Upper Tana-Nairobi Water Fund

A Business Case

Acknowledgements

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The Nature Conservancy is a leading conservation organisation working around the world to protect ecologically important lands and waters for nature and people.

The Natural Capital Project is a partnership combining research innovation at Stanford University and the University of Minnesota with the global reach of conservation science and policy at The Nature Conservancy and the World Wildlife Fund. It works with leaders around the world to test and demonstrate how accounting for nature's benefits can support more sustainable investment and policy decisions.

FutureWater is a research and consulting organisation that works throughout the world to combine scientific research with practical solutions for water management.

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List of abbreviations

CIAT	International Centre for Tropical Agriculture
KenGen	Kenya Electricity Generation Company
kWh	Kilo-watt hour
KSh	Kenyan Shilling
MW	Megawatts
NCWSC	Nairobi City Water and Sewerage Company
NGO	Non Governmental Organisation
NPV	Net Present Value
RIOS	Resource Investment Optimization System
ROI	Return on Investment
SACDEP	Sustainable Agriculture Community Development Programmes
SWAT	Soil Water Assessment Tool
TARDA	Tana and Athi Rivers Development Authority
TNC	The Nature Conservancy
USAID	United States Agency for International Development
WRMA	Water Resources Management Authority
WOCAT	World Overview of Conservation Approaches and Technologies

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Foreword

A message from the Chairman

Nairobi City Water and Sewerage Company Limited was set up in 2004 to coordinate and manage water abstractions, treatment, and distribution on behalf of the county government of Nairobi and also manage the waste-water treatment. We have seen demand grow from about 200,000 cubic meters to the current 700,000 cubic meters per day as the population and businesses in the city grows. The company has continued to deploy cutting-edge technology in water treatment and to enhance efficiency in distribution from the source to the taps.

As the elected Chair of the Water Fund, I am proud to execute my mandate in ensuring that the Water Fund is implemented to fulfil its mandate as a Public-Private-People partnership supporting long-term conservation initiatives. Taking care of the watershed is important as we endeavour to ensure our critical water-collection infrastructure remains of best possible quality. The Water Fund will help ensure the quality and quantity of water needed to plan supply, support the needs of businesses and local residents, preserve nature, and sustain life.

Eng. Philip Gichuki
Managing Director and CEO
Nairobi City Water and Sewerage Company

A message from The Nature Conservancy leadership

African cities are growing at breakneck rates on the back of unprecedented economic development. Leaders have the opportunity of a generation: to show the world that successful economic development can also protect the spectacular nature the continent is endowed with. Through tools like the Upper Tana-Nairobi Water Fund, The Nature Conservancy is working with governments, businesses, partners and communities to restore watersheds, guide sustainable development of rivers and ensure water security for all.

Giulio Boccaletti
Managing Director, The Nature Conservancy
Global Freshwater Programme

Executive Summary

This study assesses the business case for the creation of the Upper Tana-Nairobi Water Fund to help protect and restore the quality and supply of water to one of Kenya's most productive and economically important regions. The Upper Tana River basin covers approximately 17,000 km^2 and is home to 5.3 million people. The water it provides is of critical importance to the Kenyan economy. It fuels one of the country's most important agricultural areas, provides half of the country's hydropower output, and supplies 95% of Nairobi's water. It is also home to areas of unique biodiversity and iconic national parks.

Forests and wetlands in the Upper Tana play an important role in maintaining water quality and quantity, providing areas where runoff water and sediment can be stored and filtered naturally. However, since the 1970s, forests on steep hillsides and areas of wetlands have been converted to agriculture. As a result, sedimentation is becoming a serious problem, reducing the capacity of reservoirs and increasing the costs for water treatment. Today, 60% of Nairobi's residents are water insecure. The challenges to water security will likely grow as climate change brings increasingly unpredictable rainfall.

Developing a solution: the Upper Tana-Nairobi Water Fund

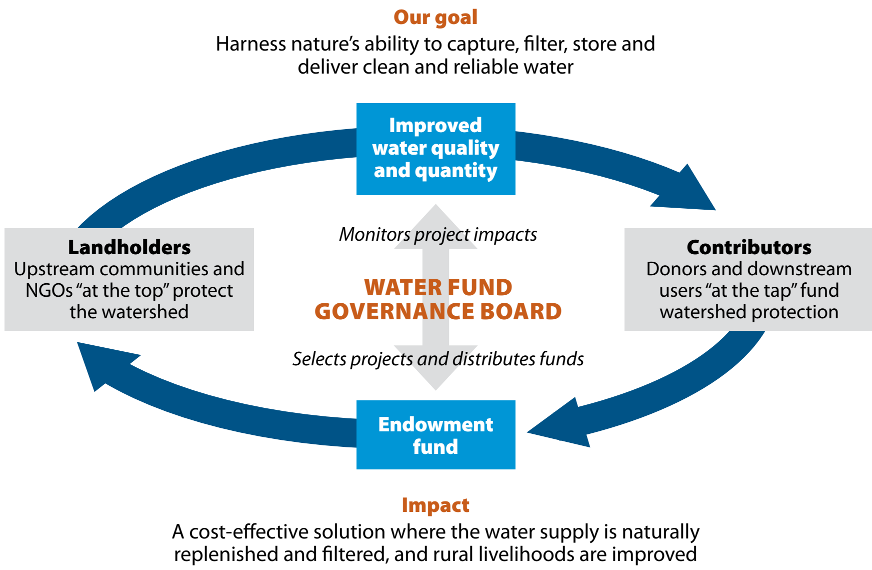
Water funds are founded on the principle that it is cheaper to prevent water problems at the source than it is to address them further downstream. Investments in *green infrastructure* using natural systems to trap sediment and regulate water often provide a more cost-effective approach than relying solely on *grey infrastructure* such as reservoirs and treatment systems. Water funds have been successfully implemented elsewhere in the world to help secure the water quality and supply of major cities including Quito, Ecuador (population 1.6 million) and Rio de Janeiro, Brazil (population 6.3 million). The Upper Tana-Nairobi Water Fund would be the first of its kind in Africa.

A water fund is a financial mechanism to fund land-conservation measures upstream. A public-private partnership of donors and major water consumers 'at the tap' contribute to the endowment. Funds are then used to support water and soil conservation measures 'at the top'. These measures benefit local farmers through increasing agricultural yields by reducing soil erosion that is so damaging both to crop production and to downstream water quality and supply.

Assessing the impact and viability of a water fund

A study to assess the economic viability of a water fund for the Upper Tana River basin was commissioned by a public-private Steering Committee comprising The Nature

Figure 1 Illustration of how a water fund works



Conservancy (TNC), Nairobi City Water and Sewerage Company (NCWSC), Kenya Electricity Generating Company (KenGen), International Centre for Tropical Agriculture (CIAT), Tana and Athi Rivers Development Authority (TARDA), Water Resources Management Agency (WRMA) as well East Africa Breweries, Coca-Cola, Frigoken Horticulture, and the water technology company Pentair. The study evaluated the impact of conservation interventions to reduce suspended sediment in waterways and increase dry season water flows, two of the key issues affecting water supply and community sustainability.

Three priority sub-watersheds of the Upper Tana River were selected for the study: Sagana-Gura, Maragua, and Thika-Chania rivers. Previous studies highlighted these sub-watersheds as areas critical for improving water quality and quantity in the basin. The analysis focused on the benefits that would arise from a US$10 million investment in these sub-watersheds disbursed over a period of 10 years.

Investment planning and watershed modelling tools were used to identify key locations to implement the following interventions and assess their effectiveness:

- Vegetation buffer zones along riverbanks
- Agroforestry
- Terracing of steep and very steep farmlands
- Reforestation for degraded lands at forest edges
- Grass buffer strips in farmlands
- Mitigation of erosion from dirt roads

The economic impact of these interventions was modelled for three key stakeholder groups:

- Farmers in the sub-watersheds
- NCWSC—the major water and sewerage service provider for Nairobi
- KenGen—the leading electric power generation company in Kenya, with several hydropower dams operating in the watershed

Results

Conservative results demonstrate a viable return on investment for the creation of a water fund:

- Over 50% reduction in sediment concentration in rivers (varying by watershed and time of year);
- An 18% decrease in annual sedimentation in Masinga reservoir;
- Up to a 15% increase in annual water yields across the priority watersheds during the dry season;
- Up to US$3 million per year in increased agricultural yields for smallholders and agricultural producers;
- Over US$600,000 increased annual revenue for KenGen as a result of increased power generation and avoided shutdowns and spillages;
- Approximately US$250,000 in cost savings a year for NCWSC stemming from avoided filtration, lowered energy consumption, reduced sludge disposal costs and fewer shutdown days;
- Improved water quality, with a potential decrease in waterborne pathogens, for more than half a million people.

Overall, a US$10 million investment in Water Fund interventions is expected to return US$21.5 million in economic benefits over the 30-year timeframe.

Conclusion

The results of the Business Case demonstrate a clear economic basis for the establishment of an Upper Tana-Nairobi Water Fund. Transforming the shared vision for the Upper Tana-Nairobi Water Fund into a reality will require the continued dedication of the Water Fund Steering Committee, the participation of NGO and community groups, and the support of the Kenyan government.

The success of the Water Fund as an independent entity will depend on expanding public and private financial support. Support is needed from major Nairobi water users, who recognise the business case behind this effort, and from generous donors interested in backing an innovative approach to development, climate change adaptation, and conservation.

Business Case

Introduction

This study assesses the business case for the creation of the Upper Tana-Nairobi Water Fund to help protect and restore the quality and supply of water to one of Kenya's most productive and economically important regions. The business case was developed on the basis of a study that modelled the economic impact and expected benefits of a fund supporting land conservation measures in the Upper Tana River Basin. The results present a case for the creation of a fund to secure the health of Nairobi's water supply, boost agricultural production, and preserve vital hydropower resources.

Tana River

The Tana River is Kenya's longest river, stretching almost 1,000 km from the edge of the Great Rift Valley to the fertile delta where it meets the Indian Ocean. The upper basin covers approximately 17,000 km^2 with about 5.3 million inhabitants. It includes two of Kenya's 'water towers': the Aberdare Mountains and Mount Kenya (Figure 1). The river also sustains important aquatic biodiversity and drives agricultural activities that feed millions of Kenyans. The upper reaches of the source mountains themselves lie largely within protected areas; however just downstream, the river is being impacted by sediments, and dry season flows are being depleted. Millions of people and the iconic wildlife that depend on the river bear the brunt of these impacts. These problems are amplified by the expected impacts of climate change including less water in the dry season and increased sediment loads during severe rainfalls.[1]

Role of a water fund in the Upper Tana

The Nature Conservancy (TNC) has spent over two years working with partners laying the groundwork to establish the Upper Tana-Nairobi Water Fund. The purpose of the Water Fund is to conserve the health of the watershed and protect one of Kenya's most important natural assets: water. The Fund will address threats to water security at their source through targeted, long-term investments in watershed conservation and management.

The vision for the Water Fund is a well-conserved Upper Tana watershed that provides the quantity and quality of water needed for all users, including Nairobi's water supply and Kenya's hydropower generation, while improving the livelihoods of the people in the watershed.

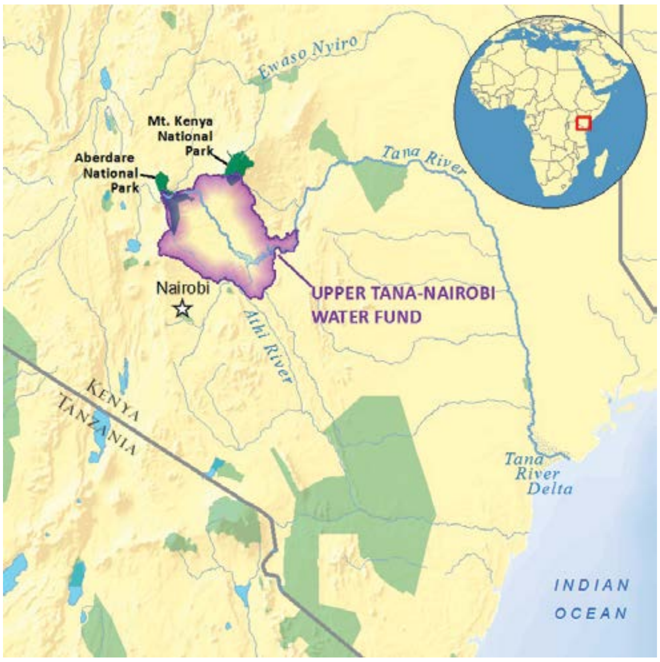
A healthy, functioning watershed has been shown to reduce water treatment costs and improve water regulation for people reliant on the watershed.[2] Investment in *green infrastructure* using natural systems to trap sediment and regulate water often provides a more cost-effective approach than relying solely on *grey infrastructure* such as reservoirs and treatment systems.

A water fund usually involves a public-private partnership and a financing mechanism to invest in watershed conservation. The watershed conservation measures are strategically designed to protect the quality and/or quantity of water available for communities and the environment. Thus, a water fund brings together 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 organisations) to participate in and contribute to the fund, given

1 Herrero, M., et al., 2010. Climate variability and climate change and their impacts on Kenya's agricultural sector. Nairobi: ILRI, ILRI Research report 22.

2 Postel, S. L. and B. H. Thompson (2005). "Watershed protection: Capturing the benefits of nature's water supply services." Natural Resources Forum 29(2): 98–108.

Figure 1 Location of the proposed Upper Tana-Nairobi Water Fund



their shared stake in a healthy water future. The water fund concept is founded on the principle that it is cheaper to prevent water problems at the source than it is to address them later.

The financial support of the water fund is used to promote sustainable management practices in lands upstream that filter and regulate water supply, such as strategically sited tree planting and land terracing. Funding is also used to support economic opportunities that enhance livelihoods and the quality of life for upstream communities, including access to water-saving agricultural technology that can boost productivity. Indeed, many of the interventions that improve water quality and quantity also lead to increased agriculture yields. A water fund can also enhance communities' ability to adapt to climate change, by building in resilience across green and grey infrastructure approaches.

The Upper Tana-Nairobi Water Fund builds upon TNC's experience addressing similar issues in Latin America, where over 30 water funds are either underway or in development. In the Upper Tana, as with Latin America, it is clear that significant green infrastructure benefits can be achieved by targeting conservation on a small fraction of the source watershed area.

The Upper Tana-Nairobi Water Fund would be the first of its kind in Africa, presenting an opportunity to establish Nairobi as a pioneering city in the use of innovative financial mechanisms to protect and preserve the watershed on which its economy and livelihoods depend.

The Tana Basin: A resource under pressure

Water resources management in the Upper Tana

The hydrologic services provided by the Upper Tana River ecosystem are of key importance for the Kenyan economy and environment. It is the most productive basin for agriculture in Kenya, provides water to key national parks, generates half of the total hydropower production of the country, and supplies 95% of Nairobi's water.[3]

Figure 2 shows the principal users that rely on the basin's water resources. Rain-fed smallholder agriculture uses 36% of the water budget, mostly through transpiration from crops. Another major water user at 33% is hydropower; although this use is non-consumptive (meaning the flow is returned to the river after being used for power generation). Irrigated agriculture utilises about 4% of the water budget, while around 2% is abstracted for Nairobi's water supply.

The Upper Tana basin supplies Nairobi city water through the Sasumua and Ndakaini dams drawing water from the Chania and Thika rivers respectively (Figure 3). Further downstream in the basin are the main hydropower reservoirs of Masinga and Kamburu.

Upstream of the Masinga reservoir, there are multiple small hydropower facilities, including the Tana power station (20 MW), Sagana power station (1.5 MW), Ndula power station (2.0 MW), Mesco power station (0.5 MW), and Wanji power station (7.4 MW). While their contribution to energy production along the Tana River is modest, sedimentation at the dams for these power stations may also be an issue.

The existing hydropower and water-supply infrastructure as well as the approximate location of a proposed new water supply

3 NCWSC Production Records 2014

Figure 2 Typical annual water use (in millions of cubic meters) of the principal users relying on the water supply of the Upper Tana River basin above Masinga dam (data from WRMA, 2011)

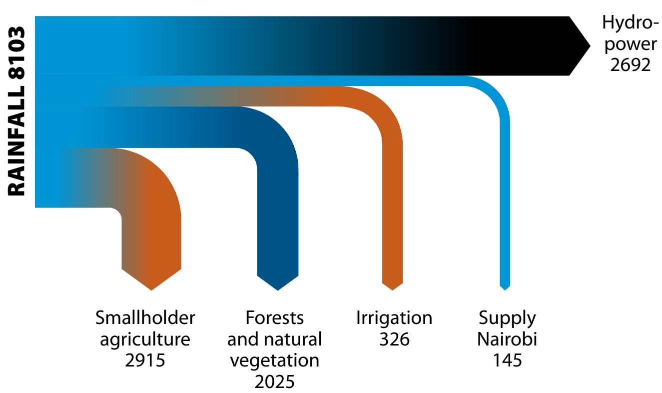


Figure 3 Diversions from the Upper Tana catchment for Nairobi's Water Supply

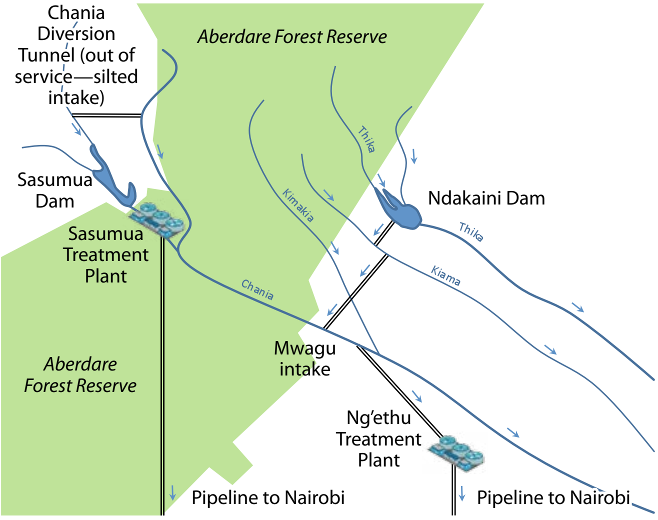
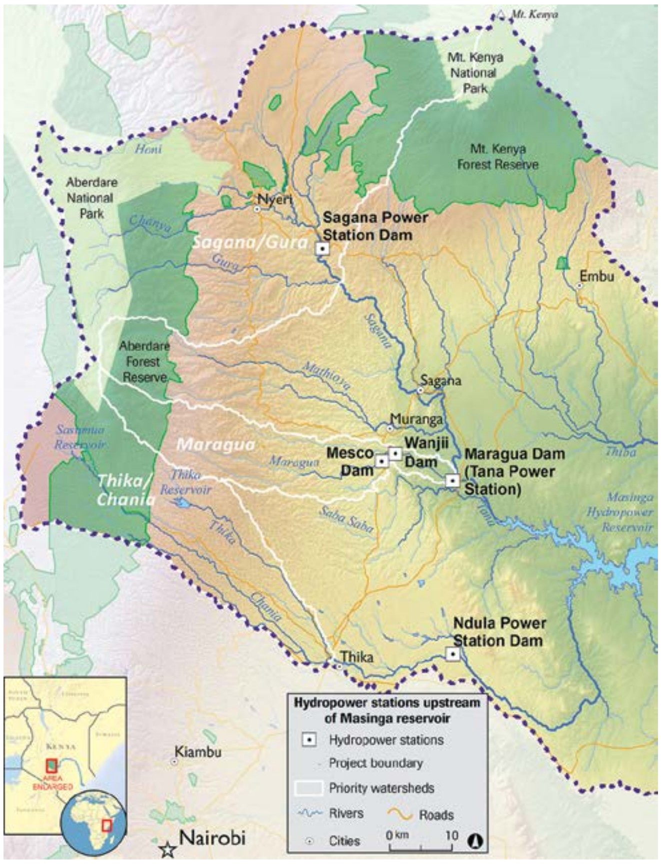


Figure 4 Major water supply and hydropower infrastructure in the Upper Tana



reservoir are shown in Figure 4. The sub-watersheds highlighted represent those prioritised for Water Fund interventions.

A list of 96 additional installations on the Tana River, mostly dams, was proposed in a recent study.[4] Given the early stage of the proposed dams, it was not feasible to incorporate these sites into this study. Their construction, however, could significantly alter the hydrologic regime of the Upper Tana as well as the sediment loads.[5]

Another relevant infrastructural project being planned is a new water transfer from the Maragua sub-watershed to the Nairobi City Water and Sewerage Company (NCWSC) facilities. This planned infrastructure development makes the Maragua sub-watershed of key importance for future investments in watershed conservation activities.

Challenges facing the Upper Tana

Since the 1970s, large areas of forests in the Upper Tana have been replaced by agricultural fields. Demand for irrigation water has increased, particularly to support horticulture production. Encroachment on natural wetlands that once stored runoff water and recharged aquifers has reduced dry-season flows. Agricultural expansion along with soil erosion and landslides has increased sediments in local rivers. The combination of these factors means that in the Tana River there are lower water yields during dry periods and increased sediment in streams.

The impact of sedimentation on water supply

Increasing suspended sediment in the river has become a major issue as it affects the quality of drinking water and increases maintenance and water treatment costs. NCWSC reports that water treatment costs often 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 get worse, as climate change causes more intense rainfall events and population growth leads to more farming on steep slopes.

Nairobi's water treatment and distribution facilities are already under pressure. The current water deficit for the city stands at 168,000 m^3 per day (or 30% of demand) when the system is operating at full capacity. New capacity added to address these

Figure 5 Erosion on a steep slope in the Upper Tana

4 WRMA (2011), Physiographical Baseline Survey for the Upper Tana Catchment Area, Nairobi, Kenya.

5 Ibid.

Water issues from the local perspective

Recent surveys of the people in the Upper Tana give a detailed picture of the water issues as local people perceive them. The data comes from two randomised cluster surveys conducted in October 2013 and April 2014 with a margin of error of 5% (*n* = 1,566).

Almost all the people in the Upper Tana are farmers (98%) who grow both cash and subsistence crops. Maize is the most common crop, but tea, coffee, green beans, and bananas are also widely grown. 72% people own a plot of land of two acres or less (mean = 2.0, SD = 2.1). There are very few large landholdings of 20 acres of more (less than 1%).

About two-thirds of people say erosion occurs on their land, and 65% say the productivity of their land has declined even though they use more fertiliser than five years ago. Almost 80% say rainfall has decreased in recent years, but the 1996-2012 data from at least one point in the Upper Tana (Ndakaini Dam) suggest that the average number of rain days per year and the average rainfall has remained roughly the same.

Most farmers say the vegetation cover on their land—helpful for erosion control and moisture retention—has declined in the last five years, and 38% say there is no buffer zone of permanent vegetation along all or most of the riverbanks in their area. A large majority (85%) say the colour of the local river is more intense after a rain than it was five years ago, an indication that sediment retention by vegetation is declining.

Most people have at least one soil conservation measure in place on their land with grass buffer zones and land terracing being the most common. Yet 36% have less than 25% of their land under soil conservation measures. Awareness of soil conservation is high, and more than 80% of people can name at least two soil conservation measures. There is also a high willingness to participate in a land and water conservation project with 95% saying they would be interested in joining such a project.

In short, a high percentage of people in the Upper Tana are aware of the water issues because it impacts them personally, and they want to address them.

The impact of sedimentation on business: Coca-Cola

Increasing sediment in the water supply is a growing problem for private sector interests. The annual water treatment and filtration costs at Coca-Cola's bottling plant in Nairobi, for example, are over US$1 million, significantly impacting production costs and the company's bottom line.

'Water is key to our sustainability. It is the most important ingredient in all of our beverages and is needed to produce many of the agricultural ingredients on which we rely. In Kenya, we have seven bottling partners, at least half of which rely on the Upper Tana source water for their industrial usage. Not least, the consumers we serve with our beverages rely on this water too for domestic and multipurpose use. Conserving the Upper Tana watershed is critical to the health and economic prosperity of our business and the communities we serve. If the communities we serve are not sustainable, we don't have a sustainable business.'—Bob Okello, Public Affairs & Government Relations Manager, Coca-Cola East Africa.

shortages must also face the challenges and costs associated with high sediment loads in the waters.

The impact of sedimentation on reservoirs

Sediment deposition in reservoirs is an increasing problem. The Masinga reservoir, for example, was designed on the basis of a siltation rate of 3 million tons per year. However, by 2010, the siltation rate was 6.7 million tons per year (two times higher). The Masinga reservoir has already lost an estimated 158 million m^3 of storage volume.[6]

Previous studies on erosion in the Upper Tana basin provided estimates on the erosion rates and the related problems. Bathymetric surveys of long-term sediment yield were conducted for four reservoirs in the Upper Tana basin (Masinga, Kamburu, Ndakaini and Sasumua) in 2011 for the Physiographical Survey.[7] Masinga reservoir has lost an estimated 10% of its capacity since 1981, and the Kamburu reservoir has lost an estimated 15% of its capacity since 1983.[8] For the upstream water supply reservoirs (Ndakaini and Sasumua), no significant long-term sedimentation was found, partly because their small size makes their propensity for sediment retention lower to begin with, but also because NCWSC engages in periodic sediment control measures that flush the sediments downstream.

6 WRMA (2011), Physiographical Baseline Survey for the Upper Tana Catchment Area, Nairobi, Kenya.

7 Ibid.

8 Ibid.

Reservoirs lose active storage capacity as they fill with sediment, limiting the ability of hydropower producers to balance production across seasons. Declining water yields translate into decreased production, particularly when they occur during the dry season. During the 2009 drought, KenGen's electricity sales dropped 12% compared to the previous year, a decline of US$19.8 million.[9]

In short, the Tana River, while providing approximately 95% of Nairobi's water and 50% of Kenya's hydropower supply, receives inadequate protection. Local residents who farm the upper watershed receive no outside investment or incentives to protect this critical resource or to implement measures to reduce soil erosion. The river is being choked by sediments, and dry-season flows are being depleted due to poor land and water management practices.

It is these factors that have prompted TNC and others to come together to assess the likely impact of implementing a water fund to preserve the Upper Tana.

Commissioning the Business Case

Establishing a Steering Committee

The first step in developing a water fund for the Upper Tana and Nairobi was the creation of a public-private Steering Committee. The Steering Committee brought together stakeholders including major utilities, NCWSC and KenGen; government agencies, Water Resources Management Authority (WRMA) and Tana and Athi Rivers Development Authority (TARDA); as well as prominent corporations in Kenya, East African Breweries, Coca-Cola, Frigoken Horticulture, and the water technology company Pentair. Scientific and coordination roles were provided by the International Centre for Tropical Agriculture (CIAT) and TNC.

The team received additional support from other stakeholders including Swedish International Development Agency (SIDA), Global Environment Facility (GEF), United Nations Environment Program (UNEP), International Fund for Agricultural Development (IFAD), and Coca-Cola.

Three Steering Committee organisations will play a primary role in both the design and implementation of the Water Fund:

NCWSC is the major water and sewerage service provider for Nairobi and the largest water utility in Eastern Africa. It was established in 2002 and is owned by the county government of Nairobi. The company is private and has an independent Board of Directors. The company is run on commercial principles; staff and management are integrated into a competitive and productive environment that is customer-focused and results-oriented. They are a member of the Water Fund Secretariat and will undertake watershed management actions as well as impact monitoring.

KenGen is the leading electric power generation company in Kenya, producing about 80% of electricity consumed in the country. The company utilises various sources to generate electricity including hydro, geothermal, thermal and wind. Hydro is the leading source, with an installed capacity of 767 MW, which is 65% of the company's installed capacity. KenGen is a member of the Water Fund Secretariat and will also undertake watershed management actions.

The Water Resources Management Authority (WRMA) is a key stakeholder in the watershed. WRMA is charged with multiple water management responsibilities: developing principles, guidelines and procedures for the allocation of water resources; monitoring water use; managing and protecting water catchments; gathering and maintaining information on water resources; and liaising with other bodies for the better regulation and management of water resources. They are a key partner that will provide overall regulatory authority and policy support. WRMA will also be responsible for project monitoring and assisting with data management systems.

Under the guidance of the Steering Committee, the assessment team assembled the best available data for the Upper Tana watershed, building on previous green infrastructure assessment projects such as the Green Water Credits Program.[10] The assessment team focused on two primary threats to water supply and community sustainability: (i) increasing levels of sediment in waterways; and (ii) decreasing dry season water flows. They also agreed to prioritise three critical sub-watersheds: Thika-Chania, Maragua, and Sagana-Gura rivers. These rivers support thousands of local farmers and are critical to Nairobi's water needs and Kenya's power supplies.

The Thika-Chania sub-watershed was selected because it provides 95% of Nairobi's water and is served by NCWSC. This organisation has been an active participant in the Business Case study providing crucial biophysical and economic data related to their activities.

Maragua was chosen because the socioeconomic survey carried out in October 2013 and an earlier study by KenGen in 2008[11] suggested that this sub-watershed has greater land and water-use issues than most of the other sub-watersheds, making it of critical importance to KenGen.[12] A new water diversion planned for the Maragua River by NCWSC makes this sub-watershed also relevant for Nairobi's water supply.

The Sagana-Gura sub-watershed was selected due to the relatively high water yield from the rivers draining both the Aberdare Mountains and Mount Kenya. It supplies water to

9 KenGen (2010). Annual report and financial statement.

10 http://greenwatercredits.net/content/kenya

11 KenGen 2008. Closing the Gap. Consultancy report Phase 1 and Phase 2.

12 Leisher, 2013. Maragua and Thika-Chania Baseline Survey for the Upper Tana Water Fund. The Nature Conservancy, UNDP, SACDEP, KENFAP and Pentair.

Nyeri town and its water-dependent businesses as well as major agricultural investments. The Green Belt Movement (GBM), a conservation ally of the Water Fund, is already active in this sub-watershed and has implemented several projects to protect forest and riverine areas.

These priority sub-watersheds act as the initial geographic scope for the Water Fund and for the analyses in this study. Neighbouring sites may be covered by specific conservation measures as determined by need and the Upper Tana-Nairobi Water Fund may expand its geographic scope over time to other areas.

Commissioning the study

A clear understanding of the benefits that would be produced by the Fund and how they can be realised is important for ensuring the fund is a wise investment and for guiding the implementation. Thus, the Steering Committee commissioned a study to be coordinated by TNC, with modelling work carried out primarily by the Natural Capital Project and FutureWater. The team used state-of-the-art planning and watershed modelling tools to identify key places to implement interventions and assess their impacts.

The analysis focused on the two primary threats identified by the Steering Group of increasing sedimentation and decreasing dry season water flows and on the three priority sub-watersheds of Thika-Chania, Maragua, and Sagana-Gura.

The economic impact of these interventions was modelled for three key stakeholder groups:

- Upstream farmers
- NCWSC's municipal water supply
- KenGen's hydropower production

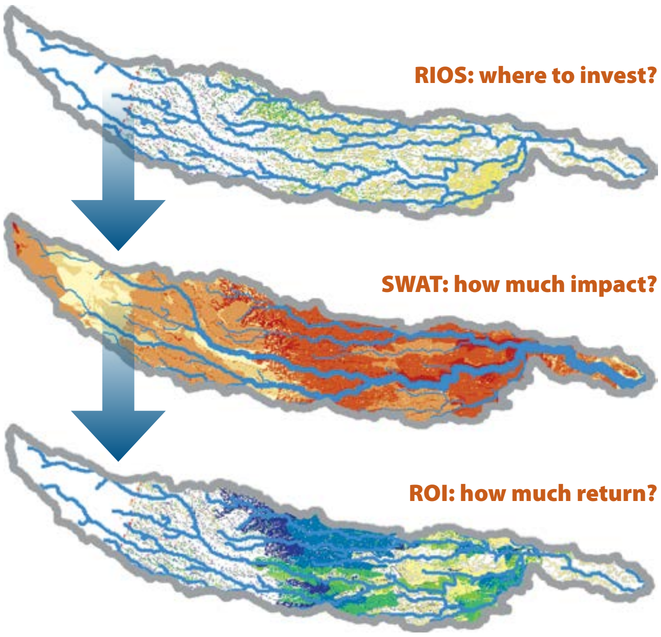
Representatives of these groups and other stakeholders including representatives from water-user associations, research institutions, and government and local non-governmental organisations contributed to the study design. Their involvement ensured that only feasible locations and activities appropriate to local conditions were considered.

Modelling the impact of a water fund

Methodology

The analysis used to model the impact of a water fund combines several widely used tools: (i) Resource Investment Optimization System (RIOS) to spatially target the investment portfolios; (ii) Soil & Water Assessment Tool (SWAT) to assess the biophysical impacts and benefits of the investments; and (iii) a range of economic valuation tools to estimate the economic benefits for upstream and downstream users, ultimately informing an assessment of the Return on Investment (ROI) (Figure 6).

Figure 6 Overall modelling approach linking the spatial prioritisation tool RIOS, impact assessment model SWAT, and Return On Investment (ROI) analysis



The combination of the RIOS and SWAT models allows for a uniquely thorough assessment of priority locations for the Water Fund to focus investments, given target budget level(s) and the biophysical and monetary benefits that could result from full implementation of the investment portfolio.

The RIOS outputs of targeted portfolios were used to drive the SWAT scenario and impact analysis. The SWAT outputs were then used to identify biophysical metrics of interest and, where possible, carry out economic valuation for the upstream land users and for the downstream stakeholders such as NCWSC and KenGen. The main economic benefits considered are:

- Increased agricultural yield for upstream farmers (due to improved soil retention);
- Reduced water treatment costs (due to reduced sediment concentrations);
- Increased hydropower production due to higher water yield;
- Increased hydropower production due to reduced sedimentation.

Additional benefits that were challenging to quantify were considered in qualitative terms.

The RIOS model developed by the Natural Capital Project and TNC is a free and open-source software tool for targeting investments in soil and water conservation activities with the goal of achieving the greatest ecosystem service returns towards multiple objectives.[13] RIOS accomplishes this by combining information on biophysical conditions and landscape context that can impact the effectiveness of activities (e.g., climate, soils, land use, and topography), social information describing feasible interventions and land-use changes, stakeholder preferences for undertaking those activities, and economic data on their costs. The output of the RIOS model is a map of the locations of selected interventions, chosen based on ranked cost-effectiveness scores to achieve one or more ecosystem services objectives. Previous work has shown that using RIOS can achieve significantly improved return on investments compared to less rigorous approaches to targeting.[14]

SWAT[15] was developed primarily by the United States Department of Agriculture to predict the impact of land management practices on water, sediment and agricultural chemical yields in large complex watersheds with varying soils, land use and management conditions over long periods of time. The SWAT model has been extensively used, is in the public domain, and is becoming the *de facto* standard for watershed service assessments.

SWAT represents all the relevant components of the hydrological cycle and includes sediment production and routing of sediments in river channels. The model partitions the watershed basin into a number of sub-basins and creates calculation units that are unique combinations of soil, land use and slope (referred to as Hydrological Response Units, HRUs). After calibration, the model can be run to assess outputs at different locations and levels of detail, and provides spatially distributed output of sources and sinks of sediment. These attributes give the model strong potential for use in scenario studies of changing land-use and management conditions.

For the Water Fund business case study, the three priority sub-watersheds were divided in sub-basins and calculation units, based on the digital elevation model and the location of monitoring points and existing infrastructure. The high detail in input data, especially on land use, results in a high number of calculation units and thus output with high spatial detail.

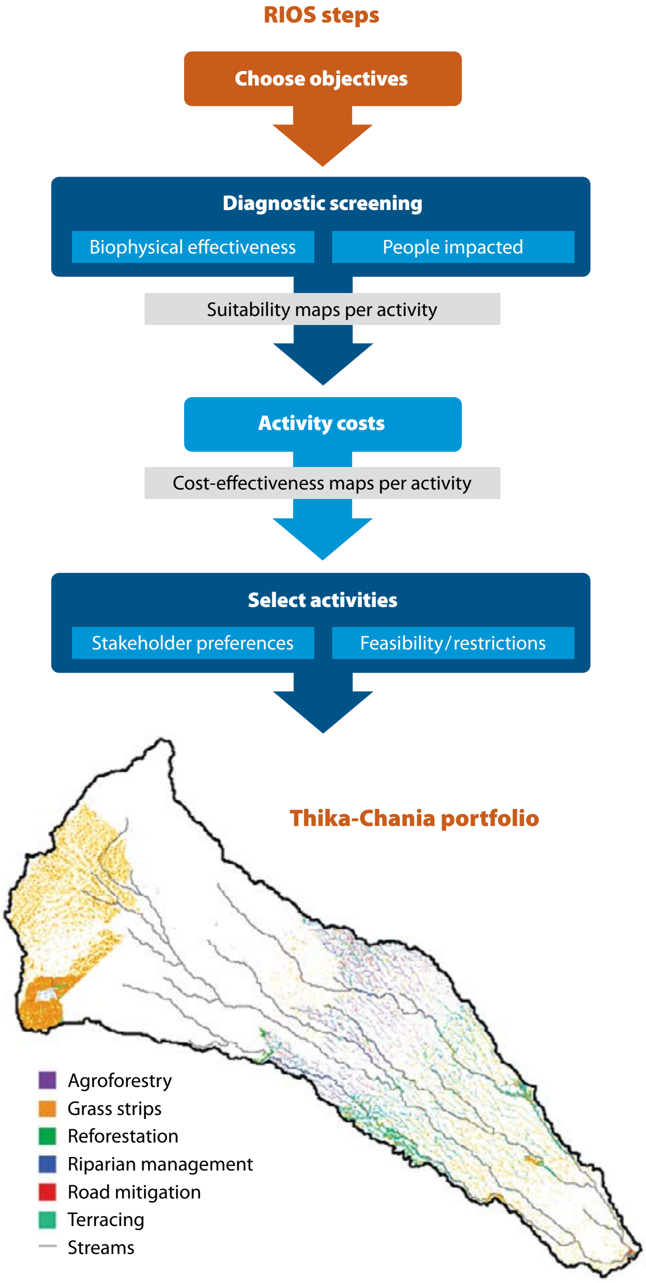
RIOS analysis

RIOS can develop investment portfolios that target a range of different water resource objectives, and the current study focused on sediment retention and maintenance of base flows.

The RIOS model requires data on physical and landscape factors such as land use and management, soils, climate, topography, etc., as well as socioeconomic information such as budgets, activity costs and preferences, and the distribution of populations who would benefit from activities within the project areas. Data was gathered from sources that included previous work in the basin (e.g., Green Water Credits), local agencies and experts (e.g., WRMA and KenGen) and national census data. Where local or national data sources were not available, either to be used as model inputs or to guide model parameterisation, global datasets and a review of relevant literature were used. See the RIOS appendix for a listing of data requirements for the RIOS model, sources, and final values applied.

In the RIOS model, the selection of priority areas is driven by the biophysical characteristics of the landscape as well as the number

Figure 7 The RIOS Investment Portfolio Advisor combines data on biophysical effectiveness, feasible activities, stakeholder preferences, activity costs, and budget to develop a portfolio of cost-effective investments



13 Vogl AL, Tallis H, Douglass J, Sharp R, Veiga F, Benitez S, León J, Game E, Petry E, Guimarães J, Lozano JS. 2013. Resource Investment Optimization System: introduction & theoretical documentation [Internet]. Stanford (CA): Natural Capital Project, Stanford University.

14 Tallis, H.T., S. Wolny, and A. Calvache (2011). "Improving Conservation Investment Returns for People and Nature in the East Cauca Valley, Colombia." Natural Capital Project and The Nature Conservancy.

15 http://www.brc.tamus.edu/swat/index.html

Additional Water Fund interventions

The study focuses on six interventions which can be clearly modelled to evaluate impact at scale. However, the Water Fund itself supports a broader range of conservation measures. Their impact is harder to quantify, but still important. These interventions include:

1. Addressing point sources of pollution.The Water Fund undertakes preventive measures in landslide prone areas by planting permanent vegetation as well as managing downhill runoff conveyance to reduce its erosive impacts and prevent further production of sediments that pollute rivers.

2. Improving quarry management practices. Most stone quarries are located along river banks. Traditional practice included clearing vegetation cover and pushing top soil downhill to pave the way for easy extraction. Implementing new ways of managing top soil to avoid erosion coupled with re-vegetation ensure these sites remain healthy even after stone extraction is completed.

3. Appropriate agricultural practices and waste disposal. By engaging coffee farmers to adopt creative tools like Rainforest Alliance certification, thousands of farmers will scale up sustainable land management on their farms in support of Water Fund objectives while positioning themselves for premium coffee prices in the international market thus creating win-win scenario for both conservation and livelihoods.

4. Reducing dry season water demand from rivers and streams by irrigators. By engaging smallholder farmers who harvest rainwater, storing it in water pans, and applying it to their crops during the dry season, the quality and quantity of the river improves which is good for downstream water users, hydropower generation, and other water needs.

5. Promoting soil conservation adoption by infrastructure developers. By promoting best practices for rural infrastructure development, much point erosion can be avoided.

of people who may potentially benefit from improvements in water services due to implementing activities in these areas (beneficiaries). For this study, the potential for people to benefit was based on the 2009 Kenya national census data, and some adjustments were made to account for the fact that important service points were not directly correlated with population density.

Soil and water conservation interventions for input to the RIOS model were chosen in consultation with the Steering Committee and TNC project staff and on a review of literature on conservation interventions. The following six activities were selected to be input into the RIOS investment portfolio analysis:

1. Riparian management such as vegetation buffer zones along riverbanks
2. Agroforestry adoption
3. Terracing of hill slopes on steep and very steep farmland
4. Reforestation for degraded lands on forest edges
5. Grass strips in farmlands
6. Road erosion mitigation

Setting the parameters for the RIOS model

The Business Case analysis focuses on understanding the portfolios and resulting benefits that would arise from a US$10 million investment spent over a period of 10 years. Ten years was selected as the timeframe for implementation as it reflects the realities of time taken on the ground for the benefits of measures such as tree planting to be seen and for local engagement in improving land management to increase as a result.

The total budget was distributed as follows among the three priority watersheds: Thika-Chania 45%; Sagana-Gura 30%; and Maragua 25%, as decided at a stakeholder forum held in Nairobi in February 2014. The budget was divided equally among the six activities, which means that each activity corresponds to 16.7% of the total budget. RIOS was then run with different investment levels: US$2.5 million; US$5 million; US$10 million; and US$15 million. For clarity, the findings in this report focus on the US$10 million scenario, the appendices discuss the impact for alternative scenarios.

The interventions modelled are not meant to limit the activities that the fund might engage in based on the results of this prioritisation; in fact some of them are intentionally broad (e.g., ‘road mitigation’). The interventions selected are representative of a range of activity types that impact different parts of the landscape in different ways—riparian corridors, crop lands, reducing encroachment in forested lands, addressing erosion from dirt roads, etc. The impact and effectiveness of these activities was assumed to reflect an average change that such activities would cause in the landscape. For example, while there are many different types of terracing possible (e.g., terracing with grass strips, bench terraces, cut-and-fill, fanya juu), the modelling

Table 1 Information on activities and costs, and where they are allowed within the RIOS modelling framework

Activity	Cost (KSh/ha)	Allowed on
Riparian management	98,800	All land types within a 15 m buffer alongside streams, except urban, open water, bare rock, native montane bunchgrass, agroforestry, and roads. Not allowed within the border of Kenya Forest Service lands.
Agroforestry	98,800	Bare soil, grassland, and croplands (except pineapple)
Terracing	30,000	Bare soil, croplands (except tea), and agroforestry lands with >12% slope and >15 m from a stream channel.
Reforestation	98,800	Grassland, shrub, and croplands (except pineapple) located up to 500 m inside the border of Kenya Forest Service lands (anti-encroachment strategy)
Grass strips	12,000	Bare soil, croplands (except tea), and agroforestry lands with <12% slope
Road mitigation	424,863	Unpaved roads

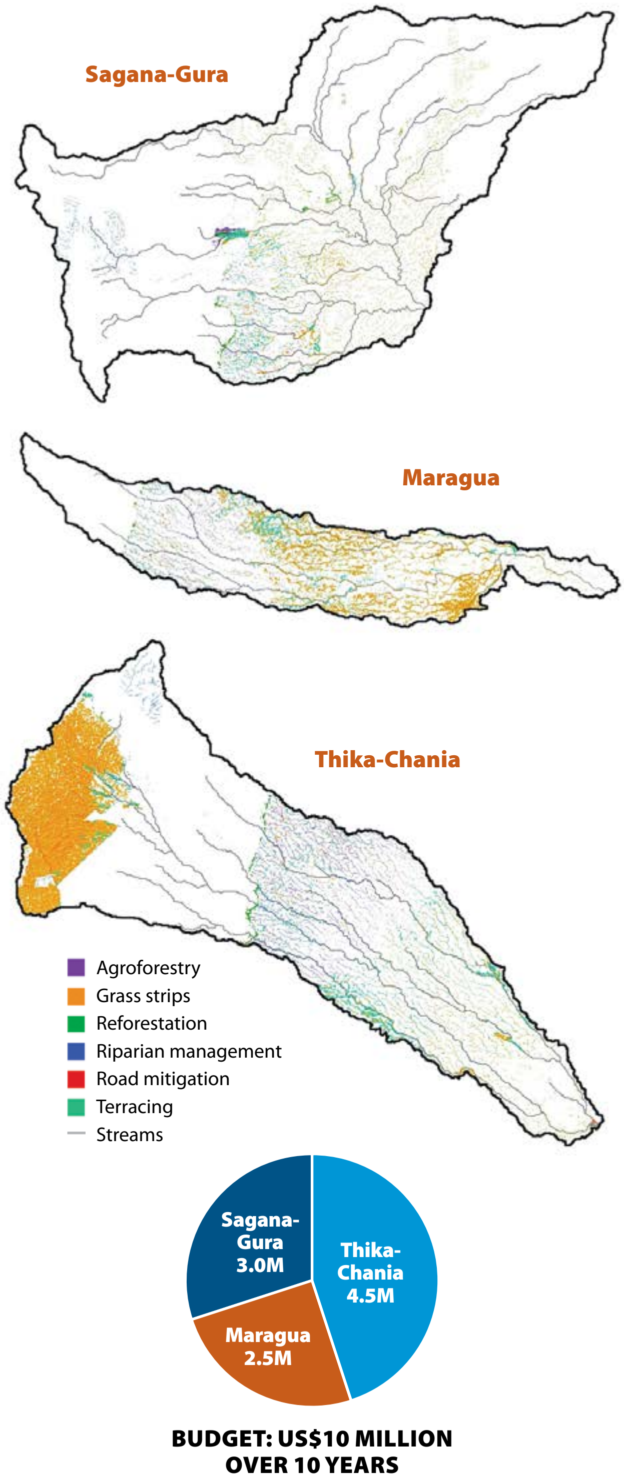
assumed that impact of the 'terracing' activity would reflect its implementation in a way best suited to specific site conditions.

Per-hectare costs for the activities were estimated from a review of the World Overview of Conservation Approaches and Technologies (WOCAT) database and refined based on consultation with stakeholders during a meeting in February 2014.[16] The per-hectare cost reflects the cost to implement each activity in its recommended best practice form and spacing on a hectare of cropland or other land use (such as roads). Costs include implementation (labour and material) and do not consider long-term maintenance costs or any compensatory payments to landholders. Some of these costs, however, are considered in the analysis of economic viability. Costs are assumed to be the same regardless of the land-use type or starting condition of the place where they will be implemented (i.e., the cost of reforestation is the same whether on tea-growing land or mixed cropland). In reality, the cost of activity implementation is likely to vary across the fund area depending on specific site conditions, changes in material costs, etc., but these spatial variations in cost are not expected to significantly impact the broader Return on Investment analysis.

RIOS also requires information on the feasibility of applying the activities on different land-use types, and any restrictions to

16 WOCAT Database 2014 (https://www.wocat.net/en.html)

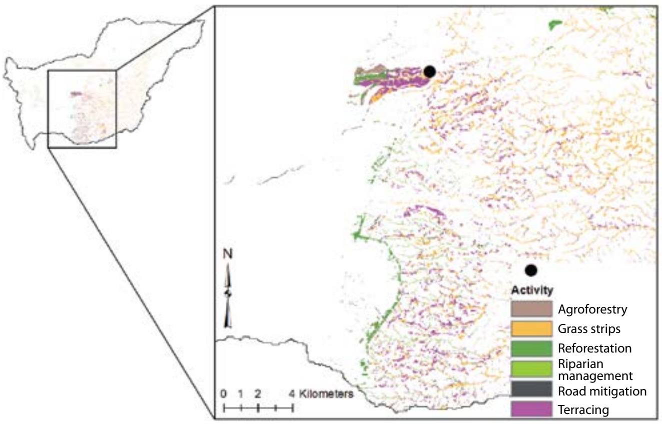
Figure 8 Investment portfolio for US$10 million budget across the three priority sub-watersheds for the Upper Tana-Nairobi Water Fund



their implementation due to physical factors, logistical or legal constraints, etc. Table 1 gives the final activities and feasibility restrictions that were applied, based on consultations with local stakeholders and the TNC assembled project teams.

The results of the RIOS analysis are four portfolios for each of the three priority sub-watersheds, representing different levels of investment. Figure 8 shows how the US$10 million budget was allocated among the Sagana-Gura, Maragua, and Thika-

Figure 9 Detail of the central portion of the Sagana-Gura sub-watershed for the US$10 million scenario.



Chania areas. The additional budget levels are shown in the RIOS appendix and are also available at www.nature.org/africa-water

The resulting portfolios highlight areas where there is the potential for the Water Fund activities to have the greatest impact, integrating across various considerations such as the current land use on each site, its slope, location relative to important water supply points, and population density.

Thika-Chania

A large portion of the area upstream of Sasumua Dam, currently under general agriculture, was chosen for grass strips. This area is one with significantly high erosion potential. For this reason, and because of its location in the catchment for NCWSC's water supply, it is an area of high priority for the Water Fund. In the remainder of that portfolio, activities tend to be focused along riparian corridors because buffers along streams can be an effective way to retain sediment before it reaches waterways. Road mitigation is the most expensive activity but is focused on unpaved roads where there are high slopes and/or where there is currently a low potential for erosion from the road to be retained before reaching the nearest waterway.

Maragua

In this watershed, recommended activities are primarily terracing and grass strips in the coffee and other cropland areas downstream of the Aberdare forest managed by the Kenya Forest Service. The activities are more evenly spread throughout the area and seem to be driven primarily by a potential for significant erosion on highly sloping agricultural lands in the watershed. The Maragua was previously identified as a significant source of sediment for the Masinga reservoir, so activities in the critical erosion areas throughout this watershed will have benefits for reservoir operations downstream.

Sagana-Gura

Here the results show a concentration of activities above the water intake point for the town of Nyeri (mostly terracing, grass strips, and reforestation). Because of the high potential for benefits to urban centres, the model chose this area for increased investment by the Water Fund. Figure 9 shows an area where the highest concentration of activities were prioritised in the Sagana-Gura, due to a combination of high slopes, high number of beneficiaries around Nyeri, and other land-management factors.

Benefits analysis

Interpretation of Business Case results

The results of the assessment demonstrate that a well-implemented Water Fund will produce benefits that outweigh their costs under a variety of assumptions. The results should be interpreted based on the following considerations:

1. Timeframes

The analysis is conducted in two steps. First, the long-term benefits are identified. These examine the difference in benefits under a landscape with fully implemented conservation investments versus one that lacks those investments, based on the SWAT outputs. Second, the manifestation of those benefits over time is considered up to a 30-year time horizon. The 30-year time period is used in order to allow sufficient time for measures such as soil retention to realise their full impact on agricultural yield. A three-year lag is assumed between the time of an intervention and its production of sediment retention benefits, and yield increases follow a particular assumed trajectory until reaching their long term level 15 years after implementation. This means, for example, that an intervention in year seven is assumed to only reach full annual agricultural yield benefits in year 25 of the project (seven years plus three year lag plus 15 years to reach full long-term value). A 30-year time horizon is therefore conservative, in that many interventions will continue to produce benefits beyond that period if properly maintained.

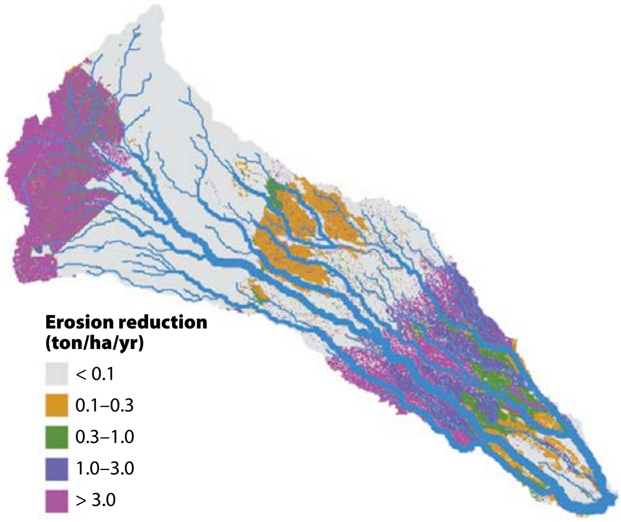
2. Time value of investments

The timing of investments is important because benefits and costs that accrue earlier are valued more highly than those that occur in the distant future (an aspect captured by *discounting*). All else equal, a farmer will prefer a 20% increase in yield next year over one that occurs in 10 years. However, for simplicity, the stakeholder-specific results are presented in undiscounted long-term annual benefits—how much each stakeholder would benefit in a given year *after* full implementation. The implications of timing and discounting are then built into the overall assessment of economic viability.

3. Modelling the future based on the past

The results of the model, except for the changes identified by the RIOS portfolios, generally assume the future looks like the past. They do not anticipate changes resulting from population growth or land-use change that will likely happen independent of the Water Fund interventions, or any new hydropower installations. Major infrastructure such as dams for hydropower or water

Figure 10 Erosion reduction for the US$10 million investment scenario (ton/ha/yr) for the Thika-Chania watershed



supply will affect the results in ways that will depend on the management details of that infrastructure. With respect to land-use change, our results are likely underestimates because the conservation interventions near streams will help filter additional erosion that may occur due to accelerated land degradation.

4. Economic v. financial assessment

The assessment of the business case for the Upper Tana-Nairobi Water Fund identifies whether the total benefits produced outweigh the costs. This is distinct from making a precise accounting of how much benefit different upstream actors (mainly farmers) provide to each of the downstream producers, which requires much more precise information. In essence, this business case assesses the economic (i.e., social) case for the Water Fund, rather than conducting a financial analysis for individual actors.

Likely impacts of Water Fund activities

The analysis reveals several key impacts from the Fund's proposed activities, which are discussed in detail below. These include:

Impact 1. A major reduction in soil loss

Impact 2. A major reduction in suspended sediment in streams

Impact 3. Significant water flow benefits

All the modelled benefits derive from either changes in flows or changes in soil erosion. This study focuses on a few illustrative

Figure 11 Average sediment concentration by month at the Mwagu intake (mg/kg), the water primary intake for Nairobi, showing sediment concentration reduced by 50–60% depending on the month.

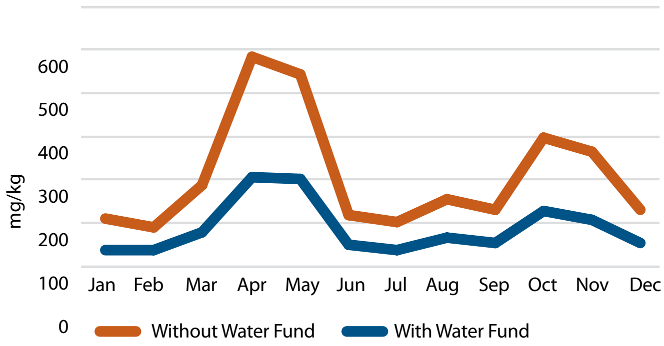
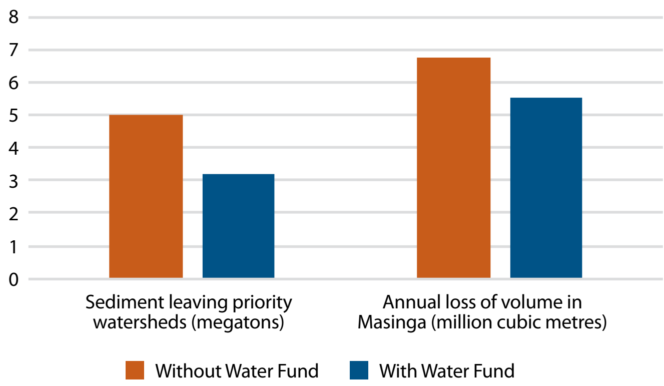


Figure 12 Sediment export from the priority watersheds and implication for lost reservoir volume



examples, but the information produced by the modelling allows for a detailed examination of outputs in specific locations.

Impact 1: A major reduction in soil loss

Erosion is the ultimate source of suspended sediment, and the SWAT results show significant reductions in erosion across all the priority sub-watersheds. This is illustrated for the Thika-Chania sub-watershed in Figure 10, which shows reduction of erosion rates by more than three tons per hectare per year in many areas. Table 2 shows the erosion impacts in each watershed for different major land covers.

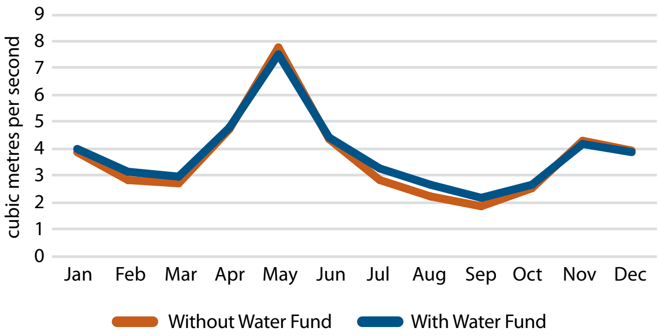
Impact 2: A major reduction in suspended sediment

Figure 11 shows the impact of the Water Fund interventions on sediment concentration at Mwagu water intake, the main diversion point for water serving Nairobi's largest water

Table 2 Reduction in erosion (in thousand tons) within each priority watershed, by land use

	Degraded land	Coffee	General agriculture	Tea	Unpaved road	Total
Sagana-Gura	-3	-55	-131	-3	-20	-212
Maragua	-142	-100	-54	-1	-100	-399
Thika-Chania	-54	-81	-179	-1	-127	-442

Figure 13 Average monthly flows (m³/second) are increased in the dry months and slightly decreased in the peak wet months



treatment plant (Ngethu). Significant reductions in sediment concentration are realised in all months, which will translate to lower treatment costs.

For reservoir storage volume, it is total sediment export from the study area that is important, rather than sediment concentration. Figure 12 shows the total sediment exported by the priority sub-watersheds with and without project conditions and the impact on lost storage volume in Masinga reservoir. Cumulative sediment export from the sub-watersheds is reduced by over 35%, which translates to approximately 1.2 million m^3 of avoided volume loss annually. The percentage impact on Masinga is smaller because Masinga also receives sediment from other sub-watersheds, where no Water Fund interventions are assumed.

Impact 3: Significant water flow benefits

The relative impact of interventions on stream flows is smaller but no less significant than reductions in sedimentation. The results show that average annual flows leaving the three sub-watersheds are likely to increase on average about 4%, leading to an increase of approximately 41 million m^3 of water into Masinga reservoir, assuming no additional withdrawals are made.[17] Annual flows may further increase if consumptive water-use reduces due to water-use efficiency measures by local residents, particularly among thousands of small-scale irrigators. A Water Fund led pilot of measures to improve local water-use efficiency is currently underway.

At the Mwagu water intake, average monthly flows in the Chania are anticipated to be slightly diminished in the wet season and slightly increased in the dry season. This is shown in Figure 13.

17 This increase is possible despite a simultaneous increase in transpiration because unproductive soil evaporation is converted to productive plant transpiration, while increasing infiltration of water that would otherwise evaporate from soil.

When averaged over the years simulated, July, August and September show increases of over 15%, during a time when water availability for Nairobi is often stressed.

The dry season increase is biggest in years where the conditions are less severe, due to the fundamental issue that watershed interventions can only do so much when there is very little water available such as in a drought. However, even a small improvement in extremely dry years may be highly valued. Furthermore, increased flows during moderate dry seasons may act to increase reservoir storage, helping to mitigate particularly severe dry periods.

Summary

Overall, the major reduction in erosion brought about by the Water Fund investments leads to significant reductions in sediment concentration throughout the watershed. Fund activities also result in greater annual water yields that could reach 15% at certain times of year.

Benefits by stakeholder group

Upstream farmers

Erosion reduction leads to more favourable soil properties in terms of soil fertility and water retention. Upstream farmers will therefore benefit through higher production and increases in revenues. These benefits can be quantified by the SWAT model. It predicts how much fertile, water-retaining soil can be saved and thus how far productivity can be increased after investing in soil and water conservations practices. The SWAT output was used to estimate the increased agricultural productivity under the different investment scenarios using the economic water productivity for each crop type.

Land conservation measures were carried out on areas representing 8% of the three priority sub-watersheds. Table 3 shows the change in revenue per hectare. As can be seen, the changes in revenue per hectare on intervened area are substantial and in the same order of magnitude as the actual income per hectare for coffee and general agriculture. It is important to note that these changes in revenue represent the difference between yields without intervention and yields with the intervention. Both are modelled as decreasing over time, because some soil is still lost even with the water fund interventions; however the decrease in productivity is much lower.

Table 3 Annual increases in revenue by crop type

Land use	Increase in revenue (US$m)	Total area with activities (ha)	Increase in revenue / ha (US$/ha)
Coffee	1.7	6,280	264
General agriculture	0.9	13,295	68
Tea	0.4	814	479

Table 4 Annual increases in upstream revenues per watershed and crop type (US$ million)

Watershed	General agriculture	Coffee	Tea	Total
Sagana-Gura	0.3	0.3	0.3	**0.9**
Maragua	0.4	0.6	0.1	**1.1**
Thika-Chania	0.6	0.5	0.1	**1.2**
Total upstream	**0.9**	**1.6**	**0.4**	**3.0**

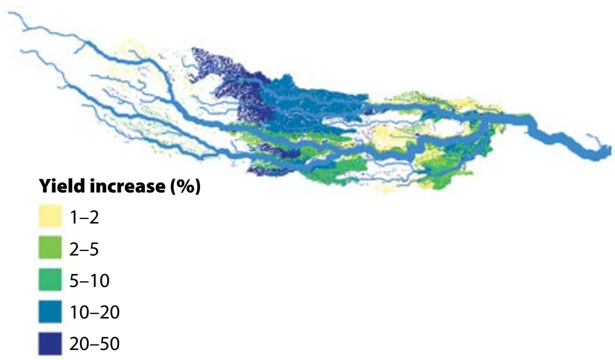
Table 4 shows the predicted economic benefits for the Water Fund by crop type in each sub-watershed. Major benefits are obtained in land classified as coffee fields (which include general agriculture among coffee trees), especially in the Maragua sub-watershed. General agriculture also sees significant benefits. The benefits are smaller for tea, but still notable, in particular in the Sagana-Gura sub-watershed.

The spatial aspect of the modelling enables the distribution of benefits to be viewed across the landscape. Figure 14 shows the relative increase in crop production. Comparison with the land cover maps reveals that most of the increase is predicted in the higher parts of the coffee zone. Spatial outcomes such as those shown in Figure 14 are available for the other watersheds in the FutureWater technical appendix.[18]

The long-term change in annual revenues that can be expected from soil preservation is approximately US$3 million per year after 10 years, levelling off slightly higher than that in the long run, as the soil reaches a new equilibrium state. However, because the economic water productivity statistics used are based on the crop export value, not all of this increase in revenue amounts to a pure 'benefit' to farmers. Some of that value is captured elsewhere in the value chain, and there are also some additional costs associated with moving the increased yields through the value chain. This means that direct benefits to farmers from the increased production will likely be lower than is suggested by the revenue change. In the reference case for the ROI analysis, benefits are scaled down by 50% relative to revenue to account for this issue.[19] However, even with this adjustment, these agricultural yield benefits comprise a major portion of benefits produced by the Water Fund.

18 Hunink, J E and Droogers, P (2015).Impact Assessment of Investment Portfolios for Business Case Development of the Nairobi Water Fund in the Upper Tana River, Kenya. FutureWater Report 133

Figure 14 Relative yield increase under the US$10 million investment scenario for the Maragua sub-watershed



There are several additional benefits to upstream farmers that are expected but could not be quantified in the Business Case:

- Increases in income from increased yields may provide secondary benefits, such as enabling farmers to reinvest their profits to shift to agriculture with higher returns or pay for schooling.
- Water Fund conservation interventions have the potential to create employment opportunities for as many as 10,000 people each year in the rural areas where they are being implemented.
- The additional fodder produced by growing buffer strips of grass would benefit local livestock and dairy production.

Municipal water supply—NCWSC and others

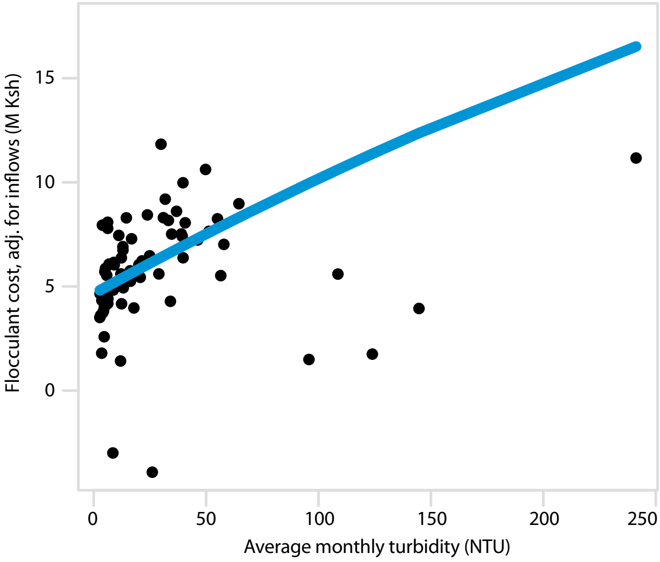
The primary benefit to NCWSC and other municipal water systems comes in the form of lowered sediment concentrations that reduce treatment and maintenance costs. For NCWSC, the analysis focused on the Mwagu intake/weir that serves the Ngethu treatment plant, as this is the single largest water withdrawal point for Nairobi's water supply (approximately 400,000 m^3 per day). The three main cost savings quantified in the Business Care are:

1. Avoided use of flocculants
2. Avoided electricity costs
3. Greater water revenue from reducing use of processed water in backwashing

High sediment concentrations can impact treatment plant cost in several ways. High turbidity leads to higher flocculant and energy use in the water treatment process. It also increases backwashing frequency for the filters. Based on statistical analysis of historical relationships between sediment concentration, turbidity and treatment costs (described in the Ecosystem Services technical appendix), results show that the long-run reduction in predicted sediment concentration would translate to approximately KSh 3.6 million (US$40,000) annually in avoided flocculants at Ngethu

19 From a theoretical standpoint, this added value could range between zero and 100 percent, neither of which are considered plausible. This study uses the midpoint and includes sensitivity analysis around this figure. The nuances of this issue are discussed further in the Ecosystem Services technical appendix.

Figure 15 Spending on flocculants as a function of turbidity at Ngethu Water Treatment Plant



treatment works. Similarly, the reduced sediment loads would translate to approximately KSh 350,000 (US$3,900) per year in avoided energy costs. Most significantly, a 30% reduction in current processed water diversion for backwashing will increase profits for the utility by around KSh 20 million (US$220,000) per year under the conservative assumptions of allowing efficiency losses and a hypothesised 25% cost of delivery associated with this water relative to recovered water.[20]

The Sasumua treatment works, run by NCWSC, would also receive significant sediment benefits. As a higher proportion of its watershed will benefit from interventions than Ngethu, it is predicted to see sediment concentrations reduce on the order of 70%. Sasumua treats 11% of Nairobi's water compared to Ngethu's 84%, but also incurs a higher unit treatment cost.

Beyond Ngethu and Sasumua, NCWSC currently has plans for more off-takes from the Maragua sub-watershed and potentially a new reservoir and treatment plant. All of these areas are expected to see significant sediment reduction benefits, on the order of 50%. This will benefit operation and maintenance costs in a manner similar to Ngethu, and confidence in lower sediment loads may allow some savings on capital costs for sediment removal infrastructure.

There are several additional benefits to municipal water treatment that are expected but could not be quantified in the Business Case:

- The largest financial benefit to NCWSC might well be the disposal of wet sludge. In the scenario modelled, the annual mass of sediment intake into the Ngethu treatment plant is expected to decrease by about 15,000 tons. Currently the sludge produced by the removal of this sediment is disposed of without cost, though NCWSC will soon be putting a sludge treatment system in place. The exact technology has yet to be decided, but if NCWSC can be sure of lower sediment loads in the future due to Water Fund investments, they could significantly reduce the size and capital investment associated with the new treatment facility. Engineers tasked with sizing and costing the design and operations of the facility can use the expected avoided sediment reduction to identify the potential value for NCWSC.
- There are other potential benefits that reduced sedimentation is likely to bring, including avoided interruptions to service during high-sediment days, and increased dry-season base flows. Both of these could potentially translate to improved service delivery.
- Finally, NCWSC is not the only water supplier drawing water from within the priority watersheds. Nyeri, Thika, Murang'a and other towns will also benefit from lowered sediment levels. Similarly, municipal water processors are going to benefit from more reliable water supply and additional quantities. However, this study did not capture the impact of sediment on their operations.

Overall, the present value of avoided costs to NCWSC is likely to be over US$3 million after scaling up for impacts on other existing and planned water supply sources (by assuming new infrastructure will increase the water being supplied) even without counting the wet sludge disposal benefits.

Hydropower production—KenGen

KenGen is expected to benefit from both increased water yields and from avoided losses in electricity production due to reduced sediment loads. The two main benefits quantified in the Business Case are:

1. Increased power generation from increased water yield.
2. Avoided interruptions in electricity generation.

The modelling results imply that on average, and assuming no significant change in consumptive water withdrawals, the Masinga reservoir should see annual inflows rise by an average of 41 million m^3 per year. If all of this increase were to be captured as increased power production, this would lead to at least 17 million additional kWh of electricity in an average year (depending on reservoir level and the efficiency with which the additional yield is captured in downstream generation). Assuming this were valued at the low average generating tariff of KSh 3.06/kWh, this corresponds to about KSh 50 million (~US$600,000) per year in revenues. KenGen's value and efficiency of generation may often be higher, particularly during the dry season.

Additionally, the smaller power plants upstream of Masinga are likely to experience fewer operational interruptions due to high sediment input. For example, at the 20 MW Tana power station just above Masinga, operations must be interrupted periodically to deal with sediment accumulation near the intake, which also has the potential to damage turbine seals. If the frequency of interruptions is approximately proportional to the sediment

20 This 25% cost is inserted to be conservative. If there is demand for water and excess capacity for it to fill pipes, then the additional cost for delivery should be minimal, as the water is already processed.

concentration, then this translates to fewer interruptions and less forgone generation. There is unfortunately very limited data to estimate this relationship, but as an example, doubling the time between interruptions from two years to four years would translate to an average of 800,000 additional kWh per year or KSh 2.5 million (US$30,000). This benefit may be relevant to other smaller upstream power stations such as Wanjii and Ndula.

There are several additional benefits to KenGen that are expected but could not be quantified in the Business Case:

- A reduction in reservoir sedimentation will lead to a greater ability to manage flows and water balance within the Seven Forks Cascade to maximise power generation. Unfortunately, it is not feasible to accurately estimate this benefit without more detailed and dynamic modelling based on engineering data on the system.
- These results also do not capture the potentially abrupt increase in maintenance cost required to keep turbine intakes open (likely using dredging), as sediment accumulation advances toward the downstream end of the reservoir toward over time. The relevance of this risk would require more detailed sediment transport modelling.

Other co-benefits and stakeholders

There are other benefits resulting from the Water Fund, that although are not quantified in monetary terms, are likely to have significant benefits for stakeholders in specific areas.

1. Cleaner drinking water for local communities

In the 2009 census, there were approximately 611,000 people within the districts in the Upper Tana whose primary water source was raw water from streams. The study suggests that conservation interventions in the watershed will improve water quality, benefitting approximately half a million residents outside Nairobi who do not have access to treated water. Improved water quality is also likely to reduce costs for those who engage in home treatment and to provide health benefits for those who do not.

Turbidity and suspended solids have been shown to be correlated with bacterial pathogen content in a number of studies.[21] The relationship between sediment concentration, pathogen content, pathogen exposure and health is complex and beyond the scope of this study. However, it is likely that a reduction in sediment being carried into streams will have some positive effect on health outcomes, most likely in terms of reduced incidence of diarrhoea, which can be both costly and deadly when adequate treatment is unavailable.

21 Irvine, K. N., Somogye, E. L., & Pettibone, G. W. (2002). Turbidity, Suspended Solids and Bacteria Relationships in the Buffalo River Watershed. Middle States Geographer, 42–51;

Lechevallier, M. W., & Norton, W. D. (1992). Examining Relationships Between Particle Counts and Giardia, Cryptosporidium, and Turbidity. Journal (American Water Works Association). 84(12), 54–60;

USGS (2012). Escherichia coli Bacteria Density in Relation to Turbidity, Streamflow Characteristics, and Season in the Chattahoochee River near Atlanta, Georgia, October 2000 through September 2008—Description, Statistical Analysis, and Predictive Modeling.

Figure 16 Harvesting Napier grass from conservation terrace bunds

2. Additional ecosystem services

Conservation measures implemented through the Water Fund will provide further valuable ecosystem services:

- Increasing vegetation buffers will create new habitat for pollinators and seed dispersal agents. It is estimated that pollinators in Kenya contribute about US$1 billion worth of ecosystem services each year. These services will be positively impacted by the Water Fund in an estimated 33,290 hectares under the US$10 million investment scenario.
- It is likely that over 100,000 new trees will be planted as part of Water Fund conservation interventions, creating a substantial carbon sink for the environment.

3. Enhanced opportunities for urban processors

Good water supply to urban-based private sector processers, including bottling plants, is crucial for quality employment, a growing economy, and a sustained source of foreign exchange for the country.

The viability of the Water Fund

The cost-benefit analysis of the Water Fund is based on a 30-year time horizon, with the investment of US$10 million being disbursed at a rate of US$1 million per year for 10 years. Figure 17 shows how benefits, costs and annual benefits are anticipated to be realised over time.

The appropriate framework for considering the overall benefits against costs is to use discounting to convert benefits and costs into present values, which accounts for the fact that benefits and costs have different values depending on when they are realised.[22]

Figure 18 shows the same annual benefits line as in Figure 17 (albeit at a different scale), but also shows the Net Present Value (NPV) at any point in time. The Net Present Value figure captures

22 The analysis focuses on a 5% discount rate, which corresponds to the average real interest rate in Kenya from 2004–2013 (World Development Indicators). Nominal interest rates are higher, on the order of 13–15%, given an average inflation rate near 10%. Alternate discount rates are explored in the sensitivity analysis.

Figure 17 Total annual benefits and costs over time including continued maintenance after 10 years (in USD million)

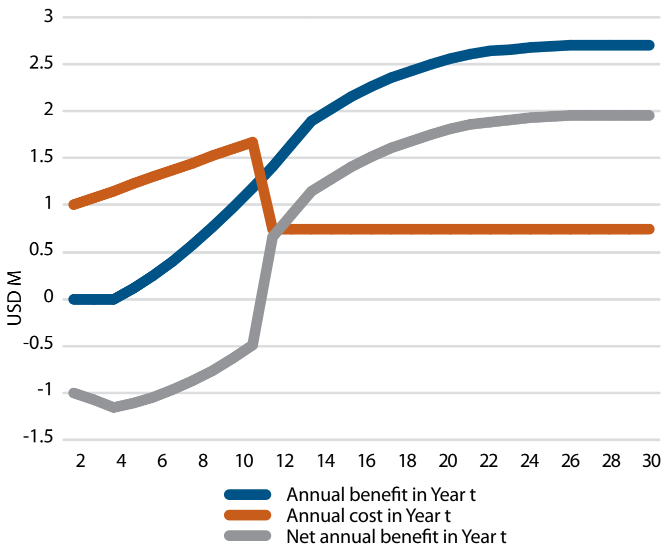
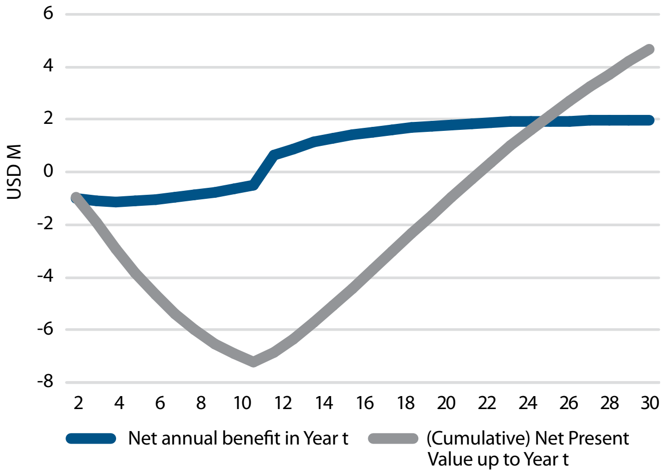


Figure 18 Annual net benefits and Net Present Value of the Water Fund as a whole (in USD million)



the discounted costs and benefits as they accumulate. Once the Net Present Value line crosses above zero, the Fund has reached viability. Under reference case assumptions, the Fund reaches viability near the 20th year after implementation. The relatively long time-period reflects the fact that investments are spread out over 10 years. While it is comparable to the 'payback period' heuristic that may be familiar from financial analysis, the payback period for an individual investment in a given year will generally be shorter. For the Fund overall, if the Net Present Value is positive at a time horizon deemed reasonable by the stakeholders, it is deemed an economically viable investment. Note that Net Present Value continues to rise rapidly as the time horizon is extended, and that in reality benefits will likely continue to accrue after 30 years.

Table 5 below represents a conservative estimate of the cumulative results across benefit streams. The result is a Net Present Value of US$5.9 million over 30 years. Further details on the underlying assumptions and parameters can be found in the Ecosystem Services Technical Appendix.

Note that the total present value of the investment is not equal to US$10 million because of the discounting that occurs over the 10-year implementation period. If all US$10 million were spent the first year, the present value of costs would be higher, but benefits would be higher as well.

In addition to the benefit streams listed in Table 5 there are a number of non-monetised benefits that have not been explicitly included in the Business Case, detailed in Table 6.

Sensitivity analysis

A sensitivity analysis was carried out to assess the impact of specific uncertainties on the overall viability of the

Table 5 Cumulative benefits across benefit streams

Stakeholder	Benefit/Cost	USD	M KSh
Water Fund	Investment cost	(7,110,000)	(640.0)
Ag producers	Net additional cost (maintenance, etc)	(8,520,000)	(767.0)
Ag producers	Upstream farmers	12,000,000	1,080.0
NCWSC	Avoided flocculant costs	394,000	35.5
NCWSC	Avoided electricity costs	36,700	3.3
NCWSC	Net revenue from saved process water	2,090,000	188.0
NCWSC	Total NCWSC benefits with scale-up	3,390,000	305.0
KenGen	Avoided interruptions	281,000	25.3
KenGen	Increased generation from increased water yield	5,870,000	529.0
KenGen	Total KenGen benefits	6,160,000	555.0
	Present Value of Benefits	21,500,000	1,940.0
	Present Value of Costs	(15,600,000)	(1,410.0)
	Net Present Value	5,900,000	530.0

Table 6 Non-monetised benefits

Stakeholder	Benefit
NCWSC	Reduction in wet sludge disposal
NCWSC	Avoided service interruptions
NCWSC	Increased dry season flows
Other water suppliers	Lowered sediment levels
Municipal water processors	More reliable water supply
KenGen	Reduction in reservoir sedimentation
KenGen	Avoided turbine intake maintenance costs
Upstream farmers	Increased fodder for livestock
Upstream famers	Additional income and employment opportunities
Urban private sector processors	Improved water supply
Local communities	Cleaner drinking water
General: Ecosystem services	More habitat for pollinators
General: Ecosystem services	Increased carbon storage in new trees planted

Business Case. The sensitivity analysis was conducted in three ways: a standard sensitivity analysis examining how overall ROI (in terms of Net Present Value) changes as key variables are changed; an exploratory analysis of the impact of less conservative assumptions; and finally a discussion of potentially important factors that are not captured in the modelling.

Parametric sensitivity analysis

Table 7 shows the impact of varying key values in the model by 10% (for continuous inputs), or one year (for time-related parameters). The benefits and costs are robust to unfavourable perturbations for all variables, from the already conservative reference case. The Ecosystem Services technical appendix discusses these sensitivities in more detail.

The switching values where Net Present Value falls to zero for the reference case are benefits decreasing by 27% or costs increasing by 37%. Anything less and the Net Present Value of the investment remains positive.

The "Net additional costs" variable is of particular interest. It does not show an extremely sensitive to a 10% perturbation, but it could vary (in either direction) by much greater than 10%. It captures (as a percentage of investment cost) both maintenance costs associated with the intervention, as well as the opportunity cost to farmers who might not have sufficient incentive to adopt measures. It also would account for benefits to farmers not accounted for elsewhere, such as improved farming practices and new income opportunities that are separate from the sediment-retention benefits provided by any intervention. (These would lower the cost value and so increase net benefits.) The reference cost (7.5% of investment costs) was based on a subset of maintenance costs identified. It could be somewhat higher or potentially negative, depending on implementation details and if there are significant benefits to farmers.

Table 7 Impact of varying key values in the Business Case model

Variable	Change	NPV after Change (US$ millions)
Benefits decrease:		
Timing of sediment benefits	One year later	5.2
Timing of agriculture benefits	One year later	4.9
Agriculture benefits relative to revenue	10% decrease	4.7
NCWSC processed water savings	10% decrease	5.6
Increase in water yield benefits for Masinga	10% decrease	5.3
Costs increase:		
Net additional costs as % investment cost	10% increase	5.1
Investment cost (also affect net additional)	10% increase	4.3
Implementation	Finish 1 year earlier	5.2
Time horizon	One year less	5.3
Discount rate	1% higher	3.8

Overall, the results also reveal the clear importance of the timing of benefits, as well as the fraction of agricultural revenues that can be considered true benefits, beyond additionally required input costs. Ideally, the relative sensitivities identified above could be assessed against plausible absolute bounds on their values, but gathering such data was a time-and cost-prohibitive exercise given the scope of this study. It is of interest for future work.

Exploring a higher-benefit scenario

For the overall analysis, some benefit streams were omitted and conservative values used in others. If a less conservative scenario assumes a higher fraction of revenue recovery as profit when NCWSC reduces back-flushing with processed water (90% vs 75%), 75% of agricultural revenue increases is captured rather than 50%, and moderately higher efficiencies in production within the Seven Forks power cascade beyond Masinga (91.5% vs 85%), then this adds 28% to the total benefits produced (from US$21.5 million to approximately US$28.5 million), which more than doubles the Net Present Value. None of these assumptions are particularly large, yet they add up to a significant impact.

As identified in the discussion of individual beneficiaries, there are other benefits that have not been quantified due to lack of data on key parameters. However, it is useful to see how the magnitude of benefits depends on the values of those missing parameters. The main benefits as yet unquantified are sludge disposal costs for NCWSC and the valuation of reduced suspended sediment by those households who get their raw water from streams. For NCWSC, valuation at approximately US$7 per ton of sediment leads to a present value of benefits of approximately US$1 million. For raw water users, if each individual valued the daily improvement in water supply at an average of one tenth of one Kenyan shilling per day (slightly over one tenth of one US cent), this would translate to approximately US$2 million of total benefits. Therefore, small values associated with these omitted factors can have large impacts.

Addressing uncertainty during implementation

Overall, the analysis demonstrates it is feasible for the Water Fund to achieve a Return on Investment of larger than one. However, the sensitivity of the results to the timing of benefits—and also the net additional costs associated with interventions—means that details of the implementation will play a crucial role in the overall viability. Prioritising interventions that generate early returns will result in benefits being larger and having more time to accrue.

In general, some interventions will likely yield additional benefits to farmers beyond those modelled, for example, participants teaching other best management practices to maximise agriculture income in the process of promoting sediment-retention activities. Another example is Napier grass, which provides sediment retention benefits, but can also be sold as fodder. On the other hand, there may be some farmers who are unwilling to participate in Water Fund activities unless they are compensated for their efforts, which would draw down the budget more quickly. Details such as these mean that careful implementation with a mind toward cost-effectiveness and early provision of benefits will be key. Fortunately, as discussed in the final chapter, two years of demonstration interventions are already providing additional information about cost-effectiveness. Continued modelling support is being developed to better understand the trade-offs between agricultural producer benefits and downstream users' costs.

While the overall soundness of the business case is on firm ground, the uncertainties mentioned above do mean that additional modelling work would be required to better understand the financial case for specific beneficiaries. This additional work would require more effort to value benefits that are currently non-monetised (such as sludge treatment at NCWSC, valuation of reduced turbidity by raw water users, and the value of reservoir storage for optimal hydropower production). It would also require improved representation of changes that will happen independent of the Water Fund, including projected land-use change and development plans for KenGen and NCWSC. Lastly, it would require greater exploration of uncertainties stemming from calibrating the models with limited data, and also the translation of Water Fund interventions into on-farm outcomes, to better assess net additional costs.

Implementing a water fund

Demonstration interventions

In order to show the value of green infrastructure interventions to meet desired outcomes, TNC, the Water Fund Steering Committee, and local NGOs have worked together to raise funds and design demonstration projects in the priority watersheds. The need for on-the-ground demonstration projects was asserted by a range of stakeholders because mobilising partners and capital for the Water Fund requires an understanding of which interventions could be scaled effectively in the Upper Tana.

In the Thika-Chania sub-watershed, more than 600 smallholder farmers have received support in implementing soil and water conservation structures in their farms. This support includes terracing to stabilise slopes and soil, installing water pans to collect and store runoff, and installing drip irrigation kits to increase water-use efficiency. Agroforestry has also been used as a means of improving soil stability and capturing runoff before it enters a stream. This work has been completed in collaboration with the Sustainable Agriculture Community Development Programme (SACDEP).

In the Maragua sub-watershed, more than 1,000 small-scale farmers are adopting water harvesting structures (e.g., water

Figure 19 Area where grass strips have been successfully implemented in the Upper Tana

pans that capture and store runoff for use in the dry season) and/or installing drip irrigation technology to support their horticulture-based livelihoods while reducing their water use. This work has been completed in collaboration with the Kenya National Federation of Agricultural Producers (KENFAP) and Frigoken Ltd.

In the Sagana-Gura sub-watershed, 7,000 coffee farmers have been recruited through the Green Belt Movement to adopt soil and watershed conservation practices that will prepare them to apply for certification by the Rainforest Alliance. The project is also engaging local women's groups in raising tree seedlings to rehabilitate two degraded forest slopes in the Mt. Kenya and Aberdare protected areas.

Working in partnership with business

Frigoken Limited is Kenya's largest vegetable processor for exports of processed vegetables, directly engaging tens of thousands of small-scale farmers in rural Kenya for its raw material supply needs. The company provides the farmers with an all-year-round guaranteed market and price for their produce. In order to secure a stable supply base, the company recognises the need to help small scale farmers adapt to the changing climatic conditions, which will inevitably impact crop yields. As part of its extension service provision on Good Agricultural Practices, Frigoken works collaboratively with the farmers, the local government and partners, like TNC, to develop and implement affordable and accessible water conservation projects that aim to address irrigation needs. One such project endeavours to support thousands of farmers establish water pans—a temporary storage solution where famers can harvest water either through pipes, nearby streams and rivers as well as rainwater.

'We are committed to working with likeminded organisations to improve the quality of life of the out growers and their communities. We commend and support TNC in the implementation of the Upper Tana–Nairobi Water Fund.'—Karim Dostmohamed, Chief Executive Officer, Frigoken Ltd

Interventions that work: Success in soil and water management

Jane Kabugi's three-acre farm is located on the slopes of the Kiama River, a tributary of Chania River close to the Ndakaini Dam operated by NCWSC. Upon retiring from public service, Jane constructed her house near the road for accessibility and kept the steeply sloping land for farming. Jane's aim was to open the remaining land for cultivation in an effort to increase food security for her family. However, this turned out to be very challenging.

During the rainy season, the water from the adjacent tarmac road would run down through her farm taking topsoil, fertiliser and sometimes crops into the Kiama River. This continued for six years until a local NGO, SACDEP, helped Jane with runoff management and knowhow on terracing in her farm as one of the pilot activities for the Water Fund.

The first stage was to install cut-off terraces above her house to redirect the storm water from the road. More terraces were excavated below the house, and Napier grass was planted to stabilise the soils. Jane also got bamboo seedlings to plant in a fragile section where soil was breaking. This stabilised the soil and is now providing fencing and construction materials. Jane is a respected farmer and leader in her community, known for growing vegetables, beans, maize and sweet potatoes. Her farm is now used as a demonstration to train other local farmers on soil conservation techniques.

'I now sell 150 to 200 kg of vegetables per week mostly to Ndakaini and Kimandi centres, which I could not do two years ago, and make about KSh 3,500 per week (US$40) which nearly matches the net salary I earned before retiring. There are even some people offering money for my Napier grass. Better still, I can now sleep without worrying about my house being washed down the hill.'—Ms Jane Kabugi

Overall, having a set of demonstration projects has proved effective in rallying new partners, developing field deployment systems, and refining the types of interventions that are likely to be successful in meeting the Water Fund's needs.

Proposed Water Fund structure

The Upper Tana-Nairobi Water Fund Steering Committee has been in place for well over a year, and meets approximately once a month. The focus of the Steering Committee to date has been guiding the design of the Water Fund's governance, oversight of project selection and implementation, and identification of opportunities to increase private-sector engagement. All this work is in preparation for Water Fund capitalisation and institutional registration.

The Steering Committee agreed that a Trust registered under Kenyan law as a charitable organisation and governed by a Board of Trustees is the preferred organisational structure. It will be a corporate legal entity in perpetuity for the sole purpose of funding soil and water conservation activities within the Upper Tana watershed.

The likely future Upper Tana-Nairobi Water Fund structure will be a Board of Trustees, which will manage the overall Water Fund operations and comprise 9 to 15 representatives from the major stakeholders of the Water Fund. It will have a set of committees as well as a Technical Secretariat, which will be responsible for implementing the decisions and policies of the board and will be responsible for the day-to-day management of the Water Fund activities. The Board of Trustees will manage the long-term funding mechanism that will provide the funds for the Water Fund's operations and conservation support.

The Water Fund Steering Committee has also noted that County government support is increasingly important to upstream activities, as agriculture has become a County government responsibility under the 2010 Kenyan Constitution.

Options for the Water Fund's structure, i.e., the mechanism in which conservation funding will be sustained, were discussed through the same stakeholder consultation process used for governance. Fund structure options reviewed by the Steering Committee include:

- **Endowment Fund**—a fund whose capital is invested in order to generate a steady annual stream of income. Only the investment interest and earnings are spent, while the principal is either maintained or increased.
- **Sinking Fund**—a fund designed to disburse its entire capital plus its investment income over a designated period of time.
- **Revolving Fund**—a fund that periodically (e.g., annually) is replenished through fees collected and/or through donor contributions.
- **Hybrid Fund**—a combination of two or more of these funding mechanisms.

At the end of the consultation process, the Steering Committee came to agreement that a 'Hybrid Fund' financial structure consisting of an endowment and a revolving fund is the best way to ensure sustainability and continuity of watershed investments. This decision can, of course, be taken up again once the Trust and Board of Trustees have been established.

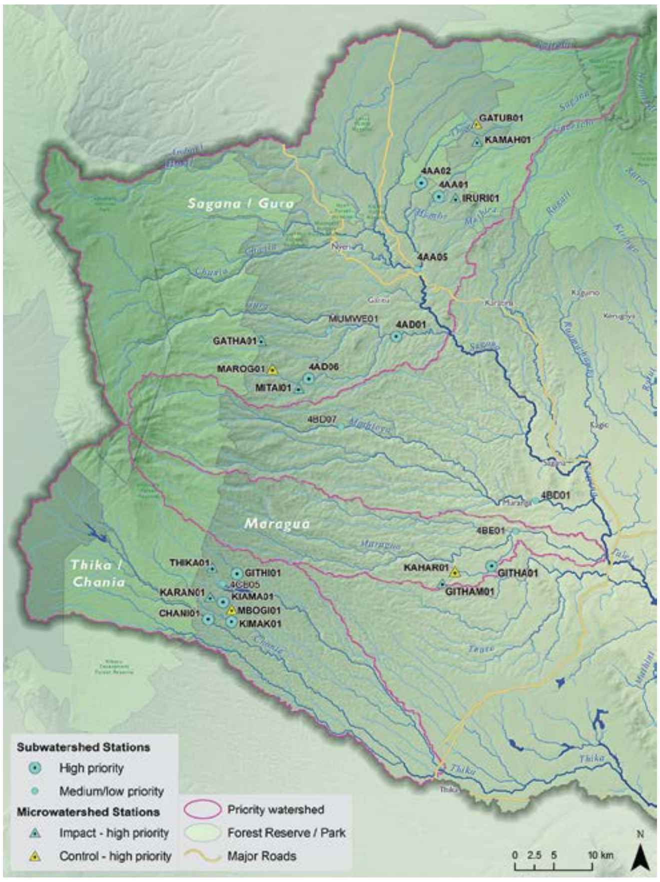
The Board of Trustees will determine the relative capitalisation of the endowment and revolving fund. In general, the Water Fund will have greater flexibility and be able to invest more in longer-term strategies if a higher proportion of the Fund is covered by an endowment.

Monitoring to support Fund implementation

Environmental monitoring

In parallel with the demonstration phase of the Water Fund effort, a monitoring framework has been developed for the Upper Tana-Nairobi Water Fund by WRMA, TNC, NCWSC, CIAT and other partners. The monitoring program is designed to help identify, refine, and prioritise management measures and demonstrate to stakeholders the progress of efforts made. In

Figure 20 Priority monitoring locations for sub-watersheds and also treatment and control micro-watersheds



addition to supporting continual improvement and adaptation, the monitoring program will also help identify larger-scale environmental trends.

Water Fund partners have prioritised 26 monitoring sites that will have new river monitoring stations installed or have their existing installations upgraded (Figure 20). Fifteen sites are considered 'sub-watershed stations' while 11 are considered 'micro-watershed stations'. Different data will be gathered at each type of station, as outlined below. Monitoring has begun prior to the formal launch of the Water Fund in order to get baseline information prior to major interventions.

Each of the sub-watershed stations will record river stage (to be converted to flow) and turbidity at a scale in which long-term trends that are meaningful to Water Fund goals can be detected. This data will be collected through automatic data recorders uploaded on a routine basis. Three critical sites for real-time monitoring have been identified along the rivers supplying the city of Nairobi—the Chania, Kiama and Kimakia Rivers—and telemetry capability will likely be installed. Manual samples will be periodically collected for turbidity, total suspended solids, and flow.

The results will be a proof of concept of the impacts of different conservation interventions and demonstrate what success looks like in the Upper Tana watershed. The full Water Fund environmental monitoring plan is available for those who are interested.

Socioeconomic assessment

A key goal of the Upper Tana-Nairobi Water Fund is to have a positive and measurable impact on the livelihoods of smallholder farmers in the area. To this end, baseline socioeconomic surveys were undertaken in Water Fund priority sub-watersheds (Sagana-Gura, Thika-Chania, and Maragua) in late 2013 and early 2014. The baseline surveys were designed to support a future impact assessment, using a design that ecologists know as a 'before-after, control-impact (BACI)' approach and economists know as a difference-in-differences (DiD) assessment. Over 1,500 people were surveyed using a randomised cluster approach.

Beyond providing valuable baseline data, the surveys led to useful recommendations for Water Fund implementation and monitoring. For example, the survey identified areas with steep and very steep farmlands that lack terraces and areas that lack buffer zones of permanent vegetation along local rivers, but where local people are eager to implement soil erosion measures. This detail can help with the micro-targeting of Water Fund activities.

The completed baseline assessment was designed to allow for either a 'panel data' or a 'cross-sectional approach' to a future impact evaluation. The Steering Committee's plan is to carry out both quantitative and qualitative impact assessments if time and resources allow.

Next steps: The Upper Tana-Nairobi Water Fund in 2015

2015 is a busy year for the Water Fund as its partners use the results of this Business Case and other inputs to move into the next phase. This next phase will commence with an official, public launch of the Water Fund in March 2015. With this launch, the process of the Water Fund registering as a Trust under Kenyan law will also begin.

While the Water Fund is transitioning to a Trust, the Steering Committee will begin to plan priorities for the next phase of implementation, building upon this study and lessons learned in the field. Future interventions will include those that were included in this study (i.e., riparian management, agroforestry, terracing, reforestation, grass strips, and road mitigation) but will also likely include those interventions that were not able to be modelled (e.g., water-efficient irrigation, quarry reclamation, reduced tillage, mulching). On-the-ground interventions will be informed by this study, but will also be responsive to the types of local-scale environmental and social needs for which no modelling data exist at the scale of the Upper Tana. The Water Fund also plans to expand its partnership with government, community groups, and the private sector including building synergies with stakeholders working on efficient and effective water delivery to Nairobi citizens.

The Water Fund will also be involved in a new modelling project funded by CGIAR's Water, Land and Ecosystems programme that will develop novel methods for integrating models that currently focus separately on ecosystem service provision and agricultural productivity. Improving the models that prioritise where to invest for both agricultural productivity and environmental benefits will be of clear utility to the Water Fund project, given the significance of the agricultural benefits discussed in this study.

Conclusion

The Upper Tana Basin is a watershed under pressure. Unsustainable land-use practices are impacting both the quality and quantity of water supply to one of Kenya's most important economic regions, including the capital Nairobi. Changes to the way in which the watershed is valued and managed will not happen unless a new approach is taken which includes financial incentives and a long-term commitment to investment in green infrastructure.

The results of the Business Case demonstrate a clear economic basis for the establishment of an Upper Tana-Nairobi Water Fund. A US$10 million investment in Water Fund inventions is likely to return US$21.5 million in economic benefits over a 30-year timeframe. In other words, for every US$1 invested by the Water Fund, stakeholders in the basin will see over US$2 worth of benefits accrued. The payback period for the investment is calculated at approximately 20 years.

The calculation of benefits was conservative. Where uncertainty existed, benefit streams were scaled down to avoid overestimation, and sensitivity analysis shows they could be reduced further while still maintaining economic viability. When less conservative but highly plausible benefits are included (for example, modest increases in hydropower production efficiency), the returns of the fund increase rapidly, even while several potentially important benefit streams remain non-monetised.

Making the shared vision for the Upper Tana-Nairobi Water Fund into a reality will require the continued dedication of the Water Fund Steering Committee, the participation of NGO and community groups, and support from government. Funding and operational support for the Water Fund has primarily been through TNC and donors such as the Global Environmental Facility and SIDA to date, and TNC will continue to act as a catalyst for the Water Fund as it transitions to an independent organisation. The success of the Water Fund as an independent entity will depend on expanding public and private financial support. That support is anticipated to be a mix of funding from major Nairobi water users, who recognise the clear business case behind this effort, and from generous donors with interests in the environment and development sectors given the clear value of the Water Fund to both.

Figure 21 Ndakaini Dam in the Thika-Chania sub-watershed provides the main water storage for Nairobi City water supply

Appendices

This Business Case document distils a great deal of technical work which could not be given adequate attention in the above text. Interested readers will find three appendices available as electronic supplements at www.nature.org/africa-water, each detailing key technical aspects of the study.

- Appendix 1: Developing Cost-Effective Investment Portfolios for the Upper Tana-Nairobi Water Fund, Kenya ("RIOS Appendix")
- Appendix 2: Impact Assessment of Investment Portfolios for Business Case Development of the Nairobi Water Fund in the Upper Tana River, Kenya ("FutureWater Appendix")
- Appendix 3: Ecosystem Services Assessment and Valuation of Proposed Investments for the Upper Tana-Nairobi Water Fund ("Ecosystem Services Appendix")

There are also other documents prepared in support of this study and the Upper Tana-Nairobi Water Fund available online.

Photo credits

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