

Original Research

The Current State and Future Prospects of Water and Sanitation Services in East Africa: The Case of Rwanda

Gratien Twagirayezu^{1,2,3}, Hongguang Cheng^{1*}, Ildephonse Nizeyimana⁴,
Olivier Irumva^{5,6}

¹State Key Laboratory of Environmental Geochemistry, Institute of Geochemistry, Chinese Academy of Sciences, Guiyang, Guizhou, 550002, China

²University of Chinese Academy of Sciences, Beijing 100049, China

³School of Environmental and Municipal Engineering, Lanzhou Jiaotong University, Lanzhou, 730070, China

⁴Water and Sanitation Officer, Rwanda-Local Government, Rwanda

⁵School of Environmental Science and Engineering, Tongji university, Shanghai 200092, P. R. China

⁶School of Eco-Environmental Engineering, Guizhou Minzu University 550025, China

Received: 29 October 2021

Accepted: 22 June 2022

Abstract

Water and sanitation are the essences of sustainable development, as evidenced by the wide variety of services they offer. Developing countries must be concerned with the way in which they provide water and sanitation services to the general public. This review paper was intended to evaluate the condition of water and sanitation services in Rwanda by comparing the actual performance of water and sanitation in different communities for durable development. In this paper, the reviewing process was based on open access papers and documents that used water supply or sanitation as a keyword. In addition, a field survey coupled with onsite interviews in some regions was also conducted. According to the findings, 87% and 86% of the entire population in Rwanda access water and sanitation services from drinking water sources and sanitation facilities that are improved, respectively. This implies that advances in people's living conditions follow the expansion of water and sanitation services. However, settlement style and financial concerns are considered to be the most significant impediments to the achievement of the aim of comprehensive coverage for water and sanitation services. This study suggests the government continues accelerating sustainable water and sanitation services to citizens by outlining the main hindrances to sanitation services and providing sustainable solutions for sustainable development.

Keywords: hygiene, water supply, transmitted diseases, improvement, sanitation

Introduction

Increasing access to potable water and proper sanitation services are some of the most valuable and efficient ways of improving public health and quality of life [1]. It is known that water is necessary for almost all living things, especially human beings and it is one of the human rights. However, there is an inequality in potable water between urban and rural areas, where urban areas have more potable water use than rural areas [2]. Recently, there has been an unprecedented increase in the use of water and sanitation services, where 2.6 billion people have reached access to potable water from 1990 to 2015 and 2.1 billion have had access to enhanced sanitation at the world level, which has resulted in a decrement of open defecation almost by half at the world level [3]. However, in most developing countries, the scarcity of water and sanitation services is a common issue. This leads to the apparition of diseases that cause the deaths of a considerable number of people annually [4]. Unfortunately, 829,000 diarrheal deaths occurred worldwide in 2016, representing 60% of total diarrheal-related diseases [3]. According to the joint monitoring programs of WHO/UNICEF [5], 1.8 billion and 2.1 billion people globally gained access to essential drinking water and sanitation services in 17 years, from 2000 to 2017.

Though there is an achievement for both water and sanitation services, there is still a gap in the world, where 16% of the rural and 4% of the urban population do not use enhanced water sources, whereas around 50% of the rural and 18% of the urban population do not use enhanced sanitation services [3], which leads to health problems. Approximately 4000-6000 children's deaths occur daily due to diseases resulting from not having access to potable water, proper sanitation, and adequate hygiene [6]. Access to enhanced water and sanitation services impacts various sectors, such as health, education, etc. Generally, school attendance is affected by the quality of sanitation facilities (latrines), which impairs schooling, especially for girls [7]. A big concern is that even in areas where water sources are pristine, people still have to deal with microbial contamination during and after collecting water from the sources [8, 9]. This causes risks of poor water quality for inhabitants that depend on their neighbors, sellers and standpipes [10, 11]. Usually, life depends on water and 70% of the earth's mass is water. 10 cups of water are consumed and excreted by average adults, whereas six to eight cups are recommended for adults each day [12]. Even though water is important for maintaining the body's homeostasis and is an important part of life, it can be harmful if its source is contaminated and has impurities [13].

Obviously, sanitation refers to establishing sanitation facilities and services to safely dispose of human faeces and urine in spite of the different meanings to different people [14]. Faecal transmission transmits infections such as diarrhea and cholera, mainly resulting from

poor water, sanitation and hygiene. It becomes more severe in high-density urban areas where water supply and sanitation services are inadequate and children from poor households are more vulnerable due to frequent exposure to risks [15]. Pit-latrines act as a component in the sanitation system and are taken as a sustainable way of collecting, treating, reusing, and properly disposing of sludge in different regions, especially rural areas. However, emptying processes are a big issue in developing countries. So, there is a need for support from institutions and social, technology and economic aspects for periodic pit latrine emptying services [16]. Moreover, wastewater treatment is not usually included in enhanced sanitation services for many developing countries. Preventing stagnated sewage in the community or discharging it into the surrounding environment is crucial for caring for our health and conserving our environment. In point of fact, a significant percentage of worldwide wastewater is released into the environment without treatment, whereas only an estimate of less than 10% is treated before discharging to the receiving environment [17]. In 2015, less than half of the population in sub-Saharan Africa was using enhanced sanitation services [18]. This means that there is a very long journey to take. As outlined by the Joint Monitoring Programme (JMP) of WHO/UNICEF, an improved sanitation facility is one that has hygienic conditions that isolate human excreta from personal interaction and if this facility is mixed together with the poor practice of hygiene, it should severely impact human and environmental health [19] and become a barrier to development. Substantial attention has been given to this problem in order to offer sanitary facilities and alter behavior in Sub-Saharan Africa. Consequently, objectives have been established at the global and national levels and a tremendous amount of financial assistance has been invested. However, progress has stalled and is sporad. Consequently, the sanitation target for environmental sustainability in MDG 7 was not met by most SSA countries; however, the goal was to reduce those without access to basic sanitary facilities by half by 2015 [18]. In both developing and developed worlds, there is a burden of diseases attributed to water, sanitation, and hygiene, especially diarrheal diseases, causing morbidity and mortality in the developing world [20]. According to sanitation and health experts, the global incidence of diarrhea showed that a major killer of children may be decreased by one-third via improved sanitation and they found that around 88% of diarrheal illness deaths in developing countries are linked to a lack of sanitation and the use of contaminated drinking water coupled with inadequate hygiene [21]. In accordance with the joint monitoring program for sanitation and water delivery, the percentage of a population that uses an upgraded sanitation facility acts as a tool to evaluate increased sanitation coverage [22]. Commonly, unimproved sanitation facilities include improved communal latrines, unclean toilets such

as flush or pour-flush toilets that release their contents into the environment, pit latrines without a superstructure, open pits, buckets, hanging toilets, and open defecation, etc. However, enhanced or improved sanitation includes non-public enhanced pit latrines, non-public conventional pit latrines with slab and superstructure, composting toilets and flush or pour-flush toilets connected to septic tanks and sewage systems. For centuries, the critical role of potable water and sanitation in sustaining health has been recognized, and the 19th and 20th centuries were marked by the sanitary revolution, which was regarded as an essential contribution in lowering illness and death due to infectious diseases in industrialized countries [23]. Palpably, water acts as the breeding site for many insect vectors, causing diseases and other issues. In developing or less developed countries, inadequate water supply and poor sanitation contribute to approximately 80% of all infirmities [17]. Water contamination occurs at the source, as well as during distribution and storage in homes; this is a problem in developing countries [17]. However, there has been no recent study that examines the existing situation and future prospects of water and sanitation services in Rwanda.

This work was intended to build awareness, reestablish institutional and national water and sanitation policies, and strengthen Rwanda's water and sanitation strategies. In addition, the outcomes of this study will insinuate possible recommendations for the government to continue accelerating sustainable water and sanitation services to the citizens. Moreover, it will also outline the main hindrances to water and sanitation services and provide sustainable solutions.

Water and Sanitation Status in Rwanda

Classification of Sanitation and Water Services in Rwanda

Rwanda established targets for universal access to sanitation and water supply services for all Rwandans by 2024 [24]. Through 1937 km of water supply systems that will be constructed, extended and rehabilitated in Kigali and other towns together with 1851 km in rural areas, access to potable water will be scaled up to all by 2024. On the other hand, through different critical investments in the sanitation sector, such as the construction of public toilets, development of standards for household toilets, etc., access to sanitation will be scaled up to all by 2024 [25]. Generally, sanitation refers to establishing sanitation facilities and services to safely dispose of human faeces and urine [26]. However, according to Rwanda's National Policy & Strategy for Sanitation and Water Supply Services, sanitation is a systematic process starting with collecting, transporting, treating, disposing or reusing human excreta and sewage for both domestic and industrial use, as well as stormwater. On the other hand,

water supply services are a systematic chain of water collection from the source, carriage, treatment, storage and handing out of safe water to the consumers [27].

In 2008, about 74% of the entire population in Rwanda had access to enhanced sources of drinking water (71% in rural and 88% in urban), whereas about 45% of the total population had access to sanitation (44% in rural and 54% in urban) [27]. Rwanda has made an effort to accelerate the increase in access to sanitation and water services, in 2016-17, the report evinced that 87% of whole Rwandan use water from enhanced drinking water sources, whereas 86% of the entire population has access to enhanced sanitation facilities. There is a big difference in improved drinking water sources in rural and urban regions, where 96% of the people living in urban areas use enhanced drinking water sources compared to 85% in rural areas. In sanitation, a population living in urban areas has more access to sanitation at 94% compared to 84% in rural areas [28].

Unimproved Sanitation and Water Services

About 13% and 14% of the population in Rwanda have no access to enhanced water sources and sanitation facilities, respectively [28]. This implies that they face poor sanitation and water service effects. In addition, people are not willing to use enhanced drinking water when they are getting water from unimproved water sources such as surface water, unprotected springs, etc., and they aren't considered to have access to improved sanitation when they don't use flush toilets and/or pit latrines with a firm slab. Roughly 4.4% of Rwandans get their water from surface sources, 7% from unsecured springs and wells, 0.1% from water tanks, and 1% from other water sources. Approximately 9.8% of the population uses pit latrines without a slab, 0.2% uses other, and 3.8% has no facility. There is inequality in the use of potable water and sanitation between urban and rural regions, where only 4% of the people in urban areas have no access to potable water compared to 15% of rural people and only 6% of the people in urban areas have no access to enhanced sanitation compared to 16% of the rural population [28]. This implies that the government needs to use more potable water and improve sanitation in rural areas.

Enhanced Water and Sanitation Services

In moving towards a modern Rwandan household, Rwanda has committed to scaling up to 100% enhanced sanitation and water by 2024 [25]. About 87% and 86% of the population of Rwanda use improved sanitation facilities and water sources, respectively. This implies that 87% of Rwandans receive their water from protected springs, protected wells, public standpipes, boreholes, water piped into their homes/yards and rainwater collection systems, while 86% use flush toilets and solid slab pit latrines. Inequality in sanitation and

water services was evinced between rural and urban areas, where the number of people using potable water is denser in urban areas than in rural ones. In addition, the number of people using enhanced sanitation facilities is higher in urban areas than in rural ones.

A person's habitat pattern has a considerable effects on their ability to obtain better drinking water. 86.9% of the population living in grouped communities (imidugudu) has better access to facilities compared to 80.9% of the people in scattered settlements. Also, the type of habitat has a significant effect on the use of enhanced sanitation facilities, where 87.4% of the people in planned settlements (umudugudu) use improved sanitation facilities compared to 74.7% of isolated rural housing in rural areas, whereas 97.7% of the people in planned urban areas use enhanced sanitation facilities compared to 94% of unplanned urban housing in urban areas. Disability also has an impact on the use of improved sanitation and water services, with 86.1% of people with disabilities using improved sanitation facilities versus 86.5% of people without disabilities, and 86.6% of people with disabilities getting water from improved water sources versus 87.6% of the people without disability.

Even though it is slight, there is a difference in the real condition of the usage of improved water and sanitation facilities between homes with male heads of families and those with female heads of families. About 25% of the entire population of Rwanda uses enhanced sources for drinking water within 0-200 m, whereas 42% use enhanced sources of drinking water within 0-500 m. Comparing rural and urban areas, 16% of households in rural areas use improved sources of drinking water within 0-200 m and 34% within 0-500 m, whereas 60% of the households in urban areas use enhanced sources of drinking water within 0-200 m and 72% within 0-500 m. Obviously, 72% of urban populations utilize improved drinking water sources within 0-200 m, while 54% of people in rural areas use improved drinking water sources within 0-500 m [29, 30].

Structures and Procedures of Water and Sanitation

In 2010, the Rwanda senate enacted Law N°97/2013 of 30/01/2014, abolishing Law N°43/2010 of 07/12/2010, constituting the Rwanda Energy, Water and Sanitation Authority (EWSA) and dividing it into two independent corporations, one for energy (REG) and the other for water and sanitation corporation (WASAC) [31]. On the other hand, in 2010, Rwandan government established the national policy and strategy for sanitation and water supply services with the objective of attaining the objectives of the Economic Development and Poverty Reduction Strategy (EPDRS1), Millennium Development Goals (MDGs) and Vision 2020. Under this policy, districts become the owners of sanitation and water infrastructure. To align it with EDPRS2,

Rwandan government has decided to update the policy and strategy in 2016. In 2004, the Rwandan government conducted an assessment of the management of water supply systems via the Ministry responsible for water and sanitation. It was found that schemes under the management of private operators were managed well, while those under the management of administrative units or communities failed.

From the assessment results, the Rwandan government established a policy that reinforced the participatory approach and private management through public-private partnership (PPP) [32]. According to the 5th Integrated Household Living Conditions Survey (EICV5), which was conducted in 2016/17, the usage of water from upgraded water sources stands at 87% for all Rwandans [25], even though the actual rate is much less than the data provided by the statistics. To address challenges such as weaknesses in the operation and management framework and water service providers that are not skillful, which was one of the reasons for the low rate of functioning. WASAC was established in 2014 to be responsible for the growth and development of the sanitation and water sectors. It is also responsible for assisting the districts in planning, designing, and implementing water and sanitation specialists (WATSAN) projects. WASAC does not work alone in this service but collaborates with ministries, institutions, and non-governmental organizations (NGOs). Generally, the responsibilities of each partner are listed below:

Ministry of Local Government (MINALOC) is concerned with decentralization and local government financing and administration issues. The Ministry of Health (MoH) is in charge of improving hygiene and sanitation for households. Obviously, MoH has established the "Community-Based Environmental Health Promotion Program (CBEHPP)" to enhance sanitation and hygiene for households. It also ensures that health centers have the necessary sanitation facilities, while the Rwanda Ministry of the Environment (REMA) has been tasked with local and national environmental issues such as climate change and natural resource management.

Ministry of the environment aims to provide solutions to environmental and resource problems, such as the mismatch between population and natural resources, which have significant implications for sectors such as agriculture, infrastructure, water resources, energy, land, and forestry in achieving national long-term sustainable development. In this cooperation, the Ministry of Finance and Economic Planning (MINECOFIN) integrates the budgeting, national planning, and financing framework, has a crucial involvement in connected parts of the sanitation and water sector and Rwanda Ministry of Education (REB) is charged with hygiene and sanitation in schools. It is intended to guarantee that schools have the necessary sanitation facilities and give hygiene education to the learners via the School Hygiene and Sanitation

Programme. Ministry of Infrastructure is responsible for formulating national policies and strategies, budgeting, sector oversight, resource mobilization and overall sector performance evaluation. Rwanda Utility Regulation Authority (RURA) guarantees regulation in two aspects: vis-à-vis the public, by ensuring affordable and sustainable services and guarding the interests of consumers; and vis-à-vis the service providers, by setting water tariffs, controlling contract management, economic viability and accountability and ensuring relevant contest.

Moreover, RURA also comprises four complementary facets of regulation, which are (1) technical, (2) economic, (3) legal and (4) consumer relations. Rwanda Environment Management Authority (REMA) recognizes and promotes the fundamental right to live in a safe and secure environment. The Rwanda Standards Board (RSB) is responsible for all activities related to creating standards, conformity assessment and metrology services in the nation. It is also the only organization authorized to grant licenses for producing and selling a wide variety of goods. Evidently, for goods to be adopted at the national level, standards must be presented to the RSB by public services and private businesses. RSB is managed by a Board of Directors comprised of key stakeholders from industry, government, academic institutions, and consumer associations. Local Administrative Entities Development Agency (LODA) is mandated to focus on local economic and community development, social protection, and building capacity of local administrative organizations within its mandate. In addition, LODA monitors and evaluates the execution of development initiatives in local governments to contribute to the capacity building of the population and decentralized organizations to reduce terrible poverty in the country. DPs (development partners) and NGOs assisting sector development in conformity with the SWAp's ideals also participate in financing sector initiatives via a range of aid modalities [32].

Obstacles to Achieving Enhanced Water and Sanitation Services

Although there are several country-specific impediments to advancing water and sanitation accessibility, there are four common barriers, as mentioned below: Inadequate funding and investment for sanitation and water infrastructure is the first problem. The second is a lack of politics that will deal with challenging issues in this area. The third is the tendency to reject or embrace novel technological or execution methods and apply conventional water and sanitation interventions without community input, even if they are inappropriate for the unique environment and community needs. The fourth is the failure to evaluate water and sanitation measures to establish their practicality and sustainability [6]. Concerns for water supply services in Rwanda include making sure that

districts have the resources they need and that financing, implementation, and monitoring are all coordinated.

To do this, building on the existing national implementation unit is necessary. In addition, excellent practices to increase the size of delegated management (PPP) while enhancing regulation and setting tariffs that balance financial sustainability with affordability. Making urban water delivery services financially viable and building a combined planning framework between the Rwanda Water and Sanitation Corporation (RWASCO) and the municipal/district authorities are also crucial. The execution of the sanitation sub-sector strategy has three significant problems in establishing sanitation services at an overall level [27].

These challenges fall into three categories; (1) start-up phase: initial efforts will be necessary due to the relative lack of experience in providing and promoting national sanitation services. As part of the 2010/11 start-up phase, there must be sufficient planning capacity and financing. 2011/12 and 2012/13 may focus on pilot projects under this plan, especially with relation to infrastructure, before implementing and scaling up initiatives in 2013; (2) Sector coordination: Effective sanitation initiatives necessitate not only infrastructural improvements but also the provision of services as well as behavior change conceptions and actions. The appropriate balance to control State interventions will require a multi-sectoral strategy comprising diverse line ministries, regulatory bodies, and administrative levels down to districts, sectors, and imidugudu, and mobilization of the private sector, community-based associations, and households; (3) Efficiency of public financing: The financing of the expected expansion in sanitation coverage must come from all available sources as well as the optimization of public investments. Because access to the domestic financial market is still limited for operators, state investments and expenditures must rely on financial contributions from public or private investor-operators such as RWASCO and others under the PPP scheme and, to a greater extent, private households.

The latter will be obliged to supply the majority of the funding for the building or improvement of the majority of household sanitary facilities. The following sectors face particular strategy conceptual and implementation issues: (1) Individual sanitation: The primary factor will be belonging to homes and the difficulty will be to create a functioning institutional setup at the district level capable of conceptualizing and implementing an effective combining of awareness programs, technology development, and reward schemes; (2) Collective sanitation: The difficulty is to plan and execute low-cost sewerage systems that combine a balanced social and technological approach, to attain cost recovery (sustainability), and finally to tap into the home financial market for sewage extension finance; (3) Stormwater management: The primary issue is to apply intelligent urban planning strategies in limiting costly construction operations; (4) Solid

waste management: The task is to build a cost-effective and sustainable solid waste management method by understanding the major drivers for the most cost-effective trash minimization and lucrative recycling, as well as mobilizing all stakeholders.

As evinced in the water and sanitation sector strategic plan [24], despite these achievements, crucial problems persist that prohibit Rwanda's poorest people from having sustained access to even essential sanitation and water supply facilities that meet with the listed challenges: (1) the accessibility and financing gap for raising service levels, particularly in unplanned and dispersed settlements on challenging, hilly territory; (2) dwindling water resources, resulting in high service provision costs; (3) there are limitations of human resources in the areas of planning, management, operation and maintenance; (4) Consolidation and reinforcement of sectorial institutional responsibilities; (5) low status of sustainability of Water, Sanitation and Hygiene (WASH) services, especial in rural areas; (6) sanitary and structural conditions of rural toilets are inadequate, particular in rural areas; (7) inadequate treatment of water and wastewater, and also solid waste management; (8) Technical and financial capacity concerns from the government, business sector, civil society, and localities to advance water and sanitation investment, as well as operation and maintenance. Regarding human capacities, capacity difficulties are also observed at the district level; (9) inadequate sector performance and accountability and (10) a feeble evaluation system.

Rwanda Sanitation and Water Supply Policies

In the country, the "National Water and Sanitation Policy" is a crucial document that leads to the provision of sanitation and water. It was concerned with "Vision 2020", "Millennium Development Goals," and "Poverty Reduction Strategy" [27]. Under the National Decentralization Policy, the policy asks for decentralization, as well as institutional aspects, monitoring and evaluation, integrated watershed management, and a stakeholder approach to sanitation and water services [27]. By optimizing water resource use and ensuring that everyone uses sanitation and water services, the policy aims to improve the population's living conditions. Marshlands are, for one, a domestic water source; therefore, developing these places could impact sanitation and water for the people. The policy aims to achieve Vision 2020, the Millennium Development Goals, and other national and international policies and agreements such as the National Investment Strategy, Agenda 21, etc. Six sanitation fronts are prioritized in the National Water and Sanitation Policy: home sanitation, collective sanitation, institutional sanitation, solid waste management, stormwater drainage, and institutional sector framework. This strategy prioritizes urban sanitation, offering a policy

framework that supports the Master Plan of Kigali's sanitation. Several vital ideas that influence sanitation and water policy development are represented in Table 1 [33].

Existing Institutional Framework for the Sanitation and Water Sectors in Rwanda

As depicted in Fig. 1 [32], the institutional framework for the sanitation and water sectors in Rwanda was implemented collaboratively by several government organizations, including multiple ministries, national autonomous bodies, and municipal governments. Firstly, the following are the primary functions and duties of the public institutions participating in the water and sanitation sectors at the national level: MININFRA (Ministry of Infrastructure) is responsible for the formulation of national policies and plans, as well as sector supervision, budgeting, and resource mobilization, as well as the evaluation of overall sector effectiveness. MINISANTE (Ministry of Health) is the organization in charge of promoting domestic sanitation and hygiene. In addition, its goal is to ensure that health centers have the right sanitary facilities to work properly.

MINECOFIN (Ministry of Finance and Economic Planning) oversees the national planning, budgeting and funding framework with a significant focus on the water and sanitation sector. MINALOC (Ministry of Local Government) is in charge of decentralization as well as topics pertaining to local government funding and administration. MINIRENA (Ministry of National Resources of Rwanda) is responsible for environmental protection, climate change mitigation, and natural resource management at both the local and national levels. MINIRENA's mission is to provide solutions to environmental and resource concerns, such as the imbalance between population and natural resources, which has major implications for sectors such as agriculture, energy, water resources, infrastructure, land, and forestry. MINEDUC (Ministry of Education) is responsible for ensuring that the schools are clean and sanitary. It ensures that schools have the right sanitation facilities and that students learn about hygiene through the School Hygiene and Sanitation Program.

WASAC (Water and Sanitation Corporation) is aimed at increasing the efficiency and efficacy of the water and sanitation sectors. Actually, WASAC Directorate of Rural Water and Sanitation Services (RWSS) includes the integration and control of rural water supply systems, in general and especially by providing technical assistance and building capacity to districts and scheme operators for project implementation, as well as operation and maintenance, and by performance measurement and sector achievements. It also distributes grant money and keeps an eye on and helps districts make good use of funds designated for certain sectors. In the future, it should put more emphasis on creating an environment that makes sanitation possible. RURA

Table 1. The vital ideas that influence the development of sanitation and water policy in Rwanda.

Items	Description
Priority to basic services	Everyone and every community have an equal entitlement to essential services like water. Meanwhile, until Vision 2020, the objective of universal access to drinkable water is achieved, „some for all” will be prioritized above „all for some.” With all of the focus, the cost will be taken into consideration.
Decentralization	Accountability for service delivery rests with the various localities. The sanitation and water sector’s missions are to create and enhance decentralized planning, implementation, and management capabilities.
Participation of the community	Throughout the project execution phase, beneficiaries of sanitation and water supply services must be actively involved in strategic planning, decision-making, and evaluation. Significantly, they will choose the service level that best fits their requirements and capabilities.
Recovering the costs and financial stability	To assure long-term service delivery, consumers must bear the costs of operating and maintaining sanitation and water supply infrastructure. Affordability should be handled by selecting appropriate technologies and increasing efficiency rather than through the awarding of subsidies. Sewerage and waste management will be governed by the polluter-pays and user-pays concepts.
Private sector participation	The sector will continue to promote delegation management via private operators as a critical strategy for enhancing rural water infrastructure durability. Water supply, treatment, disposal and sanitation should be supported and promoted by the private sector.
Improved operational efficiency and accountability	These are regarded as important in both urban and rural infrastructure construction and management to improve financial viability, reduce fiduciary risk (checks and balances), and use resources more efficiently.
The emphasis on sanitation and hygiene	The sector recognizes the critical significance of hygiene and sanitation behavior modification in delivering long-term health benefits. Sanitation and hygiene activities and initiatives will be developed in collaboration with the health and education sectors. Any water supply project must systematically include sanitation and hygiene education.
women and children’s interests	The essential functions and particular interests of women and children are adequately acknowledged. All work in the sector must be done in a way that allows both men and women to be involved and represented, as well as to pay attention to women’s views, needs, and goals.
Grouped settlements	Considering shifting habitat structures, the sanitation and water sectors prioritize service delivery in grouped communities.
Protection of the environment and water resources	Water supply and sanitation services will be developed in close cooperation with water resource management based on an integrated approach. There should be a balance between water usage that’s fair while still being accepted, as well as environmental guidelines and protections. Planning and management are needed for waste disposal in order to keep water supplies and the environment safe.
Inclusive program strategy	The sanitation and water sectors aim to develop a uniform, national strategy, combine funding and execution systems, and increase stakeholder collaboration.

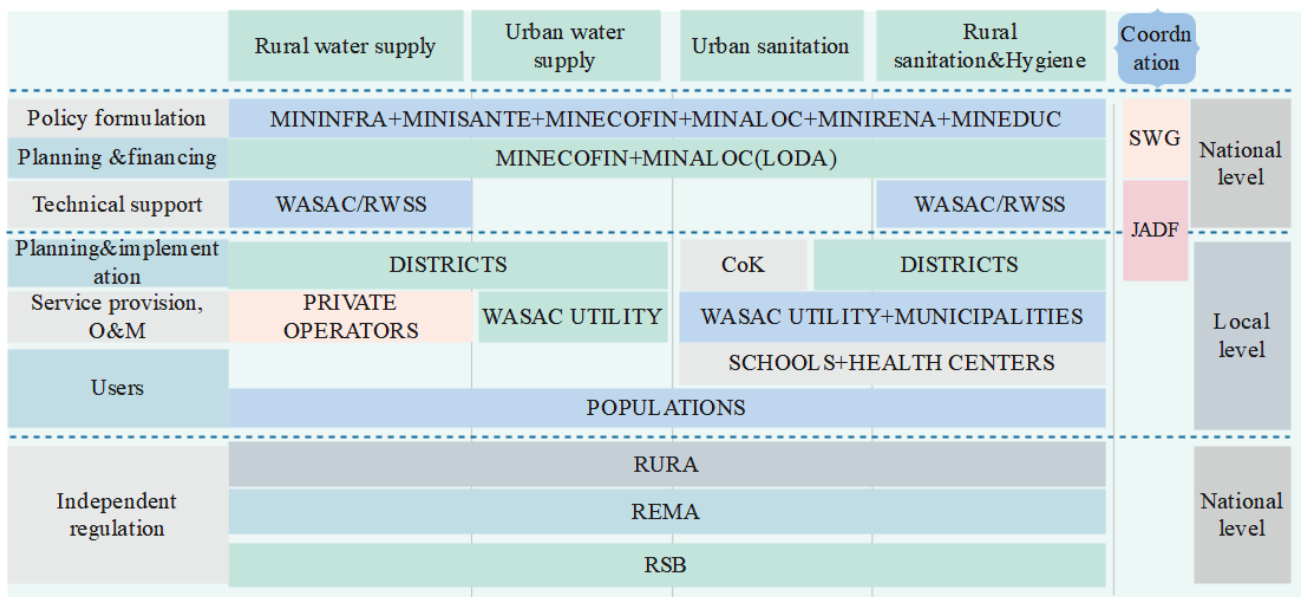


Fig. 1. Institutional framework for the sanitation and water sector in Rwanda.

(Rwanda Utility Regulatory Authority) will regulate in two ways: vis-à-vis the public, by guaranteeing affordable and adequate services and safeguarding the interests of the consumers, and vis-à-vis the service providers, by establishing water tariffs, being able to monitor contract management, financial viability and accountability and ensuring effective competition. RURA thus encompasses four complimentary components of regulation: (1) technical, (2) economic, (3) legal and (4) consumer relations. REMA (Rwanda Environmental Management Agency) oversees and enables the basic right to live in a healthy and balanced environment.

Rwanda Standard Board (RSB) oversees all operations related to the establishment of standards, conformity assessment, and metrology services in the nation. It is the only organization with authority to set and maintain national standards. The RSB can create national standards for public and private sector services and businesses. LODA (Local Administrative Entities Development Agency) LODA is a government fund administered by MINALOC. Within the framework of its mandate, LODA focuses on local economic and community development, capacity building and social protection for local administrative authorities. Additionally, LODA conducts monitoring and evaluation of the process by which development initiatives are implemented in local governments with the goal of strengthening the ability of the population and decentralized organizations to eliminate severe poverty in the country. DPs and NGOs (Development Partners) promote sector activities in accordance with the SWAp principles and contribute to funding sector initiatives via a range of aid modalities.

Secondly, the key functions and duties of public institutions active in the water and sanitation sectors at the local level are summarized below. Local governments (districts and the City of Kigali: CoK) are in charge of the provision and administration of water supply services in their respective areas. It is the responsibility of local governments to plan, budget, allocate resources, and mobilize the community as a whole. They ensure that the general public is effectively involved, monitor private sector implementation, and assist water supply service operations and maintenance. They are in charge of monitoring and reporting to WASAC and MINALOC. The Joint Action Development Forum (JADF) is present in each of the 30 districts in the country. As a result of the JADF initiative, local communities may expect to see improvements in the creation of long-term economic growth, service delivery, and domestic accountability. The private sector engages in the implementation of projects through the use of consulting companies and contractors, as well as in the operation and maintenance of infrastructure by private operators contracted by the district to do so. Rwanda's Private Sector Federation (PSF) plays a critical role in technical and vocational education, as well as

business development assistance. Populations are accountable for designing and implementing enhanced water and sanitation services.

Water Sector Characteristics

Urban Sanitation and Water Supply

As a result of rapid urbanization, the demand for sanitation and water supply services is rising. Low and middle-income regions, namely Sub-Saharan Africa, North Africa and the Middle East, the Pacific and East Asia, South Asia, the Caribbean and Latin America are characterized by a relatively high growth rate of urbanization [24]. Water supply services in Rwanda's cities and suburbs are supplied by the Water and Sanitation Corporation (WASAC). From December 2020 to March 2021, number of urban and peri-urban water subscribers served by WASAC Ltd moved to 246,941 from 242,497 connections, representing a growth of 1.8%. As shown in Fig. 2 [34], Kigali city has the higher percentage of subscribers, with 51% of the total subscribers, while the provinces have 49% of the total subscribers. However, the tariff depends on a range of monthly consumption for those subscribers, as described in Table 2 [35]. The use of enhanced water services in urban areas is about 96%, and 60% of the households in urban areas utilize enhanced sources of drinking water within 0-200 m and 72% within 0-500m, whereas the use of improved sanitation services in urban areas of Rwanda is about 93.6%. This includes 9.2% using the pour-flush toilet and 84.4% using a pit latrine with a solid slab [28].

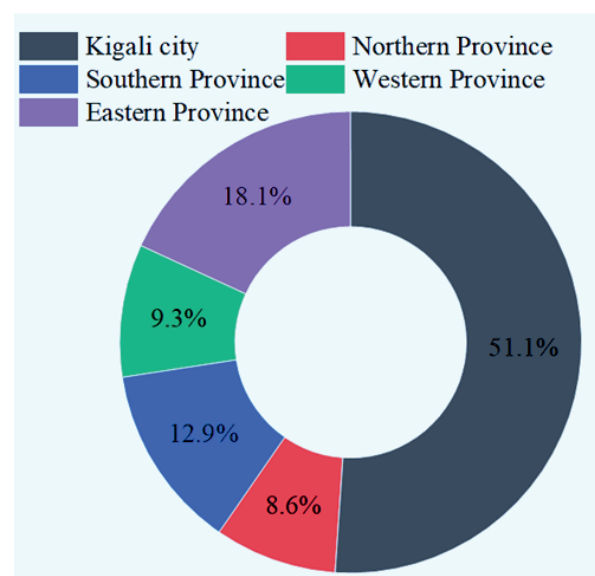


Fig. 2. Water and Sanitation Corporation subscribers by March 2021.

Table 2. The tariff of water consumption in the areas served by WASAC in urban areas of Rwanda.

Customer category	Monthly consumption block	Applicable tariff (Frw/m ³)
Public taps	N/A	323
Residential	0-5 m ³	340
	6-20 m ³	720
	21-50 m ³	845
	>50 m ³	877
Non-residential	0-50	877
	>50 m ³	895
Industries	N/A	736

Rural Water and Sanitation Services

In Rwanda, a large number of farming households are delivered by protected springs (44.8 %), public water taps (33.3%), non-protected wells or spring (8.9%), surface water (6.3%), protected wells or boreholes (4.7%), and piped on promise (1.7%), as well as over 1000 conducted water supply systems. In addition, about 20,000 improved point water sources (protected springs or boreholes and wells with hand pumps) supply rural communities [29]. The use of enhanced water sources is about 85% in rural areas, and 16% of households in rural areas utilize enhanced sources of drinking water within 0-200 m and 34% within 0-500 m [28]. Private operators manage all water supply systems and provide rural water services [32]. Households in rural areas pay for water based on the type of water supply system, as represented in Table 3 [36]. The use of enhanced sanitation services in rural areas of Rwanda is about 84.4%; this includes 0.1% using the pour-flush toilet and 84.3% using pit latrines with solid slabs, whereas the rest of the population uses unimproved sanitation services, including 4.2% practicing open defecation [28].

Table 3. The tariff of water consumption in the areas served by private Operators in rural areas of Rwanda.

Water System Type	Tariffs Vat Inclusive	
	Tariff RWF/m ³	Tariff (Frw /Jerrican)
Gravity	338	8
Electricity Pumping	863	20
Diesel Pumping	1087	25
Turbo	814	19
Complex System	704	16

Enhancement of Water and Sanitation in Rwanda

Access to improved water and sanitation is one of the most cost-effective and life-saving measures that can be taken to enhance public health and save lives. However, there are several challenges that must be addressed in order to access it properly. Commonly, incorporating education about water supply and sanitation services into technical problem solving is vital. This should help in making progress in getting and keeping water and sanitation services in the country. That can be sped up a lot by working with local communities to find water and sanitation solutions that take into account environmental, cultural, and economic factors. Rwanda has signed up for the International Millennium Development Goals (MDGs), including a goal specifically for sanitation and water services. This goal means that by 2015, the proportion of the population without sustainable, drinkable drinking water and adequate sanitation will be halved [27].

Environmental Risk and Pathogen Pathways

Unsafe hygiene, sanitation and water cause disease burden globally, resulting in different diseases, mainly diarrhea diseases. This is primarily due to the consumption of unsafe water, non-availability of water connected to inadequate hygiene, domestic and personal hygiene that is poor and agricultural practice, contacting unsafe water and improper management and development of water resources [19]. Poor sanitation and water services will result in different types of pollution, such as soil, air, water, etc. When polluted water is used, it will result in water-related diseases that affect people's lives and are mainly categorized in Fig. 3 [37].

Awareness About Improved Sanitation and Water Services

Programs that boost awareness to clarify the aims, objectives, and targeted beneficiaries are the most vital to back up the main sanitation programs, and it is good in sanitation projects to lessen the risk of only taking physical programs [38]. To achieve long-term sanitation and better public health, we need to build toilets and increase sanitary knowledge and behavior among the population. As a first step, the community should be provided with access to clean drinking water and adequate sanitation facilities, such as constructing sewer-connected toilets and latrines and providing hygiene instruction. Proper handwashing with water and soap may help reduce diarrhea cases, and rainwater harvesting devices can collect and store rainwater for use as drinking water or recharge subterranean aquifers in drought-prone areas. To provide home-based water treatment capacity by using filters or solar disinfection as well as flocculants to purify and safe water and develop solutions that need low-cost chlorine tablets

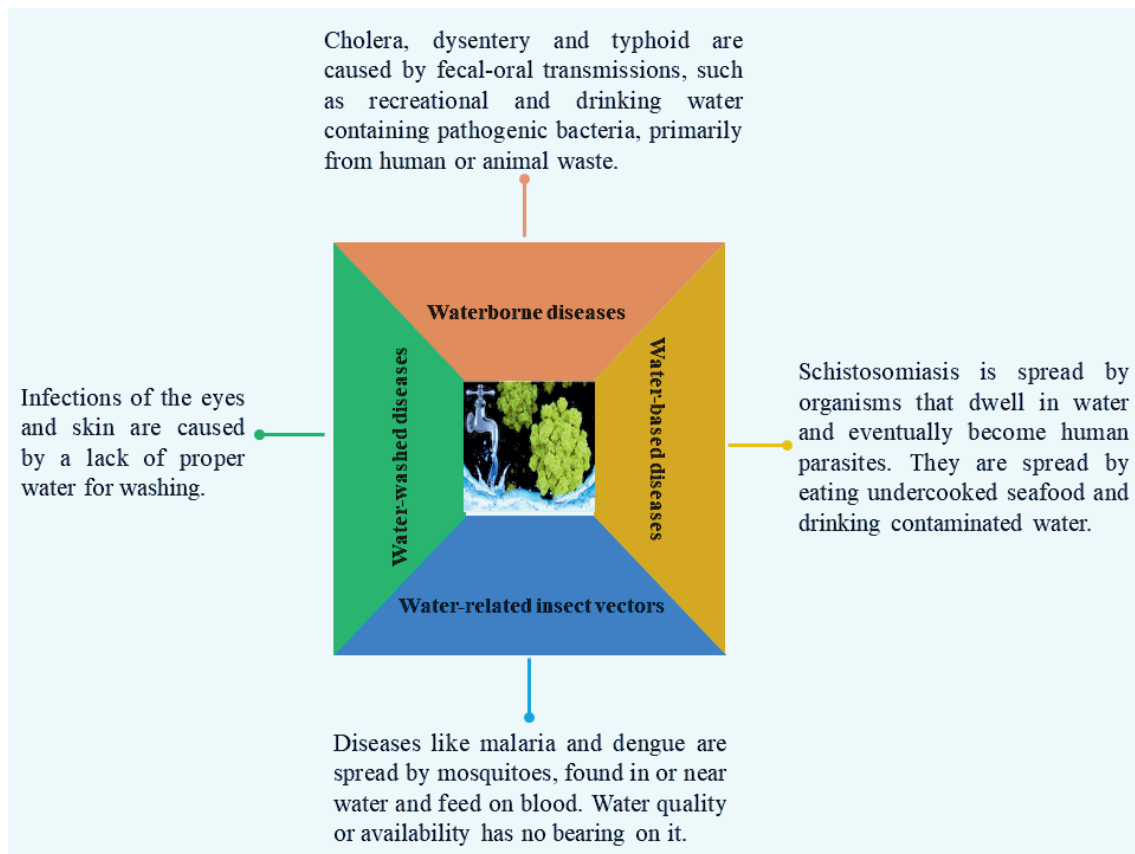


Fig. 3. Water-related diseases and their examples.

or by exposing plastic bottles to sunlight to improve water quality.

Global Project for Financing Water and Sanitation in Rwanda

Rwandan government has mobilized financial resources to conduct sanitation and water projects through construction, extension, and repair of water and sanitation infrastructure to accomplish sector objectives and targets. The Rwanda Sustainable Sanitation and Water Supply Program, funded by the Development Bank of Africa (ADB), provides sanitation and water services in Kigali, including six satellite towns and adjacent peri-urban regions. NZOVE-NTORA transmission line is being strengthened by WASAC in conjunction with Japan International Cooperation Agency (JICA) and will help evacuate 40,000 m³ of water from the NZOVE II treatment facility [29]. Also, through WASAC, Rwanda has a partnership with water for people, world vision, UNICEF, European Investment Bank, Vitens Evides International and OPEC Fund for International Development.

Recommendations and Future Perspectives

Water and sanitation should be improved to limit the consequences of inadequate sanitation and

water services. Rwanda should undertake measures to improve water supply, such as increasing public finance, improving joint planning, improving joint implementation, improving joint monitoring, and improving the assessment of the effects of particular technologies and management choices on social and economic outcomes. Furthermore, Rwanda should balance the need for clean water for the poor with the requirement to recoup expenses or provide public assistance for the operation and maintenance of piped water systems. Find out what methods may be utilized to boost private financing for water supply infrastructure via Output-Based Aid and increase the emphasis on urban water supply regulation. For sanitation and hygiene, measures such as increasing the amount of public funding for sanitation, improving collaborative planning, execution, and monitoring for both environmental and water activities and improving joint monitoring for both environmental and water activities are recommended. According to the water and sanitation strategy report, there is a need to enhance the analysis of the impact of specific technologies and management options on both social and economic outcomes, increase emphasis on the improvement of existing facilities rather than just the construction of new facilities; explore additional ways of encouraging urban councils and town boards to enforce by-laws and regulations and increase private sector participation in both hygiene promotion and on-site sanitation

companies (emptying trucks, cheaper septic tanks, safe dumping sites and latrine equipment).

Conclusion

Although accessing drinkable water and adequate sanitation is one of the best ways to enhance public health and the general well-being of the population, one of the major impediments to total improvement in sanitation and water services is a lack of funds. The government should invest heavily in sanitation and water infrastructure, especially in rural areas where these services are scarce. Also, constraints such as education, natural disasters, and scattered settlements should be settled out. The government should also invest more in building the capacity of private operators that provide sanitation and water services in rural areas and some parts of urban areas. The government should put equal effort into both sanitation and water service improvement. The government should improve the sanitation and water databases to help the government and other people know the actual situation on the terrain.

Acknowledgments

This study was financed by the Strategic Priority Research Program of Chinese Academy of Sciences (No. XDB40020402), The "Light of West China" Program, Opening Fund of the State Key Laboratory of Environmental Geochemistry (SKLEG 2022216).

Declaration of Competing Interest

The authors declared that they have no conflicting interests or personal relationships that might seem to have influenced the work described in this research.

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