatment costs for water providers. Nairobi City Water and Sewer Company (NCWSC), the major water and sewerage service provider for Nairobi, reports that water treatment costs increase by more than 33% as sediment runoff fills and disrupts treatment equipment during the wet season, causing supply interruptions. Without intervention, this problem will likely worsen, especially as climate change causes more intense rainfall events and population growth leads to more farming on steep slopes.

These impacts are coming at a time when Nairobi's water treatment and distribution facilities are already under pressure. The current water supply deficit for the city stands at 299,000 m^3 per day (or 36% of demand) when the system is operating at full capacity. New capacity added to address these shortages must also face the challenges and costs associated with high sediment loads in the water.

Furthermore, sediment deposition in reservoirs and reduced dry season flows are also a problem for hydroelectric energy production by Kenya Electricity Generating Company (KenGen). KenGen, the country's leading electric power generation company, operates several hydropower dams in the Tana watershed. The Masinga reservoir, for example, was designed on the basis of a siltation rate of 3 million tons per year. However, by 2010, the annual siltation rate was 6.7 million tons. As a result, the Masinga reservoir has already lost an estimated 158 million m^3 of storage volume, 10% of its capacity since 1981.[3] Similarly, the other major hydroelectric reservoir in the system, Kamburu, is estimated to have lost 15% of its capacity since 1983. This lost capacity substantially reduces the energy production potential of these important renewable energy sources for Kenya. As dry season flows decrease, the amount of energy that can be produced is significantly reduced. For example, during the 2009 drought, KenGen's electricity production dropped 12% compared with the previous year, a decline of $19.8 million.[4]

Water quality for residents is also being compromised by development and agricultural production in the landscape beyond just the effects of sedimentation. Livelihoods and health are being adversely affected by reduced drinking water quality and increased probability of waterborne disease. Surface and groundwater quality is affected by new and expanding settlements, especially informal settlements, towns, and markets that do not have conventional sewer systems and, as a result, are polluting nearby ground and surface water bodies. Wet coffee milling factories add pollution to the river if not managed sustainably, and other agricultural activities contribute pesticides and fertilizers, increasing pollution in the Tana River.

In short, the Tana River receives inadequate protection despite providing water and livelihoods to millions of people, 95% of Nairobi's water, and 50% of Kenya's hydropower supply. The watershed's potential to continue providing water and other vital ecosystem services is declining rapidly. Yet local residents who farm the upper watershed receive no outside investment or incentives to protect this critical resource by implementing measures that can ensure it provides abundant, safe water for everyone. If significant investments are not made to protect and improve land and water management in the Upper Tana, the river will become increasingly choked by sediments and pollutants, as well as provide less water. All these impacts will exacerbate declining productivity of farmland, water supplies, and water quality, while increasing the costs of water distribution and energy production for everyone in the Upper Tana and downstream. At the same time, the unique biodiversity that depends on a healthy Tana River will continue to be lost.

Water Security and the Upper Tana-Nairobi Water Fund

Given all the challenges the Tana River watershed faces, the Upper Tana-Nairobi Water Fund is one of Kenya's best, most cost-effective opportunities to protect these vital water supplies for millions of people, improve the livelihoods of more than 300,000 smallholder farmers, ensure sustainable production of hydroelectric power, and protect the Tana River's rich biodiversity.

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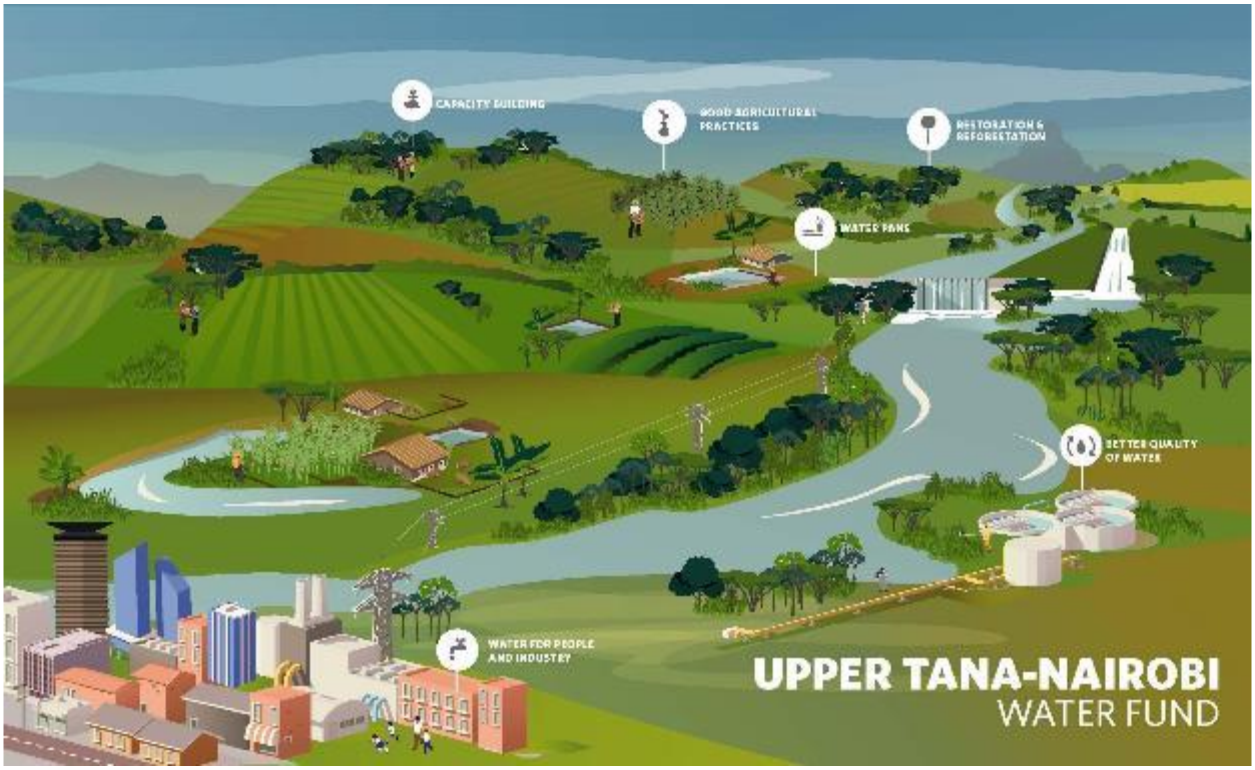
[3] WRMA 2011. Physiographical baseline survey for the Upper Tana catchment: Erosion and sediment yield assessment.
[4] KenGen 2010. Annual report and financial statements.

Why a Water Fund and How Does It Work?



Healthy, functioning watersheds that maintain ecological services have been shown to reduce water treatment costs and improve water regulation for people who rely on the watershed. Further, investment in *green infrastructure* using natural systems to trap sediment and regulate water often provide a more cost-effective approach than relying solely on *grey infrastructure*, such as reservoirs and treatment systems. Water funds are a cost-effective way for downstream water users to invest in green infrastructure that will maintain sustainable water supplies from the watershed they depend on. Water funds usually involve public-private partnership (PPP) and a financing mechanism to invest in watershed conservation. The watershed conservation measures are strategically designed to protect the quality or quantity of water available for communities and the environment. Thus, a water fund unites public and private downstream users (e.g., water utilities and major private users), upstream watershed stewards (e.g., agricultural landholders), and other interested stakeholders (e.g., development organizations) to participate in and contribute to the fund, given their shared stake in a healthy water future.

Financial support of the water fund is used to promote sustainable land and water management practices upstream that filter and regulate water supply. These management practices can include strategically sited tree planting and land terracing, natural water holding features, and on-farm soil and water management practices. Funding is also used to support economic opportunities that enhance livelihoods and the quality of life for upstream communities that further incentivize farmers and landowners to implement sustainable management practices. Indeed, many of the interventions that improve water quality and quantity also lead to increased agricultural yields. A water fund can also enhance communities' ability to adapt to climate change, by building in resilience to fluctuating water supplies and temperatures.

Implementation of water funds is a proven model founded on the principle that ***it is less expensive to prevent water problems at the source than it is to address them further downstream***. For every dollar invested in conservation strategies in the Upper Tana River watershed, it is estimated that downstream stakeholder's dependent on the water will avoid two dollars in costs of correcting impacts on water supply and energy production. The UTNWF provides a secure and transparent program through which public and private investors who depend on clean water supplies from the Upper Tana watershed can direct resources to conservation strategies that will yield the greatest returns for the common good and the economy.

Upper Tana-Nairobi Water Fund Mission and History

The Upper Tana-Nairobi Water Fund Trust was established in October 2015 and incorporated in October 2017 as a charitable Trust in Kenya. Its vision is to achieve a well-conserved and managed Upper Tana watershed that sustains healthy livelihoods and ecosystem functions in the region. To help achieve this vision, the mission of the UTNWF is to secure the long-term conservation, protection, and maintenance of the Upper Tana watershed by advancing nature-based solutions to water security. The UTNWF was the first water fund of its kind in Africa, built on experience TNC had gained from designing more than 40 water funds around the world. The UTNWF was founded by three main partners — TNC, the NCWSC, and Pentair Inc. — in order to support long-term conservation, protection and maintenance of the Upper Tana watershed and thereby improve local livelihoods, Nairobi's water security, and Kenya's renewable energy supply. The UTNWF has adopted a PPP model working collaboratively throughout the Upper Tana watershed on solutions to one of the greatest challenges to Kenya's future: source water protection. The UTNWF is working to secure water for more than 6 million people in the city and an additional 5 million who live within the watershed area.[5] The primary focus of the UTNWF is incentivize and increase adoption of farming practices that significantly improve water supply reliability and quality, and long-term watershed resilience. In doing this work, the UTNWF operates based on five key values: integrity, partnership, accountability, commitment to nature, and empowerment. Together, living and working by these values, the UTNWF will ensure that the work it does achieves the vision with transparency, equity, and collaboration.

[5] 2019 Kenya Population and Housing Census. Volume 1.

Vision
A well conserved and managed Upper Tana watershed that sustains healthy livelihoods and ecosystem functions in the region and beyond.

Mission
To secure the long-term conservation, protection and maintenance of the Upper Tana watershed and the benefits it provides for people and nature by advancing nature-based solutions to water security.

Values - I-PACE

1. *Integrity*
2. *Partnership*
3. *Accountability*
4. *Commitment to nature*
5. *Empowerment*

The Business Case for the UTNWF

The UTNWF's creation followed a study assessing the economic and biophysical viability of a water fund for the Upper Tana River basin. The study, commissioned by TNC, NCWSC, KenGen, Pentair, International Centre for Tropical Agriculture, Tana and Athi Rivers Development Trust, Water Resources Authority (WRA), East Africa Breweries, Coca-Cola, and Frigoken Limited, evaluated the potential for widespread adoption of management interventions to reduce suspended sediment in waterways and increase dry season water flows in three priority watersheds (Sagana-Gura, Maragua, and Thika-Chania). These subwatersheds were selected because previous studies highlighted them as critical areas for improving water quality and quantity in the basin. The analysis used state-of-the-art land use planning and watershed modeling tools to quantify the benefits that would arise from a $10 million investment in spatially targeted implementation of six interventions over a 10 years. The six interventions assessed were:

1. Vegetation buffer zones along riverbanks
2. Agroforestry along riverbanks
3. Terracing of steep and very steep farmlands
4. Reforestation for degraded lands
5. Grass buffer strips in farmlands
6. Mitigation of erosion from dirt roads

The annual impact of these interventions was evaluated both in terms of change in water supply and quality, as well as the economic impact for three key stakeholders: farmers in the watershed, NCWSC, and KenGen. This study concluded that over a 30-year time horizon, the benefits of strategically implementing the six management interventions at scale across all three watersheds over 10 years would result in reducing sediment concentration in the river by half, including a 20% reduction in sedimentation in Masinga reservoir, and increasing water supplies during the dry season by 15% (**Error! Reference source not found.**).

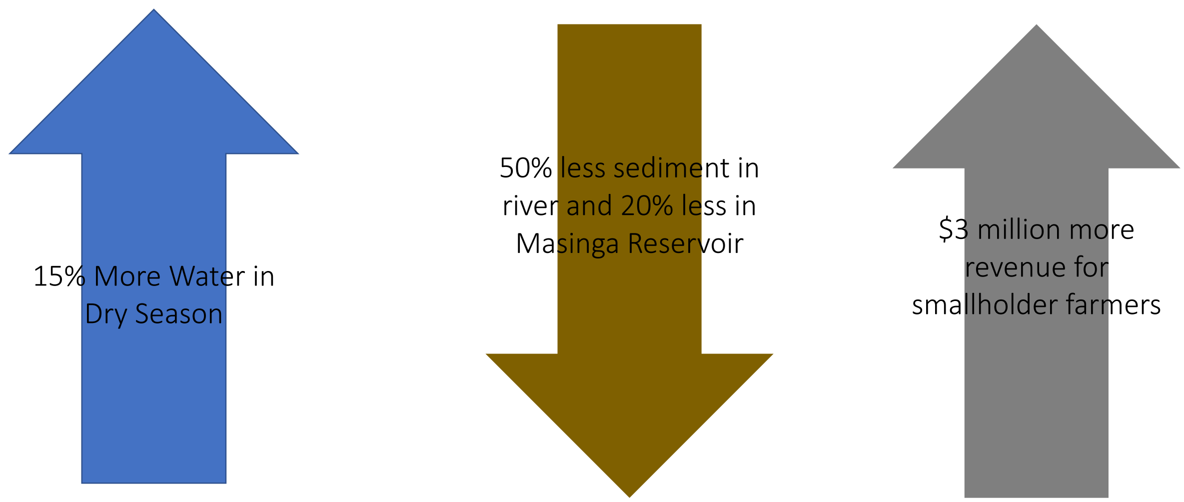


Figure 4: Predicted benefits of a $10 million investment in best land and water management practices in the Upper Tana watershed over 30 years.

The study also found that these water benefits would lead to significant economic benefits for farmers, NCWSC, KenGen and their customers. These benefits would include more clean water for half a million people; $3 million more revenue for farmers from increased crop yields; over 40 million m^3 more water in Masinga Reservoir, leading to fewer power interruptions, enough new energy to support 2 million people, and $600,000 more revenue from hydroelectric energy; and a reduction in annual water management costs of $250,000 for NCWSC.

Overall, a $10 million investment in the UTNWF is expected to return nearly $23 million in economic benefits over a 30-year time frame. In other words, for every $1 invested, stakeholders in the basin will see over $2 worth of benefits.

These calculated benefits are conservative and do not account for many other benefits that are difficult to quantify but highly valuable, including new employment opportunities, educational opportunities due to increased revenue for smallholder farmers, improved ecosystem services like pollination (worth about $1 billion each year in Kenya), and improved air quality from planting over 100,000 new trees. There is also the possibility to see greater returns on the investment if, for example, increased water yield results in greater energy production for KenGen.

UTNWF Progress 2015–2020

The UTNWF has been under implementation for five years, during which time the main focus has been establishing partnerships and trust with Upper Tana communities and local leaders, building knowledge sharing systems, and engaging the Upper Tana communities to implement practices. UTNWF management staff also are working closely with county and regional representatives, as well as other partners (NCWSC, WRA, and the National Environment Management Association), to share information and advance campaigns for policy reform and to generate government support. As a result, the UTNWF has established robust partnerships with four counties (Nyeri, Murang'a, Nyandarua, and Laikipia) in the Upper Tana River Basin. Those counties have committed to expand UTNWF's impact by making additional investments in watershed management. Also, partnerships have been established with three local NGOs in the three priority subwatersheds of Thika-Chania, Maragua, and Sagana-Gura, including with the International Centre for Research in Agroforestry (ICRAF), National Museums of Kenya, and Jomo Kenyatta University of Agriculture and Technology (JKUAT), which are supporting scientific baseline studies and impact monitoring.

Over the last five years, the UTNWF has been using these partnerships and growing financial investments to work directly with farmers and volunteers to implement the sustainable land management (SLM) interventions listed above, as well as to install water pans that collect water during the wet season and reduce river diversions. UTNWF has also been working with local communities to install biogas units as a sustainable energy source. At the same time, the UTNWF has improved existing and built new knowledge management and learning systems, including installation of 33 new automated river gauging stations and enrollment of 45,000 farmers in a mobile data monitoring program. These investments working with farmers in the watershed have already yielded significant benefits and set the stage for rapid growth and much greater impact over the next five years.

In its first five years, UTNWF has exceeded expectations, leading to significant improvements in watershed management and local livelihoods (Figure 5). To date, UTNWF has directly benefited over 200,000 farmers and is working with more than 44,725 farmers who are applying soil and water conservation practices (see Success Stories below). These improvements in management have helped 8,500 coffee farmers achieve Rainforest Alliance certification, thus increasing the value of their crop. The UTNWF is on track to be working with 70,000 farmers by 2026. Further, 15,131 water collecting pans have been installed that collectively harvest over 900 million liters of water every year. Approximately 73,000 hectares of land in the watershed are now under improved, more sustainable management, including 36,000 hectares of public forest. Also, UTNWF and partners in the watershed have already planted over 3 million trees in the last five years, which will lead to sequestering over 5 tons of carbon (CO_2e) per hectare over the next 30 years. All of this progress toward more sustainable management of the watershed is yielding the water supply and quality benefits envisaged.

The UTNWF actively collects a variety of biophysical data to measure its impact on water quality and quantity, including data on streamflow, turbidity, and total suspended solids (TSS). These data, taken together and analyzed, have been collected primarily in three main subbasins:

Sagana-Gura, Thika, and Maragua. The results over the last seven years, comparing water quality and quantity before and after UTNWF interventions, provide strong evidence that UTNWF interventions are working as promised and improving watershed health by reducing turbidity and contributing to sustained baseflow in the rivers (Appendix 2). This is evident in that turbidity in the river has remained stable or even decreased during high river flows after interventions in targeted watersheds. As much as 55 million more liters of water are now reaching Nairobi's water supply reservoirs every day with an 11% reduction in turbidity. Also, baseflows in the rivers where best management practices have been implemented are either remaining stable or increasing despite growing water demands in the watershed.

In addition to these tangible physical results on the ground, UTNWF is providing local farmers with new skills, training, and resources to improve the productivity of their land. UTNWF has deliberately sought to engage women and youth in its programs to increase their involvement and empowerment. So far, over 39% of women in the watershed are participating in sustainability programs, along with over 17% of youth (over the 10% national average[6]). These engagements have led to improved livelihoods and incomes of households, improved biodiversity, and enhanced ecosystems services for women-led households, youth, and people living with disabilities.

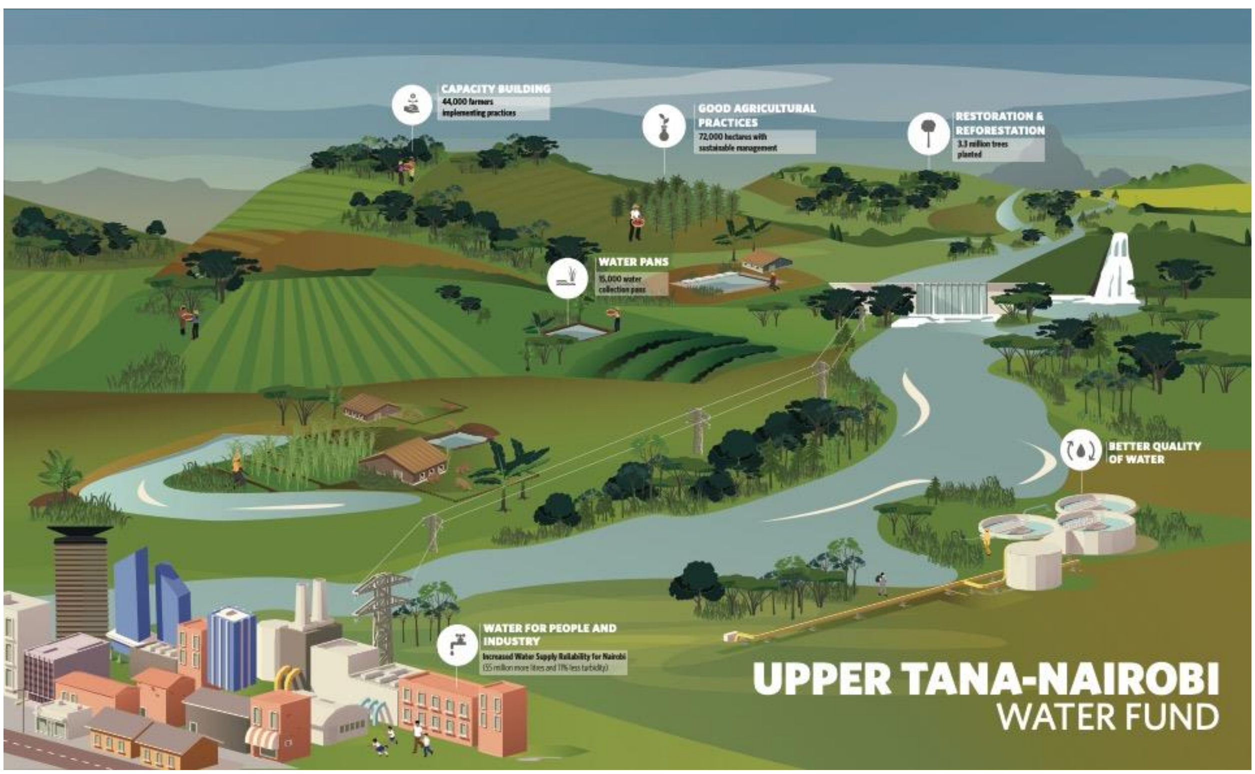


Figure 5: Watershed-scale results from the first five years of the Upper Tana-Nairobi Water Fund.

[6] Kenya Youth Agribusiness Strategy, 2018–2022.

This progress has been made possible by a growing, dedicated staff of five full-time and 30 part-time extension coordinators working directly with communities to educate farmers about practices and help them implement best management with the investments made by UTNWF. Long-term success will now depend on both scaling up implementation and having effective monitoring systems in place to measure water supply benefits being created.

This impact has occurred with 20% of the targeted $10 million total investment. The goal is to fully fund the endowment by the end of 2022.

"We have grown the UTNWF to an organization that delivers tangible results for people and nature. This water fund is well on its way to becoming the first financially sustainable water conservation initiative in Africa. Continued investment by stakeholders in the endowment fund to grow it from the current $2 million to the targeted $7.5 million will safeguard our water source and ensure its sustainability for the benefit of all."
— EDDY NJOROGE, President, International Organization for Standardization and President and Trustee, Upper Tana-Nairobi Water Fund Trust

Purpose of this Revised Strategic Plan

The next phase and future of the UTNWF is to become fully established and staffed as an independent entity, separate from TNC, beginning in September 2021. This new strategic plan provides the road map for that transition and for dramatically scaling the impact of the UTNWF on water supplies, livelihoods, and the health of the Tana River watershed over the next five years. A successful transition and increased impact will require the continued dedication of the UTNWF Steering Committee, the participation of NGO and community groups, and the support of the Kenyan government. While TNC, steering committee members, and other donors — including the Global Environment Facility, the Swedish International Development Agency, and Coca-Cola's Replenish Africa Initiative — have provided funding to date, the UTNWF's success as an independent entity will depend on expanding public and private financial support. Support is needed from major Nairobi water users who recognize the business case behind this effort, as well as from generous donors interested in backing an innovative approach to development, climate change adaptation, and conservation.

The objectives of this five-year plan are to:

1. **Create Clarity:** Establish a framework for documenting and evolving important strategic choices made by water fund leadership.
2. **Provide Focus:** Allow for more effective goal setting and purpose-based leadership by the water fund.
3. **Chart a Shared Road Map:** Drive measurable progress toward impact and systemic change.

BOX: Success Stories

Irene Wanjiru Mumiria and her husband, James, own a farm that is their only source of livelihood. They depended on rain-fed subsistence agriculture. This was a challenge because of unpredictable and poorly distributed rains, as well as low market prices for their produce, as every farmer in the market sold the same crop. In 2017, the UTNWF trained her on rainwater harvesting, agroforestry, and drip irrigation. Irene and James repaired existing soil conservation structures on their farm and planted high-value fruit trees along the contours. She excavated a 100,000-liter water pan and, by irrigating her crops, was able to grow high-value vegetables for the local market and for their household needs. In 2018, Irene bought two dairy goats worth Ksh 20,000, and in 2019, she installed a biogas unit from her farming income that now meets all her cooking and heating needs. These interventions have released time for Irene, and she is now able to join other women's activities and enjoy leisure time. The water pan on her farm has made it possible to harvest some food with unreliable rain in 2021. Irene and James can now fully pay for their two sons' secondary school education. Irene invests in shares worth Ksh 2,000 monthly from her banking group as part of a saving strategy for her family's future.

Peter Marubu was born deaf and mute and had nobody to help till the six-acre piece of land he inherited. He planted bananas, maize, and beans; reared two cows for subsistence on half an acre; relied on casual labor for income??; and leased the remaining five acres to other farmers. In 2018, UTNWF staff taught him to build terraces on his farm and harvest water for irrigation, and his nephew helped him install a water pan to harvest rainwater from his roof. He took back his land and planted tomatoes, capsicum, watermelon, maize, and spinach. The sales from his capsicum and tomato harvest made him a total of Ksh 27,200. He installed a 10-horsepower pump to complement his new drip irrigation system, and in 2019, harvests from vegetables, tomatoes, and bananas made him Ksh 110,000. Peter has invested Ksh 10,000 to construct a zero-grazing unit for his dairy cows, and in 2020, he completed building a two-room stone house to replace his mud-walled house.

In 2021, Peter completed over 75% of recommendations on his farm-specific action plan. He has further prepared over 46 pits to plant plantain bananas, which have a high demand in the region. Currently, he can feed himself and maintain a healthy life from his farm proceeds. He is generating Ksh 40,000 from his banana plantation only. Before the water fund, he relied on income earned from casual labor.

Gladys Wangeci Migwi owns a four-acre farm and is one of the 8,500 farmers who are now Rainforest Alliance certified and selling their coffee at a premium. Using UTNWF's technical advice, she built terraces and planted Napier grass to stabilize the soil on her farm. The Napier grass was used to feed her cows better and resulted in an increase in milk production from 10 to 14 liters a cow per day. She also planted more coffee trees, increasing them from 250 to 450, and the harvest grew from 3 kg to 10 kg per tree. She established a tree nursery from which she sells seedlings to her fellow farmers. She excavated a 100,000-liter water pan that enabled her to start an organic vegetable garden, which has improved her family's nutrition and whose excess produce fetches her Ksh 800 to 1,000 every week at the market. Gladys runs a poultry farm and sells the eggs, while the droppings from her fowl are used for fish farming in a pond and as fertilizer for her vegetable garden. The dung from her two cows and 18 pigs feeds her biogas unit, while the bio-slurry is used as manure for her coffee trees. She runs a fully integrated farm enterprise, and her conservation efforts earned her an award for Best Overall Woman in Agriculture at a national competition held in 2017 by the Ministry of Agriculture.

Obstacles and Opportunities for Success of the UTNWF

Strengths, Weaknesses, Opportunities, and Threats (SWOT) Analysis

Despite the significant success the UTNWF has had so far in its first five years, the watershed continues to experience significant challenges and many social and institutional barriers exist to realize the vision of a well conserved and managed Tana River watershed with improved livelihoods, healthier human and natural communities, and greater resilience to climate change. Generally, the key challenge that remains is the fact that water demands in the Upper Tana continue to rise with a growing number of diversions, leading to increasingly scarce surface water supplies. This problem is made worse by the significant soil erosion coming from many farms not enrolled in UTNWF programs, along with encroachment on riparian zones and water quality degradation due to pollution from domestic or industrial sources. Also, river flows, especially dry season flows, that are intimately linked to groundwater levels are being further impacted by increased use of groundwater wells and decreased groundwater replenishment in the watershed overall. Groundwater and surface water are being used and managed independently without any watershed-level integrated management to ensure both are being used sustainably.

In formulating this strategic plan to ensure that UTNWF can build from its success and be well prepared to address key barriers to achieving its mission, an assessment was conducted of both internal and external operating environments. Specifically, the UTNWF assessed its existing strengths and weaknesses, as well as the external opportunities and threats that will enable or hinder progress in the watershed. In implementing this strategic plan over the next five years, the UTNWF will use this assessment to enhance its internal strengths and capitalize on the most important opportunities while also addressing identified weaknesses in its operations and mitigating those factors that pose a threat to achieving success. A summary of this assessment is provided in Appendix 3.

Critical Issues and Priorities

Based on this assessment, there are three critical priorities vital to the UTNWF's success with this strategic plan:

1) **Partnership.** Active participation by county governments and local communities will be essential for implementing and scaling nature-based solutions in the Upper Tana watershed. Fortunately, the UTNWF has strong relationships with devolved governments that have committed to helping fund the UTNWF's work; with community-based organizations (CBOs); and with a well-developed network of community volunteers. Critical challenges that remain include maintaining effective partnerships with local governments, insufficient communication about the UTNWF's work and impact, and capacity to engage national and regional leaders for influencing relevant legislation. To address these issues, the UTNWF over the next five years will prioritize the following activities to increase effective partnerships:
    a. Increasing coordination with county governments and other regional groups to improve communication and increase the level of regular collaboration; mitigate

the impacts of high staff turnover in county government; and reduce impacts of incompatible legislation or lack of local enforcement.

b. Increasing the UTNWF's capacity to implement marketing strategies highlighting the benefits of its work, partnerships, and impact in order to raise levels of commitment from internal and external partners.
c. Improving the UTNWF's capacity to engage regional and national decision-makers and investors so that UTNWF can have greater influence on supportive legislation and inspire multiple levels of government to invest in upper watershed management.

2) Science and Innovation. Key to UTNWF's success will be using innovation and science-based decision-making in its planning and management. The UTNWF has helped build a more robust monitoring network that includes local volunteers and a network of remote river monitoring stations. However, environmental data being collected regularly in the watershed remains too inadequate to prioritize interventions and measure impact over time. Also, the UTNWF and its local partners do not yet have enough staff or technical capacity to deploy monitoring systems or collect and analyze data regularly. To address these problems, the UTNWF over the next five years will prioritize:

a. Modernizing and digitizing environmental data collection networks and information management systems for the watershed.
b. Recruiting, retaining, and motivating qualified, professional staff both internally and externally.
c. Increasing internal and external staff capacity to deploy monitoring systems and analyze data to guide investments so that they have the greatest environmental and social return on investment.

3) **Financial Resources.** Without adequate financial resources, the UTNWF will not be able to adequately resolve the critical issues described above or sustain and expand the implementation programs developed over the last five years. The UTNWF's goal is to secure and invest $10 million into the watershed over the next five years. This will include an approximately $1 million annual operating budget for the UTNWF and $1 million per year in direct implementation. To achieve this, the UTNWF over the next five years will prioritize the following:

a. Improving understanding of the link between environmental conditions in the Upper Tana and the needs of downstream water users.
b. Developing and executing a fundraising campaign to secure the partnerships and financial resources needed to significantly improve environmental and social well-being in the watershed.
c. Implementing and documenting the benefits of high-impact interventions in the watershed and use these projects to inspire new and bigger investments in the watershed.

The key risks and critical issues will evolve over time as some are resolved and others arise. However, over the next five years, the critical issues above will be the UTNWF's priority focus. Any other risks or critical issues that arise over the next five years will be prioritized and addressed as necessary.

UTNWF 2022–2026 Objectives and Strategies

Objectives

The UTNWF is advancing a holistic approach to supporting the long-term conservation, protection, and maintenance of the Upper Tana watershed in order to protect the environment in ways that improve the lives of thousands of smallholder farmers, improve Nairobi's water security, and ensure optimal functioning of hydropower facilities along the Tana River. This will be achieved by deploying practical conservation measures in the Upper Tana that improve livelihoods through greater water security and income, while also ensuring that downstream water users reap the benefits of their investments for water security in the upper watershed. With this holistic view in mind, the UTNWF over the next five years will focus on increasing its credibility and reputation as a leader and partner with regional and local stakeholders, applying the best available science and technology to ensure the greatest environmental and social return on investments, and securing the resources (both financial and social) to ensure the long-term sustainability of the UTNWF and its partnerships.

The goal of the UTNWF over the next five years and beyond is to improve water quality and quantity in the Upper Tana watershed for downstream users, enhance food security, protect freshwater and terrestrial biodiversity, and improve human well-being of local communities.

The UTNWF has identified four strategic objectives toward these goals:

Objective 1: Protect and Enhance the Climate Change Resilience of Biodiversity and Ecosystem Function in the Upper Tana. This objective includes improving ecosystem conservation; restoring forests, riparian zones, and wetlands; and conserving and efficiently managing soil and water.

Objective 2: Improve Socioeconomic Conditions for Local and Regional Communities Through Improved Land Management and Economic Opportunities. This objective includes improving the supply and quality of water, creating higher value and sustainable supply chains for agricultural produce of the region, contributing to economic development and poverty reduction, increasing food security, and empowering youth.

Objective 3: Protect and Increase Water Supply and Quality with Enhanced Resilience to Climate Change. This objective will include reducing overall sedimentation in the river, increasing average water yield, and increasing dry season flows.

Objective 4: Secure and Establish Effective Policies, Knowledge Management Systems, and Funding to Sustain the Water and Land Conservation Activities in the Upper Tana. Achieving this objective will include increasing the capacity and accountability of UTNWF stakeholders;

establishing robust data collection and sharing systems as part of monitoring, evaluation, and adaptive management; improving policies and investments of local governments and partners; strengthening UTNWF institutional capacity; and securing an operating endowment that can sustain the work of the UTNWF indefinitely.

Strategies

To achieve the objectives above, the UTNWF will invest in four core strategies focused on addressing the critical issues identified above and on demonstrating and scaling its impact over time. These strategies are:

1. **Demonstrate Effective Integrated Natural Resources Management** in the Upper Tana watershed by working closely with communities to implement and measure the impact of an integrated suite of interventions that protect and improve water supplies. This will include protecting intact riparian forest and wetlands, water harvesting, conserving and efficiently managing soil and water, and improving quarry management and reclamation.

2. **Increase Watershed Capacity to Improve Livelihoods, Food Security, and Economic Development** in the Upper Tana by developing value chains for niche agricultural produce, improving rural road shoulders with low-profile vegetation cover to prevent soil erosion, creating smallholder food security initiatives, automating climate and weather advisories with early warning systems, providing effective land use planning, and empowering the entire community.

3. **Build Robust Knowledge Management and Learning Systems** to strengthen accountability, stimulate learning, improve program performance, and facilitate better organizational decision-making. This will require increasing internal and external capacity through training and mentoring, building larger, more robust data collection and analysis systems, and improving reporting about watershed conditions and the social and environmental impacts of UTNWF programs.

4. **Ensure Growth and Sustainability of the UTNWF** by increasing donations and growing the endowment fund; creating and implementing plans for staff recruitment, training, and retention; implementing the successful transition to an independent fund; and finalizing UTNWF standard operating procedures for financial accounting, staffing, contracting, and partnerships.

Implementation/Action Plan

A diverse and interrelated suite of activities has been identified to implement the strategies above. These activities are intended to be measurable and specific as well as to directly contribute to meeting the ultimate objectives of the UTNWF. Some of these activities are external and, to be successful, depend on the close partnerships with stakeholders. Others are more internal and associated with managing the UTNWF as a well-functioning, accountable, and transparent organization. All these activities depend on acquiring the resources needed to make direct and indirect investments within the watershed. Table **2** lists the priority activities that the UTNWF will dedicate its time to over the next five years to achieve the objectives above.

Table 1: Strategy to Action: priority activities.

Strategy	Activities
Demonstrate Effective Integrated Natural Resources Management	1. Promote and implement terracing in sloping and steep lands 2. Promote and implement reforestation of degraded lands in forests for improved management. 3. Promote and implement grass strips on flat and gentle sloping farms 4. Promote and implement vegetation buffer zones along riverbanks 5. Promote and implement vegetation cover along rural roads 6. Promote and implement Agroforestry practices, 7. Promote rain water harvesting and efficient use through water pans and drip irrigation systems. 8. Engage 50,000 smallholder households in the catchment area with at least three Sustainable Land Management best practice or technology to help them cope with the effects of climate change, by 2026.
Support Improved Livelihoods	1. Support farmers with development of value chains through partners 2. Support Certification of farmers groups under RFA through partners 3. Provide Agronomic support and services

Build a Robust Knowledge Management and Learning Systems	1. Establish a monitoring and evaluation framework and partnership by with capacity to implement robust annual monitoring, analyze and communicate results 2. Establish a data & knowledge sharing platform for the Trust. 3. Share data, lessons and experiences of the water with partners, stakeholders, and other watersheds in Kenya 4. Build, calibrate and validate the Biological Condition Gradient (BCG) model and use it to inform land and water resources conservation. 5. Install automated climate and weather advisories systems in place to disseminate information on weather patterns, to farmers.
Ensure growth & sustainability of the UTNWF	1. Assemble, train and manage effectively a UTNWF team capable of achieving objectives 2. Develop and implement fundraising plan 3. Raise at least USD $7.5 million, generating USD $750,000 annually. 4. Participate in County, National and international forums to inform and influence policy decisions on Natural Resources management 5. Coordinate National and Local strategies and policies in the watershed

Road Map

To increase accountability, track progress, and inspire staff as well as partners to achieve the UTNWF's important objectives, the UTNWF has set specific and tangible measures of progress based on the priority activities that should lead to the achievement of the fund's five-year objectives. These metrics of success will be the standard by which UTNWF measures its progress over the next five years and to which staff will be held accountable. Each year, there will be an evaluation of progress, and adjustments will be made to strategies and activities as needed to direct the fund's resources to the most important aspects of its work and to ensure that investors' contributions are used wisely. Table **2** provides a road map of annual outcomes by strategy and activity for the next five years.

Table 2: Five-year road map of outputs for all priority activities.

Strategy	Activity	Unit of Measure	Target	Year 1	Year 2	Year 3	Year 4	Year 5
Demonstrate Effective Integrated Natural Resources Management	Promote and implement terracing on steeply sloped cropland	Meters	500,000	30,000	50,000	120,000	200,000	100,000
	Promote and implement reforestation of degraded lands	Hectares	30,000	2,500	12,000	10,000	3,500	2,000
	Promote and implement grass strips on flat and gently sloping farms	Meters	500,000	30,000	50,000	120,000	200,000	100,000
	Promote and implement vegetation buffer zones along riverbanks and with grass buffer strips in farmlands	Meters	50,000	5,000	10,000	15,000	15,000	5,000
	Promote and implement vegetation cover along rural roads	Meters	20,000	2,000	4,000	5,000	6,000	3,000
	Promote and implement agroforestry practices	# of seedlings	3 million	600,000	800,000	600,000	500,000	500,000

Strategy	Activity	Unit of Measure	Target	Year 1	Year 2	Year 3	Year 4	Year 5
	Promote rainwater harvesting through installation of water pans	# of units	5,000	500	2,000	2,000	300	200
	Promote efficient water use through drip irrigation	# of farms	300	50	100	100	30	20
	Ensure that smallholder households implement at least two sustainable land management best practices or technology	# of households	20,000	5,000	5,000	4,000	3,000	3,000
Support Improved Livelihoods	Support farmers groups in attaining appropriate certification	# of certified groups	5	1	1	1	1	1
	Support farmers by establishing improved market value chains for their products	# of new value chains	3	-	1	1	1	-
	Provide technical agronomic support and services to smallholder farmers	# of farmers reached	70,000	10,000	20,000	20,000	15,000	5,000
Build Robust Knowledge Management and Learning Systems	Finalize a monitoring and evaluation framework, and establish capacity through partnerships to implement robust annual monitoring and analyze and communicate results	Plan and partnerships		Finalized M&E plan	Monitoring partner-ships established			

Strategy	Activity	Unit of Measure	Target	Year 1	Year 2	Year 3	Year 4	Year 5
	Establish a digital and community-based data and knowledge sharing platform for the Trust	Technical and community export systems		Digital data systems developed	Community data sharing framework created			
	Share data and lessons learned from implementation with partners, stakeholders, and other watersheds in Kenya	# of reports, meetings, and events	20	3	4	4	4	5
	Monitor water quality and quantity	# of campaigns	20	4	4	4	4	4
	Download data and maintain river gauging stations	Monthly	60	12	12	12	12	12
	Field monitoring visits	# of visits	20	4	4	4	4	4
	Share data, lessons, and experiences of the water fund with partners, stakeholders, and other watersheds in Kenya	# of workshops	20	3	4	4	4	5
	Build, calibrate, and validate the Biological Condition Gradient (BCG) model and use it to inform land and water resources conservation					Completed model		

Strategy	Activity	Unit of Measure	Target	Year 1	Year 2	Year 3	Year 4	Year 5
	Install automated climate and weather advisories systems to disseminate information on weather patterns to farmers			System installed				
Ensure growth and sustainability of the UTNWF	Assemble, train, and effectively manage a UTNWF team capable of achieving objectives	# of trainings	10	5	3	2	-	-
	Develop and implement fundraising plan	Plan developed and # of fundraising events or meetings	Completed plan and 40 events	15	10	5	5	5
	Raise at least $7.5 million, generating $750,000 annually.	$USD	$7.5 million	$1.52 million	$1.52 million	$1.52 million	$1.32 million	$1.32 million
	Participate in county, national, and international forums to inform and influence policy decisions on natural resources management	# of meetings attended	10	2	3	3	1	1
	Coordinate national and local strategies and policies in the watershed and catchment	# of policies/ strategies	5		2	2	1	

Monitoring and Evaluation

Monitoring and evaluation (M&E) is critical for the sustainability and impact of a water fund. If the UTNWF fails to systematically and rigorously demonstrate the benefits of nature-based watershed management, it risks losing its political, social, and financial support and, ultimately, to achieve its vision for the Upper Tana watershed. At the core, UTNWF's M&E will focus on tracking achievement based on key performance indicators (output and outcome indicators) related to the ultimate objectives and what can be reliably reported to stakeholders.

The indicators that the UTNWF will focus on are closely tied to its theory of change, which can be summarized accordingly: If we implement at scale soil and water conservation activities that also improve the livelihoods of smallholder farmers in the Upper Tana watershed, people downstream will have better water security, people in the watershed will have improved livelihoods and well-being, and the diverse ecosystems of the Upper Tana will be conserved and made more resilient to climate change.

The project's theory of change drives the selection of output and outcome indicators. Output indicators measure project implementation progress, while outcome indicators are results that are necessary to achieve the intended impact of the water fund. The project has 14 output indicators and 17 outcome indicators covering ecological, social, and economic focal areas (Table 3).

Data for the indicators will come from several sources. Water quality data will come from 33 new or upgraded water monitoring stations. Household-level indicators will be collected via 1,000 household interviews. Greenhouse gas estimates will come from the Ex-Ante Carbon Balance Tool informed by Land Degradation Surveillance Framework surveys. Data for indicators that include acres, households, and trees will be collected and analyzed quarterly. Water quality Data will be analyzed every six months. Data for all the other indicators will be collected and analyzed annually.

In addition to enabling the UTNWF to measure its progress and remain accountable to its objectives for stakeholders, the data collected will also be an important way for the water fund and its partners to inform local communities, investors, and government. To share progress and knowledge over time, the UTNWF will establish two knowledge centers, complete annual reports on performance indicator changes, engage in school awareness programs and peer-learning groups, and present the UTNWF's work and results at workshops and seminars.

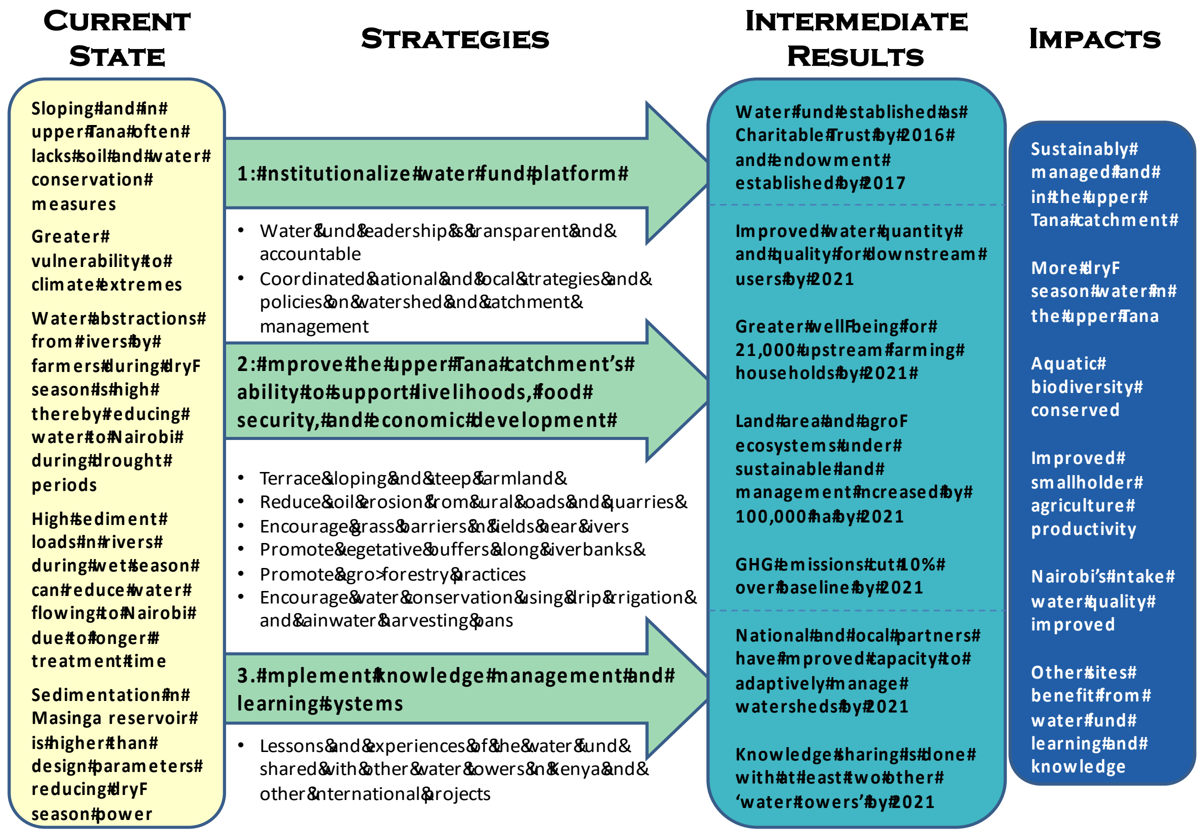
A Project Management Unit will have the primary responsibility for M&E activities, and the project's full-time M&E officer will lead this work. The M&E Committee of the UTNWF BoM will provide oversight for the M&E activities. The committee will also conduct field visits to stay informed on progress and then communicate their observations to the trustees and project steering committee members.

Table 3: Indicators of success for UTNWF priority objectives.

Objectives	Output Indicators	Outcomes
Objective 1: Protect and Enhance Climate Change Resilience of Biodiversity and Ecosystem Function in the Upper Tana	1. 100,000 hectares of natural lands and agroecosystems managed under sustainable land and water management best practices. 2. Relative abundance and composition of intolerant macroinvertebrates (BCG Attribute 2) for sites in treatment microwatersheds with BCG scores >3 increased compared with 2021 baseline data.	1. Sustainably managed lands in Upper Tana catchment. 2. % of households with increased permanent vegetation cover. 3. Increased dry period water flows in Upper Tana. 4. Acreage of forest under improved management . 5. Tons of greenhouse gas avoided or sequestered. Abundance and composition of intolerant macroinvertebrates for sites in treatment micro watersheds.
Objective 2: Improve Socioeconomic Conditions for Local and Regional Communities Through Improved Land Management and Economic Opportunities	3. 70% of smallholder farmers report increased productivity as a result of the implementation and adoption of climate smart SLM practices, compared with the 2021 baseline, by 2026. 4. 70% of smallholder farmers report increased incomes through the implementation and adoption of climate smart SLM practices, compared with 2021 baseline, by 2026.	6. Smallholder agricultural productivity improved by 30% by June 2026. 7. Improvement in water quality and quantity for downstream water users by 2026 compared with 2016 baseline. 8. The number of polymers used for treating water per m^3 for the Nairobi water supply reduced by 10% by June 2026.
Objective 3: Protect and Increase Water Supply and Quality with Enhanced Resilience to Climate Change	5. Number of installed and operational water monitoring stations in the watershed. 6. Number of km of riparian land protected. 7. Number of water pans and drip irrigation systems installed. 8. Number of acres under improved management.	9. Average total suspended sediments and the turbidity of the Upper Tana rivers are reduced by **15%** compared with the 2016 baseline data. 10. Mean annual water yield in the Upper Tana rivers increased by at least **15%** compared with the baseline annual averages of 2016. 11. Dry season flows of the Upper Tana rivers in the microwatersheds increased by **15%** as compared with baseline in 2016. 12. Annual average amount of polymers used to treat a unit volume of raw water decreased by **10%** compared with the 2015 baseline. Number of hours for which turbidity at Mwagu intake is more than 200 NTU reduced by 10% compared with 2015 baseline.

Objective 4: Secure and Establish Effective Policies, Knowledge Management Systems, and Funding to Sustain the Water and Land Conservation Activities in the Upper Tana	9. Water fund is fully transited to a separate entity by July 2021. 10. Knowledge sharing done with at least two other water towers by 2026. 11. $7.5 million invested in an endowment account, generating $750,000 annually for operations and conservation investments. 12. Four county governments within the UTNWF priority watersheds have at least four new conservation-based operational policies in place. 13. Clear annual reports on activities, budget, and outcomes are publicly available. Operating and compliance manuals completed. Annual meetings with BoM and BoT have taken place. 14. Number of coordinated national and local strategies and policies in watershed have ???	13. Other sites or water funds benefit from the water fund's learning and improved knowledge by 2026. 14. National and local partners have improved capacity to adaptively manage watersheds by 2026. 15. Water fund leadership transparency and accountability is sustained.

Figure 3: Strategic results chain reflecting plans, strategies, and outputs.



Five-Year Trust Budget

The UTNWF has an annual operating budget of $2 million. This figure includes all operational costs of the UTNWF and needed direct investments in conservation actions within the watershed. Of this total $10 million budget for five years, the UTNWF anticipates a 1:1 matching investment from counties based on their previous investments over the last five years. Exact annual budget amounts will vary based on opportunities and the phasing of work over time as the UTNWF establishes itself as an independent organization and expands its programs. Given the existing endowment and funding commitments already secured and assuming the $1 million matching investment per year from partners, the UTNWF has a funding gap of approximately $500,000 for the first two to three years, which will grow to approximately $800,000 in the final two years of this strategic plan. A priority for the UTNWF is to close this funding gap by raising $3-5 million within the first three years of this strategic plan, with a goal of securing some or all of this funding as an endowment to provide long-term operating funds for the UTNWF.

Operational Plan

The UTNWF has a governance structure that includes a board of trustees, a board of management, and six full-time staff led by an executive director (Figure 6). The UTNWF Board of Trustees is responsible for setting the vision, mission, and policy directions water fund. The trustees comprise the Board of Management, whose mandate is to oversee the overall implementation of the Trust's conservation programs, projects, and activities in a coordinated manner operating from the Trust's headquarters. Twelve full-time staff members, led by an executive director, develop and implement the strategies and day-to-day activities of the UTNWF. Complementing the BoM and staff efforts is the Counties Advisory Committee. The CAC is responsible for advising UTNWF staff and ensuring that county policies are addressed in UTNWF operations, and for enabling implementation of strategies at the county level. The CAC also serves as close partners and co-funders of UTNWF programs by aligning county programs with those of the UTNWF and providing financial support.

Finally, much of the UTNWF's work also depends on collaboration with other implementing partners, including Government of Kenya agencies, NGOs, CBOs, and the farmers who will be supported by technology promoters (TPs) and interns.

Additionally, the structure provides for other part-time positions for which staff will be engaged as and when required. These positions include retainer services (such as IT, communication, events/marketing, and human resources management and other human resource services), as well as outsourced services such as auditing, investments, tax advisory, training and fundraising. The Organograph is as displayed in Figure 6.

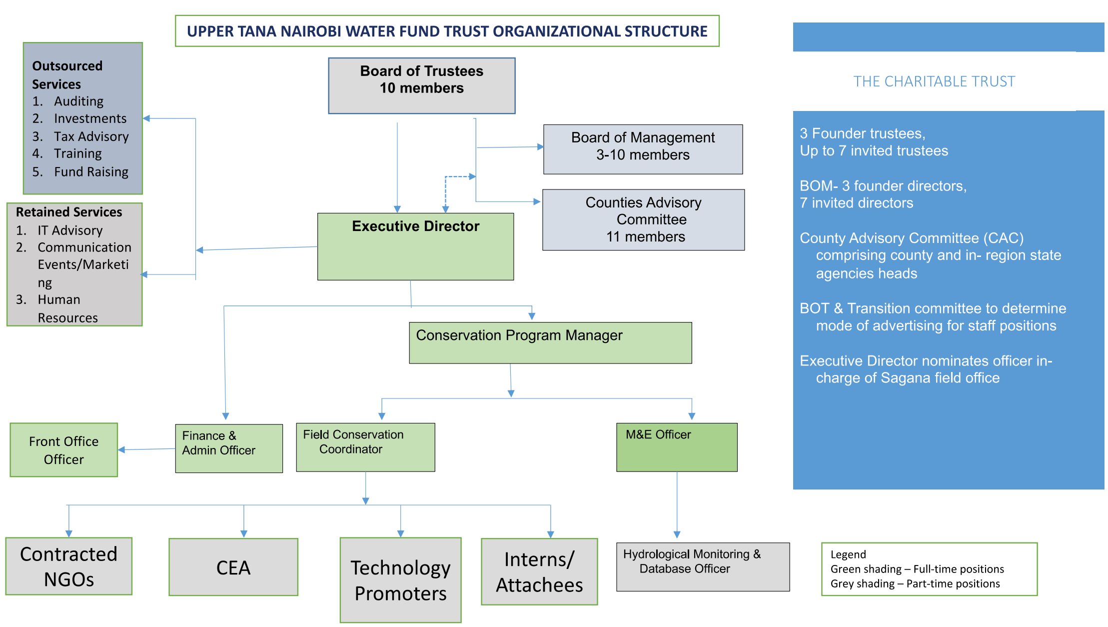


Figure 6: The Trust's organizational structure.

APPENDICES

Appendix 1. UTNWF STRATEGIC PLAN DEVELOPMENT ROAD MAP

STRATEGIC PLAN 2022–2026
Leaders Briefing Notes and Proposed Road Map

1. Introduction

The Upper Tana-Nairobi Water Fund (UTNWF) Trust is registered as a public charitable trust in Kenya.
Mission: To secure the long-term conservation, protection, and maintenance of the Upper Tana watershed and thereby improve Nairobi's water security and optimal functioning of hydropower facilities along the Tana River. (As drafted by the BoT, the mission reads, "To mobilize and efficiently deploy resources for sustainable and innovative conservation in the Upper Tana to improve livelihoods and safeguard water quality and quantity.")

Vision: A well-conserved and managed Upper Tana watershed that sustains healthy livelihoods and ecosystem functions in the region and beyond. The Trust is set up as a PPP working collaboratively throughout the Upper Tana watershed on solutions to one of the greatest challenges to our future: source water protection. The Upper Tana watershed supports 95% of the water supply for Nairobi City and generates 65% of the nation's hydropower. The Trust is hosted by The Nature Conservancy at its regional office in Nairobi.

As a trust, a governance system has been set up comprising a board of trustees, board of management, and a county advisory committee. Also in place are a management structure and partnerships with local NGOs, government agencies, and research/academia to assist with project implementation. The UTNWF is now in a transition phase and will operate independently beginning 1 July 2021. The Trust is developing the necessary management systems, human resources, financial management, procurement, and operational procedures, among other systems, necessary to achieve autonomy by the set timeline.

Over six years, the UTNWF has generated a vast array of benefits for people living in the watershed, for the residents of Nairobi, and for all Kenyans:

- 26,474 farmers are applying soil conservation and water-saving methods.
- 8,500 coffee farmers have achieved Rainforest Alliance certification.
- 1 million trees have been planted so far in the watershed.
- 15,000 hectares of land are under sustainable management.
- 28 river gauging stations are now automated, and six have been fitted with telemetric equipment.
- 37,464 farmers are enrolled in a mobile data monitoring platform.
- 2,200 people and 8,000 livestock have year-round access to a reliable and accessible water supply from two communal water pans completed in the Sasumua subcatchment.
- 800 million liters of water are harvested annually in the watershed using water pans — enough to irrigate 532 hectares of land under French beans for 60 days.
- 115 biogas digesters were installed as rewards for farmers who achieved high conservation and ecosystem services targets.
- Extensive knowledge sharing has resulted in the scaling up of two new water funds. Eldoret's is at the design phase and Mombasa's is at the feasibility phase.
- Partnerships with three local NGOs cover the three priority subwatersheds of Thika-Chania, Maragua, and Sagana-Gura.
- Partnerships with expert institutions (ICRAF, National Museums of Kenya, and Jomo Kenyatta University of Agriculture and Technology) have been established to support scientific baseline studies and impact monitoring.

- The UTNWF is registered as a charitable trust in Kenya, with dedicated volunteer leaders and a growing partnership base.

The strategic plan, therefore, will guide the Trust to systematically collect, document, and frame analyses of its internal and external environment, clarify its mission, and recalibrate priorities, goals, and strategic objectives to guide its achievement of its mission. In addition, the strategic planning process will provide an opportunity to organize and facilitate consultations with Trust leadership, key partners, staff, and stakeholders. The plan will be a guiding framework to focus and consolidate the work of the Trust for the next five years.

2. Rationale for Strategic Plan

- The UTNWF is transitioning to maturity stage — water fund development cycle.
- Post TNC–Global Environment Authoriy/International Fund for Agriculture Development incubation (project) phase.
- Governance, management, and operational systems organically developed and ready for consolidation.
- Redefine priorities and strategic choices to fully meet the business case goals and targets.
- Building blocks for organizational, financial, and operational sustainability of the Trust.

3. Proposed Approach

This first strategic plan for the UTNWF builds on a 10-year business case and five years of accelerated implementation. It will be carried out by leadership, top-level partners, and project staff.

This approach will help answer three basic questions:

- Where are we right now?
- Where do we want to be and why?
- How do we get there/what initiatives do we need to apply?

Using this proposed approach, the following activities will be done to achieve UTNWF's goals:

4. Reclarifying the Trust's purpose, its vision, its mission statements, and its core values.
5. Developing goals and strategic objectives for the Trust to accomplish its mission.
6. Identifying specific action steps (strategies) to implement each goal.
7. Identifying specific action plans[7] to implement each strategy.
8. Developing a performance M&E plan, and a mechanism for updating the plan over time.

The envisaged planning cycle and the relationship of the key elements of the plan are as illustrated below.

[7] Detailed descriptions of the specific actions, current status, and target dates associated with each strategic objective; includes person responsible and budget.

Strategic Planning Process

Strategic Planning Cycle

UTNWF Trategy Pyramid

The SWOT analysis tool is proposed for scanning the internal and external environment. The SWOT tool will be applied together with the Political, Economic, Socio, Environmental, and Legal analysis tool (PESTEL) to enrich the external environment analysis.

Upper Tana – Nairobi Water Fund Trust

Vision and Mission

Vision: A well conserved and managed watershed for sustained better life in the region and beyond.

Mission: To mobilize and efficiently deploy resources for sustainable and innovative conservation in the Upper Tana to improve livelihoods and safeguard water quality and quantity

Core Values

I-PACE

- Integrity
- Partnership
- Accountability
- Commitment to nature
- Empowerment

Slogan: More water for better life!

4. Leadership Tasks

These tasks shall be led by the Executive Committee of the BoM. They will collaborate closely with BoM members, trustees, staff, and a Coda fellow from TNC.

5. Proposed Road Map

ACTIVITY	DATES	RESPONSIBLE PARTY	REMARKS
1. Preplanning Phase:	September	WF Manager	In progress
• **Road Map**	September 18	WF Manager/Colin	
• **Coda TORs**	August 30	WF Manager	
• **Facilitator TORS**	September 25	BoM Chair	
• **SP Committee**	September 25		
2. Contracts and Engagements		WF Manager	
• **Local Consultant**	September 30, 2020	WF Manager/Colin	
• **Coda Fellow**	October 31, 2020		

ACTIVITY	DATES	RESPONSIBLE PARTY	REMARKS
3. Documents Review and SP Concept • **Strategy concept** • **Data collection tools**	October 5–6, 2020	Lead Consultant, Writer, and BoM Chair	Desk work/docs uploaded online
4. Documents review and collation of data • **SWOT Analysis** • **PESTEL analysis**	October 7–9, 2020	Lead Consultant and Writer BoM Chair BoM Chair	Desk work/docs uploaded online Online seminar Group session
5. Workshop with Partners • **Data gathering/validation**	October 14, 2020	BoM Members, Consultant	1-day workshop
6. Interviews with Key Stakeholders	June 12– 23, 2021	Lead Consultant and Select Stakeholders	Virtual or in-person as appropriate Half-day workshop
7. Workshop with BoT and BoM Members	July 10, 2021	BoM Executive Director, Lead Consultant, Writer, and SP Committee	Half-day workshop
8. Draft Strategic Plan (main elements)	August 13, 2021	Lead Consultant, Writer, and SP Committee	
9. Appendices — Investment Plan, Operational Plan, Grant Management Plan, Staffing/HR Plan, etc.	September 20, 2021	Lead Consultant, BoM, and Project Management Unit	Working sessions (virtual or in person) for key focal points
10. Final Draft Strategic Plan • **Circulate to trustees, key partners**	By November 30, 2021	Lead Consultant	Invite final comments
11. Validation workshop	December 21, 2021	Lead consultant and BoM	
12. Copy editing and layout • **Layout and copyediting** • **Printing**	January 15, 2021	WF Manager, Coda, and Communications Manager	
13. Strategic Plan Launch	March 22, 2022 (WWD corporate breakfast)	BoT President and TNC	Guest of honor — CS Ministry of Water, Sanitation, and Irrigation

Appendix 2: Land Cover Trends

Land cover has remained relatively stable since the start of the UTNWF. Previous reports have indicated significant land cover change in the Upper Tana since the 1970s.[8] Using publicly available annual Copernicus Land Cover data from 2015 to 2019 (https://land.copernicus.eu/global/products/lc), the landscape over recent years has been relatively stable (tables 1–4). These land cover data have a 100m resolution, meaning that each pixel represents 10,000 square meters on the ground. As a result, they are too coarse to assess any changes in land cover resulting from water fund interventions. That said, because the area is relatively stable in terms of land cover conversion, this allows the water fund to focus on managing and improving best management practices as opposed to engaging in efforts to control issues such as expanding deforestation.

Table 4: Maragua and cover in hectares.

Year	*Shrubs*	*Herbaceous Vegetation*	*Cropland*	*Urban*	*Open Water*	*Wetlands*	*Forests*
2015	20	27	33,406	1,992	0	16	13,294
2016	20	27	33,406	1,992	0	16	13,294
2017	20	27	33,403	1,995	0	16	13,294
2018	20	27	33,405	1,996	0	17	13,290
2019	20	25	33403	1,997	0	19	13,290

Table 5: Thika land cover in hectares.

Year	*Shrubs*	*Herbaceous Vegetation*	*Cropland*	*Urban*	*Open Water*	*Wetlands*	*Forests*
2015	21	49	4,450	438	20	12	3,292
2016	21	48	4,446	438	23	11	3,295
2017	21	47	4,441	442	16	20	3,295
2018	21	47	4,440	443	18	20	3,294
2019	21	47	4,435	445	19	19	3,297

[8] Langat, P. K., Kumar, L., Koech, R., & Ghosh, M. K. (2019). Monitoring of land use/land-cover dynamics using remote sensing: A case of Tana River Basin, Kenya. *Geocarto International*, 1–19.

Table 6: Sagana-Gura land cover in hectares.

Year	*Shrubs*	*Herbaceous Vegetation*	*Cropland*	*Urban*	*Open Water*	*Wetlands*	*Forests*
2015	3,528	10,158	89,456	3,471	13	64	97,843
2016	3,530	10,152	89,441	3,471	22	69	97,849
2017	3,525	10,149	89,437	3,471	23	73	97,856
2018	3,521	10,147	89,436	3,471	24	80	97,854
2019	3,539	10,164	89,271	3,482	27	81	97,969

Rainfall Trends

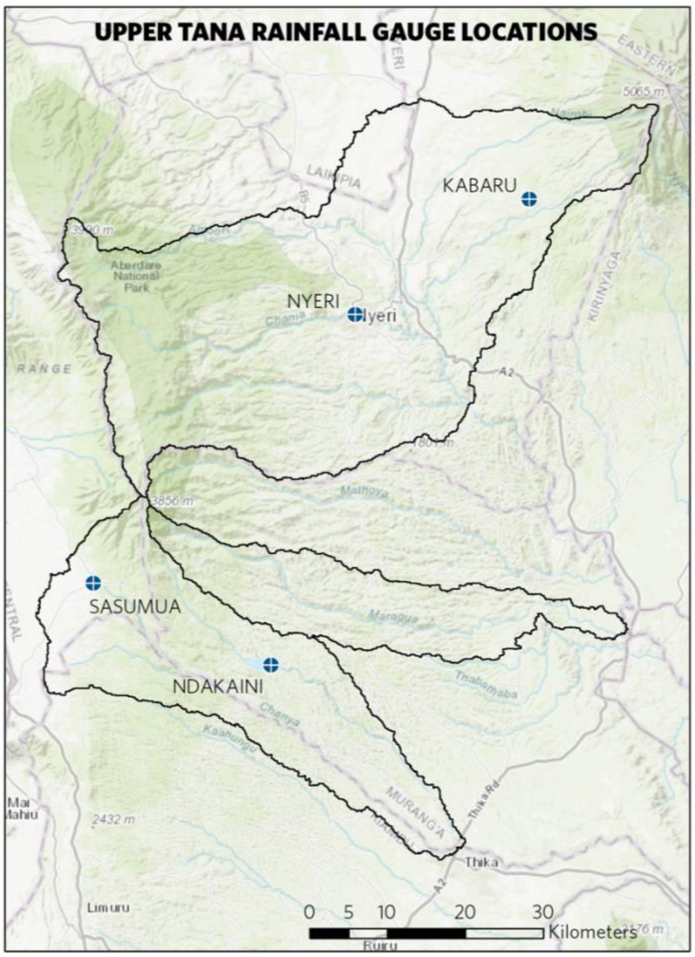


Figure 7: Rainfall gauges used in analysis.

Four daily rainfall stations within the UTNWF (Figure 1) were analyzed for monotonic (increasing or decreasing) trends in monthly rainfall using a Kendall's Tau measure with continuity correction for the time series test in R from the spatialEco package.[9,10] Data were first assessed for missing data (Table 7) and then plotted (Figure 8, Figure 10, Figure 12, Figure 14). The full time series at each site was then decomposed to look visually for any obvious trend and seasonality (Figure 9, Figure 11, Figure 13, and Figure 15). Two statistics were assessed to determine any monotonic temporal trend (Kendall's Tau) and the magnitude (amount of increase or decrease) of any trend if present (Theil-Sen slope). Kendall's Tau is a correlation with values ranging from -1 to 1 and indicate in this case whether there is a decreasing and increasing temporal trend when there is statistical significance. The Thiel-Sen slope indicates the strength and direction (i.e., the slope) of a trend when there is statistical significance.

[9] Mann, H.B. Nonparametric Tests against Trend. *Econometrica* 1945, 13, 245–259.

[10] Kendall, M. G. (1975), *Rank Correlation Methods*, Oxford Univ. Press, New York.

It is expected that there are no statistically significant annual rainfall or seasonal trends in the Upper Tana but rather that rainfall is highly variable and is affected by El Niño (heavy rainfall) and La Niña (low rainfall) years. In addition, a more recent weather phenomenon first described in 1999 and known as the Indian Ocean Dipole (IOD) is beginning to impact East Africa in a way like El Niño, further exacerbating precipitation variability and extremes in the region[11].

For the Sasumua rainfall gauge, only a relatively short time series was available (2011–2020). In general, a time series of less than 20 years of observational data are not considered suitable for climate analysis because extreme events tend to have too much weight, and the effects of both El Niño and the IOD are clearly noted in the statistical analysis below. For this reason, the results of the trend analysis at this site should be considered inconclusive. Given the longer-term data availability for other stations, it is unlikely that the noted increased rainfall observed at Sasumua represents an increasing precipitation *trend*, but rather reflects the impact that unanticipated extreme weather phenomenon can have on a short time series. More notable is that the IOD is expected to impact the region more frequently under climate change, adding to rainfall uncertainty and variability for the region and making robust watershed planning to support the ecological functioning of watersheds even more critical to ensure the potential impact from such phenomenon can be attenuated even when not anticipated.

Table 7: Daily rainfall stations used in analysis.

STATION	ELEVATION (m)	START	END	PERCENT COMPLETE	SIGNIFICANT MISSING DATA
Kabaru	2,444	January 1, 1981	March 31, 1981	97%	March–December 2007 August 2008–October 2009 December 9–31, 2020
Nyeri	1,776	January 1, 1981	February 28, 1981	97%	76% missing February–June 2009 July–October 2010 77% missing April–December 2019
Sasumua	2,540	January 1, 2011	June 27, 2020	100%	
Ndakaini/Thika	2,074	January 1, 1997	November 26, 2020	100%	5 missing days

[11] Wainwright, C. M., Finney, D. L., Kilavi, M., Black, E., & Marsham, J. H. (2021). Extreme rainfall in East Africa, October 2019–January 2020 and context under future climate change. *Weather*, 76(1), 26–31.

Kabaru

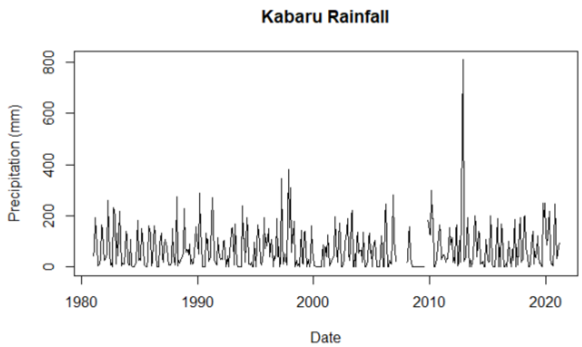


Figure 8

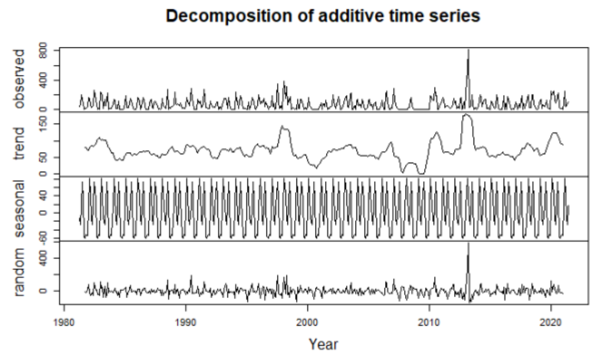


Figure 9

- Full time series (1981–2020) Theil-Sen slope = 0, Kendall's Tau = 0.003, 2-sided p = 0.9
- Pre-interventions (2014–2016) Theil-Sen slope = 0.49, Kendall's Tau = 0.1, 2-sided p = 0.3
- Post-interventions (2017–2020) Theil-Sen slope = -0.003, Kendall's Tau = -0.031, 2-sided p = 0.34

Conclusion: Results indicate there is no statistically significant trend in rainfall either long term or during pre- and post-intervention periods.

Nyeri

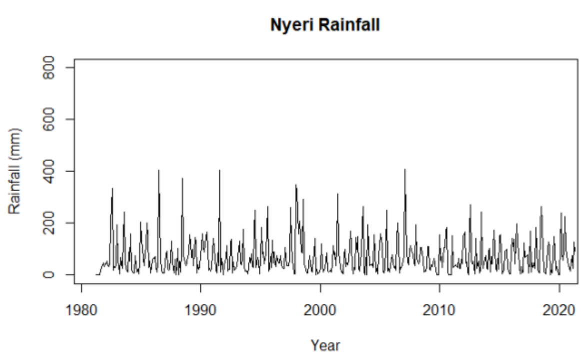


Figure 10

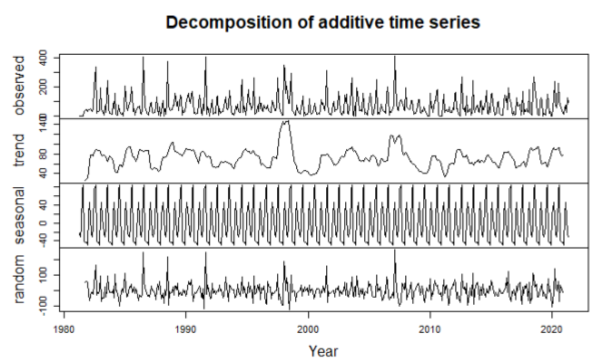


Figure 11

- Full time series (1981–2020) Theil-Sen slope = 0.007, Kendall's Tau = 0.016, 2-sided p = 0.6
- Pre-interventions (2014–2016) Theil-Sen slope = 0.17, Kendall's Tau = 0.035, 2-sided p = 0.7
- Post-interventions (2017–2020) Theil-Sen slope = 0.006, Kendall's Tau = 0.013, 2-sided p = 0.7

Conclusion: Results indicate there is no trend in rainfall either long term or during pre- and post-intervention periods. No seasonal long-term trend is indicated.

Ndakaini/Thika

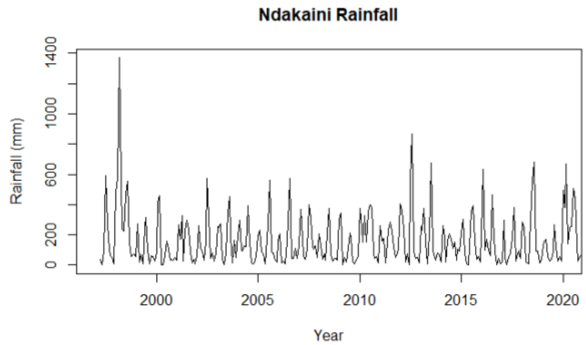


Figure 12

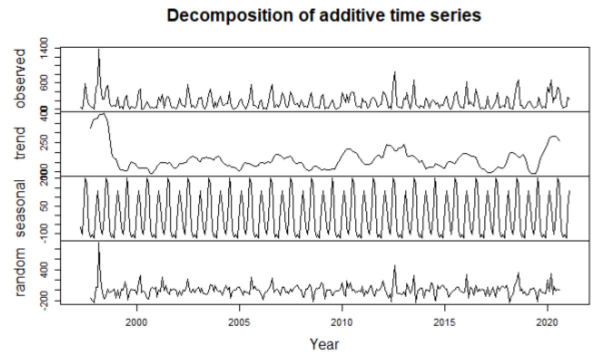


Figure 13

- Full time series (1997–2020) Theil-Sen slope = 0.013, Kendall's Tau = 0.007, 2-sided p = 0.8
- Pre-interventions (2014–2016) Theil-Sen slope = 1.82, Kendall's Tau = 0.18, 2-sided p = 0.08
- Post-interventions (2017–2020) Theil-Sen slope = -0.008, Kendall's Tau = -0.004, 2-sided p = 0.9

Conclusion: Results indicate there is no trend in rainfall either long term or during pre- and post-intervention periods.

Sasumua

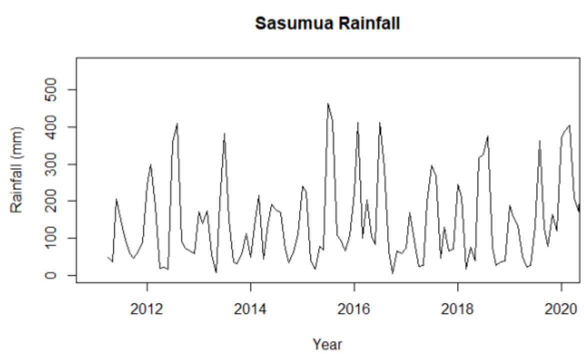


Figure 14

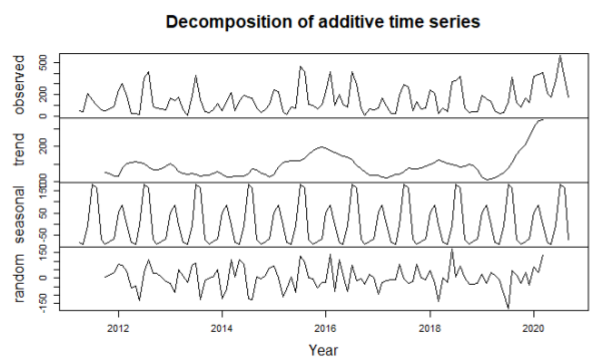


Figure 15

- Full time series (2011–2020) Theil-Sen slope = 0.59, Kendall's Tau = 0.13, 2-sided p = 0.04

- Pre-interventions (2014–2016) Theil-Sen slope = 3.88, Kendall's Tau = 0.28, 2-sided p = 0.009
- Post-interventions (2017–2020) Theil-Sen slope = 0.36, Kendall's Tau = 0.07, 2-sided p = 0.38

Conclusion: Results indicate there is a trend in over the nine-year period of record for rainfall moderately increasing overall. The increasing trend is found in the pre-interventions period; however, there is no statistically significant trend post intervention.

For the full time series, the Theil-Sen's slope = 0.59, indicating an increasing trend in rainfall. For the pre-interventions time series, the Theil-Sen's slope = 3.88, indicating a sharply increasing trend in rainfall. Further evaluation of this dataset using Pettitt's test for change in value indicates that in March 2013, there is a probable change point (p = 0.02) where precipitation values are significantly higher than the historical trend. Because this time series is shorter than others analyzed in this assessment, the influence of extreme weather events will be more pronounced.

Climate Change Trends

Under the Coupled Intercomparison Project Phase Six (CMIP6),[12] the objective of which is to better understand past, present, and future climate changes arising from natural, unforced variability, there are notable improvements in model performance for East Africa as compared with its predecessor CMIP5, though no significant rigorous study has been carried out to assess all available climate models for the region.[13] A particular challenge in climate change assessment for East Africa is the difficulty of climate models in predicting extreme rainfall events. While model performance appears to have been improved under CMIP6, there is still work to be done to improve model prediction over Africa.

A recent study of the impact of climate change on the Upper Tana[14] explored three models under CMIP5 (CAnESM2, EC-EARTH, and CNRM5) and found that there was a clear signal across all models trending toward an increase in average annual temperature, but no clear trend in rainfall.

For this assessment, average annual precipitation and temperature under eight climate models accessed through worldclim.org (Table 8) are evaluated alongside historical climate (1960–1990) for the near-future time frame (2021–2040) under Shared Socioeconomic Pathway (SSP) 2-4.5 and 5-8.5. SSP2-4.5 is considered a moderate scenario with intermediate level climate forcings

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[12] Eyring, V., Bony, S., Meehl, G. A., Senior, C. A., Stevens, B., Stouffer, R. J., & Taylor, K. E. (2016). Overview of the Coupled Model Intercomparison Project Phase 6 (CMIP6) experimental design and organization. *Geoscientific Model Development*, 9(5), 1937–1958.

[13] Ayugi, B., Jiang, Z., Zhu, H., Ngoma, H., Babaousmail, H., Karim, R., & Dike, V. (2021). Comparison of CMIP6 and CMIP5 models in simulating mean and extreme precipitation over East Africa. *International Journal of Climatology*. Preprint.

[14] Simons, G., Buitink, J., Droogers, P., & Hunink, J. (2017). Impacts of climate change on water and sediment flows in the Upper Tana Basin, Kenya.

and intermediate societal vulnerability. SSP 5-8.5 is considered the worst-case future scenario. SSP 2-4.5, IPSL-CM6ALR and SSP 5-8.5, MRI-ESM2-0 data are currently inaccessible.

Table 8: Climate models used for this assessment.

MODEL	INSTITUTE/COUNTRY	CITATION
BCC-CSM2-MR/	Beijing Climate Center (BCC), China	Wu, T., Chu, W., Dong, M., Fang, Y., Jie, W., Li J., Li, W., Liu, Q., Shi, X., Xin, X., Yan, J., Zhang, F., Zhang, J., Zhang, L., Zhang, Y., 2019. BCC BCC-CSM2MR model output prepared for CMIP6 CMIP historical Earth System Grid Federation.
CanESM5	Canadian Climate Centre, Canada	Swart, N. C., Cole, J. N., Kharin, V. V., Lazare, M., Scinocca, J. F., Gillett, N. P., ... & Winter, B. (2019). The Canadian earth system model version 5 (CanESM5. 0.3). *Geoscientific Model Development*, 12(11), 4823–4873.
CNRM-CM6-1	Centre National de Recherches Météorologiques (CNRM) and Cerfacs	Voldoire, A., Saint-Martin, D., Sénési, S., Decharme, B., Alias, A., Chevallier, M., ... & Waldman, R. (2019). Evaluation of CMIP6 deck experiments with CNRM-CM6-1. *Journal of Advances in Modeling Earth Systems*, 11(7), 2177–2213.
CNRM-ESM2-1	Centre National de Recherches Météorologiques and Cerfacs	Séférian, R., Nabat, P., Michou, M., Saint-Martin, D., Voldoire, A., Colin, J., ... & Madec, G. (2019). Evaluation of CNRM earth system model, CNRM-ESM2-1: Role of earth system processes in present-day and future climate. *Journal of Advances in Modeling Earth Systems*, 11(12), 4182–4227.
IPSL-CM6ALR	Institute Pierre Simon Laplace (IPSL), France	Hourdin, F., Jam, A., Rio, C., Couvreux, F., Sandu, I., Lefebvre, M. P., ... & Idelkadi, A. (2019). Unified parameterization of convective boundary layer transport and clouds with the thermal plume model. *Journal of Advances in Modeling Earth Systems*, 11(9), 2910–2933.
MIROC6	The Center for Climate System Research, the University of Tokyo, the Japan Agency for Marine-Earth Science and Technology, and the National Institute for Environmental Studies, Japan	Tatebe, H., Ogura, T., Nitta, T., Komuro, Y., Ogochi, K., Takemura, T., ... & Kimoto, M. (2019). Description and basic evaluation of simulated mean state, internal variability, and climate sensitivity in MIROC6. *Geoscientific Model Development*, 12(7), 2727–2765.

MODEL	INSTITUTE/COUNTRY	CITATION
MIROCES2L	National Institute for Environmental Studies, University of Tokyo	Hajima, T., Watanabe, M., Yamamoto, A., Tatebe, H., Noguchi, M. A., Abe, M., ... & Kawamiya, M. (2020). Development of the MIROC-ES2L Earth system model and the evaluation of biogeochemical processes and feedbacks. *Geoscientific Model Development*, 13(5), 2197–2244.
MRI-ESM2-0	Meteorological Research Institute (MRI), Japan	Yukimoto, S., Kawai, H., Koshiro, T., Oshima, N., Yoshida, K., Urakawa, S., ... & Ishii, M. (2019). The Meteorological Research Institute Earth System Model version 2.0, MRI-ESM2. 0: Description and basic evaluation of the physical component. *Journal of the Meteorological Society of Japan*. Ser. II.

Rainfall

As with the recent study referenced above using CMIP5 climate models, the CMIP6 models used here do not show a strong trend in average annual precipitation change (Figure 16, Figure 17). In addition, the average annual rainfall amounts to not vary markedly between SSP 2-4.5 and SSP 5-8.5.

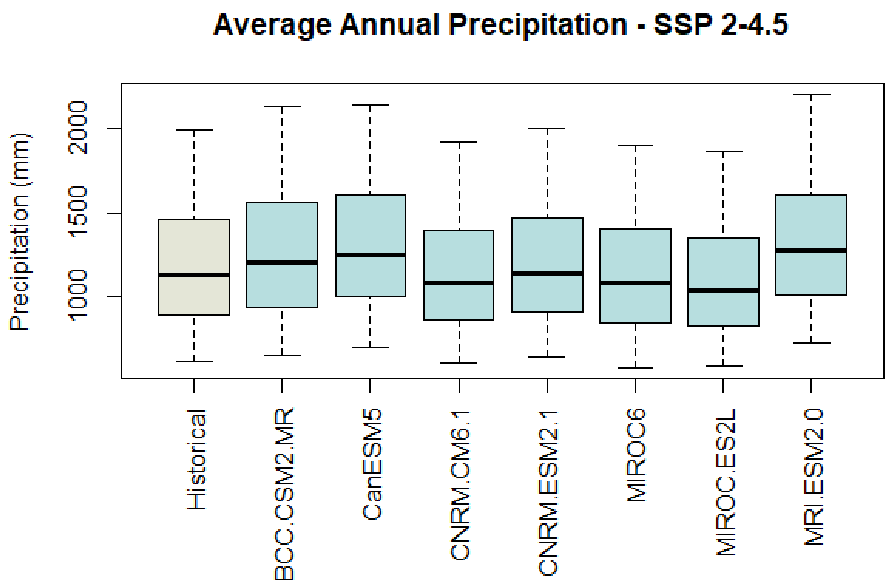


Figure 16: Average annual precipitation under SSP 2-4.5.

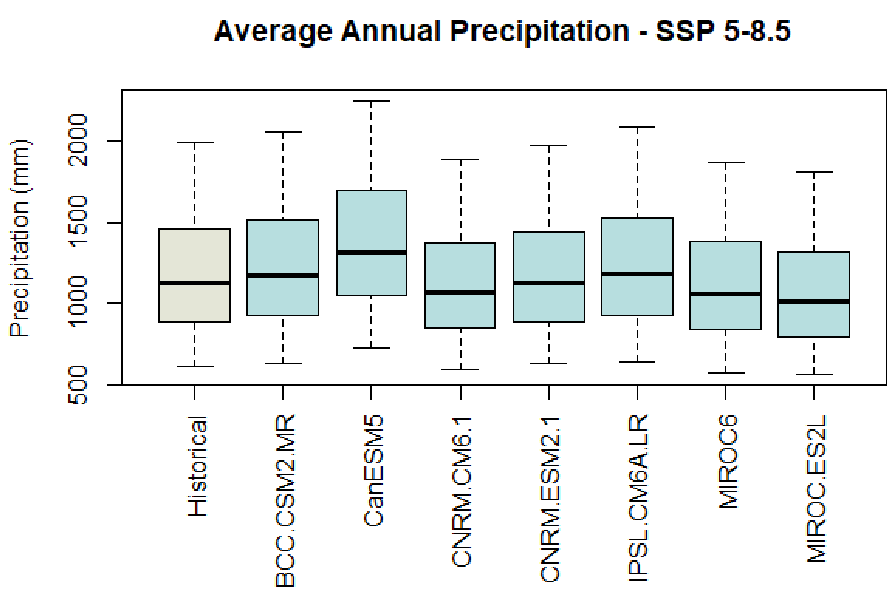


Figure 17: Average annual precipitation under SSP 5-8.5.

Temperature

Like the recent study referenced above using CMIP5 climate models, the CMIP6 models used here do show a strong trend toward higher temperatures (Figure 18, Figure 19). In addition, the average annual temperature increase does not vary markedly between SSP 2-4.5 and SSP 5-8.5.

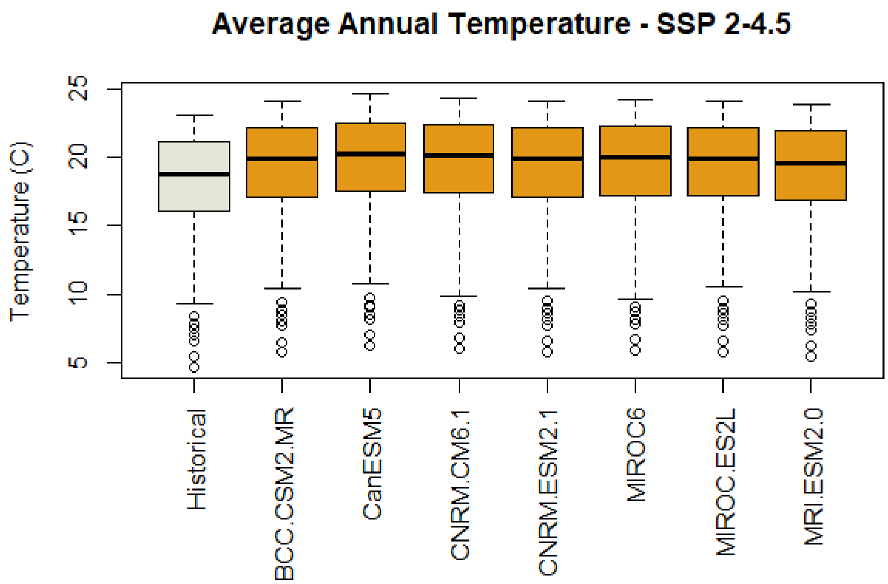


Figure 18: Average annual temperature under SSP 2-4.5.

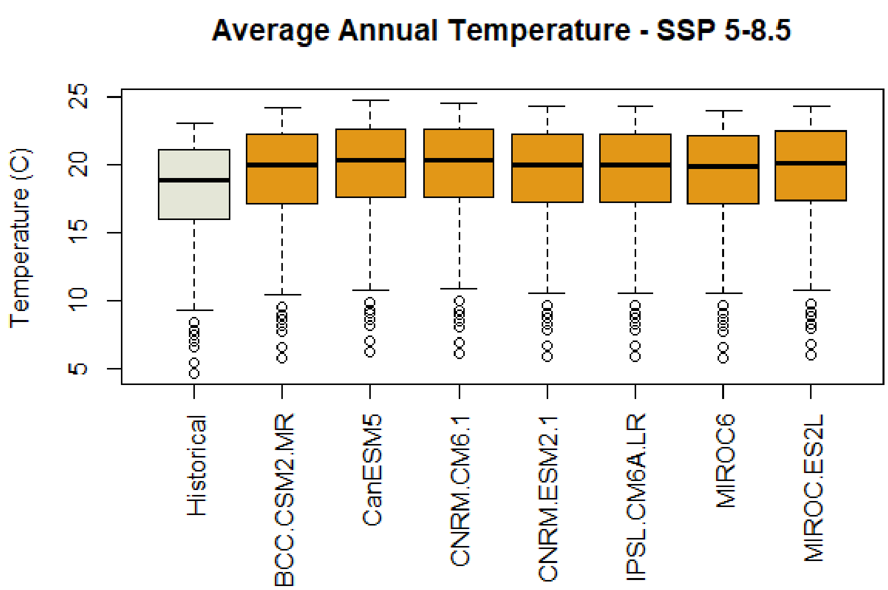


Figure 19: Average annual temperature under SSP 2-4.5.

Water Quality Trends

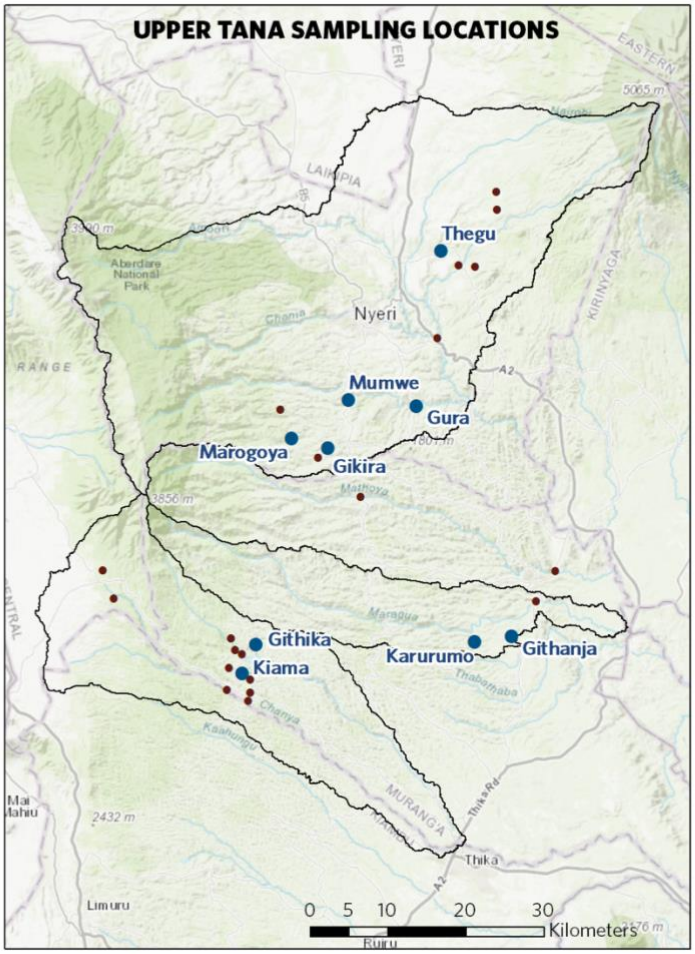


Figure 20: Water quality sampling sites used in analysis.

A selection of nine water quality sites were chosen for in-depth analysis based on whether the number of data points available met the minimum requirement for statistical analysis and included both pre- and post-interventions (Figure 14). Not all gauges were selected because it was noted across all sites that the highest streamflow didn't always result in the highest turbidity or TSS reading. For example, the Maragua site registers some of the highest streamflows in the priority watersheds, and on November 17, 2014, streamflow measured 43.375 cubic meters per second (cms) with associated turbidity and TSS measurements at 409 NTU and 100 mg/L, respectively. On November 13, 2017, streamflow measured 8.138 cms with associated turbidity and TSS measurements at 651 NTU and 35 mg/L respectively. Large spatiotemporal variations in the relationship between streamflow and turbidity and TSS across all locations — though some more pronounced than others, leading to low or even negative correlations — suggests that factors other than streamflow magnitude, such as backwater areas, stream morphology, or mass wasting events potentially play a major role in water quality at some sites and should be documented and accounted for in future analyses.

Because of the lower correlations shown below between TSS and stream discharge and fewer TSS observations overall, the primary focus of this water quality analysis is on the relationship and trends between turbidity and stream discharge.

To determine which gauges to include in this analysis, the number of available observations pre- and post-interventions and the correlation between stream discharge and turbidity was considered. Sites with fewer than eight observations pre- or post-interventions were excluded. Because the relationship between turbidity and stream discharge are known to be highly correlated in hydrology, only sites where the correlation was above 0.5 were considered for inclusion. The following analyses were carried out for the selected sites: summary statistics, turbidity and stream discharge correlation, linear regression, and trend. Summary statistics and Pearson's correlation were calculated using the full period of record, while linear regression analysis and trend were assessed pre- and post-interventions.

Summary Statistics

Summary statistics for minimum, maximum, mean, standard deviation and number of observations were computed using raw data for streamflow (cms), turbidity (NTU), and total suspended solids (TSS [mg/L]). Descriptive statistics for each analyzed water quality sites are presented in the tables below.

Sagana-Gura Subbasin

Site	Statistic	Streamflow (cms)	Turbidity (NTU)	Total Suspended Solids (mg/L)
Thegu	Mean	1.36	21.09	24.63
	SD	2.61	15.69	23.47
	Minimum	0.01	2.93	0
	Maximum	8.46	73.2	106
	N	17	55	48
Maragoya	Mean	0.30	276.06	426.07
	SD	0.28	487.29	675.81
	Minimum	0.02	9.67	8
	Maximum	1.05	2934.8	3593
	N	27	78	91
Gikira	Mean	1.36	16.52	18.40
	SD	1.51	10.64	12.18
	Minimum	0.02	1.4	0
		4.75	53.85	70
	Maximum	14	68	67
	N			
Mumwe	Mean	0.92	60.43	76.48
	SD	1.04	43.91	56.53
	Minimum	0.01	10.03	9.72
		2.95	292	339
	Maximum	15	59	55
	N			
Gura	Mean	16.73	29.10	34.12
	SD	15.88	21.32	45.19
	Minimum	0.02	4	0
		51.42	110.25	285
	Maximum	13	50	40
	N			

Muragua Subbasin

Site	Statistic	Streamflow (cms)	Turbidity (NTU)	Total Suspended Solids (mg/L)
Karurumo	Mean	0.16	287.85	159.28
	SD	0.20	300.45	159.18
	Minimum	0.0004	2.52	0
	Maximum	0.66	3320	1510
	N	53	236	359
Githanja	Mean	0.33	91.03	58.04
	SD	0.45	98.16	185.58
	Minimum	0.00	5.05	2.06
	Maximum	2.40	872.3	1787.4
	N	31	188	181

Thika Subbasin

Site	Statistic	Streamflow (cms)	Turbidity (NTU)	Total Suspended Solids (mg/L)
Githika	Mean	0.95	48.93	22.40
	SD	0.83	211.33	18.81
	Minimum	0.07	2.40	0.82
	Maximum	3.19	1508.88	69.2
	N	22	50	43
Kiama	Mean	0.78	23.29	511.99
	SD	1.09	19.45	3222.14
	Minimum	0.02	4.52	0
	Maximum	3.74	88	21398.6
	N	13	52	44

Correlations

To further explore relationships in the data and better inform on driving processes, bivariate relations were calculated using a Pearson correlation ($p=0.05$) and are presented below. Correlations were developed for each subbasin using the full set of available data and then calculated individually at each site.

Sagana-Gura Subbasin

The Sagana-Gura subbasin demonstrates a high correlation between turbidity and TSS (Table 9). Over the full subbasin, the magnitude of streamflow does not appear to influence turbidity and TSS. When examined at a site level, however, areas of the strong influence of streamflow on turbidity and TSS — the expected relationship — are apparent.

Table 9: Sagana-Gura subbasin correlations indicate a strong relationship between turbidity and TSS, but not with streamflow. This indicates that some areas in the subbasin may have other or additional codominant processes contributing to turbidity and TSS.

SITE		NTU	TSS	Q
Overall Subbasin	**NTU**	1		
	TSS	0.83	1	
	Q	-0.008	-0.04	1
Thegu	**NTU**	1		
	TSS	0.32	1	
	Q	0.6	0.31	1
Marogoya	**NTU**	1		
	TSS	0.9	1	
	Q	0.5	0.34	1
Gura	**NTU**	1		
	TSS	0.32	1	
	Q	0.65	0.55	1
Gikira	**NTU**	1		
	TSS	0.77	1	
	Q	0.76	0.58	1
Mumwe	**NTU**	1		
	TSS	0.86	1	
	Q	0.65	0.17	1

Muragua Subbasin

A moderate correlation between turbidity and TSS is present in the Maragua subbasin with low correlations to streamflow (Table 10). In this subbasin correlations are highly variable at the different water quality measuring locations.

Table 10: Maragua subbasin correlations indicate a moderately strong relationship between turbidity and TSS, but not with streamflow. This indicates that some areas in the subbasin may have other or additional codominant processes contributing to turbidity and TSS.

SITE		NTU	TSS	Q
Overall Subbasin	**NTU**	1		
	TSS	0.58	1	
	Q	0.06	-0.002	1
Karurumo	**NTU**	1		
	TSS	0.11	1	
	Q	0.71	0.76	1
Githanja	**NTU**	1		
	TSS	0.37	1	
	Q	0.6	0.25	1

Thika Subbasin

The overall Thika subbasin presented with a negative Pearson correlation for turbidity and TSS, which was unexpected (Table 11). Upon further data inspection, two sites — Kiama and Githika — were driving this poor relationship. In Githika on May 15, 2016, an unusually high turbidity reading was recorded at 9,026 NTU, but this site generally indicates 20 NTU. This value was removed from additional analyses. Overall, at individual sites, there is a moderate to moderately high correlation between turbidity and TSS (Table 11).

Table 11: Thika subbasin correlations indicates a weak relationship between turbidity and TSS, but a moderate to strong relationship with streamflow. This indicates that some areas in the subbasin may have other or additional codominant processes contributing to turbidity and TSS.

SITE		NTU	TSS	Q
Overall Subbasin	**NTU**	1		
	TSS	-0.0008	1	
	Q	0.09	0.28	1
Githika	**NTU**	1		
	TSS	0.89	1	
	Q	0.46	0.32	1
Kiama	**NTU**	1		
	TSS	-0.12	1	
	Q	0.81	0.19	1

Linear Regression Analysis

Regression models were developed between turbidity and stream discharge. Graphs of the relationship pre- and post-interventions between turbidity and stream discharge are shown with least-squares regression lines, confidence intervals, and R2 for each site (figures 15–23). Pre-intervention measurements are those taken from 2014 to 2016, and post-intervention measurements are those taken from 2017 to 2020. Both stream discharge and turbidity observations were transformed using the log base 10 function because they violated statistical assumptions of normality and equal variances.

In hydrology, there is typically a strong linear relationship between turbidity and streamflow. In the analyzed data sets, there are several items of note. First and foremost, the relationship between turbidity and stream discharge increased in the post-interventions period. This is likely due to having a person whose primary task is to take field measurements. Next, the relationship has lower confidence, as indicted by the wide confidence intervals, at the lowest and highest flows. This indicates that a more regular sampling interval, such as every six weeks, is needed to capture water quality across the full range of flows during the year. Additional observations can be collected during notable events as well. Having a regular sampling interval will improve the modeled relationship between turbidity and streamflow and this modeled relationship can then be used for further analyses with a higher degree of confidence.

Sagana-Gura Subbasin

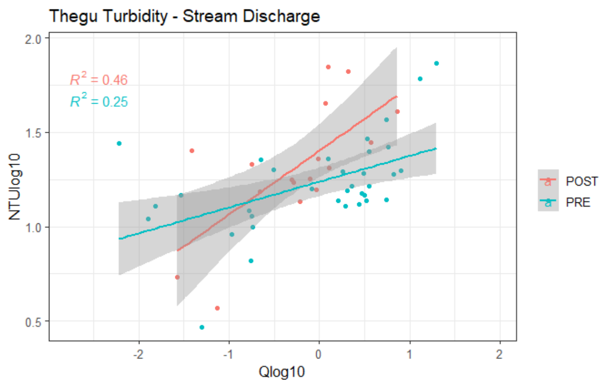


Figure 21

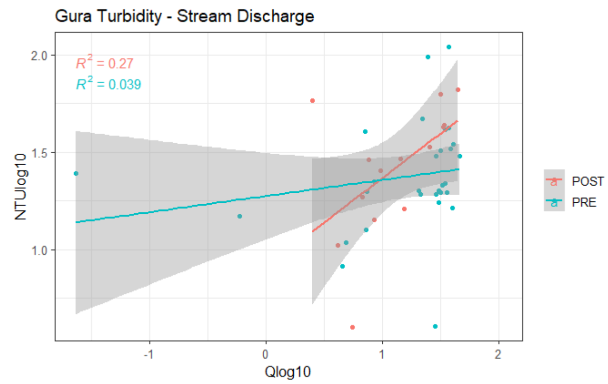


Figure 22

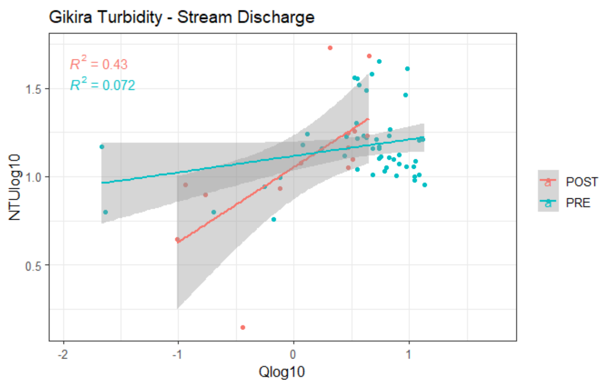


Figure 23

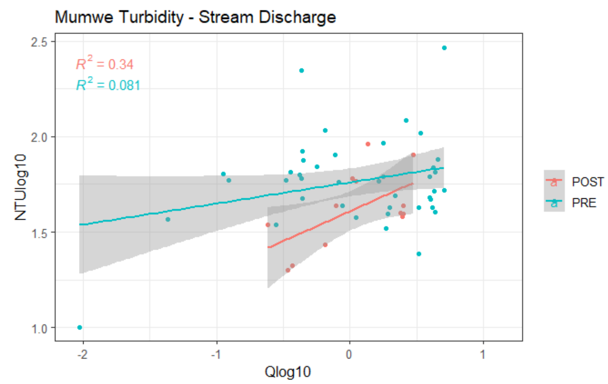


Figure 24

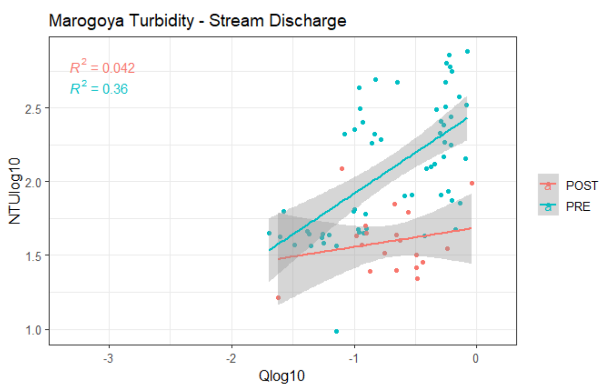


Figure 25

Muragua Subbasin

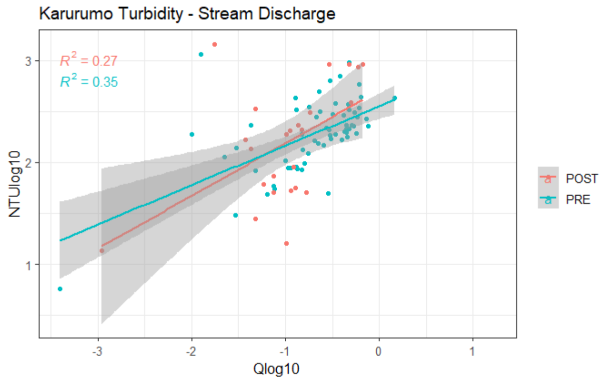


Figure 26

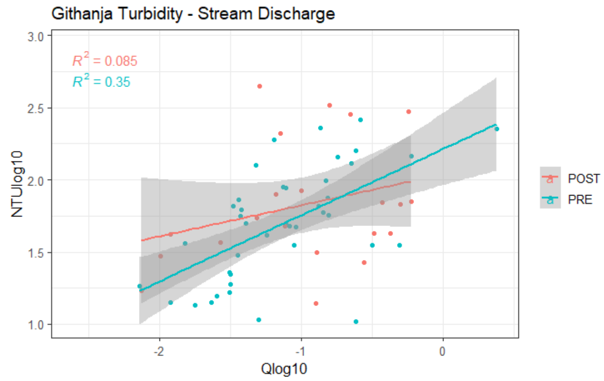


Figure 27

Thika Subbasin

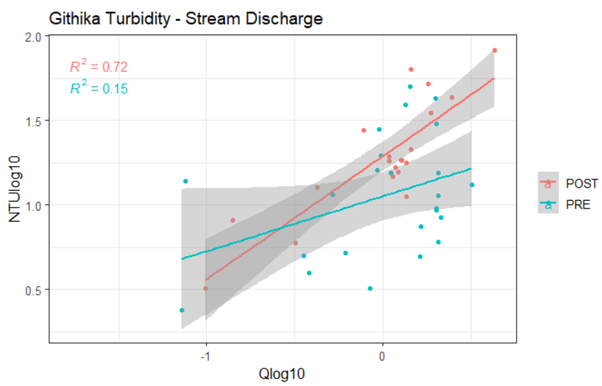


Figure 28

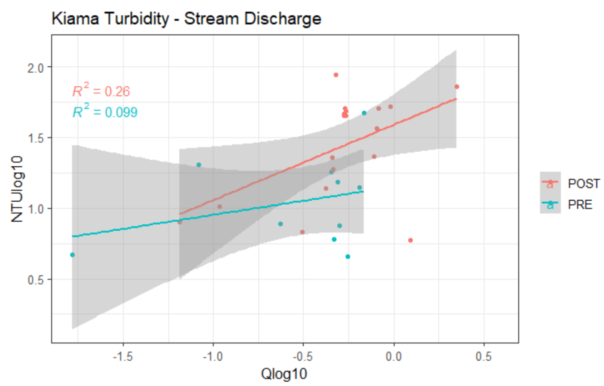


Figure 29

Turbidity–Discharge Trends

Turbidity is affected by discharge, so it is important to understand whether the same discharge results in a decrease turbidity or whether the relationship has changed pre- and post-interventions. For this reason, the trend of the ratio of turbidity to stream discharge over time is analyzed. Because of the sometimes limited and uneven availability of pre- and post-interventions observations for both turbidity and stream discharge, at the nine selected water quality sites used in this analysis (Table 12), a bootstrapping model with 999 simulations was implemented in R to determine reasonable estimates for Kendall's Tau and the Thiel-Sen slope. Only sites with at least eight ratio observations were included in this analysis.

It is important to note that the time it takes to see results from interventions on the landscape can vary. Some interventions may cause a near immediate response on water quantity and quality, while others may take months or years. In addition, interventions have been implemented on a rolling basis over several years and therefore there is necessarily variation across the basin in terms of watershed response.

Table 12: Water quality sampling sites used in assessments and the number of available observations.

SITE	PRE-INTERVNTIONS	POST-INTERVNTIONS
Kiama	18	10
Gikira	14	49
Karurumo	24	62
Gura	14	29
Mumwe	13	41
Thegu	17	35
Githanja	21	41
Marogoya	19	59
Githika	20	24

Overall, bootstrap results indicate a relatively high level of confidence in the stable estimates of p-value (at 95%), Kendall's Tau, the Theil-Sen slope, and Z-value. Ten of the 18 sites (nine pre- and nine post-interventions) indicated nonsignificant results, as evidenced by the bootstrap estimate of the p-value (Table 13). Only Karurumo had statistically significant results both pre- and post-interventions; however, all of statistic estimates have low confidence. All other significant results were found in the post-intervention observation time series. This again indicates a potential improvement in sampling.

While only 10 of the time series assessed indicated statistically significant results for both Kendall's Tau and the Theil-Sen slope, the nonsignificant results indicate trends in the direction of decreasing turbidity post-interventions. Many of the sites indicated a weak decreasing trend in turbidity pre-interventions, but for post-interventions, there is often a notable increase in the trend toward reduced turbidity (Table 14). The amount of decrease in turbidity — as noted by the Theil-Sen slope — is much greater in most cases post-interventions (Table 15). It is likely that the water fund interventions have contributed to decreased turbidity in the Upper Tana basin. Continued observations on a more regular schedule can further strengthen our understanding of how interventions may be influencing turbidity in the basin.

Table 13: Bootstrap estimate of p-value. Periods that show statistically significant results at the 95% confidence level ($p < 0.05$) are bolded. Periods where p is calculated with a high level of confidence are indicated as "High." Other values fall outside the upper and lower 95% confidence intervals. Most reported p-values have a high level of confidence.

			BOOTSTRAP MOMENTS						CONFIDENCE INTERVALS		
SITE	PERIOD	STABLE ESTIMATE	MINIMUM	1st QUANTILE	MEDIAN	MEAN	3rd QUANTILE	MAXIMUM	LOWER	UPPER	CONFIDENCE LEVEL
KIAMA	PRE	0.32	0.00	0.25	0.49	0.51	0.76	1.00	-0.44	0.72	**High**
	POST	0.07	0.00	0.23	0.52	0.51	0.79	1.00	-0.97	0.25	**High**
GIKIRA	PRE	0.83	0.00	0.25	0.51	0.51	0.78	1.00	0.55	1.74	**High**
	POST	**0.02**	0.00	0.10	0.34	0.39	0.66	1.00	-0.96	0.27	**High**
KARURUMO	**PRE**	**0.00**	0.00	0.17	0.38	0.44	0.71	1.00	-1.04	0.17	Low
	POST	**0.00**	0.00	0.06	0.28	0.36	0.62	1.00	-0.96	0.25	Low
GURA	PRE	0.51	0.10	0.54	0.70	0.70	0.87	1.00	-0.11	0.76	**High**
	POST	**0.04**	0.00	0.16	0.41	0.44	0.71	1.00	-0.95	0.24	**High**
MUMWE	PRE	0.76	0.00	0.19	0.46	0.48	0.76	1.00	0.42	1.66	**High**
	POST	**0.00**	0.00	0.07	0.29	0.37	0.62	1.00	-0.98	0.25	Low
THEGU	PRE	0.77	0.00	0.23	0.48	0.49	0.74	1.00	0.47	1.65	**High**
	POST	**0.05**	0.00	0.21	0.46	0.48	0.75	1.00	-0.97	0.23	**High**
GITHANJA	PRE	0.98	0.01	0.25	0.48	0.50	0.76	1.00	0.88	2.03	**High**
	POST	**0.02**	0.00	0.09	0.33	0.38	0.63	1.00	-0.96	0.26	**High**
MAROGOYA	PRE	0.83	0.00	0.15	0.38	0.42	0.67	1.00	0.64	1.86	**High**
	POST	**0.04**	0.00	0.07	0.29	0.36	0.62	1.00	-0.89	0.33	**High**
GITHIKA	PRE	0.07	0.01	0.35	0.60	0.57	0.82	1.00	-0.96	0.11	Low
	POST	0.19	0.00	0.11	0.37	0.40	0.65	1.00	-0.63	0.58	**High**

Table 14: Kendall's Tau in this case indicates the temporal correlation of the turbidity-discharge ratio. As values approach -1 and 1, the strength of the correlation increases, while the closer a value is to 0 indicates a weaker correlation. Periods where tau is calculated with a high level of confidence are indicated as "High." Other values fall outside the upper and lower 95% confidence intervals. Most reported tau results have a high level of confidence.

			BOOTSTRAP MOMENTS						CONFIDENCE INTERVALS		
SITE	PERIOD	STABLE ESTIMATE	MINIMUM	1st QUANTILE	MEDIAN	MEAN	3rd QUANTILE	MAXIMUM	LOWER	UPPER	CONFIDENCE LEVEL
KIAMA	PRE	0.18	-0.52	0.00	0.17	0.27	0.54	1.00	0.04	0.68	High
	POST	0.47	-0.62	0.01	0.22	0.27	0.53	1.00	0.39	1.43	High
GIKIRA	PRE	0.06	-0.57	-0.02	0.18	0.26	0.55	1.00	-0.26	0.51	High
	POST	-0.22	-0.56	0.00	0.10	0.20	0.38	1.00	-0.73	-0.18	High
KARURUMO	PRE	-0.46	-0.48	0.00	0.14	0.23	0.46	1.00	-1.25	-0.59	Low
	POST	-0.57	-0.47	-0.01	0.08	0.16	0.28	1.00	-1.43	-0.86	Low
GURA	PRE	-0.14	-0.33	0.00	0.23	0.34	0.70	1.00	-0.53	-0.05	High
	POST	-0.27	-0.52	0.00	0.12	0.21	0.41	1.00	-0.85	-0.20	High
MUMWE	PRE	-0.08	-0.71	0.00	0.17	0.24	0.49	1.00	-0.63	0.33	High
	POST	-0.66	-0.56	0.00	0.10	0.19	0.35	1.00	-1.65	-0.98	Low
THEGU	PRE	0.06	-0.52	0.01	0.18	0.26	0.48	1.00	-0.26	0.46	High
	POST	-0.23	-0.44	0.00	0.13	0.23	0.44	1.00	-0.73	-0.20	High
GITHANJA	PRE	-0.01	-0.42	0.01	0.17	0.27	0.52	1.00	-0.33	0.27	High
	POST	-0.26	-0.44	-0.01	0.10	0.18	0.33	1.00	-0.82	-0.20	High
MAROGOYA	PRE	-0.04	-0.68	0.00	0.14	0.20	0.40	1.00	-0.51	0.36	High
	POST	-0.18	-0.50	0.00	0.09	0.17	0.28	1.00	-0.66	-0.09	High
GITHIKA	PRE	-0.30	-0.45	-0.02	0.16	0.28	0.60	1.00	-0.83	-0.32	Low
	POST	-0.20	-0.51	0.00	0.13	0.20	0.38	1.00	-0.76	-0.01	High

Table 15: The Theil-Sen slope indicates the magnitude (amount of increase or decrease) of the trend. Periods where Theil-Sen is calculated with a high level of confidence are indicated as "High." Other values fall outside the upper and lower 95% confidence intervals. Most reported tau results have a high level of confidence.

			BOOTSTRAP MOMENTS						CONFIDENCE INTERVALS		
SITE	PERIOD	STABLE ESTIMATE	MINIMUM	1st QUANTILE	MEDIAN	MEAN	3rd QUANTILE	MAXIMUM	LOWER	UPPER	CONFIDENCE LEVEL
KIAMA	PRE	2.40	-5.23	-0.92	0.00	-0.10	0.58	4.73	1.94	7.86	High
	POST	6.83	-7.75	-1.67	0.00	0.40	2.00	23.94	6.08	20.43	High
GIKIRA	PRE	0.05	-4.11	-0.14	0.00	-0.01	0.05	3.74	-1.06	1.27	High
	POST	-0.15	-0.46	-0.02	0.00	0.00	0.02	0.43	-0.43	-0.18	Low
KARURUMO	PRE	-117.93	-118.05	-15.47	0.00	-0.75	15.76	128.23	-299.31	-170.92	Low
	POST	-25.55	-28.14	-3.28	0.00	-0.18	3.20	17.71	-62.51	-39.35	Low
GURA	PRE	-0.06	-0.10	-0.01	0.00	0.00	0.01	0.08	-0.17	-0.06	Low
	POST	-0.05	-0.13	-0.01	0.00	0.00	0.01	0.16	-0.16	-0.04	High
MUMWE	PRE	-0.28	-5.02	-0.33	0.00	0.10	0.54	7.27	-3.83	2.52	High
	POST	-7.26	-10.40	-0.48	0.00	-0.10	0.44	12.31	-18.62	-10.22	Low
THEGU	PRE	0.72	-6.32	-0.55	0.00	0.25	0.93	12.54	-2.24	4.60	High
	POST	-2.60	-33.73	-0.06	0.00	0.09	0.07	52.07	-10.76	0.16	High
GITHANJA	PRE	-0.17	-119.22	-2.84	0.00	3.28	11.70	114.02	-61.12	53.88	High
	POST	-14.42	-26.73	-4.18	0.00	0.07	4.25	32.10	-44.17	-13.64	High
MAROGOYA	PRE	-2.73	-38.67	-4.46	0.00	-0.32	4.18	36.37	-23.51	13.24	High
	POST	-8.66	-25.59	-3.17	0.00	0.29	4.01	25.54	-29.39	-5.85	High
GITHIKA	PRE	-0.58	-1.47	-0.07	0.00	-0.01	0.03	1.31	-1.62	-0.66	Low
	POST	-0.46	-1.03	-0.16	0.00	0.01	0.18	1.10	-1.58	-0.25	High

Table 16: Z-values indicate how close the trend is to the mean.

SITE	PERIOD	STABLE ESTIMATE	MINIMUM	1st QUANTILE	MEDIAN	MEAN	3rd QUANTILE	MAXIMUM	LOWER	UPPER	CONFIDENCE LEVEL
				BOOTSTRAP MOMENTS					CONFIDENCE INTERVALS		
KIAMA	PRE	-	-	-	-	-	-	-	-	-	-
	POST	-	-	-	-	-	-	-	-	-	-
GIKIRA	PRE	-	-	-	-	-	-	-	-	-	-
	POST	**-2.25**	-4.02	-0.94	0.20	0.14	1.18	4.69	-7.53	-1.75	**High**
KARURUMO	**PRE**	**-3.15**	-3.58	-0.77	0.00	0.01	0.80	3.95	-8.61	-4.01	Low
	POST	**-6.58**	-5.07	-1.27	0.00	-0.05	1.15	4.76	-16.39	-9.84	Low
GURA	PRE	-	-	-	-	-	-	-	-	-	-
	POST	**-2.01**	-4.24	-0.95	-0.17	-0.13	0.71	3.36	-6.36	-1.41	**High**
MUMWE	PRE	-	-	-	-	-	-	-	-	-	-
	POST	**-6.03**	-5.59	-1.12	-0.08	-0.06	1.08	5.13	-15.19	-8.81	Low
THEGU	PRE	-	-	-	-	-	-	-	-	-	-
	POST	**-1.93**	-3.94	-0.73	0.00	0.02	0.79	3.27	-6.16	-1.60	**High**
GITHANJA	PRE	-	-	-	-	-	-	-	-	-	-
	POST	**-2.37**	-4.62	-1.05	-0.01	-0.06	0.98	3.99	-7.57	-1.80	**High**
MAROGOYA	PRE	-	-	-	-	-	-	-	-	-	-
	POST	**-2.05**	-4.48	-0.94	0.14	0.16	1.26	5.06	-7.35	-1.19	**High**
GITHIKA	PRE	-	-	-	-	-	-	-	-	-	-
	POST	-	-	-	-	-	-	-	-	-	-

Baseflow Trends

One objective of the UTNWF is to influence sustained baseflow. A recursive digital filter method[15, 16] for baseflow separation was used to separate baseflow and direct runoff from total streamflow (figures 24–32). On average throughout the basin, the baseflow index (BFI), which is a measure of the ratio of long-term baseflow contribution to streamflow and is often used as a proxy indicator for groundwater recharge in rivers, varies from 0.6 to 0.75 with a notable exception at Thegu where the BFI is 0.478. Baseflow is considered a proxy for evaluating groundwater storage, which has been a concern in the basin due to limited available information on groundwater. There is a slight increase (maximum 2%) in the percentage of streamflow that that is fed by baseflow at some points in the basin, but overall baseflow has been simply sustained. Kandall's Tau and Theil-Sen's slope were calculated for the nine water sampling sites analyzed, and all had statistically significant results (Table 17). No site indicates an increasing or decreasing trend in baseflow.

Table 17: All sites indicate statistically significant results (p-value) with a trend present (Tau), but the slope of the trend is flat (Slope).

Site	Slope	Tau	Intercept	p-value	Z-value	Lower Confidence	Upper Confidence
Gikira	-0.00018	-0.13123	0.71562	0.00000	-8.05552	-0.00022	-0.00013
Githanja	0.00000	-0.07455	0.02000	0.00001	-4.44252	0.00000	0.00000
Githika	0.00020	0.21972	0.15611	0.00000	14.59422	0.00017	0.00022
Gura	0.00084	0.04786	6.96739	0.00481	2.81932	0.00027	0.00138
Karurumo	-0.00003	-0.20490	0.13157	0.00000	-12.06649	-0.00003	-0.00002
Kiama	0.00005	0.20453	0.32662	0.00000	12.18588	0.00004	0.00006
Marogoya	0.00001	0.12806	0.04990	0.00000	8.30052	0.00001	0.00002
Mumwe	0.00012	0.16534	0.22220	0.00000	9.38758	0.00010	0.00014
Thegu	-0.00001	-0.04747	0.14864	0.00252	-3.02101	-0.00002	0.00000

[15] Eckhardt, K. (2005). How to construct recursive digital filters for baseflow separation. *Hydrological Processes: An International Journal*, 19(2), 507–515.

[16] Lim, K. J., Engel, B. A., Tang, Z., Choi, J., Kim, K. S., Muthukrishnan, S., & Tripathy, D. (2005). Automated web GIS based hydrograph analysis tool, WHAT 1. *JAWRA Journal of the American Water Resources Association*, 41(6), 1407–1416.

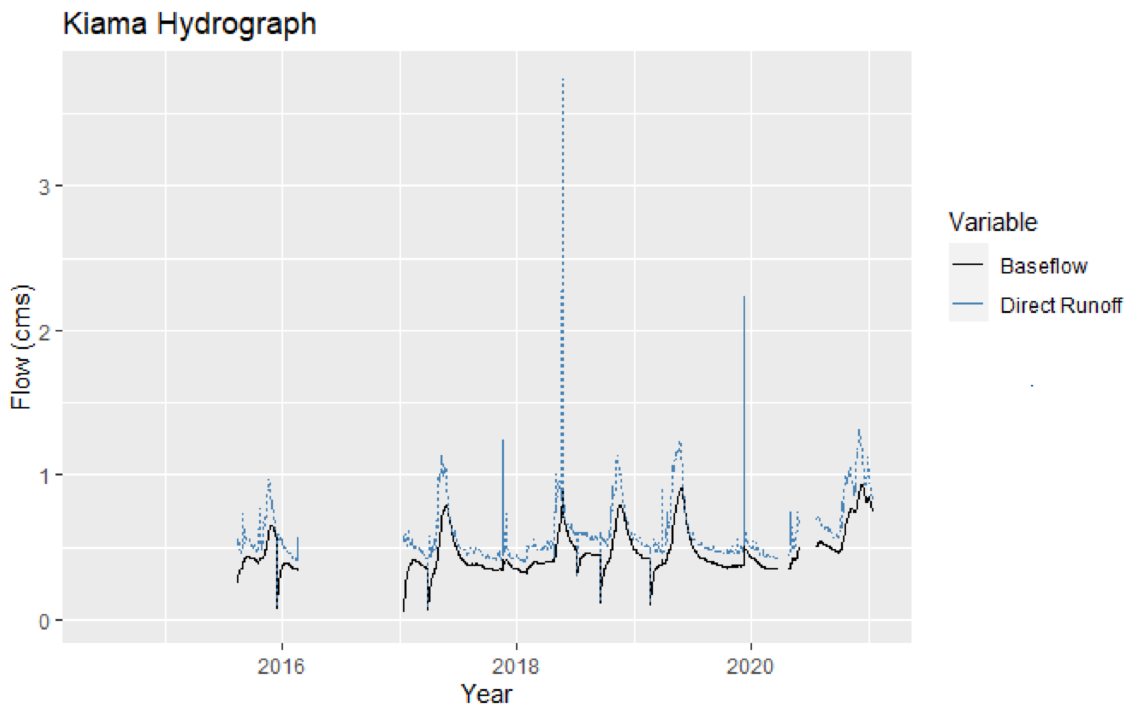


Figure 30: Baseflow index is 0.773. The pattern here suggests there may be seasonal abstractions, such as irrigation, affecting groundwater.

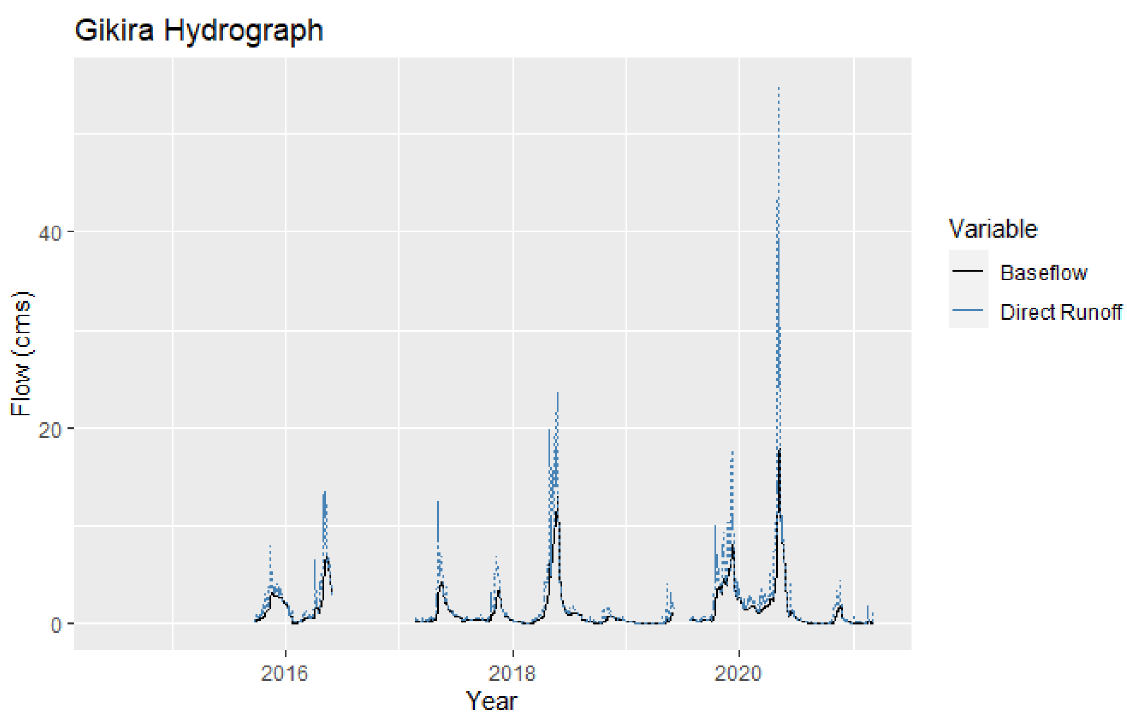


Figure 31: Baseflow index is 0.657.

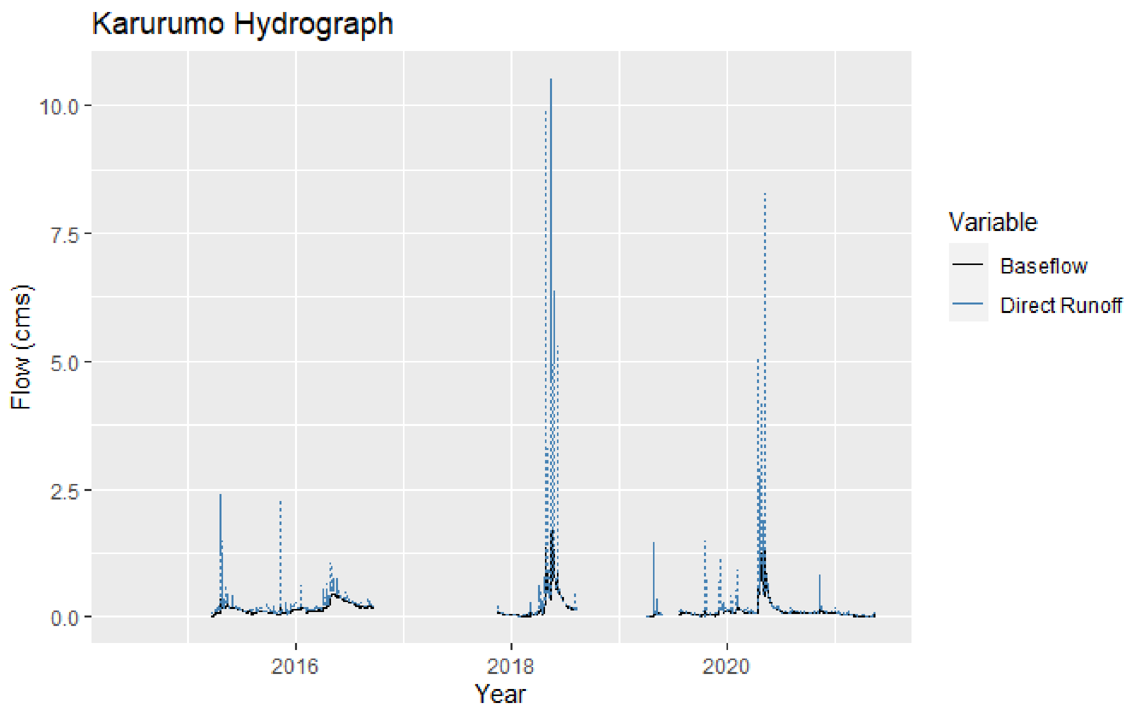


Figure 322: Baseflow index is 0.605.

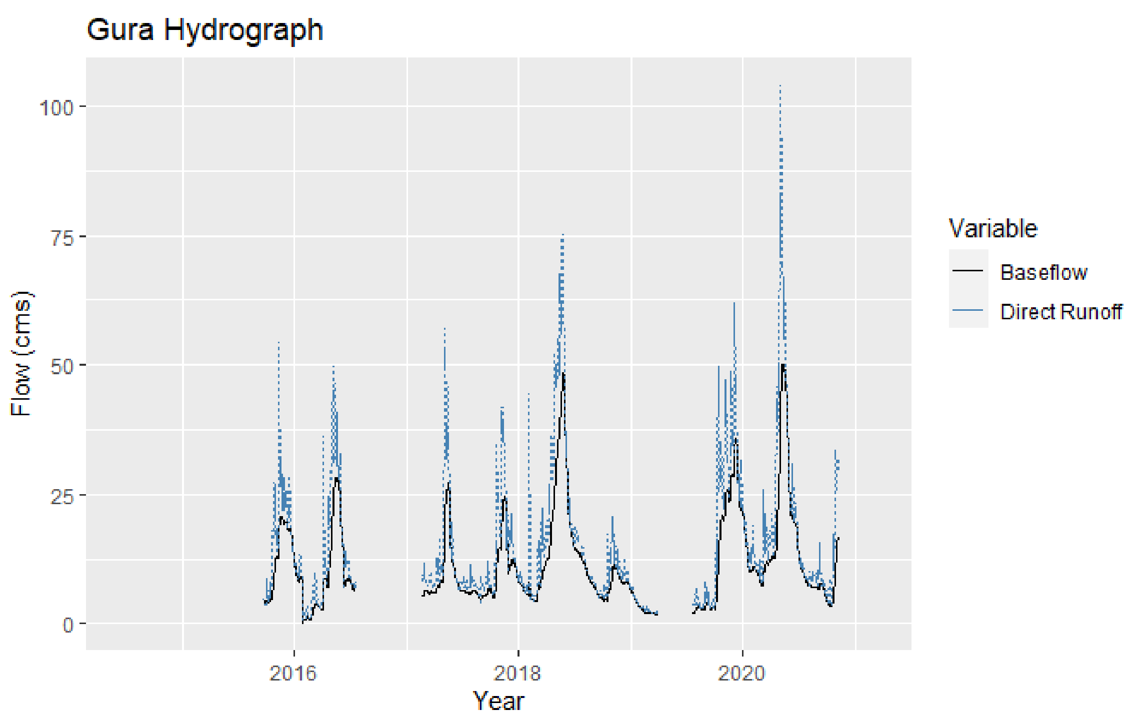


Figure 33: Baseflow index is 0.745.

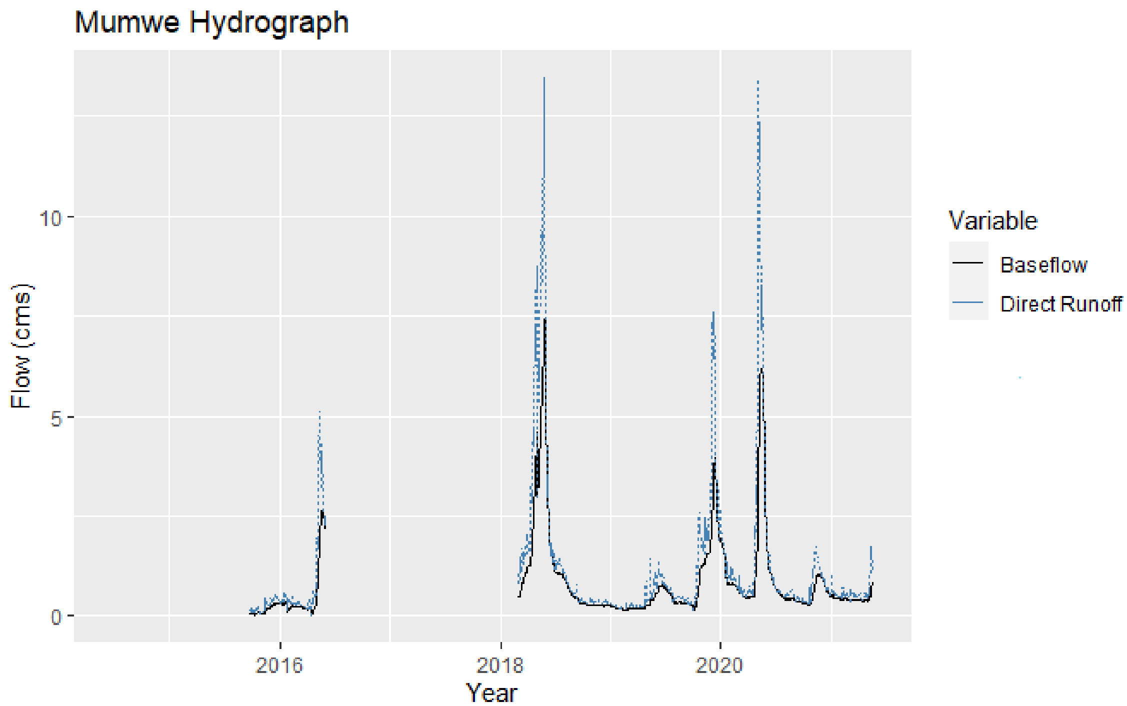


Figure 34: Baseflow is index 0.715.

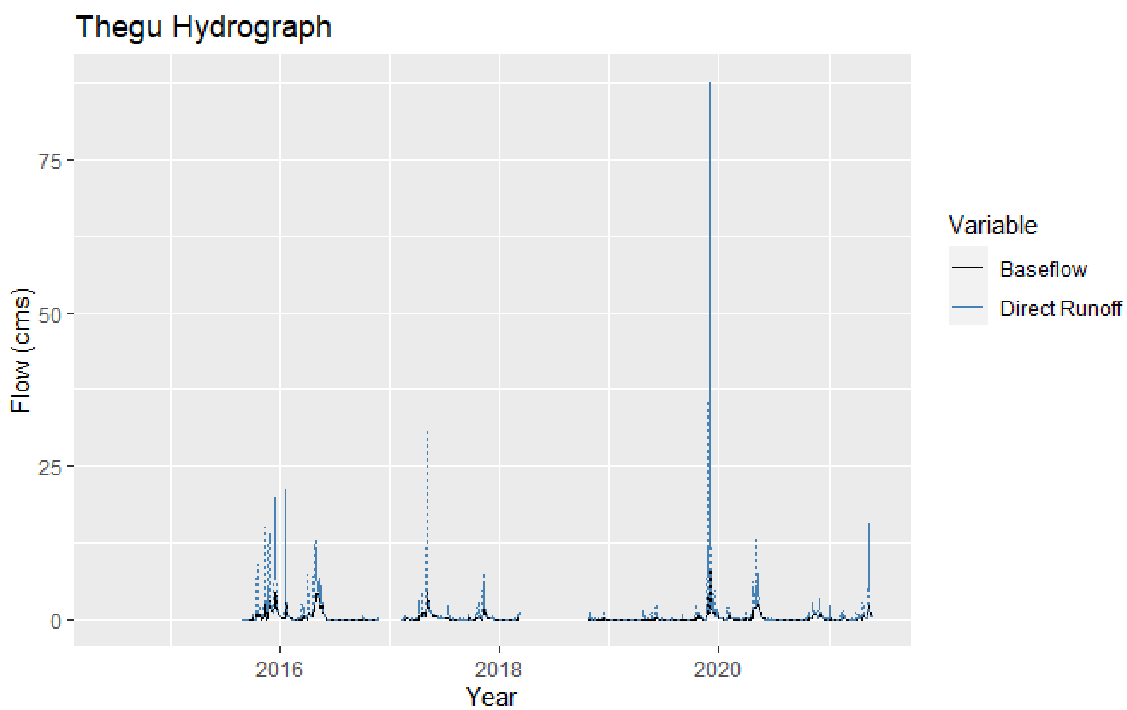


Figure 35: Baseflow index is 0.478.

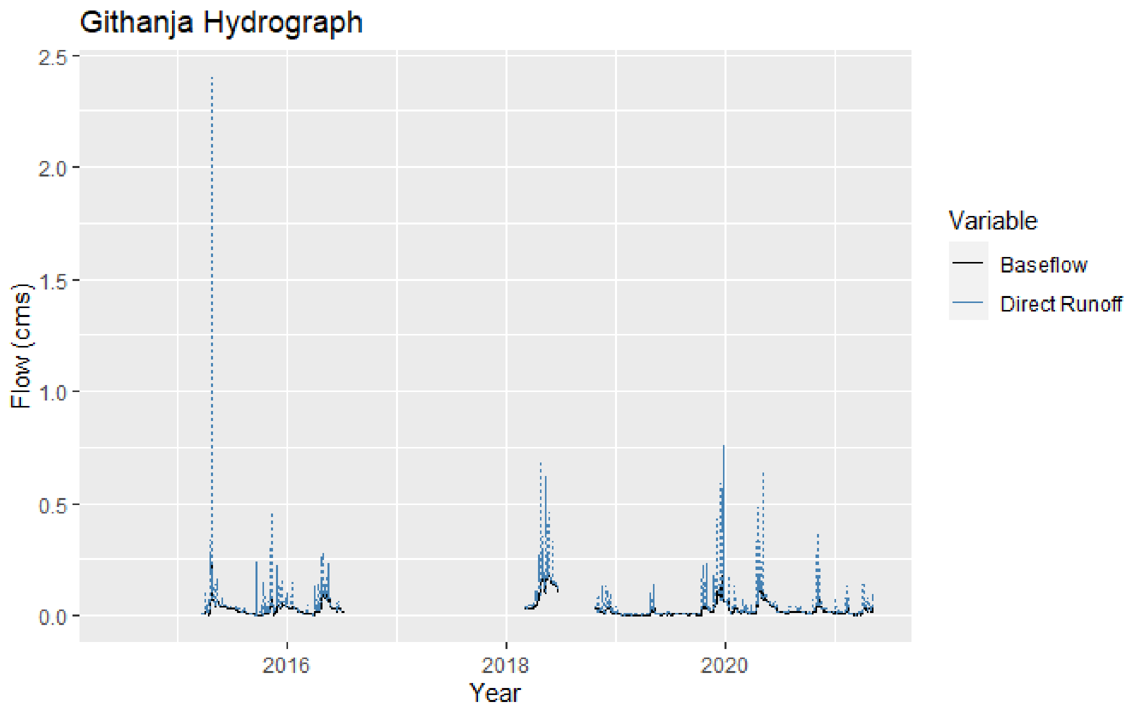


Figure 36: Baseflow index is 0.603.

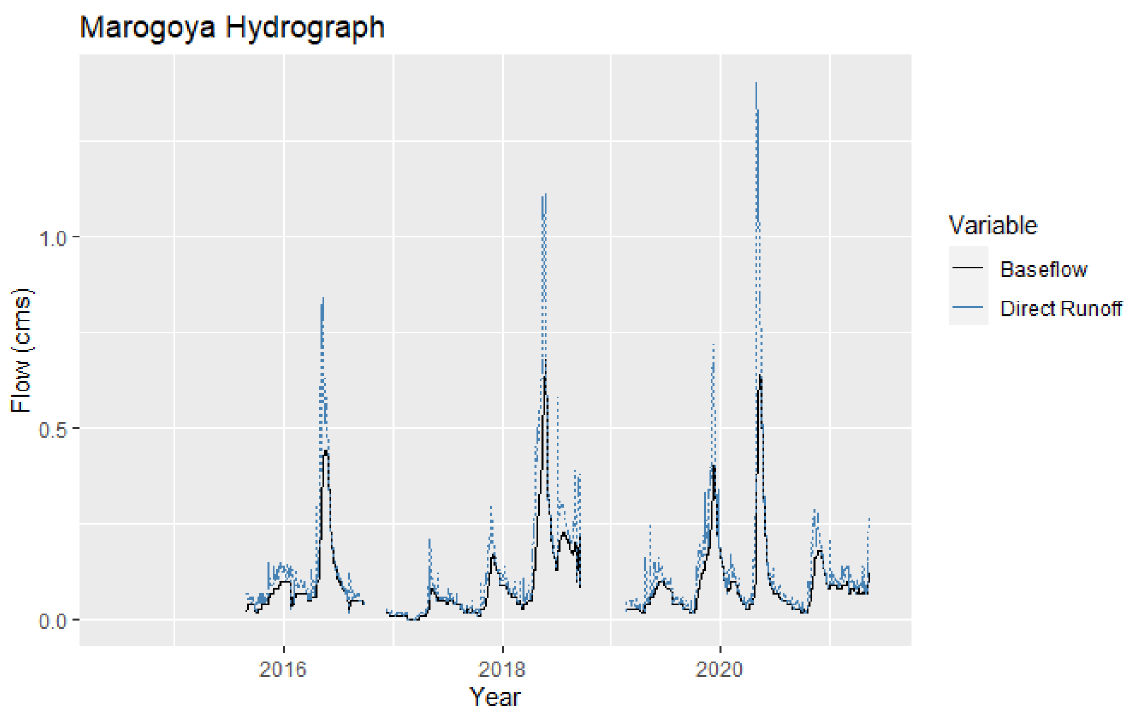
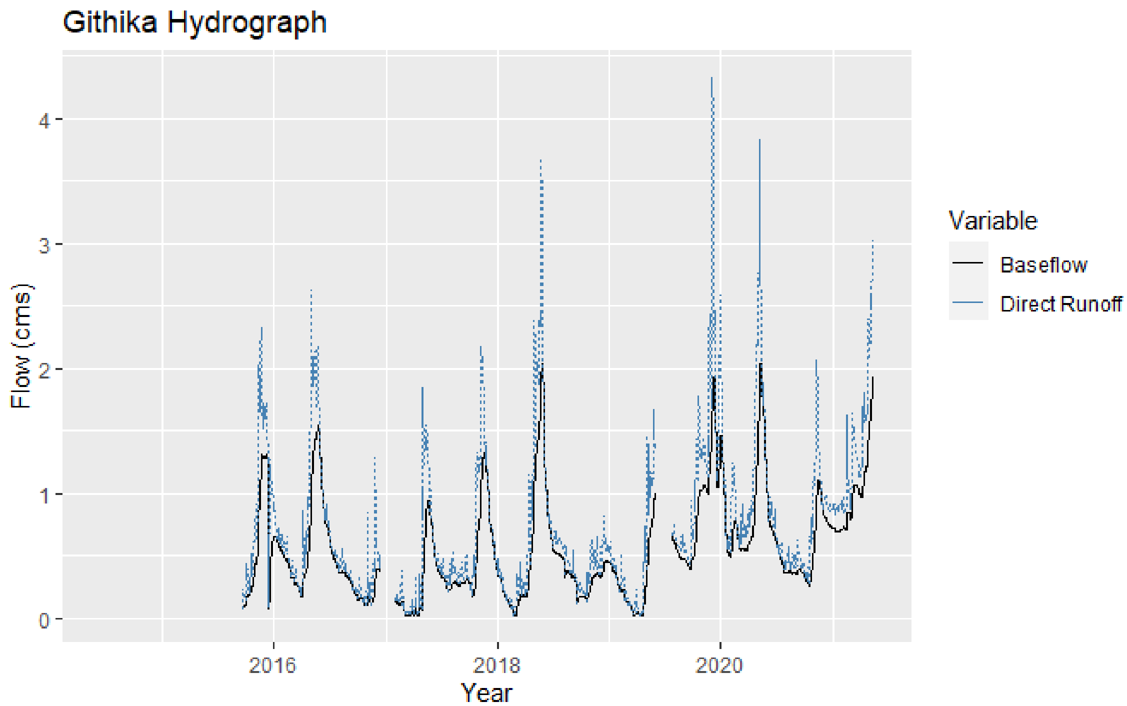


Figure 37: Baseflow index is 0.717.



Software Used for Analysis

R Core Team (2020). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria URL https://www.R-project.org/.

Evans J.S. (2020). _spatialEco_. R package version 1.3-4, https://github.com/jeffreyevans/spatialEco.

Hijmans R.J. (2020). raster: Geographic Data Analysis and Modeling. R package version 3.4-5. https://CRAN.R-project.org/package=raster.

Appendix 3. Strengths, Weaknesses, Opportunities, and Threats Synthesis

Summarized below is the strategic assessment of UTNWF's strengths and weaknesses and the external opportunities and threats that will determine the long-term success of achieving a more sustainable water future for the Upper Tana watershed.

Sector	UTNWF Strengths	UTNWF Weaknesses	External Opportunities	External Threats
Political	Strong relationship with regional and international governments with access to authorities.	Insufficient communication of results and effects on decision-makers.	Political support from parent national ministries and global partners.	Lack of alignment between county and national levels of government in policies and programs. Frequent change in staff at county level makes it hard to develop and maintain working relationships with goodwill.
Economic	Increasing financial support from public and private partners. Ability to mobilize endowment fund at local and international levels.	Weak linkage of UTNWF services to varying needs of local and regional businesses and industries.	Increasing local water demand and interest in water circular economy using green and blue water solutions. Funding from devolved government agencies (county, ward, city). Potential for establishing levies or fees for water use with devolved governments or water providers and to have some of this funding be dedicated to conservation through UTNWF. Funding opportunities from climate adaptation funds and payment for ecosystems services schemes.	Farm subdivision into smaller plots that could increase sedimentation and other problems. Economic forces causing crop conversion that can disrupt or reverse benefits from implemented best practices. Donors have many investment opportunities to choose from that are similar to UTNWF Low community economic capacity for adopting practices due to costs of installation (e.g., water pans). Long-term return on investments and high initial costs of water resources management efforts that result in low interest and

				investment on the part of potential donors or supporters.
Social	Strong partnerships with stakeholders, social groups, and CBOs.		Increasing community and water user acceptance of nature-based solutions. Increased understanding and appreciation by regional and global stakeholders of the need for improved water management and climate change adaptation, including the value of nature-based solutions. Increasing government and stakeholder advocacy of renewable and alternative water sources and efficient water use technologies. Increasing interest in action and investment on the part of the private sector. Water conservation investments as a provider of employment and poverty reduction (e.g., new technology jobs for monitoring, installation of infrastructure, and new entrepreneurial opportunities for farmers).	Community and individual attitudes towards water as a free resource that they should not have to pay for Farmers attitude that they have the right to use as much as they want, regardless of impacts to downstream water users and needs. Inequitable distribution of access to water within and across communities Inheritance: existing landowners and family members are not giving the next generation access to and ownership of the land UTNWF and its solutions still unfamiliar to many stakeholders in target areas
Technological	Potential to collect and share water resources information with real-time data collection and data transmission.	Inadequate staff, instruments, or systems to deploy information collection and dissemination broadly.	Favorable Government of Kenya IT policy. Increasingly cost-effective technology.	Inadequate environmental data on water resources and climate change impacts. Low IT capacity among stakeholders and staff.

	Strong linkages with technical institutions in the water and environment sectors with whom UTNWF can share data.		Strong, well-distributed phone networks to support data collection and distribution.	Rapid obsolescence of installed technology. Low interest by partners in adopting and paying for technological upgrades. Restrictive data sharing policies within agencies.
Legislative	Active contributions to formulating new legislation and to devolved government laws and regulations	Low capacity to influence policy formulation and implementation at necessary level for water and environment sector at national and devolved levels. Lack of ability to "compel" local or regional service providers to levy fees for water use.	Vision 2030 and Big 4 Agenda provide support at national and global level Favorable constitutional dispensation, legislation and rules. Potential to use UTNWF leadership to influence government leaders and policy.	Incompatible legislation and laws, and lack of clear implementation and enforcement for existing laws (e.g., quarry management and enforcement, coffee plants, etc.)
Governance	Strong UTNWF governance systems in place. Accountability and transparency of UTNWF. Strong community of volunteer leaders helping run the fund.	Lack of tools and process for continuous staff training on roles, operations, management, code of conduct, finances, and IT. Inadequate capacity to implement partnerships.	Emerging local and regional collaborative initiatives. Strong legal backing and operational safeguards, projects, funds, and schemes. Many influential leaders who are supporters and are enthusiastic about UTNWF.	Some key partners are not participating at the level they could to advance UTNWF impact due to lack of motivation on their part.