TECHNICAL REPORT

Guideline for Developing a Water Pollution Prevention and Control Plan for the Akaki Catchment, Ethiopia

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Front cover photo: Activities leading to pollution of Akaki River. (*photo*: Ayele Assefa)
Back cover photo: The Akaki river running through central Addis Ababa. (*photo:* Magnus Franklin)

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Acronyms and Abbreviations

AMR	Antimicrobial resistance
AAEPA	Addis Ababa Environmental Protection Authority
AAHB	Addis Ababa Health Bureau
AAWSA	Addis Ababa Water and Sewerage Authority
BMPs	Best Management Practices
CWA	*Clean Water Act*
DPSIR	Drivers, Pressures, State, Impacts, Responses (analytical framework)
EPA	Environmental Protection Authority
EPHI	Ethiopian Public Health Institute
ESβL	Extended-Spectrum Beta-Lactamase
FAO	Food and Agriculture Organization
FC	Fecal Coliforms
FS	Fecal Streptococci
KPI	Key Performance Indicator
MBR	Membrane Bioreactor
MoWE	Ministry of Water and Energy
NPS	Nonpoint Source Pollution
PSP	Point Source Pollution
RBCs	River Basin Councils
REPBs	Regional Environmental Protection Bureaus
TC	Total Coliforms
ToR	Terms of Reference
WFD	Water Framework Directive
WQM	Water Quality Monitoring

Glossary

Clean Water Act: Also known as the *Federal Water Pollution Control Act*, the *Clean Water Act* is the primary federal statute governing water pollution control in the United States.

Nonpoint Source Pollution: Pollution that enters water from sources that cannot be traced back to a single location. This type of pollution is often initiated by stormwater runoff from agricultural, urban, forestry, marina, construction and other land use areas.

Point Source Pollution: Pollution that is discharged through a pipe or other discrete source, such as municipal water treatment plants, factories, concentrated animal feeding operations or combined sewer systems.

Pollutant: Any waste discharged into water, including dredged soil, solid waste, incinerator residues, sewage, garbage, sewage sludge, munitions, chemical wastes, biological materials, radioactive materials, discarded equipment and rock.

Pollution: Refers to any condition which is hazardous or potentially hazardous to human health, safety or welfare or to living things created by altering any physical, radioactive, thermal, chemical, biological or other property of any part of the environment in contravention of any condition, limitation or restriction made under *Proclamation No. 300/2002* or under any other relevant law.

Pollution drivers: Refer to underlying activities that create a need and put pressure on the river and other water bodies.

Pressure: Refers to the stressors caused by human activities, including industrial discharges, domestic wastewater, agricultural runoff and urban stormwater. These activities introduce pollutants into the river system.

River Basin Plan: A strategic, long-term framework for managing water resources to guarantee equity and sustainability in water use.

Water Pollution: The contamination of water bodies, including rivers, lakes, oceans, groundwater and aquifers, by physical, radioactive, thermal, chemical and biological substances because of the introduction of pollutants from human activity or natural processes such as domestic, industrial, agricultural effluents and runoff.

Water Pollution Control: Measures to manage, reduce or treat pollutants already present in water bodies.

Water Pollution Prevention: Proactive measures to stop pollutants from entering water sources.

Water Quality: The characteristics of water as defined by its physical, chemical, microbiological and radiological properties.

Water Quality Assessment: An evaluation of the condition of a water body using biological surveys, chemical analyses of pollutants and toxicity tests.

Water Quality Control Plan: Plans that contain numeric and/or narrative water quality objectives and detail programs by which these objectives can be achieved for identified beneficial uses.

Water Quality Guidelines: Specific levels of water quality that, if reached, may adversely affect human health or aquatic life. These guidelines are non-enforceable and are issued by governmental agencies or other institutions.

Water Quality Monitoring: An integrated activity that evaluates the physical, chemical and biological characteristics of water relative to human health, ecological conditions and designated water uses.

Water Quality Monitoring Plan: A course of action outlining data collection, timing, location and methods for analyzing water quality in relation to project goals.

Water Quality Objective: The guideline value or narrative statement for each selected water quality indicator that aims to protect all identified community values.

Water Quality Standards: The requirements and permissible thresholds for physical, chemical, microbiological and radiological parameters.

Summary

This guideline provides a comprehensive planning framework for preventing and controlling water pollution in Ethiopia, with the Akaki Catchment as a case study. Water pollution is a growing national concern that threatens public health, reduces agricultural productivity, damages ecosystems and creates heavy economic costs. In Ethiopia, it contributes to thousands of deaths annually, accelerates biodiversity loss and increases the burden of water treatment.

The central purpose of this guideline is to serve as a practical tool for preparing pollution prevention and control plans at the catchment scale. It is targeted at authorities that are involved in river pollution control at the catchment and city levels. Existing institutional efforts are fragmented, poorly coordinated and often reactive rather than preventive. Without a unified plan at the catchment level, it is difficult to define the water quality goals society aspires to, or to judge whether current measures are sufficient. This framework enables authorities to assess existing efforts, identify gaps and design the most cost-effective mix of additional solutions needed to achieve and maintain safe and sustainable water quality.

Beyond addressing immediate problems, the guideline seeks to harmonize pollution control initiatives across institutions, strengthen monitoring systems and embed catchment-level planning as the standard approach. The Akaki Catchment is used as a demonstration case, but the methods and structure outlined in the guideline are designed for replication in other urban rivers across Ethiopia, making it a scalable national model.

Using the DPSIR (Drivers–Pressures–State–Impacts–Responses) framework, the guideline provides a structured way of analyzing water pollution. Rapid population growth, unregulated urbanization, industrial expansion and weak infrastructure are identified as the main drivers. These drivers create pressures such as untreated sewage, industrial discharges, solid waste dumping, livestock waste and agricultural runoff. The state of the river is therefore severely degraded, with high levels of pathogens and heavy metals, affecting people, livestock and irrigated crops that rely on the polluted water.

The impacts of these conditions are far-reaching. They spread waterborne diseases, contribute to antimicrobial resistance, lower crop productivity, increase treatment costs and erode the ecological functions of rivers. The guideline highlights that only through a coordinated catchment-scale plan can these interconnected impacts be addressed systematically and sustainably.

The document also reviews international and national legal frameworks and maps ongoing initiatives, including the Addis Ababa Wastewater Master Plan, the Rivers and Riverside Development Program and the Awash Basin Strategic Plan. Although these initiatives are promising, they face limitations due to weak enforcement, inadequate coordination and limited community participation. This further underlines the need for a catchment-based prevention and control plan that integrates different actors under a shared vision.

To overcome these barriers, the guideline proposes a coordinated action plan with clear roles and responsibilities, well-defined accountability measures and effective monitoring mechanisms to track progress at the catchment level.

If implemented effectively, this plan will not only reduce pollution and protect public health but also restore the ecological integrity of the Akaki River and support efficient agricultural and livestock value chains. More importantly, it will establish a model for comprehensive, catchment-scale pollution prevention and control planning that can be applied to other river basins across Ethiopia, supporting long-term sustainability and national development goals.

Introduction

Background and context

According to a recent World Health Organization (WHO) report, water pollution and inadequate sanitation contribute to nearly 1.4 million deaths globally each year. Unsafe water alone is responsible for more than 485,000 deaths from diarrheal diseases such as cholera and typhoid (WHO 2022). In Africa, around 400,000 deaths annually are linked to unsafe water and poor sanitation, with Sub-Saharan Africa accounting for nearly 70% of global water-related deaths among children under five (WHO and UNICEF 2022). The global economic cost of contaminated water is estimated at 260 billion US dollars annually, mainly due to healthcare expenses and productivity losses (World Bank 2016).

Ethiopia faces a significant share of this burden. Unsafe water and poor sanitation contribute to around 20,000 deaths each year, representing about 13% of child mortality in the country (IHME 2019). In Addis Ababa, Ethiopia, water pollution costs 66.6 million USD, which is 1.1% the GDP (Xie et al. 2022).

The ecological impacts are equally concerning. Polluted water disrupts aquatic ecosystems, causing biodiversity loss and habitat degradation. In India's Ganges River, the number of fish species declined from 140 in the 1950s to fewer than 90 recently, while the population of the Ganges River dolphin dropped by over 50% (Vass et al. 2010; WWF 2020). In Lake Victoria, East Africa, more than 200 endemic cichlid species have become extinct since the 1980s, primarily because of pollution (Witte et al. 2007). Similar impacts are visible in Ethiopia's Akaki River, where species richness index of macroinvertebrate number falls below 1.0 in polluted sections, compared to over 2.5 in cleaner upstream areas (Beyene et al. 2009).

It is against this backdrop that the present guideline has been developed. Its purpose is to assist the Ministry of Water and Energy (MoWE), the Federal Environmental Protection Authority (EPA) and other stakeholders in Ethiopia in preparing catchment-scale water pollution prevention and control plans, starting with the Akaki Catchment. This guideline begins by introducing the context and necessity for water pollution prevention and control. It then outlines the approach used to develop the guideline, ensuring it is grounded in sound methodology. The document details the process for creating a comprehensive water pollution prevention and control plan, followed by methods for monitoring the impacts of implementing these plans. An actionable plan is provided, specifying steps and responsibilities. The guideline emphasizes the importance of stakeholder engagement throughout the process and concludes by reinforcing the commitment to effective and sustainable water pollution management.

Purpose of the guideline

The guideline provides a practical framework for MOWE, the Federal EPA and stakeholders to develop a comprehensive, evidence-based and implementable water pollution prevention and control plan, using the Akaki River as a case study. The primary purpose is to facilitate effective water quality management by outlining methods to identify pollution sources, apply context-specific preventive and remedial measures, and strengthen regulatory enforcement. This approach is guided by monitoring key parameters to ensure it is evidence-based and applicable to other urban rivers in the country. The plan will help to restore and protect water quality for ecological health, human and economic use, and sustainable development.

The Akaki Catchment: Significance and challenges

The Akaki Catchment is characterized by diverse land use patterns, with rainfed agriculture occupying the largest share at 34%, followed by built-up (26%), grassland (18%), forest (13%), bare land (5%), irrigation (3.4%) and water bodies (0.6%). Northern areas feature contiguous forest patches, while the southeastern and southern regions are mainly farmland, with grasslands in the east. The catchment includes two river systems: The Big Akaki and the Little Akaki. The Big Akaki sub-catchment comprises 62% of the area and features major tributaries, including the Kebena and Bulbula Rivers, as well as two reservoirs: Legedadi and Dire. The Little Akaki River, also originating from the Entoto Mountains and Wechecha Mountain, includes the Gefersa Reservoir upstream. Both rivers eventually flow into the Aba-Samuel Reservoir (Bekele et al. 2022).

This catchment is a vital watershed that supplies water to Addis Ababa and the surrounding area. It supports urban agriculture and industry while providing ecosystem services. The water from the river is used for various purposes, such as domestic consumption, irrigation, washing of materials, bathing, cattle consumption and waste disposal. However, the catchment is facing severe water pollution due to untreated or partially treated domestic wastewater, industrial discharge, solid waste dumping, agricultural runoff and urban runoff. This pollution is causing degraded rivers, public health risks, contamination of underground water and loss of biodiversity.

A rapid assessment report in Akaki indicates that Addis Ababa hosts over 2,000 industries, and Bole Lemi Industrial Park represents 65% of the country's industrial activity. Most of this industrial activity is situated along riverbanks in the western and southern parts of the city. Alarmingly, around 90% lacks wastewater treatment plants, resulting in the release of untreated solid, liquid and gaseous wastes into the environment. People living near the rivers dispose of waste directly into the river (IWMI 2022). Consequently, human and animal waste, along with other organic and inorganic pollutants, contaminate the catchment (Figure 1). Little Akaki is mostly affected by industrial waste, with some contribution from domestic waste. The catchment contains large- to medium-sized and small-sized manufacturers, including beer factories, hospitals, tanneries, pharmaceuticals, abattoirs and large-scale agricultural activities. However, its most upstream part is polluted by waste from farmlands and livestock (Figure 2). A recent global survey that included 137 rivers from 104 countries, the Akaki River in Addis Ababa ranked third in the world for active pharmaceutical ingredient (API) content at over 50 ug/L, indicating the contribution of pharmaceuticals and hospitals to river pollution (Wilkinson et al. 2022).

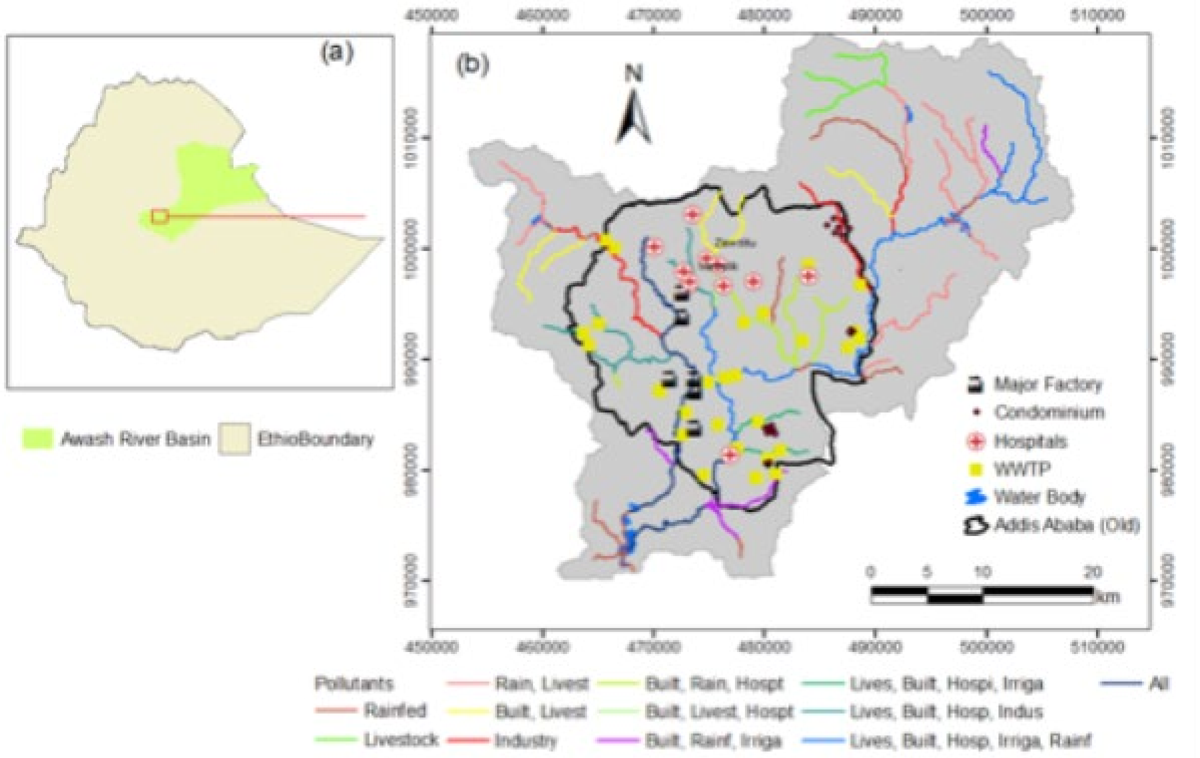

Figure 1. (a) Location of the study site in Ethiopia; (b) Spatial distribution of pollution sources along the Akaki River and its tributaries.

Source: Authors' creation.

Vegetable farming along the Akaki River accounts for about 60% of the total market supply for the city (Gashaye 2020; Mengesha et al. 2023). Humans and animals within the Akaki Catchment are exposed to pollutants through several interconnected pathways. Direct contact with contaminated river water is common, particularly among residents who use it to swim, bathe, and wash clothes and cars. Livestock frequently drink from or wade in the polluted water as well. Ingestion represents another major route of exposure. Humans consume crops irrigated with contaminated water and drink untreated water from the river. Similarly, animals ingest pollutants by drinking river water or grazing on vegetation irrigated with contaminated supplies. Skin absorption occurs when the skin encounters polluted water or soil, affecting agricultural workers and livestock. These exposure pathways are further complicated by the presence of biological pollutants (such as *E. coli* and antibiotic-resistant bacteria), chemical contaminants (including heavy metals and pesticides) and pharmaceutical residues released from industrial, agricultural, hospital and residential sources throughout the catchment. Drinking water, irrigation water, food products and recreational sources and lakes are just a few examples of how humans and animals can be exposed to antimicrobial resistance (AMR) (Figure 2).

Figure 2. Human and animal exposure pathways of pollutants at the Akaki Catchment.

Source: Ayele Assefa.

Rationale, scope and objectives

Rationale

The results of our assessment of institutional plans show that several institutions have developed water pollution control and prevention plans. These are the Addis Ababa City Administration, Addis Ababa Water and Sewerage Authority (AAWSA), Addis Ababa Environmental Protection Authority (AAEPA), Ministry of Water and Energy (MoWE), Federal Environmental Protection Authority (EPA) and Awash Basin Authority. These plans focus on rehabilitating and beautifying urban rivers, managing water quality, integrating water resources, enforcing pollution limits, expanding sewer coverage, and reducing flood and pollution risks. However, these sectoral plans have been developed largely in isolation without a coordinated framework to minimize redundancies, maximize synergy or collectively achieve water quality objectives. Consequently, the overall impact of these interventions on the water quality of the Akaki River remains unclear. This emphasizes the urgent need to develop a comprehensive, catchment-scale pollution prevention and control guideline that integrates existing sectoral initiatives, monitors their cumulative impacts and identifies additional actions required to meet the water quality targets in different parts of the Akaki River Basin.

Moreover, we have identified the absence of an institutional platform or coordinating body responsible for overseeing such an integrated catchment-based approach. While the Akaki Catchment serves as the immediate focus, similar challenges are emerging in other rapidly urbanizing cities across Ethiopia, where rivers are increasingly vulnerable to pollution. Hence, the guideline developed for Akaki can serve as a model for designing water pollution prevention and control strategies for other urban river systems in the country.

Developing a targeted and integrated pollution prevention and control guideline presents a strategic opportunity to align institutional responsibilities, enhance preventive and remedial measures, and foster stakeholder engagement at all levels. Implementing a robust water pollution prevention and control guideline plan for the Akaki Catchment is essential not only for public health but also as a critical step in protecting the environment, improving climate resilience and promoting sustainable development in the region.

Scope

This guideline provides a comprehensive framework for the prevention and control of water pollution at the catchment level, using the Akaki River as a case study while remaining applicable to other urban rivers in Ethiopia. Its primary focus is on identifying major pollution sources, applying preventive and remedial measures, strengthening regulatory enforcement and promoting integrated approaches to water quality management. The guideline emphasizes widely recognized water quality parameters for Water Quality Monitoring (WQM) site selection and assessment, including dissolved oxygen, chemical oxygen demand, nitrate, heavy metals and microbial indicators of water quality (Vadde et al. 2018; Haile et al. 2025). Furthermore, the guideline establishes a structured approach for developing targeted strategies for pollution prevention, control and remediation. It further defines clear institutional roles and responsibilities, introduces robust monitoring protocols, and outlines implementation mechanisms to ensure the plan's effectiveness. Ultimately, the guideline aims to support sustained improvements in water quality and ecosystem health within the Akaki Catchment and to serve as a transferable model for other urban river basins across the country.

Objectives

The general objective of this guideline is to enable the Ministry of Water and Energy (MoWE), the Federal Environmental Protection Authority (EPA) and the Addis Ababa Environmental Protection Authority (AAEPA) to design and implement a comprehensive catchment-scale water pollution prevention and control plan in collaboration with relevant stakeholders: the Addis Ababa Water and Sewerage Authority (AAWSA), Addis Ababa Health Bureau (AAHB), Ethiopian Public Health Institute (EPHI) and Addis Ababa University. The specific objectives are:

- To outline the steps and activities needed for the preparation of catchment-scale water pollution prevention and control plan
- To support harmonization and integration of water pollution prevention and control plans developed by various institutions operating within the same catchment
- To provide clear practical guidance for preventing pollutants from entering water bodies and for managing existing pollution sources within the Akaki River Catchment
- To strengthen the implementation of a regular Water Quality Monitoring (WQM) program and pollution surveillance systems that facilitate timely, evidence-based responses to pollution threats.

Guideline Development Approach

The guideline was developed using a co-development approach, engaging stakeholders throughout the process to ensure relevance, ownership and practicality. The process was iterative and participatory, combining technical analysis with collaborative decision-making to produce an evidence-based and locally adaptable guideline. The overall process consisted of the following main stages (Figure 3):

1. **Preparation and scoping (April 2025)**

   This initial stage focused on laying the foundation for the guideline development. The scope of the guideline, geographically, thematically and institutionally, was clearly defined to ensure focus and coherence. Key stakeholders from relevant sectors were identified and engaged early in the process to foster inclusiveness, shared understanding and collective commitment.

2. **Co-discovery (May 2025)**

   In this stage, core stakeholders worked together to define the overall goal and specific objectives of the water pollution control guideline. Through collaborative discussions, participants mapped out the main content areas and structural components of the guideline, including the steps and responsibilities for developing the guideline.

3. **Co-design (May 2025)**

   The co-design stage emphasized the collaborative refinement of the goals and objectives identified earlier. Through the workshop, stakeholders jointly identified relevant indicators and the Driving Forces–Pressure–State–Impact–Response (DPSIR) framework and its components to ensure a comprehensive understanding of the factors influencing water pollution and their interconnections. At this stage, action points were set for the preparation of a draft guideline that integrated scientific evidence, institutional realities and locally informed management measures, ensuring that the document was both technically sound and practically applicable.

4. **Co-development (June to August 2025)**

   Multidisciplinary teams and sectoral experts worked together to draft the guideline, building on the results of the co-design phase. The recommendations made by the combined technical analysts were in line with the institutional, legal and policy frameworks that were already in place. Through a number of online meetings and phone calls, stakeholders were continuously consulted to make sure the draft document remained correct, pertinent and user-friendly.

5. **Validation and finalization (September and October 2025)**

   The draft guideline was presented in a stakeholder validation workshop for review and feedback. This stage focused on assessing the balance between the ambition of the proposed actions and their realistic implementation potential, particularly in terms of institutional capacity and available resources. Feedback from participants was incorporated to refine the content, improve clarity and strengthen alignment with national policies and institutional mandates. The refined document was then finalized for adoption and dissemination.

6. **Monitoring and continuous improvement**

   The final stage established mechanisms for continuous review and learning to maintain the guideline's relevance over time. These include defining performance indicators, setting up monitoring and evaluation frameworks, and outlining procedures for periodic review and updating. Lessons learned from implementation were to be systematically documented and integrated into future revisions to promote adaptive management and long-term improvement.

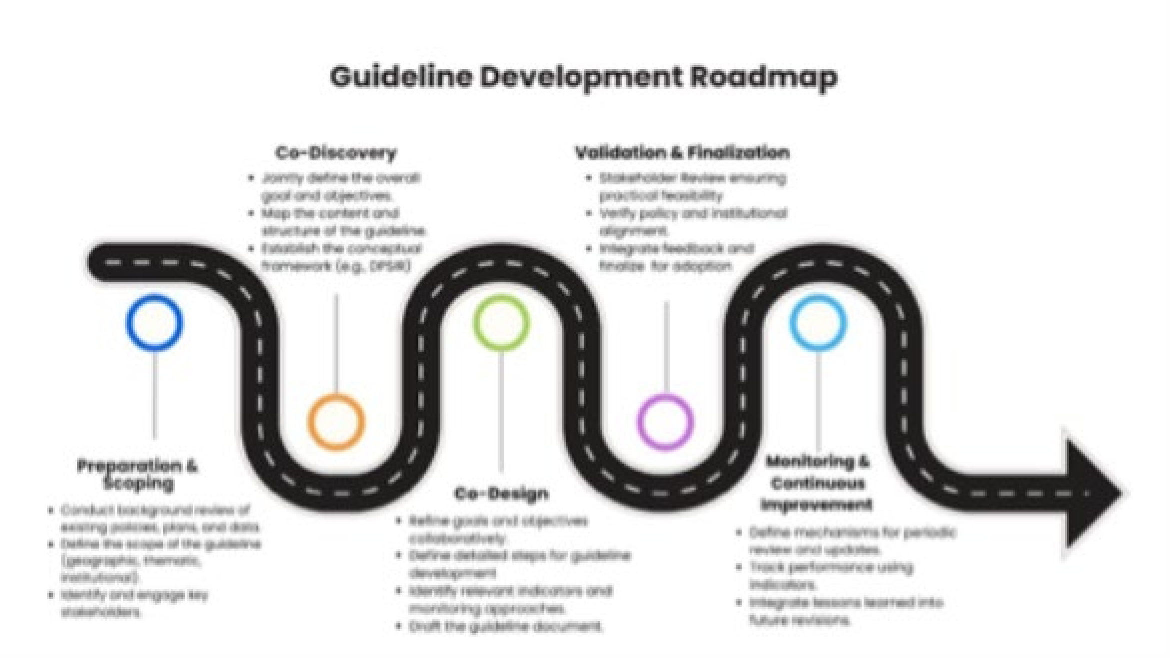

Figure 3. Process for developing the water pollution control plan guideline.

Source: Authors' own creation.

Development of a Water pollution Prevention and Control Plan

This section outlines the steps for developing a water pollution prevention and control plan. The process begins by assembling a multidisciplinary team of experts to conduct a **baseline assessment**, which involves diagnosing the current condition of the water body and identifying key pressures and impacts on its quality. Once the baseline is established, the next step is to **define clear pollution control objectives that are** specific, measurable and aligned with environmental standards and community needs. Following this, a **review and integration of existing water pollution prevention and control programs** will be conducted to ensure that all ongoing efforts are considered, avoiding duplication and promoting synergy. An **effectiveness assessment** of the current plans will then evaluate their performance. This step was conducted only once in this study, but we recommend conducting such assessment yearly to evaluate the effectiveness of new plans. It helps identify gaps and limitations in existing strategies. To address these gaps, **additional solutions and interventions** will be proposed, which may include new technologies, policy adjustments or community engagement initiatives. Finally, the **feasibility and effectiveness of the proposed interventions** will be assessed to ensure they are practical, sustainable and capable of achieving the desired outcomes (Table 1).

Table 1. Steps in the development of water pollution prevention and control plan.

No	Step	Purpose	Outputs	Methods
1	**Establish the Baseline**	Diagnose the current situation, identify pressures and impacts	Baseline report on water quality, pressures (drivers) and impacts	Field sampling, lab analysis, GIS mapping
2	**Set Pollution Control Objectives**	Define clear, time-bound, measurable goals for pollution reduction	Water quality targets per river stretch with deadlines.	National water quality standards, WHO guidelines and stakeholder workshops
3	**Map Existing Plans & Programs**	Review and integrate ongoing initiatives to avoid duplication	Inventory of relevant projects, policies and programs	Policy review, institutional mapping and program evaluation tools

4	**Simulate Effects of Current Plans**	Assess whether ongoing actions are enough to meet objectives	Simulation results showing pollution trends vs. targets	Modelling tools (SWAT, WEAP, QUAL2K[1]), scenario analysis and impact assessment
5	**Identify Additional Solutions**	Propose new solutions to bridge gaps left by existing plans	List of potential pollution prevention and control solutions	Best practices review, technology assessment, expert input, participatory planning
6	**Assess Cost-Effectiveness & Select Solutions**	Ensure proposed solutions are feasible and efficient	Ranked list of solutions, cost-effectiveness analysis and final action package	Cost-benefit analysis, multi-criteria decision analysis (MCDA), stakeholder validation
7	**Develop an implementation strategy and monitoring framework**	Create an actionable road map for execution and accountability	Established system and calendar to track progress and to measure effectiveness	Action plan, Stakeholder workshop, Define KPI, Data collection protocol and Schedule review intervals

Source: Authors' survey.

Understanding the baseline

Understanding baseline conditions of a catchment is a critical step in developing effective water pollution prevention and control guidelines. Baseline information serves as a reference point for evaluating current water quality status, tracking future improvements, assessing the effectiveness of interventions and ensuring regulatory compliance. In the case of the Akaki Catchment, the baseline assessment is conducted using the DPSIR framework (Figure 4), a widely recognized approach for water vulnerability and environmental assessment (Kristensen et al. 2004).

Figure 4. Definition of the Drivers–Pressures–State–Impacts–Responses (DPSIR) framework components.

Source: Authors' survey.

[1] SWAT: Soil & Water Assessment Tool; WEAP: Water Evaluation and Adaptation Planning; QUAL2K: Quality Simulation 2000.

The DPSIR framework provides a structured and comprehensive method for analyzing water quality issues by examining the relationships between social, economic and environmental drivers (Driving Forces) the pressures these drivers exert on water resources (Pressure), the current condition of the water environment (State), the consequences for ecosystems and human populations (Impact), and the measures taken to mitigate or manage these issues (Response) (Zhao et al. 2024). By applying this framework, it is possible to capture the complex interlinkages between human activities, environmental pressures and water quality outcomes, ensuring that management strategies are evidence-based and targeted.

To effectively operationalize the DPSIR framework, a comprehensive literature review is required to systematically identify relevant indicators for each component. This process should emphasize the inclusion of quantitative data and ensure that both environmental and socio-economic variables are considered. Such a structured and data-driven approach enables the formulation of robust, context-specific guideline that reflect the catchment's current conditions, key challenges and potential points for effective intervention.

DPSIR Framework

Drivers

In this study, we define the drivers as social and economic developments that put pressure on the environment (Hammond et al. 2018). These refer to underlying human activities that create demand and exert stress on rivers and other water bodies. The Akaki Catchment is experiencing significant pollution challenges driven by rapid population growth, unregulated urbanization, intensive livestock and agricultural practices, accelerated industrial and economic expansion, insufficient infrastructure, poor sanitation, excessive water abstraction and weak environmental management.

Land use and land cover (LULC) changes in the Akaki Catchment have been pronounced over the past few decades. Between 1982 and 2022, forest cover declined from 15.3% to 9.4%, while water bodies and river corridors decreased by approximately 468 hectares (Addis Ababa City Administration 2024). Deforestation was driven by the expansion of built-up areas, fuelwood and charcoal production, and the conversion of forest land for agriculture and grazing. Urbanization has intensified alongside these LULC changes. The share of urban land in the Akaki Catchment increased from 8% in 1990 to nearly 30% in 2020 (Negash et al. 2023), while Addis Ababa's urban area expanded from 3.6% in 1990 to 5.1% between 2010 and 2020 (Busho et al. 2021). Rapid population growth—from 2.7 million in 2007 to 5.96 million in 2023 at an annual growth rate of over 4%—has fueled the demand for housing and infrastructure, further increasing the extent of built-up and impervious surfaces (CSA 2022; Macrotrends, 2023). These changes have intensified surface runoff and increased pollutant loads in rivers.

Informal settlements have expanded rapidly in response to this urbanization and housing demand. Nearly half of Addis Ababa's housing is informal, covering approximately 2,000 ha and housing roughly 300,000 people in 60,000 units by 2000, with growth rates nearly doubling by 2001 (Taye et al. 2025). These settlements—concentrated in areas such as Akaki Kaliti, Reppi, Kotebe, Meri-Ayat, Hanna Mariam, Jimma Road and CMC—often discharge untreated waste directly into the Akaki River. Their expansion is driven by rural-to-urban migration, severe housing shortages and informal land purchases by peri-urban farmers.

Sanitation coverage remains limited in the city. Only about 16% of residents are connected to a separate sewerage network (Eriksson and Sigvant 2019), while 63% rely on shared pit latrines and 20% have no access to sanitation facilities, resulting in widespread open defecation (WRI 2021). Wastewater generation exacerbates water pollution: condominiums in Bole Sub-City produce approximately 372 m^3 of wastewater daily, yet less than a quarter of households are connected to the sewer system, contributing to untreated effluent loads entering the Kality treatment plant (Abebe and Demoze 2017).

Solid waste management is similarly inadequate. Addis Ababa generates between 2,400 and 3,000 tons of municipal solid waste per day, with households contributing 76%, institutions 9%, street cleaning 6%, hotels 3% and healthcare facilities 1%. About 8% of this waste is potentially hazardous (Addis Ababa Cleansing Agency 2022). However, only 70% is properly collected, leaving large amounts to accumulate or be washed into rivers during rainfall events (Getachew et al. 2021). Improper disposal of medical waste further poses health risks due to contamination by blood and other body fluids (Yohannes and Elias 2017).

Agricultural and livestock activities in the peri-urban areas also contribute to pollution. In 2020, Addis Ababa's livestock population (excluding dairy) was estimated at 655,624. Animal waste and fertilizer use increase concentrations of bacteria, nitrates, nitrites, ammonia, phosphates and herbicides in surface waters (Weldesilassie et al. 201; Dessie et al. 2024).

Water abstraction further aggravates pollution. The Legedadi and Dire reservoirs—key components of the Big Akaki River system—supplied 165,000 m³/day historically, rising to 195,000 m³/day by 2019, with a combined storage capacity of around 120 million m³. The Gefersa Reservoir adds about 30,000 m³/day. By regulating headwater flows, these reservoirs reduce downstream discharge, particularly during dry seasons, leading to low-flow conditions that heighten pollutant concentrations in both the Big and Little Akaki Rivers (Yohannes and Elias 2017; Addis Ababa Water & Sewerage Authority 2019; Negash et al. 2023).

Climate change also affects the catchment by altering rainfall patterns and increasing temperatures, resulting in both flooding and drought in different areas. These shifts disrupt hydrologic processes, impact water quantity and quality, and influence pollutant transport in surface runoff (Takala et al. 2016; Guyasa et al. 2024).

Finally, weak governance and poor policy implementation exacerbate water pollution. Inadequate enforcement has allowed industries to discharge untreated effluents (Hirpe and Yeo 2021), while institutional fragmentation and overlapping mandates reduce effective coordination (Van Rooijen and Tadesse 2009). Limited monitoring capacity, ineffective waste management and low stakeholder engagement—combined with financial and technical constraints—continue to hinder effective river management (WWAP 2017; Dessie et al. 2024a).

The water quality of the Akaki River is significantly influenced by environmental and socioeconomic variables. Unplanned settlements and waste have developed due to rapid urbanization, and untreated wastewater is disposed of because of poor sewerage coverage. Heavy metal-laden effluents that surpass safety regulations are released by the industrial sector. Large-scale water abstraction lowers downstream flows, which concentrates pollutants, while livestock husbandry in peri-urban areas contributes substantial amounts of nutrients and bacteria to the river. Furthermore, unpredictable rainfall and warming temperatures brought on by climate change are exacerbating drought, flooding and nutrient runoff. As a result, the ecosystem of the Akaki River is degrading more quickly (Figure 5).

Figure 5. Driver Pressure Linkages that affect water quality in the Akaki Catchment.

Source: Ayele Assefa.

Pressure

In this document, “pressure” refers to stressors caused by human activities, including industrial discharges, domestic wastewater, agricultural runoff and urban stormwater, which introduce pollutants into the river system (Song and Frostel 2012). The main pressures on the Akaki Catchment were identified through a literature review and result from both human activities and environmental conditions, such as landscape changes and climate variability.

Rapid urbanization and population growth have intensified pressures on water resources. The expansion of built-up areas has increased domestic wastewater discharge, solid waste dumping and untreated sewage entering the Akaki River. Informal settlements exacerbate these pressures by discharging untreated sewage directly into waterways and contributing additional solid and liquid waste (Berhahu et al. 2024). This urban expansion strains local infrastructure and services, including water supply, sanitation and solid waste management in Addis Ababa and the upper Awash basin (Eriksson and Sigvant 2019; Gashaye 2020).

Industrialization, linked to rapid economic growth averaging 7–10% annually, is another major contributor to river pollution. Approximately 89% of wastewater entering the Akaki River originates from three industrial sectors: leather and footwear, food and beverages, and textiles (Getachew et al. 2021). Most industries are located along riverbanks in the western and southern parts of the city, and around 90% lack wastewater treatment facilities. Consequently, untreated solid, liquid and gaseous wastes—including detergents, heavy metals, salts and dyes—are discharged directly into waterways (Yohannes and Elias 2017; Menbere and Menbere 2019). Currently, over 1,360 industries, primarily tanneries, textiles, metalworks and pharmaceuticals, release effluents with heavy metals such as chromium and lead at concentrations three to five times above WHO guidelines (EEPA 2021; Xie et al. 20221).

Agricultural activities also contribute to water quality degradation. Runoff from irrigated fields carries fertilizers rich in nitrogen and phosphorus, causing nutrient enrichment and eutrophication, while the use of pesticides introduces hazardous organic compounds into waterways, which accumulate in sediments and aquatic organisms, posing long-term ecological and human health risks (FAO 2019; Bekele et al. 2020). Poorly managed livestock production further increases microbial contamination and organic loads in surface and groundwater resources. These rapid changes in land use and landscape have accelerated surface runoff by more than 70%, altering hydrological cycles and impairing ecological and environmental functions (Negash et al. 2023). Increased stormwater flow and the frequency of extreme hydrological events also intensify local flooding. This situation was compounded by the increasing trend of extremely high variability in daily, monthly and annual rainfalls observed at the Addis Ababa Observatory between 1951– 2004 (Moges et al. 2014).

Climate change magnifies these pressures by altering seasonal rainfall patterns, causing recurrent floods and droughts, and affecting hydrologic processes in the catchment. For example, future projections suggest phosphorus loading in the Akaki River may increase by 70%, from 608.56 to 1,038.18 mg/L; nitrate concentrations may rise by 115%, from 2,805.16 to 6,022.69 mg/L; ammonia may increase by 61%, from 18 to 29 mg/L; and nitrite by 79%, from 0.43 to 0.77 mg/L (Gulie et al. 2024). These changes exacerbate pollutant transport and water quality degradation.

Inadequate sanitation infrastructure further compounds river pollution. Limited access to sewerage facilities and insufficient toilet coverage result in raw sewage entering waterways. Residential and healthcare facilities generate significant amounts of liquid and solid waste, including medical waste contaminated with blood and other body fluids, posing additional health risks (Yohannes and Elias 2017). Livestock operations upstream and along rivers also contribute pollutants via runoff or direct dumping of animal waste.

Weak governance and poor enforcement of environmental regulations exacerbate these pressures. Industrial discharges often occur without treatment due to lax enforcement (Beyene et al. 2012), and limited monitoring capacity, ineffective waste management practices, low stakeholder engagement, and insufficient financial and technical resources further hinder pollution control (Amare et al. 2014; UNEP 2016; WWAP 2017). As a result, despite existing policies, the Akaki River remains heavily polluted, posing serious risks to public health, irrigation and ecosystem integrity.

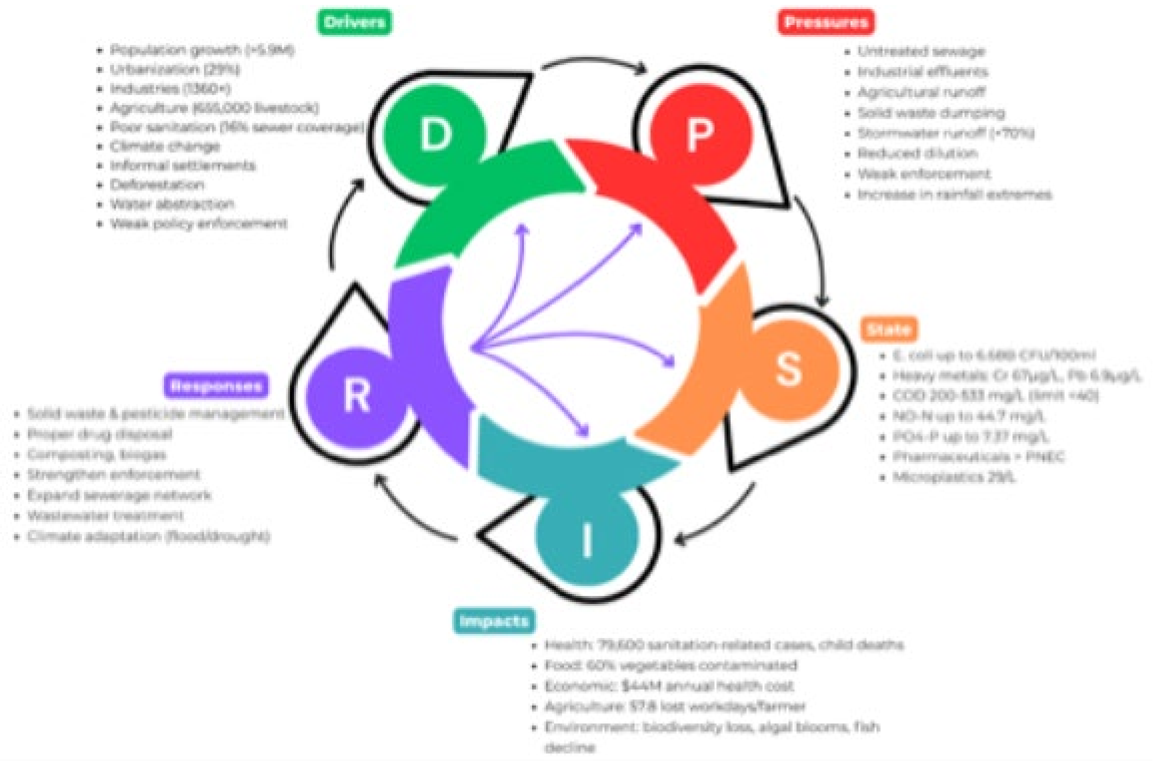

Figure 6. DPSIR Framework Diagram for the Akaki Catchment.

Source: Authors' survey.

State

The "state" refers to the physical, chemical and biological conditions of a water body at a specific time, reflecting the combined effects of natural processes and human activities such as industrial discharge, agricultural runoff and domestic wastewater (Kristensen et al. 2004). Key parameters for assessing water pollution include nutrient concentrations, suspended solids, heavy metals, pathogens and emerging contaminants. However, availability of adequate measurements is a constraint to defining the state of rivers because of lack of regular surveillance of water quality.

In the Akaki Catchment, water pollution is evaluated through multiple indicators: microbiological quality, heavy metals, organic and nutrient pollution (DO, COD, BOD, nitrate and phosphate), organophosphates, pharmaceuticals and microplastics. Studies show that much of the surface water in the catchment exceeds irrigation standards for microbial quality (Gebre and Rooijen 2009; Hiruy et al. 2022). Surface water, including water used for irrigation, has elevated levels of toxic heavy metals and other pollutants, with concentrations in the Little Akaki River surpassing permissible limits set by Ethiopian Drinking Water Quality Guidelines (Aschale et al. 2019; Mengesha et al, 2023). Organic pollution indicators such as COD, BOD and DO frequently fall outside acceptable ranges, while nutrient indicators, including PO_4^{3-} and NO_3^{-}, are notably high in the Little Akaki River (Derso et al. 2017; Angello et al. 2020; Halie et al. 2025).

Emerging contaminants are also a concern. Data on pharmaceutical pollutants is limited, but Gessew and Desta (2024) reported high concentrations of ciprofloxacin, cefotaxime and sulfamethoxazole in the Little Akaki River, at levels predicted to promote antibiotic resistance. Addis Ababa has been identified as the third-worst city globally for pharmaceutical pollution, with cumulative concentrations of active pharmaceutical compounds exceeding 50 mg/L (Wilkinso et al. 2022). Microplastics have also been detected at high levels; for example, Lake Aba Samuel contained an average of 29 particles per liter (Gebremedhin et al., 2025). Additionally, banned organochlorine pesticides such as DDT and Dieldrin were documented in the catchment (Kassegen et al. 2020). A summary of water quality parameters and their values is shown in Appendix A.

Water quality exhibits clear spatial variability within the Akaki Catchment. The middle section is the most affected, showing elevated concentrations of E. coli, NO_3^- and PO_4^{3-}, while upstream and downstream regions generally have lower levels (Eriksson and Sigvant 2019). Overall, dissolved oxygen is low throughout the catchment, although some upstream sites have higher DO and elevated levels of ESβL-producing Salmonella enteritidis and Shigella flexneri. Hospitals and dense residential areas along the Kebena River contribute to localized increases in resistant and indicator bacteria, whereas upstream and downstream parts of the Akaki River generally show lower concentrations (Haile et al. 2025).

Impacts

The impacts of water pollution in the Akaki Catchment can be assessed across health, economic and environmental dimensions. Health impacts are associated with waterborne diseases, microbial contamination, and exposure to heavy metals and pharmaceuticals. Economic impacts relate to medical costs, lost productivity and reduced agricultural and livestock productivity due to polluted water. Environmental impacts are reflected in water quality indicators (BOD, COD, nutrients, metals), biodiversity loss and ecosystem degradation, such as eutrophication and plastic pollution. Systematic monitoring across multiple sites, seasonal sampling and surveys are essential for understanding how pollution affects both human well-being and ecosystems.

Health impacts

Water pollution in the Akaki Catchment poses serious risks to human health, leading to water-based, waterborne and water-related diseases due to exposure to pathogens. Residents within and outside Addis Ababa rely on river and stream water for irrigation, livestock watering, washing and other domestic purposes (Gashaye et al. 2020; Mengesha et al. 2023). Approximately 60% of the city’s vegetables are irrigated with contaminated river water (Mekuria et al., 2021), resulting in crops with high microbial loads and elevated concentrations of heavy metals, such as Cr, Co and Fe, exceeding recommended limits (Aschale et al., 2021). Consumption of these contaminated vegetables has been linked to outbreaks of diseases including cholera, typhoid, dysentery and other sanitation-related illnesses (Eriksson and Sigvant 2019).

Addis Ababa has reported high incidences of diarrheal diseases, typhoid cholera and hepatitis. For example, the 2008 Annual Report from Nifas Silk Health Centre indicated that out of 320,000 individuals, 79,608 (24.8%) were infected with sanitation-related or fecal-oral transmitted diseases (Mazhindu et al. 2012). Intestinal parasites affected 5.8% of the population, common diarrhea 4.5%, respiratory infections 3.7%, amoebic infections 2.9%, typhoid 2.7% and dysentery 2.6%. In 2005, the city reported over 14,000 cases of typhoid, nearly 9,000 cases of bloody diarrhea and more than 10,000 cases of severe dehydration in children under five, resulting in 89 deaths (Gebre and Van Rooijen 2009).

Microplastics and pharmaceutical contaminants further threaten health through bioaccumulation and the development of multidrug-resistant pathogens. Recent studies reveal high levels of pharmaceutical residues, fostering antibiotic-resistant bacteria that endanger downstream water users (Wilkinson et al. 2022). Ingested microplastics affect humans, livestock and wildlife through the food chain, compounding health risks.

Economic impacts

Water pollution imposes significant economic costs, including increased water treatment expenses, reduced availability of safe water for drinking and irrigation, and losses in agricultural and livestock productivity. In Addis Ababa, inadequate water, sanitation and hygiene facilities are estimated to result in health-related costs of approximately US$44 million annually (Xie et al. 2022). Around 1,240 ha of farmland are irrigated with wastewater from the Little Akaki River (Weldesilassie et al. 2011). Farmers report productivity losses and health impacts, including 57.8 lost workdays per year due to wastewater-related illnesses, corresponding to a marginal health cost of 319.90 ETB per person. Pollution also affects livestock, reducing milk production and market value (Fufa 2015). Additionally, soil salinization, heavy metal contamination and overfertilization from wastewater irrigation further exacerbate economic losses. Despite the few studies mentioned here the economic impacts and economic externalities from water pollution remains largely undervalued.

Environmental impacts

Organic pollutants and nutrients in the Akaki Catchment often exceed recommended Ethiopian and WHO standards, disrupting aquatic ecosystems and causing biodiversity loss. Besides the aquatic system, these pollutants also lead to the disruption of entire landscape thorough the loss of wetlands, riverine areas which are usually very rich ecosystems. Macroinvertebrate diversity is significantly lower in polluted areas, with diversity indices falling below 1.0 compared to over 2.5 in cleaner upstream sites (Gebrehiwot et al., 2017). Excess nutrient loads have led to eutrophication, resulting in oxygen depletion, excessive algal growth and declines in fish populations (Solomon 2007; Dadi et al. 2017).

Plastic pollution is an emerging environmental threat. Plastic wastes degrade into microplastics (MPs), which compromise water quality, harm aquatic life and carry drug-resistant pathogens, posing risks to human health through the food chain. In Lake Aba Samuel, MPs were detected at mean concentrations of 29 ± 0.6 particles/L in water and 42 ± 0.5 particles/kg in sediment.

Pressure impact analysis

Pressure–impact analysis traces how various pressures (sources of pollution or stressors) influence the environment and human health through defined pathways, ultimately resulting in measurable impacts. The pressure–impact relationships for the Akaki Catchment are illustrated in Figure 7.

Figure 7. Pressure impact analysis showing the impact pathways.

Source: Authors' own creation.

Responses

Responses refer to strategic actions and policy interventions aimed at reducing pollution sources and mitigating their impacts (Appendix C). In the Akaki Catchment, these responses focus on restoring river water quality and protecting both public and environmental health (Kristensen et al. 2004; Song and Frostell 2012). The specific responses were identified through stakeholder workshops.

For the agricultural sector, participants proposed several measures to address both point and nonpoint sources of pollution. These included: (i) implementing proper waste management and controlling pesticide use in the upper catchment of the Big Akaki River; (ii) promoting source control through biogas production and composting; (iii) restricting open grazing; and (iv) improving slaughterhouse waste management practices.

For healthcare waste, strategies focused on preventing pharmaceutical and medical contaminants from entering the water environment. These included managing leftover drugs at the community level through reverse logistics, developing a guideline to control pharmaceutical waste and enhancing the management of healthcare waste within facilities.

The above responses were identified during the co-design and validation workshops with stakeholders. These should be considered preliminary results since identification of responses requires further assessment and decisions on whether to target drivers, pressures, the state or impacts. Hence, further joint work will be required in revise, expand and prioritize the responses.

Setting water quality goals and objectives

Defining water quality goals and objectives is a critical foundational step for developing effective water pollution prevention and control guideline. Clear goals provide direction, establish priorities and enable measurable progress, while objectives translate these goals into practical, time-bound actions. They ensure that all stakeholders share a common vision for improving water quality and restoring ecosystem health.

For the Akaki Catchment, stakeholders engaged in a thorough, participatory discussion to agree on the following goal and objectives:

Goal: To enhance the ecological integrity of the Akaki River by reducing pollution loads and achieving provisional services, cultural services and regulatory and maintenance services through the One Health approach.

Objectives: The general water quality objective is to improve the quality of the Akaki River water by strengthening catchment ecosystem resilience through the One Health Approach. The specific objectives are shown in Table. 2.

Table 2. Specific water quality objectives set for the Akaki River.

No	Objectives	Target	Recent Data (Baseline) for the Akaki River
1.	Improve microbial water quality in the Akaki River by reducing fecal contamination and AMR risks with a strategic focus on reducing the trends of critical AMR markers	*E. coli* < 200 CFU/100 mL for recreation	148.850 CFU/100 ml
2	Reduce loads of COD and BOD below the WHO limits and control nutrient pollution in the Akaki River	COD and BOD below the WHO limits	COD 412 mg/l BOD: 168.91 mg/l
		DO $\geq$ 6.5 mg/	2.85 mg/l
		NO_3 < 10 mg/L PO_4 < 0.5 mg/L	NO_3-N: 0.293 mg/L PO_4-P:7.3 mg/L
3	Limit toxic contaminants (heavy metals, pesticides) in the Akaki River.	Reduce hazardous discharges and ensure that they meet WHO/FAO/EPA standards for irrigation and aquatic life while reducing their residues by 50% from the 2025 baseline.	DDT: 29.9- 91.75 ng/L, Dieldrin: 4.85 DDT 16-42.45: Lindane: 15.4
4	Strengthen ecosystem resilience through nature-based solutions by restoring the ecological integrity of the Akaki Catchment	Rehabilitating a minimum of 1,000 ha of riparian zones and wetlands and increasing riverbank vegetation cover by 30%	No baseline

5	Institutionalize One Health and cross-sectoral coordination	Operationalizing a One Health-based water governance framework, establishing an integrated water-health-agriculture database by 2026 and conducting semi-annual joint monitoring, risk assessment and reporting across sectors	No baseline

Source: Authors' survey.

Review of legal frameworks and existing water pollution prevention and control plans

Reviewing relevant legal frameworks and existing water pollution prevention and control plans is a critical step in developing an effective guideline. This process ensures that new initiatives build on prior efforts, align with international and national regulations, and promote coordination across sectors. It also helps identify gaps, avoid duplication of efforts and strengthen the overall effectiveness of pollution control measures.

In this context, international and national regulatory frameworks were examined, and existing water pollution prevention and control plans and programs in the Akaki Catchment were mapped. This review provides a foundation for harmonizing interventions and guiding the implementation of a comprehensive, catchment-scale pollution prevention and control plan.

Review of international policy and regulatory frameworks

Globally, a variety of regulatory frameworks and legal instruments have been applied to prevent and control water pollution. Understanding these international experiences is essential for informing the development of a comprehensive water pollution prevention and control plan for the Akaki Catchment.

Table 3 presents seven key water-related policy and regulatory documents, including two Water Framework Directives, two water-related Acts, two water quality or pollution prevention guidelines and additional river protection, management and action plan policies. These frameworks collectively provide valuable guidance on structuring regulatory measures, monitoring and enforcement, as well as on integrating ecosystem and catchment-based approaches.

The international water pollution prevention and control-related regulatory framework documents mostly target national (or regional) scales. Hence, there is a need for a guideline at the catchment scale that can be linked with frameworks or plans at national and regional scales. Lessons from these frameworks offer critical insights for the Akaki Catchment. A robust water pollution strategy should integrate catchment-based planning as emphasized by the UN Environment Programme (UNEP) and the European Union; enforce pollution discharge standards as in the *U.S. Clean Water Act* and China's regulations; invest in essential infrastructure such as wastewater treatment systems (India); and adopt an integrated, ecosystem-based approach to water resource management, as practiced in Tanzania and Rwanda. By blending regulatory control with adaptive, locally appropriate interventions, the guideline can support long-term improvements in water quality while ensuring ecological and social sustainability in the Akaki Catchment.

Table 3. International water pollution prevention and control-related regulatory framework documents.

No	Framework Document	Year of Publication	Main Features of the Documents
1	*The Clean Water Act (CWA)*, used as a central set of water pollution regulations in the USA	Kapp (2014)	The legislation established a framework for regulating pollutant discharges into U.S. waters, granting the EPA authority to implement pollution control programs and set wastewater standards for industries. It also upheld requirements for water quality standards for all surface water contaminants and made it illegal to discharge pollutants from a point source into navigable waters without a permit.
2	European Union, Water Framework Directive (WFD) (A policy document developed for a basin)	Directive (2000)	The EU Water Framework Directive (WFD) provides a framework for member states to establish and implement coordinated yet individually chosen objectives for water quality and pollution control, allowing significant flexibility in how these objectives are achieved.
3	UNEP, Framework for Water Pollution Control (Management Principles for Catchment or river basin level are described)	Helmer and Hespanhol (1997).	The framework document outlines procedures for identifying and analyzing water pollution issues, defining long-term and short-term objectives for control. It details necessary management interventions and establishes an action plan with implementation, monitoring and updating procedures.
4	Guidelines for Water Quality Management Plan, India, (A nationwide Management Plan)	Central Pollution Control Board of India (2008)	The document outlines the step-by-step activities needed to formulate an action plan for restoring water quality. Additionally, the guideline presents various options that may be considered for the action plan.
5	Water Pollution Prevention and Action Plan (China)	State Council of the People's Republic of China	The plan sets targets for reducing water pollution, focusing on ten heavily polluting industries. It mandates small factories to meet specific pollution reduction goals, with closures for those that fail to comply, and requires the installation of abatement technologies in these plants.
6	Water Management Act, Tanzania (A country-level Act for Water resources protection)	United Republic of Tanzania (2009)	The Act aims to ensure sustainable management and protection of water resources in Tanzania. It establishes a legal framework for managing water resources, grounded in the principles of Integrated water resources management.
7	Water Quality Management Plan for Rwanda: Management Guidelines (National Water Resources guidelines)	Rwanda Environment Management Authority (REMA) (2012)	The Source-Pathway-Receptor-Use framework is a useful tool for water quality management. It categorizes management options by analyzing pollutant sources, their pathways to surface water and transport in water bodies, while also considering both consumptive and non-consumptive water resource use.

Source: Authors' survey.

Analysis of national legal frameworks on water pollution control in Ethiopia

Ethiopia has established a range of legal frameworks to manage and protect water and environmental resources. Reviewing these policies is essential for developing an effective water pollution prevention and control plan in the Akaki Catchment, ensuring cross-sector coordination and compliance. Ten key documents have been examined (Table 3) and categorized into environmental policies, water-related strategies, and regulations on solid waste and riverbank management.

These frameworks set national goals, regulate discharge standards and promote integrated watershed management, linking water quality to sectors such as irrigation, sanitation and energy. They also introduce effluent standards, waste management rules and localized protections, providing a foundation for a catchment-scale approach aligned with national law and sustainable water quality management.

The effectiveness of the legal frameworks is constrained by overlapping institutional responsibilities, weak local implementation, delayed policy ratification and a focus on urban areas that often overlooks rural pollution sources.

The governance of water quality faces additional challenges due to conflicts among key institutions. For instance, the MoWE develops water policies and sets standards, while the EPA regulates pollution, creating confusion over regulatory authority for wastewater discharge. Regional Environmental Protection Bureaus (REPBs) implement the EPA's regulations but also assert their own regional standards, while the Rover Basin Councils (RBCs) oversee integrated water resource management and pollution prevention. The Addis Ababa City Government further enforces riverbank protection and urban waste management, overlapping with the MoWE, EPA and REPBs. These overlapping roles fragment accountability, complicate coordination and reduce the effectiveness of urban pollution control and watershed protection. Limited public participation and poor inter-agency coordination further weaken enforcement and long-term impact.

Table 4: List of legal framework documents on water pollution control in Ethiopia.

No	Name of the Document, Authority or Power Vested in the Document	Year of Publication	Purposes Related to Water Pollution Control	Remarks on Water Quality and Pollution Control
1	The Constitution of the FDRE (Article 44 & 92/4 - Environmental Rights)	1995	To establish the government's duty to ensure that all Ethiopians live in a clear and healthy environment	Provides the fundamental constitutional right to a clean environment
2	Environmental Policy of Ethiopia (Environmental Protection Authority and Regional EP Bureau)	1997	The policy outlines guidelines for water conservation, environmental assessments, monitoring water quality and protecting wetlands and forests	Broader policies for the prevention of land, air and water pollution are indicated
3	Ethiopian Water Resources Management Policy (Ministry of Water Resources)	1999	The policy document outlines the national goals, objectives and guiding principles for managing water resources	The policy sets water use limitations and waste disposal and catchment management methods
4	Ethiopian Water Resources Management Proclamation (Ministry of Water Resources) Power delegated to RWB and BDO	2000	Protect and utilize the country's water resources effectively. Prevent harmful effects related to water, ensuring proper management of these resources	The proclamation authorized the Ministry of Water Resources to set standards for processing applications to discharge polluted water into waterways
5	National Water Sector Strategy (Ministry of Water Resources)	2001	The national strategy covers irrigation, water and sanitation, hydropower, transboundary water management and environmental mitigation for hydraulic infrastructure	Promote effective watershed management practices to conserve water, increase water yields, enhance water quality and reduce reservoir siltation
6	Environmental Pollution Control Proclamation No: 300/2002 (Environmental Protection Authority and Regional EPAS)	2002	Reduce or prevent pollution caused by social and economic development activities, as it is an undesired consequence	EPA shall formulate standards for the discharge of effluents into water bodies and sewage systems
7	Water Resources Management Regulations (Ministry of Water Resources)	2005	Defines the rights and responsibilities of water users and government entities regarding water usage, effluent discharge permits, waterworks construction and well installation	There is an article regarding water quality control, specifically on wastewater discharge permits. In this context, the Ministry of Water has a regulatory role
8	River Basin Councils and Authorities Proclamation	2007	Promote and monitor the integrated water resources management process in the river basins	River basin plan preparation to establish effective water resources management and facilitate integrated management
9	Solid Waste Management Proclamation (Environmental Protection Agency, Federal and Regional)	2007	Enhance at all levels the capacities to prevent the possible adverse impacts while creating economically and socially beneficial assets out of solid waste	The proclamation focuses on solid waste management planning, which may impact river water quality, rather than directly addressing water pollution control

10	Prevention of Industrial Prevention Council of Ministers; Regulation No. 159/2008	2008	**Directly prevent and control pollution** through enforceable measures such as permits, standards, monitoring and penalties	**Primary enforcement tool**. It empowers the EPA to establish specific effluent standards for wastewater, issue permits for discharges and take legal action against polluters
11	Draft National Water Policy and Strategy (Ministry of Water, Irrigation and Energy)	2020	Guide and coordinate all national efforts towards efficient, equitable and optimum utilization and management of the water resource	The strategy outlines a plan for integrated watershed management aimed at improving water quality and controlling pollution. Its goal is to ensure safe water, protect public health and protect water resources
12	Riverbank Development and Pollution Prevention Regulation, City Government of Addis Ababa	2024	The regulation aims to prevent environmental pollution and make the city clean, and make the rivers and their banks in the city a clean and healthy environment	The initial policy document clearly outlines the protection of rivers and riverbanks from pollution, including prohibited actions and control measures for implementation

Source: Authors' survey.

Mapping and simulation of existing water pollution prevention and control plans and programs

Different government agencies and partners are developing various plans to address water pollution and enhance water quality in the Akaki Catchment. Table 5 displays a summary of the plans, implementing agencies, objectives and key activities. Overall, while multiple efforts are in progress or planned, challenges remain in enforcement, coordination and implementation. Key challenges include weak enforcement of regulations, delays in executing planned programs and limited community engagement. While the strategies are comprehensive and forward-looking, many of them are not well aligned. To improve effectiveness, stronger institutional coordination, faster implementation, better enforcement and increased public participation are crucial. It is therefore important to integrate the existing national and local plans and programs into a single plan to achieve the desired water quality goal and objectives, as shown in Table 6.

The Akaki watershed encompasses urban, industrial and rural areas, which are governed by various instruments for water pollution control, including environmental standards, basin strategic plans, urban wastewater strategies, environmental impact assessments and donor-supported programs. Despite providing a normative policy foundation, there are critical gaps in numerical targets, operationalization, monitoring, coordination and enforcement, which limit the effectiveness of these policies in managing pollution at the watershed scale.

Ethiopia, especially Addis Ababa, has various policies for water pollution control, but these 12 plans are fragmented and inconsistently enforced. They often lack clear targets and coordinated monitoring at the watershed level. While standard-setting for pollutants is emphasized, integration with operational activities and multisectoral coordination is weak. Many documents, such as the National Integrated Water Resources Management Program Draft and the Addis Ababa Integrated Solid Waste Management Master Plan, are outdated and lack crucial details, which undermines accountability.

The existing plans for the Akaki watershed offer a strong normative basis through standards and strategic goals, but they lack the specificity, coherence and operationalization needed to guide pollution reduction efforts effectively. Harmonization of targets, integration of monitoring systems, spatially explicit planning and scenario-based modelling (e.g., via SWAT) are essential steps to bridge the policy–implementation.

Table 5. Existing water pollution prevention and control plans and programs in Ethiopia.

No	Water Pollution Control Plan/Program	Key Activities Listed	Objectives of the Plan/Program	Target Values	Lead Implanting Agency	Publication Date
1	Environmental Standards for environmental pollution control	Monitoring, penalties and environmental audits	Control nutrient loading, maintain oxygen levels, reduce organic load, protect public health and prevent toxic contamination in aquatic life	Nitrate, 20 mg/L, Total Phosphate 10 mg/L, BOD, 80 mg/L, COD, 250 mg/L, *E. coli* / Total Coliform,400 per 100 mL, As 0.25 mg/L, Cd 1 mg/L Cr: 2 mg/L, Cu 2 mg/L, Pb 0.5 mg/L, Hg 0.001 mg/L, Ni 3 mg/, Zn 5 mg/L	Environmental Protection Authority (EPA)	2020
2	Draft Guideline for Discharge of Sewage Effluent into Surface or Inland Water	Setting Discharge Standards Recommendation Pollution Prevention and River Rehabilitation Monitoring and Sampling	Protect water bodies from pollution, safeguard public health and ensure treated wastewater meets environmental standards	Nitrate 15 mg/l, Phosphate 10 mg/l, DO ≥5 mg/l, COD,200 mg/l, BOD 80 ml/l, *E. coli* 400 cfu/100 ml, Cu mg/l, 2, Cr 2 mg/l, Cd 1mg/l, Ni 3 mg/l, Fe 1 mg/l, Mn 5 mg/l, Pb 0.5, Zn 5 mg/l	Environmental Chair, School of Chemical and Bio Engineering, AAU	2003
3	Esia for eastern catchment wastewater treatment plant and sewer line	Reduce nutrient pollution in surface waters, enhance water quality, lower organic pollutants and loads to improve DO levels and health safety	Assess the environmental Social impacts of the wastewater treatment and sewer line project in Addis Ababa's Eastern Catchment, complying with Ethiopian laws and international standards	Nitrate 5–8 mg/L, Phosphate 2 mg/L, COD 30–34 mg/L, BOD_5 5–22.5 mg/L	Addis Ababa Water and Sewage Authority	2022
4	Awash Basin Water Quality Strategic Plan	Revise the WQM program	Ensure that water quality is suitable for its intended use	Nitrate: WHO standard: FAO standard for irrigation: Chromium and Manganese are mentioned; WHO standards are referenced but not listed numerically	Awash Basin Authority	
5	Towards a Water Management Programme for the Awash Basin	Detect sudden adverse changes Assess general water quality and pollution control effectiveness Analyze trends for long-term planning	Setting Objectives Designing Monitoring Network Sampling Programme Laboratory Analysis Rehabilitation and Pollution Control 1Use of SMART Technologies	To prevent eutrophication, control nutrient enrichment, maintain dissolved oxygen, reduce pollution and ensure safe drinking water by managing microbial contamination and monitoring toxic metals	MoWE	2018

6	National Integrated Water Resources Management Program Draft Report	- Harmonize pollution control regulations - Strengthen water quality labs - Monitor pollution sources - Support urban wastewater treatment	Harmonize and develop national pollution prevention policies and instruments Develop the capacity to monitor hazardous pollutants .	The document outlines strategic actions to develop national standards and guidelines for water quality parameters without specifying exact target values		2018
7	Water Sheds Development Plan	Improve river water quality by reducing pollution from sewage, waste and stormwater. Prevent industrial discharge and maintain a minimum flow of 1 m³/s in dry seasons to support aquatic life. Use small dams and reservoirs to manage seasonal shortages	Interceptor sewers: expand and connect to Kality WWTP, Stormwater and sewage pipelines: install across all zones, roads and pedestrian paths: improve access and safety	Enhance Kebena River water quality and maintain ecological flow by installing smart monitoring for pH, DO and NO_3. Reduce illegal dumping and improve solid waste collection. Build small-scale dams and reservoirs for stable water supply	KOICA	2023
8	Addis-Adama water resources management and protection framework	Ensure proper waste disposal, Water quality assessment	Water quality management	Not specified	Addis Ababa Water and Sewerage Authority	2017
9	World Bank Urban Resilience Project	Create a stormwater master plan, enhance waste management, stabilize riverbanks, install retention ponds and improve river catchment management	Reduce flood and pollution risks in the city	Not specified	World Bank, Addis Ababa City Administration	2021
10	Beautifying Sheger Project	Upgraded wastewater infrastructure improvements, public toilets, stormwater management, vegetation buffers, expanded sewer network, enhanced waste management and pollution control	Minimize microbial contamination, reduce urban and industrial pollution, increase DO levels for healthy ecosystems and control toxic metal discharges and runoff	Not specified	Addis Ababa City Administration	2019
11	Addis Ababa Integrated Solid Waste Management Strategic Master Plan	Install a leachate collection system at Reppie landfills and implement a safety monitoring program Align the SWM manual with landfill operational training programs.	Install and operationalize a leachate collection and treatment system	Not specified	AA City Administration	2024

12	Urban wastewater management strategy	Protect the environment from wastewater discharge Reuse of treated effluent and sludge	Create criteria for effluent reuse (irrigation, groundwater recharge), joint monitoring with ministries, track heavy metals and salinity, promote compliance technologies and enforce regulations	Not specified	MoWE	2017

Source: Authors' survey.

Table 6. Integration of existing water pollution prevention and control plans.

No	Water Pollution Control Plan /	Key Activities (Output)	Output Indicators	Outcome	Outcome Indicators / Target Values	Impact	Impact Indicators	Spatial Target / Sub catchment	Target Year
1	Environmental Standards for Environmental Pollution Control	Monitoring programs, penalties and environmental audits	# of monitoring stations; % compliance inspections completed	Reduced nutrient and pollutant load in rivers	Nitrate ≤ 20 mg/L, Total Phosphate ≤ 10 mg/L, BOD ≤ 80 mg/L, COD ≤ 250 mg/L, E. coli ≤ 400/100 mL	Improved aquatic ecosystem health	DO levels stable; reduced bioaccumulation of metals	Urban & industrial subcatchments (Addis Ababa zones, Kality WWTP downstream)	2025
2	Draft Guideline for Discharge of Sewage Effluent	Set discharge standards, technology recommendations, river rehabilitation and regulatory enforcement	# of industries complying with standards; volume of treated wastewater	Reduced point-source pollution	Nitrate ≤ 15 mg/L, Phosphate ≤ 10 mg/L, DO ≥5 mg/L, COD ≤ 200 mg/L, BOD ≤ 80 mg/L, E. coli ≤ 400/100 mL	Safer water for public use; reduced chemical contamination	Concentrations of Cu, Cr, Cd, Ni, Fe, Mn, Pb, Zn within limits	Urban/industrial zones; rivers receiving treated effluent	2025
3	ESIA for Eastern Catchment WWTP & Sewerline	Construct WWTP and sewer lines; implement monitoring	WWTP operational; # km of sewer pipelines installed	Reduced nutrient and organic pollution downstream	Nitrate 5–8 mg/L, Phosphate 2 mg/L, COD 30–34 mg/L, BOD_5 5–22.5 mg/L	Improved DO and public health	Healthier aquatic ecosystems; reduced disease incidence	Eastern Catchment subcatchments (AAWSA coverage)	2026
4	Awash Basin Water Quality Strategic Plan	Revise WQM program	# of monitoring stations installed; frequency of monitoring	Water quality suitable for intended uses	Nitrate ≤ 50 mg/L (WHO); Irrigation ≤ 30 mg/L (FAO); Cr & Mn within WHO/FAO limits	Sustainable water resources	Long-term ecosystem stability	Critical subcatchments in Awash Basin	2025

Source: Authors' survey.

3.5. Identify additional measures for pollution control and prevention

The purpose of this step is to propose new solutions that address gaps in existing plans and harmonize ongoing efforts. During the stakeholder co-design workshop, participants identified potential water pollution prevention and control measures for the Akaki Catchment. They first mapped the key pollution sources in the catchment and then proposed prevention measures tailored to each source (Table 7). In addition, stakeholders suggested management solutions aimed at reducing existing water pollution in the rivers. These proposed measures will require feasibility studies before implementation to ensure they effectively support the water quality objectives of the Akaki Catchment.

Table 7. Additional actions proposed for the different waste streams.

Waste Stream	Pollution Sources	Pollution Prevention	Water Quality Management/ Remediation
Domestic & Municipal	Untreated sewage Poor sanitation & open defecation Household greywater Medical waste	Expand sewerage coverage Improve sanitation facilities Household soak-away pits Public awareness campaigns	Expand/upgrade WWTPs Decentralized low-cost treatment (wetlands, lagoons, biogas) Sludge management Solar disinfection
Industrial	Tanneries, textiles, breweries, Heavy metals, dyes, chemicals, APIs	Cleaner production & circular economy Enforce pre-treatment & effluent standards Environmental audits & penalties	Install primary & secondary treatment (e.g., membrane bioreactor (MBR) Hazardous waste facilities Real-time effluent monitoring Sludge treatment
Agricultural & Livestock	Manure runoff from livestock Fertilizer & pesticide residues Slaughterhouse waste	Biogas from manure Composting Controlled pesticide/fertilizer use Restrict open grazing near rivers	Riparian buffer zones Constructed wetlands Slaughterhouse waste treatment Micro-watershed management
Pharmaceutical & Healthcare	Hospital effluents (antibiotics, pathogens) Improper drug disposal	Reverse logistics for expired drugs Guidelines for safe disposal Improve hospital waste treatment facilities	Install hospital-specific treatment (ozonation, membranes) Strengthen AMR surveillance Separate drainage for medical waste
Cross-Cutting/ Nature-Based	Urban stormwater runoff Flood-related pollution Weak institutional coordination	Greening & riverbank rehabilitation Public-private partnerships One Health approach	Flood mitigation measures Reservoirs & oxygenation Urban drainage upgrades Integrated stakeholder coordination

Source: Authors' survey.

Assessment of the cost-effectiveness and select solutions

Assessing the cost-effectiveness of water pollution prevention and control measures is important in guideline preparation because it helps to ensure that limited financial and technical resources are used in the most efficient way. To aid in decision-making, the Multi-Criteria Decision Analysis (MCDA) method can be applied, which involves rating and selecting options according to several criteria and methodically weighing the benefits and drawbacks of each option (Ngubane et al. 2024).

Identifying the roles and responsibilities of the organizations

Identifying the roles and responsibilities of organizations is essential in preparing a water pollution prevention and control guideline, as it provides clarity, strengthens accountability and enhances coordination among stakeholders. Clearly defined responsibilities help avoid overlaps and gaps, ensure efficient use of resources and establish ownership of actions. This allows for effective implementation, monitoring and enforcement, while fostering collaboration between institutions, communities and other actors to achieve sustainable pollution prevention and control. Careful selection of an organization to lead, coordinate and ensure the effective implementation of the guideline was proposed (Appendix B).

Monitoring the Impacts of Implementing the Plans

This part of the document outlines a systematic approach to monitor progress, evaluate outcomes and assess the impact of implementing the Water Pollution Prevention and Control Plan in the Akaki Catchment. The primary goal is to ensure alignment with the plan's objectives and sustainable water quality improvement through data-driven decision-making, accountability and adaptive management. The objectives of monitoring and evaluation are:

- Measure progress toward achieving the goal of enhancing the ecological integrity of the Akaki Catchment
- Track the implementation of planned activities and interventions and measure their effectiveness
- Assess changes in water quality indicators
- Evaluate stakeholder participation, policy enforcement and institutional coordination
- Identify challenges, gaps and opportunities for adaptive management.

The Water Quality Monitoring (WQM) design developed through the efforts of the International Water Management Institute (IWMI) (Haile et al., 2025), which can be used as a reference for the WQM to show the impacts of the Akaki Catchment water pollution control and prevention plan (Figure 8). Multiple approaches were adopted, in the following order: literature review of previous studies in Akaki Catchment; field observations of pollution sources and previously monitored sites; spatial analysis of catchment characteristics including pollution sources to support design of the monitoring sites; identification of one-time monitoring sites at 40 locations with stakeholders; water sample collection; and laboratory analysis and pollutant "hotspot" identification to propose targeted sites for regular monitoring. Hotspots were identified based on chemical oxygen demand, dissolved oxygen, ammonia, pollution sources and biological data. In addition, a water quality assessment framework is attached in Appendix B.

Figure 8. Steps followed for systematically preparing the Water Quality Monitoring plan.

Source: Haile et al., 2025.

Action Plan

This action plan is developed to guide the implementation of the water pollution control plan through a coordinated, multisectoral approach. It builds on the findings of the DPSIR framework analysis and stakeholder consultations, aiming to integrate existing efforts and fill critical gaps in pollution control. The action plan provides a clear roadmap for turning these strategic goals into concrete, time-bound activities. The action plan helps define roles and responsibilities, ensuring that efforts are coordinated rather than duplicated. By assigning responsibilities and timelines, the action plan promotes transparency and accountability among implementing agencies and stakeholders. The details of the action plan are attached in Appendix C.

Stakeholder Engagement

Stakeholder engagement and partnership are essential for the implementation of the water pollution prevention and control plan, ensuring that all relevant interests are adequately represented. Such engagement provides valuable input on the issues at hand, aids in developing evaluation criteria for analyzing management options and informs the preferred management strategies (Figure 9). Stakeholders should be involved throughout all stages of the development of the guideline. This section outlines who to consult, inform, involve and collaborate with at various stages or components of preparing and implementing a water pollution control plan. For this document, the key stakeholders were identified through stakeholder analysis conducted in 2022, in the framework of the One Health Program at the Akaki Catchment. These are: Addis Ababa Water and Sewerage Authority (AAWSA), Ministry of Water and Energy (MoWE), Addis Ababa Health Bureau (AAHB), Addis Ababa Environmental Protection Authority (AAEPA), Ministry of Health (MoH), Ethiopian Public Health Institute (EPHI), Addis Ababa University and the media. The levels of engagement, activities, purpose and strategies are shown in Appendix D.

Figure 9. Co-design workshop: Identifying the structure and contents of the guideline for preparation of a water pollution control plan.

Source: Ayele Assefa.

Stakeholders contributed to the preparation of water pollution control and prevention for the Akaki Catchment in three stages. First, they were consulted to understand existing efforts, gaps and opportunities for preparing the plan. Next, a co-design workshop was organized. The objective of this workshop was to collaboratively prepare a comprehensive guideline for a pollution control plan that enhances the water component of the One Health approach. This involved stakeholders from various sectors to ensure integrated and holistic pollution control. The stakeholders reviewed the water pollution control and prevention plan, which was revised to address their comments and suggestions. Therefore, by integrating their knowledge, concerns and capacities, this engagement fosters a sense of shared ownership, improves coordination across often fragmented mandates, builds public trust and ultimately leads to more sustainable, equitable and effective solutions that are rooted in local realities and supported by those responsible for their execution.

Conclusion

This guideline provides a comprehensive framework for developing and implementing a catchment-scale water pollution prevention and control plan. It highlights the importance of understanding baseline conditions through the DPSIR framework, setting clear water quality goals, reviewing legal and institutional frameworks, and integrating existing plans and programs. The document also highlights the fragmented nature of current efforts and the urgent need for coordinated multisectoral action. It proposes practical interventions, including infrastructure development, regulatory enforcement, stakeholder engagement and public awareness campaigns. The guideline underscores the importance of regular monitoring and evaluation to track progress, assess impacts and adapt strategies as needed. By aligning institutional responsibilities, promoting integrated water resource management and fostering collaboration among stakeholders, this plan aims to restore the ecological integrity of the Akaki Catchment and serve as a model for other urban catchments in Ethiopia and beyond. Its successful implementation will contribute to improved public health, environmental sustainability and socio-economic development.

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Appendices

Appendix A. The state of water quality in the Akaki Catchment

No	Parameters	Observed Values	References
1	Microbial	*E. coli*: 148.850 CFU/100 ml	Eriksson and Sigvant (2019)
		ESβL-producing *E.coli*:1.40 Log cfu/100mL	Haile et al. (2025)
		ESβL-producing *K. pneumoniae*:3.44 Log cfu/100mL	
		ESβL-producing *Salmonella-Shigella:* 4.02 Log cfu/100mL	
		ESβL-producing Total Coliforms:1.28 Log cfu/100mL	
		E. coli in water used for irrigation: 2.09 log10 CFU/100 ml,	Beyene et al. (2017)
2	Organic and nutrient pollutants	COD: 412 mg/l	Haile et al. (2025)
		BOD: 168.91 mg/l	
		DO: 2.85mg/l	
		PO_4-P:7.3 mg/, NO_3-N: 0.293 mg/L	Eriksson and Sigvant (2019)
3	Heavy metals	Cr: 67 µg/L, Co: 2.62 µg/L, Cu: 5.61 µg/L, Fe: 1076 µg/L, Pb: 3.13 µg/L, Mn: 1540 µg/L, Zn: 25.5 µg/L	Ascahle et al. (2021)
4	Pharmaceutical pollution	Ciprofloxacin, cefotaxime, sulfamethoxazole (above PNEC levels for resistance)	Gessew and Desta (2024)
		Active Pharmaceutical Ingredients (API)	Wilkinso et al. (2022)
5	Microplastics	29 particles/L in water and 42 particles/kg in sediment	Gebremedhin et al. (2025)
6	Organophosphates	DDT:29.9- 91.75 ng/L, Dieldrin:4.85	Kassegne et al. (2020)
		DDT 16-42.45 : Lindane: 15.4,	

Appendix B. Key roles and responsibilities of organizations and water champions

No	Organization	Role	Key Responsibilities
1	Ministry of Water and Energy (MoWE)	Lead Coordinator	Establish task force; Set water quality goals; Oversee integrated water resource management
2	Federal Environmental Protection Authority (EPA)	Regulator	Set effluent standards; Conduct audits & enforcement; Support awareness campaigns
3	Addis Ababa Environmental Protection Authority (AAEPA)	Local Enforcer	Map pollution sources; Enforce regulations locally; Run awareness campaigns
4	Addis Ababa Water and Sewerage Authority (AAWSA)	Infrastructure Manager	Expand sewerage coverage; Upgrade treatment plants; Monitor water quality
5	Addis Ababa City Administration	Urban Planner	Support sewer expansion; Manage solid waste; Enforce riverbank protection

6	Ministry of Health (MoH)	Public Health Oversight	Conduct health risk assessments; Lead health campaigns; Integrate water-health objectives
7	Addis Ababa Health Bureau (AAHB)	Local Health Authority	Promote community health; Assess local health risks
8	Ethiopian Public Health Institute (EPHI)	Technical Support	Provide lab analysis; Monitor antimicrobial resistance (AMR)
9	Academic & Research Institutions	Knowledge Providers	Conduct studies; Provide policy briefs; Support monitoring & evaluation
10	Addis Ababa Cleansing Management Agency	Waste Manager	Coordinate waste collection; Implement reduction programs
11	International Water Management Institute (IWMI)	Technical Coordinator	Support stakeholder coordination; Design monitoring plans
12	Media	Public Awareness	Disseminate information; Run campaigns & outreach
13	Water champions	Advocate and coordination	Incorporate pollution control into the institution's mandate, foster stakeholder collaboration and lead efforts to enhance water quality through awareness, monitoring and enforcement.

Appendix C. Water Quality Assessment Framework

No	Section	Elements	Details
1	Assessment Objectives	Baseline	Establish baseline water quality conditions
		Sources	Identify pollution sources and pathways
		Monitoring	Monitor key water quality parameters
		Evaluation	Evaluate effectiveness of interventions
		Policy	Support adaptive management & policy refinement
2	Assessment Indicators	Microbiological	*E. coli,* Total Coliforms, ESβL bacteria, AMR markers
		Chemical	Heavy metals (Pb, Cd, Cr, Hg, Fe, Mn, Zn); Nutrients (NO_3^-, PO_4^{3-}); Organic pollutants (BOD, COD, DO)
		Emerging	Pharmaceuticals (ciprofloxacin, sulfamethoxazole), Microplastics, Organophosphates (DDT, Dieldrin)
		Physical	Temperature, Turbidity, pH, Conductivity
3	Monitoring Design	Site Selection	Upstream, midstream, downstream; High-risk zones (industrial, agricultural, residential); Reservoirs & tributaries (Legedadi, Dire, Gefersa)
		Frequency	Monthly (core), Seasonal (emerging pollutants), Event-based (floods/spills)
		Methods	Field sampling, Lab analysis, GIS & remote sensing, Modeling tools (SWAT, QUAL2K, WEAP)
4	Data Management & Analysis	Database	Centralized water quality data system

		Tools	Dashboards for real-time monitoring
		Analysis	Statistical analysis (trends, anomalies)
		Modelling	Scenario modelling for interventions
5	Evaluation Criteria	E. coli	<1,000 CFU/100mL (irrigation); <200 CFU/100mL (recreation) → Public health
		BOD	<30 mg/L → Organic pollution control
		COD	<75 mg/L → Organic pollution control
		Nitrate	<10 mg/L → Nutrient pollution control
		Phosphate	<0.5 mg/L → Eutrophication prevention
		Heavy Metals	Within WHO standards → Toxicity control
		DO	>5 mg/L → Aquatic life support
6	Institutional Roles	MoWE	Lead agency, coordination & policy
		EPA	Regulatory oversight & effluent standards
		AAWSA	Sewerage expansion & wastewater treatment
		Awash Basin Authority	Basin-level monitoring & integration
		City Government	Urban waste management & riverbank protection
7	Reporting & Review	Reports	Annual water quality reports
		Reviews	Mid-term reviews of effectiveness
		Stakeholders	Workshops for feedback & updates
		Integration	One Health monitoring systems

Appendix D. Action Plan for water pollution prevention and control guideline development

No	Objectives	Targets	Activities	Year I	Year II	Year III	Year IV	Year V	Lead/ Partners
1	Improve Microbial Water Quality	75% reduction in *E. coli* <200 CFU/100 mL recreation)	Expand sewerage system, upgrade WWTPs, decentralized systems, AMR & MWQ monitoring	Expand sewer lines to 40%; pilot decentralized wetlands,	Start AMR monitoring.	Communal & public toilets sanitation programs	Expand Sewer coverage to 50%; upgrade/add WWTPs	Achieve 75% sewer coverage; effluent reuse for irrigation	AAWSA, MoWE, EPA, MoH, AA City Admin. AACAHB
		50 % reduction in leftover Antibiotics to the environment	Awareness creation, Biomedical waste disposal facilities	Launch awareness campaigns for antibiotic disposal	Initiate leftover Antibiotics Reverse logistics activities to the nearby Health centre	Expand awareness to other health institutions	Reduce 25% Left leftover Antibiotics through Reverse logistics activities to the nearby Health centre	Reduce 50% Left leftover Antibiotics through Reverse logistics activities to the nearby Health centre	EFDA, EPA, MoH, AA City Admin, AACAHB
2	Reduce Organic Load and Control Nutrient Pollution (Nitrate & Phosphate)	Effluent BOD_5 <30 mg/L, COD <80 mg/L	Industrial pre-treatment; WWTPs;	Enforce industrial pre-treatment; initiate 1 new WWTP	Launch awareness campaigns for antibiotic disposal	Upgrade wastewater treatment plants (WWTPs)	Expand WWTPs (Eastern catchment, South Akaki); Decentralized WWTP	Monitoring to Maintain Effluent Compliance	AAWSA, MoWE, EPA, Ministry of Industry, Industry Associations
		Nitrate <50 mg/L, Phosphate <0.5 (1-2) mg/L	Watershed mgmt.; buffer zones development along riparian; wastewater reuse Biogas/composting	Capacitate the local farmers, Introduce compost and vermicompost product	Initiate wastewater reuse programs	Scale composting and biogas initiatives	Establish riparian buffers; wastewater reuse in peri-urban farms, scale-up composting/biogas	50% of vegetable farms adopt safe irrigation practices	Ministry of Agriculture (MoA), MoWE, Awash Basin Authority
		Increase 30 % greenery coverage for the urban watershed	Physical and biological soil and water conservation practices	Initiate urban Watershed management practices			Income generation activities	50 % communities living in the pri-urban watershed. Additional income generation, 50 % the watershed coverage rehabilitated	MoA, MoWE, Awash Basin Authority

No	Objectives	Targets	Activities	Year I	Year II	Year III	Year IV	Year V	Lead/ Partners
3	Minimize Toxic Contaminants (Metals & Pesticides)	Heavy metals and Pesticides within WHO limits; 25% pesticide reduction (from 2025 baseline)	Enforce effluent standards; hazardous waste handling facility; IPM training with demonstration	Industry audits; Practical IPM training for farmers with demonstration	Conduct IPM training sessions	Construct hazardous waste facilities	Hazardous waste facility operational; full enforcement in industries	Continuous monitoring of metals/pesticides in the food chain	EPA, MoA, MoWE, IWMI, AACAHB, Academia
4	Buffer zone delineation and development	Restore 1,000 ha riparian zones; +30% vegetation cover,	Community Livelihood restoration; wetlands establishment; enforce ecological flows; Maintain the existing rehabilitated 286 ha buffer zone	Pilot decentralized wetlands Buffer zone delineation, Community riverbank restoration starts.	Pilot decentralized wetlands Establish riparian buffer zones	Construct wetlands for water purification	Large-scale wetland construction; stabilize riverbanks with 15% vegetation coverage	Full restoration target achieved (1,000 ha, +30% cover)	AA City Admin., MoWE, Basin Authorities, NGOs,
5	Institutionalize and coordinate One Health	One Health governance by 2027; an integrated Database by 2028	Inter-ministerial Task Force/Advisory group; integrated and coordinated monitoring, & database establishment	Task Force/Advisory group design started; labs strengthened	Establish database	Maintain the Advisory groups Database	Operational; annual joint reporting	Operational One Health, National scale-up; replicate to other urban catchments	MoWE, EPA, MoH, AA City Admin., Research Institutions

Appendix E. Stakeholder Engagement

No	Stakeholders	Levels of engagement	Stages of engagement*	Engagement Activities	Purpose of engagement	Engagement Strategy
1	MoWE	Involve	All stages	Co-Design Workshop, serving as members of Water Champions, Mapping of pollution sources	Mapping existing, planned activities, propose additional solutions, assess the most cost-effective ones; Identify roles and responsibilities Setting water quality goals	Collaborative planning and joint implementation
2	Federal EPA	Involve	Stages 2-4	Joint planning, Co-design of projects, monitoring team, Workshop, serving as members of the Water Champions	Ensure regulatory compliance and environmental safeguards, setting water quality goals	Participatory monitoring and co-design
3	Addis Ababa EPA	Involve	All stages	Pollution source mapping, local enforcement and awareness campaigns	Strengthen regulatory capacity and enforcement	Local-level monitoring and regulation
4	MoH	Collaborate	Stages 4 & 5	Joint health–water risk assessments, Public health campaigns, Data sharing, Workshop	Integrate water quality and public health objectives	Cross-sector coordination and joint campaigns
5	AA Health Bureau		Stages 2-4	Local health risk assessments, Community health promotion, serving as members of Water Champions	Address community-level health risks linked to water quality	Community-based programs and local action plans
6	AAWSA	Collaborate	All stages	Joint water quality monitoring, Sewerage system planning, Data exchange	Improve wastewater management and reduce pollution loads, setting water quality goals	Integrated water and sanitation management
7	Academic and research Institutions	Consult	All stages	Technical studies, Policy briefs, Expert reviews	Collect feedback to improve the plan of action; Provide evidence-based solutions.	Knowledge-sharing platforms and consultation meetings
8	Addis Ababa Cleansing Management Agency	Collaborate	Stage 2–4	Waste management coordination, Source reduction programs	Reduce solid waste inflow into water systems	Joint operational planning and clean-up campaigns
9	IWMI	Collaborate	All stages	Technical and backstopping coordination of all stakeholders	Coordination, data collection	Participatory monitoring and co-design

10	Media	Inform	Stages 3-5	Public information campaigns, Social media updates, Press releases	Raise awareness and understanding	Strategic communication and public outreach

Engagement stages

1. Preparation and scoping
2. Co-discovery
3. Co-design
4. Co-development
5. Validation and finalization
6. Monitoring and continuous improvement

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