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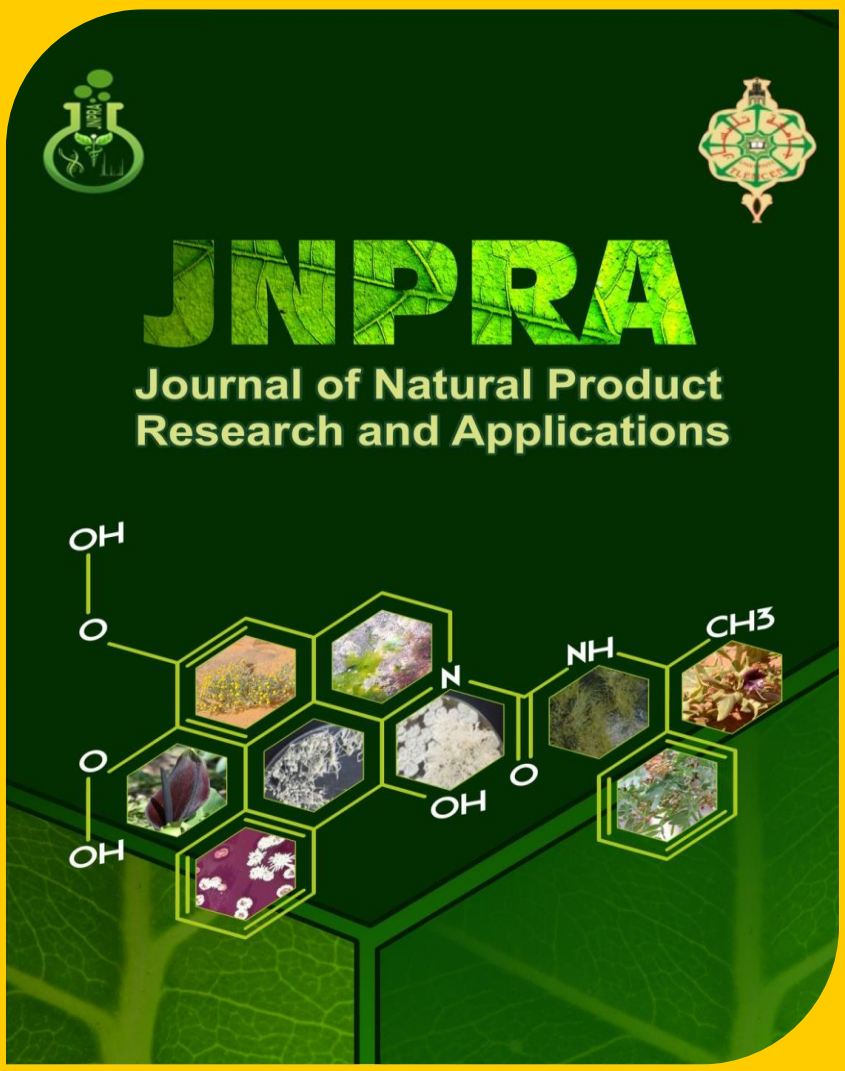

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Research Article

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Household and related waste management challenges and opportunities Case of Bujumbura - Burundi

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Highlights

- Household and Waste management (HRW) analysis in Bujumbura by using the SWOT matrix;
- Solid waste must be placed in a risk and resource management perspective;
- The household waste exposes the inhabitants and Lake Tanganyika to an environmental disaster.

Graphical Abstract

Abstract
Cities in developing countries have been struggling with households and related waste management due to galloping demography, uncontrolled urbanisation, enhanced economic activities, unsuitable environmental governance, low technical and financial capacities, etc. The city of Bujumbura is not an exception. The Government of Burundi developed and made public the National Sanitation Plan, which unfortunately did not improve the household and related waste management service in Bujumbura. This paper attempts to analyse challenges and opportunities of the solid waste sector in Bujumbura through the SWOT scheme and to provide some lasting solutions by favouring a sustainable approach to integrated management of households and related waste based on formal structures through the strengthening and revitalisation of the public-private partnership and informal structure through its recognition and its integration into the solid waste management system.

Keywords: Solid Waste Management; Household waste; Sustainable development; SWOT; Bujumbura, Burundi

1. Introduction

According to the World Bank (2016), the world generates 2.01 billion tons of solid waste per year. Worldwide, waste generation per capita and per day is about 0.74 kilograms but varies widely, from 0.11 to 4.54 kilograms depending on the living standard, high-income countries generate around 34% (683 million tons) of those waste. In low-income regions such as sub-Saharan Africa, South Asia and the Middle East, solid waste generation is low. However, the World Bank estimates that the generation rate will triple by 2050. Households and related waste are often generated from varying sources of anthropogenic activities (Kodwo et al., 2015). Several studies showed that households and related waste in developing countries are (55 to 88%) generated by households, followed by commercial or market sectors (10 to 30%) (Nabegu, 2010; Nagabooshnam, 2011; Okot-Okumu, 2012).

Solid Waste Management in developing countries may appear less problematic than water or air pollution (Jules, 2015). The storage, collection, transportation and final treatment/disposal of wastes have become a major problem in urban centres (ADB 2002; Kaseva & Mbuligwe 2005; Okot-Okumu & Nyenje 2011; Rotich *et al.*, 2006). In most cities in DCs, solid waste management poses enormous difficulties and goes against certain principles of ecological prudence and sustainable development (Zalissa, 2013). In particular, poor waste management practices, particularly the widespread discard of wastes into water bodies and their uncontrolled dumping, exacerbate the generally low sanitation problems in the cities of these countries (Mwesigye et al., 2009). Solid waste management appears to be so challenging because the public authorities of these cities try to copy and paste the models displayed by the countries of the North (Europe, North America and Japan), themselves modelled on the quality corresponding to the standards posed and promoted by international organisations such as the World Bank, the United Nations Environment Program etc. (Durant, 2012). In search of this quality, they are caught up by the economic, financial, human or urban contexts, which are distinct. Brunner and Lederrer (2011) showed that while globally developed countries spend more than 0.4% of their GDP on managing their household and related waste, developing countries only spend less than 0.1% for this purpose. Precisely because developed countries treat sustainable development as an environmental concept emphasising intergenerational equity focused on future needs (Carter, 2001), while most developing

countries focus on intragenerational equity by focusing on current needs, which are often social and economic.

However, in an integrated vision of sustainable development, solid waste cannot be treated as an isolated element or limited to only recovery and disposal aspects. It must be placed in a risk and resource management perspective, covering the entire waste life cycle, from generation to final treatment. According to Philippe et al. (2005), solid waste management in urban centres is one of the most worrying environmental issues for DCs, particularly in certain African capitals where less than 30% of waste is removed and treated. As collection and disposal techniques are not efficient, waste is a factor in the degradation of the urban environment.

In Bujumbura, the economic capital of Burundi, due to the lack of regular waste collection, residents abandon the solid waste in the middle of the street or throw them into the rivers that cross this city to flow into Lake Tanganyika. Powerless in the face of this state of affairs, they are the first to suffer the consequences: piling up of rubbish, unbearable odours, more and more rats, cockroaches, and flies thriving around open dumpsites, contamination of water resources, land degradation and increase in air pollution, causing dangerous diseases for these populations forced to live in "garbage quarters" and increasing their vulnerability to the effects of climate change.

In this perspective, this article proposes to analyse the problem of household and related waste management (HRW) in Bujumbura by using the SWOT matrix (Strengths, Weaknesses, Opportunities, Opportunities, Threats).

2. Legislative and institutional framework

In recent decades, we have witnessed a legislative production rooted in the international conventions ratified by Burundi. It aims to comply with these international commitments' internal legislative and regulatory framework.
Among the promulgated legislation, the most important for the sanitation sector are:

- ✓ Decree-law n ° 1/16 of May 17, 2005, relating to the Public Health Code and the National Health Policy;
- ✓ Decree No. 100/241 of December 31, 1992, regulating the evacuation of wastewater in urban areas;
- ✓ Law n ° 1/010 of June 30, 2000, on the Environmental Act in Burundi;
- ✓ Ministerial Order No. 630/770/142/2008 on the classification and management of biomedical waste produced in health care structures;
- ✓ The Water Act (2012);
- ✓ The Highway Act (2012) and;
- ✓ The 2018 hygiene Act.

The essential conventions on which all these sanitation regulatory tools are based are:

- ➢ The Bamako (2001) and Basel (1997) conventions on hazardous waste;
- ➢ The Convention on Biological Diversity (1996);
- ➢ The United Nations Framework Convention on Climate Change (1997);
- ➢ The Convention on the Sustainable Management of Lake Tanganyika (2004);
- ➢ The Stockholm Convention on Persistent Organic Pollutants (2005)

Overall, according to Nsavyimana (2015), households and related waste management have been disadvantageously left to households. The environmental code exists, but there is an absence of policy and application texts about liquid and solid waste.

The hygiene and sanitation sector in Burundi is marked by a fragmentation of responsibilities between multiple actors. Among the government actors, four ministries are concerned:

- The Ministry of Public Health and AIDS Control (MSPLS), through the Directorate for the Promotion of Health, Hygiene and Sanitation;
- The Ministry of the Environment, Agriculture and Livestock;
- The Ministry of Energy and Mines;
- The Ministry of the Homeland, Patriotic Training and Local Development.

The mandates of the different public institutions are theoretically clear, there are many overlaps in practice, and some responsibilities are not assured. It is also observed that institutions are often in competition for the exercise of certain powers. Another recurrent institutional problem in Burundi is that of frequent changes in the attributions of ministries. According to the same source, at the territorial level, an emerging actor is the municipality. It participates in the management of hygiene and sanitation in several ways: it has the prerogative to take the necessary measures for the preservation of the environment; it is responsible for the project management of local development; it is the owner of the infrastructures built and can delegate their management to service providers. However, despite these few relatively general elements, no specific provision validates the competence of the municipalities in matters of Solid Waste Management.

3. The study area

3.1 Geographic and physical aspects

Burundi, a state in East Africa, landlocked 1,200 km from the Indian Ocean, 2,000 km from the Atlantic Ocean, is located between 28 ° 58 'and 30 ° 53' East longitude and between 2 ° 15 'and 4 ° 30' South latitude. Rwanda bounds it to the north, the Democratic Republic of Congo (R.D.C.) to the west and Tanzania to the south and east. It covers 27,834 km^2, of which the Burundian part of Lake Tanganyika occupies around 2,000 km2. It currently has 18 provinces subdivided into 125 Communes. Being the central city of the country, Bujumbura is the economic capital of Burundi. It is located in the western part of Burundi on the shores of Lake Tanganyika. Its geographic coordinates are between 3 ° 22 ′ 32 ″ South and 29 ° 21 ′ 33 ″ East. The city of Bujumbura is subdivided into 3 Communes which are: Ntahangwa, Mukaza and Muha. It has 800,000 inhabitants (in 2015) over an area of more than 100 km^2. The principal economic activities that are sources of income for its inhabitants are agriculture for the inhabitants of the North and the South, petty trade towards the Center and services and large trade in the city's heart. In the city of Bujumbura, the generation rate of solid waste is about 0,7 kg per capita and per day.

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Figure 1. Administrative division of Bujumbura

4. Methodology

Understanding the problem of household and related waste management in Bujumbura was carried out through the SWOT matrix, which allows analysing the sector of household management according to its strengths and weaknesses, future opportunities and potential threats (Ricardo, 2009). The diagram will give rise to a matrix of cross-referencing to propose solutions likely to allow the different actors to take control of the situation and the actions required.

The methodology of qualitative inductive research was used for this article because it aims to build a theory from the observation and study of the research object and the practices of the actors (Sahraoui, 2011). This methodology has been extended to the typical case study, according to David (2005). According to Hamel (1997), the case study consists of relating an event to its context and considering it in this aspect to see how it manifests itself and develops there. Thus, a documentary analysis was carried out consisting of consulting all the documentation available on solid waste management in Burundi in general and in Bujumbura in particular. Then, field observations, direct and semi-direct informal interviews were conducted with certain actors on the field.

5. Results and discussion

5.1. SWOT analysis

The strength of solid waste management in Bujumbura is based on the political will of developing and adopting regulatory texts and the authorities in charge of managing

environmental protection and public health. Particularly, facilitating and supporting cooperatives/citizen associations; also NGOs play an essential role in collecting and transporting solid waste with municipal authorities' involvement. However, the lack of a regulatory and institutional framework specific to solid waste management, the absence of selective sorting of solid waste at the household level and before deposit in the landfill, and the insufficient human resources and inadequate material capacities are factors of weakness to management strategy. The SWOT analysis and the practical possibilities offered by the analysis of solid waste management in Bujumbura are respectively presented in tables 1 and figure 2

According to Yoshida (2012), the history of waste management worldwide is divided into four stages. The first step is to ensure public health and establish waste collection and transport services in cities. The second step is to protect the environment and properly dispose of the collected solid waste, which minimises the environmental impact. The third step is to introduce intermediate processing technologies and reduce the final disposal volume. The fourth step is to form a material cycle society or circular economy for waste management and efficient use of resources for sustainable development.

By following this logic and given the results contained in figure 2, it can be seen that the city of Bujumbura is still at the first stage. The legislative and regulatory texts and the institutional provisions in terms of sanitation and hygiene have been adopted, which more or less ensures public health in the city of Bujumbura. In addition, according to Mizero et al. (2015), at a time when the municipal technical services collected only 8% of the HRW before they handed over these responsibilities to private operators in 2010, it should be noted that the collection of HRW has improved significantly (46%). The efficiency of the collection is due to the increase in private investors interested in waste collection and transportation after the gradual withdrawal of when municipal technical services from this sector. However, the question arises concerning the final disposal of waste collected by them.

In addition, figure 3 illustrates how acutely the chain of HRW management in the City of Bujumbura is still being posed. This waste piled up and burned in the open on the banks of the Ntahangwa river, a direct tributary of Lake Tanganyika, is heterogeneous but is essentially dominated by HRW. The health risks for the riparian populations and the environmental risks for the Lake Tanganyika ecosystem are apparent.

Table 1. SWOT analysis of solid waste management factors in Bujumbura.

Strengths	Weaknesses
❑ Development and adoption of regulatory texts; ❑ Ministries in charge of managing environmental protection and public health; ❑ Cooperatives/citizen associations; ❑ Involvement of municipal authorities, ❑ Solid waste disposal site	❑ Lack of a regulatory and institutional framework; ❑ Lack of socially integrated solid waste management; ❑ Low commitment of urban populations to ecological solid waste management activities; ❑ Insufficient human resources and inadequate material; ❑ Inadequate solid waste transport system and irregular collection.
Opportunities	**Threats**
❑ Development of a regulatory framework; ❑ Creation of a decentralised institutional framework; ❑ Creation of a Technical Landfill Center and solid waste transfer centres; ❑ Promoting the creation of solid waste material/energy recovery channels; ❑ Capacity building of solid waste collectors; ❑ Modernisation of solid waste collection and transport systems; ❑ Public awareness and environmental education; ❑ Elimination of illegal dumps scattered	❑ Strong urban growth; ❑ Galloping demography; ❑ Climate change; ❑ Pandemic and other diseases; ❑ Widening of social inequalities and economic and intellectual properties; ❑ Increase in anarchic constructions in public spaces; ❑ Mismatched knowledge and awareness; ❑ Poor organisation of the solid waste management system; ❑ Political and/or social instability

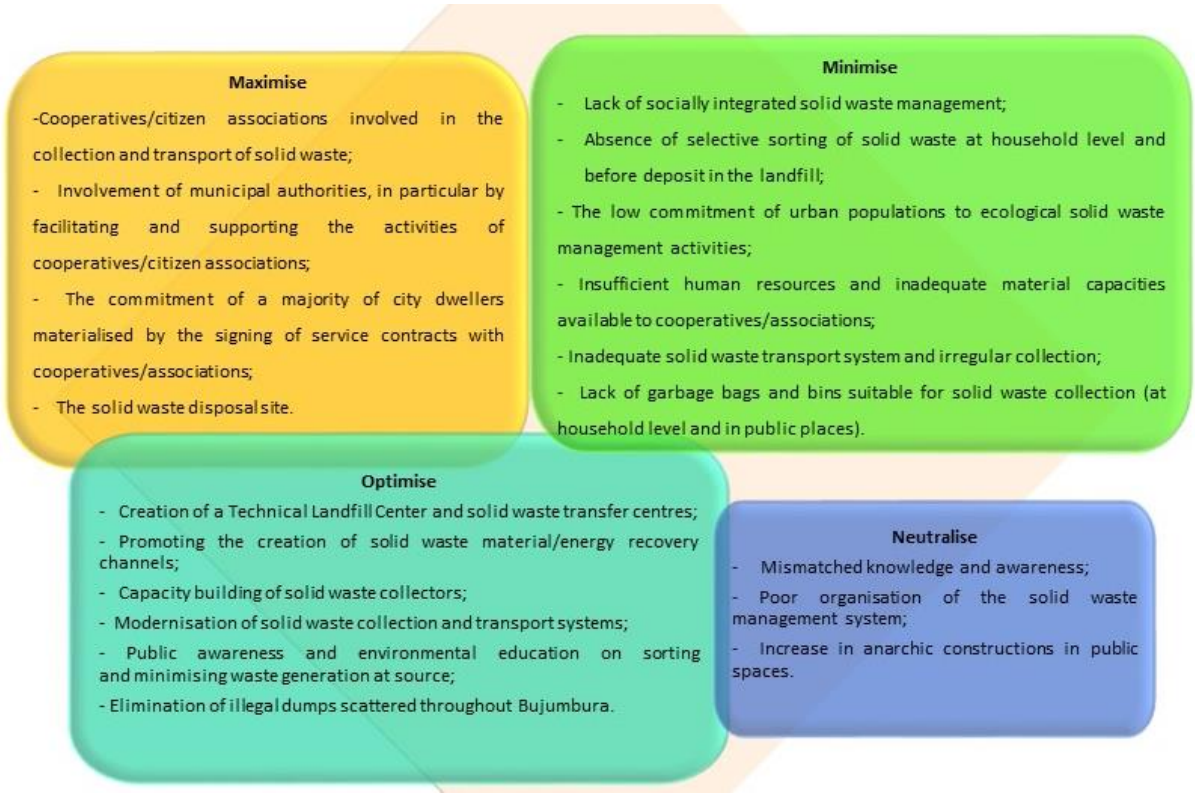

Figure 2. The practical possibilities offered by the SWOT analysis.

Figure 3. Situation of Household and solid waste management: a) Mound of solid waste deposited and burned savagely on the banks of the Ntahangwa river; b) Open dump site near the Cotebu Market; c) A resident carrying a bag full of household waste to throw them in a wild dump created in the middle of the Nyakabiga neighbourhood

Recovering from long decades of civil war, the government of Burundi has invested since 2005 in the multiplication of socio-economic infrastructures to offer populations modern spaces where they can comfortably carry out their activities. Thus, the city of Bujumbura alone has ten modern public markets spread from north to south: Kinema, Kamenge, Niagara, Jabe, Buyenzi I (commonly known as "Ruvumera"), Buyenzi II ("said at Siyoni"), part of the Central Market, Cotebu, Kinindo and Kanyosha. The activities carried out in these public facilities and from different premises generate enormous quantities of waste per day despite the ignorance of the quantity generated and the quality of their composition.
However, knowledge of the quantity of waste produced in a given environment is essential for planning a solid waste management system to predict better the size of the collection and treatment facilities and the waste storage centre (Charnay, 2005; Aina, 2006). Knowledge of the qualitative composition of waste makes it possible to determine management methods and possibly promote treatment and recovery channels (Aloueimine, 2006). Therefore, it is crucial to put in place infrastructures with modern facilities to allow the quantification and qualitative determination of the waste produced in Bujumbura.

To date, there is only one landfill, unfortunately uncontrolled, located in Mugaruro area of the Buterere zone near the water treatment plant less than 1 km from Lake Tanganyika. It is also important to point out that the Kinyankonge river, a tributary of Lake Tanganyika, passes right next to this open dumpsite, implying that the probabilities of water transfer of pollutants between these two water sources are high (Nsavyimana, 2015).
In addition, less than 200 meters from this open dumpsite live the households who never stop complaining because of the unbearable odour from the fermentation of waste piled up in the open air of this dumpsite and fearing for their health. Worse still, the road leading to this landfill has been impassable for several weeks because of the mud and rubbish thrown there in total disorder (Iwacu, 2019). The informal waste collectors who frequent the landfill daily searching for recoverable/immediately edible objects/products find themselves exposed to very high health risks.

However, according to Yoshida (2018), “insufficient management of the final disposal site [of household and related waste is dangerous for residents and causes environmental pollution given that many of these residents are vulnerable”. Thus, this state of affairs exposes the populations living around this dumpsite to an imminent health disaster, the best indicators of the return of contagious diseases and the proliferation of endemic foci.
This situation is worrying as the waste is of domestic origin and industrial and hospital origin with high risks of infections and often unknown composition. Neither at the source nor the collectors, no selective sorting is carried out. It emerges from the above that *setting up a sanitary landfill fitting in the sound environmental and social standards* is the priority if the municipal authorities meet the challenges posed by the SWM in the city of Bujumbura.

The frequency of collection and transportation of HRW by the various actors being low added to the inadequacy of the storage equipment, the waste being discarded in public spaces and the banks of the rivers that cross the City of Bujumbura to many open dumpsites. Indeed, as in most towns in developing countries, according to Ben and Foully (2008), "the waste collection rate is rarely efficient, except in specific privileged neighbourhoods (shopping centres, tourist areas, residential neighbourhoods in High Standards). It generally ranges from 50 to 70%, but it is much lower in working-class neighbourhoods. In these cases, it is not uncommon to see residents depositing their garbage in drains and gutters or vacant lots, thus obstructing pipes or the creation of illegal dumps ".

Likewise, in Bujumbura, everywhere in the most peripheral and unplanned settlements inhabited by poor populations who cannot afford to pay for the services of private cooperatives engaged in the collecting, transporting and dumping of HRW are visible mounds of garbage. This proves that it is necessary to adopt the "polluter pays" concept to Bujumbura. It is necessary to multiply *actions likely to increase citizen engagement* throughout the management chain of HRW.

However, the bitter failure experienced by the Bujumbura Cleaning Company (BCCO) should serve as a lesson for the parties concerned and thus know that a measure that does not rely on the formal and informal system already in place for some time cannot rise to the challenge posed. Unfortunately, only a few weeks after its starting, it disappointed. The collection rate has significantly decreased for various reasons not yet elucidated. Its failure may have its roots in the very conception of the public-private partnership, which must necessarily be rethought and adapted to the local context, even if it means promoting transparency and inspiring confidence. For the HRW management chain to be operational and efficient, it is necessary to scrupulously analyse the state of play, plan its actions according to the needs expressed by the situation and, above all, ***leave no one behind***. The current situation in the city of Bujumbura is so complex and alarming that everyone must be involved.

5.2. Integrated approach for sustainable management

To overcome HRW in Bujumbura, the best approach to embrace is inevitably the integrated sustainable management approach of solid waste. This three-dimensional approach taking into account the actors, elements and aspects, all condensed in the process of sustainability, is contingent on society, and its implementation depends on the willingness of leaders to embrace that path. The actors concerned principally include those of the formal sector (Municipal Technical Services and private companies/community-based organisations) and the informal collectors (waste pickers). One of the mistakes that the municipal authorities of Bujumbura made was the withdrawal of the Municipal Technical Services in the chain of management of the HRW when they had a significant role to play. The formal sector needs to be strengthened while the informal sector needs to be recognised and integrated to divert some waste to landfill.

Informal waste collectors refer to people who make a living selling recyclable materials found in waste. They are found on city streets, landfills, and municipal trucks that collect and transport waste to disposal sites (Wilson et al., 2006; Scheinberg et al., 2011). These community actors often ignored in the traditional and conventional planning of solid waste management in Bujumbura where the recycling and elimination of household and similar waste remains problematic. Infact, according to Sonia (2016) increasing the lifespan of waste disposal sites, is possible by regularly feeding the recycling market of waste.
Indeed, according to Gupta (2012), in most developing countries, the informal recovery sector manages between 15-20% of waste and thus generates significant financial and environmental benefits for municipalities.

By adopting an integrated approach to the sustainable management of HRW, whom the strengthening of formal structures shall condition success through public-private partnership and the recognition and integration into the established system of community actors from the informal sector, all parties (Ministries having environment and hygiene in their assignments, the Municipality of Bujumbura and private sector investors) would agree to pursue the following specific objectives:

- Optimising the waste collection chain in a global approach of the sectors: collection, sorting and treatment;
- Modernise the waste collection system based on traditional know-how;
- Participate in the management of household and relates waste to control them;
- Reduce, to eliminate as much as possible pollution resulting from poor solid waste management;
- Encourage material and energy recovery;
- Promote/strengthen efforts to create jobs relating to the collection, transport and disposal of solid waste;
- Revitalise the public-private partnership for sustainable development;
- Contribute to the consolidation of national skills in the field of solid waste management;
- Design and develop public information/education actions on waste reduction and sorting;
- Raise awareness and strengthen the technical capacities of community organisations involved in waste collection and transport;
- Identify and eliminate open dumpsites.

The results to be achieved would be as follows:

In the short term

- ✓ The actions of the private actors/community organisations are coordinated;
- ✓ Informal waste collectors are recognised and integrated into the waste management system;
- ✓ The waste collection and transport system is reformed;
- ✓ The cost-recovery process of fees from service users is reformed;
- ✓ The illegal dumps near households and public places are removed;
- ✓ Door-to-door collection and waste transport services by service providers to a specialised site are improved;

In the medium term

- ✓ The technical, material and human capacities of private actors/community organisations engaged in the collection of household and related waste are reviewed and strengthened;
- ✓ Quantitative and qualitative prevention of waste through public awareness and education;
- ✓ Promoting the introduction of efficient practices of regular waste collection at the level of cooperatives in order to fulfil their missions following environmental standards;
- ✓ Creation of jobs through informal structures to reduce unemployment;

In the long term

- ✓ Prevent or reduce the production and harmfulness of waste;
- ✓ Organise the transport of waste and limit it in terms of distance and volume;

- ✓ Recovering waste by reuse, recycling, or any other action aimed at obtaining, from the waste, reusable materials or energy;
- ✓ Provide information to the public on the effects on the environment and public health of waste production and disposal operations as well as on measures intended to compensate for the harmful effects;
- ✓ Encourage the emergence of environmental awareness among the urban city populations, particularly in the outlying districts.

For this approach to be successful, the following conditions must first be met:

- ➢ Review of institutional arrangements;
- ➢ Sensitisation and capacity building of primary actors;
- ➢ The establishment of norms, standards and guidelines;
- ➢ The design of appropriate and adapted infrastructures.

The benefits to be drawn from the implementation of an integrated approach to the sustainable management of household and similar waste will be, without being exhaustive, the following:

- ✓ Minimising the impact of waste on the natural and human environment;
- ✓ The attractiveness of the city of Bujumbura;
- ✓ Preservation of aquatic ecosystems, including Lake Tanganyika;
- ✓ The conservation of natural resources;
- ✓ Reducing the toxicity of waste.

6. Conclusion

The SWOT matrix is a strategic analysis tool that enabled us to identify the strengths, weaknesses, opportunities and threats of the household and similar waste service in Bujumbura. It was noted that Burundi is still at the first stage according to the logic developed by Yoshida (2012). Solutions proposed through the matrix of cross-referencing of internal and external factors allowing to maximise strengths, optimise opportunities, correct some weaknesses and neutralise specific threats in the Burundian context were presented in favouring, in particular, the integrated approach of sustainable waste management.
The technical facilities for collection and transport, the frequency/regularity of collection, the waste deposal/storage infrastructure, and human resources are all challenges to be taken up. So it is critical to strengthen formal structures and integrate informal structures in the scheme of management of HRW so that no one is left behind while tackling the enormous challenges posed by the overgrowing mounds of household waste that expose the inhabitants and Lake Tanganyika to an environmental disaster.

Conflict of interest

Authors declare no conflict of interest.

Author Contribution Statement

F.N. Carried out the survey. F.N., W.E.Z., and A.E.B. discussed the results and contributed to the preparation of the manuscript

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