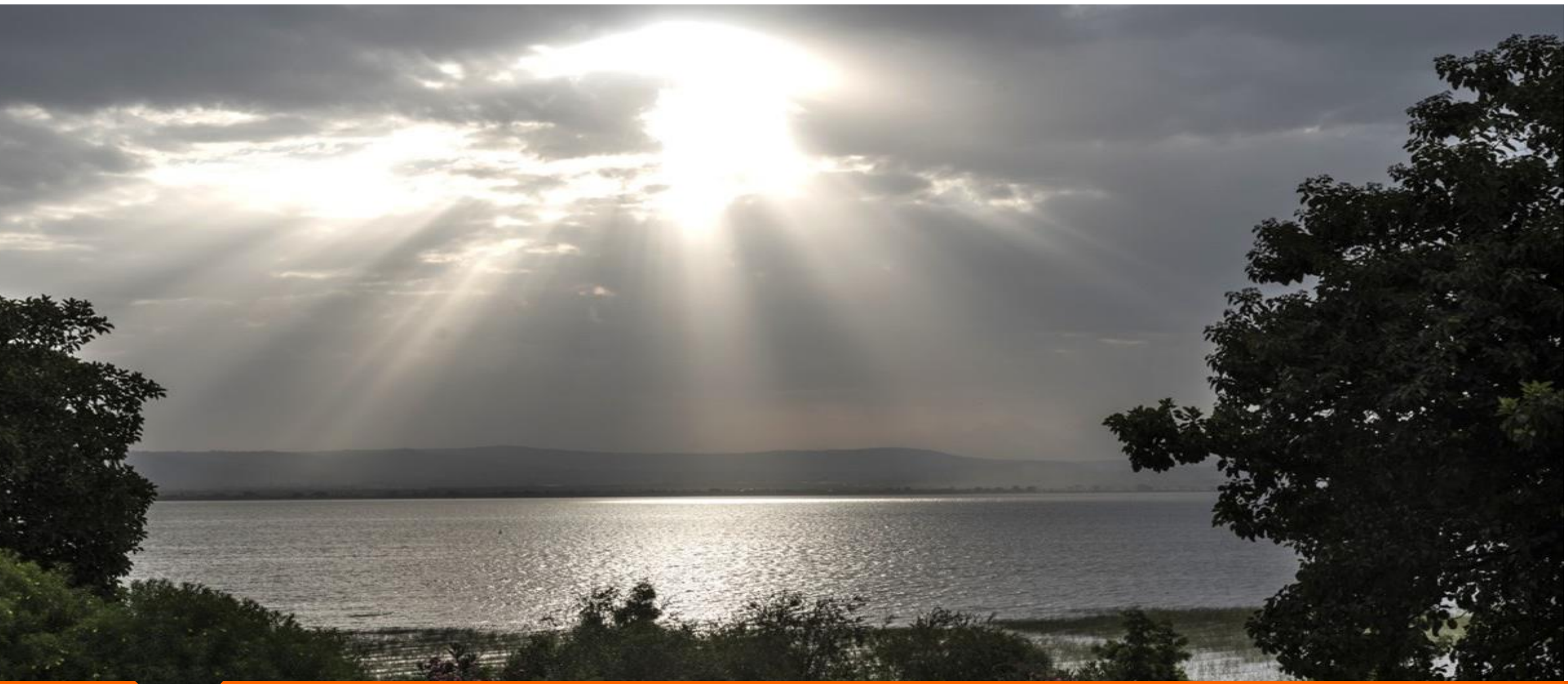
Feasibility Assessment Report



Addis Ababa Water Fund

Addis Ababa, Ethiopia

15 March 2021

EXECUTIVE SUMMARY

Purpose of Feasibility Assessment

This Feasibility Assessment seeks to assess whether a Water Fund is an appropriate and a feasible mechanism to improve water security for the citizens of Addis Ababa. Water Funds are financial and governance mechanisms developed by The Nature Conservancy for safeguarding watersheds. They seek to protect and restore strategic ecosystems that are key to supplying water to cities across the globe. Typically, water funds involve downstream water beneficiaries as payers to upstream watershed keepers to sustain conservation effort at scale. They sometimes draw capital contributions from large water users such as: water supply companies, hydroelectric schemes, beverage companies, and irrigation districts, in an organized and transparent manner. Then, they invest these capital resources in ecosystem conservation in upstream catchments to maximize utility to all stakeholders.

This Feasibility Assessment is the first step in a well-defined project cycle of designing, capacitating, and establishing a prospective Water Fund. It is a critical step in informing the key stakeholders whether to invest in the next steps of the process. A Water Fund for the Addis Ababa City and key watersheds in the Oromia Region could play a key role in the water security challenges facing the area. A Water Fund could make a transformational contributions toward:

i. Developing a shared and feasible vision of Water Security needs that creates **cohesive** water-related decision making, implementation and governance; and
ii. Convening different stakeholders to generate socio-political will around these water security needs, to enable significant, positive impact through **collective action;** and
iii. Offering an attractive vehicle for pooling a multitude of resources to ensure the **continuity** of investment in source water protection and conservation

A Water Fund in this context could also contribute generally to other supportive improvements in the source water sector such as scientific evidence to improve knowledge around the water security challenge, and driving implementation of NbS and other innovative projects in the Akaki Watershed.

Structure of Feasibility Assessment

This Feasibility Assessment has been structured to outline key thematic profiles that characterise Addis Ababa's water supply *status quo* and water resources management context. The Feasibility Assessment can be used as a reference document to detailed information on the key thematic profiles. The report is laid out in sections that respond to the main disciplines of Team's feasibility assessment. This introduction section provides a brief overview of Addis Ababa's water supply background and challenges, which is followed by Section 2 that highlights key development initiatives that need to be carefully considered as the water fund concept progresses. Sections 3 to 6 outline the specific profiles required for the feasibility assessment, including: (3) technical and environmental; (4) institutional; (5) political; and (6) financial and economic. Finally, Section 7 provides concluding remarks and makes some early recommendations.

Technical and Environmental Profile

The City of Addis Ababa is facing a water crisis, which is most starkly characterised by a deficit in potable water supply of almost 50%. A prospective Water Fund could provide some targeted, strategic responses to this crisis, through collective action with the private sector, catchment residents and civil society organisations (CSOs) to increase the financial capacity to implement the response. It could also be catalytic in mobilising resources for other long-term water security interventions. Specifically, these will include soil and water conservation activities in the upper catchment that contribute to increasing water supply to Addis Ababa through: minimising soil erosion (which decreases the capacity of reservoirs); increasing groundwater aquifer recharge (especially important to manage a growing reliance on groundwater resources); and increasing baseflow to watercourses which supply the City's main reservoirs. Ultimately, a potential Water Fund would drive the implementation of multipronged measures to address water security problems. The proposed modality is one where the Water Fund would actively implement nature-based solutions and conservation activities to protect source waters and ecological infrastructure in the Akaki Watershed. In addition, the Water Fund would play a transformative role by serving as a mechanism to support collective action in other green and grey infrastructure solutions also to improve the water sensitivity of Addis Ababa, and the efficiency of the City water supply system.

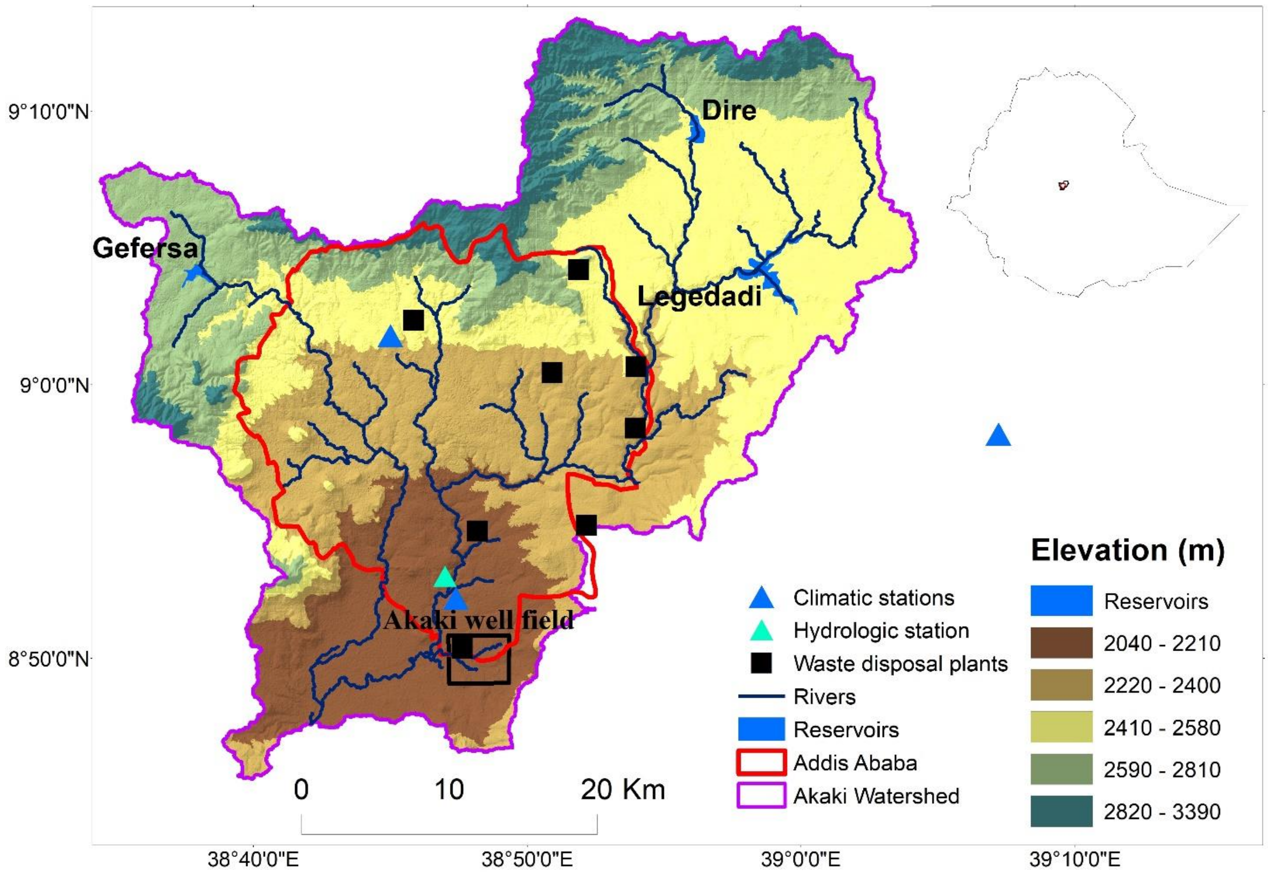


Figure 1 The Akaki watershed showing locations of Legedadi, Dire and Gefersa reservoirs and Akaki well fields. The background image is the elevation map with the boundary of the Addis Ababa city in red. Climate and streamflow monitoring stations are also indicated in the map

A watershed modelling study was undertaken on the Akaki Watershed by the Team to assess current and future water demand and supply to Addis Ababa from the Dire, Legedadi and Gefersa Reservoirs, as well as the Akaki groundwater wellfield (see Figure 1). The modelling shows that the gap between the City's potable water demand and supply has been widening, primarily due to urban population growth and socio-economic lifestyle improvements. The population of Addis Ababa was 392,000 in the 1950s and it grew to more than 4 million by 2015, with projections suggesting it will surpass 6 million by 2037 (Addis Ababa Water and Sewerage Authority, 2020). There has also been a decrease in relative water supply due to the diminishing efficiency of existing reservoirs and the depletion of the groundwater aquifer. The water demand and water supply analysis showed that demand will not be met for several years during the period 2020-2050 without interventions to safeguard water resources and increase supply capacity.

Four scenarios were modelled to understand the impacts of various water supply interventions. The water supply may be met around 2030 when all the planned surface water and groundwater development projects will be implemented. In its 10-year development plan (Addis Ababa Water and Sewerage Authority, 2020), the AAWSA planned various projects to increase the water supply of the City from 599,000 m^3/day in 2019 to 1.076 Mm^3/day by 2029. However, because of increasing population, the water demand will surpass the supply after 2030. This suggests that if any of the planned water supply projects will not be materialized, the gap between the supply and demand will be substantial. In the worst-case scenario, continuing only with the existing water supply sources, the water supply will cover only 17% of the demand in 2050.

Institutional Profile

The Institutional Profile sets out the various laws, policies and strategies that define the regulatory framework relevant for a future Water Fund, as well as legal institutional context of the activities it performs. None of these hinder the establishment of a Water Fund or provide restrictive measures against collective action to conserve source waters. These policies support the creation of a Water Fund as they encourage multi-stakeholder governance by helping to bring together public, private and civil stakeholders. This will serve to attract political influence, societal trust, and credibility to a Water Fund's creation, as well as initiate interventions. However, gaps in policy implementation and organisation mandate overlaps have been cited as a hindrance to natural resource conservation and rehabilitation.

There are numerous laws, policies and strategies that define the regulatory framework relevant for a future Water Fund. However, institutional mandates, arrangements, and relationships for WRM and water supply in Ethiopia are not well defined and integrated. The following institutions and their mandates are most notable, when considering a steering committee for the creation of a water fund: (i) Federal - Ministry of Water, Irrigation and Energy (MoWIE) and Ministry of Finance (MoF) via the Water Resources Development Fund (WRDF); (ii) Regional - Oromia Bureau of Agriculture and Natural Resources and Oromia Bureau of Minerals, Water and Energy; (iii) Local – Addis Ababa City Administration (AACA) represented by the Addis Ababa Water and Sewerage Authority (AAWSA); and (iv) Other – Awash Basin Authority.

The **Oromia Bureau of Agriculture and Natural Resources** committed to aligning their own resources with objectives of the Water Fund, as well as offering political support to the initiative. The Bureau has an interest in both runoff flow and ground water recharge potential as reduced percolation is emerging as a challenge in many parts experiencing rapid urbanisation. The Bureau is also invested in supporting the communities residing in Oromia Region, especially in building capacity to protect the watershed. The **Addis Ababa Water and Sewerage Authority** are committed to engaging with the Water Fund to address their water security concerns around security of supply, siltation, and watershed degradation. The Authority has an interest in supporting rural livelihoods in taking care of the watersheds. They have already been involved in some preliminary conservation actions at the Woreda level in soil and water conservation activities. Potential **private sector partners (breweries and beverage companies)** have also indicated interest in supporting the Water Fund as part of corporate social responsibility (CSR) as well as corporate social investment (CSI) to help their organisations mitigate water-related challenges.

The Water Fund would benefit from involving representatives from existing programmes and institutions that are active in the water sector are also involved in the Water Fund steering committee or organisation. This is to ensure that the Water Fund can align with and support existing efforts, as well as to address a current overarching institutional challenge in the Ethiopian water sector – overlapping mandates. Public partners have made good progress in facilitating multi-stakeholder engagements in the water sector; however, this has only been on a short-term, project-specific basis.

Both direct, and indirect water-related conflicts over the last ten years have been identified in the Akaki Watershed at the regional level. It is most notable that no overarching functional agreements currently exist between Addis Ababa and Oromia Regional State – not only on water use, but also on sanitation, solid waste disposal, pollution, etc. This causes uncertainty when, among other things, water resources need to be shared, feeding into the institutional misalignment that undermines effective watershed management.

Financial and Economic Profile

At the local level in Addis, AAWSA sets a common tariff structure, which is applied across domestic and non-domestic users which increases per cubic metre with greater consumption. Currently, tariff revenues do not fully cover operational costs, and capital expenditure is predominantly supported by loans and grants from the Federal Government or International Cooperating Partners (ICPs). Revenue collection through tariffs is therefore an unlikely income avenue for the proposed Water Fund, as is the case with other funds in Africa. At present, there is no private sector support for capital projects. Payments and agreements between AAWSA and the Oromia Regional State for WRM appear to be managed on a project-by-project basis, with no formal or standing arrangements in place. This shines light on a financially resource-constrained environment in Addis Ababa, which could be a short-term barrier to the proper establishment of the prospective Water Fund, unless alternative revenue mechanisms can be identified at the Design Phase.

The niche for the Water Fund in Ethiopia is the **public-private partnership (PPP)** structure and **catalysing collective action** around water resources management. The private sector support to rural communities in the catchment and targeted water security measures and practices within Addis must be complemented by public sector contributions. Engagements with the private sector at Feasibility Phase have been limited by the absence of a detailed business case. During the Design Phase it will be necessary to re-engage private sector representatives with a clearer understanding on investment decision metrics and results from a detailed financial assessment.

An institutional structure or organisation form into which the private sector is willing to place their money will be essential – the configuration of which must be developed in the Design Phase. The Public-Private Partnership Proclamation no1076/2018 is the appropriate vehicle through which to understand the potential Water Fund structure. Whilst the Proclamation states that the Federal Government entity responsible for the relevant infrastructure service will normally initiate PPP proposals and transactions, these will be subject to the approval or direction of a new PPP Board. The requisite multi-stakeholder composition of the board suggests that the water sector will be a likely area for future PPP activity, but it remains to be clarified whether water resources management and ecological infrastructure will be approved given the initial conceptual focus on applying this model for (grey) infrastructure and its operation and maintenance.

Concluding Remarks

A multi-pronged approach is required to address the water security crisis for Addis Ababa. A Water Fund could play a strategic and catalytic role in responding to this crisis over the long-term. Practically, a potential Water Fund could assist with the implementation of multipronged measures that balance conservation activities to protect source waters in the Akaki Watershed, and engineered solutions to improve the efficiency of the City water supply system. A set of early recommendations are made in this report, including: (a) long-term institutional strengthening using the Water Fund to establish a multi-stakeholder governance platform; (b) fostering early ownership of the Water Fund by establishing a steering committee soon; (c) undertaking nature-based solution (NbS) and other soil and water conservation activities in the upper-Akaki watershed; (d) decentralised water supply options within Addis Ababa's urban delineation; (e) maximising reservoir potential, by fully harnessing the existing reservoir catchment areas; (f) other surface water options outside the Akaki watershed must be explored urgently; and their design integrates green infrastructure investments in the source waters, and (g) groundwater recharge interventions should be prioritised in urban and rural areas of the Akaki watershed.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

AA	Addis Ababa
AACA	Addis Ababa City Administration
AARPO	Addis Ababa Resilience Project Office
AAWSA	Addis Ababa Water and Sewerage Authority
ABS	Access and Benefit Sharing
AfDB	African Development Bank
ARBA	Abbay River Basin Authority
AwBA	Awash Basin Authority
BoAs	Bureaus of Agriculture
BLAUs	Bureaus of Land Administration and Use
CALM	Climate Action through Land Management
CBO	Community-based Organisation
CRGE	Climate Resilience and Green Economy
CSE	Conservation Strategy of Ethiopia
CSI	Corporate Social Investment
CSO	Civil Society Organisation
CSR	Corporate Social Investment
EBSFMIA	Ethiopian Bottled Water, Soft Drink Food and Manufacturing Industries Association
EFCCC	Environment, Forest and Climate Change Convention
EIA	Environmental Impact Assessment
EPA	Environmental Protection Agency
EPE	Environmental Policy of Ethiopia
FAO	Food and Agriculture Organisation
FDRE	Federal Democratic Republic of Ethiopia
GBP	Great British Pound
GCF	Green Climate Facility
GEF	Global Environment Fund
GHG	Greenhouse Gas
GIS	Geographical Information System
GRCN	Global Resilient Cities Network
IKI	International Climate Initiative (German Government)
ITCZ	Inter-tropical Convergence Zone
IWRM	Integrated Water Resources Management
LDC	Least Developed Country
MOU	Memorandum of Understanding
MOWIE	Ministry of Water, Irrigation and Energy
MRV	Measurement, Reporting and Verification
M&E	Monitoring and Evaluation
NAMA	Nationally Appropriate Mitigation Actions
NAP	National Action Plan
NAPA	National Adaptation Plans of Action
NBSAP	National Biodiversity Strategic Action Plan
NDC	Nationally Determined Contribution
NGO	Non-Governmental Organisation
NRMD	Natural Resources Management Directorate
NRW	Non-Revenue Water

OMWEB	Oromia Minerals, Water and Energy Bureau
PPP	Public-Private Partnership
RBA	River Basin Authority
RBHC	River Basin High Commission
RBO	River Basin Organisation
RCP4	Representative Concentration Pathway 4
RCP8	Representative Concentration Pathway 8
RVLBA	Rift Valley Lakes Basin Authority
S2T	Source to Tap
SAP	Strategic Action Plan
SC NIP	Stockholm Convention National Implementation Plan
SDG	Sustainable Development Goals
SGP	Small Grants Programme
SLMP	Sustainable Land Management Programme
SWAT	Soil and Water Assessment Tool
TNC	The Nature Conservancy
UN	United Nations
UNCCD	UN Convention to Combat Desertification
UNDP	UN Development Programme
UNFCCC	UN Framework Convention on Climate Change
USD	United States Dollar
VEI	Vitens Evides Internationale
WASH	Water, Sanitation and Hygiene
WB	World Bank
WF	Water Fund
WHO	World Health Organisation
WRDF	Water Resources Development Fund
WRM	Water Resource Management

1 Introduction

This Feasibility Assessment Report is for a prospective Water Fund in the City of Addis Ababa, in partnership with Oromia Regional State (specifically Akaki, Burayu, Gelan, Salulta and Sendafa). The report is the first of three deliverables as part of the Feasibility Phase of the Water Fund development process (process outlined in Figure 2. The other two deliverables include: (a) plans and budgets for the next two water fund development phases (Design and Creation Phases); and (b) a decision-support document, to aid key decision-makers in how to proceed. The Feasibility Phase has two primary objectives, to:

(i) determine if a Water Fund is an appropriate and feasible mechanism to improve water security for the citizens of Addis Ababa, in partnership with Oromia Regional State; and

(ii) recommend whether to proceed with the water fund design and other stages (Figure 2), or not.

Figure 2: Stages in the Development of a Water Fund[1]

Our Team's multi-disciplinary assessments focus on the three (3) predominant watersheds to the north of the City, namely: Dire; Gefersa; and Legedadi, as well as one (1) predominant aquifer to the south of the City.

The report is laid out in sections that respond to the main disciplines of Team's feasibility assessment. This introduction section provides a brief overview of Addis Ababa's water supply background and challenges, which is followed by Section 2 that highlights key development initiatives that need to be carefully considered as the water fund concept progresses. Sections 3 to 6 outline the specific profiles required for the feasibility assessment, including: (3) technical and environmental; (4) institutional; (5) political; and (6) financial and economic. Finally, Section 7 provides concluding remarks and makes some early recommendations.

[1] Accessed from TNC's Water Funds Toolbox, here: https://waterfundstoolbox.org/how-are-water-funds-developed

1.1 WATER SUPPLY BACKGROUND

The provision of potable water supply to Addis Ababa (referred to herein as the "City") began in 1901[2] after 15 years of its formal establishment in 1886. The water supply sources were Kebena and Kechene rivers of the City (Sime, 1998; Adam, 1999). The Entoto water treatment plant with a capacity of 1,500 m^3 day^{-1} was commissioned in 1938 to treat water of Kebena River and Kidane Mehrete springs (Adam, 1999). However, unprecedented growth in the City's urban population and economic activity significantly increased the water demand, especially after the 1950s.

The population of Addis Ababa was 392,000 in the 1950s and it grew to more than 4 million by 2015, with projections suggesting it will surpass 6 million by 2037 (Addis Ababa Water and Sewerage Authority, 2020). Along with this rapid rise of population, the demand for water has outgrown the supply capacity and the Addis Ababa Water and Sewerage Authority (AAWSA) should make urgent steps to meet the increasing water demand. AAWSA has been producing water from different sources such as: spring developments; Entoto Water Treatment Plant; successive Gefersa reservoir constructions; Legedadi Reservoir and Water Treatment Plant; Dire reservoir; and other well and spring developments (Sime, 1998; Adam, 1999). Development of these surface water and groundwater sources enabled AAWSA to increase its water supply from 219,380 m^3/day in 2005 to 599,000 m^3/day in 2019 (Table 3-3, AAWSA, 2020). Currently, the majority of the potable water production is sourced from groundwater sources (62%) and the remaining 38% comes from surface water sources (i.e. Legedadi, Dire and Gefersa surface water reservoirs) (Table 3-3). The increase in the water supply for the period 2005 to 2010 was mainly achieved through development of multiple groundwater bore halls (Table 3-3).

The Legedadi reservoir was commissioned in 1970 through the government of Ethiopia, and in the early years of its establishment, it was supplying 50,000 m^3 per day of water (Sime, 1998). Due to an increase in water demand in the City, the Legedadi Water Treatment Plant was expanded by building the Dire Reservoir Project in 1998, upstream of the existing Legedadi Reservoir. This increased the water storage capacity of Legedadi Reservoir. The combined water storage of the two reservoirs is 120 Mm^3 (86 Mm^3 and 34 Mm^3, respectively), and thereby supplies 165,000 m^3/day to Addis Ababa City (AAWSA, 2011). The Gefersa Reservoir I/II is another source of surface water which was constructed in 1944 (Adam, 1999). To increase water storage capacity of Gefersa Reservoir I/II and also to trap silt, Gefersa reservoir III was constructed in 1966. Gefersa Reservoir systems have a water storage capacity of about 8 Mm^3 and supply 30,000 m^3/day of water to Addis Ababa City (FDRE: MoWR, 2002). These surface water supply sources, their original commissioning dates, reservoir volumes, and daily water supply amounts are summarized in Table 3-4.

Groundwater sources which are located throughout the City, such as the Akaki wells, springs, and deep wells, are other sources of water for the City. Until 2010, springs, shallow- and deep-wells have been supplying 75,156 m^3/day to the city (AAWSA, 2011). Thereafter, significant investment was made in groundwater bore hole development. For example, the new Akaki well field, which supplies 73,000 m^3/day of water was commissioned in 2012 (AAWSA, 2012). Other springs, wells and deep wells have been commissioned in

[2] All years are in Gregorian Calendar

different parts of the City since 2012 (Table 3-2). In fact, the AAWSA developed a Business Plan for the period 2011 to 2020 that increases the groundwater contribution from 75,156 m^3/day in 2010 to 599,000 m^3/day in 2019 (AAWSA, 2020). Future groundwater wells are planned to be developed in the Akaki, Legedadi, Ayat, Sebeta and Melka Kuntire areas which are located in the southern, northern and south western parts of the City (AAWSA, 2020). Most of the planned groundwater bore holes are located in the Akaki Watershed, Melka Kuntrie borehole site.

Recently, the City Government has taken multiple measures to improve the water supply and demand management. AAWSA has been increasing water sources and taking measures that reduces water losses due to leakage and misuse. In the City water supply system, more than 30-36% of the supplied water is lost through leakages and other inefficiencies in the distribution system (AAWSA, 2012), which is significant for a city of this size. Based on the volume of domestic and non-domestic water demand of 2019, about 292,000 m^3/day of water is lost (AAWSA, 2020).

1.2 WATER SUPPLY CHALLENGES

While water supply has been increasing in the City, it has not kept pace with the demand. Moreover, most of the increases in the water supply, especially since 2010, came from investments in groundwater sources. Water supply from groundwater sources more than doubled between 2010 and 2015, but the supply from surface sources did not increase (see Table 3-4).

Although the City has regularly increased its water supply, significant urban population growth has caused an unprecedented increase in water demand over the last two decades. This trend will likely continue into the foreseeable future. For example, according to Alemu and Dioha (2020), unmet water demand in 2030 may be 841,096 m^3/day, which means that the unmet demand between the period 2015 to 2030 may increase by 48%.

Soil erosion is a significant issue in Ethiopia and in the Northern Akaki Watershed where the water supply reservoirs for the City are located. The soil erosion, therefore, has been causing siltation of water supply reservoirs and thereby reducing reservoirs live water storage volume. For example, the storage capacity of Legedadi Reservoir reduced by 4.5% (i.e. from 45.9 Mm^3 to 43.8 Mm^3) in the period 1979 to 1998 (Dar Al Omran, 2011).

Non-Revenue Water (NRW) and water loss issues also constrain AAWSA’s ability to maintain supply at pace with demand. Current demand management practices include improving efficiency of water delivery and minimizing losses by fixing leakages in pipes, storage tankers, distribution systems and processing points (FDRE MoWR, 2002). The other measure to improve the demand side water management was implementing tariffs on domestic, non-domestic and industrial water users (Addis Ababa Water and Sewerage Authority, 2012). However, AAWSA still experiences an almost 40% NRW measure (Addis Ababa Water and Sewerage Authority, 2020).

Climate change is another factor which exacerbate the existing disparity between water supply and water demand in the City. Under intermediate climate change scenario of RCP4.5 (Representative Concentration Pathway 4.5) and high population growth rate of 3.3%, the unmet water demand in the City will be 239,506 m^3/day, 43,3917 m^3/day and 1,043,095 m^3/day in 2030, 2035 and 2037, respectively (Arsiso et al., 2017). Under low population growth rate of 2.5% for the year 2037, unmet water demand will be 704,876 m^3/day and 862,767 m^3/day for the RCP8.5 and RCP4.5, respectively (Arsiso et al., 2017). The RCP8.5 scenario represents an extreme climate change condition.

2 Existing & Planned WRM Initiatives

Maintaining awareness and alignment between ongoing projects and programmes in water resources management will be a key activity for the Addis Ababa Water Fund. The following are important programmes which are already underway that bring together some of the key institutions identified above, and notably, have facilitated co-financing toward water resources management and conservation.

2.1 IWRM 4 WASH

Integrated Water Resources Management for Water Sanitation and Hygiene (IWRM 4 WASH) 2019

The IWRM for WASH project is underway through a partnership between the Royal Netherlands Embassy, Vitens Evides Internationale (VEI), AAWSA, and the Oromia Water, Energy and Minerals Bureau (OMWEB). IWRM 4 WASH seeks not only to benefit the population of Addis Ababa, but also, target towns in Oromia Regional State: Akaki, Burayu, Gelan, Salulta and Sendafa

There are key areas of alignment between this programme and the proposed Addis Ababa Water Fund, as evidenced by the IWRM 4 WASH programme's eight objectives:

1. To strengthen the trans-regional dialogue between Addis Ababa City Administration, AAWSA, OMWEB and other stakeholders in Upper Awash River Basin
2. To enhance the water quality and reduce the risk of siltation of the water reservoirs in Legedadi and Gefersa, in order to improve reliability and quality of water supply for AAWSA and the population of Addis Ababa.
3. To enhance the livelihood of rural people living in water resource areas of Addis Ababa (Legedadi, Gefersa, Dire and Akaki in Oromia) by creating alternative income opportunities as incentives to encourage conservation activities for communities living within and adjacent to sources of water.
4. To develop alternative and reliable sources of water for the same rural communities especially those living adjacent to water resource facilities
5. Enhance economic instruments and systems of economic incentives (positive or negative) with the aim to change behaviour and enhance environmental protection.
6. Develop institutional capacity of Addis Ababa City administration, AAWSA, OMWEB and other stakeholders in Upper Awash River Basin in IWRM.
7. Promote knowledge management and sharing of emerging solutions and experiences for replication and upscaling.
8. Support the potential of young people to contribute to Ethiopia's water, sanitation and hygiene and water resources management.

This programme demonstrates a willingness by government institutions (in this case AAWSA and OMWEB) to contribute financially to Public Private Partnerships (PPPs). The IWRM4WASHmshows that the precedent for establishing PPPs for water resource management and conservation has also already been set.

2.2 SOURCE TO TAP AND BACK (S2T&B)

Through a partnership between Vitens Evides International BV, Adama Town Water Supply and Sewerage Service Enterprise; Addis Ababa Water and Sewerage Authority; Ethiopian Public Health Institute; MetaMeta; Oromia Water, Mineral and Energy Bureau; Rijksinstituut voor Volksgezondheid en Milieu; Waterschap Vallei and Veluwe, and Waterschap Zuiderzeeland, the Source to Tap and Back project aimed to achieve improved river basin management, safe deltas and improved WASH in the Upper Awash Basin of the Oromia Regional State. The projects key interventions included:

1. Integrated water resource protection
   - Establishment of a framework for integrated water resource protection and water quality monitoring using a stakeholder approach;
   - Improve control of wastewater discharges focussing on the Upper Awash and Akaki Rivers.
2. Drinkwater reservoir protection
   - 50% reduction of sedimentation in catchment reservoirs around Addis Ababa;
   - Improved sanitation for 25,000 people in buffer zones around these reservoirs of Addis Ababa.
3. Improved water services with AAWSA, Addis Ababa and AWSSE, Adama
   - Water Safety Plans and Performance Improvement Plans implemented within AAWSA and AWSSE;
   - Reduction and Management of Non-Revenue Water (see box below) in order to improve
4. Water Supply and Increase Water Safety in Addis Ababa
   - Access to safe water for 25,000 people in Adama;
   - Implementation of emergency programme for improved supply of water in Adama.
5. National Joint Capacity Education and Information Centre
   - Building and establishment of the Joint Capacity Education and Information Centre;
   - Capacity building for trainers and training material.

2.3 UNDP GEF SMALL GRANTS PROGRAMME (GEF-SGP)

Ethiopia joined the Global Environment Facility (GEF)-SGP in 2005, in line with the key eligibility criteria set out by the GEF Council. One of the important considerations was strong efforts made by the Government of Ethiopia to address the threats facing the country due to climate change and deteriorating environmental conditions. Since the SGP was officially launched in June 2006 it has funded and provided technical supports for a total of 227 grantees (GEF-SGP, 2019). Out of the allocated/committed resources to the grantees (Community Based Organisations (CBOs) and Non-Governmental Organisations (NGOs), 34% was in-kind co-finance which has been covered by the grantees and local governments.

With regards to the focal area distribution, Land Degradation thematic area was the largest portfolio sharing (51.5%) followed by Biodiversity (28.6%), Climate Change (16.3%), Capacity Development (2.2%), Chemicals and Wastes (0.9%), and International Waters (0.4%). The key achievements during the most recent operational phase were; 2883 hectares of degraded land have been rehabilitated and restored through area closure and sustainable forest management, the productivity of 1864 hectares of farmland has been improved as a result of compost application, 1896 energy efficient stoves and 2010 solar panels were distributed to the beneficiaries that contribute to global GHG emission reduction. A total of 2740 people were benefiting from the income generating activities of which 59 % are women (GEF-SGP, 2019).

SGP has created momentum around focal areas for source water protection (land degradation, regenerative agriculture, biodiversity maintenance etc). The model for the GEF SGP involves a widespread call for proposals in Amharic and other local languages, as well as extensive engagement with CBOs. This precedent for engagement and inclusivity is an essential foundation on which the Addis Ababa Water Fund could build.

2.4 SUSTAINABLE LAND MANAGEMENT PROGRAMME (SLMP)

Over the past 15-20 years, the GoE has established a well-developed institutional and technical framework for supporting work on sustainable land management at scale. In order to mitigate ongoing erosion and soil nutrient loss in the productive agricultural highlands of the country, the government of Ethiopia initiated a Sustainable Land Management Program (SLMP) targeting 209 woredas (districts) in six regions of the country. It has terraced hillsides, constructed bunds to collect rainwater and allow it to seep into the soil, lightly dammed gullies, planted trees and practised climate-smart agriculture through composting, managing landscapes, and agroforestry - among other measures with a national focus (Global Environment Facility, 2017).

The key supporting partners are the World Bank and the Global Environment Facility. The institutional responsibility for leading and coordinating action on SLM is the responsibility of the Ministry of Agriculture (MoA). Under the MoA, the Natural Resource Management Directorate (NRMD) and Rural Land Administration and Use Directorate (RLAUD) are instrumental. At regional and local level, support is channelled and delivered by regional Bureaus of Agriculture (BoAs) and Land Administration and Use (BLAUs), and administrations at the woreda level (equivalent to district). Other ministries and agencies also play relevant roles, for example, the Ministry of Women and Children Affairs leads in defining and monitoring the policy and regulatory framework for economic and social empowerment of women and girls; and the Environment, Forest and Climate Change Commission (EFCCC) is responsible for coordinating and ensuring the forestry objectives and principles indicated in the forestry policy of Ethiopia are implemented. The Ministry of Water, Irrigation and Electricity (MoWIE) is responsible for the development and management of its water and energy resources in a sustainable manner.

2.5 ETHIOPIA OFF-GRID PROGRAMME

Innovative funding solutions to the tune of $1.5 billion are being explored for an energy-water-food nexus approach in Ethiopia as an attractive way to crowd in a wider spectrum of capital. The programme would like to remain in close collaboration with the development of the prospective Water Fund due to the water resources focus and the potential synergies and co-financing opportunities. SouthSouthNorth (SSN), through funding from the German Government's International Climate Initiative (IKI), has been supporting the mobilisation of capital for the implementation of Nationally Determined Contributions (NDCs), thereby assisting several developing countries towards realising their low-emission and climate-resilient development goals.

The Memorandum of Understanding (MOU) for the provision of technical support was entered in Addis Ababa between the MoWIE, and SouthSouthNorth (SSN), to facilitate the creation of an enabling environment for mini-grid systems in Ethiopia. SSN is working closely with Veritas Consulting (based in Addis Ababa) and Powerhive (a US-based firm) to identify potential levers and policy recommendations that will support the Government of Ethiopia in facilitating private sector investment in off-grid rural areas and in creating an enabling environment for the mini-grid sector. Ultimately, the mini-grids sub-sector solution was considered to be the most appropriate and viable for investigation in the next phase of the IKI MI project. The project has developed a financial model to enable MoWIE to evaluate and plan mini-grid projects, and further work includes the collection of data to validate 50 mini-grid sites in Ethiopia.

3 Technical & Environmental Profile

3.1 INTRODUCTION

The technical profile for the water fund feasibility assessment was conducted using secondary data from different sources (e.g. AAWSA, 2020; 2012; 2011) and watershed modelling. The study assessed current and future water demand and supply in the Addis Ababa City (hereafter called the City). The modelling study was focused on the Akaki watershed (Figure 3) where all the current water supply reservoirs and groundwater well fields are located. The Akaki watershed is located in the Awash River Basin of Ethiopia surrounded by the Entoto, Menagesha and Yerer Mountains. What follows is a summary that presents only key messages from the full technical analysis, which is presented as Appendix A.

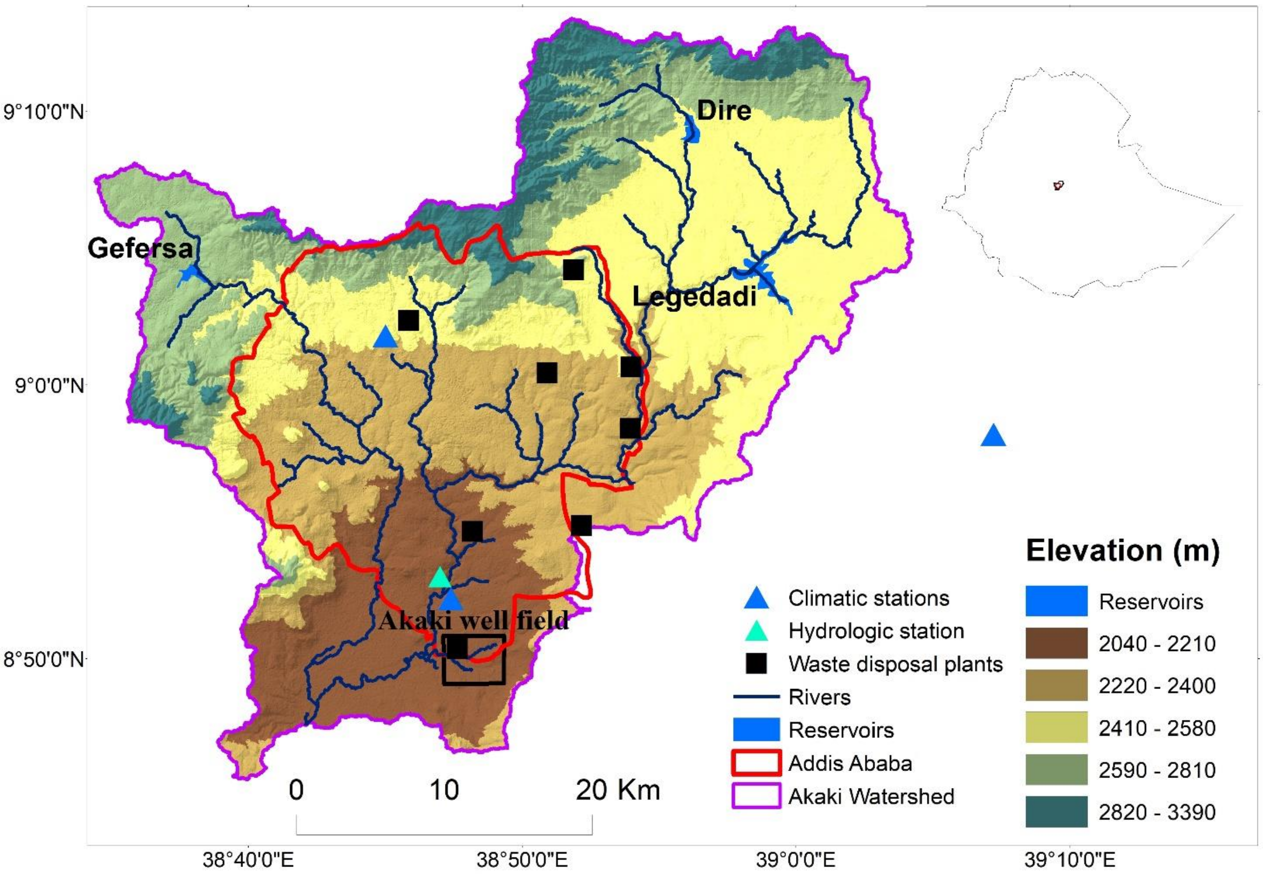


Figure 3 The Akaki watershed showing locations of Legedadi, Dire and Gefersa reservoirs and Akaki well fields. The background image is the elevation map with the boundary of the Addis Ababa city in red. Climate and streamflow monitoring stations are also indicated in the map

3.2 CLIMATE AND ECOSYSTEM PROFILE OF THE AKAKI WATERSHED

The Akaki Watershed has generally a mild climate. There are two rainfall seasons: the main rainfall season occurs during the period June to September and the short rainfall season spans the period March to May. The months from October to February are generally dry. The upper part of the Akaki Watershed is characterized by cool, humid and moist highlands because of mountains such as Entoto, Wochecha and Menagesha. The downstream part of the watershed is under a moderate temperature zone with the average temperature in the range of 16 °C and 21 °C (MoA, 1998). The spatio-temporal long-term average annual rainfall in the Akaki watershed is about 1000 mm, and the spatio-temporal long-term average monthly temperature ranges between 16 °C and 19 °C.

3.2.1 LAND COVER IN THE AKAKI WATERSHED

The Akaki Watershed is largely covered by cultivated land and built-up areas (Table 3-1 and Figure 4). The land use classes estimated between 1985 and 2016 to show considerable changes in the land use dynamics over a period of 30 years. The cultivated land showed modest decrease from 1010 km^2 (70% of the watershed) in 1985 to 906 km^2 (62.7% of the watershed) in 2016. Cultivated land exists in most parts of the watershed, especially the eastern and southern parts. Both 1985 and 2016 maps showed mosaic land uses in the western part of the watershed with a concentration of forest and other vegetation patches in certain areas such as the Entoto, Menegesha and Yerer mountains. The forest cover reduced from 14% in 1985 to 7.5% in 2016. The reduction in the cultivated land, forest and grazing land is mainly due to an increase in the built-up area with the expansion of the Addis Ababa City. The built-up areas increased from 43 km^2 (3% of the watershed in 1985) to 308 km^2 (21.3% of the watershed) in 2016. The rapid expasion of the City occurred mainly to the southern directions, which may be attributable to rugged and steep topography in the northern direction preventing such expansion. The swamp land cover class increased from 1985 to 2016 while the water bodies decreased. The water bodies represent the City water supply reservoirs such as the Legedadi, Dire and Gefersa Reservoirs and Abba Samuel Lake. The Aba Samuel Lake is not part of the water supply system; it is rather used as a wetland to reduce pollution flowing into the downstream ecosystems.

Table 3-1 Land use classes in the Akaki watershed for the 1985 and 2016 (Authors own analysis using USGS, 2015).

Land use type	Years			
	1985		2016	
	Area (km^2)	% of watershed	Area (km^2)	% of watershed
Built-up area	43	2.976	308	21.315
Cultivated land	1010	69.896	906	62.699
Forest	202	13.979	108	7.474
Grazing land	119	8.235	33	2.284
Shrub land	56	3.875	76	5.260
Swamp land	1	0.069	7	0.484
Water body	14	0.969	7	0.484

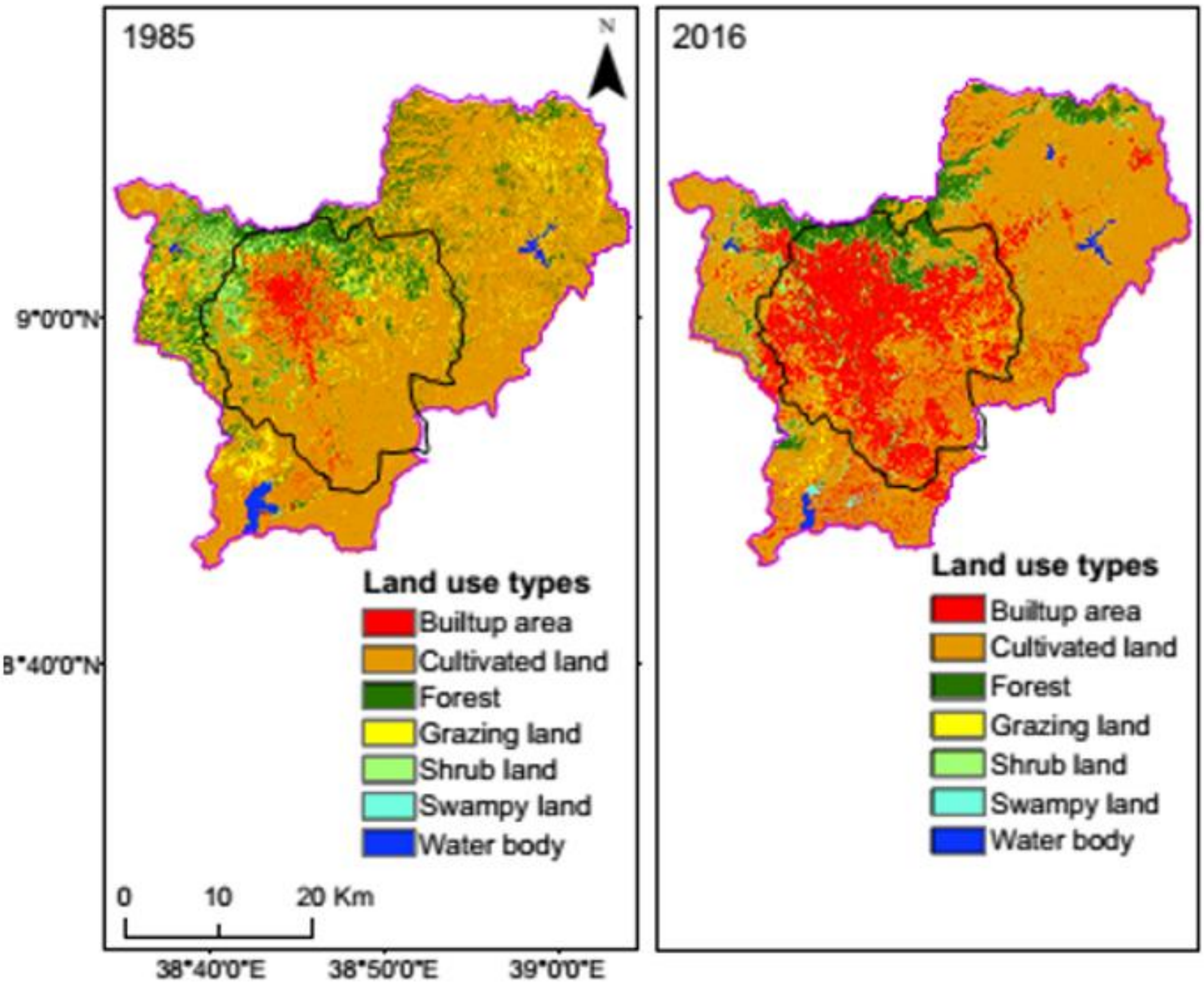


Figure 4 Land Use maps of the Akaki Watershed 1985 and 2016 (Authors own analysis using USGS, 2015

3.2.2 BIODIVERSITY IN THE AKAKI WATERSHED

The Akaki watershed which consists of the Entoto, Menagesha, and Yerer mountains, and multiple wetlands and water bodies (e.g. Abba Samuel Lake, surrounding wetlands) and has rich biodiversity (USAID, 2008). The rich biodiversity is treasured due to the diverse topography of the watershed, the unique forest reserves, and the beautiful terrain (e.g. Entoto, Wochecha and Menagesha mountains). Because of its source of fresh air to the City, the Entoto mountain is referred as the "lung of Addis Ababa city". Moreover, the mountains are the source of many of rivers of in the Akaki watershed. For example, Kebena, Little Akaki and Big Akaki start from the Entoto Mountain. The Aba Samuel Lake, and surrounding wetlands are the other key biodiversity sources and functioning ecosystems in the Akaki watershed that have been naturally cleaning domestic, commercial and industrial wastes generated from the City thereby reducing pollution entering into the Awash River and the groundwater aquifer (Worku, 2017). Urban ecosystems and natural habitats for biodiversity include the City's green spaces, city parks and hotel and church forest reserves that have been serving recreational, social, and religious functions in the urban and peri-urban environments.

The Entoto mountain forest, for example, comprises of different vegetation species. It has woody species of 3374 stems/ha in tree density including Juniperus procera, Carissa spinarum, Rosa abyssinica and Myrsine

Africana (Woldegerima et al., 2017; Atinafe et al., 2020). About 179 of the tree species in the Entoto mountain belong to 107 genera and 60 families (Table 3-2). Of the total tree species, 77 were woody plant species where Eucalyptus globulus, Eucalyptus camaldulensis, Casuarina equisetifolia, Juniperus procera and Cupressus lusitanica are the dominant woody species (Atinafe et al., 2020). The Entoto Mountain is also home to different animal species. For example, there are about 517 individual birds belonging to 49 species. Asefa (2018) reported that over 20 of the bird species are endemic to Ethiopia; 11 of them are shared with only one or two other countries. In the Entoto National park, 200 species of birds have been recorded; two of which are Ethiopian endemics. Esayas and Bekele (2011) observed 124 bird species belonging to 14 orders and 44 families in the Entoto Natural Park from July to October 2009 .The Akaki watershed is also home to several mammals including hyena, monkeys, small antelope, mole rats, civet cats, wild cats, leopards, and rodents. Likewise, different species of insects were reported in the forests of the in the vicinity of the Entoto mountain. For example, Adugna (2010) reported 18 families of insects in Ankorcha forest, 25 in Sheger park and 64 in Gulelle botanic garden.

Table 3-2 Biodiversity in the Entoto Mountain of Akaki Watershed

Taxonomy	Total number of species	Endemic species	Reference
Trees and shrubs	179	20	Atinafe et al., 2020
Birds	200	11	Asefa, 2018
Mammals	8	-	Fasil Adugna, 2010
Insects	43	-	Fasil Adugna, 2010

The Menegasha mountain forest consists of dry afromontane forests, which has been protected since the 1600's. The forest covers about 9248 hectares of land, of which, 5000 hectares of land is covered by natural forests; 3000 hectares of land is covered by plantation forest; and the rest is occupied by nursery station and grassland (The Ethiopian Herald, May 6/2020). Fetene et al. (2010) reported the presence of 142 different woody plant species which belong to 56 families in the Menagesha mountain forest. They reported that 59 of the woody plant species were identified to offer different non-timer forest products. Acacia melanoxylon, Juniperus procera, Myrsine Africana, Olea europea and Scolopia thiefolia are the dominant woody species of the Menagesha forests. Tilahun et al. (2015) reported that the total density of trees per hectare, and basal area of trees with DBH >2.5 cm were 4,362.08 and 84.17m^2/ha, respectively. A vertical stratification study showed that most of the species in the Menagesha Amba Mariam Forest were found in the lower storey (Tilahun et al., 2015). There are also different non-woody species such as herbaceous flowering plants. A total of 128 species representing 102 genera and 44 families of herbaceous flowering plants were recorded in the Menagesha Forest (Etefa, 2011). The Menagesha mountain forest is also home to different fauna species including about 32 species of mammals such as Colobus Monkey, Anibus Baboon, Hyena, Minilik's Bushbuck, Warthog (The Ethiopian Herald, May 6/2020). The Menagesha mountain forest also hosts a number of bird species. For example, the Ethiopian Herald (May 6/2020 issue) reported availability of about 186 bird species in the Menagesha mountain that belong to 16 orders and 45 families. Among these bird species, four of the species namely Yellow Fronted Parrot, Abyssinian Wood Pecker, Black Headed Siskin, Abyssinian Catbird are endemic to Ethiopia (The Ethiopian Herald, May 6/2020). Desalegn et al., (2021) reported that in the

Menagesha mountain the highest species diversity (H'=3.60) was recorded in the forest habitat and the lowest species diversity (H'=2.95) in the farm land. Bekele (1996) observed about 12 different species of rodents in the Menagesha forests from November 1991 to July 1993.

Table 3-3 Biodiversity in the Menagesha Mountain of Akaki Watershed

Taxonomy	Total number of species	Endemic species to Ethiopia	References
Trees and shrubs	142	-	Fetene et al., 2010
Birds	186	12	Desalegn et al., 2021
Mammals	32	1	The Ethiopian Herald, May 6/2020
Rodents	12	1	Bekele, 1996
Herbaceous plants	128	14	Etefa, 2011

Yerer mountain of the Akaki watershed also consists of rich biodiversity with dry afromontane forests. The forests of the Yerer mountain covers an area of 3254 ha which consist of mixed native forests and established plantations. Bato et al. (2020) reported that the plantations cover 1793 ha while the mixed natural forests cover 1461 ha. Yahya et al. (2019) identified 31 indigenous woody species in the Yerer mountain forests which belong to 23 families. The dominant woody species in the Yerer mountain forest include Juniperus procera, Pittosporum abyssinicum, Buddleja polystachya, Rhus retinorrhoea, Croton macrostachyus, Prunus Africana, Acacia bussei, Hagenia abyssinica, Olea europaea subsp, Podocarpus falcatus, Cordia Africana, Eucalyptus globulus, Cuppressus lustanica, Eucalyptus camandulensis, Eucalyptus saligna, Pinus patula, and Grevillea robusta (Yahya et al., 2019; Bato et al., 2020). There are also different fauna species in the Yerer mountain forest. For instance, Bato et al. (2020) reported 7 species of rodents during wet and dry seasons.

Wetlands and waterbodies such as Aba Samuel Lake and the surrounding wetlands were identified as homes to different bird and fish species in the Akaki watershed (USAID, 2008). For example, Kassegne et al. (2019) identified two fish species (i.e. African catfish (Clarias gariepinus) and common carp (Cyprinus carpioL.) in the Aba Samuel Lake: Janko (2014) reported that this Aba Samuel Lake and the surrounding wetlands has the potential to support 234 ton/year of fish. Moreover, Fetene and Worku (2013) identified 74 species of trees and shrubs in different sub-cities of Addis Ababa. Fetene and Worku (2013) reported that a woody species diversity of 1.35, and species richness and evenness of 44 and 0.80, respectively in the city of Addis Ababa.

3.2.3 ECOSYSTEM SERVICES OF THE AKAKI WATERSHED

The Akaki watershed has different ecosystem services ranging from most human dominated ecosystems (e.g.urban areas) to less human dominated ecosystems (e.g. mountain forests and wetlands). The mountain ecosystems are located in the upstream of the watershed, while human dominated, cultivated and wetland ecosystems are located in the middle and downstream of the watershed. The mountain ecosystems include the Entoto, Wochecha and Menagesha with average annual rainfall and potential evapotranspiration in the range of 1000-1050 mm and 1300-1500 mm, respectively. Wetland ecosystems are located surrounding the Abba Samuel Lake and along the river courses of the watershed. Based on agroecological zonation which accounts physiography, soil, vegetation, climate, animal and human activities (MoA, 1998), the upstream of the Akaki watershed is characterized by cool humid and moist highlands, while the downstream part of the watershed is under tepid (moderate) temperature zone, in which the average temperature ranges between 21°C and 16 °C. Based on the Millennium Ecosystem Assessment (MEA) report of 2005 (MEA, 2005), the ecosystem services in the Akaki watershed are presented as provisioning services, regulating services, cultural services, and supporting services in the following sections.

Provisioning Services

The Entoto, Menegesha and Wochecha mountains of the Akaki watershed have been sources of freshwater, food and firewood for the Addis Ababa City and surrounding communities. For example, the Entoto, and Menegesha mountains are source of water for many rivers such as Kebena, Little Akaki and Major Akaki tributaries that supply domestic and industrial water to the Addis Ababa City and surrounding communities. Likewise, the highlands in the Akaki watershed have been used as sources of pure water to multiple bottling companies. The highlands of the Akaki watershed have also been releasing water for irrigation activities to the downstream communities in the watershed. These irrigation activities have been contributing to the market demands of vegetables, fruits and other agricultural commodities to the City and surrounding community. The forests of the Entoto Mountain have been sources of fuelwood to the City's population and the local community (Amare et al. (2016). Likewise, forests of Mengesga mountain consists of about 59 tree species that provide different non-timer forest products such as traditional medicine, household utensil, honey and bee-wax, fuelwood, farm implement, animal fodder, edible forest products, smoke wood, and flavoring and spices (Fetene et al., 2010).

Regulating Services

The elevated topography and forests of Entoto mountain in the Akaki watershed provide unique ecosystem services of regulating the local temperature and rainfall. The forests in the Entoto mountain have also been helpful in sequestering carbon, and reducing soil erosion in the highland areas (Amare et al., 2016; Woldegerima et al., 2017; Feyissa and Gebremariam, 2018). The unique topographic features of the Entoto Mountain (i.e. steep and elevated mountain aspect) resulted in a stratified local climate in the City. The mountains of the Akaki watershed (i.e. Entoto, Menegesha and Wechecha) have relatively higher wind speed that facilitates air circulation and thereby provides fresh air to the City (Feyissa and Gebremariam, 2018). As such, the Entoto Mountain is referred as the "lung of Addis Ababa city". The potential role of Akaki mountains in carbon sequestration was also studied by Woldegerima et al. (2017) in which they showed that in the dense, medium and open forests of Entoto Mountain, the carbon density were 293 ton/ha, 142 ton/ha and 132 ton/ha, respectively.

The forests and vegetation patches in the Akaki watershed have high water holding capacity , which helps to reduce peak streamflow, surface runoff, and soil erosion. Woldegerima et al. (2017) showed that indigenous trees such as juniperus forest and mixed forests in the Entoto mountains has lower soil erosion rate than their counterpart Eucalyptus forests in the watershed. Feyissa et al. (2018) have also reported that parts of city that have no or little vegetation cover are highly vulnerable to extreme temperature and rainfall events including flooding compared to areas which have better vegetation cover. Moreover, the wetlands in the Akaki watershed played significant role in cleansing polluted water coming from eroded areas and industries. For example, the Aba Samuel Lake, and the surrounding wetlands have been naturally cleaning domestic, commercial and industrial wastes coming from the City and the upstream areas (Worku, 2017).

Cultural Service

The Akaki watershed has beautiful landscapes including mountains, city parks, and public (hotel and church) forest reserves that provide recreational, cultural, religious, and ecoturism sevices. For example, the church forests in the Entoto Mountain have been destinations of religious practices to the Addis Ababa City and the surrounding community (Kent and Orlowska, 2018). Due to its beauty, multiple cultural and historical sites, and accessibility to the Addis Ababa City, the Entoto Mountain has been a critical ecotourism site (Asefa, 2018). The famous Entoto St. Mary church which has rich historical artifacts (e.g. houses, mural paintings and precious antiquities) is located in the Entoto Mountain is a key historical site of importance, which also elevates the profile of cultural ecosystem services in the area (Ambaw, 2015).

Supporting Ecosystem Services

Litter and leaves that fall from trees and grasses in natural ecosystems of the Akaki watershed have been the source of organic nutrients for the soils of the area (cf. McDonald and Healey, 2000). The topographic diversity also facilitates soil formation due to the prevailing physical and chemical weathering, soil erosion and deposition processes (cf. Krasilnikov et al., 2007). The forests in the Akaki watershed has been providing key primary production such as oxygen and habitat to wild animals.

Threats to the ecosystem services in the Akaki Watershed

The ecosystem services in the Akaki Watershed are under extensive pressure from increasing urban population growth, agricultural activities, and expansion of industries. These socio-economic drivers together with the erratic rainfall and other climate impacts threaten the ecosystem services in the Akaki watershed. For example, increasing rate of vegetation loss and expansion of human dominated land use types (i.e. increasing of built up areas, agricultural and industrial activities) are causing an increase in surface runoff, land surface temperature, and flooding as well as a reduction in groundwater recharge. Moreover, the decrease in the forest coverage in the watershed may result in degradiation of biodiversity and lose of habitat.

The expansion of urban areas, agricultural and industrial activities have increased pollution of the surface water and groundwater resources in the Akaki watershed. For example, industries that are located in the Gefersa sub-watershed release industrial effluents without sufficient waste treatment that cause fresh water quality impairment. The Legedadi and Dire sub-watersheds also host several industries (e.g.the Ethio-Turkish International Industry) that extensively use surface water sources and release pollutants to the downstream freshwater without adequate treatment (ACATIAWATER, 2020). Anteneh et al. (2018) studied the water quality of Legedadi and Dire reservoirs using pH, Turbidity, Total hardness, lead (Pb), iron (Fe), and chromium (Cu) as water quality indicators and found that most of the water indicators were below the standard showing serious water pollution happening in the reservoir watersheds. Like the surface water resources, the groundwater resource experienced serious threats of pollution and over extraction. Most (about 90%) of the waste generated from the Addis Ababa City is dumped close to the Akaki well fields, which is the source of the majority of the groundwater supply to the City (ACATIAWATER, 2020). Moreover, the extensive groundwater extraction by the AAWSA and private water bottling companies is depleting the groundwater aquifer in the Akaki well fields. Industries located in Addis Ababa City and its surrounding areas (e.g. Legedadi, Sebeta, Akaki and Dukem) are also using substantial amount of groundwater for their industrial activities. Due to this uncontrolled extraction of the groundwater by public institutions and private companies, about 84.5% of the wells in the Akaki well-field are below water level. For example, the old Akaki well field is severely depleted in which 13 out of 24 wells are abandoned as water level and groundwater discharge is too low to pump (Muleta and Abate, 2020).

Lastly, limited nature based conservation measures are currently implemented to improve water supply and environmental sustainability in the Akaki watershed, especially in the watersheds of Legedadi, Dire and Gefersa reservoirs. The implemented catchment conservation measures include terraces, check- dams, afforestation, vegetative strips, drainage ditches and stone/soil bunds (Dar Al Omran, 2011). However, a large area of the watershed, especially the cultivated lands, is exposed to soil erosion without any of these conservation measures (Estifanos, 2015).

3.3 ADDIS ABABA'S CURRENT WATER SUPPLY SYSTEM

3.3.1 EXISTING WATER DEMAND AND SUPPLY

The increase in population and simultaneous lifestyle improvements have caused an increase in water demand in the City. The AAWSA has been developing surface water and groundwater sources to address this ever-increasing water demand (Table 3-4). Construction of surface water storage dams for water supply started in 1944 when the Gefersa Dam-I/II was built. The latest developments in surface water storage infrastructures is expansion of the Legedadi Dam through construction of the Dire Dam in 1998. Lately, the AAWSA has been supplying additional water through groundwater well developments. As of 2005, groundwater sources were supplying only 31,381 m^3/day of water; however, the water supply from groundwater sources increased to 169,000 m^3/day in 2015 (Table 3-4). However, the latest water supply and demand data for the period 2005 to 2015 collected from AAWSA showed that the supply does not meet the City's demand (Addis Ababa Water and Sewerage Authority, 2012; Addis Ababa Water and Sewerage Authority, 2020). For example, the water supply in 2019 met only 54% of the water demand (Table 3-4 and Table 3-5).

Table 3-4 Existing water supply from surface and groundwater sources to Addis Ababa City (source: AAWSA, 2011; AAWSA, 2020).

Year	Water supply (m^3/day)				Water demand including losses (m3/day)
	Legedadi-Dire	Gefersa	Groundwater	Total water supply	
2005	165,000	23,000	31,381	219,381	380,041
2006	165,000	23,000	39,014	227,014	NA*
2007	165,000	23,000	48,381	236,381	NA
2008	165,000	23,000	54,208	242,208	NA
2009	165,000	23,000	64,605	252,605	NA
2010	165,000	30,000	75,156	270,156	541,491
2011	165,000	30,000	94,058	289,058	NA
2012	165,000	30,000	111,707	306,707	NA

Year	Water supply (m³/day)				Water demand including losses (m3/day)
	Legedadi-Dire	Gefersa	Groundwater	Total water supply	
2013	165,000	30,000	131,027	326,027	NA
2014	165,000	30,000	133,767	328,767	NA
2015	180,000	30,000	169,000	379,000	737,306
2019	195000	30000	374000	599,000	1,103,885

*NA refers no data.

3.3.2 CHALLENGES IN THE CURRENT WATER SUPPLY SYSTEM

The gap between the water demand and water supply for the City has been widening due to population increase and lifestyle improvements creating a demand that outpaces supply because of diminishing efficiency of existing reservoirs and depletion of the groundwater aquifer. The efficiency of the reservoirs is reducing because of sedimentation and leakages from the dams. Soil erosion is severe in the reservoir catchments, which is aggravated due to improper land management practices including tillage of steep slopes. Such land management practices are causing landslides and the formation of gullies in the tributaries that supply water to reservoirs. Other biophysical factors such as land use and climate changes may also exacerbate the gap between the water demand and water supply. For example, field observations and consultation with experts indicated that eucalyptus trees predominate the forest cover, and increased soil erosion has been a challenge since shades from the eucalyptus trees cannot allow growth of vegetation which could protect the soil layer. Effective watershed rehabilitation or protection practices are not implemented to restore and abate the soil erosion in the reservoir catchment areas. Moreover, there is no buffer zone for the reservoirs themselves. Settlements, agriculture and quarrying of minerals occur in the reservoir catchment areas. Such practices are increasing soil erosion/sedimentation and pollution.

3.3.3 STATUS OF GROUNDWATER WELLS IN THE AKAKI WATERSHED

The Addis Ababa City requires additional water supply sources due to a critical shortage of supply, especially for residents living at the outskirts of the city and at topographically high places (Muleta and Abate, 2020). Groundwater well development was considered as an option to overcome the problem. All the groundwater well fields developed until March 2020 for the City are located in the Akaki Watershed (Muleta and Abate, 2020). Since the Akaki Watershed is located adjacent to the main Ethiopian Rift Valley, it is in a zone with a complex geological structure (Muleta and Abate, 2020). Fractured basalt, coriaceous basalt, scoria, fractured ignimbrite or a combination of these rock formations constitute the major aquifers of the Akaki Watershed (Muleta and Abate, 2020). Muleta and Abate (2020) conducted pumping tests on 166 deep borehole which are located in the Akaki well field and found that hydraulic conductivity and transmissivity in the area vary from 0.02 to 256 m/day and 5.4×10^1 to 2.16×10^4 m^2/day, respectively.

The Akaki well fields are under a risk of depletion due to high extraction and competition between AAWSA (i.e. water supply to the City) and private industries including groundwater mining companies (ACATIAWATER, 2020). For example, in the old Akaki well field, 13 out of 24 wells are abandoned as water level and groundwater discharge is significantly declined (Muleta and Abate, 2020). Using three profile groundwater mapping, Muleta and Abate (2020) reported that average static water levels across the watershed ranges between 40 m to 54 m below ground surface. Based on the water level contour map for Akaki well-field, Muleta and Abate (2020) reported that 84.50% of the current pumping water levels were below the dynamic water level, and only 15.5% are in good enough condition that the pumping water levels are above the dynamic water level. Such findings, therefore, suggest that care should be taken in relaying only on the limited groundwater resources to supply water to the Addis Ababa City.

3.4 WATERSHED MODELLING TO ASSESS AVAILABLE WATER RESOURCES

The available water resources and soil erosion situation in the Akaki Watershed was estimated using a SWAT model. The Akaki Watershed has an area of 1445 km^2 with elevation range of 2040m and 3400m. The SWAT model was calibrated and validated using observed streamflow and sediment data at the outlet of the Akaki Watershed. The performance of the model simulation was evaluated using various statistical evaluations and provided satisfactory results. This calibrated and validated model was used to estimate available water resources and sediment storage at different time steps in the three existing water reservoirs (i.e. Legedadi, Dire and Gefersa). The watershed simulation was conducted for the period 1983-2013 due to availability of climate data. However, due to insignificant annual climate variability over the watershed, this simulation period provides sufficient insight on the water supply potential in the Akaki Watershed and the three reservoirs. Detailed description of model inputs, modelling approaches, evaluations and results are presented in the full technical report (Appendix A).

3.4.1 WATER SUPPLY POTENTIAL OF EXISTING RESERVOIRS

The watershed simulation results showed that the Legedadi Reservoir has the highest annual water supply (Figure 5). The highest amount of water is collected in the month of August (Table 3-5). The Legedadi Reservoir provides an average annual water supply of 132 Mm^3 water followed by Gefersa and Dire at 55 Mm^3 and 51 Mm^3, respectively (Table 3-5). Currently, the annual water supply from the Legedadi-Dire integrated reservoirs and Gefersa Reservoir are 71 Mm^3, and 11 Mm^3, respectively (AAWSA, 2012; DAR AL-OMRAN, 2011). This indicates that the upstream areas of the reservoirs have a sufficient amount of water to supply more than what is delivered currently. However, the current reservoir volumes are too small to capture the streamflow generated upstream of the dams (Table 3-2). For example, Legedadi Reservoir has been supplying only 53% (71 Mm^3/year) of the streamflow that could be generated upstream of the reservoir. Assuming 30% release for environmental flow requirements, more than 20 Mm^3/year of water could be harnessed in the Legedadi Reservoir. Achieving this requires raising the height of dams and/or building new dams to harnesses the potential water resources available in the upstream catchments of the reservoirs.

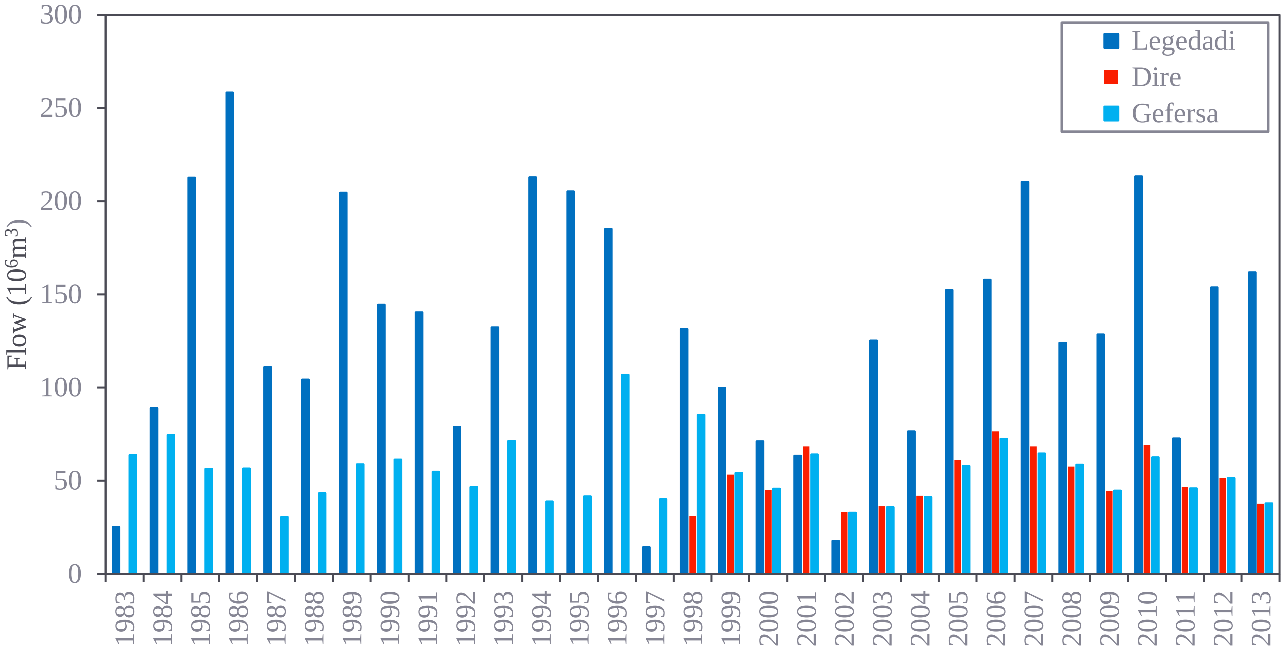


Figure 5 Annual simulated inflow (million m³/year) in the Legedadi, Dire, and Gefersa Reservoirs in the Akaki Watershed.

Table 3-5 Simulated long-term (1983-2013) average monthly and annual inflow volume (in million cubic meters, Mm3) into the Legedadi, Dire and Gefersa reservoirs.

Reservoir	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Annual	Reservoir volume
Legedadi	0.00	0.39	0.17	0.44	0.40	4.77	24.44	68.08	30.00	2.08	0.00	0.77	131.55	86
Dire	0.00	0.18	0.10	0.58	0.75	1.84	11.86	22.49	11.06	2.22	0.23	0.09	51.39	20
Gefersa	0.00	0.15	0.29	1.17	2.01	3.17	14.54	20.75	10.73	1.88	0.11	0.05	54.85	8
Total	0.00	0.72	0.55	2.18	3.16	9.79	50.84	111.32	51.79	6.17	0.34	0.92	237.78	114

3.4.2 SOIL EROSION AND SEDIMENTATION OF EXISTING RESERVOIRS

Soil erosion is generally a serious problem in the Akaki Watershed in which the simulated ***average annual*** soil erosion ranges between 3.3 tons/ha and 12 tons/ha (Figure 6). The highest soil erosion was observed in areas which are dominated by cultivated lands, mainly areas located in the north western, central, and southern parts of the watershed. The erosion was the lowest in the urban areas.

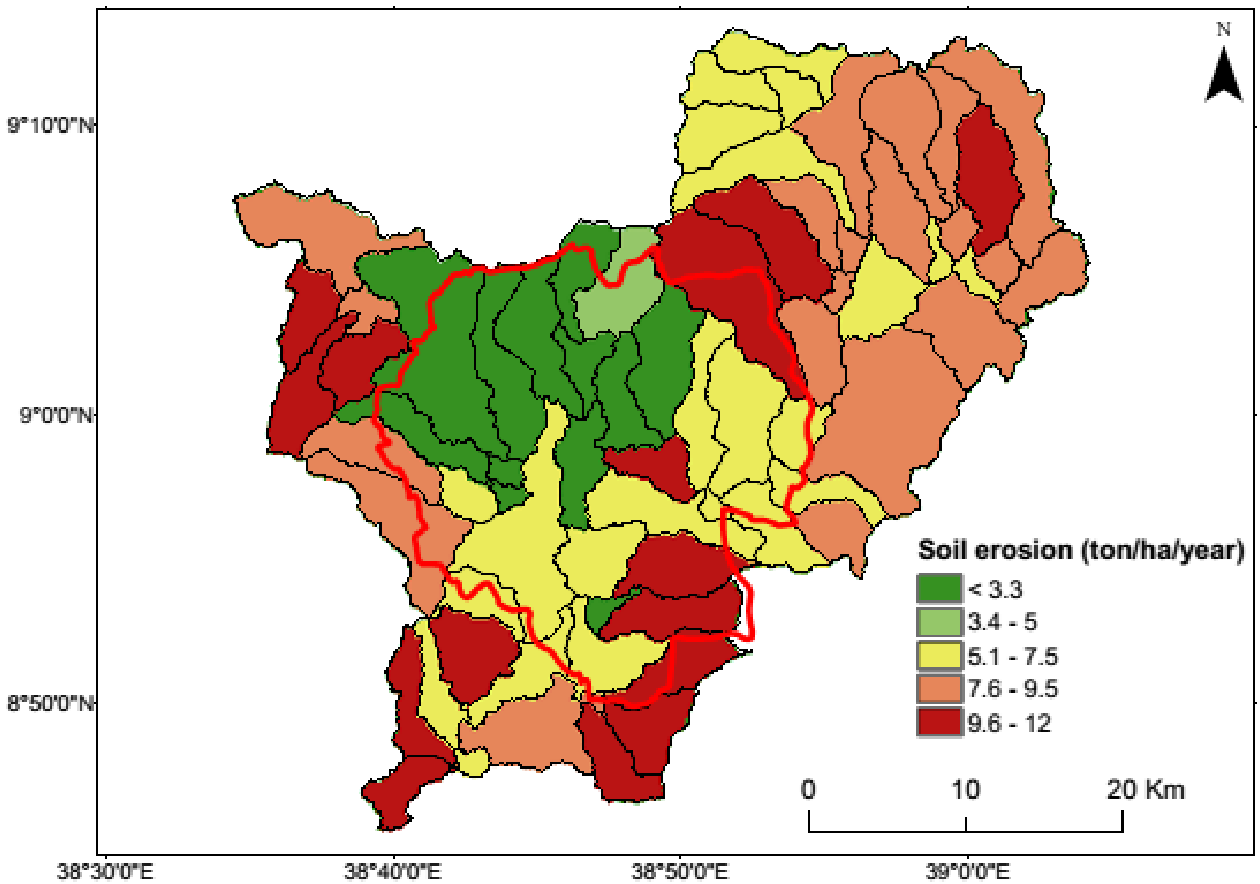


Figure 6 Long-term (1980-2013) average annual soil erosion (tons/ha) in the Akaki watershed.

Because of its large catchment area, the Legedadi Reservoir received the highest sedimentation followed by the Dire and Gefersa, respectively (Table 3-6). The ***average annual*** sedimentation in the Legedadi, Dire and Gefersa Reservoirs was 127,244, 30,715 and 26,970 tons, respectively (Table 3-6). Most of the sedimentation occurred during the rainfall season. Like the inflow volume, the highest sedimentation occurred in August (Table 3-6). The results indicated that reservoirs are quickly losing live storage capacity. For example, the Legedadi and Gefersa Reservoirs have been losing about 0.3% of their useful live storage per year.

Table 3-6 Average long-term (1983-2013) monthly and annual sediment deposition (in tons) in the Legedadi, Dire and Gefersa reservoirs.

Reservoirs	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Annual
Legedadi	0	367	162	427	392	4630	23658	65819	29038	2012	0	740	127,244
Dire	0	102	59	345	446	1102	7089	13443	6612	1326	136	55	30,715
Gefersa	0	65	132	539	1137	1575	7016	10130	5383	919	51	23	26,970

Simulation results showed that more than **3 Mm³, 0.62 Mm³ and 0.38 Mm³** of water storage loss due to sediment accumulation in the **Legedadi, Gefersa and Dire Reservoirs for the period 1983-2013**, respectively (Figure 7). The Legedadi and Gefersa reservoirs have lost more than 10% of their volume by 2013 due to sediment deposition (Z&A P. ANTONAROPOULOS AND ASSOCIATES S.A., 2016).

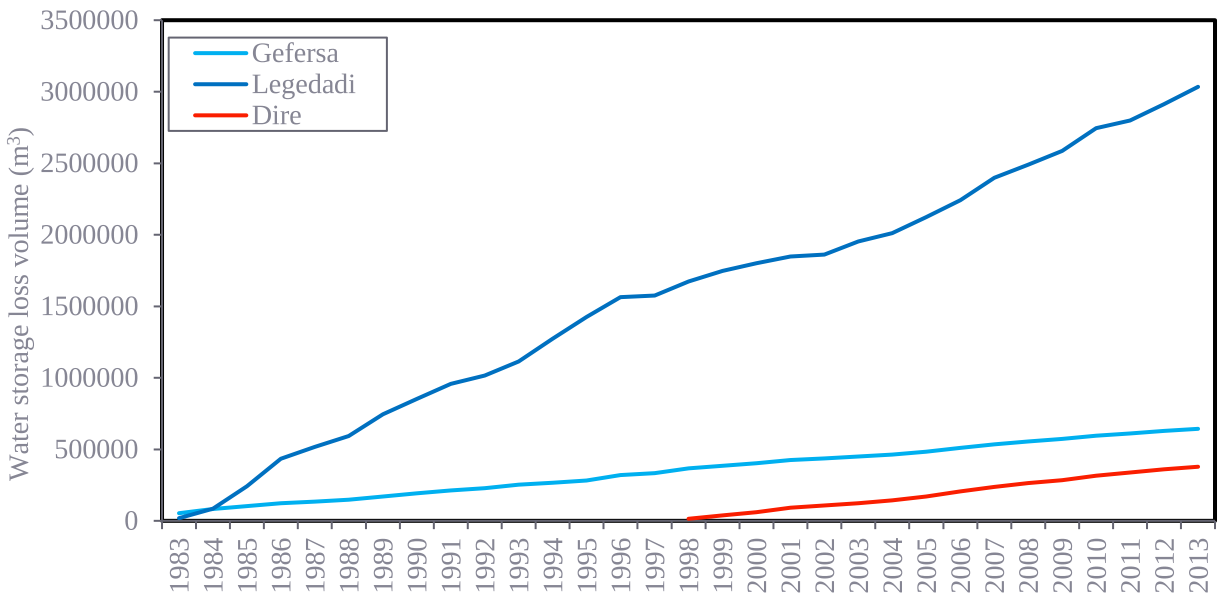


Figure 7 Cumulative water storage loss due to sediment accumulation in the Gefersa, Legedadi and Dire Reservoirs for the period 1983 to 2013.

3.4.3 FUTURE WATER DEMAND AND SUPPLY

The projection of future water demand was compared relative to a baseline period of 2019 when supply data was available (Table 3-7). The City was supplied with treated water of ~220 Mm³ in 2019 although 80.5 Mm³ was lost over the year because of various inefficiencies in the system. AAWSA (2020) indicated that about 36% of treated water is lost due to leakage and other system losses from production to distribution to customers. Simulation results showed that the catchment areas upstream of the three reservoirs have the potential to supply about 237 Mm³/year, which is more water than the current treated water supply of ~220 Mm³/year (i.e. surface water supply from reservoirs of ~83 Mm³ and ground water supply of 137 Mm³). However, increase in water demand due to population growth, economic activity, and lifestyle improvements will increase the water demand further as examined in the following sections. Moreover, existing reservoir sedimentation and excessive water loss will undermine the potential of the existing reservoirs. Therefore, to meet the ever-increasing water demand, the potential of existing reservoirs should be enhanced and new water sources should be developed.

Table 3-7 Total water supplied (in millions of m3, Mm3) to Addis Ababa in 2019 from reservoirs and groundwater sources (AASWA, 2020).

	Legedadi and Dire	Gefersa	Surface water supply contribution to total	Ground water supply	Total water supply	Surface water supply contribution to total (%)	Groundwater water supply contribution to total (%)
Treated water (Mm^3/year)	71.17	11.31	82.48	137.60	220.08	37.5	62.5
Water loss (36% of supply, Mm^3/year)	25.62	4.07	29.69	49.53	79.066	37.5	62.5
Net water supply (Mm^3/year)	45.55	7.24	52.79	88.06	141.01	37.5	62.5

The current and future water demand was determined based on population data collected from the AAWSA (2020) and a daily per capita water requirement to have basic standard of living. The 2019 baseline population for the City was 4,235,773, and estimates showed that the current per capita available water was well below the international standard. The population of the City is projected to be 5,863,301, 7,880,000 and 10,590,000 in 2030, 2040 and 2050, respectively (AAWSA, 2020). Based on the World Health Organization's (WHO) recommendation, this study assumed a daily per capita water requirement of 100 litres in 2019. An increase of 5% per capita water requirement per 5 years was considered to account for an increase in demand due to improvements in lifestyle (Table 3-8).

Planned water supply projects

In its 10-year development plan, the AAWSA planned various projects to increase the water supply of the City from 599,000 m^3/day in 2019 (Table 3-8) to 1.076 Mm^3/day by 2029 (AAWSA, 2020). This capacity will be reached through investments in groundwater well developments and construction of water supply dams.

The AAWSA development plan indicated that new wells that can supply 7,000 m^3/day will be developed every year in different pockets of the city (AAWSA, 2020). Some of the planned groundwater well development projects are located around Koyefechie, Tuludimtu and Kilinto condominium sites, which are expected to supply about 40,000 m^3/day. The South Ayat North Fanta well field project, which has a capacity to supply 66 000 m^3/day, is under construction and is 85% is complete. There are other groundwater supply projects in the Sebeta, Holeta and Tefki areas and in different parts of Addis Ababa City (AAWSA, 2020).

Dam developments include expanding of existing dams and building new ones. For example, the Legedadi Phase 2 project, which supplies 86,000 m^3/day will be added into the water supply system by 2021. Gerbi Dam, which is under construction and expected to be commissioned in 2023, has a capacity to produce 65,700 m^3/day of water to the northern parts of the City (AAWSA, 2011). Sibilu dam, which has a design capacity of supplying 385,200 m³/day, is expected to be completed in 2026 (Sime, 1998; AAWSA, 2020). The Robi-Jeda Dam, which has the potential to supply 540,000 m³/day, will be added into the water supply system by 2029 (AAWSA, 2020).

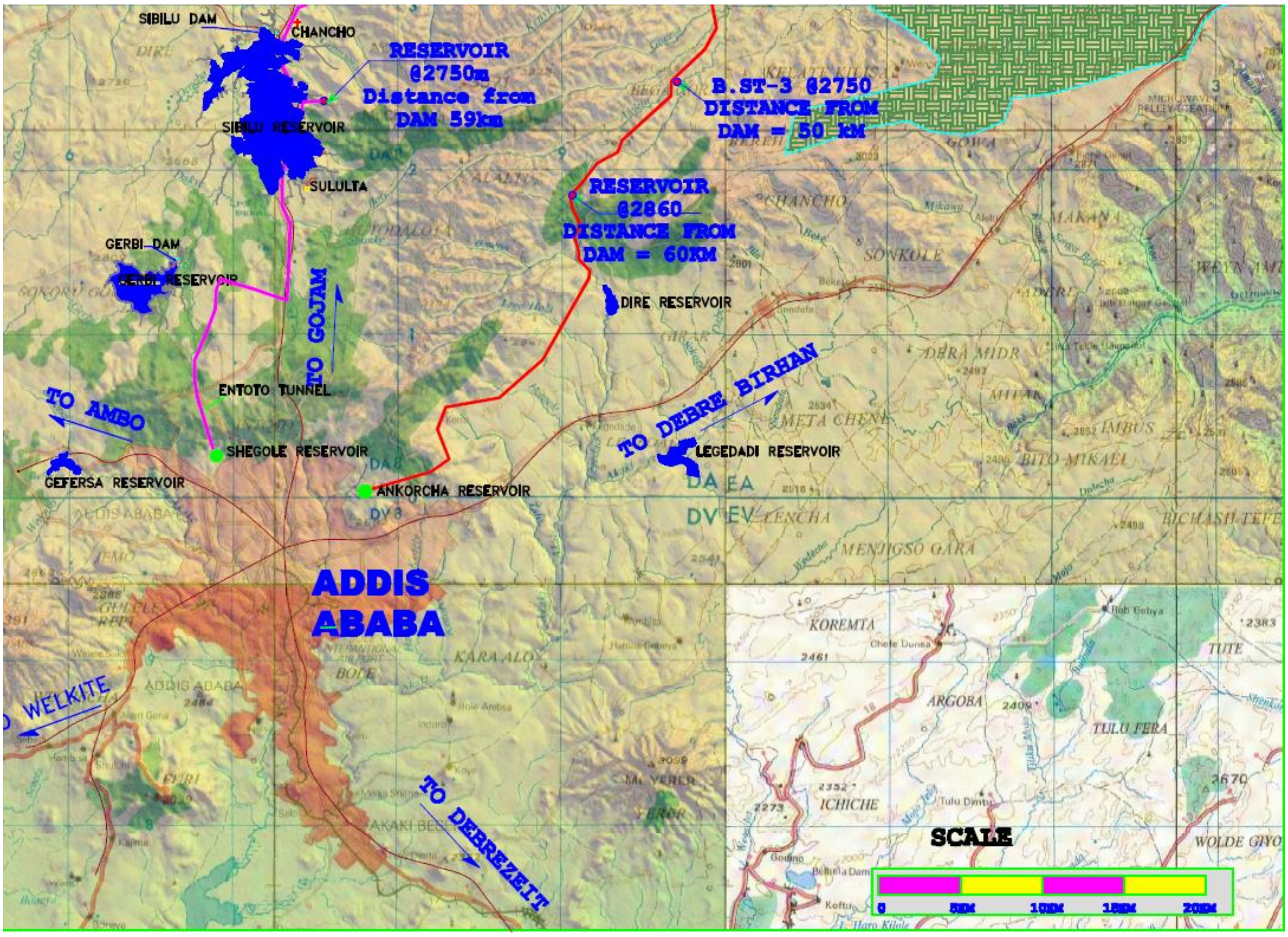


Figure 8 Jida-Robi Transmission line showing reservoir locations

Similarly, groundwater supply projects are under development in the Oromia Special zones, which surround the Addis Ababa City. For example, in the Sendafa, Bekie, Sefera, Chebie, Dire and Legetafo areas, a water supply project which can produce 40,000 m³/day is under construction. Groundwater wells that can produce 43,000 m³ /day of water are also under construction to supply water to Sebeta, Burayu, Legebri legehola, Sululta, Gelan and Akaki areas of the Special Zone (AAWSA, 2020). Development of these groundwater projects around the Addis Ababa City may directly or indirectly support the water supply system in the City.

Future water demand *vs* water supply with different plans

Based on information from the AAWSA (2020) 10-year development plan and insights from the watershed modelling results, the water demand vs water supply was assessed until 2050 for four likely scenarios (Table 3-8). The Scenario descriptions are:

- Scenario 1 represents continuation of the current water supply system and situations in which any of the planned projects are not be materialized. It means that Scenario 1 will supply the current 220 Mm³/year (or 0.599 Mm³/day) water to the city until 2050 (Table 3-7).

- Scenario 2 represents use of the optimum potential of the existing three reservoirs (e.g. enhancing their capacity by raising their height or expanding them in different forms) and the current groundwater supply. The three reservoirs have a potential of supplying ~237 Mm^3/year (~0.67 Mm^3/day). With the current groundwater supply of 137 Mm^3/year, the total water supply in Scenario 2 may become 374 Mm^3/year.

- Scenario 3 considers the materialization of all the planned projects by AAWSA in their respective proposed periods. In Scenario 3, the total water supply progressively increases from 220 Mm^3/year in 2020 to 643 Mm^3/year in 2029; beyond which the 10-year development plan does not provide any information.

- Scenario 4 examines the potential of the surface water in the Akaki watershed to bridge any of the water supply deficits if multiple dams will be built in the watershed while implementing the planned groundwater projects. The analysis assumes releasing of 30% of the watershed's streamflow for environmental flow requirements.

Scenario 1 will result in significant water supply shortage in the City. In Scenario 1, the water supply coverage will reduce from 54% in 2019 to 17% in 2050. Although making use of the optimum potential of three reservoir catchments in Scenario 2 may improve the water supply coverage, it will not fully address the water demand now and in the future. In Scenario 2, the water supply coverage ranges from 95% (in 2019) to 30% (in 2050). Implementation of the planned water supply projects under Scenario 3 will certainly improve the water supply coverage but will not ensure full coverage for the coming 30 years. In Scenario 3, the water supply coverage will increase from 54% in 2019 to 105% in 2030 and it may fall back to 50% in 2050 unless additional projects will be implemented from 2029 to 2050. Investment in surface water developments in the Akaki Watershed together with planned groundwater projects in Scenario 4 may meet demand only until 2025. Scenario 4 results suggest that some of the planned surface water developments in Scenario 3 should be developed in watersheds outside the Akaki Watershed delineated in this study.

Table 3-8 Estimated water demand and water supply for the period 2019 to 2050 for four likely scenarios.

Water demand is estimated based on projected population and basic per capita daily water requirement. Scenario 1 represents if the current water supply will continue until 2050. Scenario 2 considers optimum potential use of surface water in the existing reservoirs and existing groundwater sources. Scenario 3 represented water supply based on AAWSA proposed projects. Scenario 4 examines the potential of surface water resources in the Akaki Watershed together planned groundwater development projects to meet future water demand. The potential supply of existing reservoirs was estimated based on SWAT model.

		Base period (2019)	2020	2025	2030	2035	2040	2045	2050	References
Population of Addis Ababa (10^6)		4.235	4.363	5.058	5.863	6.797	7.880	9.135	10.59	AAWSA, 2020
Domestic water demand standard (m^3/capita/day)		0.1	0.11	0.115	0.120	0.125	0.130	0.135	0.140	Howard and Bartram, 2003
Total domestic water demand (10^6 m^3/ day)		0.463	0.479	0.582	0.704	0.849	1.024	1.233	1.483	AAWSA, 2020
Total non-domestic water demand (10^6 m^3/ day)		0.347	0.359	0.436	0.528	0.636	0.767	0.924	1.111	AAWSA, 2020
Total Water loss (10^6 m^3/ day)		0.292	0.302	0.366	0.444	0.535	0.645	0.777	0.934	Estimate in this study
Total water demand (10^6 m^3/ day)		1.103	1.140	1.384	1.676	2.020	2.436	2.934	3.528	Estimate in this study
Scenario 1 – Baseline ((Existing surface and groundwater sources	Surface water (10^6 m^3/ day)	0.225	0.225	0.225	0.225	0.225	0.225	0.225	0.225	AAWSA, 2020
	Groundwater (10^6 m^3/ day)	0.374	0.374	0.374	0.374	0.374	0.374	0.374	0.374	AAWSA, 2020
	Total supply (10^6 m^3/ day)	0.599	0.599	0.599	0.599	0.599	0.599	0.599	0.599	Estimate in this study
	Coverage (%)	54	53	43	36	30	25	20	17	Estimate in this study

Scenario 2: using optimum potential of the three existing reservoirs	Surface water (10^6 m^3/ day)	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	Estimate in this study
	Groundwater (10^6 m^3/ day)	0.374	0.374	0.374	0.374	0.374	0.374	0.374	0.374	AAWSA, 2020
	Total supply (10^6 m^3/ day)	1.044	1.044	1.044	1.044	1.044	1.044	1.044	1.044	Estimate in this study
	Coverage (%)	95	92	75	62	52	43	36	30	
Scenario 3: materialization of the planned water supply projects within their respective timeline	Surface water (10^6 m^3/ day)	0.225	0.225	0.291	1.215	1.215	1.215	1.215	1.215	AAWSA, 2020
	Groundwater (10^6 m^3/ day)	0.374	0.419	0.540	0.547	0.547	0.547	0.547	0.547	AAWSA, 2020
	Total supply (10^6 m^3/ day)	0.599	0.644	0.831	1.763	1.763	1.763	1.763	1.763	Total supply
	Coverage (%)	54	57	60	105	87	72	60	50	
Scenario 4 – using Potential of streamflow generated at the outlet of Akaki watershed (10^6)	Streamflow (70%) (10^6 m^3/ day)	0.837	0.837	0.837	0.837	0.837	0.837	0.837	0.837	Estimate in this study
	Groundwater (10^6 m^3/ day)	0.374	0.419	0.540	0.547	0.547	0.547	0.547	0.547	AAWSA, 2020
	Total supply (10^6 m^3/ day)	1.211	1.256	1.377	1.377	1.377	1.377	1.377	1.377	
	Coverage (%)	109	110	99	82	68	56	47	39	

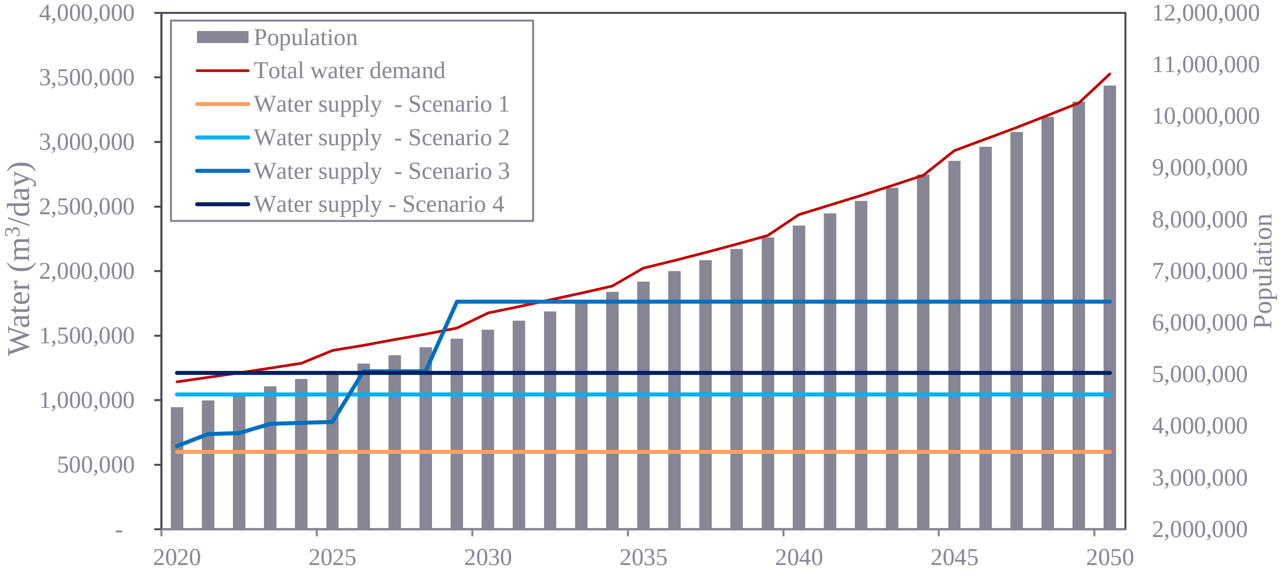


Figure 9 Estimated water demand and supply for the period 2020 to 2050 under different scenarios.

Scenario 1 represents the situation if the current water supply will continue until 250; Scenario 2 considers optimum potential use of surface water in the existing reservoirs and existing groundwater sources. Scenario 3 represents water supply based on AAWSA proposed projects. Scenario 4 examines the potential of surface water resources in the Akaki Watershed together planned groundwater development projects to meet future water demand. The demand is estimated based on projected population data and assumed basic per capita per day water requirement.

3.5 KEY RECOMMENDATIONS TO ADDRESS CHALLENGES TO WATER RESOURCES MANAGEMENT IN THE AKAKI WATERSHED AND WATER SUPPLY FOR ADDIS ABABA CITY

This study has applied watershed modelling and data analysis techniques to estimate the current and future water demand and water supply to suggest strategies that bridge the gap. The study also considered the ecological condition, biodiversity and hydro-ecosystem services of the Akaki Watershed to understand what options might exist to better protect source waters, enhance groundwater recharge and baseflow to streams, and reduce soil erosion and sedimentation that lead to the loss of reservoir water storage volume.

The water demand and water supply analysis showed that the water demand will not be met for number of years during the period 2020-2050. The water supply may be met around 2030 if all the planned surface water and groundwater development projects will be implemented as per the AAWSA 10-year development plan. However, the continued degradation of the watershed and increasing population, suggests that even with the planned water supply projects to expand extraction, the gap between the supply and demand will be substantial. The analysis also showed that surface water developments outside the Akaki Watershed should be implemented to meet the growing demand until 2050 (Figure 9).

Therefore, while the Akaki Watershed has the potential to supply the required surface water resources together with the groundwater sources, a holistic approach to water resources management and water supply must be implemented. Overall, multipronged measures should be taken to improve the water supply situation in the Addis Ababa City as listed below:

- Implementation of nature based solutions on steep slopes of agricultural, grazing and barren lands can reduce watershed degradation and thereby improve water resources availability to the Addis Ababa City. Implementation of effective soil and water management practices can address some of the critical environmental problems in the Addis Ababa water supply system and thereby contribute to improving water resources availability in the watershed. These management practices reduce soil erosion in the erosion hotspot areas, which are mainly located in the highlands of the watershed, and enhance groundwater recharge and baseflow. If the practices are widely adopted, they can also reduce flooding problems by temporarily storing and slowly releasing storms. The best management practices include implementation of conservation tillage, terraces, soil/stone bunds, agroforestry, check dams, afforestation, etc. Since these practices may be implemented in high slope cultivated and grazing lands, socio-economically acceptable practices may need to be selected. For example, agroforestry and afforestation practices can meet environmental benefits of reducing soil erosion and enhancing groundwater recharge and baseflow while providing socio-economic benefits.Some of the nature based solutions are presented as follows:

  Biological soil and water conservation measures that include afforestation, contour farming, strip cropping, implementation of cover crops, vegetative filiter strips, and area closure. These biological soil and water conservation measures are helpful to sustain ecosystems, reduce soil erosion, and nutrient leakage into the freshwater ecosystems. These measures can also improve watershed greenness and thereby stabilize the local climate. These conservation measures can be implemented on erosion prone cultivated, grazing and barren lands (Desta et al., 2005; Betrie et al., 2011; Waidler et al., 2011; Hurni et al., 2016). The erosion prone areas were identified through the watershed modelling excercise.

  Physical soil and water conservation measures that reduce soil erosion and enhance groundwater recharge by reducing the velocity of the surface runoff and promoting infiltration (Hurni et al., 2016). Moreover, some of the physical soil and water conservation measures (e.g. wetlands) can temporarily store the surface runoff and its pollutants, and facilitate decaying of the nutrients through multiple biophysical processes, and also promote groundwater recharge. The physical soil and water conservation measures include wetlands, check dams, retension basins, terraces, fanya juu, soil/stone bunds, and planting pits (Desta et al., 2005). These conservation measures can be implemented in erosion hotspot areas and river channels, which were identified in the watershed modelling exercise. Wetlands may also be established downstream of many of the industrial plants to contain some of the nutrients that may pass the industrial plant’s waste water treatment process.

Creating buffer zones where, currently, the reservoir catchments do not have buffer zones. Settlements, agricultural practices, and mining activities are occurring nearby the reservoir sites. Such practices are aggravating soil erosion/landslides and pollution that undermine reservoirs' water storage capacity and incur more cost for treatment. Creating a reasonable buffer zone for the reservoirs can promote vegetation growth and wetland formation which can reduce soil erosion and nutrient flow into the reservoirs. Likewise, agricultural activities and grazing are happening close to the river courses, which has been promoting landslide and gully formation in the Akaki watershed and in Ethiopia in general. Establishment of a reasonable buffer zone across the river channels reduces landslide and gully formation and thereby reduces sediment entry into the reservoirs. Along some junctures in the small tributaries, especially in areas close to industrial plants, wetlands maybe created to store the water temporarily and facilitate decay and settlement of some pollutants and sediments. Moreover, these wetlands can enhance groundwater recharge.

- There is substantial amount of water loss in the current water supply system. Data from AAWSA showed that almost half of the supplied water is lost in different forms (AAWSA, 2020). Serious measures should be implemented to reduce losses. Some of the losses may be addressed by upgrading the water supply infrastructure to reduce leakage in the distribution system. Other measures may include implementation of tariffs that encourage efficient water use practices.

- The potential of the existing reservoir catchment areas is not fully harnessed. By extending the current dams (e.g. by raising dam height, or building new dams in the catchments, etc), it is possible to increase the current water supply coverage. However, unless sufficient watershed treatment practices are implemented, the capacity of the reservoirs may be impaired. Therefore, watershed treatment practices such as terraces, filter strips, buffer zones, area closures should be implemented (especially in erosion prone areas) to reduce soil erosion and reservoir sedimentation for the existing and future reservoirs.

- Most of the groundwater supplying wells have a depth of more than 300 m. Evidence from the AAWSA (2020) showed that several groundwater wells were abandoned because of depletion of the groundwater aquifer. Since too much reliance on the groundwater resource may cause such exhaustion of the groundwater aquifer in the surrounding area, significant investments in the wells may not be a sustainable approach. Rather, it is preferable to focus on developing surface water resources in the Akaki and nearby watersheds. In addition, implementing different practices that enhance the groundwater recharge may help to replenish the aquifer for the existing groundwater sources. Practices that help recharge include construction of artificial wetlands, recharging pits, check dams, etc.

- The Addis Ababa City has many impervious areas including rooftops. Surface runoff can be collected from these impervious areas and used for various purposes with modest water treatment. The surface runoff may be collected from individual building rooftops, or at larger scale areas that include roads, parking lots, etc. Adugna and Jensen (2018) reported that rainwater collected from 588 rooftops of large public institutions in Addis Ababa City can provide up to 2.3% of the City's 2016 water supply.

The study further added that if rainwater is collected from all large public institutions of the City, it can supply up to 9.2% of the City's water supply (Adugna and Jensen, 2018). Development of such decentralized water supply options can lessen the pressure on the larger centralized water supply system.

- Currently, only a fraction (about 10%) of the wastewater (i.e. in the form of grey water) is collected and treated either in centralized or decentralized systems (ACATIAWATER, 2020). If the wastewater treatment system of the City is improved, the treated effluent can be reclaimed for reuse. Such practice is becoming common globally.

Ultimately, a potential Water Fund would drive the implementation of multipronged measures to address water security problems. The proposed modality is one where the Water Fund would actively implement nature-based solutions and conservation activities to protect source waters and ecological infrastructure in the Akaki Watershed. In addition, the Water Fund would play a transformative role by serving as a mechanism to support collective action in other green and grey infrastructure solutions also to improve the water sensitivity of Addis Ababa, and the efficiency of the City water supply system.

4 Institutional Profile

4.1 APPLICABLE REGULATORY FRAMEWORK

The following laws, policies and strategies define the regulatory framework relevant for a future Water Fund. They are listed chronologically in the table below.

Table 4-1 Relevant laws, policies, and strategies in the regulatory framework

Item	Overview	Mandated Custodian[3]
The Conservation Strategy of Ethiopia (CSE) and the Environmental policy of Ethiopia (EPE) (1997)	Adopts a holistic view of the natural, human-made, and cultural resources and their use and abuse. Seeks to integrate existing and future Federal and Regional State Government planning in all sectors that rests upon the natural and human-made environments.	Federal Ministry of Environment, Forestry and Climate Change; National Conservation Strategy Secretariat
Ethiopian Water Resources Management Policy (1999), Strategy (2001) and Proclamation (no. 197/2000)	Aimed to put the water resources of Ethiopia to the highest social and economic benefits for its people through appropriate protection and due management; introduced RBOs and IWRM approaches	Awash River basin Authority and Ministry of Water, Irrigation and Energy to set water abstraction/use price and treated wastewater discharge charge.
Ethiopian water resources management regulations (Reg. 115/2005)	Detailed the implementation of the Proclamation such as the permit systems, water quality control, water users' cooperative societies, fees and charges, dispute settlement, and other miscellaneous provisions	The basin authorities are empowered to fix water charges and permit fees for both abstraction by utilities and direct users of surface and ground water.
River Basin Councils and Authorities proclamation no.534/2007[4]	To manage technical support to the Basin Higher Council (BHC) and MoWIE on dispute settlement, allocation and use of water resources in the basin; promoted IWRM through river basin authorities	Awash Basin Authority
Climate Resilient Green Economy (CRGE) vision and strategy (2011)	A holistic guiding vision that outlines Ethiopia's aspiration to become a low-carbon and climate-resilient economy.	Environment, Forest and Climate Change Commission (EFCCC)
Organisation of Civil Societies Proclamation (no.1113/2019)	To regulate the operations of and funding flows to CSOs	Civil Society Organizations Agency
AAWSA 10-year Strategic Plan (2020)	To guide operations and planning for the water authority between 2020 – 2030.	Addis Ababa Water and Sewerage Authority

[3] For a full list of active institutions at the national and basin level see http://www.fao.org/nr/water/aquastat/data/institutions/search.html?country=238&type=-1&activity=-1&keywords=&submitBtn=Search

4 In addition, Council of Minister's Regulation no. 441/2018 on the national river basin authority with will coordinate all basin authorities such including the Awash one - https://chilot.me/2020/04/definition-of-power-duty-and-organization-of-the-basin-development-authority-regulation-no-441-2018/

4.2 INSTITUTIONAL ARRANGEMENTS

The institutional landscape for water resources management (WRM) and water supply is structured through Federal, Regional, and Local administrative units, as well as Basin management structures. The table that follows, indicates relevant institutions, and whether they are primarily responsible for (a) master planning, (b) WRM, and/or (c) water supply.

Table 4-2 Institutional Landscape for Water Resources Management in Ethiopia (Overseas Development Institute, 2015)

Jurisdiction	Institution	Role
Federal (Master planning, WRM)	Ministry of Water, Irrigation and Energy (MoWIE), specifically the Water Development Commission	MoWIE is responsible for overall/master planning and coordination of WRM as well as monitoring the implementation of WRM and development programmes within the sector. MoWIE is also the lead institution responsible for policy, strategy and national project development and overall monitoring of the water sector at the national level (i.e., water supply projects financed by the Federal Government Budget). MoWIE issues licenses for large and medium-scale irrigation schemes. MoWIE's activities relating to water are caried out within the Water Development Commission which is part of the ministry.
Federal (Water supply)	Water Resources Development Fund (WRDF)	The WRDF was established by MoWIE in January 2002 through Proclamation 268/2002 as a semi-autonomous loan-granting body. The Fund provides small-scale financing to water supply, sanitation, and irrigation development initiatives. Loans are granted for extended periods of up to 30 years, to be repaid through the collection of tariffs with fixed interest rates of 3%.
Federal (WRM and Water Supply - financing)	Ministry of Finance (MoF)	MoF provides financing for national Water Infrastructure, WRM and WRD (and sub-national projects where funding is needed and available), including investments under the Water Master Plan/Strategy. MoF also sets development priorities and strategies in cooperation with the other ministries, formulates strategies for managing foreign aid and loans, negotiates and signs aid and loan agreements and monitors their implementation.

Jurisdiction	Institution	Role
Federal (WRM)	Environment, Forest and Climate Change Commission (EFCCC)	The Environmental Protection Authority (EPA) was established in 1995 (Proclamation No. 9/1995). It developed an Environmental Impact Assessment (EIA) guideline, which was given a legal basis with the adoption of EIA Proclamation No.299/2002 (in the same Proclamation, the EPA was given legal mandate to conduct EIAs). An EIA directive under article 5 of the EIA proclamation was issued in 2008 (Directive no.1/2008), listing the type of projects that require EIA. Proclamation No. 300/2002 on environmental pollution is also provided the legal mandate to the EPA to undertake management and enforcement of pollution measures. In 2013, the EPA was upgraded into (and its tasks transferred to) the EFCCC. The EFCCC is in charge of EIAs at the federal level and decides on EIAs for projects that are likely to produce trans-regional impacts. Regionally, EIAs are a competence of the Regional State's respective environmental agencies. The monitoring and evaluation of EIAs is delegated to 6 sector institutions: Ministry of Mines and Energy; Ministry of Health; Ministry of Transport; Ministry of Water, Irrigation and Energy; Ministry of Trade and Industry; and Ministry of Agriculture. EFCCC (together with MoFEC) is also a Coordinating Entity for the CRGE; in this role, it has focused on putting in place the overall technical approach and system for coordination for CRGE implementation and the monitoring of progress.
Federal (WRM)	Ministry of Agriculture (MoA)	Responsibility for leading and coordinating watershed management (especially in terms of sustainable land management activities), water harvesting and small-scale irrigation schemes. These activities are normally implemented by corresponding regional bureaus and woreda administrative offices
Federal	The National Meteorological Agency	Establishes and operates a national network of meteorological stations, including hydrological monitoring

Jurisdiction	Institution	Role
Regional	Regional Authorities (Oromia Regional State in this case)	According to the Ethiopian Constitution (art. 52 c), Regional States have the power to administer land and natural resources in accordance with laws enacted by the Federal Government. Proclamation 197/2000 further provides for the possibility of the Federal Government delegating its powers to manage water and other resources to Regional States. In Oromia, the key Regional State bureaus include: 1. Oromia Bureau of Agriculture and Natural Resources 2. Oromia Bureau of Minerals, Water and Energy. Regional water bureaus are the executive organs responsible for the implementation of federal policies, strategies and action plans through adapting them to the specific conditions of the region. Their role includes: - Planning, Implementing, Monitoring and Evaluating Water Supply projects; - Coordinating and Monitoring projects implemented by Woredas and Urban Water Utilities; - Exercising regulatory duties delegated to them by the Ministry; - Drafting Laws and Regulations for Town Water Supply and Sewerage Enterprises
Basin	AWASH Basin: River Basin High Commissions (RBHCs) and River Basin Authorities (RBAs)	Management and regulatory functions as set out in Proclamation 534/2007: - RBHCs: prepare the basin plan in a participatory way and submit it to the Federal Government (MoWIE) for approval; it has final responsibility for coordination of stakeholders at basin level. - RBAs: implement the basin plan, coordinate water-related interventions at basin level, and manage permit and information system.
Local (City Administration)	Addis Ababa City Administration represented by Addis Ababa Water and Sewerage Authority (AAWSA)	As the local water utility, AAWSA’s role includes planning, implementing, operating, monitoring, and evaluating urban water supply & sewerage systems.

Institutional arrangements and relationships for WRM and water supply in Ethiopia are not well defined and integrated. This is despite these institutions being structured to operate at multiple levels, such as: Federal, Basin, Woreda (district/region) and Kebele (local i.e., urban water supply utilities and rural supply schemes) (Addis Ababa Institute of Technology, 2018). As listed in Table 4-2 above, the main line ministries in Federal Government include the: MoWIE; EFCCC; and MoA. Apart from these, the River Basin Councils and Authorities Proclamation No 534/2007 provides for the establishment of River Basin authorities to oversee the water management aspects of the different river basins in the country.

The Federal Government has a responsibility to formulate and implement the country's policies, strategies, and plans. Likewise, the Regional State has the powers and functions to formulate and execute economic, social and development policies, strategies and plans of the state as well as to administer land and other natural resources in accordance with federal laws (Hailu, et al., 2017). For the Awash Basin in particular, the MoWIE Basin Directorate at the Federal Government level is in charge of planning for overall WRM, including surface water; groundwater; recycled water; environmental; and water resources quality. Nonetheless, the Ministry can delegate responsibilities to the Regional State Bureaus and River Basin Authorities. For the study area, the Oromia Bureau of Agriculture and Natural Resources undertake all soil and water conservation activities as part of broader watershed management (Personal Communication, Oromia Regional State, December 2020).

These activities are implemented through the Bureau's Zonal[5] and Woreda government[6] offices known as Water Desks. Local area experts and managers are trained to define and coordinate soil and water conservation activities by mobilising community labour through the Kebele offices.[7] Communities are engaged toward managing surface water, groundwater, environmental management, and water quality control. In reality, they tend to lack financial and human resources capacity to fully realise this management function. The role of the Kebele is practical in nature, involving coordination on the ground, community mobilisation and labour which is mostly provided in-kind by the communities and beneficiaries. For example, as part of the GEF SGP, 45 Kebele's have been involved in land management. Kebele's are usually made up of respected and selected community members who might be managing water access points, or water user associations. The Oromia Regional State manages 7,000 micro-watersheds in the whole Oromia Region, and are active in mobilising 7 million people for 30 – 35 days of in-kind labour per year. The Oromia Regional State has 2 million hectares of land managed through these activities.

It seems that the responsibilities are concentrated and centralized at the higher government structures with few devolutions of power (Hailu, et al., 2017). In the study area, The Oromia Regional State has jurisdiction in its territory, while the Addis Ababa City Administration has jurisdiction in its boundaries. The institutional hierarchy is outlined in Figure 10. It is important to note that since the overthrow of the military regime in 1991, there has been some decentralisation resulting in the city of Addis Ababa being granted autonomy equivalent to the Regional States. The City Administration reports directly to the central government (rather than the to the Oromia Regional State). Furthermore, the Regional States have significant autonomy and decision-making power in regional affairs. That is, while Federal Government have the primary law-making and strategic oversight, they have no mandate to supply water, or implement and fund projects for sub-national levels. In this regard, the Regional States have sufficiently devolved powers to administer and operate with some autonomy within the Regional boundaries.

[5] The presence of a Zone Government level depends on the size of the region and the requirement for additional administrative units. Considering the autonomy of Regional governments, it is their mandate to set up Institutional hierarchies and structures as they see fit.

[6] The Woreda Government is the lowest ***administrative*** tier of government in Ethiopia.

[7] Kebele's are the lowest division in government similar to wards. The Kebele's do not have administrative power but are the main point of contact for community mobilisation

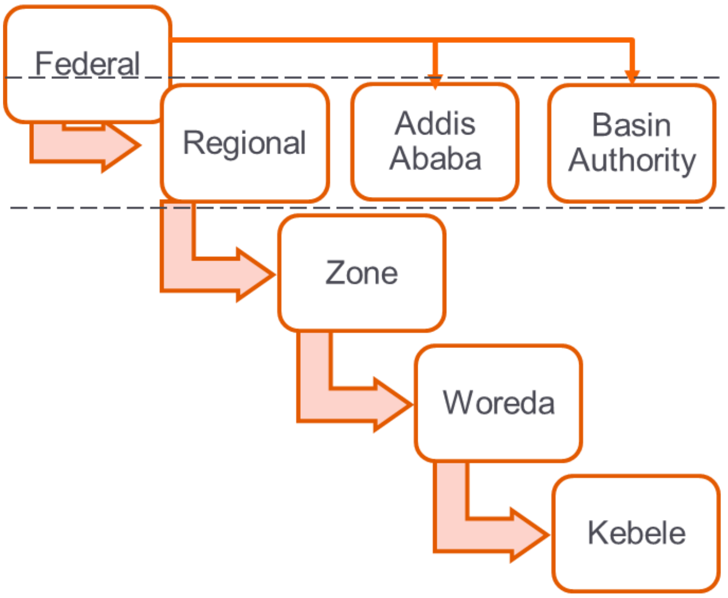


Figure 10 Government Institutional Hierarchy in Ethiopia

The Awash Basin Authority is active in the basin in infrastructure development, licensing and allocation, operation and maintenance of infrastructure, policy, and strategy, but is not perceived as an administrative unit with legislated powers.

4.3 KEY INSTITUTIONS FOR THE WATER FUND

The relevant and active institutions to be considered in the development of the Water Fund are categorised in the table below according to the nine key stakeholder types stipulated in the Terms of Reference. Those institutions highlighted **in bold** have been engaged in this or previous engagement efforts or expressed interest and willingness toward working with the Water Fund. Ultimately, an institutional structure or organisation form into which the private sector is willing to place their money, and which facilitates multi-stakeholder mandate alignment will be essential – the configuration of which must be developed in the Design Phase.

Table 4-3 Stakeholder Summary

Stakeholder Type	Institution
Critical stakeholders	**1. Addis Ababa Water and Sewerage Authority;** 2. **Oromia Regional State Bureaus of Agriculture and Natural Resources**, and Water, Energy and Minerals **3. Ministry of Water, Irrigation, and Electricity (MoWIE)** 4. **Ministry of Finance (MoF), including the Water Resources Development Fund (WRDF)**
Academic Institutions and Think Tanks	Ethiopian Institute of Water Resources and the Addis Ababa Institute of Technology (Addis Ababa University); Water and Land Resource Centre of Ethiopia

Stakeholder Type	Institution
Key Government Stakeholders	City: **Addis Ababa Water and Sewerage Authority**
	Regional**: Oromia Agriculture and Natural Resource Bureau**; Oromia Water, Energy and Minerals Bureau; Cooperative Promotion Agency
	Federal**: Ministry of Water, Irrigation and Energy (MoWIE); Ministry of Finance (MoF);** Planning and Development Commission (PDC); Federal Cooperative Agency
Intergovernmental and Development Partners	**Addis Ababa Resilience Project Office (Global Resilient Cities Network); UNDP GEF Small Grants Programme (UNDP GEF SGP); IMWI Ethiopia; Agricultural Transformation Agency**
Industry associations	Ethiopian Bottled Water, Soft Drink Food and Manufacturing Industries Association (EBSFMIA)
Professional organisations	**International: Vitens Evides Internationale**; MetaMeta
	National: consulting firms such as Metaferia Consult; Water Works Design and Supervision Enterprise
Private Companies	**CocaCola Ethiopia; Pepsi Cola MOHA Bottlers**; Nestle, BGI, Heineken,
Civil Society	SOS Sahel
Water User Organisations	None to report to date.

Since the first inception meeting of the Water Fund concept in Addis Ababa in September 2017[8], there have been a range of stakeholders that have indicated interest and willingness to participate in the prospective Water Fund for Addis Ababa and the Oromia Region. These institutions are outlined according to where they operate (Addis Ababa, Oromia Region, or at the Federal Level) as well as their affiliation as a public or private sector actor, or public partner, below in Figure 11. This collection of institutions, a subset of the relevant institutions outlined above, may be considered for potential membership of a Water Fund Steering Committee.

These institutions indicated their willingness to form part of an interim steering committee for the development and establishment of a Water Fund. Some specific contributions are outlined as follows:

The **Oromia Bureau of Agriculture and Natural Resources** committed to aligning their own resources with objectives of the Water Fund, as well as offering political support to the initiative. The Bureau has an interest in both runoff flow and ground water recharge potential as reduced percolation is emerging as a challenge in many parts experiencing rapid urbanisation. The Bureau is also invested in supporting the communities residing in Oromia Region, especially in building capacity to protect the watershed.

The **Addis Ababa Water and Sewerage Authority** are committed to engaging with the Water Fund to address their water security concerns around security of supply, siltation, and watershed degradation. The authority has an interest in supported rural livelihoods in taking care of the watersheds. They have been involved in some preliminary conservation actions at the Woreda level in Soil and Water Conservation, tree planting, water

[8] Fred Kihara (TNC) undertook a successful trip to Addis Ababa in 2017 where initial engagements took place toward defining the Addis Ababa Water Fund Feasibility objectives. TNC engaged again with many of the same institutions in early 2020 to bring the Addis Ababa Resilience Project Office into the process.

tanks distribution and supplying water for rural people and have been investing about 150 million Birr annually in this regard (Tesfaye, 2017, personal communication).

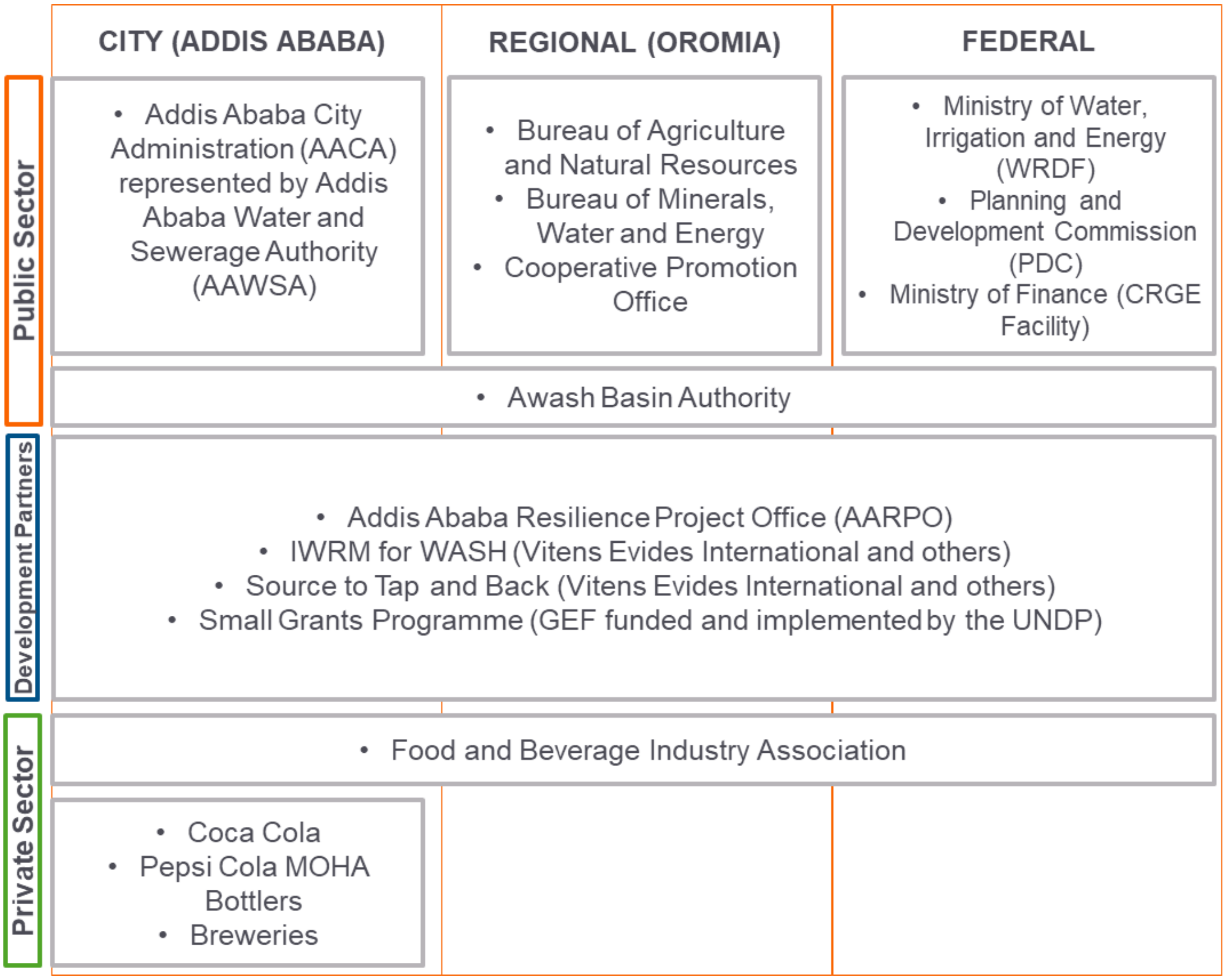


Figure 11 Institutional Matrix for the Water Fund

Potential **private sector partners (Breweries and beverage companies)** have also indicated interest in supporting the Water Fund as part of corporate social responsibility, as well as to help their organisations mitigate water-related challenges through corporate social investment. In general, private sector actors involved in the beverage industry are highly interested in the Water Fund concept and want to participate in an effort to prevent water insecurity becoming a risk for the industry. Pepsi Cola MOHA factories in Addis Ababa at two places at least (Teklehaimanot and Summit) have suffered from shortage of water and the problem seems to be exacerbating continuously. Operations have only been made possible through the transportation water through water tankers. Representatives expressed a strong desire to be part of the steering committee and assist with the management of the proposed Water Fund, particularly if it will be a PPP model. Owing to the broader recognition of the importance of water security and sustainability, the Ethiopian Bottled Water and Soft Drink Manufacturing Industries Association (EBSMIA), with the support of Nestlé Waters Ethiopia, Coca-Cola Beverage Africa, and 2030 Water Resources Group (2030 WRG), won the Partnership for Green Growth and Global Goals 2030 (P4G) 2019 Start-Up Partnership Award, which recognizes new partnerships deemed to have exceptional potential for advancing social, environmental, and economic progress. The award includes a funding of USD 100,000, which the Association together with its partners plan to use to establish an Ethiopian Beverage Alliance for Water (EBAW) to promote collective action for sustainable water resources management amongst beverage industry actors, government, and communities. The Alliance aims to build a first-of-its kind industry-wide water accounting framework based on a sample survey of overall water use efficiency among its partners in beverage and develop a roadmap towards increased sustainability and accountability. The survey – not widely practiced in the Ethiopian industrial sector — will be an essential study to highlight the current and future balance of supply and demand for water resources. The study will facilitate key partners to convening around clear data to develop action plans for more sustainable beverage industry standards and practices, and creating benefits for the environment, and communities surrounding the water resources accessed by the industry. The EBAW is in the early stages of implementation, and is intended to have a national focus but would be a key partner for the proposed water fund, aligned to the mission of collective action for sustainable water resources management.

Lastly, it is recommended that representatives from existing programmes and institutions that are active in the water sector are also involved in the Water Fund steering committee or organisation. This is to ensure that the Water Fund can align with and support existing efforts, as well as to address a current overarching institutional challenge in the Ethiopian water sector – overlapping mandates. Public partners have made good progress in facilitating multi-stakeholder engagements in the water sector; however this has only been on a short-term, project-specific basis. Therefore, the potential Water Fund has a key role to play in facilitating multi-stakeholder engagements in a more permanent and lasting mechanism that builds on the efforts made by public partners.

4.3.1 ADDITIONAL INSTITUTIONS FOR THE WATER FUND

In addition to the key institutions listed above, this Feasbility Assessment has identified five potential partners for the Water Fund to consider engaging with, including inviting them to the Water Fund’s Stakeholder Workshop. They are mostly indirectly active in Ethiopia’s water sector. These organsiations, their objectives, and the roles they could play for the Water Fund, are listed below.

1. The Gates Foundation

The Gates Foundation collaborates with partners in Ethiopia and contributes resources to help the country improve agricultural productivity and increase the coverage of life-saving health and nutrition interventions. It works closely with donors, governments, the private sector and civil society to address systemic challenges and capture emerging opportunities in the agriculture and health sectors (Gates Foundation, 2021). As such, the interventions implemented through the Water Fund focused on improving water quality and quantity in the Akaki watershed would impact the Foundation’s agricultural and WASH projects. The Foundation and its partners could collaborate with the Water Fund to assist in implementing NbS interventions.

2. International Water Management Institute (IMWI) Ethiopia

IWMI is a research-for-development (R4D) organization, focused on science for transformation. IMWI works with different actors in Ethiopia, including governments, farmers, water managers, development partners and businesses, to solve water problems and scale up solutions. They combine research with data to build and enhance knowledge, information services and products, strengthen capacity, convene dialogue and deliver actionable policy analysis to support the implementation of solutions for water management (IMWI, 2021). Current projects include its 'Water Security in Ethiopia' project and 'Natural Resources Management for Resilience and Economic Development in Rural Ethiopia'. The lessons learnt from these projects would be beneficial to the Water Fund, and it could collaborate with the IWMI to align with its projects and support existing efforts.

3. Agricultural Transformation Agency (ATA)

The ATA is a strategy and delivery oriented government agency created to help accelerate the growth and transformation of Ethiopia's agriculture sector. ATA works with project teams on the ground to implement production & productivity and agribusiness & markets programs. These include, *inter alia*, projects focused on inputs, soil health and fertility, irrigation and drainage, and private sector development in agriculture (Agricultural Transofrmation Agency, 2020). The Water Fund could collaborate with the ATA to engage with smallholder farmers in the Akaki watershed and help implement interventions.

4. Ethiopian Orthodox Church

The Ethiopian Orthodox Church, to which more than half of Ethiopians belong, views natural forests as a symbol of heaven on Earth. As such, many churches are surrounded by forests, which can range from 3 to 300 hectares and host evergreen trees, shrubs, and flowering plants (National Geographic, 2019). In the past few years, small international research programmes have started to document the depleted biodiversity areas, particularly in the northern regions of the country. In the South Gonder Region, for example, researchers used grants from the National Geographic Society to host a series of workshops with over 150 priests to educate them about the importance of biodiversity conservation, and encourage church communities to build protective stone walls around their woods to save them from damage (Nature, 2019). As a result of this work, some priests have become stewards of their forests and more than 20 communities in the region have erected walls around their forests. This work has positively impacted the water quality of these small forest areas. The Water Fund could engage with the researchers of this programme to support existing efforts in the Oromia region.

5. SOS Sahel

This NGO is dedicated to improving the living standards of smallholder farmers and marginalized pastoralists through better management of their environment (SOS Sahel Ethiopia, 2021). The work of SOS Sahel focuses on community-based natural resources management, food security, agriculture, policy analysis, value chain analysis and development, pro-poor value chain development. As SOS Sahel operates in Oromia, the potential Water Fund should include the NGO in stakeholder workshops to ensure consistency in delivering mandates.

4.4 TRANPARENCY AND CORRUPTION

Ethiopia has made promising improvements in anti-corruption and transparency efforts. The country's Corruption Perception Index rank, score, and improvement is higher than the region's average (Table 4-4), and several studies have demonstrated encouraging results showing that, compared to its African peers, Ethiopia has lower levels of petty bureaucratic corruption in basic services *(Otto, et al., 2019)*. For the country's rural water supply, Ethiopia has made significant strides in policy development, financing, governance, and management, resulting in generally low levels of corruption and perceptions of corruption along the value chain *(Calow, et al., 2012)*. Additionally, Ethiopia has developed a strong legislative framework to prevent and sanction corruption. Ethiopian anti-corruption law is primarily contained in The Revised Federal Ethics and Anti-corruption Commission Establishment Proclamation and the Revised Anti-Corruption Law which criminalizes major forms of corruption including active and passive bribery, bribing a foreign official, and money laundering. Facilitation payments are illegal, and it is forbidden for civil servants to accept gifts or hospitality that may affect their decisions *(GAN Integrity, 2020)*.

Table 4-4 Ethiopia's Corruption Perceptions Index[9] (Transparency International, 2019)

Rank	96/198
Score	37/100
Places change (since 2018)	+18

According to publicly available literature, corruption overall in the country, is however, high. Sometimes, facilitation payments and bribes are necessary to keep land leased from the state, to obtain government contracts, and to obtain an electrical or water connection *(GAN Integrity, 2020)*. There is also a high risk of corruption in Ethiopia's natural resources sector. Financial records relating to natural resource exploitation are not publicly available. According to *(Wheatland, 2015)* there have been concerns that the Grand Ethiopian Renaissance Dam was developed without competitive bidding and the quality of the environmental assessment was lacking. Moreover, it is understood that the country's legal anti-corruption framework is not often enforced, and the judiciary has been known to be politically influenced in the past *(GAN Integrity, 2020)*

Transparency in the water sector is additionally low, as tendering and procurement records are not easy to find and check (Calow, et al., 2012) (Otto, et al., 2019). In theory, information should be available from the regional bureaus that commission, oversee, and approve work. Regional and zonal bureaus should also compile and use well completion reports, not only as a check on what has been built and where but also to inform future contract design. In practice, records are sometimes incomplete or lodged with different levels of government, and archived data are lost or inaccessible (Calow, et al., 2012). Additionally, despite the development of large-scale decentralisation in the water sector, as well as increased stakeholder engagement and increased finance, little is known about how robust or effective these systems are in preventing corruption. The extent of water decentralisation, questions about the lack of staff, experience, and resources at lower levels, as well as the increased activity and resources being invested in the water sector are all risk factors for corruption.

These levels of corruption and lack of transparency could impact the Water Fund's ability to facilitate collective action for Addis Ababa's water crisis, avoid conflicts, and create a shared ownership of water management

[9] The CPI scores and ranks countries/territories based on how corrupt a country's public sector is perceived to be by experts and business executives. The CPI score uses a scale from 0 to 100 whereby 100 is very clean and 0 is highly corrupt. It is a composite index, a combination of 13 surveys and assessments of corruption, collected by a variety of reputable institutions. The CPI is the most widely used indicator of corruption worldwide.

interventions between stakeholders. It could additionally hinder the Fund's ability to mobilise resources from foreign and/or private sources.

5 Political Profile

5.1 WATER-RELATED CONFLICTS

In the Akaki Watershed, we have identified water-related conflicts over the last ten years at the regional level. These conflicts can be divided into two categories: direct water-related conflicts, and indirect water-related conflicts. The former includes the issue of a growing water demand deficit[10] and misuse, whilst the latter includes that of: (i) the exclusion of stakeholders in the decision-making process; (ii) mandate disputes between authorities; and (iii) limited resources at the local watershed level. All four of these issues are central to effective water resources management (WRM) and water supply, and are therefore critical to consider in the development of a Water Fund. Furthermore, it is most notable that no overarching functional agreements currently exist between Addis Ababa and Oromia Regional State – not only on water use, but also on sanitation, solid waste disposal, pollution, etc. This is often a primary cause of uncertainty when, among other things, water resources need to be shared.

5.1.1 GROWING WATER DEMAND AND MISMANAGEMENT

The Akaki Watershed is growing economically, and demand for water is increasing rapidly. Some of these economic developments are planned and others are unplanned (urban sprawl, farmer financed expansion) (Overseas Development Institute, 2015). Water resource competition, scarcity, and misuse are growing at the community and regional level, as are instances of water shortage (Hailu, et al., 2017). Consequently, misunderstandings regularly occur between upstream and downstream water users, including between the governing bodies in the Oromia Region and Addis Ababa City. The team understands that a loose conflict exists between Addis and Oromia. This is not so much focused on the availability of water but rather on the management and conservation of the watershed in response to a growing water demand. There is a disparity in water resource priorities between the Oromia Ministry of Agriculture, who are implementing catchment management interventions, and AAWSA, who are increasingly accessing water from upstream sources. This is not a physical conflict but causes political tensions. At the local level, water demand misunderstandings typically result in small verbal conflicts over water allocation (Hailu, et al., 2017), which are primarily taking place in rural areas where surface water quantity, particularly during the dry season, is not sufficient to meet the water requirements of farming communities for irrigation.

The Team understands that water allocation conflicts at the local level are often settled by clan elders[11]. Such community-based arrangements facilitate amicable access to water and grazing areas, and ensure equitable distribution of resources (Hailu, et al., 2017). However, beyond the community level, local communities do not always have the means or know-how to negotiate with large-scale commercial farms and state enterprises,

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[10] The demand for potable water significantly outstrips water supply.

[11] Clans are formed as groups of families or villages. They are prevalent in the watershed and are often led by elders or traditional chiefs (Hailu, et al., 2017).

due to power asymmetry and diversities of interest[12]. The powerful actors, such as foreign and domestic investors, receive special incentives (i.e. finance, water, and land access under the federal auspices). Consequently, the local communities are excluded from fair and equitable access to riparian water points and grazing areas, which creates tension in the watershed (Hailu, et al., 2017).

As Addis Ababa and the Oromia Region's populations continue to growth rapidly, and their respective water demands increases in proportion with population growth, so too is the likelihood that these conflicts will continue. We understand that at a high level, Addis and Oromia authorities sometimes attempt to discuss water management improvements, but that this is not practically completed. This is therefore a central issue for the prospective Addis Ababa Water Fund to be aware of and will be critical to its successful establishment. Going forward, the participation and representation of different upstream and downstream stakeholders in the prospective Water Fund will be key to avoid these disputes after establishment.

5.1.2 EXCLUSION OF COMMUNITY STAKEHOLDERS IN THE DECISION-MAKING PROCESS FOR IWRM AND WATER SUPPLY

Grassroot level customary institutions[13] play a critical role in effective WRM and water supply. These institutions involve the local community, resolve water-related conflict, mediate equitable resource access, and empower women and disadvantaged groups (Hailu, et al., 2017). They are believed to better understand where real contestations are in situ without necessarily being intervened by federal government ministries. A systematic means to address the source of water conflict requires recognizing customary institutions, yet evidence suggests formal water institutions have not formally recognised them. For example, many of these stakeholders were not involved in the IWRM policy-making process, and as such they have felt undermined (Hailu, et al., 2017). For a future Water Fund to avoid conflict between water institutions at the federal, regional and community levels, the role of customary institutions and practices will need to be understood and recognised, and a range of stakeholders will need to be included in decision-making processes. As the Oromia Bureau of Agriculture and Natural Resources is invested in supporting the communities residing in Oromia Region, especially in building capacity to protect the watershed, they could provide insight into this as the Water Fund develops.

Furthermore, a lack of compensation, and/or adequate compensation, to communities for lost land due to major infrastructure projects is also a recurrent issue and underlying cause of conflict. There is a proclamation focusing on this, but communities in Oromia Region often feel as though they are not sufficiently compensated.

[12] There is a power imbalance between communities and authorities in the region, who are implementing watershed conservation interventions, and large-scale commercial farms and enterprises who are not focused as much on water management.

[13] Customary water institutions (also known as informal institutions) are not legal institutions. In the Awash River Basin, these are committees called *Maallaqa Bishaanii* drawn from the local elders. *Maallaqa Bishaannii* are responsible for day-to-day water allocation, distribution, conflict management, and determining priority for the users (Hailu, et al., 2017).

5.1.3 MANDATE DISPUTES BETWEEN AUTHORITIES

The lack of clarity among water authorities as to their role in managing water resources contributes to the continuation of direct water-related conflicts. The MoWIE is responsible for dispute settlement, allocation, and use of water resources in the basin, whilst the RBHC settles conflicts that might arise between regions and coordinated among the key stakeholders. However, there is a lack of delineation of the powers and authorities of the river basin authority and the regional states. Additionally, water permits are issued by competing regional states and federal authorities, often outside the scope of Basin Master Plans (when these exist), and with insufficient consideration of the sustainable and equitable allocation of water resources (Overseas Development Institute, 2015).

The point of controversy between the regional and federal governments is rooted in the interpretation of the Constitution and the water resources management policy. This is an ongoing conflict affecting water allocation. The conjecture and confusion regarding the responsibility for water resources is the underlying factor for the perpetuation of conflicts related to water and land resources in the Awash Basin today (Hailu, et al., 2017). A future Water Fund will need to make its roles and responsibilities clear in order to avoid this.

5.1.4 LIMITED RESOURCES AT LOCAL WATERSHED LEVEL

Local institutions such as Woredas, Woreda Water Desks and Kebele Offices, have been created to manage water resources and provide water supply services throughout the Akaki watershed. A key problem, however, is that they typically suffer from limited human capacity, skills, and knowledge, both in technical and managerial terms, and do not always provide the services for which they were established (Calow, et al., 2013). Whilst the district and Kebele level government structures have the power to manage surface water, groundwater, environmental management, and water quality control, in reality, they lack financial and human resource capacity to realize it (Hailu, et al., 2017). This could be a potential point of contention between authorities at different levels of government and impact the implementation of interventions from a future Water Fund.

5.2 LOCAL POLICIES IMPACTING THE CREATION OF A WATER FUND

5.2.1 POLICIES FOSTERING THE CREATION OF A WATER FUND

Table 4-1 in Section 4 above outlines the laws, policies and strategies that define the regulatory framework relevant for a future Water Fund. These regulations reinforce the need for improved water quality and quantity, and for sustainable watershed management. These policies support the creation of a Water Fund as they encourage multi-stakeholder governance by helping to bring together public, private and civil stakeholders. This will serve to attract political influence, societal trust, and credibility to a Water Fund’s creation, as well as initiate interventions. The key regulations to note from this list that foster the creation of a Water Fund are:

1. Ethiopian Water Resources Management Regulations

These regulations detail the implementation of the Water Resources Management Proclamation, notably on issues regarding water use. It outlines the protection and management of water for Ethiopia, and details, inter alia, the implementation of RBOs, IWRM approaches, water fees and charges, and dispute settlements. The focus on IWRM and the role of RBOs will support the outcome of the Water Fund and the decentralisation of initiatives.

2. River Basin Councils and Authorities Proclamation

This proclamation enables River Basin Councils and Authorities to manage technical support to the Basin Higher Council (BHC) and MoWIE on dispute settlement, allocation and use of water resources in the basin, and to promote Integrated Water Resource Management. This will help unite stakeholders regarding contributions to water security though sustainable watershed management.

Table 5-1 builds on

Table 4-1 and outlines additional conventions and national planning frameworks that support the establishment of a Water Fund for Addis Ababa. Many of these programmes contain environment and climate issues as policy directions and measures to reduce societal vulnerabilities to climate change. These are national priorities with which the Water Fund is aligned, and present opportunities for the Water Fund to obtain government and development partner support to implement its projects.

Table 5-1 Conventions and Planning Frameworks fostering the creation of a Water Fund (GEF-SGP, 2019)

Conventions & National Planning Frameworks	Date of ratification / completion
Convention on Biological Diversity (CBD)	Ethiopia signed in 1993, ratified it in May 1994 (proc. 98/1994. CBD Signed 5 June 1992, parties 196; signatories 168; effective as of 29 Dec 1993
UN Framework Convention on Climate Change (UNFCCC)	Opened for signature in May 1992, entered in to force on 21 March 1994.
UN Convention to Combat Desertification (UNCCD)	Parties 196; drafted 17 June 1994; signed 14 October 1994; effective 26 December 1996.
Strategic Action Programmes (SAPs) for shared international waterbodies (IW)	In 1995, the GEF Council-approved Operational Strategy (strategic action programmes, SAPs) for shared international waterbodies.
UNCCD National Action Programmes (NAP)	Ethiopia developed the National Action Programme to Combat desertification in 1998
CBD National Biodiversity Strategy and Action Plan (NBSAP)	Ethiopian NBSAP December 2005, Addis Ababa, Ethiopia.
SC National Implementation Plan (NIP)	Declare for transmission of NIP on 17 May 2006; transmitted NIP on 9 March 2007
UNFCCC National Adaptation Plans of Action (NAPA)	As of Dec 2008, UNFCCC secretariat received NAPAS from all LDC; Ethiopia's NAPA received on June 2008

Conventions & National Planning Frameworks	Date of ratification / completion
UNFCCC Nationally Appropriate Mitigation Actions (NAMA)	Negotiations pursuant to the Bali action plan concluded at Cop18 in 2012
Nagoya Protocol on Access and Benefit-Sharing (ABS)	Entered into force on 12 Oct 2014
UNFCCC National Communications (1st, 2nd, 3rd)	Second national communication 2015.
Nationally Determined Contributions (NDCs) for Paris Accord	Submitted to the UNFCC in 2015
UN 2030 Sustainable Development Goals (SDGs)	Adopted by all United Nations Member States in 2015
Nationally Determined Contributions (NDCs) for Paris Accord	Submitted to the UNFCC in 2015. Update expected in January 2021
National Adaptation Plan of Ethiopia (NAP-E)	Prepared in 2017
Voluntary National Reviews (VNRs) for the UN SDGs	Ethiopia submitted the VNR report to HLPF in 2017
GEF-7 National Dialogues	Convened in April 2019

5.2.2 POLICIES HINDERING THE CREATION OF A WATER FUND

This feasibility assessment has not identified any local regulations or policies that might hinder the creation of a Water Fund. However, gaps in policy implementation and organisation mandate overlaps have been cited as a hindrance to natural resource conservation and rehabilitation (GEF-SGP, 2019). Ethiopia has a policy and legislative framework that supports IWRM, but its implementation is poor; institutional roles are not sufficiently well articulated, nor are coordination mechanisms for WRM, especially at sub-national level (Overseas Development Institute, 2015). The lack of capacity at national, regional and local government levels are a hurdle to execute project activities and to access available opportunities from climate change and environmental services (GEF-SGP, 2019). This will not hinder the creation of a Water Fund, though it may cause problems in its later phases as it develops and implements interventions.

Discussions with representatives of the Small Grants Programme indicated, through their experience, that government organisations responsible for supplying water to Addis Ababa city dwellers and for watershed management (at Federal, AA City Administration and Oromia Regional State levels), in addition to Civil Society Organisations and the private sector, are, in principle, supportive of establishing a Water Fund for Addis Ababa. However, a failure to effectively communicate amongst relevant stakeholders and agree on the institutional form of the Water Fund could undermine this establishment.

5.3 ISSUES TO CONSIDER FOR A WATER FUND STEERING GROUP

The key issues to be considered when developing a Water Fund Steering Committee will be that of representation and mandate. The steering committee must have a balanced representation of institutions from the Oromia Region and from Addis Ababa (including relevant Feredal Government representation) to ensure all relevant actors are adequately heard, and different actors' interests are represented. This will include ensuring local and upstream community stakeholders are recognised and included, alongside stakeholders from Addis Ababa downstream in a balanced committee structure. Additionally, identifying the mandate of the Water Fund steering group will be essential to engaging stakeholders in a targeted manner. The Cooperative Promotion Office used by the SGP Ethiopia could provide suggestions for who to include in the steering group and what powers the group will have.

When developing a Water Fund Steering Committee, the success of the SGP in Ethiopia should also be considered and built on. The SGP Ethiopia has been running since 2006, during which time it has supported projects designed to improve the livelihood of the community and contribute positively to the local and global environment through local actions. The projects were designed to fully align with the national priorities, and their implementation has been met with high community acceptance and replicability (GEF-SGP, 2019). We would like the Water Fund to learn from and expand on the SGP Ethiopia, notably when trying to meaningfully involve communities at the lowest level of government.

Speaking with the previous National Coordinator for SGP Ethiopia, we understand that national government authorities have a positive view of the programme and believe it has been impactful. As the SGP Ethiopia is well established and is supported by different stakeholders, the Water Fund should consider partnering with the programme to extend its positive activities to communities in the Akai Watershed of the Oromia Region authorities. Additionally, the Water Fund should consider a two-step engagement process to involve different actors. Firstly, the Water Fund and Water Fund Steering Committee should help government and community stakeholders engage together and serve to understand their different interests. Moving beyond this, additional actors could be involved, such as the private sector.

5.4 ALTERNATIVE NAMES FOR THE WATER FUND

A range of alternative names have been considered for the Water Fund, including:

- The Addis-Oromia Water Facility
- The Oromia and Addis Ababa Water Facility
- The Akaki Water Facility
- The Oromia Region Water Facility
- The Upper Awash Basin Water Facility
- The Upper Awash-Addis Water Facility

The term 'fund' has not been suggested for these names as, in Ethiopia, this implies resources have already been mobilised for deployment. Instead, using the term 'facility' could help gather support for the Fund's purpose.

'The Oromia-Addis Water Facility' is proposed by team based on discussions throughout the feasibility assessment as a name for the Water Fund as it conveys a clear purpose for the Fund, the key partner regions, and would enable future adjoining catchments to partake in it. Due to the size of the Oromia Region however, the Water Fund might look to narrow this name further and specify what area of the Oromia Region it is focused in, potentially the Finfinne Zone. 'The Upper Awash Basin Water Facility' and 'The Akaki Water Facility' have also been suggested as alternative names for the Water Fund as we believe including the catchment area provides an institutional and geographic link between the City and the Oromia Region. However, as the population and water demand in Addis increase, the city could look to expand its water supply beyond the Akaki Watershed and Awash River Basin through inter-region water transfers. As such, the Water Fund may not want to be limited to one watershed and the beneficiaries in this area.

We would suggest establishing a naming process between Addis Ababa and Oromia Region representatives to gather their input and create a sense of shared ownership of the Fund. Once the name has been agreed upon in English, we would recommend that this be translated into Amharic. The Water Fund needs to gather support from stakeholders beyond the city of Addis Ababa, and this would be a way to engage communities in the Oromia Region.

6 Financial and Economic Profile[14]

6.1 WATER CHARGING AND TARIFF ANALYSIS

The existing institutional setup for water resources administration, allocations, and charging in the Awash Basin is characterized by mandate overlaps between the Federal and Regional government authorities, as well as with the basin authorities[15] (Addis Ababa Institute of Technology, 2018; Hailu, et al., 2017). At the local level in Addis Ababa, AAWSA charges a common tariff (Table 6-1), which is applied across domestic and non-domestic users, and which increases per cubic metre with greater consumption.

Table 6-1: Addis Ababa Water and Sewerage Authority Tariff Structure for 2020/2021

Customer type	Consumption Category	Tariff Rate in Birr (per m^3)	Tariff Rate in USD (per m^3)
Domestic and Non-Domestic Water Users	0-7 m^3	2.40	0.06
	8-20 m^3	4.85	0.13
	21-40 m^3	9.71	0.25
	41-100 m^3	14.57	0.38
	101-300 m^3	19.42	0.51
	301-500 m^3	24.28	0.63
	500 m^3 above	26.71	0.70
Public Fountain (Water Taps)	Any	2.40	0.06

The AAWSA tariff is charged monthly, but tariff revenues are not cost reflective. It appears from AAWSA's 10-year development plan (Addis Ababa Water and Sewerage Authority, 2020) that anticipated revenue from tariffs will only cover 60% of operational costs; meaning there are no other tariff resources to cover planned capital expenditures. Costs relating to chemicals, pipe and fittings maintenance, water meter installation and reading, pump and electromechanical equipment costs, sewer trucks, and light vehicles are covered by transfers from Federal Government treasury as well as loans from multi-lateral partners such as the World Bank.

Capital expenditure is predominantly supported by loans and grants from Federal Government or loans from development finance institutions (DFIs). Publicly available audited financial statement summaries from 2017 show that support from the World Bank is in the order of 400 million Birr (US$ 10 million), and support from

[14] USD = 38.38 Ethiopian Birr

[15] At sub-national level, three River Basin Organisations have been established since 2008, comprising a Basin High Council and River Basin Authorities to ensure integrated water resources management at basin level:

1. Awash Basin Authority (AwBA), replacing the former only basin-level institution the Awash Basin Water Resources Management Agency (ABWRMA). Most of the medium-and large-scale irrigation projects and salinity and flooding problems are concentrated in this basin;
2. Abbay River Basin Authority (ARBA);
3. Rift Valley Lakes Basin Authority (RVLBA).

the Chinese Exim (export and import) Bank is in the order of 250 million Birr (US$ 6 million) annually (AAWSA, 2016 - 2017). At present, there is no planned private finance for capital projects. Over the next decade AAWSA plan to adjust the tariff structure to improve cost recovery for operational and recurring costs. AAWSA seek to increase their annual revenue from tariffs to 15.94 billion Birr (approx. US$ 400 million) from the current (2020) collections of 1.34 billion Birr (approx. US$ 34 million) by 2029 (Addis Ababa Water and Sewerage Authority, 2020), which equates to an increase of 1,190%. Based on historical financial statements (FY 16 and FY17), this sharp increase in tariff revenue over a decade seems improbable.

AAWSA currently recognises just over 500,000 customers[16] as outlined in Table 6-2. However, the calculation differs for domestic and non-domestic customers[17]. Domestic users are charged in a stepwise manner where the tariff is applied in consumption blocks. Non-domestic customers are charged at the rate commensurate with their total water consumption for the month.

Table 6-2 Breakdown of customers across tariff categories

Type of customer	No of customers	Proportion across categories
Domestic customer	486,935	92.22%
Non-Domestic customer	38,643	7.32%
Public Fountain	2,457	0.47%
Total	**528,035**	**100%**

As outlined in AAWSA's 10-year Strategic Plan, planned expenditure by AAWSA over the next decade for activities that will address: all water supply; water resource management; and wastewater management activities, is anticipated to exceed 270 billion Birr (US$ 6,9 billion). The full list of capital projects is summarised in Appendix A. The required capital is expected to be sourced from the Federal Government (in budget allocations channelled through the Addis Ababa City Administration), from internal revenues and loans. Out of the total capital required, 65% is expected to be covered by the Federal Government, 28% from internal revenues (tariff collections) and the remaining 7% from bi- and multi-lateral lenders who engage directly with AAWSA (Addis Ababa Water and Sewerage Authority, 2020).

At present, it is evident that billing mechanisms and revenue collection at AAWSA are ineffective. There are clear capacity constraints and a lack of effective information systems and record management. Therefore, unlike in the case of some Water Funds in Africa, tariff and revenue collection may not be an appropriate

[16] Based on customer accounts in November 2020.
[17] For example, a non-domestic customer who consume 105 m^3 of water will be charged 105*19.42= **2039.1 Birr.** A domestic customer who consumes 105 m^3 of water would be charged as follows:

category	Tariff Rate in Birr	Consumption in Birr
7 m3	2.40	16.80
20 m3	4.85	97.00
40 m3	9.71	388.40
38 m3	14.57	553.66
	Total	**1055.86**

avenue through which the proposed Water Fund might secure future income. As such, other potential sources of funding for water resource conservation are explored below.

6.2 FUNDING FOR WATER RESOURCE CONSERVATION

According to representatives from both AAWSA and the Oromia Bureau of Agriculture and Natural Resources, payments and agreements between AAWSA and the Oromia Regional State for WRM are currently managed on a project-by-project basis, with no formal or binding agreements in place. In the event that project implementation requires the transfer of rights to farmland, or existing buildings, AAWSA has historically paid a fee in the form of compensation to affected communities. Where water infrastructure for Addis Ababa has been developed in Oromia Regional State territory, AAWSA has developed water wells and provided clean water to residents around such infrastructure, accordingly. While there are no formal or binding agreements, AAWSA has also supported the Oromia Regional State in the past by establishing a nursery site for plantation activities, as well as including local communities in construction and maintenance work for water infrastructure. The prospective Water Fund may be a useful mechanism through which AAWSA may contribute more consistently to catchment conservation and water resources management.

Currently, no explicit budget line item exists for water resource conservation in AAWSA's 10 Year Strategic Plan, AAWSA has however an allocation of over 925 million Birr (US$ 23.6 million) for "compensation in catchment area" over the next two financial years in preparation for the water supply projects included in the 10-year development plan. The full budget requirements for AAWSA's capital projects are outlined in Appendix A.

Several other funds and programmes are operational in Ethiopia, with some having a distinct sectoral focus on water resources management; soil and water conservation activities; as well as land management for enhancement of ecosystem goods and services. A non-exhaustive summary is found in Table 6-3, with descriptions provided thereafter. It is evident that a significant amount of funding has been directed to the sector, however it clear that these flows have been on a project and/or short-term basis. This signals a need for a permanent and coherent mechanism through which funding for water resource conservation can be channelled – A key function of a potential Water Fund.

Table 6-3 Summary of Water Resource Management funding in Ethiopia

Programme or Fund	Amount allocated to WRM/Soil and Water Conservation
UNDP GEF Small Grants Programme	US$ 3.1 million between 2006 and 2019 (for all active regions in Ethiopia, none of which are in the Akaki Watershed)
Climate Resilient and Green Economy Facility	Fund capitalised with GBP 15 million (allocation to WRM specifically is unclear)
Sustainable Land Management Programme	Approximately US$ 125 million between 2008 - 2018
Source to Tap and Back	€7,100,000 between 2014 and 2018
IWRM for WASH	€ 9,345,695 between 2021 and 2024

6.2.1 UNDP-GEF SMALL GRANTS PROGRAMME

Since the SGP was officially launched in June 2006 it has funded and provided technical supports for a total of 227 grantees (GEF-SGP, 2019). Out of the allocated/committed resources to the grantees (CBOs and NGOs), 34% was in-kind co-finance which has been covered by the grantees and local governments.

With regards to the focal area distribution, the land degradation thematic area was the largest portfolio sharing (51.5%) followed by Biodiversity (28.6%), Climate Change (16.3%), Capacity Development (2.2%), Chemicals and Wastes (0.9%), and International Waters (0.4%). The key achievements during the most recent operational phase were: 2,883 hectares of degraded land have been rehabilitated and restored through area closure and sustainable forest management; the productivity of 1,864 hectares of farmland has been improved as a result of compost application; 1,896 energy efficient stoves and 2,010 solar panels were distributed to the beneficiaries that contribute to global GHG emission reduction. A total of 2,740 people were benefiting from the income generating activities of which 59 % are women, by 2019 (GEF-SGP, 2019).

6.2.2 CLIMATE RESILIENT AND GREEN ECONOMY FACILITY

In its Climate Resilient Green Economy Vision and Strategy (2011), Ethiopia identified the establishment of a National Climate Fund as one of the main components for the Strategy's implementation. To this end, the Climate Resilient Green Economy Facility was set up in December 2013, as a dedicated entity to attract and channel climate finance from international, public and private sources to implement initiatives towards establishing a climate-resilient, green-economy.

To date the CRGE Facility has mobilised over 200 million USD for low carbon and climate resilient development projects, from cooperating partners, such as: bi-laterals (Austria, Denmark, Norway and the UK); multi-laterals (WB, AFDB); and international climate change funds (GCF and Adaptation Fund). Using this capital, the Facility is funding several promising climate change projects and programmes in priority sectors of interest, including but not limited to those listed in the figure below.

Figure 12 Priority sectors of interest for the CRGE Facility

Water, irrigation and Energy

- Dissemination of Solar Energy Technologies and its use for water supply and irrigation
- Upgrading the national climate and hydrological information system
- Accelerating implementation of the National Biogas Programme

Agriculture

- Piloting climate smart agriculture
- Implementing Measuring, Reporting and Verification (MRV) and Monitoring and Evaluation (M&E) systems and developing a long-term investment plan

Transport

- Non-motorized transport: Developing pilot walking and cycling facilities in selected cities

Urban Development

- Developing integrated solid waste management systems
- Urban greenery

Ecosystems and Forestry

- Ecosystem rehabilitation and afforestation
- Participatory forest management – with emphasis on improving income status of women

Industry

- Developing a GHG baseline and MRV system
- Piloting energy efficiency in selected industry sub-sectors
- Greening industry parks

6.2.3 SUSTAINABLE LAND USE MANAGEMENT PROGRAMME

Since 2009, Ethiopia's SLM programme has brought over 575,000 hectares of land under sustainable landscape management or climate-smart agricultural practices in the 135 watersheds, stretching across six of the country's regional states. It has terraced hillsides, constructed bunds to collect rainwater and allow it to seep into the soil, lightly dammed gullies, planted trees and practised climate-smart agriculture through composting, managing landscapes, and agroforestry - among other measures (Global Environment Facility, 2017).

With significant support from the World Bank's Climate Action through Land Management Programme (CALM) and additional support from the Global Environment Facility (GEF), the programme introduced SLM practices and improved livelihood activities in significant areas of the highlands, treating more than 860,000 hectares of degraded landscapes in 1,820 micro-watersheds. The SLMP contained a series of two operations to be implemented over the 12-year period 2008–19, although it was restructured to close in 2018. Incentives for farmers to adopt SLM worked mainly because of the efforts to provide up-front economic benefits and to sensitize and engage local communities. A key challenge for the SLMP was to design a participatory long-term watershed management approach that reduced land degradation but offered productivity improvements and timely economic and livelihood benefits to the communities and land users. Failure to create incentives through early benefit flows has been a long-standing constraint to successful soil and water conservation in Ethiopia, prompting smallholders to remove physical structures introduced through various top-down government programs.

The SLMP I project financing totalled just over US$ 26 million and had the following components:

1. **Watershed management**: To support the scaling up of best practices in SLM for smallholder farmers in selected watersheds that were increasingly becoming vulnerable to land degradation and food insecurity. There were four subcomponents: (i) capacity building, (ii) communal land and gully rehabilitation, (iii) farmland and homestead development, and (iv) community infrastructure.

2. **Rural land certification**: To strengthen land tenure security for smallholder farmers in the project area by increasing the government's enhanced land certification process.

3. **Project management:** To provide financial and technical assistance to the Ethiopian Ministry of Agriculture and Rural Development and local government units responsible for SLM to effectively support coordination and implementation of SLMP I and the broader SLM Program.

The SLMP II project financing totalled just under US$ 100 million and had the following components:

1. **Integrated watershed and landscape management**: To support scaling up and adoption of appropriate sustainable land and water management technologies and practices by smallholder farmers and communities in the selected watersheds or woredas. The component also aims to reduce greenhouse gas emissions at the watershed level and to enhance productivity through the promotion and adoption of low-carbon, climate-smart technologies and practices. There were two subcomponents: (i) sustainable natural resource management on public and communal lands and (ii) homestead and farmland development, livelihood improvements, and climate-smart agriculture.

2. **Institutional strengthening, capacity development, and knowledge generation and management**: To strengthen and enhance capacity at the institutional level and build the relevant skills and knowledge of key stakeholders.

3. **Rural land administration, certification, and land use:** To enhance the tenure security of smallholder farmers in the project area and increase their motivation to adopt sustainable land and water management practices on communal and individual land.

4. **Project management**: To partially finance the operation of the SLM Support Unit to support the Ethiopian Ministry of Agriculture in ensuring efficient delivery of project resources and adequately monitoring and documenting progress and results.

6.2.4 SOURCE TO TAP AND BACK

VEI was the leading partner in the Public Private Partnership (PPP) Source to Tap and Back. The PPP was based on an integrated water chain approach towards water supply safety and water security. The approach improves water and sanitation services in Addis Ababa and Adama, and aimed to ensure water availability for Ethiopia's core economic region and improve the quality and sustainability of services.

Key lessons from S2T&B should be considered for the establishment of the Water Fund's Public-Private Partnership (PPP) structure. S2T&B undertook a number of pilot implementations for catchment protection, and established contact with various stakeholders including the local Woreda administration and Agricultural office, as well as farmers and community members. Ensuring this level of engagement will be essential for the effective implementation of finance toward water resource conservation. These stakeholders together with AAWSA and all watershed specialists agreed to focus on source protection near the headlands instead of constructing scattered engineered solutions. The S2T&B programme established a shared understanding for the Addis Ababa and Oromia region that source protection is technically more effective and socio-economically acceptable.

6.2.5 IWRM FOR WASH

VEI is partnering with Ababa Water and Sewerage Agency (AAWSA) as well as with Oromia Water Bureau (OWB) and associated water utilities of Akaki, Burayu, Gelan, Salulta and Sendafa to implement an Integrated Water Resources Management for Water Sanitation and Hygiene (IWRM 4 WASH) project in the catchment areas of Addis Ababa. The overall objective of this project is to improve water resource protection in Addis Ababa's water catchment by up scaling and anchoring IWRM approaches with special focus on increased water and sanitation supply benefiting approximately 1.3 million people. The main source of financing for the project is the Royal Netherlands Embassy in Ethiopia (70%), and is to be co-financed by VEI, AAWSA, OMWEB (30%). The entire project budget is € 9,345,695 of which €6,485,695 is contributed by Netherlands' Embassy, €1,800,000 by VEI, €530,000 by AAWSA and OMWEB each.

6.3 OTHER RELEVANT FUNDING IN THE WATER SECTOR

In addition to the water resource conservation funds mentioned above, the **Water Resources Development Fund (WRDF)** is another key potential funding sources for the proposed Water Fund to engage with.

The WRDF is a semi-autonomous government institution that was established in January 2002, with proclamation no.268/2002, to serve as a strategic financial wing for urban water, sanitation, and irrigation development projects. The fund is implemented by pooling funds from different multilateral and bilateral financial sources and provides long term loans for towns' potable water supply and sanitation enterprises as well as irrigation associations. The core values of the WRDF include:

- Ensuring efficient and quality services;
- Effective utilization of resources Providing equitable loan service;
- Fairness and justice;
- Serving the public; and
- Creating teamwork spirit

The duties and responsibilities and responsibilities of the WRDF organisation are to:

- Facilitate conditions for mobilization of funds from different financers for loan financed projects.
- Carrying out follow up activities for the collection of all funds committed from external development partners.
- Providing technical support to borrowers in the preparation, revision of design, feasibility study and business plan documents.
- Give technical advice to potential borrowers based on WRDF's loan requirements.

- Carry out project appraisal and based on facilitate on lending agreements to be signed with the borrowers.
- Ensuring that all procurements and contracts are carried out based on pre-set procedures and regulations.
- Providing no objection to RFPs, bid documents, bid evaluation report, and contract agreements of projects.
- Check disbursement requests submitted from borrowers in compliance with the on-lending agreement.
- Carry out project monitoring and evaluation activities to ensure quality and timely accomplishment of projects.
- Facilitate capacity building program for borrowers in collaboration with development partners.
- Carry out loan repayment activities.
- Ensure that loans are collected timely and re -invested as a revolving fund.

Ultimately the proposed Water Fund and the WRDF will operate at different ‘points’ in the WRM and water supply The WRDF funds cost recovery and technical infrastructure efficiency improvements targeting Non-Revenue Water, as well as capacity building for water supply and sanitation for town and urban water utilities. The WRDF has financed 122 projects in this regard. The Fund is capitalised by foreign concessional loans, and the WRDF then provides on-lending or grants to town water utilities.

The WRDF’s Organizational Structure includes its own board of management which consists of members of higher officials comprised from different public bodies and assigned by the Federal Government, including the Director General of WRDF. This management board is in charge of overseeing the fund’s overall operation and is accountable to the Ministry of Water, Irrigation & Electricity (MOWIE).

The WRDF and proposed Water Fund might collaborate by addressing grey and ecological infrastructure focuses, respectively. This is to say that the proposed Water Fund might engage with a focus on catchment management and soil and water conservation activities, while the WRDF’s mandate directs it to engage with infrastructure improvements and efficiency of engineered projects and systems. Both institutions might contribute to capacity building in their respective areas of focus.

6.4 IMPROVING FINANCIAL FLOWS TO SOURCE WATER PROTECTION

At this early stage of assessment, a potential niche for the Water Fund in Ethiopia could be the increasing **participation of the private sector** and thereby **catalysing collective action** around water resources management. If private organisations in Addis Ababa provide support, in the form of funding, to rural communities in the upper catchments, as well as potential targeted water security measures within Addis Ababa, it must be complemented by public sector contributions that are not simply in-kind. An appropriate structure (host institution, mechanism and governance arrangements) into which the private sector is willing to place their capital will be essential. This configuration must be developed in the Design Phase.

The **Public-Private Partnership Proclamation (no.1076/2018)** provides some of the most appropriate guidelines through which to understand a potential Water Fund structure. The Proclamation sets out the new PPP legislative framework with a view to promoting and implementing privately financed infrastructure projects by enhancing transparency, fairness, value for money and efficiency through the establishment of specific procedures. Whilst the Proclamation states that the Federal Government entity responsible for the relevant infrastructure service will normally initiate PPP proposals and transactions, these will be subject to the approval or direction of a new PPP Board.

The new PPP Board must consist of The Ministry of Finance and Economic Co-operation (who will chair the Board), The National Bank of Ethiopia, The Ministry of Water, Irrigation and Electricity, The Minister of Transport, The Ministry of Public Enterprises, The National Planning Commission, The Ministry of Federal and Pastoralist Affairs and two members from institutions representing the private sector. This board composition suggests that the water sector will be a likely area for future PPP activity, but it remains to be clarified whether water resources conservation and ecological infrastructure will be a focus area given the initial conceptual focus on applying this model for (grey) infrastructure, and its distinct operation and maintenance requirements. Therefore, it will be important for the Water Fund to contribute to the following enablers to improve the flow of capital to source water protection:

i. **Clarity in the mandates for WRM:** It is clear that a multi-stakeholder forum for actors in the water sector across water supply and WRM is lacking in Ethiopia generally, and in the study area in particular. The proposed Water Fund has a key role to play in facilitating multi-stakeholder engagements in a more permanent and lasting mechanism that contribute to clarifying mandates for which budget and funding can be deployed more effectively. Stakeholders expressed that they would welcome a water fund to coordinate the sector actors citing a lack of such a multi-stakeholder platform as a key issue in the sector.

ii. **Local level resource mobilisation and partnerships:** The GEF SGP has set an important precedent for the way in which rural communities are engaged and involved in land and water resources management. A key economic impact is that of local and community resource mobilisation and partnership building which further strengthen the ownership of interventions and contribute to sustainability of the achieved results (GEF-SGP, 2019). In the case of the GEF-SGP, these resources (despite being mostly in-kind contributions) have come from individuals, formal or non-formal community associations, NGOs, and government in the past. The Water Fund has a unique opportunity to build on key achievements and partnerships to extend these to the Akaki watershed region.

7 Stakeholder Engagement and Site Visits

7.1 STAKEHOLDER ENGAGEMENT

Various stakeholder engagements were undertaken to better understand the technical, institutional and political profiles of the feasibility assessment. Table 7-1 details the complete/current stakeholder inventory and other associated details related to the stakeholder engagement. This analysis will be continuously updated and refined with the WF Director and selected members of the Steering Committee to ensure the inventory and evaluation remains current.

Table 7-1 Completed stakeholder engagements[18]

Organisation	Date	Meeting attendees
GRCN/VEI/AAWSA/AARPO	28th October 2020	Katrin Bruebach (GCRN) Dana Omran (GCRN) Adriaan Mels (VEI) Daniel Truneh (VEI) Deberie Tujo (AAWSA) Yohannes Ameha (AARPO) Dr Moges Tadesse (AARPO)
Vitens Evides International (VEI)	13th November 2020	Mr Daniel Truneh
AARPO	16th November 2020	Mr Yohannes Ameha Dr Moges Tadesse
AAWSA	17th November 2020	Mr Deberie Tujo Mr Balem Bahru
UNDP Small Grants Programme (Former National Coordinator up until 2017))	24th November 2020	Mr Zeleke Tesfaye
CIAT	30th November 2020	Mr Lulseged Destu Mr Wuletawu Abera
Water Resources Development Fund	10th December 2020	Mr Wanna Wake
Oromia Regional State Bureau of Agriculture and Natural Resources	11th December 2020	Mr Sileshi Lemma
Climate Resilience and Green Economy Facility (Ministry of Finance)	14th December 2020	Mr Zerihun Getu
Vitens Evides International (VEI) (site visit to Dire Dam)	16th December 2020	Mr Daniel Truneh and Mr Solomon Walteneghus

[18] Meeting notes can be provided upon request.

Oromia Regional State Bureau of Agriculture and Natural Resources (site visit to Legedadi Reservoir)	17th December 2020	Mr Seleshi Lemma

7.1.1 SUMMARY OF INSIGHTS FROM STAKEHOLDER MEETINGS

The purpose of the stakeholder engagements was to connect with different organisations who might impact the development of a Water Fund for Addis Ababa and the Oromia Region. In particular, they assisted in providing missing information needed for the technical, institutional and political profiles of the feasibility assessment, as well as enabling snowball sampling interview methods. These insights have already been integrated into the various profiles above, but a summary of them is also provided below.

Technical insights

Information relating to the technical profile for the feasibility assessment was gained through the stakeholder meetings. The meetings confirmed that siltation is a key water challenge experienced by communities in the catchment area. They also provided information on water loss, the depth of groundwater wells, the changing water table height, water sources and distribution maps for Addis, current wastewater treatments, organisations who have a mandate to produce and supply water for the city, as well as the key water supply challenges in Addis. Engagement with the Oromia Bureau of Agriculture and Natural Resources also provided insights into the catchment management activities taking place in the study area and how these are funded.

Institutional insights

The meetings provided the team with a better understanding of the institutional structure of the water sector in Addis Ababa and the Oromia Region, including uncovering the key actors integral to the success of the Water Fund and those leading on watershed management in the catchment. The meetings also provided insights on the perspective of the Federal Government in relation to the proposed Water Fund. It became evident from these meetings that the critical entities for the Water Fund include the Ministry of Water, Irrigation and Energy (MoWIE), the Oromia Bureau of Agriculture and Natural Resources, and the Addis Ababa Water and Sewerage Authority, and that the active involvement of these actors is important. Key private sector actors relevant to the WF, such as Coca-Cola and Heineken, were also identified through the engagement with the UNDP Small Grants Programme.

These meetings additionally provided insights into other initiatives taking place that could be of relevance to the Water Fund. AARPO, for example, provided information on the status of the Resilience Strategy and resilience actions, such as their Mountain Range Rehabilitation Programme, which the WF could collaborate on. VEI and UNDP also provided details on their lessons learnt from the S2TB, WASH, and Small Grants Programme, including how to engage communities, government officials and other stakeholders in the catchment area to gain a consensus on catchment management activities to improve water quality.

Political insights

The meetings provided the team with an understanding of the context into past and current water-related conflicts and mandate disputes in the catchment area, including causes of tension and actors involved. This included uncovering any political issues between Oromia and Addis, such as the challenges with inter-regional working arrangements.

The stakeholder engagements also proved insightful in understanding issues to consider for the Water Fund Steering Group, such as that of representation. Speaking with the UNDP Small Grants Programme (SGP), it became clear the success of the SGP in Ethiopia should be considered and built on when developing the Water Fund steering committee. Including this well established and supported programme would minimise confusion among stakeholders and ensure alignment with ongoing activities by communities and the Oromia Region authorities in the catchment area.

7.2 SITE VISITS

In mid-December 2020 two site visits were undertaken to the Dire and Legedadi dams to engage stakeholders and gain an understanding of the key water challenges communities are facing, and any activities being undertaken to mitigate the impacts of these.

The site visits revealed that rural communities in the catchment area face water accessibility challenges. Water is primarily supplied from four sources that each face water quality and/or quantity issues. Deep wells are relied upon by rural communities; however, these are largely seasonal and dry up during the long dry seasons (end of December to May), making some of these water points non-functional. Natural springs are also located across some communities in the catchment; however, these are open to contamination from the environment and are not always kept clean (see Figure 16). Rural communities are sometimes provided with water points from factories in the vicinity of the dams, though this is not consistent, and others are supplied with water from the dam reservoirs themselves, where there are multiple water users. In the Legedadi Reservoir, for example, cattle were observed drinking and grazing in the reservoir area (see Figure 14). These varied supply points hinder communities' accessibility of water, and often result in community members having to travel far to fetch water. Community dwellers, often women, use donkeys or manual labour to carry cans filled with water across long distances (see Figure 15), in turn limiting employment and education opportunities and increasing gender inequalities.

In addition to water access challenges, the site visits confirmed erosion and siltation to be the biggest land degradation and water quality problems in the catchment area. The team observed this to be a result of three primary issues, the most notable including unchecked farming activities that are carried out on every available plot of land, such as on steep slopes and to the edge of tributaries, that result in soil run-off in the feeder rivers to the dams (see Figure 17). Sparse vegetation cover in the upper catchment also contributes to this challenge, as noted from the mountain chains above Dire Dam that are devoid of vegetation cover. Thirdly, experts with whom the team engaged confirmed that the invasive Eucalyptus tree is signficant in the catchment area and limits the growth of under shed vegetation which cannot surpass the deep-rooted nature of the trees (see Figure 18). Consequently, the team noted that the water around the dam reservoirs is visibly muddy, silted and receding, thus impacting the water's quality.

Despite these issues, the team saw no retaining structures prohibiting the soil from polluting the tributaries and dams, nor learnt of any soil and water conservation activities being implemented by the Oromia Bureau of

Agriculture and Natural Resources. No catchment rehabilitation activities, including gully protection, soil retention, nor afforestation, have been implemented near the Dire Dam, and no ongoing development structures were observed. Though some stakeholders understood the impacts of their economic activities on downstream water quality and quantity, overall, the team observed that communities prioritise the development of economic activities, including traditional farming, over conservation activities such as the use of buffer zones. If soil and water conservation activities are implemented, this ought to be driven by policy and their value addition needs to be clearly articulated to ensure stakeholders are engaged. Overall, the site visits underscored a need for adequate policy systems, livelihood alternatives and training resources for communities to implement and maintain soil and water conservation activities.

Figure 13 Cattle grazing inside the receding Legedadi Reservoir.

Figure 14 Water access point in the upper catchment of the Dire Dam

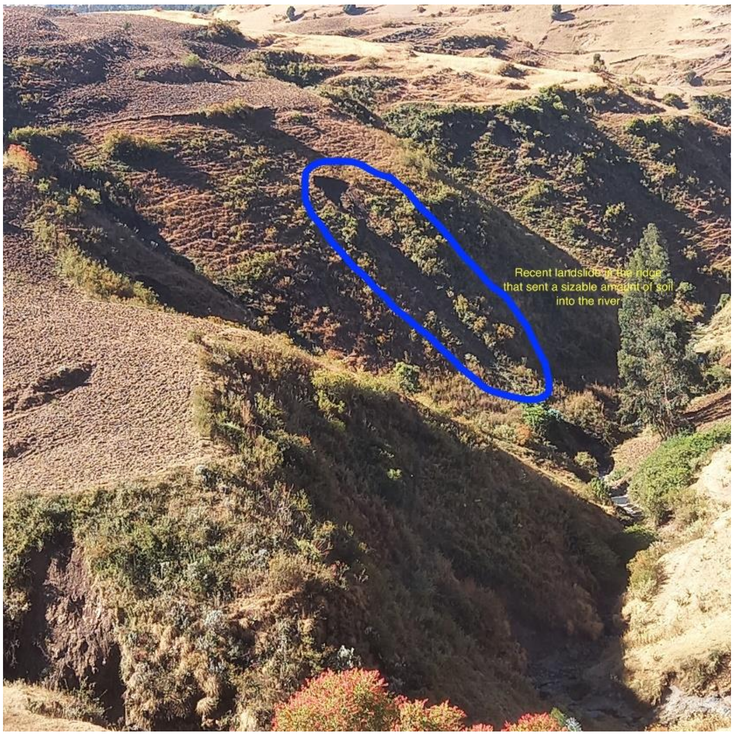

Figure 16 Recent landslide into the river because of agricultural activities on steep slopes

Figure 15 Poor drinking water quality from springs

Figure 17 Eucalyptus trees with no under shed vegetation

8 Conclusion

A Water Fund for the Addis Ababa City and key watersheds in the Oromia Region could play a key role in the water security challenges facing the area through the following impacts.

Firstly, while it is evident that a significant amount of funding has been directed to the sector, it is clear that these flows have been on a project and/or short-term basis. A potential Water Fund would become a permanent and coherent mechanism ensuring **continuity** in funding channelled for water resource conservation. Secondly, institutional misalignment and mandate overlaps and gaps are undermining the effectiveness of watershed management and water resources conservation. The Water Fund would be both a multi-stakeholder platform, and an honest broker through which the Private Sector can play a more significant role, supporting **collective action** in watershed management.

The City of Addis Ababa is facing a water crisis, which is most starkly characterised by a deficit in potable water supply of almost 50%. A prospective Water Fund could provide some targeted, strategic responses to this crisis, underpinned by collective action. It could also be catalytic in mobilising resources for other long-term water security interventions. The sub-sections that follow provide some concluding remarks for the assessment of technical and environmental, institutional, political, and financial and economic profiles of Addis Ababa WRM and water resources status quo. The final sub-section offers some early recommendations that could be the basis of ongoing debate to respond to this crisis.

8.1 TECHNICAL PROFILE

A watershed modelling study was undertaken on the Akaki watershed by the Team, to assess current and future water demand and supply in Addis Ababa. The Akaki watershed is located in the Awash River basin of Ethiopia surrounded by Entoto, Menagesha and Yerer mountains, and is largely covered by cultivated land and built-up areas. There is great potential to improve the endemic and antural vegetation to enhance biodiversity and wildlife in the three mountain ecosystems assessed. The modelling shows that the gap between the City's potable water demand and supply has been widening, primarily due to urban population growth and socio-economic lifestyle improvements. There has also been a decrease in relative water supply, due to the dimensioning efficiency of existing reservoirs and the depletion of the groundwater aquifer. The projection of future water demand was compared relative to a baseline period of 2019. The water demand and water supply analysis showed that the water demand will not be met for a number of years during the period 2020-2050.

The efficiency of the reservoirs is reducing because of sedimentation and leakages from the dams. Soil erosion is a serious problem in the Akaki watershed, with average annual soil erosion ranging between 3.3 and 12 tons/ha. The highest soil erosion was observed in areas which are dominated by cultivated lands, that feed into the City's reservoirs. Other biophysical factors such as land use and climate change may also exacerbate the gap between water demand and water supply.

Specifically, these will include soil and water conservation activities in the upper catchment that contribute to increasing water supply to Addis Ababa through minimising soil erosion (which decreases the capacity of reservoirs), increasing groundwater aquifer recharge (which will be especially important to manage a growing reliance on groundwater resources), and increasing baseflow to streams and rivers which supply the city's main reservoirs.

8.2 INSTITUTIONAL PROFILE

There are numerous laws, policies and strategies that define the regulatory framework relevant for a future Water Fund including AAWSA's recently developed 10-year Strategic Plan (2020). These regulations reinforce the need for improved water quality and quantity, and for sustainable watershed management. Furthermore, these laws sets out the institutional landscape for water resources management (WRM) and water supply is structured through Federal, Regional, and Local administrative units, as well as Basin management structures. However, institutional mandates, arrangements and relationships for WRM and water supply in Ethiopia are not well defined and integrated. Based on publicly available information and the Team's stakeholder engagements, the following institutions and their mandates are most notable, when considering the creation of a water fund:

- **Federal:** MoWIE is responsible for overall/master planning and coordination of WRM as well as monitoring the implementation of WRM and development programmes within the sector. MoWIE is also the lead institution responsible for policy, strategy and national project development and overall monitoring of the water sector at the national level (i.e., water supply projects financed by the Federal Government Budget). MoF provides financing for national Water Infrastructure, WRM and WRD (and sub-national projects where funding is needed and available), including investments under the Water Master Plan/Strategy. MoF's Water Resources Development Fund (WRDF) provides small-scale financing to water supply, sanitation, and irrigation development initiatives.
- **Regional:** The Oromia Bureau of Agriculture and Natural Resources plans, oversees and undertakes soil and water conservation activities at a community level through the region, in collaboration with the Woredas and Kebeles. The Oromia Bureau of Minerals, Water and Energy plans, implements, monitors and evaluates water supply projects.
- **Local:** As the local water utility, AAWSA's role includes planning, implementing, operating, monitoring, and evaluating urban water supply & sewerage systems. The Addis Ababa City Administration is the executive body for the City, with the Mayor as the head. City Administration is ultimately responsible for decision-making on material initiatives, such as a prospective Water Fund.
- **Other:** The Awash Basin Authority is active in the basin in infrastructure development, licensing and allocation, operation and maintenance of infrastructure, policy, and strategy, but is not perceived as an administrative unit with legislated powers.

It is the Team's early observation that these organisations would provide valuable representation and insights on the prospective Water Fund's governing body / steering committee. Potential private sector partners have also indicated interest in supporting the Water Fund as part of corporate social responsibility, as well as to help their organisations mitigate water-related challenges. Their representation might be useful, too. In addition, representation from existing water-sector development programmes would ensure that the Water Fund can align with and support existing efforts, as well as address the overarching institutional challenge in the

Ethiopian water sector of overlapping mandates. Importantly, the potential Water Fund has a key role to play in facilitating multi-stakeholder engagements in a more permanent and lasting mechanism that builds on the efforts made by public partners.

In respect of government transparency and corruption, Ethiopia has made promising improvements in anti-corruption and transparency efforts. The country's Corruption Perception Index rank, score, and improvement is higher than the region's average, and several studies have demonstrated encouraging results showing that, compared to its African peers, Ethiopia has lower levels of petty bureaucratic corruption in basic services.

8.3 POLITICAL PROFILE

In the Akaki Watershed, we have identified water-related conflicts over the last ten years at the regional level. These conflicts can be divided into two categories: direct water-related conflicts, and indirect water-related conflicts. The former includes the issue of a growing water demand deficit and misuse, whilst the latter includes that of: (i) the exclusion of stakeholders in the decision-making process; (ii) mandate disputes between authorities; and (iii) limited resources at the local watershed level. All four of these issues are central to effective water resources management (WRM) and water supply, and are therefore critical to consider in the development of a Water Fund.

The Institutional Profile set out the various laws, policies and strategies that define the regulatory framework relevant for a future Water Fund. None of these hinder the establishment of a Water Fund or provide restrictive measures against collective action to conserve source waters. These policies support the creation of a Water Fund as they encourage multi-stakeholder governance by helping to bring together public, private and civil stakeholders. This will serve to attract political influence, societal trust, and credibility to a Water Fund's creation, as well as initiate interventions. However, gaps in policy implementation and organisation mandate overlaps have been cited as a hindrance to natural resource conservation and rehabilitation.

The key issues to be considered when developing a Water Fund steering committee will be that of representation and mandate. The steering committee must have a balanced representation of institutions from the Oromia Region and from Addis Ababa to ensure all relevant actors are adequately heard, and different actors' interests are represented. This will include ensuring local and upstream community stakeholders are recognised and included, alongside stakeholders from Addis Ababa downstream in a balanced committee structure. Additionally, identifying the mandate of the Water Fund steering group will be essential to engaging stakeholders in a targeted manner. The Cooperative Promotion Office used by the SGP Ethiopia could provide suggestions for who to include in the steering group and what powers the group will have.

The naming of the prospective Water Fund is an important element of its success. The Team has considered a range of alternative names for the Water Fund. The term 'fund' has not been suggested for these names as, in Ethiopia, this implies resources have already been mobilised for deployment. Instead, using the term 'facility' could help gather support for the Fund's purpose. The Team's principal suggestions in respect of a name, is to establish a clear naming process between Addis Ababa and Oromia Region representatives to gather their input and create a sense of shared ownership. Once the name has been agreed upon in English, we would recommend that this be translated into Amharic.

8.4 FINANCIAL AND ECONOMIC

At the local level in Addis, AAWSA sets a common tariff structure, which is applied across domestic and non-domestic users which increases per cubic metre with greater consumption. The AAWSA tariff is charged monthly, but tariff revenues do not fully cover operational costs. Capital expenditure is predominantly supported by loans and grants from the government treasury or loans from international financiers like the World Bank and the Chinese Exim (export and import) Bank. At present, there is no private sector support for capital projects. This shines light on a financial resource constrained environment in Addis Ababa, which could be a short-term barrier to the proper establishment of the prospective Water Fund. Therefore, unlike in the case of some Water Funds in Africa, tariff and revenue collection may not be an appropriate avenue through which the proposed Water Fund might secure future income

Payments and agreements between AAWSA and the Oromia Regional State for WRM appear to be managed on a project-by-project basis, with no formal or standing arrangements in place. Several other funds and programmes are operational in Ethiopia, with some having a distinct sectoral focus on water resources management; soil and water conservation activities; as well as land management for enhancement of ecosystem goods and services. While it is evident that a significant amount of funding has been directed to the sector, it is clear that these flows have been on a project and/or short-term basis. This signals a need for a permanent and coherent mechanism through which funding for water resource conservation can be channelled – A key function of a potential Water Fund.

Lastly, the niche for a prospective Water Fund in Ethiopia is the public-private partnership (PPP) structure and catalysing collective action around water resources management. The private sector support to rural communities in the catchment and targeted water security measures and practices within Addis must be complemented by public sector contributions. An institutional structure into which the private sector is willing to place their money will be essential – the configuration of which must be developed in the design phase.

8.5 EARLY RECOMMENDATIONS

A multi-pronged approach is required to address the water security crisis for Addis Ababa. We believe that a Water Fund could play a strategic and catalytic role in responding to this crisis over the long-term, as conceptulaised in the diagram below.

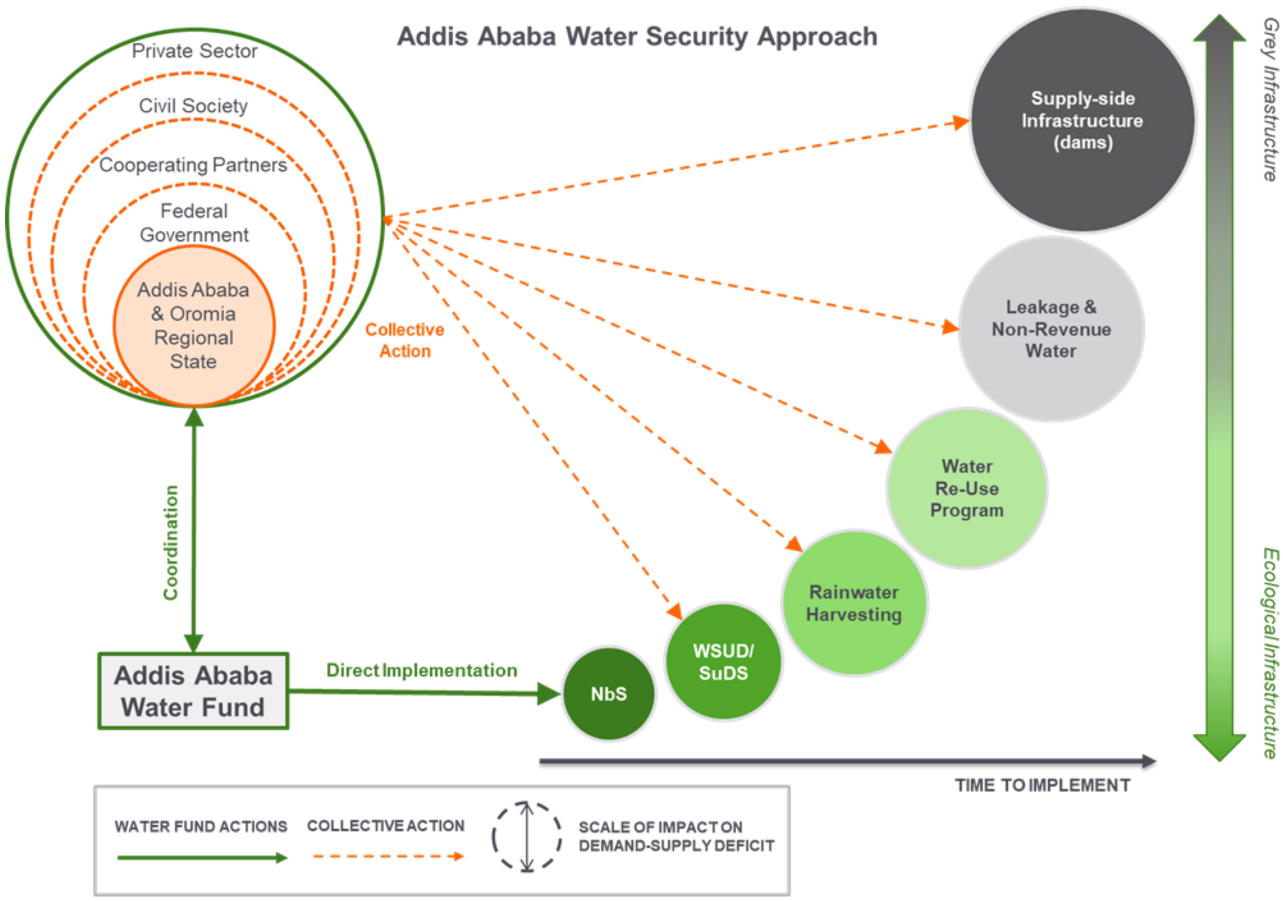

Figure 19 Proposed Water Fund Concept

The following early recommendations should be considered:

i. **Long-term institutional strengthening:** A Water Fund could establish a multi-stakeholder governance platform to: (a) encourage improved communication and alignment between actors in the water sector; (b) facilitate awareness and education; and (c) identify key gaps and formulate targeted activities for the Water Fund to support (i.e. not those that might be covered by existing funds and government programmes).

ii. **Fostering early ownership:** A steering committee should be established as soon as possible, and include representatives from the key federal, regional and local government institutions outlined in this report. As the design of the water fund progresses, this committee could include private sector businesses and development partners who have a particular interest or aligned purpose. An approach to involving communities in the rural areas of the Akaki watershed should also be initiated early in the water fund development process.

iii. **Key technical activity:** The key Water Fund activity that appears to be most applicable as a collective action mechanism is soil and water conservation activities and nature-based solutions (NbS) in the upper catchments of the Akaki watershed. Other collective action-type activities could include rainwater harvesting and decentralised supply technologies within the City's urban delineation.

In addition to these three niche interventions for the proposed Water Fund, there are other related interventions that the Water Fund may consider:

iv. **Decentralised water supply options:** The Addis Ababa City has many impervious areas including rooftops. Surface runoff can be collected from these impervious areas and used for various purposes with modest water treatment. The surface runoff may be collected from individual building rooftops, or at larger scale areas that include roads, parking lots, etc. Adugna and Jensen (2018) reported that rainwater collected from 588 rooftops of large public institutions in Addis Ababa City can provide up to 2.3% of the City's 2016 water supply. The study further added that if rainwater is collected from all large public institutions of the City, it can supply up to 9.2% of the City's water supply (Adugna and Jensen, 2018). Development of such decentralized water supply options can lessen the pressure on the larger centralized water supply system.

v. **Maximising reservoir potential:** The potential of the existing reservoir catchment areas is not fully harnessed. By extending the current dams (e.g. raising dam highest, building new dams in the catchments, etc), it is possible to increase the current water supply coverage as assessed in Scenario 2. However, unless sufficient watershed treatment practices are implemented, the capacity of the reservoirs may be impaired. Therefore, watershed treatment practices such as terraces, filter strips, buffer zones, area closures should be implemented (especially in erosion prone areas) to reduce soil erosion and reservoir sedimentation for the existing and future reservoirs.

vi. **Other surface water options:** Accounting for 30% of the streamflow for environmental flow requirements, the Akaki watershed has the potential to meet water demand together with planned groundwater development projects until 2025 (Figure 5). Thereafter, surface water development projects should occur outside the delineated Akaki watershed including nearby watersheds.

vii. **Groundwater recharge:** Most of the groundwater wells have a depth of more than 300 m. Evidence from the AAWSA (2020) showed that several groundwater wells were abandoned because of depletion of the groundwater aquifer. Since relying too much on the groundwater resource may cause such exhaustion of the groundwater aquifer in the surrounding area, significant investments in the wells may not be a sustainable approach. Rather, it is better to focus developing surface water resources in the Akaki and nearby watersheds. However, implementing different practices that enhances the groundwater recharge may help to replenish the groundwater aquifer for the existing groundwater sources. Practices that help recharge include construction of artificial wetlands, recharging pits, check dams, etc.

Furthermore, there are additional in-direct interventions that would be particularly useful in augmenting Addis Ababa's future water supply. These are unlikely to be in the remit of the prospective Water Fund, as they are not premised on collective action, and tend to be capital intensive. Two prominent options include:

viii. **Wastewater reuse:** Currently, only a fraction (about 10%) of the wastewater is collected and treated either in centralized or decentralized systems (ACATIAWATER, 2020). If the wastewater treatment system of the City is improved, the treated water can be reclaimed for reuse after passing through intensive water treatment process. Such practice is becoming common in different parts of the world.

ix. **Water losses:** There is substantial amount of water loss in the current water supply system. Data from AAWSA showed that more than 1/3rd of the supplied water is lost in different forms (AAWSA, 2020). Serious measures should be implemented to reduce losses. Some of the losses may be addressed upgrading the water supply infrastructures to reduce leakage losses in the distribution system. Other measures may include implementation of tariffs that encourage efficient water use practices.

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Full Technical and Environmental Analysis

INTRODUCTION

OVERVIEW OF WATER SUPPLY INFRASTRUCTURE

The provision of potable water supply to Addis Ababa (referred to herein as the “City”) began in 1901[19] after 15 years of its formal establishment in 1886. The water supply sources were Kebena and Kechene rivers of the City (Sime, 1998; Adam, 1999). The Entoto water treatment plant with a capacity of 1,500 m^3 day^{-1} was commissioned in 1938 to treat water of Kebena River and Kidane Mehrete springs (Adam, 1999). However, unprecedented growth in the City’s urban population and economic activity significantly increased the water demand, especially after the 1950s.

The population of Addis Ababa was 392,000 in the 1950s and it became more than 4 million by 2015 (AAWSA, 2012), and projected to surpass 6 million by 2037 (AAWSA, 2020). Therefore, the Addis Ababa Water and Sewerage Authority (AAWSA) should make urgent steps to meet the increasing water demand. AAWSA has been producing water from different sources such as: spring developments; Entoto Water Treatment Plant; successive Gefersa reservoir constructions; Legedadi Reservoir & Water Treatment Plant; Dire reservoir; and other well & spring developments (Sime, 1998; Adam, 1999). Development of these surface water and groundwater sources enabled AAWSA to increase its water supply from 219,380 m^3/day in 2005 to 599,000 m^3/day in 2019 (Table 3, AAWSA, 2020). Currently, the majority of the potable water production is sourced from groundwater sources (62%) and the remaining 38% came from surface water sources (i.e. Legedadi, Dire and Gefersa surface water reservoirs) (Table 3). The increase in the water supply for the period 2005 to 2010 was mainly achieved through development of multiple groundwater bore halls (Table 3).

The Legedadi reservoir was commissioned in 1970 through the government of Ethiopia, and in the early years of its establishment, it was supplying 50,000 m^3 per day of water (Sime, 1998). Due to an increase in water demand in the City, the Legedadi water treatment plant was expanded building the Dire reservoir Project in 1998, upstream of the existing Legedadi reservoir. This increased the water storage capacity of Legedadi reservoir, and the combined water storage of the two reservoirs is 120 Mm^3 (86 Mm^3 and 34 Mm^3, respectively), and thereby was supplying 165,000 m^3/day to Addis Ababa City (AAWSA, 2011). The Gefersa reservoir I/II is another source of surface water which was constructed in 1944 (Adam, 1999). To increase water storage capacity of Gefersa reservoir I/II and also to trap silt, Gefersa reservoir III was constructed in 1966. Gefersa reservoir systems have a water storage capacity of about 8 Mm^3 and supply 30,000 m^3/day of water to Addis Ababa City (FDRE:MoWR, 2002). These surface water supply sources, their original commissioning dates, reservoir volumes, and daily water supply amounts are summarized in Table 1.

Table 1. *Addis Ababa City surface water supply sources and period of commissioning (AAWSA, 2011; AAWSA, 2020).*

[19] All years are in Gregorian Calendar.

Reservoir	Volume (Mm^3)	Water Supply (m^3/day)	Original Commissioning Year
Legedadi	86	50,000	1970
Extension of Legedadi reservoir through construction of Dire reservoir	120	19,500	1998
Gefersa reservoir I/II	1.5	5,600	1944
Gefersa reservoir III	6.5	24,400	1966

Groundwater sources such as the Akaki wells, springs and deep wells, which are located throughout the City, are other source of water for the City. Until 2010, springs, shallow- and deep-wells have been supplying 75,156 m^3/day (AAWSA, 2011). Thereafter, significant investment were put in groundwater bore hall development. For example, the new Akaki well field, which supplies 73,000 m^3/day of water was commissioned in 2012 (AAWSA, 2012). Other springs, wells and deep wells have been commissioned in different parts of the City since 2012 (Table 2). In fact, the AAWSA developed a Business Plan for the period 2011 to 2020 that increases the groundwater contribution from 75,156 m^3/day in 2010 to 599,000 m^3/day in 2019 (AAWSA, 2020). Future groundwater wells are planned to be developed in the Akaki, Legedadi, Ayat, Sebeta and Melka Kuntire areas which are located in the southern, norhern and south western partn of the city (AAWSA, 2020). Most of the planned groundwater bore halls are located in the Akaki watershed, Melka Kuntrie borehole site.

Table 2. *Groundwater sources, their water supply amount to the City, and their respective commissioned year (Source; AAWSA, 2020)*

Groundwater sources	Water Supply (m^3 day^{-1})	Commission Year
Springs, shallow- and deep-wells	10,551	2010
Akaki well field	73,000	2012
Akaki well field - 3	70,000	2015
Legedadi well field - 1	40,000	2015
Koyefichie, Kilinto and Tuludimtu well fields	40,000	2016
Ayat-Fanta well field	68,000	2017
Legedadi well field - 2	86,000	NA

The water supply from the surface and groundwater supply for the period 2005 to 2015 are summarized in Table 3. Likewise, the water demand for the period 2005 to 2019 including losses (where data was available) are also presented in Table 3. The water supply and demand data in 2005, 2010, 2015 and 2019 indicated that the supply had met only 57%, 50%, 51% and 54% of the demand, respectively.

Table 3. Existing water supply from surface and groundwater sources to Addis Ababa City (AAWSA, 2011; AAWSA, 2020)

Year	Water supply (m^3/day)				Water demand including losses (m^3/day)
	Legedadi-Dire	Gefersa	Groundwater	Total water supply	
2005	165,000	23,000	31,381	219,381	380,041
2006	165,000	23,000	39,014	227,014	NA*

2007	165,000	23,000	48,381	236,381	NA
2008	165,000	23,000	54,208	242,208	NA
2009	165,000	23,000	64,605	252,605	NA
2010	165,000	30,000	75,156	270,156	541,491
2011	165,000	30,000	94,058	289,058	NA
2012	165,000	30,000	111,707	306,707	NA
2013	165,000	30,000	131,027	326,027	NA
2014	165,000	30,000	133,767	328,767	NA
2015	180,000	30,000	169,000	379,000	737,306
2019	195,000	30,000	374,000	599,000	1,103,885

*NA refers no data.

CHALLENGES MEETING GROWING WATER DEMAND

Recently, the City Government has taken multiple measures to improve the water supply and demand management. AAWSA has been increasing water sources and taking measures that reduces water losses due to leakages and misuses. In the City water supply system, more than 30-36% of the supplied water is lost through leakages and other inefficiencies in the distribution system (AAWSA, 2012), which is significant for a city of this size. For example, based on the volume of domestic and non-domestic water demand of 2019, about 292,000 m^3/day of water is lost (AAWSA, 2020).

Water supply has been increasing in the city although it was not in par with the demand. Moreover, most of the increases in the water supply, especially since 2010, came from investments in groundwater sources. For example, the water supply from groundwater sources between 2010 and 2015 more than doubled, but the supply from surface sources was not increasing during the period 2005 to 2015 (Table 3). Likewise, to address the water loss issues, current demand management practices include improving efficiency of water delivery and minimizing losses fixing water losses due to leakages in pipes, storage tankers, distribution systems and processing points (FDRE: MoWR, 2002). The other measure to improve the demand side water management was implementing tariffs on domestic, non-domestic and industrial water users (AAWSA, 2012).

Although the City has regularly increased its water supply, significant urban population growth has caused an unprecedented increase in water demand over the last two decades. This trend will likely continue into the foreseeable future. For example, according to Alemu and Dioha (2020), unmet water demand in 2030 may be 841,096 m^3/day, which means that the unmet demand between the period 2015 to 2030 may increase by 48%.

Climate change is another factor which exacerbate the existing disparity between water supply and water demand in the City. Under intermediate climate change scenario of RCP4.5 (Representative Concentration Pathway 4.5) and high population growth rate of 3.3%, the unmet water demand in the City will be 239,506 m^3/day, 43,3917 m^3/day and 1,043,095 m^3/day in 2030, 2035 and 2037, respectively (Arsiso et al., 2017). Under low population growth rate of 2.5% for the year 2037, unmet water demand will be 704,876 m^3/day and 862,767 m^3/day for the RCP8.5 and RCP4.5, respectively (Arsiso et al., 2017). The RCP8.5 scenario represents an extreme climate change condition.

Soil erosion is a significant issue in Ethiopia and in the Akaki watershed where the water supply reservoirs for the City are located. The soil erosion, therefore, has been causing siltation of water supply reservoirs and thereby reducing reservoirs live water storage volume. For example, the storage capacity of Legedadi reservoir reduced by 4.5% (i.e. from 45.9 Mm^3 to 43.8 Mm^3) in the period 1979 to 1998 (DAR AL OMRAN, 2011).

THE PURPOSE OF THE TECHNICAL ASSESSMENT

Evidence suggests that the existing water supply efforts by the City Government of Addis Ababa is not comparable with the current and future water demands of the City's urban population. Therefore, it is important to understand the current and future water supply and water demand estimates under different environmental and socio-economic conditions. This study, therefore, intends to investigate the high-level water supply potential of different reservoirs and groundwater wells of Addis Ababa using a physically based model. A calibrated and validated Soil and Water Assessment Tool (SWAT)[20] hydrologic model was used to estimate the surface runoff, groundwater flow contribution, total water yield, and actual evapotranspiration of the Akaki Watershed. The Akaki watershed was selected for this study since all of the water supplying reservoirs and ground water sources of the City are located inside this watershed.

MATERIALS AND METHODS

STUDY AREA

Location

The Addis Ababa City is located inside the Akaki watershed (Figure 1), which is a tributary of Awash River in Ethiopia. The Akaki watershed, which starts from the Entoto Mountain of Addis Ababa, is located in Central Ethiopia along the western margin of the main Ethiopian Rift valley. This watershed is surrounded by Entoto Mountain from the north, Menagesha Mountain from the north-west and Yerer Mountain from the east. The geographic coordinate system of the watershed is located between 8◦ 45′ to 9◦ 14′N latitude and 38◦ 35′ to 39◦04′E longitude. The watershed has an area of 1445 km^2 with elevation range of 2040 m and 3400 (Figure 1).

The watershed consists of Legedadi, Dire and Gefersa rivers which flows from north to south. Reservoirs were built in these rivers to supply water to the City of Addis Ababa.

- The Legedadi reservoir has an area of 510 ha. The catchment area upstream of the reservoir is 207.3 km^2 (Table 4) and extends between 09° 01′ 50″ to 09° 12′ 56″ N latitude and 38° 56′35″ to 39° 04′ 13″ E longitude (Figure 1).

[20]SWAT is a physically based model which is developed to predict the impact of land management practices on water, sediment and agricultural chemical yields (e.g., fertilizer and pesticides) in complex watersheds with varying soils, land uses and management conditions (Arnold et al., 1998).

- The Dire reservoir has an area of 165 ha. The catchment area upstream of Dire reservoir is 77.5 km^2 and it extends between 09° 08′ 23″ to 09° 13′ 20″ N latitude and 38° 49′ 44″ to 38° 57′ 52″ E longitude (Figure 1).

- The Gefersa reservoir -I/II/III reservoirs (all together) has an area of 130.5 ha. The catchment area upstream of the Gefersa reservoirs is 53.5 km2 and is located at 9°3'59" N and 38°37'56" E.

The physical characteristics and location of the water supply reservoirs to the City are summarized in Table 4. The location of the reservoirs with their reservoirs and tributary rivers are shown in Figure 1. Although this study is focused more on simulating the water balance of the reservoirs which are feed by stream flow, the study also mapped the Akaki well fields that supplies groundwater to the City.

Table 4. Physical characteristics of the water supply reservoirs to the Addis Ababa City (DAR AL OMRAN, 2011)

Reservoir	Area (ha)	Catchment area (km^2)	Distance from Addis Ababa (km)
Legedadi	510	207.3	30
Dire	165	77.5	40
Gefersa	130.5	53.3	18

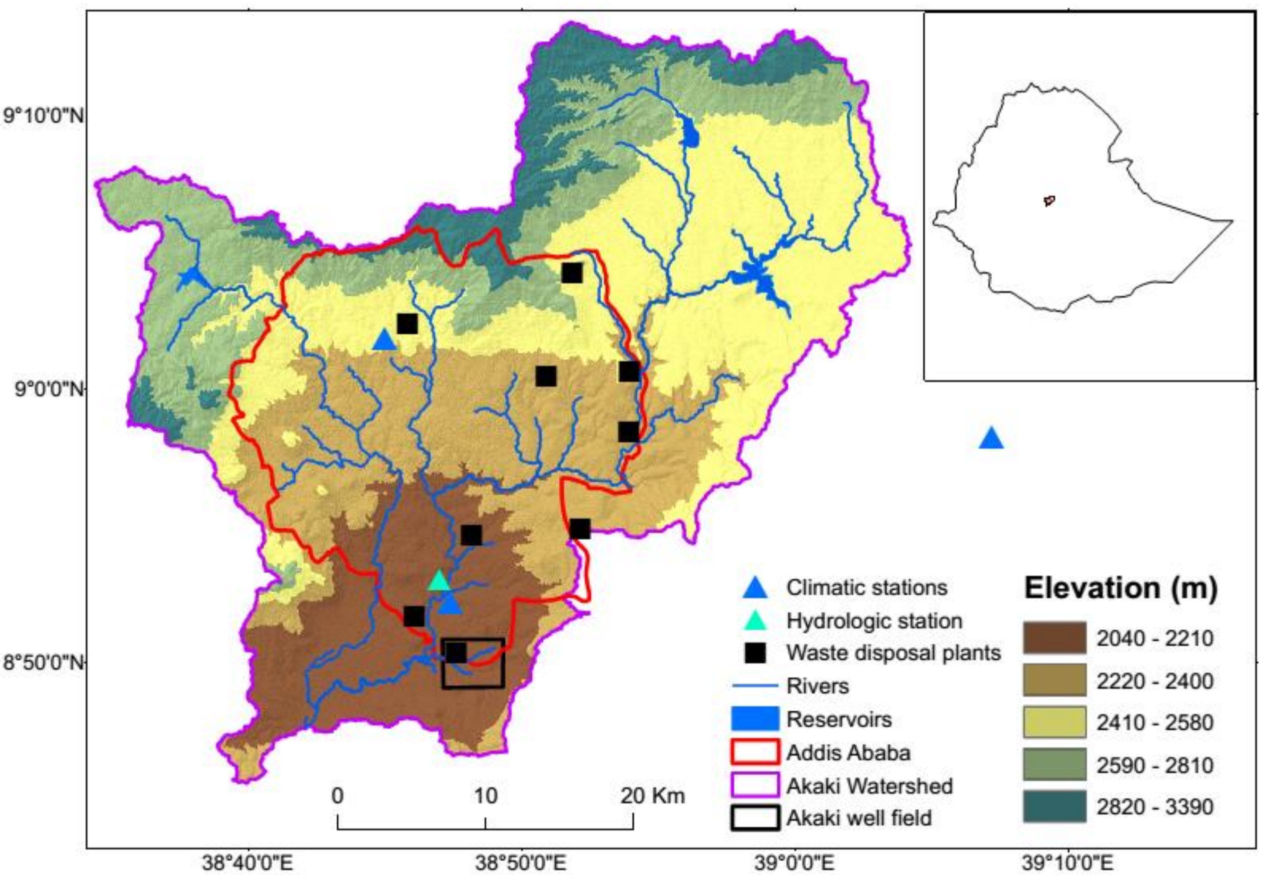


Figure 1. Location of Legedadi, Dire and Gefersa reservoirs and Akaki well fields in the Akaki watershed. The background image is the elevation map. The Addis Ababa City boundary is also overlaid over the map. Climate and hydrological monitoring stations are also indicated in the map

Topography

The Akaki watershed has a diverse topography with chains of mountains, valleys, undulating and flat plains (Figure 1). The upstream part of the watershed is characterized by a chain of mountains with elevations range of 2040 to 3340 m.a.s.l[21]. The middle- and lower-stream of the Akaki watershed are under flat plains with gentle slope. The highest elevation areas are located in the northern and north-western part of the City (Figure 1), which, in part, necessitated locating the water-supplying reservoirs in these locations to deliver the water using gravity system.

Land cover/land use

The Akaki watershed is largely covered by cultivated land and built-up areas (Figure 4a). The water bodies such the Legedadi, Dire and Gefersa reservoirs and Aba Samuel Lake cover a fraction of the watershed. Reports showed that there has been unprecedented land use change in the Akaki watershed, mainly due to the expansion of the Addis Ababa City and conversion of grassland into cultivation land. Anteneh et al., (2018) reported that grasslands in the Legedadi-Dire catchments were converted to cultivation land and built-up areas due to increasing settlement. Built-up areas in the Addis Ababa city increased from ~19% to ~34% during the period 1986 to 2011. In the same period, the grassland land use reduced from ~23% to ~14% (Teferi and Abraha, 2018).

Climate

The rainfall of the Central Highlands of Ethiopia is driven by the moisture from the Indian Ocean, equatorial east Pacific, Gulf of Guinea, Mediterranean region and Arabian Peninsula (Seleshi and Zanke, 2004; Viste and Sorteberg, 2011). As a result, the rainfall of the Akaki watershed is driven by these large scale intercontinental processes including the [22]Intertropical Convergence Zone (ITCZ) (EPCC, 2015). The main rainfall season spans the period June to September (Figure 2) and short rainfall season occurs for the period March to May. The months from October to February are largely dry. The spatio-temporal long-term average annual rainfall of the Akaki watershed is 1026 mm, and the spatio-temporal long-term average monthly temperature ranges between 16 °C to 19 °C. The lowest minimum temperature and the highest maximum temperature were observed in December and May, respectively (Figure 2).

[21] "m.a.s.l." means metres above sea level.
[22] Intertropical Convergence Zone is a narrow zone near the equator where northern and southern air masses converge, typically producing low atmospheric pressure.

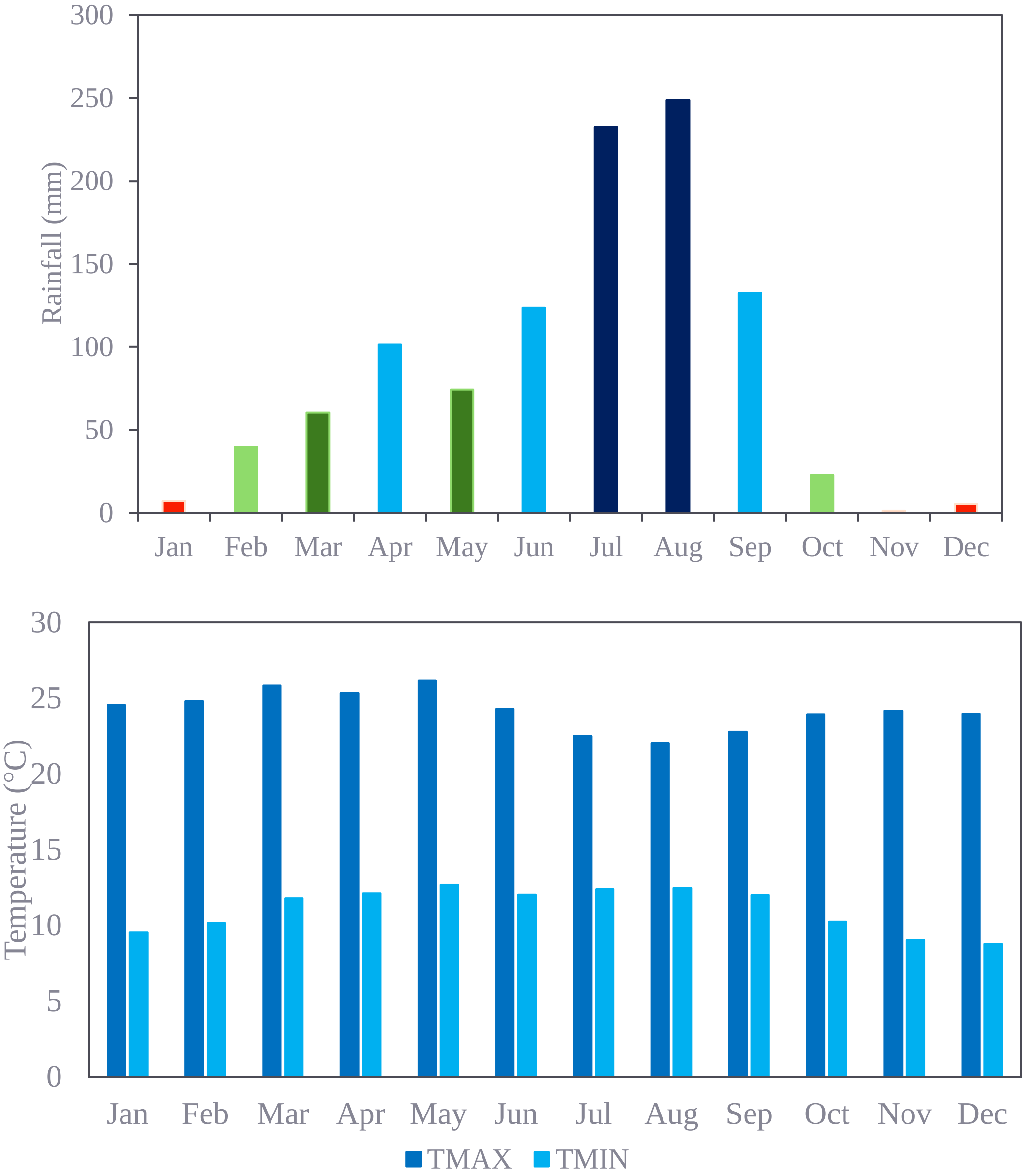


Figure 2. *Long-term (1983-2013) average monthly rainfall (above, A) and Maximum and Minimum Temperature (below, B) in the Akaki watershed*

WATERSHED MODELING

INPUT DATA

The SWAT model requires spatial data such as Digital Elevation Model (DEM), soil, and land use to discretise the watershed and define Hydrological Response Units (HRUs). An HRU is the smallest hydrological unit in the SWAT model which is represented by a unique combinations of slope class, land use and soil types within a subbasin. DEM data is used to estimate slope, stream networks and sub-basin and watershed boundaries. A DEM data, which has a 30m resolution, was obtained from the Shuttle Radar Topographic Mission (SRTM) (https://earthexplorer.usgs.gov/). The land use data for the year 2016 was produced from Landsat 8 Operational Land Imager (OLI) employing supervised image classification method and maximum likelihood algorithm. The land use map was prepared with Kappa (K) statistics and overall accuracy of 84% and 82%, respectively. According to the 2016 land use map of the Akaki watershed, 74% is cultivated land, 15% is urban land, 6% is grazing land, 3% is forest and the remaining land is shrub land, waterbody and bare land. The study used soil data obtained from the Africa Soil Information System (AfSIS) which has a spatial resolution of 250 m and consists of up to six layers of soil physical and chemical properties data (Vågen et al., 2010; Leenaars et al., 2014; Hengl et al., 2015). All the spatial data were projected to the same projection system of Ethiopia, which is UTM Zone of WGS 1984 and 37 N.

Climate data such as rainfall, maximum/minimum temperature, solar radiation, wind speed and relative humidity are required to simulate different hydrological processes. Observed rainfall and maximum/minimum temperature data of stations located inside and around the Akaki watershed were used (Figure 1). The climate data was obtained from the Ethiopian National Meteorological Services Agency. A weather generator based on Addis Ababa climate station was used to fill missing records and generate daily solar radiation, wind speed and solar radiation data (Arnold et al., 2012). The model was calibrated based on monthly observed streamflow data for the period 1990-2004 at the Akaki River gauging station. The observed streamflow was obtained from the Ethiopian Ministry of Water, Irrigation and Energy (MoWIE, 2018). The location of observed climatic and streamflow gauging stations is shown in Figure 1.

Water supply and water demand of the City was analysed using data from the AAWSA (2011; 2012; 2020). Water losses 36% was considered in the overall water supply system (AAWSA, 2012). The water supply network that shows the distribution of the water supply system from surface water reservoirs and ground water sources is presented in Figure 3. The water supply network indicates that the distribution networks are not evenly distributed throughout the city. The water sources from the surface water reservoirs cover a large part of the city while the groundwater sources supply water locally. Building multiple temporary tankers at the centre of the city may temporarily store water and buffer water shortages in times of water supply disruptions.

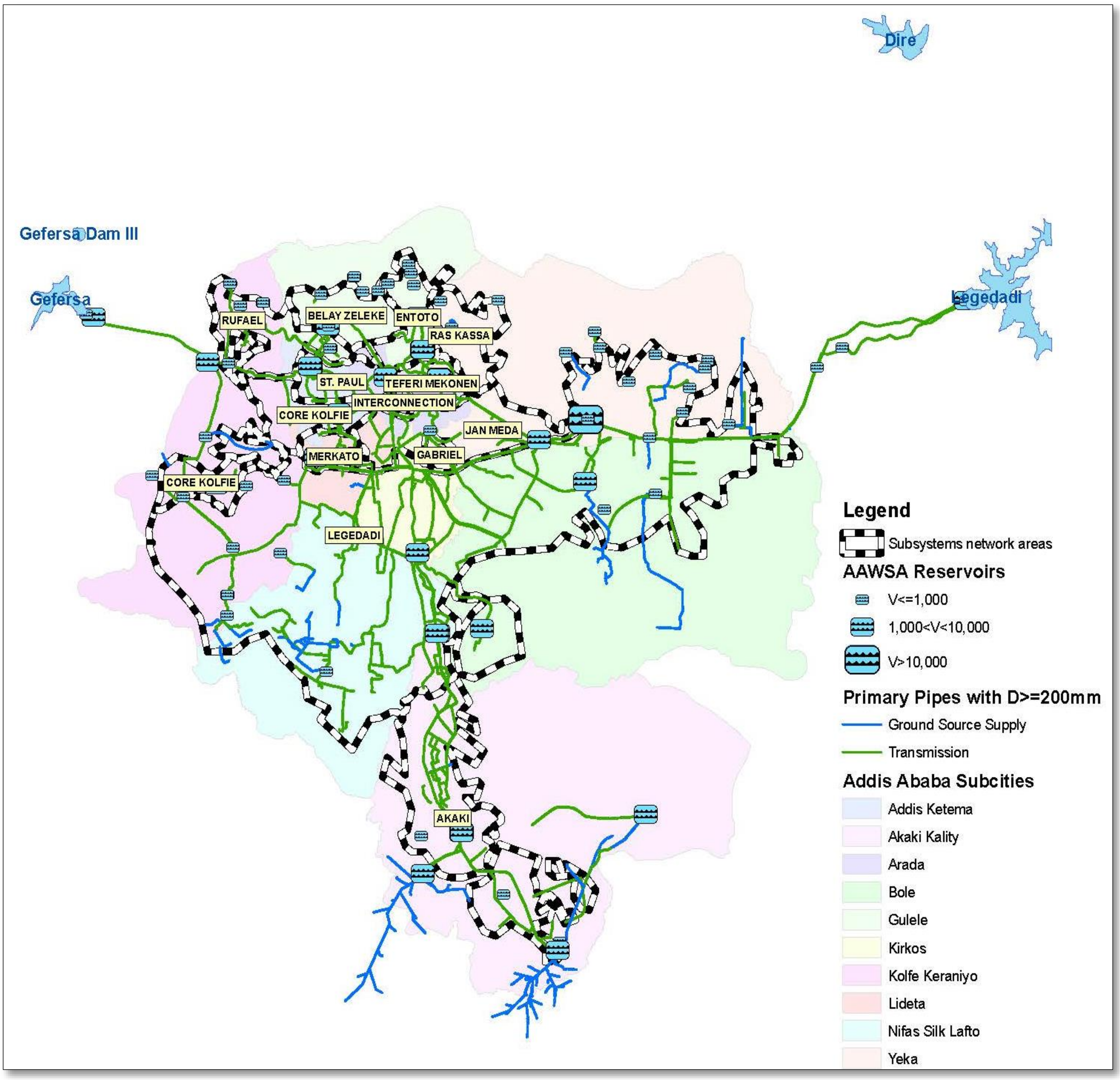


Figure 3. *Water supply network of the Addis Ababa City with locations different reservoirs.*

HYDROLOGICAL MODEL SETUP

The available water resources and soil erosion in the Akaki watershed was estimated using the SWAT hydrologic model. The Akaki watershed was discretized into 65 sub-basins using a threshold area of 16 km^2. A threshold area is the smallest area that is required to initiate a stream network in a watershed. The modelled watershed had an area of 1,445 km^2 and 634 HRUs. Multiple HRUs were defined within a sub-basin to have better biophysical representations across the watershed.

Different equations were used to estimate biophysical processes. The Soil Conservation Service (SCS) Curve Number (CN) method (USDA-SCS, 1972) was used to estimate surface runoff. Studies showed that the CN method can successfully estimate surface runoff in tropical watersheds (Dile et al., 2016). The potential evapotranspiration (PET) was estimated using the Penman-Monteith method. The flow of water across the sub-basins was estimated using the variable routing method.

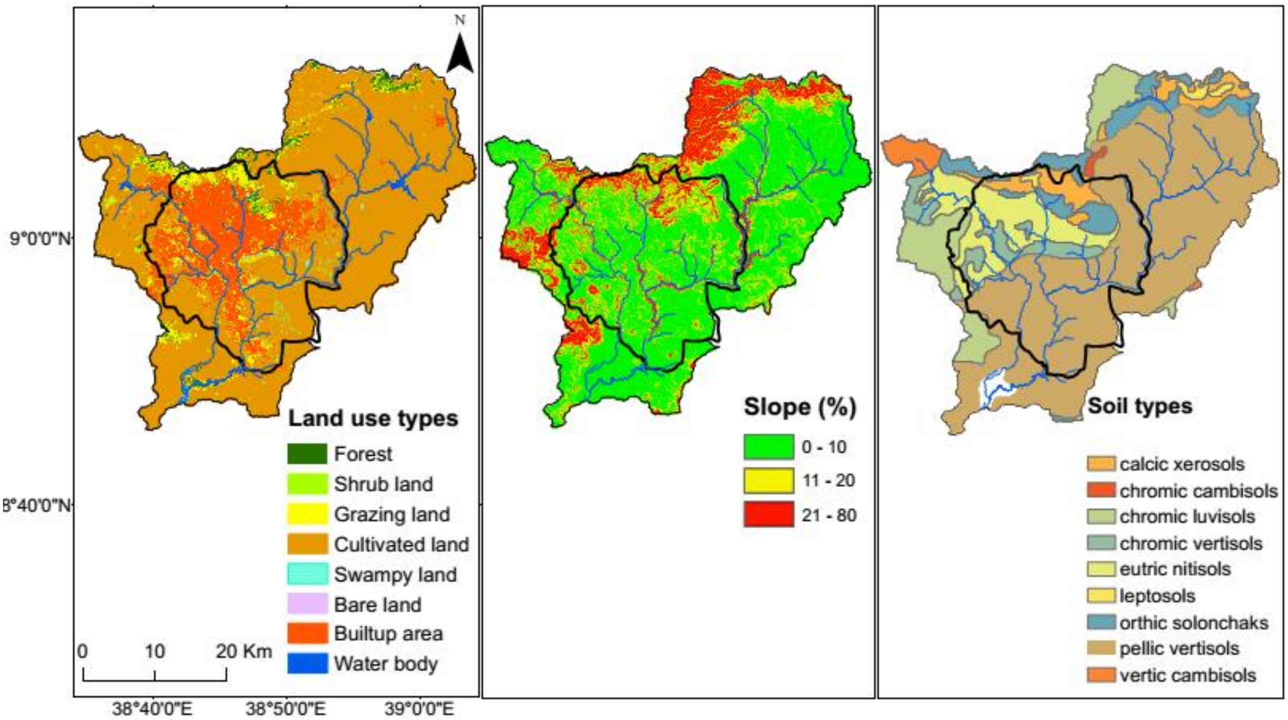


Figure 4. *Maps of land use, slope classes, and soil types in the Akaki watershed.*

In the rainfed agricultural, land management practices that are based on farmers' experience were incorporated in the model to improve its simulation performance. The dominant crops cultivated in the Akaki watershed include Wheat, Barley and Teff (*Agrostis* Teff).

MODEL CALIBRATION AND VALIDATION

Model was calibrated to represent actual biophysical conditions on the ground. Calibrations was done using observed streamflow data. The calibrated model was validated using an independent observed streamflow data (i.e. data which was not used for the model calibration). The model calibration and validation for streamflow related parameters were conducted for the period 1990-1995, and 1998-2004, respectively. Soil erosion related parameters for the Akaki watershed was calibrated based on observed sediment concentration data from the adjacent Melka Kuntrie watershed. The sediment load data at the Akaki watershed was generated from observed streamflow and sediment concentration data using the Load Estimator (LOADEST) tool (Runkel et al., 2004). The sediment load for the period 1990-1995 was used for model calibration while the period 1998-2004 was used for validation. The sediment calibration and validation was performed at the Melka Kuntrie watershed and the sediment related parameters were transferred into the Akaki watershed since both watersheds have similar watershed characteristics which is a standard practice in the SWAT modelling approach (Cao et al., 2006; Santhi et al., 2009). Akaki watershed and Melka Kuntrie watershed have similar biophysical characteristics such as topography, land use, soil and climate. For example, similar to the Akaki watershed, elevation in the Melka Kunture watershed is in the order of 1,948m to 3,575 m. The land use in the Melka Kuntrie watershed is dominated by cultivated land (86%) followed by grazing land (9%) and other land uses account only a small fraction. In the Melka Kuntrie watershed, about 27% of the watershed area is under a slope class of 0-10%, 38% is under slope class of 10–20% and 34% is under the slope class of more than 20% (Tolera et al., 2018).

Model calibration was performed using the Sequential Uncertainty Fitting (SUFI-2) algorithm in the SWAT Calibration and Uncertainty Program (SWAT-CUP, Abbaspour et al, 2004). SUFI-2 algorithm in the SWAT-CUP was also used to identify the most sensitive parameters that significantly affect streamflow and sediment yield simulations.

The performance of calibration and validation of the model was evaluated using Nash and Sutcliffe Efficiency (NSE) and percent Bias (PBIAS) which are standard goodness-of-fit evaluation criteria in hydrology (Moriasi et al., 2015). The NSE is normalized statistics that measures the relative magnitude of the residual variance compared to the observed data variance (Nash and Sutcliffe, 1970). An NSE value >0.50 is generally considered as an acceptable level of performance for streamflow and sediment yield simulations (Moriasi et al., 2015). PBIAS measures the average tendency of the simulated data to be larger or smaller than the observed data. A PBIAS value of ±25% and ±55% are considered as reasonable for streamflow and sediment yield simulations, respectively (Moriasi et al., 2015). The uncertainty of the model simulation in the SUFI-2 is evaluated in terms of the p-factor and r-factor (Abbaspour et al, 2004). The p-factor measures the percentage of observed data bracketed within the 95 percent prediction uncertainty (95PPU) while the r-factor measures the thickness of the uncertainty band. A p-factor of 1 and an r-factor of 0 represents an ideal agreement between simulated and observed flow (Abbaspour, 2015; Abbaspour et al., 2007).

RESULTS AND DISCUSSION

MODEL SIMULATION PERFORMANCE

Based on the SWAT modelling results, the most sensitive streamflow related parameters in the Akaki watershed include Curve Number (CN2), soil available water capacity (SOL_AWC), soil evaporation compensation factor (ESCO), effective hydraulic conductivity in the main channel (CH_K2), base-flow alpha factor (ALPHA_BF), Groundwater delay (GW_DELAY), threshold water depth in the shallow aquifer for flow to occur (GWQMN), groundwater revap[23] coefficient (GW_REVAP), and threshold depth of water in the shallow aquifer for "revap" to occur (REVAPMN) (Table 5). While the most sensitive soil erosion related parameters include channel cover factor, channel erodibility factor, channel re-entrained linear parameter and channel re-entrained exponent parameter (Table 5). Landscape process related parameters such as support practice factor (USLE_P), average slope length (SLSUBBSN) and average slope steepness (HRU_SLP) were sensitive to sediment yield simulation both in the Melka Kuntrie and Akaki watersheds (Table5). Detailed description of these model parameters is presented in the SWAT model Input/Output documentation (Arnold et al., 2012).

[23] Water in the shallow aquifer returning to the root zone.

Table 5. Calibrated parameters, parameter ranges and final fitted values. The detailed parameter descriptions are presented in Arnold et al. (2012).

	Sensitive Parameters	**Parameter ranges**	**Final Fitted values**
Parameters sensitive to flow	Curve number, *r__CN2.mgt	-0. 2- 0.2	-0.055
	Soil evaporation compensation factor, v__ESCO.hru	0.5-0.95	0.683
	Available water capacity of the soil (mm), r__SOL_AWC.sol	-0.2 - 0.2	-0.197
	Groundwater delay (days), a__GW_DELAY.gw	-20-450	28.17
	Threshold depth of water in the shallow aquifer required for return flow to occur (mm), a__GWQMN.gw	0-2000	135.00
	Base-flow alpha factor (days), v__ALPHA_BF.gw	0.0 - 1.0	0.1875
	Groundwater "revap" coefficient, a__GW_REVAP.gw	0-0.18	0.070
	Threshold depth of water in the shallow aquifer for "revap" to occur (mm), a__REVAPMN.gw	0-250	139.37
	Effective hydraulic conductivity in the main channel, v_CH_K2.rte	5.0-130	57.81
Parameters sensitive to sediment	Channel erodibility factor, v_CH_COV1.rte	0.25 – 0.6	0.546
	Channel cover factor, v_CH_COV2.rte	0.4 - 1	0.602
	Jan channel erodibility factor, v_CH_ERODMO(..).rte	0.8 - 1	0.322
	Channel re-entrained linear parameter, v_SPCON.bsn	0.001 - 0.005	0.0037
	Channel re-entrained exponent parameter, v_SPEXP.bsn	1.2 - 1.5	1.126
	support practice factor, v_USLE_P.mgt	0.8 - 1	0.582
	Average slope steepness, r_HRU_SLP.hru	0.1 – 0.5	0.303
	Average slope length, r_SLSUBBSN.hru	-0.1 – 0.1	-0.068

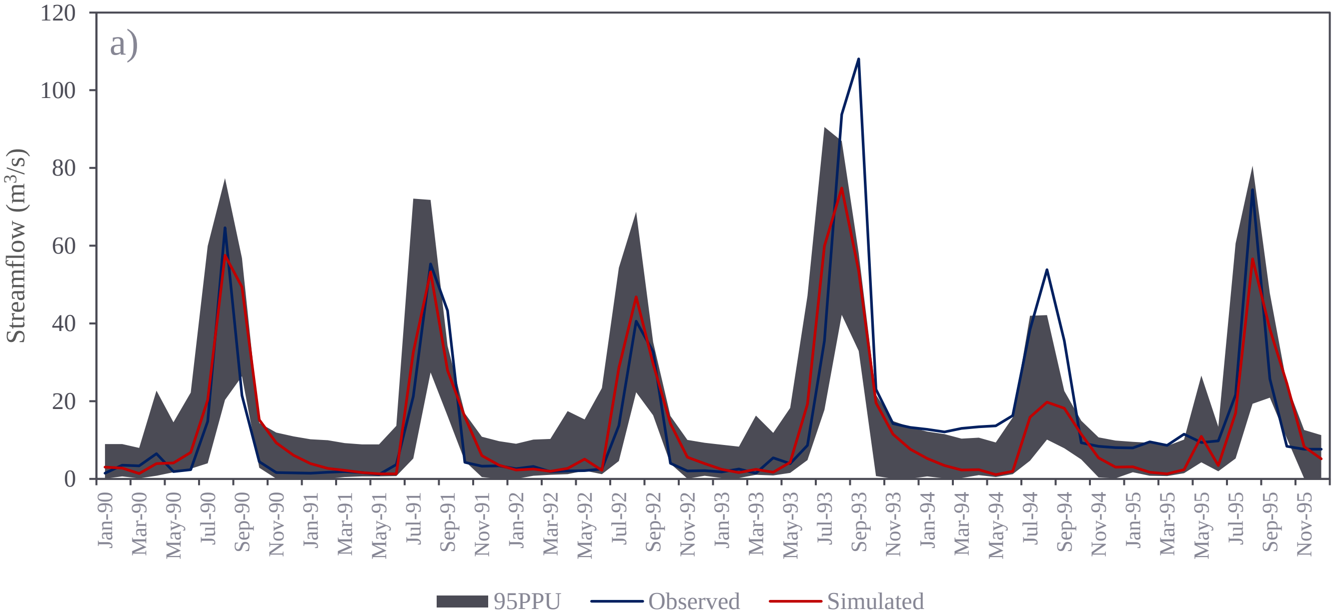
*The qualifier (r_) refers to a relative change in the parameter where the default values are multiplied by 1 plus a factor in the parameter range, (v_) refers to the substitution of the default parameter by a calibrated value while (a_) refers the calibrated values are added to the default parameter value. The extensions (e.g. hru, bsn, .gw, etc.) indicate the SWAT parameter family.

Satisfactory streamflow simulation performance was found both during the model calibration and validation periods (Moriasi et al., 2015). Evaluation of the model streamflow simulation using the NSE, R^2 and PBIAS provided 0.70, 0.71 and 9.1, respectively during the calibration period (Table 6 and Figure 5a). The goodness-of-fit evaluation values during the validation period also indicated satisfactory streamflow simulation performance (Table 6 and Figure 5b). The monthly simulated and observed streamflow hydrographs also showed reasonable agreement except missing to capture certain streamflow peaks (e.g. 1993, 1998 and 1999) (Figure 5).

Table 6. *Model streamflow simulation performance during the calibration and validation periods at the Akaki River gauging station.*

	Calibration (1990-1995)	Validation (1998 - 2004)
R^2	0.71	0.64
NSE	0.70	0.63
PBIAS	9.4	11.1
P-factor (%)	86	74
R-factor	0.93	0.70

Uncertainty analysis during the calibration and validation periods showed that 86% and 74% of the observed data were bracketed within the 95PPU, respectively, which represents acceptable model performance (Abbaspour, 2015). However, the uncertainty evaluation using the r-factor, which measures thickness of the 95PPU, was not that satisfactory in both during the calibration and validation periods (Table 5 and Figure 5). Generally, r-factor ranges between 0 and 1; and a value close to 0 represents a simulation with minor uncertainty. Overall, the model evaluation results showed that the calibrated and validated SWAT model can be used to estimate available water resources in the Akaki watershed with a high degree of confidence.



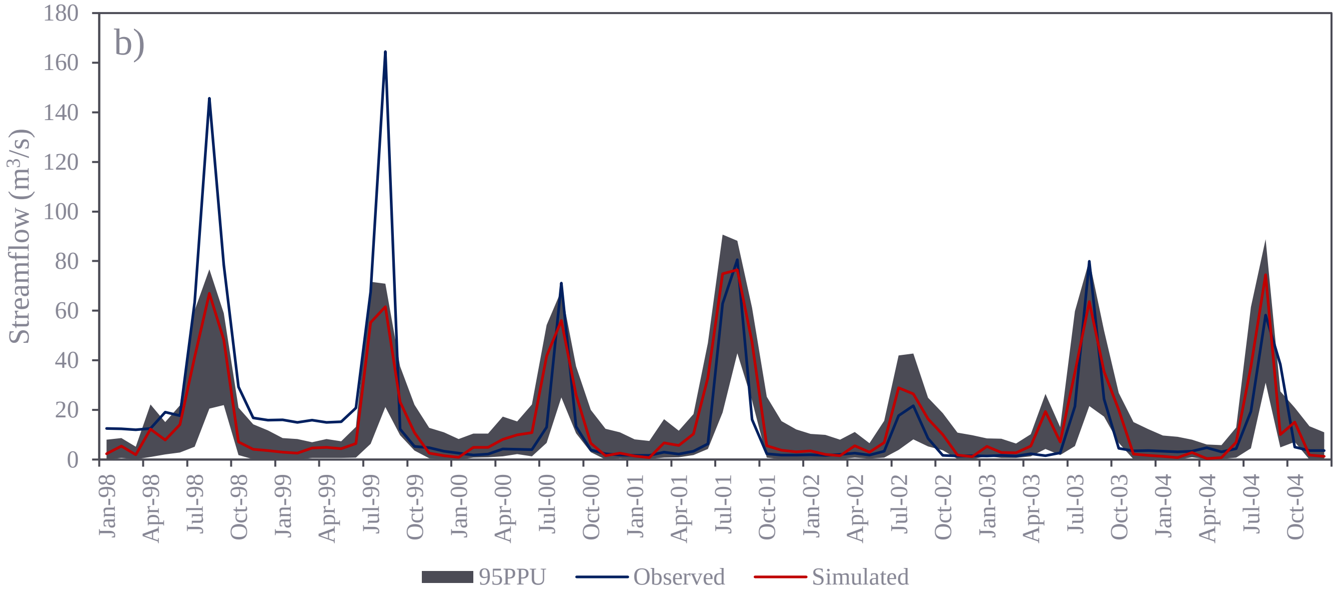


Figure 5. *Observed and simulated monthly streamflow at the outlet of the Akaki watershed during (a) calibration (1990-1995) and (b) validation (1998-2004) periods.*

The evaluation of model calibration for sediment yield simulation showed good performance with NSE and PBIAS values of 0.62 and 8.6, respectively (Table 7). Likewise, the model validation provided acceptable performance with NSE and PBIAS of 0.57 and -0.6%, respectively (Table 7). Although the monthly simulated sediment yield agreed well with the monthly observed sediment yield in the rising and fallings limps of the hydrograph, it did not capture well the peak sediment yield in 1998 and 1999 (Figure 6). The model was not also able to capture peak streamflow in these periods, which affects sediment yield simulations as sediments are carried by the streamflow. The inability to capture the peak streamflow and sediment yield may be related to the quality of observed streamflow and sediment load data during peak periods, which are often difficult to measure accurately.

Table 7. S*ediment calibration and validation performance of the SWAT model at the Akaki River gauging stations*

	Calibration (1990-1995)	Validation (1998-2004)
R^2	0.62	0.57
NSE	0.62	0.57
PBIAS	8.6	-0.6
P-factor (%)	36	26
R-factor	1.05	0.57

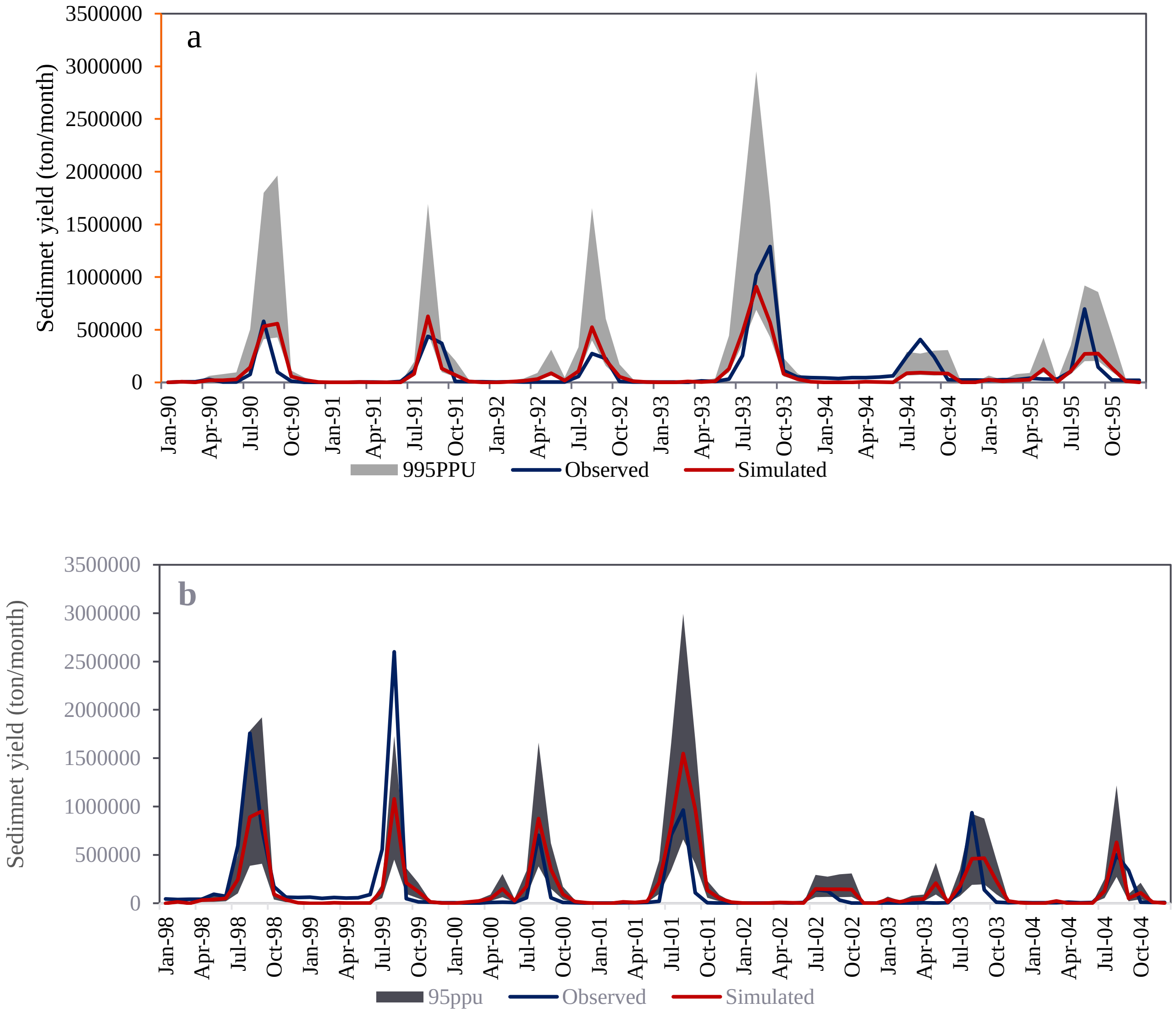


***Figure 6.** Observed and simulated sediment during (a) calibration (1990-1995) and (b) validation (1998-2004) in the Akaki watershed.*

WATER BUDGET ESTIMATION

The long-term mean annual water balance analysis (1983-2013) showed that surface runoff and evapotranspiration are the dominant water balance components of the Akaki watershed. The downstream part of the watershed has higher rainfall, surface runoff and total water yield. The highest long-term average annual rainfall and available streamflow were 1,100 mm and 540 mm, respectively. The lowest available water resources were estimated in the north-western part of the watershed (Figure 7). However, two of the existing water supply reservoirs are located in the northern part of the watershed where the streamflow is relatively smaller compared to the downstream part of the watershed.

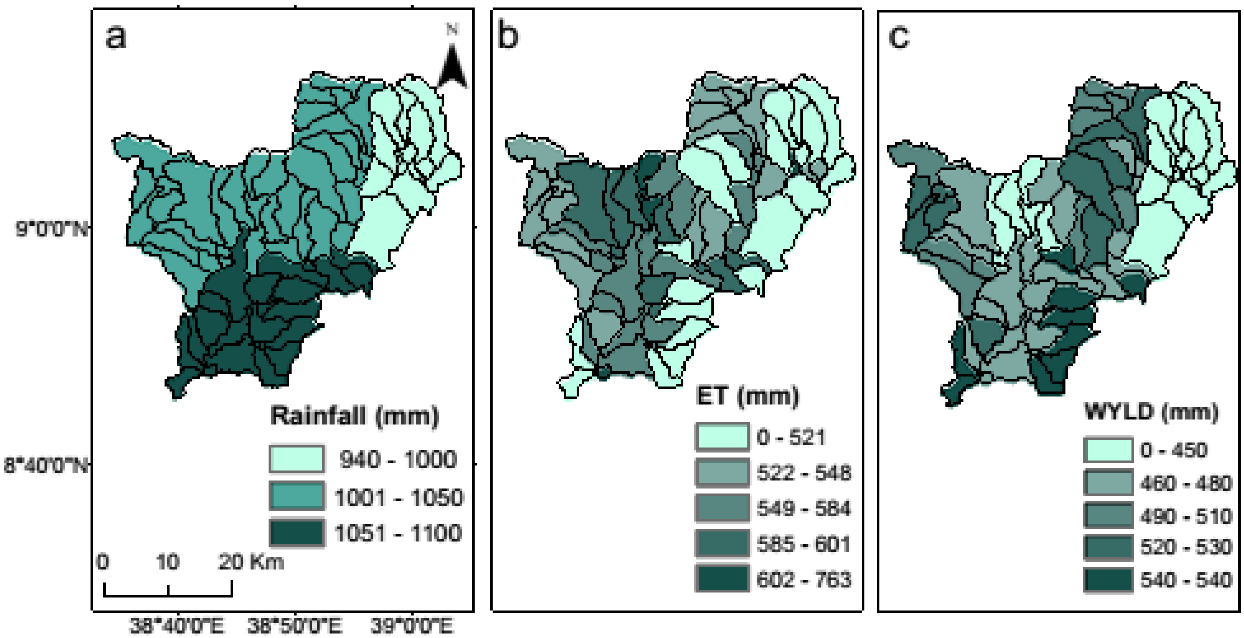


***Figure 7.** Annual water balance components of the Akaki watershed; a) rainfall, b) actual evapotranspiration, and c) water yield. The estimates represent long-term average annual for the period 1980-2013. The water balance analysis showed that two of the water supply reservoirs are located in part of the watershed where the streamflow generation is the smallest.*

The water balance analysis showed that the Akaki watershed is strongly responsive to rainfall occurrence. For example, a large proportion of the rainfall was converted to surface runoff (38%) and evapotranspiration (53%). While the rainfall that infiltrates into the soil and that further percolates as groundwater contribution to streamflow was very low, which was only 18%. The water balance analysis showed that the hydrological dynamics is largely influenced by dominant cultivated land and built-up area land use types which promoted surface runoff generation, and actual evapotranspiration, respectively.

The fact that the watershed's hydrology is dominated by surface runoff processes indicated that building reservoirs is one of the best strategies to store the available water resources and supply it to the City. On the other hand too much reliance on groundwater bore halls as a water supply option is not sustainable. The water balance analysis showed that the long-term (1980-2013) [24]average spatio-temporal annual rainfall and water yield in the Akaki watershed was 1,026 mm and 475 mm, respectively. Water yield is the summation of the surface runoff and groundwater contributions. The long-term spatio-temporal average annual actual evapotranspiration was 552 mm.

RESERVOIR SIMULATIONS

WATER AVAILABILITY

The water entering into Gefersa, Legedadi and Dire reservoirs was estimated at monthly and annual time steps. The simulations showed that higher inflow was observed in the Legedadi reservoir (1983–2013) than

[24] Average spatio-temporal refers the average amount over space (i.e. across the watershed) and time (e.g. 1980-2013) in this case.

Gefersa (1983–2013) and Dire reservoirs (1998–2013) (Figure 8). The inflow to Gefersa and Dire reservoirs was comparable (Figure 8 and Table 8).

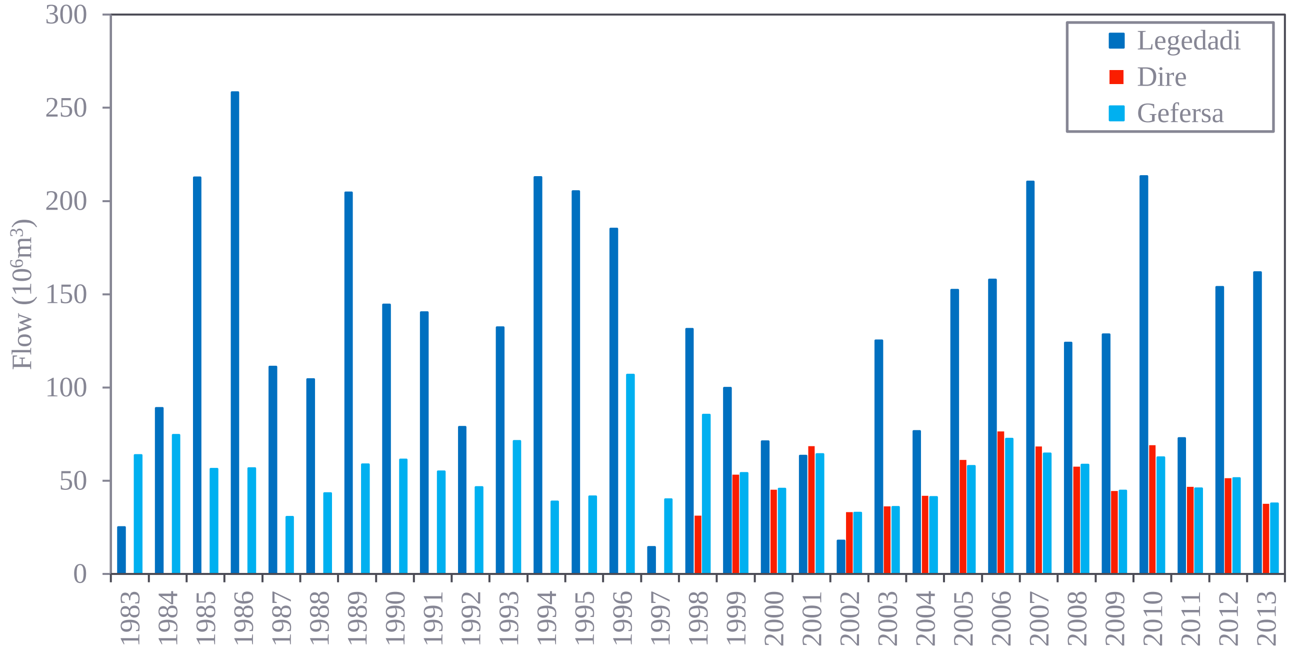


Figure 8. *Annual simulated inflow (million m^3/year) in the Gefersa, Legedadi and Dire reservoirs of the Akaki watershed*

In all the three reservoirs, the highest inflow was recorded in the month of August in which Gefersa, Legedadi and Dire reservoirs receive about 20.75 Mm3, 68.08 Mm3 and 22.48 Mm3 of water, respectively. Upstream part of the Gefersa reservoir has the potential to provide about 54.85 Mm3 of water (Table 8) while currently the water supply from the Gefersa reservoir is about 11 Mm3 of water per year (AAWSA, 2012). Annually, Legedadi and Dire reservoirs receive about 182 Mm3 of water from the upstream area (Table 8). DAR AL-OMRAN (2011) also estimated that the Legedadi and Dire catchments have the potential to annually receive 86 Mm3 and 50 Mm3 at annual time scale. While AAWAS (2011) reported that the annual surface water supply from both Legedadi and Dire reservoirs is 60 Mm3 in 2011. This indicates that the upstream areas of the reservoirs have more water to supply than the current supply from the reservoirs. Hence, more water resources can be harnessed from the upstream catchments of the reservoirs by raising the height of reservoirs and/or building new reservoirs.

Table 8. *Simulated long-term (1983-2013) average monthly and annual inflow volume (in million cubic meters, Mm^3) into the Legedadi, Dire and Gefersa reservoirs.*

Reservoir	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Annual	Reservoir volume
Legedadi	0.00	0.39	0.17	0.44	0.40	4.77	24.44	68.08	30.00	2.08	0.00	0.77	131.55	86
Dire	0.00	0.18	0.10	0.58	0.75	1.84	11.86	22.49	11.06	2.22	0.23	0.09	51.39	20
Gefersa	0.00	0.15	0.29	1.17	2.01	3.17	14.54	20.75	10.73	1.88	0.11	0.05	54.85	8
Total	0.00	0.72	0.55	2.18	3.16	9.79	50.84	111.32	51.79	6.17	0.34	0.92	237.78	114

SOIL EROSION AND SEDIMENTATION

Simulation results showed that the average annual soil erosion in the Akaki watershed was between 3.3 and 12 tons/ha/year in which the spatio-temporal average annual soil erosion was ~8 tons/ha (Figure 9). The highest soil erosion was observed in areas which are dominated by cultivated lands, which are in the north-western central and southern parts of the watershed. Lower soil erosion was estimated in urban areas (Figure 9). If soil erosion is more than 5 ton/ha/year, it is considered as high in the United States and best management practices will be called for to reduce the soil erosion. Because of the topographic situation and lack of better soil and water management practices, soil erosion rate is generally higher in the Ethiopian highlands. The simulated soil erosion in the Akaki watershed are comparable to estimates reported in other parts of Ethiopia. For example, Haregeweyn et al. (2008) reported ~10 tons/ha in the northern part of Ethiopia. In fact there are also studies that reported more than estimated in this study. Tamene et al. (2006) reported that the average annual soil erosion in the upstream areas of 11 reservoirs in the semi-arid highlands of northern Ethiopia was 19 tons/ha/year. Soil erosion rate in these watersheds vary due to differences in climate, topography, land use and soil types.

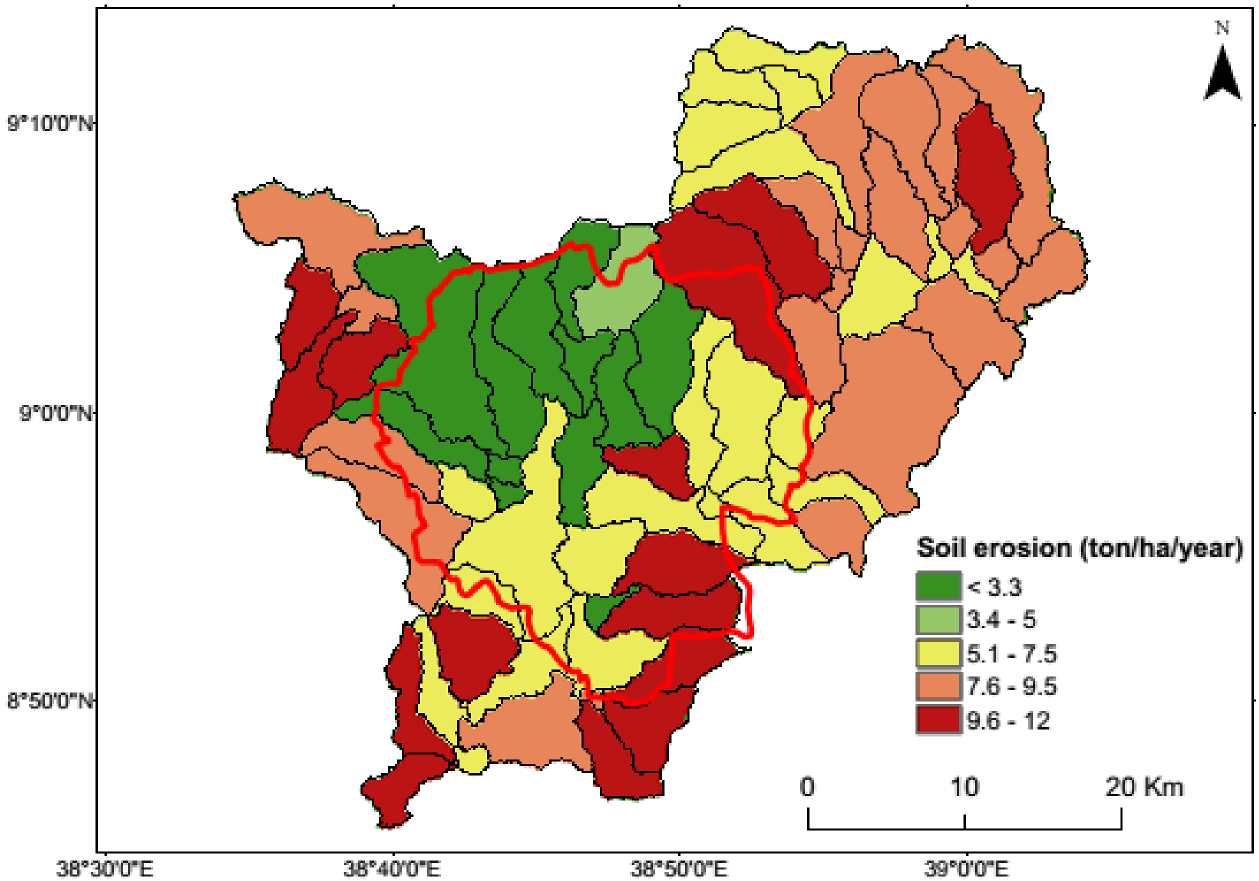


Figure 9. Long-term (1980-2013) average annual soil erosion (tons/ha) in the Akaki watershed.

Similar to streamflow, high soil erosion was observed in 1998 and 1999. The highest sediment yield was also observed in July and August months where the rainfall amount and surface runoff generation were peaking (Figure 10).

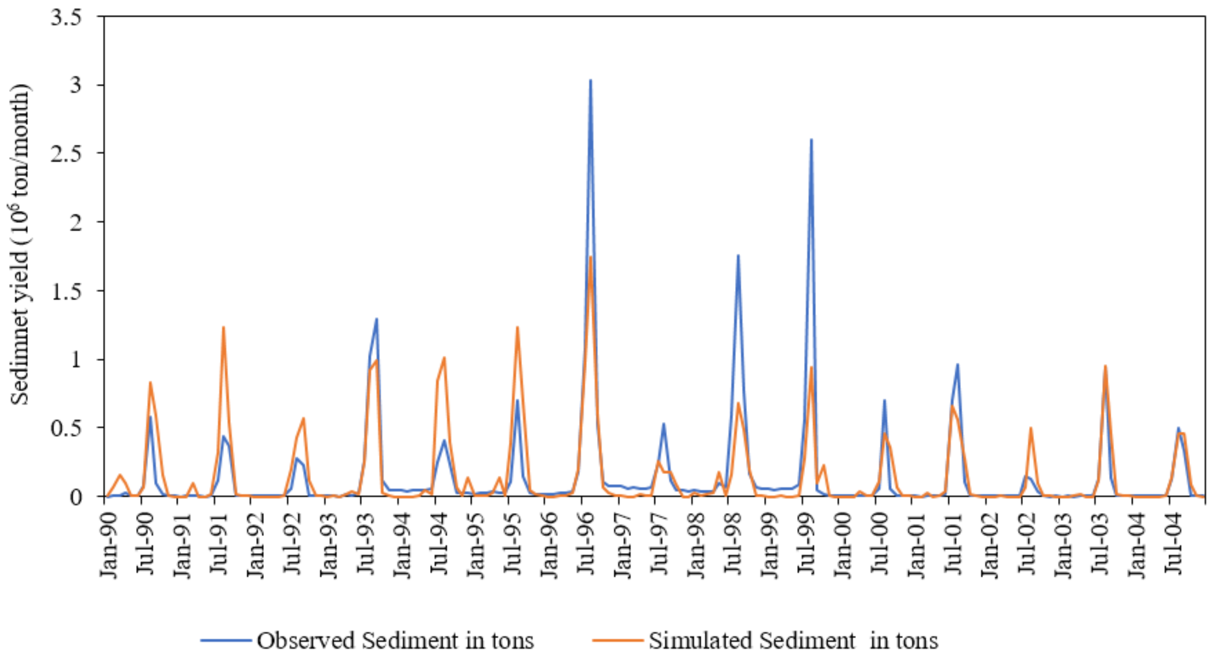


Figure 10. Observed and simulated sediment yield at the outlet of Akaki watershed.

The sedimentation of the Legedadi, Dire and Gefersa reservoirs at annual and average monthly scales are presented in Figure 11, and Table 9, respectively. The annual sedimentation in the Gefersa, Legedadi and Dire reservoirs was 26,970 tons, 127,244 tons and 30,715 tons, respectively (Figure 11). Substantial sedimentation occurred during the rainfall season (Table 9). The highest sedimentation occurred in the month of August and estimates in the Gefersa, Legedadi and Dire reservoirs were 10,134 tons, 65,819 tons and 13,443 tons, respectively (Table 9). Other studies (e.g.Tarekegn, 2012; Daba, 2017) reported comparable results of sediment deposition in the Gefersa and Legedadi reservoirs. For example, for the period 1990-1997, Daba (2017) estimated that the average annual sediment deposition in Gefersa reservoir was 27,288 tons. There are also other studies that provided higher sedimentation estimates than reported in this study. For example, a bathymetric map Report (1999) estimated that the annual sedimentation in Legedadi reservoir was more than 154,000 tons and another study (DAR AL-OMRAN, 2011) reported that the annual sedimentation in Gefersa reservoir was 32,718 tons. These sedimentation estimates indicate that the reservoirs that supply water to the City are quickly losing their useful live storage capacity.

***Table 9.** Long-term (1998-2013) average monthly and annual sediment deposition (tons) in the Gefersa, Legedadi and Dire reservoirs of the Akaki watershed.*

	Reservoirs	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Annual
1	Gefersa	0	65	132	539	1137	1575	7016	10130	5383	919	51	23	**26,970**
2	Legedadi	0	367	162	427	392	4630	23658	65819	29038	2012	0	740	**127,244**
3	Dire	0	102	59	345	446	1102	7089	13443	6612	1326	136	55	**30,715**

Sediment deposition in the reservoirs has been reducing the lifetime of the reservoirs. For example, the Legedadi and Gefersa reservoirs have been losing about 0.3% of their useful live storage every year.

Comparable estimates of reduction of Legedadi and Gefersa reservoirs storage capacity was reported by DAR AL OMRAN (2011).

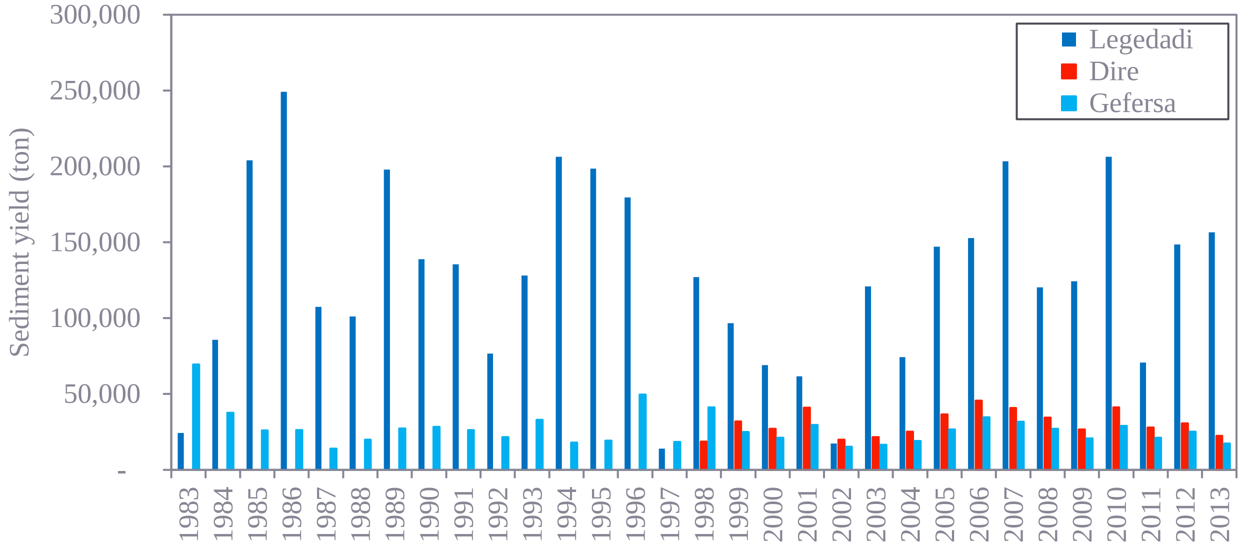


Figure 11. Annual sediment yield in the Gefersa, Legedadi and Dire reservoirs of the Akaki watershed.

Cumulative sediment deposition from 1983 to 2013 revealed significant sediment deposition in these reservoirs (Figure 12 and Figure 13). From 1983 to 2013, about 4 million, 0.8 million and 0.5 million tons of sediment was deposited in the Legedadi, Gefersa and Dire reservoirs, respectively (Figure 12).

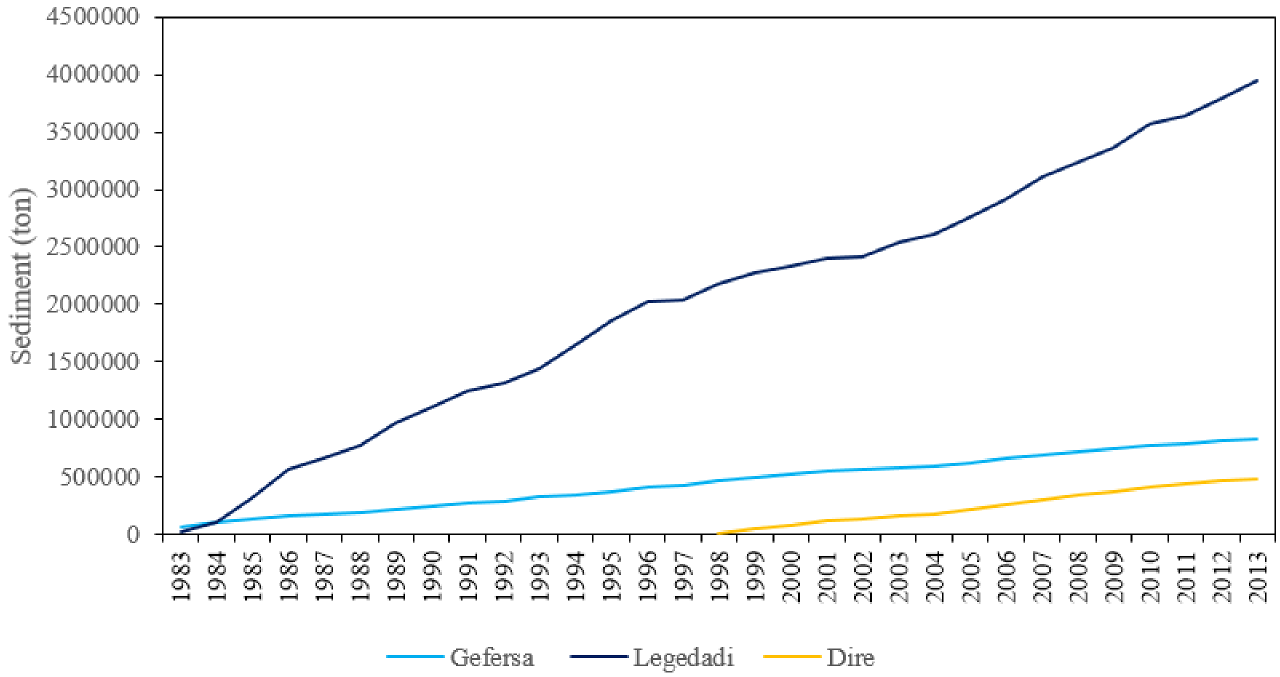


***Figure 12.** Cumulative sediment deposition (tons) in the reservoirs of the Akaki watershed from 1983 to 2013*

The sediment accumulation reduced the potential water storage volume by 3 Mm^3, 0.64 Mm^3 and 0.38 Mm^3 for the period 1983 to 2013 in the Legedadi, Gefersa and Dire reservoirs, respectively (Figure 13). During this period, sedimentation reduced the storage capacity of Legedadi and Gefersa reservoirs by 9.3% and 10.29%, respectively. This is equivalent to a 10% decrease in water supply potential, which will further reduce due to demand side losses (leakages, inefficiencies, etc.). The rate of sedimentation was different among the reservoirs due to differences in size of catchments, land use types, slope and other biophysical features. The results indicate that the soil erosion problem is sever in the reservoir catchment areas, which is largely driven by continuous expansion of cultivated land. This shows that measures should be taken to reduce soil erosion that helps increasing the life span of the reservoirs. For example, implementing different land management practices such as vegetative channels, buffer strips in agricultural fields, silt traps and terraces may reduce soil erosion from the channels and landscapes, and thereby increase the service life of the reservoirs.

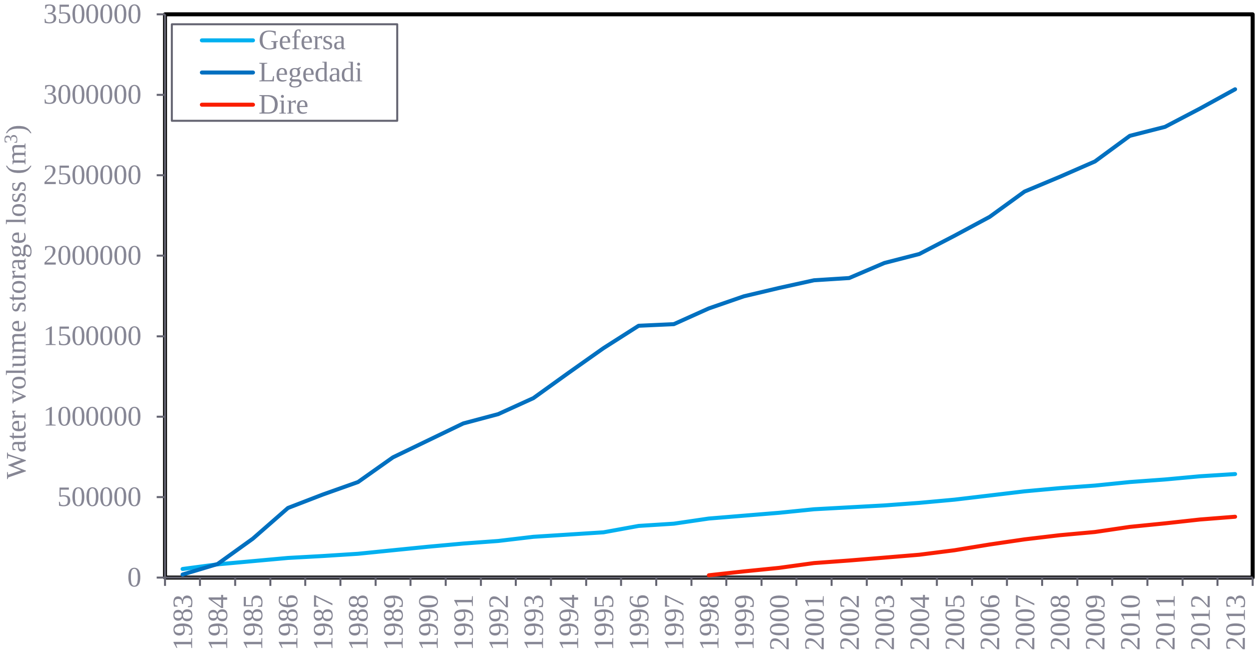


Figure 13. *Cumulative water volume loss (m3) due to sediment accumulation in the Gefersa, Legedadi and Dire reservoirs of the Akaki watershed for the period 1983 to 2013.*

PROJECTED WATER SUPPLY AND DEMAND OF ADDIS ABABA CITY

WATER DEMAND

The ever-increasing population growth and economic activity caused a substantial increase in water demand of the City. Expansion of industries and different institution also caused an increase in non-domestic water demand. This study used 2019 as a base period since it is the latest year in which water supply data was available. In the 2019, water required to meet the domestic and non-domestic water demand was 463,000 m^3/day and 347,000 m^3/day, respectively (AAWSA, 2020).

This study has estimated future total water demand accounting population growth and standard per capita domestic water requirement in the City. The total population of Addis Ababa is projected to be 5.86 million, 7.88 million, and 10.59 million in 2030, 2040 and 2050, respectively (AAWSA, 2020). The World Health Organization (WHO) and other agencies recommended 50-100 litres per capita per day water as a standard domestic water demand for a basic quality of life. This study, therefore, assumed 100 litre/capita/day as the current per capita water demand standard (Howard and Bartram, 2003; AAWSA, 2011). However, the per capita water demand will increase due to improvement in socio-economic conditions and improvements in lifestyles (Gleick, 1996). To account this increase in per capital water demand, an increase in the current demand by 10-40% was assumed over a period of 2020 to 2050 (Table 11). Water loss is another factor which causes significant increase of water demand. A 36% water loss of domestic and non-domestic water demand was used as reported in the AAWSA (2020). Therefore, based on the projected population, per capita water demand, and water losses (Table 11), the total water demand was estimated. Total water demand is projected to increase from 1.103 Mm^3/day in 2019 to 3.528 Mm^3/day in 2050 (Table 11).

PROJECTED WATER SUPPLY

Different scenarios were used to analyse the water supply of the City under different situations until 2050. The scenarios considered the existing water supply, proposed water projects and model simulated results. The scenario descriptions are presented as follows:

Scenario 1 (Baseline scenario): Because of availability of water supply data, 2019 was used as a baseline year for the water supply and water demand analysis. In Scenario 1, ~220 Mm^3/year of water was supplied to the City from reservoirs (82 Mm^3 /year) and groundwater sources (137 Mm^3/year) (AAWSA, 2011, AAWSA, 2012; AAWSA, 2020). Table 10 presents treated water supply from surface and ground water sources, the corresponding losses and net supply to the City in 2019. Based on the baseline water supply, water supply coverage ranges from 54% in the base period (2019) to 17% in 2050 (Table 11). This indicates there will be sever water shortage in the future if planned projects in the 10-year development plan (AAWSA, 2020) will not be materialized.

Table 10. *Total water supply (in millions of m^3) to the Addis Ababa City in 2019 from surface water reservoirs and groundwater sources (AASWA, 2020).*

	Legedadi and Dire	Gefersa	Ground water	Total water supply
Treated water (Mm^3/year)	71.17	11.31	137.60	220.08
Loss (36%)	25.62	4.07	49.53	80.54
Net water supply(m^3/year)	45.55	7.24	88.06	140.85

Scenario 2: Making use of optimum potential of the existing three reservoirs. Scenario 2 assumes using the optimum potential of the existing the reservoirs through raising their height or building new dams. The hydrological model simulation results showed that the current reservoir (Legedadi, Dire and Gefersa) catchment areas has the potential to supply 237 Mm^3 of water per year. With the existing groundwater sources

(137 Mm^3/year), using optimum potential of the reservoirs can increase water supply of the City to 374 Mm^3/year. Based on Scenario 2, the water supply coverage ranges between 95% in the base period (2019) and 30% in 2050 (Table 11 and Figure 14). Scenario 2 will improve the water supply coverage compared to scenario 1, but significant water supply shortage will remain.

Scenario 3: Water supply situation if all the proposed water supply projects materialized in their respective time period. The AAWSA 10-year development plan indicates that new wells that supply 7,000 m^3/day of water will be constructed per year in the period 2020 to 2030. Moreover, the 10-year AAWSA development plan indicated that additional surface water supply systems will also be built from 2020 to 20. In 2021, the Legedadi Phase 2 project that supplies 86,000 m^3/day will be added in the water supply system. Besides, the Gerbi reservoir with volume of 65,700 m^3/day, Sibilu Reservoir with volume of 385,200 m^3/day and the Robi-Jeda Reservoir with volume of 540,000 m^3/day will be added in the water supply system in 2023, 2026 and 2029, respectively (AAWSA, 2020). These proposed water supply projects could increase the total water supply from 599,000 m^3/day in 2019 to 644,000 m^3/day in 2020, 831,000 m^3/day in 2025 and 1,763,000 m^3/day in 2029. The planned Robi-Jeda Reservoir is located outside of the Akaki watershed. The other projects are within the Akaki watershed. The 10-year plan has not mentioned any water supply project after 2029. If the proposed water supply projects are completed in the intended period, the water supply coverage will increase from 54% in 2019 to 105% in 2030 and then decreases to 50% in 2050 (Table 11). The realization of the Robi-Jida project contributes to the significant increase of the water supply coverage in 2030. However, due to continuous increase in water demand, the proposed projects will fully meet water demand after 2035 (Table 11 and Figure 14). The water coverage results presented as in Table 11 can be achieved only if the planned projects are fully completed in their respective timeframes, and they operate effectively without major setbacks. Thus, substantial decisions to increase water supply from surface water and groundwater sources are non-trivial.

Scenario 4. Making use of the potential of streamflow generated at the outlet of Akaki watershed and planned groundwater sources. This scenario is intended to assess the surface water flow potential of the Akaki watershed (i.e. upstream of the watershed outlet in Figure 1) together with the planned groundwater development projects to meet the City's water demands until 2050. The hydrological model showed that about 0.837 Mm^3/day of water can be harvested from the watershed. This is considering 30% for environmental flow requirements. Hence, together with planned groundwater developments, the surface water potential of Akaki watershed can fully meet the water demand until 2025; thereafter, it can support 82% of the water demand in 2030 to 39% of the demand in 2050. Hence, to fully meet water demand in the City until 2050 water supply projects should be conducted outside the delineated Akaki watershed (Table 11). Likewise, some of the surface water development projects in Scenario 3 should be implemented outside the delineated Akaki watershed to meet their intended target.

Table 11. *Estimated water demand[25] and water supply in the base (2019) and future (2020-2050) period under different scenarios.*

[25] Water demand is estimated based on projected population and basic per capita daily water requirement. Water supply is based on the existing water supply (Scenario 1), using optimum potential of existing reservoirs (Scenario 2) and proposed water supply projects of AAWSA (Scenario 3). The potential supply of existing reservoirs was estimated based on SWAT modelling results.

		Base period (2019)	2020	2025	2030	2035	2040	2045	2050	References
Population of Addis Ababa (10^6)		4.235	4.363	5.058	5.863	6.797	7.880	9.135	10.59	AAWSA, 2020
Domestic water demand standard (m^3/capita/day)		0.1	0.11	0.115	0.120	0.125	0.130	0.135	0.140	Howard and Bartram, 2003
Total domestic water demand (10^6 m^3/ day)		0.463	0.479	0.582	0.704	0.849	1.024	1.233	1.483	AAWSA, 2020
Total non-domestic water demand (10^6 m^3/ day)		0.347	0.359	0.436	0.528	0.636	0.767	0.924	1.111	AAWSA, 2020
Total Water loss (10^6 m^3/ day)		0.292	0.302	0.366	0.444	0.535	0.645	0.777	0.934	Estimate in this study
Total water demand (10^6 m^3/ day)		1.103	1.140	1.384	1.676	2.020	2.436	2.934	3.528	Estimate in this study
Scenario 1 – Baseline ((Existing surface and groundwater sources	Surface water (10^6 m^3/ day)	0.225	0.225	0.225	0.225	0.225	0.225	0.225	0.225	AAWSA, 2020
	Groundwater (10^6 m^3/ day)	0.374	0.374	0.374	0.374	0.374	0.374	0.374	0.374	AAWSA, 2020
	Total supply (10^6 m^3/ day)	0.599	0.599	0.599	0.599	0.599	0.599	0.599	0.599	Estimate in this study
	Coverage (%)	54	53	43	36	30	25	20	17	Estimate in this study
Scenario 2 - using optimum potential of the three reservoirs	Surface water (10^6 m^3/ day)	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	Estimate in this study
	Groundwater (10^6 m^3/ day)	0.374	0.374	0.374	0.374	0.374	0.374	0.374	0.374	AAWSA, 2020
	Total supply (10^6 m^3/ day)	1.044	1.044	1.044	1.044	1.044	1.044	1.044	1.044	Estimate in this study
	Coverage (%)	95	92	75	62	52	43	36	30	
Scenario 3- using the proposed water supply projects	Surface water (10^6 m^3/ day)	0.225	0.225	0.291	1.215	1.215	1.215	1.215	1.215	AAWSA, 2020
	Groundwater (10^6 m^3/ day)	0.374	0.419	0.540	0.547	0.547	0.547	0.547	0.547	AAWSA, 2020
	Total supply (10^6 m^3/ day)	0.599	0.644	0.831	1.763	1.763	1.763	1.763	1.763	Total supply
	Coverage (%)	54	57	60	105	87	72	60	50	
Scenario 4 – using Potential of streamflow generated at the outlet of Akaki watershed (10^6)	Streamflow (70%) (10^6 m^3/ day)	0.837	0.837	0.837	0.837	0.837	0.837	0.837	0.837	Estimate in this study
	Groundwater (10^6 m^3/ day)	0.374	0.419	0.540	0.547	0.547	0.547	0.547	0.547	AAWSA, 2020
	Total supply (10^6 m^3/ day)	1.211	1.256	1.377	1.377	1.377	1.377	1.377	1.377	
	Coverage (%)	109	110	99	82	68	56	47	39	

The unprecedented population increase in the City and associated improvement in living standards will cause a significant increase in water demand (Figure 14). Unless new water supply sources are built and losses in the system averted, the future demand will overwhelm the existing water supply system of the City (Figure 14).

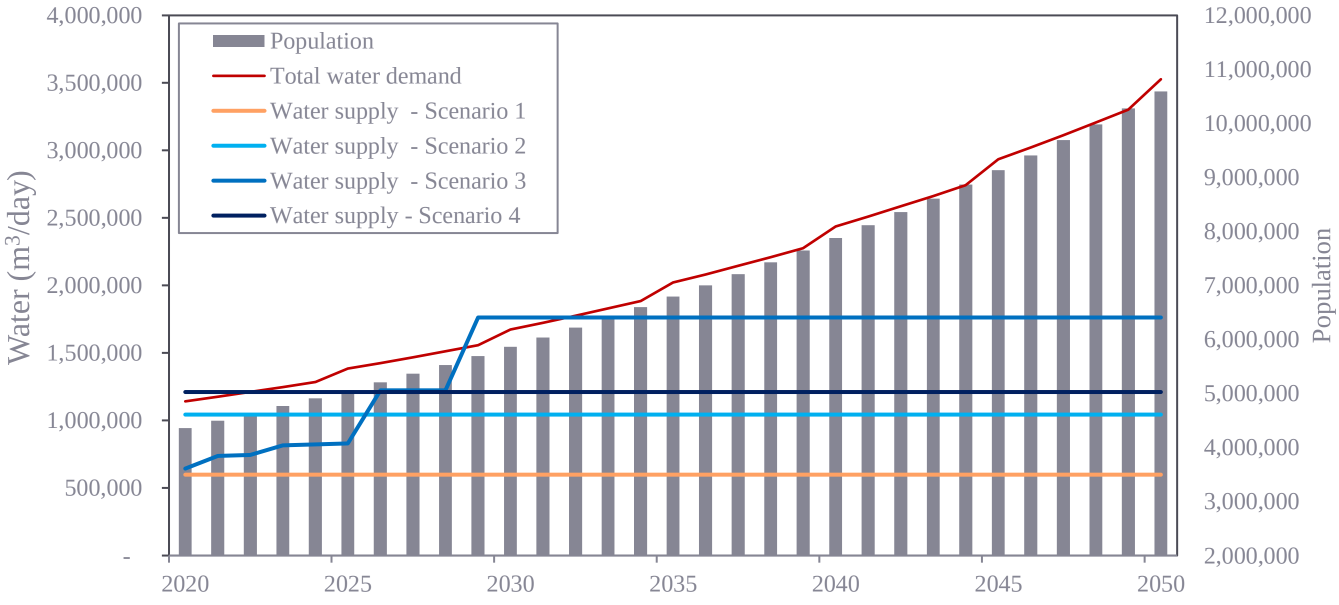


Figure 14. Estimated water demand and water supply (2020-2050) under different scenarios.

Scenario 1 represent the existing surface and groundwater supply with no change in the future; Scenario 2 considers making use of the optimum potential of existing reservoirs and current groundwater supply; Scenario 3 considers the existing and proposed water supply projects with their respective timeline of supply provision; and Scenario 4 considers using streamflow generated from the Akaki watershed leaving 30% of the streamflow for environmental flow requirement. Existing and proposed water supply data are based on AAWSA 10-year development plan. The demand is estimated based on projected population data and assumed basic per capita water requirement per day while considering water losses. The potential of existing reservoirs and potential of Akaki watershed stream flow to meet water demand were estimated based on model simulations.

In the proposed projects, high proportion of water is intended to be supplied from surface water sources than groundwater sources. Large increase of surface water can be incurred in 2030 if the proposed projects will be materialized (Figure 15). There could be no water shortage from 2030-2035 if the intended surface water projects such as Rob-Jida and Sibilu are completed.

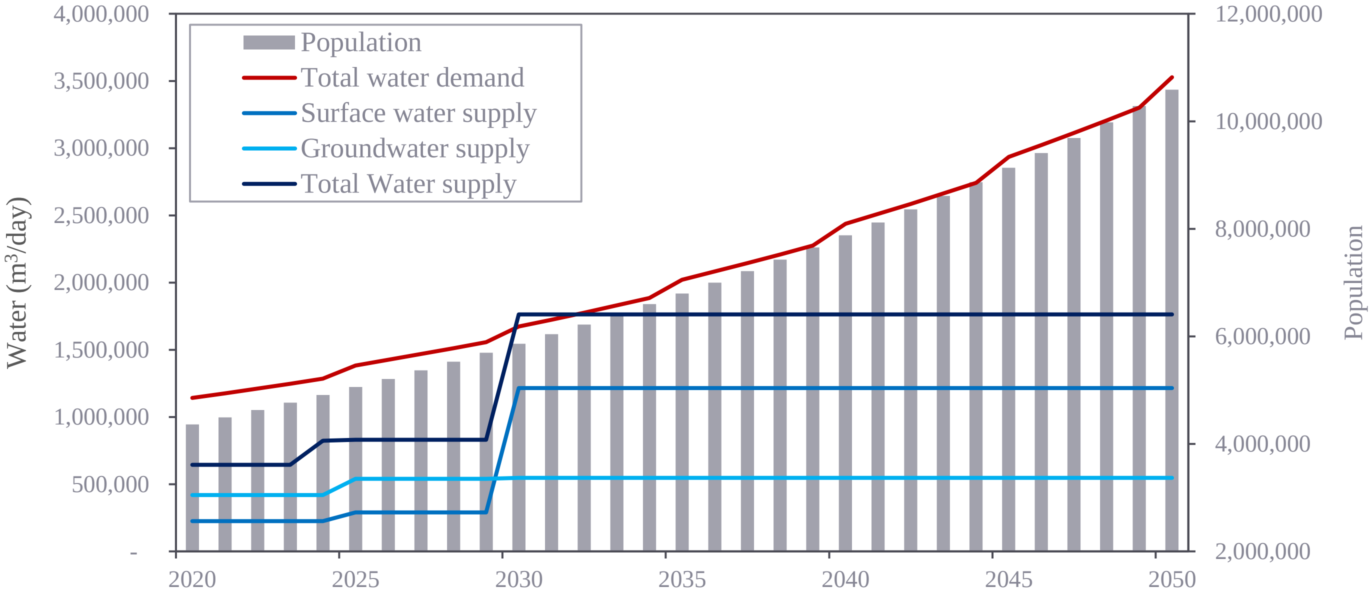


***Figure 15.** Estimated water demand and water supply in terms of surface water and groundwater sources (Scenario 3). Proposed water supply data are based on AAWSA 10-year plans. The demand is estimated based on projected population data and assumed basic per capita water requirement per day.*

WASTE DISPOSAL IN THE AKAKI WATERSHED

Although wastewater disposal plants existed in Addis Ababa city since 1982, their capacity has not been up to the status of the City. After the commissioning of the Akaki wastewater disposal plant in 1982, the Koteb wastewater treatment plant was commissioned in 1999. In recent years, the expansion of Condominium houses[26] necessitated expanding decentralized wastewater disposal plants. The capacity of operating decentralized waste disposal plants is about 362,000 m^3/day (Table 12). Currently, decentralized waste disposal plants are under construction in the Arat Killo, Mikililand, Ayat/bolehomes and Gelan and Gergi Condominium sites. However, the waste disposal capacity of these plants is not more than 18,000 m^3/day. The location of some waste disposal sites is also presented in Figure 1.

***Table 12.** Waste disposal plants in operation in the Addis Ababa City (AAWSA, 2020)*

No.	Wastewater disposal plant	wastewater treatment capacity (m^3/day)
1	Kality	100,000
2	Akaki	85,000
3	Eastern	150,000
4	Non-centralized (Membrane Bio Reactor/MBR)	27,000
	Total	**362,000**

[26] Condominium houses are a large building in which group of housing are served and the dwellers share ownership of common areas.

ECOSYSTEM PROFILE OF THE AKAKI WATERSHED

The Ethiopian agroecological classifications was produced considering physiography, soil, vegetation, climate, animal and human activities (MoA, 1998). Accordingly, the upper part of the Akaki watershed is characterized by cool humid and moist highlands (Figure 16). This part of the watershed includes mountains such as Entoto, Wochecha and Menagesha with average annual rainfall and potential evapotranspiration in the range of 1000-1050 mm, and 1300-1500 mm, respectively. The downstream part of the watershed is under tepid (moderate) temperature zone (Figure 16), in which the average temperature ranges between 21°C and 16 °C (MoA, 1998).

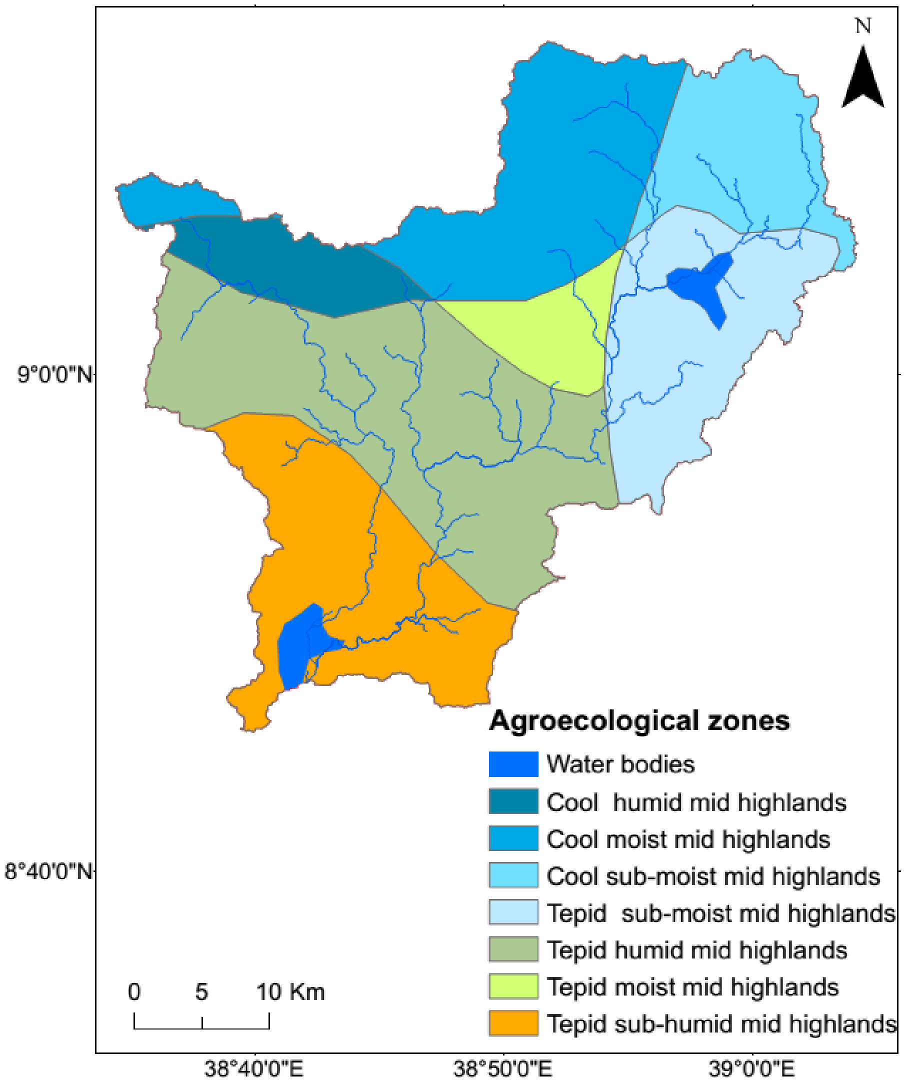


Figure 16. *Agroecology of the Akaki watershed. The water bodies indicated in the map are the Legedadi reservoir in the upstream part of the watershed and Aba Samuel artificial reservoir in the downstream part of the watershed.*

The Akaki watershed has beautiful terrain (e.g. Entoto, Wochecha and Menagesha mountains) with thriving ecosystem (Figure 17). For example, in the Entoto Mountain alone, Atinafe et al., (2020) reported that there are about 179 tree species belonging to 107 genera and 60 families (Atinafe et al., 2020). The mountain forests provide different ecosystem services such as temperature regulation, carbon sequestration, provision of wooden logs, and soil erosion reduction (Woldegerima et al., 2017). In fact, the Entoto Mountain is referred as the "lung of Addis Ababa city" as it provides fresh air to the City. Moreover, the mountains are the sources of many of rivers of the rivers in the Akaki watershed. For example, Kebena, Little Akaki and Big Akaki start from the Entoto Mountain.

Figure 17. *Satelite image showing the forest landscape of the Entoto mountain, which is part of the Akaki watershed.*

The Aba Samuel Lake, and surrounding wetlands are the other critical ecosystems in the Akaki watershed that have been naturally cleaning domestic, commercial and industrial wastes generated from the Addis Ababa City. These aquatic ecosystems play an essential role in reducing pollution entering into the Awash river and groundwater resources (Worku, 2017). Other critical ecosystems include green spaces, city parks, and public (hotel and church) forest reserves that have been providing recreational, social and religious functions in the urban and peri-urban environments.

WATER RESOURCES DEGRADATION IN THE AKAKI WATERSHED

Rapid population growth, continuous agricultural practices, rapid urbanization, expansion of industries and inadequate land use and water policies and implementation put intense pressure on availability and quality of water in the Akaki watershed (van den Berg et al., 2019). These physical and socio-economic drivers cause continuous extraction of surface and sub-surface water sources as well as their contamination. Water resources assessment such as water quality monitoring, groundwater depth measurement and reservoirs capacity monitoring are essential for optimal water resources use and management.

The surface water resources are under high risk of contamination due to agricultural land expansion and contamination and industrial establishments inside the Akaki watershed. For instance, in the Gefersa sub-watershed there are various industries that cause water quality problems. Similarly, the Legedadi and Dire sub-watersheds host many industries such as the Ethio-Turkish International Industry which extensively uses the surface water resources in the Legedadi catchment (ACATIAWATER, 2020). Studies in the sub-watersheds of Akaki showed that their water quality limits are transgressed due to untreated industrial effluent releases. Anteneh et al., (2018) studied pH, Turbidity, Total hardness, Pb, Fe, and Cu in water samples from the Legedadi and Dire reservoirs. Their result showed that the water in the reservoirs were highly polluted.

Besides the surface water sources, the groundwater resource has plethora of problems which include serious threat of pollution, high level of extraction, and operational problems. Large volume of waste of the City is discharged towards the Akaki River where Akaki well fields are located and surrounding locations. About 90% of the waste of the City is discharged without treatment into the areas where groundwater recharge is occurring while only 10% of waste of the City's wastewater is treated (ACATIAWATER, 2020). The mountains and groundwater well fields in the watershed are under a risk of total depletion due to high extraction and competition between government (AAWSA) and private companies. For instance, about 84.5% of the wells in the Akaki well-field are below water level. Particularly, the old Akaki well field is severely depleted in which 13 of the 24 wells are abandoned as water level and groundwater discharge significantly declines(Muleta and Abate, 2020).

WATERSHED MANAGEMENT PROGRAMS IN THE AKAKI WATERSHED

To maintain the sustainability of water supply reservoirs and ensure other environmental and economic benefits of natural resources, the government of Ethiopia has implemented different watershed development programs (Estifanos, 2015). In the watersheds of Legedadi, Dire and Gefersa reservoirs, different physical and biological soil and water management structures such as terraces, check dams, afforestation, vegetative strips, drainage ditches and stone/soil embankments were practiced (DAR AL OMRAN, 2011) to reduce sedimentation, flooding and pollution problems. An integrated master plan was developed in 2000 for the rehabilitation of the reservoirs in the Akaki watershed. For example, the TAHAL master plan was developed in 2000 to rehabilitate the Gefersa, Legedadi and Dire catchment areas, and thereby to reduce soil erosion and sedimentation of the reservoirs (DAR AL OMRAN, 2011).

However, there is area of cultivated lands without soil and water management structures which are a major source of the sediment to Legedadi and Dire reservoirs (Estifanos, 2015). Thus, substantial and sustainable watershed development interventions are needed to sustain the water holding capacity of the reservoirs and to get the optimum benefits from the reservoirs.

KEY RECOMMENDATIONS TO IMPROVE THE WATER SUPPLY SITUATION IN THE ADDIS ABABA CITY

The water demand and water supply analysis showed that the water demand will not be meet for number of years during the period 2020-2050. The water supply may be met around 2030 when all the planned surface water and groundwater development projects (Scenario 3) will be implemented. However, because of increasing population, the water demand will surpass the supply after 2030 (Figure 5). This suggests that if any of the planned water supply projects will not be materialized, the gap between the supply and demand will be substantial. In the worst-case scenario of (Scenario 1) of continuing with the existing water supply sources, the water supply will cover only 17% of the demand in 2050. The analysis also showed that surface water developments outside the Akaki watershed (Figure 1) should be implemented to meet the growing demand until 2050 (Table 5). The Akaki watershed (Figure 1) has the potential to supply the required surface water resource together with the planned groundwater sources until 2025. Thereafter, surface water developments should include water resources development downstream part of the studied Akaki watershed including other nearby watersheds. Overall, multipronged measures should be taken to improve the water supply situation in the Addis Ababa City. Some of the measures to consider are laid out as follows:

- There is substantial amount of water loss in the current water supply system. Data from AAWSA showed that more than 1/3rd of the supplied water is lost in different forms (AAWSA, 2020). Serious measures should be implemented to reduce losses. Some of the losses may be addressed upgrading the water supply infrastructures to reduce leakage losses in the distribution system. Other measures may include implementation of tariffs that encourage efficient water use practices.

- The potential of the existing reservoir catchment areas is not fully harnessed. By extending the current dams (e.g. raising dam highest, building new dams in the catchments, etc), it is possible to increase the current water supply coverage as assessed in Scenario 2. However, unless sufficient watershed treatment practices are implemented, the capacity of the reservoirs may be impaired. Therefore, watershed treatment practices such as terraces, filter strips, buffer zones, area closures should be implemented (especially in erosion prone areas) to reduce soil erosion and reservoir sedimentation for the existing and future reservoirs.

- Accounting 30% of the streamflow for environmental flow requirements, the Akaki watershed delineated in Figure 1 has the potential to meet water demand together with planned groundwater development projects until 2025 (Figure 5). Thereafter, surface water development projects should occur outside the delineated Akaki watershed including nearby watersheds.

- Most of the groundwater supplying wells has a depth of more than 300 m. Evidence from the AAWSA (2020) showed that several groundwater wells were abandoned because of depletion of the groundwater aquifer. Since relying too much on the groundwater resource may cause such exhaustion of the groundwater aquifer in the surrounding area, significant investments in the wells may not be a sustainable approach. Rather it is better to focus developing surface water resources in the Akaki and nearby watersheds. However, implementing different practices that enhances the groundwater recharge may help to replenish the groundwater aquifer for the existing groundwater sources. Practices that help recharge include construction of artificial wetlands, recharging pits, check dams, etc.

- The Addis Ababa City has many impervious areas including rooftops. Surface runoff can be collected from these impervious areas and used for various purposes with modest water treatment. The surface runoff may be collected from individual building rooftops, or at larger scale areas that include roads, parking lots, etc. Adugna and Jensen (2018) reported that rainwater collected from 588 rooftops of large public institutions in Addis Ababa City can provide up to 2.3% of the City's 2016 water supply. The study further added that if rainwater is collected from all large public institutions of the City, it can supply up to 9.2% of the City's water supply (Adugna and Jensen, 2018). Development of such decentralized water supply options can lessen the pressure on the larger centralized water supply system.

- Currently, only a fraction (about 10%) of the wastewater is collected and treated either in centralized or decentralized systems (ACATIAWATER, 2020). If the wastewater treatment system of the City is improved, the treated water can be reclaimed for reuse after passing through intensive water treatment process. Such practice is becoming common in different parts of the World.

APPENDIX A AAWSA Capital Projects and Budget Requirements

Table 0-1 AAWSA Capital Projects Summary

No	Project	PROJECT COST	BUDGET YEAR (Gregorian Calendar)									
			2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
1	**OTHERS (NRW+)**											
1.1	Pipe Relocation	390 000 000	305 000 000	85 000 000								
1.2	Water Meter	850 000 000	85 000 000	85 000 000	85 000 000	85 000 000	85 000 000	85 000 000	85 000 000	85 000 000	85 000 000	85 000 000
1.3	Performance based	8 400 000 000	2 100 000 000	2 100 000 000	2 100 000 000	2 100 000 000						
1.4	Old Pipe Replacement	220 000 000	22 000 000	22 000 000	22 000 000	22 000 000	22 000 000	22 000 000	22 000 000	22 000 000	22 000 000	22 000 000
1.5	New pipe line for condo	200 000 000	20 000 000	20 000 000	20 000 000	20 000 000	20 000 000	20 000 000	20 000 000	20 000 000	20 000 000	20 000 000
1.6	EM -Surface pumps rehabilitation	4 000 000			2 000 000	2 000 000						
1.7	Catchement Management	10 000 000	1 000 000	1 000 000	1 000 000	1 000 000	1 000 000	1 000 000	1 000 000	1 000 000	1 000 000	1 000 000
1.8	EM workshope Bdg	229 000 000	200 296 000	28 704 000								
1.9 1.1	Legedadi flap `gate, Dire bottom outlet	200 000 000	-	200 000 000	-	-	-	-	-	-	-	-
		10 503 000 000	**2 733 296 000**	**2 541 704 000**	**2 230 000 000**	**2 230 000 000**	**128 000 000**	**128 000 000**	**128 000 000**	**128 000 000**	**128 000 000**	**128 000 000**
2	**WATER SUPPLY PROJECTS**											
2.1	Compensation for catchement area	925 000 000	462 500 000	462 500 000								
2.2	New Wells driling, EM, Ciuvil works	662 634 000	331 317 000	331 317 000								
2.3	Central Scada	520 000 000		173 333 333	173 333 333	173 333 333						
2.4	Ground water modeling	258 269 600		258 269 600								
2.5	SANF	265 000 000	265 000 000									
2.6	Legedadi II	8 200 000 000		8 200 000 000								
2.7	Gerbi	13 853 280 000				13 853 280 000						
2.8	Sibilu	43 309 285 000							43 309 285 000			
2.9	Aleltu Dam,WTP & Transm	64 963 927 500										64 963 927 500
	Sub Total (ETB)	133 457 396 101	1 058 817 000	9 572 086 600	320 000 000	14 153 280 000	40 000 000	20 000 000	43 329 285 000	-	-	64 963 927 500
	GRAND TOTAL (ETB	**143 960 396 101**	**3 792 113 000**	**12 113 790 600**	**2 550 000 000**	**16 383 280 000**	**168 000 000**	**148 000 000**	**43 457 285 000**	**128 000 000**	**128 000 000**	**65 091 927 500**

No	Project	PROJECT COST	BUDGET YEAR (Gregorian Calendar)									
			2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
3	**CAPITAL PROJECTS**		-						-	-	-	-
3.1	Nefas S/Branch (G+5)	80 000 000		40 000 000	40 000 000							
3.2	Gurdsholl-2 Branch (G+5)	80 000 001		26 666 667	26 666 667	26 666 667						
3.3	Mekanissa Branch (G+5)	80 000 000		20 000 000	20 000 000	20 000 000	20 000 000					
3.4	Arada Branch (G+5)	80 000 000				20 000 000	20 000 000	20 000 000	20 000 000			
3.5	Project Office (G+12)	180 000 000		60 000 000	60 000 000	60 000 000						
	TOTAL (ETB)	500 000 001		146 666 667	146 666 667	126 666 667	40 000 000	20 000 000	20 000 000			

Table 0-2 AAWSA Budget Requirements up to 2030

Expenditure category	Budget Entry (Budget Title Statement)	Total Budget	2020/21-2029/30 Budget Requirements								
		Granted for 2020/21	2021	2022	2023	2024	2025	2026	2027	2028	2029
Total Sum		ETB 2 151 039 798	ETB 2 135 033 322	ETB 3 207 792 649	ETB 3 902 125 003	ETB 5 269 025 464	ETB 6 527 169 188	ETB 7 664 176 894	ETB 11 234 984 315	ETB 12 476 989 422	ETB 14 488 603 918
For Human Services		ETB 623 873 674	ETB 681 292 010	ETB 1 121 927 108	ETB 1 345 851 759	ETB 1 610 952 766	ETB 2 541 842 916	ETB 2 818 580 758	ETB 3 125 880 728	ETB 3 467 203 067	ETB 3 846 416 259
Payments to Employees		ETB 509 599 336	ETB 541 750 810	ETB 892 218 010	ETB 1 071 781 320	ETB 1 282 988 238	ETB 2 011 863 802	ETB 2 231 883 705	ETB 2 476 395 392	ETB 2 748 209 346	ETB 3 050 474 739
Allowance and Benefits		ETB 49 888 410	ETB 71 676 610	ETB 117 686 943	ETB 139 499 210	ETB 166 882 446	ETB 260 235 992	ETB 288 091 416	ETB 318 928 896	ETB 353 067 742	ETB 390 861 462
Public Pension Contributions		ETB 50 587 374	ETB 53 322 177	ETB 88 017 407	ETB 105 734 538	ETB 126 564 493	ETB 215 794 498	ETB 238 884 509	ETB 264 445 152	ETB 292 740 783	ETB 324 064 047
For Community Based Health Insurance Fund		ETB 13 798 553	ETB 14 542 412	ETB 24 004 747	ETB 28 836 692	ETB 34 517 589	ETB 53 948 625	ETB 59 721 127	ETB 66 111 288	ETB 73 185 196	ETB 81 016 012
For Goods and Services		ETB 598 505 139	ETB 876 007 632	ETB 1 093 864 755	ETB 1 366 004 736	ETB 1 808 117 900	ETB 2 290 590 691	ETB 3 260 450 349	ETB 4 103 272 016	ETB 5 406 630 754	ETB 6 859 795 047
For perishable/consumable items and equipme		ETB 188 296 982	ETB 332 430 367	ETB 409 880 552	ETB 508 367 869	ETB 618 954 795	ETB 778 490 960	ETB 1 164 554 512	ETB 1 459 646 405	ETB 2 051 086 597	ETB 2 576 459 543
For Trips and Accommodation		ETB 2 504 204	ETB 2 908 482	ETB 4 800 949	ETB 5 767 338	ETB 6 903 518	ETB 10 789 725	ETB 11 944 225	ETB 13 222 258	ETB 14 637 039	ETB 16 203 202
for Renovation and Maintenance Services		ETB 101 721 698	ETB 135 743 876	ETB 181 515 774	ETB 243 133 992	ETB 326 127 355	ETB 437 958 042	ETB 588 698 081	ETB 791 942 606	ETB 1 066 042 734	ETB 1 435 769 928
for Contractual Service Prov		ETB 298 654 315	ETB 395 032 187	ETB 484 312 306	ETB 590 706 054	ETB 831 792 431	ETB 1 030 493 231	ETB 1 450 894 241	ETB 1 778 575 708	ETB 2 194 019 581	ETB 2 722 221 888
Movable Properties and Construction		ETB 545 225 993	ETB 188 879 116	ETB 521 265 963	ETB 424 461 071	ETB 963 325 625	ETB 789 250 256	ETB 649 754 017	ETB 1 826 639 638	ETB 1 374 955 541	ETB 1 418 063 046
Immovable Properties		ETB 461 325 993	ETB 84 004 116	ETB 390 172 213	ETB 260 593 884	ETB 758 491 641	ETB 533 207 776	ETB 329 700 916	ETB 1 426 573 262	ETB 874 872 571	ETB 792 959 334
For Construction		ETB 83 900 000	ETB 104 875 000	ETB 131 093 750	ETB 163 867 188	ETB 204 833 984	ETB 256 042 480	ETB 320 053 101	ETB 400 066 376	ETB 500 082 970	ETB 625 103 712
Other Payments		ETB 383 434 992	ETB 388 854 564	ETB 470 734 823	ETB 765 807 437	ETB 886 629 173	ETB 905 485 325	ETB 935 391 770	ETB 2 179 191 933	ETB 2 228 200 059	ETB 2 364 329 566
Subsidies, investments, and gift payments		ETB 8 363 104	ETB 36 550 676	ETB 88 475 735	ETB 76 726 798	ETB 161 302 742	ETB 140 288 523	ETB 126 337 560	ETB 312 454 573	ETB 257 923 236	ETB 282 682 932
Debtors		ETB 375 071 888	ETB 352 303 888	ETB 382 259 088	ETB 689 080 639	ETB 725 326 431	ETB 765 196 802	ETB 809 054 210	ETB 1 866 737 359	ETB 1 970 276 824	ETB 2 081 646 634