

# Sanitation for Sustainable Development in Informal Settlements in Kigali City, Rwanda: A Synthesis of the Evidence to Inform Policy and Practice

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## Abstract

This paper synthesises the literature on sanitation in Kigali city, Rwanda. The synthesis is limited to solid and liquid waste generation and management in Kigali. It describes initiatives adopted to achieve sanitation for sustainable development, identifies current challenges and offers some solutions to help the city respond appropriately. The synthesis is part of a wider innovative evidence informed policy making initiative known as Utafiti Sera (research policy communities) that facilitates the building of communities of stakeholders working together to ensure that appropriate and negotiated civic actions and policy uptake occur around a particular public problem for which there is research evidence. Thus, the synthesis brings together two sets of evidence to draw the policy recommendations: in-depth discussions among urban governance stakeholders in Kigali between September 2017 – December 2018 and a review of the literature on sanitation in Kigali. Efforts to improve sanitation for residents in informal settlements in Kigali are hampered by three main challenges: lack of a central sewerage management and treatment system, lack of standardised communal landfill to manage solid and liquid waste and inadequate funding for projects aimed at improving sanitation. While there are strategies laid down to deal with sanitation issues in the upcoming Kigali masterplan of 2020, measures such as strengthened awareness at local level will be necessary.

**Keywords:** Sanitation; Solid wastes; Liquid wastes; Informal settlements; Kigali city

## Introduction

The World Health Organisation (WHO) defines sanitation as “the provision of facilities and services for the safe management of human wastes (faeces, urine) and ability to maintain hygienic conditions through garbage collection, storage, transportation and waste water treatment and disposal [1]. Proper sanitation on one hand has a significant positive effect on public health as well as on the socio-economic aspects of livelihoods [2,3]. On the other hand, poor sanitation could lead to deaths: it is estimated that poor sanitation kills about 800,000 people annually especially from middle and lower-income countries [4,5].

Even though sanitation is fundamental to health and productive urban life, the provision of sanitation facilities and services for fast growing cities in developing countries remains a major challenge [6]. According to the UN Habitat, Africa has the highest urbanisation rate worldwide, estimated at 3.44% between 1995 - 2015 [7]. Within Africa, the fastest urbanising region is East Africa, which is also the world's least urbanised [8].

Globally, access to improved sanitation rose from 54% in 1990 to 68% in 2015 and then to 74% in 2017; Yet, 2 billion people worldwide are still lacking access to improved sanitation [5, 1].

Access to improved sanitation means that both solid and liquid waste are managed as per set standards [9, 10]. It involves effective solid waste collection, separation, temporary storage and then safe transportation to a treatment plant for further treatment before being discharged or reused (ibid). Similarly, the liquid waste has to be stored and emptied with specialised truck from onsite production. It can also be conveyed through the sewerage network line towards wastewater treatment plant(s) before being discharged into the environment [11].

Poor access to improved sanitation is particularly critical in rapidly expanding informal settlements of urban areas [12]. This is due to rapid expansion of the urban dwellers population coupled with limited infrastructure and poor urban planning (ibid). Hence, the need for providing access to improved sanitation in those areas in attempts to make cities habitable and achieve sustainable development.

Provision of proper sanitation in urban areas is linked to several Sustainable Development Goals (SDGs) outlined by the United Nations. It is most explicitly linked to SDG 6, “Ensure availability and sustainable management of water and sanitation for all” [13]. Its indicators lay emphasis on universal access to clean water sanitation and hygienic treatment of waste water including re-use and recycling. SDG 6 is aimed at ensuring reliable and equitable sanitation services and facilities including ending open defecation, especially for people living in vulnerable places such as urban informal settlement and camps [13]. Other SDGs linked to sanitation include SDG 11 on “Make cities and human settlements inclusive, safe, resilient and sustainable” whose objectives include universal access to affordable housing, supporting infrastructure and access to basic services such as waste management. To the extent that proper sanitation reduces health hazards such as diarrhoea, soil and air pollution, there is a link between good sanitation and SDG 3 on “good health and wellbeing” [14].

A study conducted in the informal settlements of Kigali indicated that 56.3% of the Kigali dwellers use improved sanitary facilities while 43.6% use unimproved sanitary facilities which is a threat to the public health [15] and a threat to the Government's targets of achieving 100% access to improved sanitation by 2030. This study used the Joint Monitoring Progress/ World Health Organisation (JMP/WHO) definition of “improved sanitation” which excludes shared sanitation. Government of Rwanda (GoR)'s sanitation statistics include “shared sanitation” under “improved sanitation” category. More recent findings following GoR criteria indicated that 97% of the people living in informal settlement have access to improved sanitation [16]. Though 97% of this population has access to improved sanitation (which shows good progress towards achieving sustainable development goals), sanitation in informal settlement is still a threat to the Government's targets of achieving improved sanitation to all by 2030. Main challenges include the lack of sewer networks, dense population and a high number of pits. Pits are shared among households and emptying services

are rare and expensive, which forces dwellers to physically go into the pits to remove faecal sludge. Sludge is then disposed-off in new pits or thrown into the drainage nearby, which ultimately is a threat to sanitation [15, 17, 18]. Over the years, Kigali's informal settlements have consistently developed within few kilometres from the inner city, which has not been without consequence. This unchecked development has compromised sanitation and hygiene standards in the city [19]. Land scarcity and the unsustainable construction of new latrines, lack of sewer line networks, and emptying services that cannot reach the informal settlements have compromised sanitation in Kigali. In this respect, this study aims at contributing to the scarce literature describing the status and challenges of sanitation in urban settlements of Kigali city. This paper looks at the informal settlements of Kimisagara, Muhima, Gitega, Rugunga and Gatsata, which are located within 3-10 km from the city centre, and where over 70% of its houses are in informal settlements [15]. The paper is structured as follows; section 2 reviews the literature on the current status of sanitation in Kigali, with a focus on liquid and solid waste. Section 3 identifies initiatives in the sanitation sector. Section 4 provides the challenges and associated solution related to sanitation in the city. The last section is the conclusion, which recommends actions to improve sanitation in Kigali's informal settlements.

## Sanitation in Kigali

Rwanda has a total estimated population of 11.893 million people. Fully, 82% of the population lives in rural areas, the rest live in urban areas. Kigali has an estimated population of 1,631,000 inhabitants [20], which constitutes about three quarters of the urban population of Rwanda. Approximately 79% of the Kigali city dwellers live in informal settlements. The NISR (2018) reports reveals that 95.1 percent of people living in Kigali, have access to improved sanitation [19].

Kigali city is characterised by hilly landscape, with limited accessibility to houses due to congested housing. Moreover, informal settlement houses are fairly sturdy single storey houses. Fully 78% of them use pit latrines with slab while 12% uses water to flush toilet which generate a more liquid sludge and 9% of the households use off-plot toilets [21]. Although there are existing sanitation facilities in the informal settlements of Kigali such as de-slugging which help to maintain public health, they are disorganised and not well established. Thus, they demonstrate a weakness in their physical function because they fail to meet hygiene standards. This attracts houseflies and brings potential health hazards to the communities living nearby [15].

Currently, Kigali does not have a comprehensive liquid and solid waste management framework. In spite of that, the study by [18] revealed that up to 86 percent of households in unplanned settlements have their waste collected. Of this 86 percent, 75 percent households had their waste collected weekly. Households whose waste was not collected, disposed of their waste through burning or burying [15].

Sanitation facilities in Kigali are dominated by on-site sanitation facilities comprised of pit latrines and septic tanks. Up to 65 percent of households in Kigali use latrines. Of this, 60 percent are shared by households. Usually, when latrines are full, they have to be emptied by specialised trucks [17]. However, due to infrastructural challenges that prevent emptying services from reaching informal settlements, most households opt to dig new latrines when the ones they use fill up [22]. Consequently, due to scarcity of land, with time, there will not be enough land available to construct new latrines. Off-site sanitation is compromised by lack of sewer line networks. The offsite sanitation facilities are not enough to accommodate the whole population of Kigali city [23, 24]. Nevertheless, WHO recommends that sanitation interventions should ensure coverage of entire communities with safe toilets that, as a minimum, safely contain excreta, and address technological and behavioural barriers [5].

## Liquid Waste

Unlike other cities in East Africa, Kigali has no single central sewer system and wastewater treatment facility for treating the municipal, industrial and domestic wastewater it produces. Consequently, sewage from the ridges and municipalities is disposed of on a daily basis in untreated form into informal settlements, which are not legally approved [15, 16, 21]. The large volumes of wastewater produced are either discharged untreated into wetlands surrounding the city or allowed to infiltrate into ground water, polluting fresh water resources as well as the soil [25].

Most of the liquid waste generated by Kigali's 1.2 million inhabitants is either disposed in septic tanks or pit latrines [21, 15] and supplemented by flushing toilets, except for the few modern housing or industrial estates that are equipped with small, decentralised waste stabilisation ponds [26]. The pit latrines in the informal settlements are rarely emptied due to inaccessibility to the emptying services [15]. Moreover, the off-site facilities, for both liquid and solid waste are transported to the communal dumpsite of Nduba, which is at the top of a hill, and when it rains, the flow spreads out the contamination into the neighbourhood area [27].

The manner in which the liquid waste is disposed poses several risks. Firstly, the open stabilisation pits where the liquid waste is disposed are not fenced. This poses a risk to the families with children who live in the neighbourhood. Secondly, the waste decomposition process releases methane and other harmful gases into the atmosphere with short-term risk of fires and long-term risk of pollution. Thirdly, there is a risk of pollution of water sources, for both ground water and underground water sources [26].

Liquid waste is also harmful in settlements of Kigali, where there is lack of runoff water drainage systems. This affects the housing structures and make the settlements prone to landslides due to soil erosion. During the rainy seasons, the storm water and floods overflow and sweep away the pit latrines, resulting in faecal contamination of the shallow wells and ground water [28]. As a consequence, due to the topography of the informal settlements coupled with lack of access to waste management, sectors of Muhima, Gitega, Nyakabanda and Rugunga are prone to frequent outbreaks of waterborne diseases, especially cholera and diarrhoea. A study made in Nyabugogo catchment which drains whole storm water from Kigali into Nyabugogo river outlet, indicated a high concentration of heavy metal in the water bodies attributed to the disposal of untreated liquid waste from the municipalities of Kigali into the river [25, 29].

Kigali's lack of provision of effective faecal-sludge, wastewater collection and transport to a safely- functioning treatment facility is in itself, a huge sanitation challenge. A study conducted in 2010, indicated that the City of Kigali generates over 32040m<sup>3</sup> per day of waste water and this poses a threat to the environment whereby 4151kg/day of total nitrogen and 1384kg/day of total phosphorus pollutants were released in the environment due to the lack of waste water treatment and recycling technology [30]. Recent findings indicate that Kigali city produces between 300 to 400 tons of waste per day, which is actually collected and transported to a single dumping site [31]. Therefore, the existing service gap may render the national target of safely managed sanitation for all by 2030 essentially impossible to achieve.

Despite these challenges, Kigali's Nduba landfill has potential to be a valuable asset, should the authorities choose to manage its waste sustainably. The dumped waste can be sorted into organic and inorganic waste with the former being processed into fertilisers, energy and other resources. Similarly, some of the waste such as plastics and paper can be recycled. These sustainable options have proven to be a source of employment in other jurisdictions where communities are involved, hence creating jobs and improve livelihoods. For example, 3.3-5.6 million people in Chinese cities are involved in informal waste recycling [32].

## Solid Waste

Due to poor sewerage infrastructure, most off-site sewerage in Kigali is privatized with the city authorities contracting waste collection to private companies. The Rwanda Utilities Regulatory Authority has licensed more than 143 companies in cleaning and 23 companies in solid waste collection [27]. Majority of these operate in the city. Each household pays private refuse companies contracted by the city council. The user charge is set at RwF 2,000 (USD2.20) for low and middle-income households and at RwF 3,000 (USD3.30) for high-income households [33].

Solid waste collection in informal settlements is hampered by poor infrastructure. Narrow and disorganized roads make it difficult to access houses and collect rubbish. This results in a steady accumulation of waste with adverse health effects. For households that are unable to pay for the service of waste collection, they either burn, bury or simply dispose waste outside, leading to waste mounds. Deep-seated fires, methane explosions, landslides and leakages threatening rivers and groundwater are some of the common problems of such basic dumpsites. Notably, there is only one operating dumpsite in Kigali, which receives 300-400 tons of waste per day compared to 640 tons of waste produced per day [31]. According to an assessment by the Office of the Auditor

General (2016), of the 400 tonnes of waste dumped daily at the city's main landfill in Nduba Sector, only two per cent is recycled. Kigali city has neither a centralized waste treatment facility nor systems to recycle solid waste. The city generates between 1,800 and 2,000 tonnes of solid waste daily, of which only 400 tonnes is collected and disposed at the Nduba landfill [28]. This is partly due to the small number of licenced recycling firms. As of January 2018, the Rwanda Utilities Regulatory Authority had only licenced three companies; Agruni Ltd, Ecoplastic and Greencare Rwanda [34]. These recycling companies also have a narrow specialisation, mostly recycling plastic waste and biodegradable municipal solid waste to produce briquettes and manure. The high capital investment needed to set up recycling plants is prohibitive hence the focus is on recycling paper and plastics.

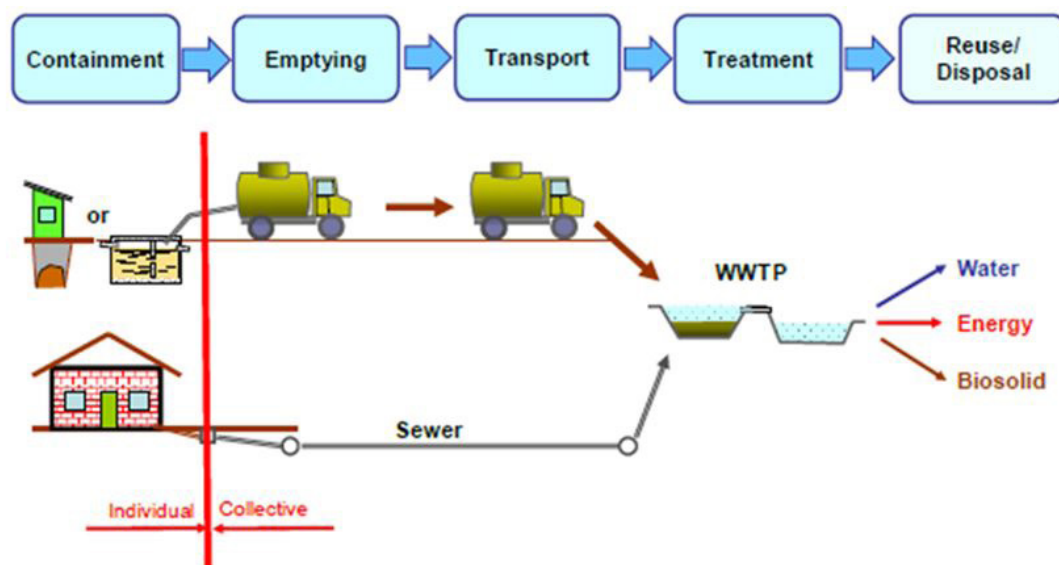
Like most developing countries, Rwanda is experiencing an increase in electronic waste (known as e-waste). Users discarding old and obsolete electronic devices such as television sets, mobile phones and computers generate this. Rwanda is estimated to generate close to 10,000 tonnes of e waste annually. In 2017, the government through the Ministry of Trade and Industry, supported by Rwanda Green Fund (FONERWA) licenced an e-waste recycling company Enviroserve Rwanda to run a recycling facility in Bugesera Industrial Park for 10 years in a Public Private Partnership. Currently there are three collection centres with the long-term plan being to have thirty collection points with every district represented [35]. As of October 2018, the company had managed to collect 700 tonnes of e-waste of which 434 tonnes of waste was dismantled and recycled. The country also developed an e-waste policy in August 2018 to provide guidelines in management of e-waste.

Overall, the fraction of all recycled waste is much smaller than total waste produced [26]. Some quantitative assessments show a waste generation range of 500-800 tons per day for the City of Kigali [31]. The State of Environment and outlook report 2013 shows estimate of waste produced ranging between 1800-2000 tons per day country wide [36]. Studies also indicate that only 12% of the waste generated in Kigali is recycled [37]. As a point of comparison in East African countries, the waste recycled in Nairobi stands at 30%, while in Kampala and Dar es Salaam it is respectively at 11% and 18%. Actually, estimates of waste generation in Kigali is below the average waste rate of 0.74 kg/day per capita in urban sub-Saharan Africa [37].

Initiatives for Access to Improved Sanitation

### Initiatives for Access to Improved Sanitation

The sanitation target for the Government of Rwanda is to achieve 100% of the households having access to improved sanitation by year 2020 [35]. To attain this target, the country aims at shifting from building standard pit latrines and toilets to providing safe onsite and offsite waste management (see Figure 1). However, Onsite sewerage is managed by pit latrines, flush toilets or septic



Source: MININFRA, 2016

Figure 1: On and off-site Waste management



tanks, for both collective and individual waste collection [15]. Under normal circumstances, sewerage collection has to be directly conveyed through sewerage network line and undergo treatment at waste treatment plant for generating water, energy or biosolid. However, given onsite characteristics, individual waste is collected using vacuum trucks that empty the waste and dispose it of at treatment plant for reusing or recycling in other products for better environmental management in the city [35]. Figure 1 proposes complementary on- and off-site sanitation systems in Rwanda.

Rwanda has several strategic policy documents that guide its implementation of urban sanitation. These include different programs initiated by the Government of Rwanda such as *Vision 2020*, *National Transformation Strategy 1, 2017-2024*, ratification of different international treaties and program such as *Sustainable Development Goals 2030* and *African Union Agenda 2063*, which recognises the need to have access to improved sanitation and achievement of sustainable development [38, 39, 40, 4].

There are also existing policies and strategies which were formulated to accelerate the sanitation development in Rwanda including *National Sanitation Policy, 2016*; *National Sanitation Implementation Strategy, 2016*; *National Urbanisation Policy, 2016*; *National E-Waste Management Policy, 2015*, And *National Water Supply Policy, 2016* [41, 35]. Apart from programs, strategies and policies such as: National Sanitation Policy, 2016; Rwanda Environment and Climate Change Policy of 2019; Organic law no 04/2005 of 08/08/2005 aiming at conserving environment (by reducing negative effects on the environment) and replacing the degraded environment, key institutional framework was also defined in a bid to enforce key sanitation principles towards sustainable development as shown in Table 1.

Solutions / facilities →	Individual Sanitation		Collective Sanitation	
	On-site (households)	Off-site sludge management	On-site (households)	Off-site networks
Responsibilities ↓	(Latrines, toilets w/ septic tanks, not connected to network)	(sludge emptying services, sludge disposal facilities)	(Waterborne toilets connected to network)	(Sewerage networks, public or private wastewater treatment plants)
Planning (Policy, strategy)	MININFRA with contribution MoH, MINALOC		MININFRA with contribution MoH, MINALOC, REMA	
Legislation	MININFRA, MoH, MINALOC		MININFRA, MoH, MINALOC	
Standards	MININFRA, MoH, REMA, RSB		MININFRA, MoH, REMA, RSB	
Masterplans	Districts with support MININFRA		Districts with support MININFRA	
Coordination	New Individual Sanitation Program Unit at MININFRA or MINALOC		MININFRA	
Demand generation				
Awareness	MoH + Districts		MININFRA, MoH, Districts	
Marketing	Shops, masons	Service providers, District	WASAC (urban areas), District, private service providers	WASAC (urban areas), District, private operators
Enforcement	District	REMA, RURA, District	District	REMA, RURA, CoK, District
Access provision				
Equipment, material	Shops, trade	District, private service providers	Shops, trade	WASAC (urban areas), private operators
TVET	MINEDUC	MINEDUC	MINEDUC	MINEDUC
Construction	Masons (hired by households, with support by District)	District (sludge disposal)	Masons (hired by households/owners, with support by District)	WASAC (urban areas), private operators
O&M	Households	WASAC (urban areas), District, private service providers	Households (owners/users)	WASAC (urban areas), District, private operators
Financial (CAPEX)	Households	MINECOFIN, MININFRA, District, private service providers	Households (fees)	WASAC (MINECOFIN), private operators
Sanitary inspection	-	-	-	-
M & E	NISR, MoH	NISR, MoH, RURA, REMA	NISR	NISR, MoH, RURA, REMA

MININFRA: Ministry of Infrastructure; MINEDUC: Ministry of Education; NISR: National Institute of Statistics of Rwanda; MoH: Ministry of Health; RURA: Rwanda Utilities Regulatory Authority; REMA: Rwanda Environment Management Authority; WASAC: Water and Sanitation Corporation; MINECOFIN: Ministry of Finance and Economic Planning; MINALOC: Ministry of Local Government and RSB: Rwanda Standards Board.

Source: MININFRA, 2016

**Table 1:** Institutional framework for achieving effective sanitation in Rwanda both sexes (right and left sides)

The established institutional framework shows key responsibilities of the institutions involved in improving sanitation in view of on-site and off-site facilities for both individual and collective sanitation. In addition, the government sensitises communities on the importance of sanitation in communities during national community work (*Umuganda*), and through health advisors at village levels[42]. City authorities collaborate with specialised companies in waste collection and mobilize support for upgrade of informal settlements.

Kigali City has a septic sludge treatment stabilisation pits treat the liquid wastes at Nduba landfill without application of chemicals save for sodium carbonate or lime [26, 43]. The government has also secured funding for a liquid waste treatment plant under the project “Kigali Centralised Sewerage” worth 95.8 million Euro to be established at Gitikinyoni, in Kimisagara sector [44, 45].

The treatment plant which would treat about 12000 m<sup>3</sup>/day using solar energy, will manage liquid wastes from Mahima, Kimisagara and Nyakabanda sectors as a mitigating factor to the liquid waste disposed-off in the open channels without treatment. In addition, Kigali City Masterplan of 2013 which is currently under review will be updated following the widespread concerns of city dwellers on multiple issues related to shortage of low-cost housing, access to public facilities such as sanitation facilities, water, electricity among others. Feedback from these public consultations will be incorporated in the design and implementation of the Kigali Masterplan targets by 2050. It will be implemented in five phases [45].

## Sanitation challenges & Solutions in Kigali

### Waste generation

The Office of the Auditor General (2016) revealed that Rwanda is facing significant challenges in relation to solid waste management. Waste generation is increasing, and a sizeable portion of it is disposed on improperly located and operated dumpsites such as Nduba Landfill, resulting in adverse impacts on environment and health [28, 27]. The 2050 Masterplan needs to address this issue such that every district of Kigali owns its own dumpsite, which may reduce the rate of waste disposal at single Nduba dumpsite. Meanwhile, poor implementation of sanitation regulations leaves a gap for sustainable environment management and public health. Using the programs, policies and strategies that the government has developed, there should be enough commitment to implement these through the governance structures linking national government, municipal authorities and communities.

As a rapidly urbanising city, Kigali can pursue several sanitation options in the short and long run-on safe collection, transport and disposal of waste. Recycling of waste involves the processing of waste into new useful products. Some products such as paper and plastic are easy to recycle thus it is cheaper and simpler to roll out such initiatives at community level. Certain products such as electronics are much more complex and require sophisticated technology to recycle. Currently the country is processing less than 10% of the e-waste produced [41, 26], as such there is need to expand existing facilities or to contract other e-waste processing organisations to cover this shortfall. Key in recycling solid waste is segregation of waste at source, if possible, at disposal or before collection. This allows the separation of recyclable material from non-recyclable ones.

Recycling has several advantages. One, it provides economic, environmental and social positive responses by creating markets within informal settlements, through community-based organizations. Two, the extracted biodegradable waste can be decomposed, and the product processed into agricultural fertiliser or mulch. Three, sorting waste at source with the option of recycling and composting reduces the amount of waste that is disposed of at a landfill. Notably, it is illegal to dispose non-biodegradable waste at Kigali's only landfill (Nduba).

Given that Rwanda is rapidly urbanising and Kigali's populations growing, especially in the informal settlements, the city authorities can also consider implementing semi centralised wastewater treatment systems, as the city plans for a sewer system.

### Urban Planning

Sanitation provision in poor neighbourhoods provides a big challenge to city officials and planners in Kigali, because Kigali City Council has never had a city master plan for settlements and environmental infrastructure [44]. Currently, the existing informal

settlements area cannot allow better planning of central sewer networks, which is needed to convey the liquid waste from the houses in Kigali. Newly constructed buildings are still using septic tanks, which is not sustainable in the long run due to land scarcity in Kigali and its high population density [46].

Consequently, if there is no connection between central sewerage line and the houses, sanitation will continue to be threatened. Research indicates that the scattered and uncoordinated manner of building construction creates an urban planning crisis, which makes it harder to design the environmental and sanitation infrastructure [47].

## Waste Management

The on-site sanitation facilities in Kigali city are dominated by pit latrines and septic tanks, which are poorly maintained in the informal settlements and rarely emptied. This is due to poor road infrastructure in the informal settlements, some sites are not accessible due to narrow steep roads through which latrines mostly in the informal settlements are accessed. The available emptying services are not enough to empty soakage pits and septic tanks of Kigali City [48]. The biggest challenge is that these pit latrines are filled up quickly and they are vulnerable to leakages and collapse during heavy rain. This causes an overflow to the water bodies which cause bad smell, attracting the flies as well as causing the water borne diseases [27, 17]. Moreover, even for citizens with the capacity to empty fluids from latrines, the sludge is not always disposed of in a proper manner. While it may be transported to the communal landfill, the available technology to recycle is still insufficient [24]. In view of this, neglecting pit emptying or employing poor quality emptying services can have serious health and environment consequences such as dysentery, diarrhoea diseases, cholera outbreaks which often results in high infant mortality.

These challenging issues are related to how safely the waste is contained, emptied, transported, treated and disposed of [46]. This is a new focus of the Sustainable Development Goals (SDGs), which shifted from only addressing access to sanitation facilities to considering safe waste management along the entire sanitation service chain, from waste generation to disposal or re-use.

## Knowledge

While Kigali is renowned for the cleanliness of its streets, there is limited research about life in informal settlements. This raises a pressing need to understand the nature and magnitude of the issues affecting sanitation provision and to find cost-effective and sustainable sanitation alternatives to address them. Certainly, limited research has addressed solutions to sanitation challenges. Increased focus on sustained sanitation should be a basis for addressing health related issues that match with the context of informal settlements in Kigali. The different approaches need to raise the awareness on the sanitation. Localised solutions have proven to be fruitful to develop different programs of WaSH all across the country [17].

## Funding

Funding also remains a major challenge; the city cannot afford a centralized sanitation system because of the high cost of the associated physical infrastructure, which includes networks of pipes, treatment plants and maintenance. In particular, as many cities in low- and middle-income countries, Kigali faces pressure to expand sewage, but is not able to provide adequate collection and treatment systems [49, 22]. For example, the challenge in Rwanda is that city officials encounter fast growing population in the city, while there is not enough investment on sustainable urban wastewater management infrastructure to provide adequate and equitable services to all, particularly people living in poor neighbourhoods [50].

## Conclusion

This study aimed at reviewing related literature on sanitation Kigali, identifying the major initiatives taken to enhance sanitation, identifying major sanitation issues and challenges in informal settlement of Kigali City, and providing solutions to these challenges [51] believe that a well-managed system for piped water, sanitation, and drainage and garbage removal would improve the health



of cities' residents. However, introducing and maintaining centralized systems in developing cities has been hampered by political, economic, ecological and social instability. This is detrimental to the environment and causes perpetual breakdowns. The existing water and sanitation infrastructure in the city of Kigali needs to improve as the existing infrastructure is not environmentally friendly and does not provide its citizens with adequate services.

Kigali City in collaboration with private sector reached a remarkable progress in solid waste collection but the liquid waste emptying is still a challenge. Moreover, both liquid and solid wastes are disposed-off at Nduba communal land fill untreated, which is in not in line with the pillars of sustainable development.

Therefore, to implement sanitation guidelines and regulations established by the city of Kigali, this study proposes a set of recommendations:

(i) Designing and establishing waste management services unit, raising capacity building and improving the management of both liquid and solid wastes. This would invariably lead to realisation of Kigali city vision of becoming a centre of urban excellence in Africa [45, 26]

(ii) Installing a sustainable solution of transforming wastes disposed-off at Nduba communal landfill into energy

(iii) Improving waste segregation at production site and the establishment of composting plant which would generate fertilisers from organic wastes

(iv) Installing an incineration plant at landfill to control the hazardous waste, which is harmful to the lives of the people

(v) Developing regularly inspection and environmental impact assessment at dumping site, which would generate the information on socio-economic and environmental risks generated by the landfills and potential mitigation measures

(vi) Raising awareness and sensitization to inform the public on the importance of waste segregation, proper disposal practices, waste minimization and policing against solid waste malpractices

(vii) Enforcing the "Polluter Pays" principles, so as to reduce the waste production. Applying penalties in order to prevent disposing wastes in unplanned places [26, 27].

In a nutshell, Kigali city master plan development should consider building the central sewerage system, which would inevitably minimise poor municipal's liquid waste that are discharged-off into runoff channels. We recommend to conduct a cost benefit analysis of such a system.

In conclusion, universal sanitation cannot be achieved without strong stakeholder's engagement and community consultations. In tandem with existing sanitation policies, implementation of Kigali Masterplan and the community engagement, proposed solutions to sanitation challenges when collectively implemented would assure sustainability of the health status in informal settlements.

## Conflicts of Interest

The Authors declare no conflict of interest.

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## References

1. WHO&UNICEF (2015) 25 years of Progress on sanitation and drinking water: 2015 update and MDG assessment, World Health Organization (WHO) and United Nations Children's Fund (UNICEF), 20 Avenue Appia, 1211 Geneva 27, Switzerland.
2. Mara D, Lane J, Scott B, Trouba D (2010) Sanitation and Health. *PLoS Med* 7: e1000363.
3. Erin Hetherington, Matthijs Eggers, Joyce Wamoyi, Jennifer Hatfield, Mange Manyama, et al. (2017) "Participatory science and innovation for improved sanitation and hygiene: process and outcome evaluation of project SHINE, a school-based intervention in Rural Tanzania". *BMC Public Health* 17:172.
4. UN (2015) The millennium development goals report, United Nations (UN), New York, USA.
5. WHO&UNICEF (2018) Drinking water, sanitation and hygiene in schools: global baseline report 2018, World Health Organization (WHO) and United Nations Children's Fund (UNICEF), New York, USA.
6. UNDP (2018) Urbanisation: a multidimensional challenge and opportunity for health, wellbeing and equity, United Nations Development Programme (UNDP).
7. UN-Habitat (2016) World Cities Report: Urbanization and Development: Emerging Futures, UN-Habitat, Nairobi.
8. R. Muggah (2016) Urban governance in fragile cities *Appl Knowledge Serv* 46: 1-4.
9. Sthianopkao S, Ming Hung Wong (2013) Handling e-waste in developed and developing countries, practises, and consequences, *Sci. Total Environ* 464: 1147-53.
10. Sudharshini S, T. S. Selvavinayagam (2018) Supervision as an effective intervention in improving water, sanitation and hygiene facilities in government health facilities of Tamil Nadu, *Int J Community Med and Public Health* 5: 3.
11. Sisay A, Berihu Demewoz (2017) Assessment of the Liquid Waste Management Practice of Condominium Houses in Addis Ababa, Ethiopia, *International for innovative research and development* 6: 214.
12. Jochen M, Sophie Schramm (2017) Toward the network city? Translating technological ideas and planning models in water and sanitation systems in Dar es salaam, *Int J Urban and Regional Research* 41: 104-25.
13. UN, (2015) Transforming the world: the agenda for 2030 sustainable development, United Nations, New York, USA.
14. Andersson, K. D. S. & R. A (2016) Towards "sustainable" sanitation: challenges and opportunities in urban areas. *Sustainability* 8: 1289.
15. Tsinda, A. P. K. A. O. & C. Challenges to achieving Sustainable Sanitation in Informal Settlements of Kigali, Rwanda, *Int J Environ Res Public Health* 10: 6939-54.
16. Hitayezu, P. R. A. & S. D (2018) "The dynamics of unplanned settlements in the city of Kigali," *Int. Growth Centre* 12: 1.
17. Tsinda A, P. A. J. C S P, M K (2017) Improving sanitation in informal settlements of East African cities: hybrid of market and state-led approaches, *Int J of Water Resources Development* 34: 229-44.

18. Hitayezu, P. R. A. & S. D (2018) The dynamics of unplanned settlements in the city of Kigali, *Int Growth Centre* 12: 1.
19. NISR (2018) The Fifth integrated households living conditions survey: 2016/2017 Rwanda Poverty Profile Report, National Institute of Statistics Rwanda (NISR), Kigali.
20. NISR (2012) The Fourth Rwanda Population and Housing Census, National Institute of Statistics Rwanda (NISR), Kigali.
21. Ian Ross PJ (2017) Kigali Urban Sanitation Study Oxford Policy Management Limited 6: 1.
22. Kazora, A. S. B. T. M. K (2018) Improving faecal sludge management for sustainable sanitation, Rwanda, *SciFed Biotech & Bioeng J* 1: 1-10.
23. Eugene D (2007) Impacts of Inadequate Sanitation and Unsafe Drinking Water on Human Health: A Case Study of Kigali City, the Capital of Rwanda.
24. Akumuntu J. B. W. U. M. M, B. D. (2017) Enabling the sustainable Faecal Sludge Management service delivery chain—A case study of dense settlements in Kigali, Rwanda, *Int J Hyg Environ Health* 220: 960-73.
25. Naphi I., W. B. U. H. N. E. B. R. K. (2011) Assessment of water pollution levels in the Nyabugogo catchment, Rwanda. *The Open Environmental Engineering J* 4: 40-53.
26. OAG (2016) Performance Audit on Management of solid and liquid sewage waste in city of Kigali, Office of the Auditor General of state Finances (OAG), Kigali.
27. Alice U, M. Y. N. U. D. N. N. N. (2017) Liquid Wastes Treatment and Disposal in Rwanda, *J Pollut Eff Cont* 5: 149.
28. Josephine I, D. N. (2016) The State Key Laboratory of Pollution Control and Resource Reuse, *Nature Index* 94: 10.
29. RWFA (2017) IWRM Programme Rwanda TR24 - Catchment Plan Nyabugogo 2017-2023, Rwanda Water and Forestry Authority (RWFA), Kigali.
30. Umuhoza M (2010) Assessment of Wastewater Management Practices in Kigali City, Rwanda, *The Open Environmental & Biological Monitoring Journal* 3: 2.
31. Anirudh R. A. B. A. S. G. (2019) Assessing waste management services in Kigali,” *Int. Growth Centre* 1: 38435.
32. Kaza S. Y. L. B.-T. P. & V. W. F. (2018) What a waste 2.0: a global snapshot of solid waste management to 2050, *Open Knowledge Repository* 1-295.
33. GGGI (2019) Solid Waste Management in Secondary, Global Green Growth Institute, Seoul.
34. Bizimungu (2018) Inside Rwanda’s enduring battle to eliminate e-waste.
35. MININFRA (2016) National sanitation policy, Ministry of Infrastructure, Kigali.
36. REMA (2015) The state of environmental outlook report, Rwanda Environmental Management, Kigali.
37. Kabera T (2019) Systems analysis of municipal solid waste management and recycling system in east Africa: benchmarking performance in Kigali city, Rwanda, in *E3S Web of Conferences*.

38. MINECOFIN (2017) 7 Years government programme: National Strategy for Transformation (NST1) 2017-2024 Kigali: Ministry of Finance and Economic Planning.
39. MINECOFIN (2012) Rwanda Revised Vision 2020, Kigali: Ministry of Finance and Economic Planning.
40. AU (2015) African Union Agenda, 2063: The Africa we want, a shared strategic framework for inclusive growth and sustainable development. First ten-year implementation plan 2014-2023, Addis Abeba: African Union (AU).
41. MINIRENA (2015) National E-Waste Management Policy for Rwanda, Kigali: Ministry of Natural resources.
42. Uwimbabazi (2012) An analysis of umuganda: the policy and practice of community (Dissertation).
43. RHA (2018) Assessment of current storm water management storm water management and flood in the city of Kigali areas, Rwanda housing Authority (RHA), Kigali.
44. The New times (2019) Construction of Kigali sewerage system to kick off in June.
45. CoK (2019) About city of Kigali, City of Kigali (CoK), Kigali.
46. Aime Tsinda, Pamela Abbott, Jonathan Chenoweth (2015) Sanitation markets in urban informal settlements of East Africa Habitat International 49- 21-29.
47. Buckley (2014) Affordable Housing in Rwanda: Opportunities, Options, and Challenges: Some Perspectives from the International Experience. in Rwanda National Forum on Sustainable Urbanization, Kigali.
48. Tsinda (2018) Affordable Housing in Kigali: Issues and Recommendations. In.
49. Tsinda A, A. P (2017) Between the Market and the State: Financing and Servicing.
50. MININFRA (2016) National sanitation policy, Ministry of Infrastructure (MININFRA), Kigali.
51. Collier, P. G. E. V. A. B. M. a. M. P. (2019) Policy options for informal settlements, International Growth Centre 1: 1-38.
52. WHO (2018) Drinking water, sanitation and hygiene in schools global baseline report 2018, World Health Organisation, Geneva.