



THE CITY OF KIGALI



Kigali (Rwanda) **Solid waste management strategic plan**

Final report



BTC – PAPSDSK Rwanda

Elaboration of the solid waste management strategic plan of the City of Kigali (Rwanda)

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Abbreviations

BCA	Belgian Cooperation Agency
BTC	Belgian Technical Cooperation
CoK	City of Kigali
MoH	Ministry of Health
MinInfra	Ministry of Infrastructure
EWSA	Energy Water and Sanitation Agency
REMA	Rwanda Environment Management Authority
RURA	Rwanda Utilities Regulatory Authority
RECPC	Resource Efficient and Cleaner Production Centre
UNIDO	United Nations Industrial Development Organization
WHO	World Health Organization
PSF	Private Sector Federation
DW	Domestic Waste
CW	Commercial Waste
HW	Healthcare Waste
IW	Industrial Waste
USD	United States Dollars
EUR	Euros
RWF	Rwandan Francs

Foreword

Context of the request

A strategic plan for solid waste management was expressed by the City of Kigali as a need for a better environment of livelihood and a framework for projects related to the solid waste collection and treatment. As part of the assistance to the City of Kigali, this study was funded by the PAPSDSK programme of the Belgian Cooperation Agency.

The PAPSDSK programme is to provide an institutional support to the conception and implementation of a strategic health development plan for the City of Kigali in close relationship with the Ministry of Health. It has started in January 2009 for a duration of 4 years.

Scope of the study

The geographical perimeter of the study is the territory of the City of Kigali with its 3 districts. The City of Kigali is the central province of the country and has the responsibility of defining the waste management strategy.

The technical perimeter of the study corresponds to the main solid waste generated by human activities on the territory of the City of Kigali. The four different types of waste therefore considered in this study are household waste, commercial waste, healthcare waste and industrial waste.

Executive summary

This report is gathering all the statements and recommendations made by the study allowing the design of the solid waste management strategic plan of the City of Kigali. The study has been carried out between the 20th of February and the 19th of March 2012, with a stay in the field from the 20th of February until the 15th of March.

Situation analysis

First of all, a situation analysis of current solid waste management and identified projects in the City of Kigali has been carried out. In particular, it allowed the identification of the main stakeholders, current practices, and flows of waste and related money.

The produced amount of solid waste has been estimated by origin (domestic, commercial, healthcare and industrial waste) and also by potential resource: the current production is around 170 000 tons per year, with almost 90% coming from households. It is relatively low but should much increase in the ten years to come, with a high population growth rate and the current growth of the local industry.

Some good projects have been identified and endorsed by the strategic plan, like the sanitary landfill and beside tools. However, the household collection has to be improved quantitatively from about 44% of coverage (with almost 0% in rural areas of the province) and qualitatively in terms of organisation and the valorisation of waste should also be developed through a composting facility and a sorting centre.

Modalities of improvement

The report identifies and quantifies potential markets for compost (30 000 tons) and recycled materials in the country that are very encouraging the development of valorisation. It also sets some realistic objectives of collection and valorisation: the collection would go from 44% to 62% for households and the global valorisation rate would achieve 39% which is very honourable.

From a range of conditions allowing an improved solid waste management and some critical analysis of projects, recommendations are made in the form of various projects to be integrated into the strategic plan. A main asset is the implementation of a sorting facility on the landfill site, in two phases with two lines first and an additional line in 2017.

Strategic plan

The strategic plan is retaking the recommendations presented around six components:

Component I : Collection

Component II : Valorisation

Component III : Treatment

Component IV : Empowering

Component V : Incentives

Component VI : Communication

The components are precisely described, budgeted for a total amount of almost 11 million Euros and planned in the next ten years.

Some endorsement of this strategic plan has been done during a workshop organized on the 14th of March and having allowed it to be comforted and enriched by comments and remarks. A requested comparison between the two options considered shows a higher environmental negative impact for sorting at transit and

a higher social and economic impact for sorting at facility, so it is recommended to choose the sorting facility in order to induce further development of the country through solid waste management.

In the case of a sorting facility, the expected direct employments to be created by the programme would be of 68 private employments and 23 public employments, plus all indirect employments in the local recycling industry. The amount of solid waste to be diverted and valorised in the industry would be 21 503 tons per year.

1. Situation analysis of solid waste management

1.1 General context

1.1.1 Rwanda

The country of Rwanda is located in central Africa, in an area where hills are predominant. The climate is tropical with two rainy seasons, but it is moderated by an average altitude of about 1 000 meters.

The total population of Rwanda is about 10 million with 1 million in the City of Kigali and it is mostly rural. Its density is the most important in Africa because of various inner and outer immigrations, especially in the City of Kigali.

Rwanda is a dynamic country where the economy growth rate has been around 8% in the past few years. It is expected to remain about the same because of an ambitious plan of development based on external investment.

1.1.2 City of Kigali

The City of Kigali (CoK) is the capital city and the largest city of Rwanda. It is also one of five Provinces of Rwanda, situated in the centre of the country

Kigali is about 104 years old, having started in 1907 as a small colonial outpost. It is now a safe and clean city, with a political vision to make it competitive and modern which seems to be on a good way.

The territory is characterized by inter-linked convergent little hills and separated by large valleys. The average altitude is about 1400 metres above sea level.

The population of Kigali is about 1 million inhabitants spread on a territory of 730 km², showing a density of 1370 inhabitants per square kilometre. The population growth is of 4.4 % per annum which is about two times bigger than the national population growth rate.

The City of Kigali is made up of the three districts of Nyarugenge, Kicukiro and Gasabo, as shown on Illustration 1, and then divided in 35 sectors, 161 cells and 1084 villages (imidugudu). The most populated districts are the ones of Nyarugenge (where the centre hill lies) and Kicukiro.

Erreur ! Des objets ne peuvent pas être créés à partir des codes de champs de mise en forme.

Illustration 1 : Districts and sectors of the City of Kigali

The territory of the City of Kigali is mostly urban but is characterized by a significant surrounding of rural environment. The rural population may be estimated of about 30% from the figures in the referred [8] document in [Appendix 1](#), as in Table 1.

Table 1: Population broken out by district

District	Population		Rural fraction	
Nyarugenge	235 544	26%	18%	42 398
Kicukiro	249 284	27%	15%	37 393
Gasabo	426 150	47%	45%	191 768
Total	910 978	100%		271 558

1.2 Analysis of the institutional and legal framework

1.2.1 Relevant institutional stakeholders

1.2.1.1 Ministries

- Ministry of Health:

The Ministry of Health (MoH) is among the most active ministries about solid waste management in the country. Because health is also dependent on waste collection and treatment, it cares of the spreading of good practices in solid waste management, especially through the Environmental Health Desk and its network of environmental health officers at the district level.

For instance, MoH was at the origin of the edition of guidelines about solid waste management at household level (only available in Kinyarwanda language) where it is recommended to separate organic waste in order to use it as compost. These guidelines should be integrated into the Hygiene Law to be published after the review of the Ministry of Local Government.

MoH also plays a specific role in the healthcare waste management where it usually takes the lead within the coordination of the so-called National Hygiene Inspection Team. Such a way, the Ministry of Health has drafted the National Strategic Plan for the Management of Healthcare waste and it will be considered as the reference institutional stakeholder for healthcare waste.

Recently, the Environmental Health Desk initiated a five-year plan for healthcare waste management where more precise data were gathered. It also coordinated the improvement of the final treatment of the most infectious waste.

- Ministry of Environment and Natural Resource:

The Ministry of Environment and Natural Resource is logically concerned by all waste management issues, on behalf of possible pollution from waste but also on behalf of an environmental resource management. Its first role is then to publish the appropriate legislation like the Law for Environment.

It also assumes the responsibility of following the good application of the law and its principles through its Management Authority (REMA) which is directly involved in solid waste management. This may be done by the edition of guidelines and the fostering of environment friendly projects in the country.

- Ministry of Infrastructure:

The Ministry of Infrastructure (MinInfra) is responsible for the proper design and management of structural equipment used in the country. To do so, it is divided in various departments responsible for technical assessment and assistance to projects.

About solid waste management, the relevant organization is EWSA (Energy, Water and Sanitation Agency) which provides necessary information to projects and assess them in terms of priority for the country and the City of Kigali. This technical role may be determinant for final acceptance and possible funding by the political authorities.

Where waste treatment is an important issue like in Kigali, EWSA is the main institutional stakeholder for technical aspects. Its position has to be central in the design of the technical solutions adopted in the strategic plan.

- Ministry of Trade and Industry:

The Ministry of Trade and Industry is in charge of all policies regarding business and its impacts on economy and environment. Since the country is developing rapidly, it plays therefore an important role in the regulation of the way the growth of both sectors should operate.

In particular, commercial and industrial waste should increase proportionally to the production that is around 7%. However, some actions could be carried out to reduce it in coordination with initiative like the Rwanda Resource Efficient and Cleaner Production Centre (RECPC) supported by UNIDO.

- Ministry of Finance and Economic Planning:

The Ministry of Finance and Economic Planning is a potential partner for projects that would have been recommended by the competent ministry. After an assessment process, first politically and then financially, it plays the role of the national coordinator for funding.

It is important to note that it can provide funding for investments but also in the operations of a project, which might be very important in the case of environmental waste management. Indeed, some treatments required by the environment preservation prevent the projects from being cost effective.

1.2.1.2 Authorities

- Rwanda Utilities Regulatory Authority (RURA):

The Rwanda Utilities Regulatory Authority is a governmental institution that regulates all types of services by balancing the profit of private companies and the quality to the consumers. In order to do so, it is allowed to publish regulations and guidelines to complement policies set by ministries.

About solid waste management, RURA published the guidelines to regulate the design and operation of landfills in the country and also the transportation rules for waste (to be translated in English). RURA also verify the licences of collection and recycling companies on an annual basis: this is in order to manage the contracts signed with the local administration.

- Rwanda Environment Management Authority (REMA):

The Rwanda Environment Management Authority plays the role of implementer of the environmental policy of the Ministry of Natural Resource and of regulation for all environmental matters. In particular, it is responsible of all environmental impact assessments.

About solid waste management, REMA has especially emphasized the nuisances caused by plastic bags (visual pollution, sewage obstruction, animal ingestion, irrigation blocking and burning emissions) which originated the banning law. It also fosters studies about the interest of composting in the country and the ways to care of electronic waste.

REMA may sometimes authorize some strategic equipment, even if the environmental impact has not been carried out. This seems to be the case in recent projects like for the incinerator of healthcare waste.

1.2.1.3 The City of Kigali

Until today, the City of Kigali has the responsibility of solid waste management in the whole territory of the province and is allowed to develop its rules according to the existing laws and guidelines. This responsibility stands for collection and treatment, whatever the origin and the type of waste is.

In accordance to the decentralization law, the three districts of Kigali (Gasabo, Kicukiro and Nyanrugenge) participate to the choices made and are responsible for the implementation of the rules defined. It also plays the role of collecting taxes.

The operational level of solid waste collection and communication towards the population is on sector level, in coordination with the districts. The sectors coordinate the collection by the cooperatives or companies, try to impose some price framework, control the effectiveness and even impose some fines to the reluctant households (case of Nyanrugenge).

1.2.2 Relevant laws and rules

1.2.2.1 Environmental law of Rwanda

The environmental law of Rwanda was voted in 2005. It defines all the rules to be applied in order to preserve the living environment for the whole population of Rwanda, especially in urban areas.

In order to find solutions to the environmental problems and ensure the protection of the environment, five basic principles should be kept in mind: protection, sustainability, polluter-pays, information, and cooperation. These principles have been used to define rules about solid waste management but the law is sometimes self-sufficient.

The law also sets out institutional and legal reforms with a view to providing the country with a coherent and harmonious framework for coordination of sector and cross-cutting policies. It furthermore introduces innovations including, among others, the establishment of a Rwanda Environment Management Authority and provincial and district or town committees responsible for environmental protection.

About solid waste management, Title VI especially gives preventive provisions like the prohibition of any dumping or disposal of any solid, liquid or gaseous substances in a stream, river, lake and their surroundings, and also in wetlands. Another article prohibits the piling, importing, immersing, burning or eliminating waste by any process which do not respect the rules applied in Rwanda.

1.2.2.2 National policy for water supply and sanitation services

The national policy for water and sanitation was designed in 2010 by the Ministry of Infrastructure. It rules the ways the supply of water on the one hand, and liquid and solid waste on the other hand should be managed in the country.

In particular, it is recalling "Vision 2020" of the country (dated of 2000): "At least 80% of the Rwandan population will have easy access to adequate waste management systems and will have mastered individual and community hygiene practices." However, this objective should be defined more in detail.

The implementation of solid waste management corresponds to Objective 8 of the policy and is dependent on social acceptance and financial and technical feasibility. Its priorities are defined as below:

- Minimize waste;
- Develop an integrated approach for solid waste management;
- Recover value from waste and promote safe collection involving the private sector (with 70% of composting in 2020);
- Ensure a safe disposal of residual waste.

Additionally, some emphasis is put on the need for the self-supported recycling through private sector companies. Public Private Partnerships (PPP) arrangements are also mentioned about bigger facilities in order to alleviate public financing needs and ensure costs recovery.

1.2.2.3 National strategic plan for the management of healthcare waste

A national strategic plan for healthcare waste management plan was adopted by the Ministry of Health to define a framework to improve by putting in place safe practices in healthcare facilities for sorting, collection, transportation, storage and disposal. It is supported by the five-year operational plan that details its implementation.

The operational plan especially calls for a district-decentralized management of healthcare waste. It also sets the conditions of transportation and treatment of healthcare waste.

Two types of typical healthcare waste are distinguished : toxic waste that is defined by quoting the type of products concerned (cellulosic dressing, PVC blood bags, PUR and silicon rubber gloves and catheters, and other disposables made of PE, PMMA, rubber, etc...) and non-toxic waste (needles, bistouries, etc...). Hospitals also emit general waste coming from the people sometimes living with their family.

The toxic waste fraction should be treated by large-scale incineration equipment with good standards under the supervision of the Environmental Health Desk, but it also has to be reduced by an improved sorting of healthcare waste. The other types of non-toxic waste might be treated with a lower regulation.

1.2.2.4 Standards on the management of waste disposal sites

It was decided that RURA designs the management of disposal sites through guidelines that were adopted from 2001. The resulting standards define the way the landfill should be located, designed and operated.

In particular, the landfill site should:

- have three metres of earth above the seasonable high ground water level,
- not be closer than 100 metres upstream from a public water supply well,
- not be located in aquifer recharge areas or public water supply catchment areas.

Additionally, not to lessen the impacts, it should:

- not be closer than three thousand (3 000) metres from an airport,
- not be closer than four hundred (400) metres from an existing residential development,
- not be closer than hundred (100) metres from an area to which the public have access.

All new landfills should be constructed with double composite liner to provide a secondary containment for leachate and a collection system installed between liner layers, able to detect leakage before it enters the groundwater underneath the landfill. There is no requirement about the emission of greenhouse gas that could be collected.

1.3 Analysis of the supply chains

1.3.1 Collection

1.3.1.1 Current situation

The current collection system is common to waste from the households, businesses, industries and part of the healthcare waste: it is mainly composed of a single transportation from waste producers to the landfill. No transfer station officially exists since it has been banned for environmental reason and lack of space in the urban area.

However, some pre-collection does exist in the most hilly and poor neighbourhoods because the trucks cannot use the ways up to the households. The collectors use wheelbarrows or bags to bring the waste to trucks that then play the role of mobile transfer stations.

The operators of the collection are only private companies (2) or semi-private cooperatives (30). They have to be annually licensed by RURA to contract the waste producers, according to a price usually following some agreement at the sector level but without any obligation to cover any territory.



Illustration 2 : View of the collections means used in the City of Kigali

As a matter of fact, there are many areas where no collection is proposed because the households are too poor to pay the fee or because they do not have the will to contribute. With success, some repressive measure has been taken in the district of Nyarugenge to avoid such behaviour by paying the collectors with means of the district.

Most of collection companies and cooperatives use little trucks of common type for the country of about 12 m³, and the cooperatives usually hire them. To a much less extent, some pick-ups are also used.

An average number of 60 each day can be counted at the entrance of the landfill. As the density of the collected waste is supposed to be around 250 kilos per m³, it means that some 180 tons per day are collected: this may be used to calculate the collection coverage after recycling.

Additionally, a street sweeping service is performed by five associations of the three districts: with six little trucks of 5 m³, it brings about 10 tons per day to the landfill. This service is managed and paid by the City of Kigali for the main roads and by the districts for secondary roads.

In the case of commercial waste coming from either markets or supermarkets, a separation of the large fraction of organic waste is sometimes organized in order to make compost used in agriculture (case of the Nyabugogo food market). The principle of the collection is gathering the waste in one place close to the markets or supermarkets and the transportation is done by the associations paid by the sectors.



Illustration 3 : Views of market waste in the City of Kigali

For the household waste produced in a country like Rwanda, the production ratio is at least 0.4 kilogram per inhabitant per day and this could be confirmed by some figures from the collection companies. A collection coverage rate is of 44% has been calculated from the solid waste being brought to the landfill which is about 180 ton per day.

The coverage rate is quite low and surprising since not much waste can be seen in the streets. It might be explained by very little service in rural areas where self-composting is efficient, informal recovery of packaging throughout the city and probably still open burning of household waste.

Actually, this was confirmed by some discussions at the district level that the collection service almost does not exist in rural areas. It means that the actual population concerned by the collection is around 70%, i.e. 700 000 inhabitants, and the collection rate for the urban population is 64%.

Especially for industrial solid waste, some kind of transfer station can be observed in one location near the industrial area at least. Waste is sorted by material before being sent to local factories in the country or in Uganda and Kenya.

1.3.1.2 Identified projects

One of the collection companies, namely COPED, has recently initiated some collection with sorting at source in businesses and in high-income households, following the pattern of what is practiced in many European countries. It even started to communicate towards the population in order to foster it.

1.3.2 Treatment

1.3.2.1 Current situation

- Household, commercial and industrial waste

The main treatment of solid waste is currently the dumpsite of Nyanza, at only about ten kilometres from the city centre. It is now near a residential area and that should be closed in the near future on a political decision.

It is a common landfill for various types of solid waste originally from households, businesses and industries, without any specific installation to reduce its environmental impact. It is also used for liquid waste treatment.

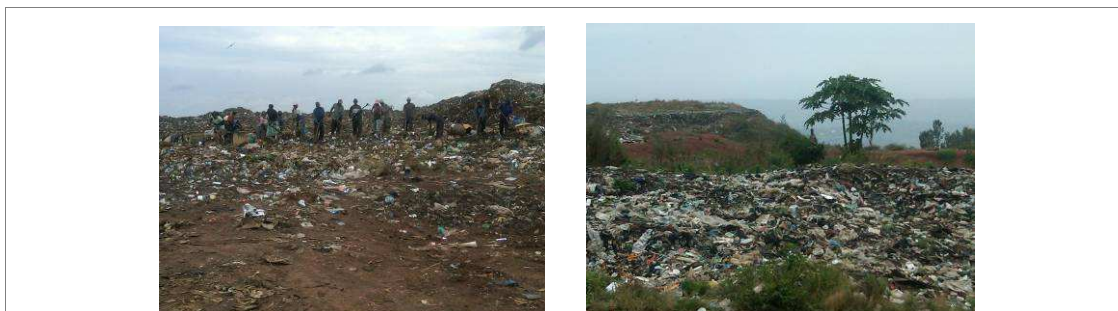


Illustration 4 : Views of the current landfill of Nyanza

The only contract that the collection companies have to sign with the City of Kigali is for their allowance to deliver waste to the landfill. The tipping fee does not directly depend on weight or volume because it is not measured but, as a matter of fact, is around 1 000 RWF per ton.

- Healthcare waste

Healthcare waste comes from the seven hospitals of the City of Kigali (about 2 000 beds) and its health centres, including the two referent hospitals (namely the Teaching Hospital of Kigali and King Faycal Hospital). It is sorted at source in toxic waste (mostly coming from the pharmaceutical industry), infectious waste and general waste.

The infectious and toxic waste has a special treatment through local basic incineration at about 800 °C with no further treatment and the general waste is oriented to Nyanza landfill. The ashes of incineration are run by a specific collection contract and are also dumped at the Nyanza landfill.



Illustration 5 : Views of the current treatment in the hospitals of Kigali

Apart from that, the hospital incinerators are used to burn some end-of-life non used medicines or needles, known as toxic waste, coming from CAMERWA in charge of buying devices for hospital. This amount of waste is estimated at about 100 tons per year.

According to the healthcare strategic plan recently adopted, the current incinerators are being replaced gradually by more environmental tools complying with the WHO thresholds, showing a capacity of 60 kilograms per hour and homologated by the Ministry of Health. The most infectious waste and the toxic waste coming from the pharmaceutical industry should be oriented to an even safer performing incinerator.

1.3.2.2 Identified projects

In the preparation for the current landfill closing, a temporary landfill has been defined in a site of Nduba at about 20 km of the city centre. This site will not have any sanitary specifications for solid waste and its use will imply the expropriation of many people.

A new sanitary landfill complying with the RURA standards is planned for 2014 and is being studied by a team of German consultants. The site chosen should be in a location called Ruliba at 12 kilometres of the city centre, where some large cavities lies, but it would require some adjustments of soil because of the close presence of water.

The last project about disposing waste is the rehabilitation of the current Nyanza landfill. This will be a tricky project because it was not planned but has to be set in order to prevent the local residents from any further nuisance.

A national incineration tool with a high environmental level will be implemented after an investment of about 1 million USD, in order to provide a safer treatment to toxic healthcare waste from the hospitals: it is designed according to WHO (World Health Organization) standards including a fume treatment device and also filters. It should be privately run and might accept other types of hazardous waste, depending on the acceptance of the Ministry of Health and the capacity of 200 kilograms per hour.

1.3.3 Valorisation

1.3.3.1 Current situation

At the truck arrival to the landfill, many scavengers sort the recyclable waste (mainly metals, plastics and paper packaging) in order to sell it to intermediate dealers or directly to recycling companies. The solid waste diverting from landfill is informal and occurs mainly at this last stage or at earlier stages of the collection.

The supply chains of recycling in the country are for organics, steel, polyethylene (HDPE and LDPE) and office paper, depending on the local presence of manufacturing. Other materials like aluminium, glass, PET or board are oriented to Uganda or Kenya for recycling, if not to India and China after some shredding.

Since 2002, an interesting way to valorise organics has been developed by a local cooperative called COOCEN (see [Appendix 3](#)). After sorting from collection between organics and recyclables that are sold to informal dealers, the organic waste (about 60 tons per day) is dried, shredded, compacted and cut in "briquettes" that may be used as combustible and that has already found some markets.

The private company COPED has implemented a factory, now independently run and called ECO-PLASTIC that can recycle LDPE and HDPE films by the manufacture of bags that are used for waste collection (see [Appendix 4](#)). It represents the first closed loop in the country.

In particular, the local industry has been consulted in order to evaluate the local capacities in a qualitative way (see [Appendix 5](#)). It was basically confirmed that some possibilities already exist and should develop in the following years in existing companies for paper and plastics, but also that they would need some sensitization and maybe support for that.

1.3.3.2 Identified projects

In order to face the huge amount of organic waste not yet valorised, the projected new site of treatment at Ruliba will integrate a composting facility able to treat the organic fraction of waste coming from households at least. It is to be designed by the German consultancy along with the landfill and a Mauritian company has proposed to privately operate it.

Similar to the COOCEN initiative, a project of the NGO AMIZERO and a private investor is reported to produce compressed fuel balls from the organic part of waste but could not be visited. It is being studied technically and economically at the level of IRST.

1.4 Estimation of the solid waste amounts

1.4.1 Solid waste by origin

1.4.1.1 Household solid waste

Household solid waste may be defined as the solid waste that is produced at the level of the households. It mainly contains general waste like cooking residue and packaging waste, and a limited part of hazardous waste like batteries and electronic waste.

The production of waste at household level has been estimated through a few ratios calculated in various areas. From the statement of a waste collector, the ratio in a poor neighbourhood drops down to 0.2 kilogram per inhabitant and per day, which is very low.

Since the poor neighbourhood are still major in the City of Kigali, the global ratio is assumed not to be higher than 0.4 kilograms per inhabitant per day. This basis has been used for the estimation of the amounts of household waste.

Without any reliable measurements, a classical composition for a country like Rwanda has been applied in order to get the amounts of each main material. As usually accepted, the proportion of organic waste is considered of 70% and the other fractions have been taken from the experience of collection companies.

Table 2: Estimated production of household solid waste

			Emitted weight (tons per year)										
Resources	Composition	Ratio	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Organics	70%	0,28	102 200	107 888	113 892	120 230	126 921	133 985	141 441	149 313	157 622	166 394	175 654
Plastics	5%	0,02	7 300	7 653	8 022	8 410	8 816	9 242	9 688	10 156	10 646	11 161	11 700
Paper	6%	0,02	8 760	9 183	9 627	10 092	10 579	11 090	11 626	12 187	12 776	13 393	14 040
Aluminium	3%	0,01	4 380	4 596	4 823	5 061	5 311	5 573	5 848	6 136	6 439	6 757	7 090
Glass	1%	0,00	1 460	1 534	1 611	1 692	1 777	1 867	1 961	2 060	2 164	2 273	2 387
Various	15%	0,06	21 900	23 004	24 163	25 381	26 660	28 004	29 415	30 898	32 455	34 091	35 809
Total	100%	0,40	148 012	155 870	164 152	172 880	182 080	191 777	201 997	212 769	224 122	236 089	248 702

From the current production, some assumption has been made for the production in the next ten years, considering the current population growth in the City of Kigali of 4% and an extra increase of the ratio of 10% during the ten years has been applied additionally with on a regular basis. Due to the expected economic development of the country, the composition has been considered to slightly evolve to more packaging with 5 points passing from organics to plastics (2 points), paper (2 points) and aluminium (1 point).

The production of household solid waste is expected to increase of about 68% in ten years. There will be more than 100 000 additional tons per year coming from households, reaching up to 250 000 tons per year.

1.4.1.2 Commercial solid waste

Commercial solid waste may be defined as the solid waste produced in markets or supermarkets. It is mainly composed of organics and packaging without hazardous part.

The production of commercial solid waste is directly dependent on the population and therefore on the production of households which are the clients. According to the experience of the consultant in similar contexts, it is 2% of production from households.

Table 3: Estimation production of commercial solid waste

			Emitted weight (tons per year)										
Resources	Composition	Ratio	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Organics	75%	0,008	2 738	2 875	3 020	3 173	3 333	3 500	3 677	3 862	4 057	4 261	4 476
Plastics	10%	0,001	365	383	403	423	444	467	490	515	541	568	597
Paper	5%	0,001	183	192	201	212	222	233	245	257	270	284	298
Glass	5%	0,001	183	192	201	212	222	233	245	257	270	284	298
General	5%	0,001	183	192	201	212	222	233	245	257	270	284	298
Total	100%	0,010	3 650	3 834	4 027	4 230	4 443	4 667	4 903	5 150	5 409	5 682	5 968

No particular change in the ratio per inhabitant has been considered during the ten-year period, since some effort might be done in order to reduce packaging. No change has been considered in the composition.

The production of commercial solid waste will logically increase in the same way as the one from households. It will remain relatively low but still difficult to manage.

1.4.1.3 Healthcare solid waste

Healthcare solid waste may be defined as all solid waste produced inside the hospitals. This actually includes three types of solid waste to be differentiated:

- the toxic healthcare waste (medicines, dressings, gloves, bags, catheters and other disposables, etc...);
- the infectious (non-toxic) healthcare waste (needles, bistouries, etc...);
- and the general solid waste (similar to household waste).

The production of healthcare waste has been reported in the document referred as [7] in [Appendix 1](#). The production in the seven hospitals of the province of Kigali (including the Kigali Teaching Hospital and the major King Faycal Hospital) is about 28% of the national production.

The total quantities of healthcare waste are 15 tons per day including the health centres, so the production in the City of Kigali should be of around 4 tons per day. The three fractions of healthcare waste can be considered as according to the following table.

Table 4 : Estimated production of healthcare solid waste

			Emitted weight (tons per year)										
Resources	Composition	Ratio	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Infectious	50%	0,002	730	767	805	846	889	933	981	1 030	1 082	1 136	1 194
Toxic	25%	0,001	365	383	403	423	444	467	490	515	541	568	597
General	25%	0,001	365	383	403	423	444	467	490	515	541	568	597
Total	100%	0,004	1 460	1 534	1 611	1 692	1 777	1 867	1 961	2 060	2 164	2 273	2 387

No particular evolution has been considered either in production ratio or in composition during the ten-year period. It is therefore only following the population increase.

The production of healthcare solid waste will logically grow the same way as household ones. It should remain relatively low but still hazardous.

1.4.1.4 Industrial solid waste

The industrial solid waste may be defined as the solid waste that is actually produced by the industrial plants, except the construction sector that mostly has mineral waste considered to be internally managed as embankment by the companies. It is qualitatively very different in each industrial the sector and might include a fraction of hazardous waste.

Some estimation of the produced waste has been made from a recent list of companies present on the territory of the City of Kigali obtained at the Ministry of Trade and Industry. Usual production of industrial waste has then been calculated on the basis of some common production in the country after discussion.

Table 5: Estimation production of industrial solid waste

Resources	Composition	Emitted weight (tons per year)										
		2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Organics	49%	7 056	7 691	8 383	9 138	9 960	10 857	11 834	12 899	14 060	15 325	16 704
Minerals	17%	2 448	2 570	2 699	2 834	2 976	3 124	3 281	3 445	3 617	3 798	3 988
Glass	6%	864	933	1 008	1 088	1 175	1 269	1 371	1 481	1 599	1 727	1 865
Textile	5%	720	778	840	907	980	1 058	1 143	1 234	1 333	1 439	1 554
Iron	3%	432	454	476	500	525	551	579	608	638	670	704
Aluminium	2%	288	302	318	333	350	368	386	405	426	447	469
Plastics	2%	288	305	324	343	364	385	409	433	459	487	516
Paper	2%	288	311	336	363	392	423	457	494	533	576	622
Various	14%	2 016	2 197	2 395	2 611	2 846	3 102	3 381	3 685	4 017	4 379	4 773
Total	100%	14 400	15 542	16 778	18 117	19 567	21 138	22 839	24 683	26 681	28 847	31 194

The current annual growth of 7% in the manufacturing industry responsible for the larger emission of waste has been considered along the ten-year period. A distribution of this growth was done according to the expected more growing sectors such as the food industry.

The production of industrial solid waste is expected to double in ten years. It seems to be worth considering an appropriate treatment for industrial waste that could be managed nationally in the future.

1.4.2 Global amounts by origin

The amounts of each origin are gathered and presented together in the following table. This is to show the quantitative importance of each category currently and in the future.

Table 6: Global amounts of solid waste by origin

Origin	%	Emitted weight (tons per year)										
		2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Household	88%	148 012	155 870	164 152	172 880	182 080	191 777	201 997	212 769	224 122	236 089	248 702
Commercial	2%	3 650	3 834	4 027	4 230	4 443	4 667	4 903	5 150	5 409	5 682	5 968
Healthcare	1%	1 460	1 534	1 611	1 692	1 777	1 867	1 961	2 060	2 164	2 273	2 387
Industrial	9%	14 400	15 542	16 778	18 117	19 567	21 138	22 839	24 683	26 681	28 847	31 194
Total	100%	167 522	176 779	186 568	196 920	207 868	219 449	231 700	244 661	258 376	272 890	288 252

Industrial waste should double in weight in ten years and will grow from 9% to 11% of global solid waste amounts. It seems to be quite important to plan some specific management.

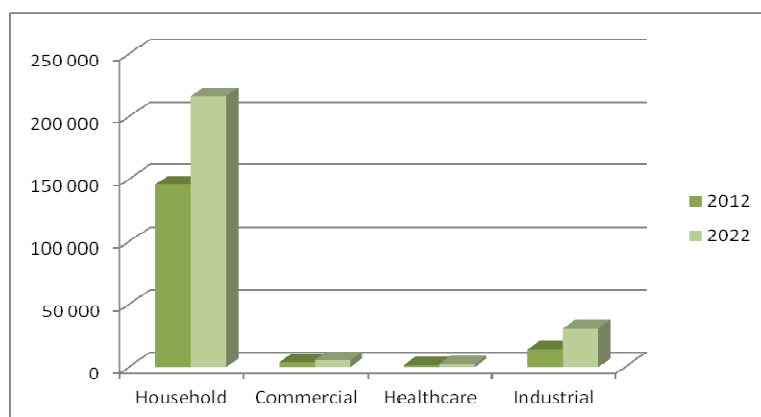


Illustration 6 : Global amounts by origin

1.4.3 Global amounts by resource

Since the materials of solid waste were quite similar upon their origin, it was interesting to classify them by resource in order to manage it by priority. The following table and illustration are quite significant.

Table 7: Global amounts of solid waste by resource

Resources	Composition	Emitted weight (tons per year)										
		2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Organics	67,9%	112 249	118 723	125 577	132 837	140 525	148 668	157 295	166 434	176 117	186 378	197 252
Minerals	1,5%	2 448	2 570	2 699	2 834	2 976	3 124	3 281	3 445	3 617	3 798	3 988
Plastics	4,8%	7 971	8 360	8 769	9 197	9 646	10 117	10 611	11 130	11 673	12 244	12 842
Paper	5,6%	9 252	9 709	10 188	10 691	11 220	11 775	12 357	12 969	13 612	14 287	14 996
Textile	0,4%	720	778	840	907	980	1 058	1 143	1 234	1 333	1 439	1 554
Iron	0,3%	432	454	476	500	525	551	579	608	638	670	704
Aluminium	2,8%	4 679	4 910	5 153	5 407	5 674	5 954	6 248	6 557	6 881	7 221	7 578
Glass	1,4%	2 328	2 471	2 623	2 785	2 957	3 141	3 337	3 546	3 768	4 006	4 259
Infectious	0,4%	730	767	805	846	889	933	981	1 030	1 082	1 136	1 194
Toxic	0,2%	365	383	403	423	444	467	490	515	541	568	597
Various	14,6%	24 153	25 450	26 820	28 267	29 795	31 409	33 115	34 918	36 824	38 839	40 969
Total	100,0%	165 328	174 575	184 353	194 693	205 630	217 198	229 436	242 385	256 086	270 585	285 932

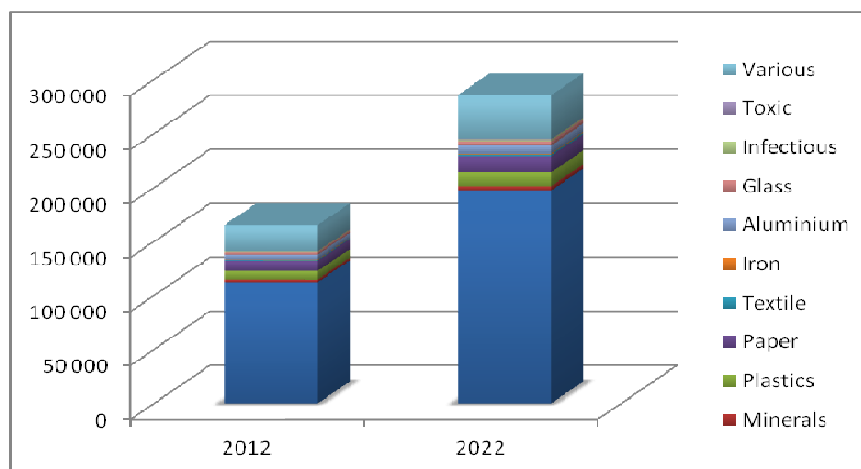


Illustration 7 : Global amounts by resource

Without any doubt, organic waste is and will remain the most important fraction of global solid waste and should be faced at first. After "various waste", it is "recyclable materials" that will all increase in amount and constitute more secondary raw materials for the local industry.

1.5 Analysis of the financial flows

1.5.1 Current situation

1.5.1.1 City of Kigali

For now, quite little expenses are made by the City of Kigali for solid waste management, because it was chosen to externalize many services like the collection. Basically, it concerns one position and a few contracts especially at the landfill site.

The only revenue comes from the entrance of the landfill where each truck of the collection companies has to pay some tipping fee of either 3 000 RWF or 5 000 RWF. The average is around 1 000 RWF per ton.

Some surprising information is that there would not be some specific budget for solid waste management at the City of Kigali for the time being. However, it seems that some districts would have such a budget coming from the general management and potential fines.

1.5.1.2 Waste collectors

The collection service is paid by households, businesses and industry from 2 000 RWF per month for a basic household to 20 000 RWF per month (or even more) for a hotel or a restaurant, depending on the number of persons and the amount of waste generated. Some companies like COPED have well defined a tariff pattern for their clients, including the purchase of plastic bags.

According the possible number of persons per household, the production of solid waste may vary from 50 to 200 kilograms per month. This means that the money got ranges from 20 to 50 RWF per kilograms or 20 000 to 50 000 RWF per ton.

The companies have to pay the personnel and the petrol that is quite expensive in Rwanda. However, the profit of the collection companies is supposed to be good with a low the tipping fee at the landfill.

1.5.2 Foreseen projects

A price frame is generally admitted to be missing, especially for the collection service. RURA should take care of defining some framework in accordance with the current practice and the price of 2 000 RWF has been mentioned as a minimum.

Weighing waste at the entrance of the new landfill and other facilities should be implemented through a weighbridge. Such a way, the waste would be paid per weight on the steady basis.

2. Modalities for an improved solid waste management

2.1 Conditions for a sustainable improvement

2.1.1 General framework

It seems very important that the solid waste management benefit of some better institutional and regulatory framework. It will be the basis of a successful implementation of the strategic plan.

From an institutional point of view, the responsibilities of the various stakeholders have to be clear. The same way, the rules that should be followed for the collection and treatment of the various types of solid waste have to be clearly designed.

2.1.2 Sustainable development

The recommendations have to be guided by the principles of sustainable development, according to its three social, environmental and economic pillars. It means that the solutions will be chosen in order to minimize the negative impacts and maximize the positive impacts at all three levels from the current situation.

In order to achieve it, these potential impacts have to be integrated in the thinking and design. Some prospective assessment of the expected social and environmental impacts of the solutions proposed by the plan will also be done.

2.1.3 « 4 R » priority rule

The plan will be designed in order to follow the priority rule of the "4R": reduction; reuse; recycling; recovery. It means that it will try to consider each waste solution before the following one.

In the case of the City of Kigali like in many places of the developing world, the reuse seems to be quite developed already. The implementation of the priority rule should probably more focus on reduction, recycling and recovery.

2.1.4 Appropriate means

Some evidence to ensure the effectiveness of implementation is that each stakeholder has the necessary and appropriate means to achieve its objectives. This might be seen in four different ways: budget, equipment, personnel and training.

The plan will therefore ensure that every stakeholder should have the required budget, equipment, personnel and training. Otherwise, it will schedule the necessary measure and corresponding expenses.

2.1.5 Communication of guidelines

About waste management that highly depends on the producer behaviour, it is essential to include a large communication component. This investment is always worth and contributes to a better efficiency of any programme.

The producers will first be targeted, especially if they are involved in some sorting. The operators at the end of supply chain like the recycling companies might also be concerned.

2.2 Critical analysis of identified projects

2.2.1 Collection

A collection with sorting at source of solid waste has started to be employed by the COPED Company. It is actually working only for the richest part of the population that has already been sensitized to this.

This kind of collection allows maximising the utilisation (up to 25%) of the valuable materials (paper, glass, textiles, and plastics) and also avoiding accumulation of heavy metals in wastes already at the stage of waste selection at the household level. It may be seen as good from the environmental standpoint, provided that the transportation of the recyclables is not too far.

From the social standpoint, only the working conditions of people might be seen as poor because they are in direct contact to waste and exposed to injuries causing diseases like tetanus. Indeed, they rarely wear protective clothes and never wear glasses and masks to protect their eyes and mouth.

2.2.2 Treatment

- Incineration project:

Incineration of municipal solid waste with or without utilization of exhaust gases is widely used throughout the world. Countries with relatively small land area and high population density were the first ones who started to introduce such incineration facilities.

The many years of experience allow to clearly articulate strengths and weaknesses of waste incineration. They are presented below.

The strengths are:

- reduction of the volume of waste (approximately by 10 times),
- reduction of waste transportation costs,
- possibility of heat recovery (incineration of 5 tons of healthcare waste is equivalent to 1 ton of fuel equivalent),
- reduction of the risk of soil and water contamination (provided that relative sterilization of material is ensured at 1200°C).

Weaknesses are also obvious:

- high capital intensity of construction (7-15 times higher than with the bio-mechanical treatment);
- irreversible loss (destruction) of valuable recyclable materials;
- low efficiency of ferrous metals recovery from sludge;
- high output of ashes from sludge (over 30% by mass);
- air contamination with multiple pollutants.

In the case of incineration, emissions of heavy metals, chlorinated organic compounds, hydrogen chloride and fluoride with smoke and dust, requires complicated and expensive response. Environmental contamination by dioxin causing pathologies in new-borns as well as various tumours represents a particular hazard if the temperature is under 1 200 °C.

About the incineration planned for toxic healthcare waste, incineration seems to be the appropriate treatment with some referent equipment of French manufacturer ATI of which documentation has been

found. However, it seems important that the combustion of fumes goes up to 1 200 °C, in order to be allowed to dump the ashes (otherwise, it would be necessary to build a specific landfill).

- Temporary landfill project:

The temporary landfill was planned in little time and obviously not in accordance with the international standards on the management of waste disposal sites. As evidence, the RURA guidelines should at least have been applied.

Main potential nuisances of this landfill are first social and will concern the local population that will have to be evacuated for a use that is supposed to last only a few years. If not, it would have to stand the noise of the transportation and odour from the biogas emission, which will increase the risks of infectious disease.

Environmentally, the quality of the whole landscape will first be affected. Additionally, the effluents of the site will probably not be collected and will pollute the area.

The traffic of trucks will increase dramatically on the road of 12 kilometres leading to Nduba from the main road and cause nuisance to the local population with additional dust and danger for children. On the site, a primary school has been noticed in front of the potential site.

- New landfill project:

The new sanitary landfill complying with the RURA standards is planned for 2014. The selected site is located at about 12 kilometres to the South-West of the centre of the city.

The soil of the site is clay-based but non homogeneous. It is good for the operation, but the initial works will be quite expensive.

The site shows some wetlands that should be covered by a 3-meter layer of earth in order to meet the requirements of RURA that is in line with international standards. Assessing the possible environmental impacts of this new sanitary landfill, the site is being studied by a team of German consultants.

Possible environmental impacts will result from activities to be carried out during construction and operational phase of the project. During the operations, the impacts should be much lower than the current ones with regard to leachate plus biogas collection and treatment.

Main sources of these impacts are solid and liquid wastes as well as noise and dust emissions. Magnitude of these impacts on the environment such as air, water and soil have to be explained along with the mitigation measures that are required to be taken in order to minimize these impacts.

In the case of the considered site that was visited, the mitigation measures might include a higher location of the landfill in order to move away from the groundwater table. It would also reduce the cost of the landfill construction because there would be less earth necessary to raise the ground level.

- Nyanza landfill rehabilitation project:

At the end of the operation period, the Nyanza site should be processed with its closure and rehabilitation. The main impacts of this phase will be related to:

- collection and leachate management;
- collection and storm water management;
- collection and management of gas;
- covering and planting of plants.

Collection and management of a landfill leachate is the biggest environmental problem, especially for surface water and groundwater, especially after the closure of the landfill. This leads us to focus particularly on this issue by introducing the compensatory measures necessary to mitigate the resulting impacts.

The measures to be taken into account during this phase are:

- monitoring and maintenance of the system of collection and storage of leachate;

- separation of storm water and leachate to reduce the volume of contaminated effluents;
- treatment of leachate quantities of waste after evaporation / re-injection at the landfill;
- installation of three monitoring surveys: one upstream of the discharge (control) and two placed below the outlet to allow monitoring of the quality of the water at the landfill operation and during 30 years after closure.

With the aim to preserve water resources in the study area, the landfill operator shall ensure that:

- storm water from the outside of the landfill will be collected and transported to streams;
- storm water runoff from the landfill body will be collected and stored in the basin of rainwater.

Upon closure and rehabilitation of the landfill Nyanza, the operator will conduct coverage of the landfill by the introduction of a layer of topsoil and then planting greenery. This greenery will integrate the discharge into the natural landscape of the region and ensure full coverage and camouflage of the landfill.

2.2.3 Valorisation

- Composting facility:

Composting is basically a process in which organic portion of solid waste decomposes. In more scientific terms, composting can be defined as an aerobic biochemical reaction.

During aerobic stabilization in windrow, temperature goes up to 60 °C and kills pathogenic microorganisms present in solid waste. Stabilization process continues for 30 to 45 days depending on climate and aeration method.

At the end of this period, temperature of waste piles drops down. The product obtained is compost which is like an organic fertilizer used as soil regulator.

Depending on the process used, the amount of compost is about 50% of the waste processed and a portion of 15% of the original waste goes to atmosphere as vapour and gaseous emissions. Remaining waste should be disposed of by means of other methods such as landfilling.

The proposed composting plant will be relatively clean and will only generate small amounts of recyclable leachate and gaseous waste. Located beside the landfill, no further transportation will be needed.

The windrow composting area must be a cemented platform with a proper drainage system to prevent any access of the leachate into the soil and inland waterways. The fresh solid waste that is received at the sorting operations does not emit offensive odours.

The organic fraction of the solid waste is allowed to accumulate, it will quickly start to decompose and generate offensive odours. The odour will be especially strong if the decomposition is anaerobic with a methane production as well as various VOCs, hydrogen sulphide, ammonia, and mercaptans that cause distinctive foul and offensive odour.

The wastewater generated in the composting facility may be reused by collecting and spraying on to the windrows. The following are the potential sources of wastewater: leachates from the incoming waste and washings from the reception.

Fugitive air emissions and odour are generated due to poor housekeeping and improper operations of the sorting and composting equipment. The air and odour emissions are from the following sources: early decomposition of waste at reception or during aeration process.

The windrow composting process is highly affected by weather conditions and must be kept under aerobic conditions. Adequate turning of the windrows is very important to ensure aerobic conditions, the lack of which has a high potential for odour generation.

However, the composting seems to be an ideal way of valorisation for the large organic part of waste because it is quite simple to carry out and it allows the use of the product at a local scale. It shows some environmental benefits in the way it can enrich the earth for agriculture.

- AMIZERO project:

The association AMIZERO has developed some process in order to manufacture fuel balls in replacement of the charcoal widely used in the country, firstly funded by the European Commission and in partnership with IRST. It is now privately funded and has acquired the necessary equipment to operate.

The raw material is waste coming from both households and agriculture through a local cooperative of women. Basically, the fully automatic process consists in a drying, shredding, formulation, mixing, humidification, granulation and final drying before conditioning.

The final product is said to have a higher calorific power compared to charcoal. As a new product, it is planned to be sold at about 200 RWF per kilogram.

The social benefit is clear with the creation of 17 employments at the factory and maybe 50 persons employed temporarily. Additionally, the company should make some margin and be able to invest in some extension or duplication of the factory at the city scale.

Environmentally, this seems to be a good idea to replace the use of charcoal and such a way struggle against deforestation. However, some environmental assessment should be performed in order to know the actual benefit and make sure it is not only a transfer since there seems to have a great consumption of petrol to make the engines work.

2.3 Overview of the valorisation markets

2.3.1 Organic products markets

2.3.1.1 Compost products

Peri-urban agriculture is quite developed on the territory of the City of Kigali, especially in the wet lands that could recently be reserved for this activity. Mainly for local food, horticulture is dominant with major productions including pineapple, avocado, coal, beans, carrots, celery and spinach.

Some rough estimation of the land used for horticulture within the City of Kigali gives around 4 000 hectares. Organic fertilizers like compost is advised for such agriculture with at the rate of 10 tons per hectare and per year: this means that there is a potential market of 40 000 tons of compost.

Currently, the farmers use manure made of cow defections but there is a lack of local availability and they would appreciate having some more organic fertilizers. The actual need could be estimated at 30 000 tons per year, knowing that the manure is only used by about one quarter of the farmers.

Knowing that organic waste produces about half of its weigh in compost, the waste to be composed in order to comply with the need is about 60 000 tons of organic waste which is about two third of the quantity that is emitted by households of Kigali at this time. This consequent market encourages a centralized production of compost at the periphery of the city.

However, the compost used should be of quality and for that, the organic fraction of household waste has to be separated from the other waste in order to avoid any contamination. Even if there does not seem to be a standard for compost, some international standard could be used and controlled under the supervision of the Ministry of Agriculture.

2.3.1.2 Fuel products

The local use of charcoal is widespread in the country, according to the numerous trucks that can be seen transporting bags of this fuel. Unfortunately, this contributes much to the national deforestation.

As the COOCEN "briquettes" sales, the current project of fuel ball manufacturing from organic waste shows that there is some replacement market for charcoal. The expected production is 500 tons per year which seems to correspond to more than 1 000 tons per year of organic waste both coming from households and agriculture.

Some study is still being carried out by the University of Gembloux in Belgium and IRST to optimize the process and the product. Obviously, the key point seems to optimize the composition and also the extent to which the combustion is initiated to increase the calorific power.

With regard to the huge amount of charcoal used in the City of Kigali, there is no doubt about the market for such products. After final setting of process, the development will only need appropriate marketing at sales and then should imply the implementation of other operation sites.

2.3.2 Secondary material markets

2.3.2.1 Paper and board

There is no paper factory in the country yet, so there is no local possibility of recycling. The main factory converting paper in the City of Kigali is SUPA Company which manufactures hygienic paper made of recycled material.

A meeting at SUPA factory allowed knowing that it imports its raw material from Tanzania under the form of recycled paper in rolls. SUPA has a project of integrating a paper machine into its process, but the local water availability does not seem to be reliable enough for it: this is part of the local context to be improved.

2.3.2.2Plastics

There are about seven plastics manufacturers in the City of Kigali, mainly located in the industrial area of Gikondo. They especially use injection moulding but also rotomoulding of various products that might accept recycled material.

Many collected plastics such as PET find a way to recycling in other countries. It was mainly found that they were going to Uganda and Kenya to lower extent.

The visits made to two quite representative companies show that only local recycling of plastics with their production waste seems to be common. However, it is only beginning with waste coming from households with trials carried out by one of the biggest injection moulders (MIRONKO) and some fear of being out of own standards.

Obviously, the local plastic industry exists and might be estimated at about 1 000 tons per year for now and should develop. However, it lacks of information about the technical and economic conditions of use of recycled materials which are for their own interest and they would also probably need some support from the government to help them implement the appropriate equipment.

In 2022, there should be some 13 000 tons per year of plastic waste coming from various origins. The local plastic industry should implement the additional process to take advantage of it like ECO-PLASTICS, instead of importing expensive virgin raw materials.

2.3.2.3Aluminium

Some aluminium recycling is already happening in the City of Kigali with the recovery and pressing of aluminium cans by the K.S.A.W. company. However, the main process is located in Uganda where the aluminium sheet are made of 100% recycled material.

The challenge is to attract some local transformation of recycled aluminium by the same company, since the local amount of waste emitted by household would probably be enough in 2022 with 8 000 tons per year. It would allow some local employment and transport savings.

2.3.2.4Steel

In the country of Rwanda, the current major company transforming steel is RWAMAGANA which is located at about 70 kilometres to the East of Kigali. It delivers steel bars that could incorporate some fraction of recycled steel for some products and all recovered steel waste seems to be oriented to it.

The production of the plant must induce a need for recycled material much exceeding the emitted quantity of steel waste in the households and industry. Without any market problem, steel recovery has to be fostered by integrating it to the sorting system.

2.3.2.5Glass

Glass is the material that currently lacks of valorisation supply chain. Indeed, there is no factory able to transform waste glass in the country and the factory of Burundi that was formerly accepting it from Kigali has closed recently.

There seems to be some factory in Kenya. However, the price of transportation is probably too high to face by the dealers and that is why glass is now dumped at Nyanza.

2.4 Recommendations for a sustainable improvement

2.4.1 Institutional aspects

2.4.1.1 City of Kigali

- The City itself

The City of Kigali and its department of solid waste management should be responsible for the general coordination of the solid waste management strategic plan. For that, the officer in charge should be trained enough in terms of management and communication.

Some training program seems to be necessary for the responsible officer at first and for the district officers as well. It could include some participation to an international seminar and visits to facilities in foreign countries slightly more developed than Rwanda.

- The districts

The three districts of the City of Kigali should work in close relationship with the department of solid waste management and participate to the making of all decisions to implement the strategic plan. Especially about communication towards population, which is a key point of solid waste management, the advice of the three districts must be taken into account during the design of the campaigns.

- The sectors

The sector (umurenge) is the official level which is the most relevant to implement the strategic plan in terms of collection and communication. Indeed, it was found that this is the meeting level of both the population and the administration.

As a matter of fact, the sector already organizes some arrangements about the conditions of the collection in order to achieve a good coverage and to allow the population benefit of the service. It is important to encourage it by reinforcing this local structure that only cares of solid waste management as the same time of so many other subjects.

2.4.1.2 National authorities

The relevant national authorities have an important role to play in the follow up of the strategic plan.

- RURA

RURA will take care of all regulation aspects and compliance with the main guidelines. It will be likely to make some extension at the national scale if necessary.

- REMA

REMA will make sure the plan is always oriented to the lowest environmental impacts. It could also ensure the coordination with some national project such as composting.

- EWSA

EWSA will intervene as the stakeholder who will inform the new investors of the plan framework. It will be of good technical assistance for any further feasibility study and in the design of new equipment.

2.4.1.3 Technical ministries

The so-called technical ministries will be responsible of the technical supervision of some part of the implementation of plan: for that, they will need to have an additional inspector who will have to be trained.

- Ministry of Health

The Ministry of Health will be responsible for all technical aspects of healthcare waste, which are especially sensitive, and make sure the operational plan is followed. In particular, it will also give the authorization for the acceptance of all new waste into the incineration tool and control the delivered waste.

- Ministry of Agriculture

The Ministry of Agriculture will be responsible technically for all the waste at the entrance of the composting facility. It should first develop some specifications to be followed and control the delivered products on a regular basis.

- Ministry of Trade and Industry

The Ministry of Trade and Industry will be responsible for all technical aspect of prevention and recycling. Indeed, it is the closest to the industry that will use in the end the recycled materials.

2.4.1.4 Steering committee

A steering committee should be set, in order to follow the implementation of the plan and the design of the planned facilities. Its role also might be to possibly correct the plan in case of major change of the context.

It should include all the institutional stakeholders and all technical ministries. The Ministry of Economic Planning and Finances should also be included as the ministry that could help adequate projects to be financed and to agree financial supports.

The management of the steering committee has to be assumed by the City of Kigali. In order for the program monitoring and achievement of its components according to the schedule, it will have to produces some statement up-date at least once a year.

2.4.2 Regulatory aspects

2.4.2.1 Status

Every type of solid waste should benefit of a status which determine the way it should be collected and treated and to what institution its management has to refer. The following types depending on origin would be considered, with a particular attention put on hazardousness.

- Domestic waste (DW):

The City of Kigali is directly responsible for management of this type of solid waste representing the much largest part of it. At the household level, the organic fraction of domestic waste should be sorted out as well as the hazardous waste (batteries).

The recyclable fraction has to be sorted out, including the electronic waste, in order to be valorised in the industry. The best way to do it will have to be chosen shortly by the City of Kigali: it may be a sorting during collection or at a sorting facility.

The main final treatment after sorting of domestic waste is the sanitary landfill. Only the hazardous waste will have to be incinerated at more than 1 200 °C.

- Healthcare waste (HW):

The Ministry of Health is technically responsible for the management of this type of solid waste. According to the operational plan for the management of healthcare waste, the infectious waste have to be incinerated at the hospital level with an incinerator including a combustion of fumes while the toxic waste have to be incinerated with a combustion of fumes going up to 1 200 °C, the ashes of which may be oriented to a usual landfill.

The general solid waste is the part coming from the patients and their family. They may be considered as similar to domestic waste and have to follow the same way of management with a sorting of organics at source oriented to composting and final treatment at the landfill.

- Commercial waste (CW):

As the domestic waste, the management of this type of waste should be part of the responsibility of the City of Kigali. They should be managed like domestic waste with a separation of organics that have to be composted and the recyclables that should be recycled.

- Industrial waste (IW):

The Ministry of Trade and Industry should be technically responsible for the management of this type of solid waste. The industrial waste should be sorted at source and valorised as much as possible but the hazardous part should be allowed into the national incinerator, the remaining waste being oriented to the landfill.

In the near future, it is advised that the industrial waste shall be managed nationally instead of depending on the provincial plan. Indeed, the nature of industrial waste mostly depends on the sector and not on the province of emission so the national management by the Ministry of Trade and Industry would be more logical.

2.4.2.2 Supervision

- City of Kigali:

A general supervision of the implementation of the strategic plan for solid waste management will have to be assumed by the City of Kigali, as it is foreseen in its responsibilities. Such a way, it will have the role of organizing the meeting of the steering committee, for instance every two months.

Especially, the City of Kigali will be responsible of the follow-up of the implementation of the strategic plan according to its schedule. The setting of indicators will help it play such a role.

On this purpose, the City of Kigali should dispose of its own budget for solid waste management mainly coming from the entrance fees at the various treatment facilities. It will be used for any meeting organization but also to support potential projects.

- Technical Ministries:

The technical supervision of the treatment made of the solid waste will be ensured by the so-called technical ministries, i.e. the Ministry of Health for incineration, the Ministry of Agriculture for composting and the Ministry of Trade and Industry for recycling.

On their own budget, they will ensure the specifications of the treatment tool are properly respected with the help of a specific inspector. The inspector will report to its department that will report to the City of Kigali.

2.4.2.3 Contracts

- Collection:

Some collection contracts have to be signed between the producers of waste like households or businesses and the collection companies. In particular, it should at least mention the frequency of collection, specify the separation at source for the organic fraction and propose the use of bags for this fraction.

Additionally, another contract should be signed between the collection company and the sector (representing the City of Kigali) and require the responsibility of the company to cover the whole territory of the sector. For information, this has already been practised which success and is thought to allow more professionalism of the collection companies or cooperatives.

- Valorisation:

Further to the public investment, the general rule would be to privately operate the valorisation facilities which are the composting centre and the sorting centre. Such a way, a national tender will have to be performed in order to get a private contractor.

The contractor will have to sign an operation contract with the City of Kigali or the technical ministry responsible (Ministry of Agriculture for composting and Ministry of Trade and Industry for sorting). At least, this contract will include: the duration of contract, the installation hiring price, the conditions of operation, the fraction of entrance fee to be ceased to the City of Kigali.

Then, some valorisation contracts will have to be signed between the collection companies, the private operator of the concerned valorisation and the City of Kigali. It should specify the type of waste normally allowed and the entrance fee depending on weight for the operation.

- Treatment:

Further to the public investment, the general rule would be to privately operate the treatment sites. Such a way, a national tender will have to be performed in order to get a private contractor and hire the site and the equipment to the City of Kigali.

The contractor will have to sign an operation contract with the City of Kigali or the technical ministry responsible. At least, this contract will include: the duration of contract, the installation hiring price, the conditions of operation, the equipment maintenance price, the fraction of entrance fee to be ceased to the City of Kigali.

Then, some treatment contracts will have to be signed between the collection companies, the private operator of the concerned treatment and the City of Kigali. It should specify the type of waste normally allowed and the entrance fee depending on weight for the operation.

For any new waste to be admitted into the treatment facility compared to the plan, an authorization will have to be asked by the collection companies to City of Kigali or the technical ministry responsible. This will be enclosed into the operation and treatment contracts of both companies.

2.4.3 Technical aspects

2.4.3.1 Prevention

According to the "4R" priority rule, the strategic plan should first start by prevention measures allowing some solid waste reduction. Such measures can be found for solid waste coming from industry and households and integrated shortly.

- Pharmaceutical waste:

First of all, it seems that much pharmaceutical waste is produced because the need of the products (either equipment or medicines) was expected to be higher. The amount of such waste could be estimated at 100 tons per year, but the treatment of such waste will shortly cost about 800 RWF per kilogram so some 80 million RFW.

The measure that should be taken concerns the estimation of the need. Some responsible department at the Ministry of Health should estimate the need of each year more accurately and order with a limited security margin.

- Inner recycling:

The inner recycling is some other way of doing reduction at source. Additionally, it is the easiest way of recycling because it closes the loop without any specification problem.

Even if it is already implemented in a few factories, it should be encouraged by some communication towards industrial companies. This could be done by the Ministry of Trade and Industry.

- Environmental consumption:

The ecological consumption consists in taking environment into account while consuming. Applied to solid waste management, it means reducing the amounts of waste by preferably choosing product that has a reusable packaging instead of a packaging difficult to recycle.

Products that should be avoided depend on the local context of solid waste management. Such a measure has to be properly design in order to integrate the national further development in recycling.

This measure would imply some specific communication campaign towards population that probably would be receptive, according to the way Rwanda has banned plastic bags. The communication campaign could be done nationally by RURA or some other national Authority by popular means like advertising in the supermarket and radio announcements.

- Domestic composting:

The domestic composting already exists especially in rural areas of the city. It is a good way of using the waste and actually avoiding it because it is finally not emitted.

Since not all the organic waste will be subjected to industrial composting, the last measure to be taken has to make sure this habit will not disappear in the countryside. Even more, it should become a reality even for urban agriculture if there is some.

This measure should concern only organic household waste. It is the matter of another communication campaign towards any potential cultivator that could be managed at the same time as some communication for the use of compost in agriculture.

2.4.3.2Collection

- Principles:

Apart from the framework as seen before, the technical principles of collection are recommended to be based on the current system which seems to be convenient. Some exception is that the workers have to be more protected from the contact with waste, so they should wear at least protective clothes, gloves and mask.

In order to limit the transportation density, the trucks used for collection should be of at least 12 m3. The use of wheelbarrows or any other small vehicle would be still permitted to go up to remote places with streets in poor conditions.

The recommended frequency for household waste is once a week, in order to limit transportation and to allow it to the range of the objective. Actually, it was shown in other countries that this is the best frequency considering the environmental impacts.

About sorting, two different options should be considered and chosen because a combination of both option is not advisable in order to have only one collection system which is easier to manage. One is close to source and happening at the collection, while the other one is done later.

Option 1: sorting at transit

For household waste and any general waste coming from businesses, hospitals and industries, the first recommended option operates some primary sorting while collecting. It implies the use of compartmented trucks:

- one compartment for organics that will have been separated at source by the producer of waste;
- one compartment for recyclables that will be first separated into 4 fractions by the collector as an additional service : plastics, paper and board, aluminium and metals;
- one compartment for all other waste that will have to be treated, including the hazardous waste like electronic waste.

Option 2: sorting at facility

The other option considered implies the construction and use of a sorting facility, ideally located at the periphery of the urban area on the way to the new landfill or on the new landfill site, which would optimize the transportation. The second location of such a sorting facility will obviously be studied by the German consultancy as well.

- Objectives:

Starting from the calculated 44% for household waste, the coverage rate is expected to grow especially thanks to the new contracts. The objective could be to reach 80% (starting from 64%) in urban areas while in rural areas it would be 20% (starting from 0%), achieving a global objective of 62%.

For commercial waste, the collection rate should easily cover 80% of the waste through the obligation of the companies to make it under contract with the sectors. With similar contracts with the factories, the industrial waste is supposed to be collected at 70%.

According to the operational plan of healthcare waste management, the waste should be all classified and collected in the hospitals. However, the considered coverage rate will be of 90%.

- Capacities:

With the objectives considered and the amount of waste expected in 2022, the involved capacity at collection in 2022 corresponds to about 860 trucks of 12 m³ working on the basis of one collection per week. The relative collection capacity in weight per type of waste is of half for the organics and of one quarter for the recyclables and the remaining: it basically gives the relative dimensions of compartments for Option 1.

2.4.3.3 Valorisation

- Principles:

The main principle is to separate all the valuable waste in order to valorise it and to divert it from the more expensive treatment that will be implemented.

The first one is the organic fraction that will be mainly composted but also used in the manufacture of fuel balls to lower extent. In both options, it will be driven to the composting centre that should be near the landfill as well as to the fuel balls factories.

The other valorisation possibilities concern the various recyclable fractions for which some markets have been identified in the country or in neighbour countries. For now, it is the matter of eight materials: HDPE, mixed PE, PET, paper and board, aluminium, steel, glass.

All these materials will have to be separated with a concern of quality, in order to be sold back to the industry. This involves different rules depending on the option.

Option 1: sorting at transit

With this option, the collection companies will sell the recyclable waste to dealers that they will meet after making appointments. The appointments could be located at one place on the way to the landfill.

Some further sorting will still be necessary in order to get the waste separated by materials and this will be the first task of the material dealers. The dealers might be specialized in only a few materials and would use bags per material they recover.

Option 2: sorting at facility

The existence of the sorting facility will allow the separation of all interesting material in one stage. The sorting facility should accept only solid similar to domestic waste, i.e. domestic waste and general waste coming from the businesses and the hospitals.

The separation will be only manual. It will involve two elevated lines equipped by a sorting table with a conveyor belt and seven containers to where the sorters will drop each waste material selected positively.

According to the most likely markets, the materials that will have to be sorted are at least: stiff HDPE, soft PE, PET, paper and board, aluminium, steel and glass. They will have to be prepared for sales in the appropriate form, partly in compressed packs.

The operation should first be in two shifts and it could go to three shifts in the future. The sorting tasks should imply some local personnel and might have some social role of insertion.

In the near future, the sorting facility should include a workshop specialized in the dismantlement of electronic waste whose presence will develop in household waste. The purpose will be to separate all precious metals and other materials constituting this type of waste that can be valorised at 90%.

The sorting facility would be privately managed under a contract with the City of Kigali. The contract will include the transportation of the refuse to the landfill, which would be about half of the amount entering into the facility.

- Objectives:

At the delivery of the organics to the composting facility, there will be some sorting to ensure the compost will be a good quality. Since the only sorting to this time will be the one at source, it is expected a rate of 20% refuse that will be oriented to the landfill next door and the objective will be of 80% recovered, then a process rate of 90% is considered.

For recyclables, the objective of sorting will be much different depending on the option chosen. For option 1, it is expected to be so low as 40% because there will not be any control and only stand on business; for option 2, the sorting will be much more efficient and the rate is expected to be of 70% recovered.

Globally, such objective would allow the achievement of the following valorisation rates:

- 45% of organics (with relation to the produced organics);
- 18% and 30% of recyclables (with relation to the produced recyclables) respectively for Options 1 and 2.

This means a global valorisation rate (with relation to the emitted waste) of 36% in the case of Option 1 and 39% in the case of Option 2 of the emitted waste, which would be very honourable.

Table 8: Processing rates of supply chains in 2022

	Collected		Sorted		Processed		Valorised	
	Rate	Amount	Rate	Amount	Rate	Amount	Rate	Amount
Organics (both options)	63%	124 269	80%	99 415	90%	89 474	45%	89 474
Recyclables (option 1)	66%	47 783	30%	14 335	90%	12 902	18%	12 902
Recyclables (option 2)	66%	47 783	50%	23 892	90%	21 503	30%	21 503
Total (option 1)	64%	182 996					36%	102 375
Total (option 2)	64%	182 996					39%	110 976

- Capacities:

In order to be able to process the rate of various types of waste with the expected amount of waste emitted in 2022, the equipment will have to meet the following capacities:

- composting facility: 120 000 tons per year;
- sorting facility: 45 000 tons per year.

The installation and equipment of facilities will be quoted in accordance with such capacities.

It is advised to start the sorting facility with two lines of 15 000 tons per year each, which would be enough at the beginning of the program. A similar sorting line will be implemented later.

At this time, it seems convenient to include the implementation of a dismantlement workshop in order to care of the electronic waste. It will be integrated in the same facility and imply an additional container on each sorting line upstream.

2.4.3.4 Treatment

- Principles:

The final treatments of solid waste in the City of Kigali would involve a sanitary landfill facility and an incineration facility which are both scheduled and even financed for the second item. The recommended principles of final treatment will be based on the following orientations which are basically in accordance with the various plans and decisions made.

Should be oriented to landfill all non-hazardous solid waste collected from households, businesses, industries and hospitals that could not be previously sorted as organic or recyclable. As well, the landfill will receive the refuse of the sorting facility and the ashes of the incinerator.

After some necessary weighting at the delivery, the landfill facility will first use three stages of 100 000 m³ before some possible extension. The sanitary landfill treatment should include at least a leachate recovery and treatment and the gas recovery would be an asset even if there is less gas produced without organic waste.

All toxic solid waste coming from the hospitals and other hazardous waste coming from households and industries should be oriented to the new sanitary incinerator. Some control at the entrance of the facility seems to be necessary.

Provided that the temperature remains above 1 200 °C during the incineration cycle, the ashes of the toxic waste incinerated will be admitted in the sanitary landfill. This option is preferred to a hazardous waste section in the landfill (as suggested by the German consultancy), but it might be wise to keep it for the case there is not enough capacity in the sanitary incinerator.

- Objectives:

There is no specific objective to be considered. As a principle according to the high cost of both treatments, it is advisable that the amount of waste treated is the lower as possible.

- Capacities:

The amount of solid waste that is expected to be delivered to the landfill in 2022 is about 80 000 tons per year. The necessary capacity of the landfill will have to be calculated in volume according to the compression ratio: if it is of 2, the annual need will be of 133 000 m³.

The expected amount of waste that will meet this definition is of about 700 tons per year, with the hypothesis of about 100 tons per year of industrial waste. This capacity could be achieved with the ordered machine working in two shifts.

2.4.4 Financial aspects

2.4.4.1 Collection

By principle, the collection of solid waste should not be a financial charge for the City of Kigali. Indeed and on purpose, it is separated and left to the private sector that directly contracts the waste producers.

In accordance to the contracts signed with the waste producers, the financial flows at collection will be to the private collection companies. However, some financial support might be provided by the City of Kigali to them through the sectors in order to improve the coverage only in the case of proven problems for the households to pay the fees.

2.4.4.2 Valorisation

- Composting:

The collection companies will bring the organic waste to the composting facility, provided that the organic waste will be properly sorted either by the household or by them. In either way, they will have the final responsibility of sorting the organics.

Otherwise, the collection companies would have to pay an entrance fee based on weight of waste at the composting facility that will be determined in order to support the sorting of waste. A part of this fee could be due to the City of Kigali, as well as the price for hiring the composting facility.

By principle as a valorisation tool, the composting facility should be self-supported by the sales of compost to the local farmers and therefore should not receive any financial support from the City of Kigali. The price will be fixed by the City of Kigali in accordance with the Ministry of Agriculture.

- Sorting:

The collection companies would bring the remaining waste after possible first sorting to the sorting facility and pay an entrance fee based on weight that will be fixed by the City of Kigali and is advised to be close to the current tipping fee at the landfill (1 000 RWF per ton). A part of this fee (probably around 10%) will be due to the City of Kigali, as well as the price for hiring the facility.

By principle as a valorisation tool, the sorting facility should be self-supported by the sales of recyclables and therefore should not receive any financial support from the City of Kigali. The price will be fixed by the local markets of solid waste with a possible framework from the Ministry of Trade and Industry.

To the industrial companies using recycled materials, some financial support of the Ministry of Economic Planning and Finances should be implemented in order to encourage the investment needed. Within a full strategy, this should take the form of incentive calculated upon weight of recycled materials actually used but this would only concern for household waste which is the most difficult to manage.

2.4.4.3 Treatment

- Landfilling:

The companies bringing waste to the landfill will be the collection companies in case of Option 1 and the operator of the sorting facility in case of Option 2 (even if next to the landfill). They will have to pay the tipping fee based on weight that will be fixed by the City of Kigali and a part of which (probably around 10%) will be paid to it, as well as the price for hiring the facility.

As a tool allowing greenhouse gas reduction through the recovery of biogas, the landfill is eligible to carbon credits that could help its operation financially. The request should be formulated to the World Bank or some other organization in charge of carbon credit management.

Some further financial support from the Ministry of Economic Planning and Finances will probably be necessary to run this treatment, because it does not generate any revenue. The support price will have to be calculated in deeper studies.

- Incineration:

The collection companies that will bring the solid waste to incineration will come from either hospitals or industries. They will have to pay an entrance fee that will be fixed by the Ministry of Health, a part of which (probably around 10%) will be due to it, as well as the price for hiring the facility.

Since there is no energy recovery, this tool does not generate any revenue. A financial support from the Ministry of Economic Planning and Finances will probably be necessary to run it.

2.4.5 Aspects of communication

2.4.5.1 To the waste producers

- About waste prevention:

The first messages to be communicated to the waste producers are about the ways they could reduce their production. The concerned stakeholders are especially households (domestic composting, environmental consumption), businesses (own composting) and industries (inner recycling and purchase schedule).

These messages will be sent to various communication ways depending on the target groups. Messages to households might use mass media like radio but even better public advertisements on purchase locations, and those to businesses and industries will be more personalized and possibly passed by the Ministry of Trade and Industry.

About any sensitization, the City of Kigali should identify the best communication relays. For households, it might be the hygiene officers on sector level.

- About waste collection, sorting and treatment:

In order to be better sensitized of the importance of what they are encouraged to do, all waste producers will have to be initially informed of the ways the different types of solid waste will be collected, sorted and treated. The messages will only be related to the waste produced by the concerned stakeholder.

This communication should use flyers edited and printed by the City of Kigali but distributed by the collection companies. In case of need, the same campaign could be started again.

2.4.5.2 To the recycling companies

- About the interest of using recycled materials:

To foster the use of recycled materials in the country, the companies potentially concerned will be visited in order to sensitize the manager and its personnel of the economic interest of such a practice for appropriate products. Indeed, the recycled materials are usually more than twice less expensive than the virgin materials that have to be imported.

- About the incentives to use post-consumer waste:

The same companies will also be informed by the City of Kigali of the possibility they have to ask for incentives and they might be assisted by it in their request. The incentives might be the investment participation to acquire recycling equipment and also the exemption of tax for the operations involved.

2.5 Elements of costs and planning

2.5.1 Collection

The collection system might imply private investment because the trucks would have to be larger and also separated in case of Option 1. However, this will be an investment of the collection companies only.

With the principle of full coverage by the collection companies, it is expected that the system has to support the gaps of collection coverage for a reason of affordance. This should be taken from the budget of the City of Kigali through the districts dispatching between sectors to compensate the lack of means by households in difficulty after previous confirmation by the sector.

Globally, the transport for collection will increase first in relation to the coverage of households from 44% to 62% i.e. of about 40%, and then it will basically follow the population growth of 4%. This increase is quite important and has to be taken into account in the city development plan especially in terms of road structures.

2.5.2 Valorisation

2.5.2.1 Composting facility

The composting facility should be designed with a forced aeration in order to get a reduced duration of aerobic formation process. This hypothesis is done and the considered total duration of process has been of 4 months for the cost estimation below.

Some leachate will additionally have to be collected. However, they are supposed to be treated in the unit planned in the landfill because they will be on the same site.

Table 9: Composting facility investment costs

	Object	Unit	Number	Unitary cost (EUR)	Cost (EUR)	Cost (RWF)
Construction	Pavement	m ²	20 000	50	1 000 000	800 000 000
	Cover	m ²	1 000	100	100 000	80 000 000
	Delivery area	number	1	60 000	60 000	48 000 000
	Aeration system	number	1	140 000	140 000	112 000 000
Equipments	Sorting conveyor	number	1	50 000	50 000	40 000 000
	Weighting machine	number	1	50 000	50 000	40 000 000
	Screen drum	number	1	60 000	60 000	48 000 000
	Air pumping system	number	1	30 000	30 000	24 000 000
	Shredder	number	1	70 000	70 000	56 000 000
	Bulldozer	number	1	80 000	80 000	64 000 000
	Fenwick	number	1	30 000	30 000	24 000 000
	Packing machine	number	1	40 000	40 000	32 000 000
	Generator	number	1	70 000	70 000	56 000 000
Total					1 780 000	1 424 000 000

All the necessary main equipment has been considered and show as slightly higher investment than the one expected by the German consultancy, mainly because of the necessary pavement surface. The amortization and maintenance have to be considered in the operational costs.

Including the amortization of equipment, the composting facility might be financially self-supporting with the sales of the compost the price of which is difficult to estimate. However, the operator would require some incentive upon weight from the Ministry of Economic Planning and Finances through the City of Kigali.

2.5.2.2 Sorting facility

The investment of the sorting facility is advised to happen in two phases:

- the first phase will cover the two third of the required capacity with two lines;
- the second phase will consist in a third similar sorting line and an electronic waste dismantlement facility.

According to the expected amounts of solid waste in the following years, the need for the additional line is expected to be in 2017 and will determine the second phase of the programme.

The sorting lines will be only manual and allow the separation of seven materials at the capacity of 15 000 tons per year with a packing workshop to prepare the sorted material to sales. The facility will work in two shifts for the capacity to be achieved.

Table 10: Sorting facility investment costs

Phase 1	Object	Unit	Number	Unitary cost (EUR)	Cost (EUR)	Cost (RWF)
Construction	Pavement	m ²	2 000	5	10 000	8 000 000
	Cover	m ²	1 500	100	150 000	120 000 000
	Sorting lines	number	2	100 000	200 000	160 000 000
Equipments	Sorting conveyors	number	2	50 000	100 000	80 000 000
	Sorting positions	number	14	20 000	280 000	224 000 000
	Bulldozer	number	2	80 000	160 000	128 000 000
	Fenwick	number	1	30 000	30 000	24 000 000
	Compression machine	number	1	30 000	30 000	24 000 000
	Generator	number	1	70 000	70 000	56 000 000
Total					1 030 000	824 000 000
Phase 2	Object	Unit	Number	Unitary cost (EUR)	Cost (EUR)	Cost (RWF)
Construction	Sorting lines	number	1	100 000	100 000	80 000 000
Equipments	Sorting conveyor	number	1	100 000	100 000	80 000 000
	E-waste dismantlement workshop	number	1	100 000	100 000	80 000 000
	Sorting positions	number	7	20 000	140 000	112 000 000
	Bulldozer	number	1	60 000	60 000	48 000 000
	Fenwick	number	1	30 000	30 000	24 000 000
Total					530 000	424 000 000

All the necessary main equipment has been considered. The amortization and maintenance have to be considered in the operational costs.

From the first year of service, the operation of the sorting facility is expected to deliver sorted amounts of recyclable waste to about 12 000 EUR after estimation. The breaking out of the various materials and use of current market prices for the corresponding material waste gave an average of 123 000 RWF per ton or about 150 EUR per ton.

Including the amortization of the equipment and considering the low operating expenses, the separate operation can be considered as profitable. As a consequence, this facility would not need any incentive to be run separately by a private operator.

2.5.3 Treatment

2.5.3.1 Former landfill site rehabilitation

The current site of Nyanza and the planned temporary site of Nduba will have to be rehabilitated at least by a basic coverage, in order to mitigate adverse effects on the local environment. This should be considered in the investment costs to plan by the City of Kigali.

Table 11: Landfill site rehabilitation costs

Phase 1	Object	Unit	Number	Unitary cost (EUR)	Cost (EUR)	Cost (RWF)
Nyanza	Covering	m ²	60 000	12	720 000	576 000 000
Nduba	Covering	m ²	30 000	12	360 000	288 000 000
Total					1 080 000	864 000 000

2.5.3.2 Sanitary landfill

The sanitary landfill on the planned site at about 12 kilometres to the South-West of the city centre will require an important public investment. It is currently being studied by a German consultancy with a funding of UNDP and the first stage is designed to accept about 200 000 cubic meters of waste, which is not enough to cover the need of the next ten years.

Technically, the landfill site is equipped by all necessary covering and a leachate treatment unit. However, it is not designed with wells to drive the biogas since it will not be so important without organic waste.

According to our estimation, the need of disposition during the ten-year period is actually of about 650 000 tons which roughly corresponds to about 720 000 cubic meters with a compression rate of 3. In 2022, it will have reached the flow of 80 000 tons per year.

A basic quotation of the investment needed for this first phase is given in the table below in accordance with the local data, including a full treatment of leachate and the rehabilitation of this phase of landfill. It is enough to cover the need of the ten-year period of this study.

Table 12: Sanitary landfill investment costs

Phase 1	Object	Unit	Number	Unitary cost (EUR)	Cost (EUR)	Cost (RWF)
Study	Design	ton	650 000	0,5	325 000	260 000 000
Construction	Expropriation	m ²	30 000	0,4	12 000	9 600 000
	Works	ton	650 000	3	1 950 000	1 560 000 000
	Leachate recovery system	ton	650 000	1	650 000	520 000 000
	Full leachate treatment unit	number	400 000	1	400 000	320 000 000
Equipments	Weighting machine	number	1	50 000	50 000	40 000 000
	Leachate pumping system	number	1	40 000	40 000	32 000 000
	Shredder	number	1	70 000	70 000	56 000 000
	Bulldozer	number	2	80 000	160 000	128 000 000
	Excavator	number	2	100 000	200 000	160 000 000
Rehabilitation	Site rehabilitation	ton	650 000	0,8	520 000	416 000 000
Total					4 052 000	3 241 600 000

All the necessary main equipment and supervision of works have been considered to cover the needs of the ten-year period of the plan. The amortization and maintenance have to be considered in the operational costs.

Some important remark at this stage is that the theoretical tipping fee will dramatically increase in line with the increment of treatment quality to an expected level according to the main expenses of around 5 000 RWF per ton (5 times higher than currently). In order not to transfer this tipping fee to the collection companies or other operators, the landfill facility will have to be financially supported by the Ministry of Economic Planning and Finances through the City of Kigali at a rate to be precisely calculated later.

2.5.3.3 Sanitary incinerator

The new sanitary incinerator that will be used in the plan for the most hazardous solid waste is already bought and almost installed. The total amount of the investment was around 1 000 000 EUR.

Logically, it will not be included into the public investment necessary for this plan. It is also assumed that all other smaller incinerators for the hospitals have already been financed and they should not be included into this plan.

2.5.4 Empowering

2.5.4.1 Recruitment

- City of Kigali:

In order to manage the whole strategic plan properly, the responsible officer at the City of Kigali will have to be supported by a full-time assistant to be recruited. Able to speak English and French, this person will be in charge of day-to-day follow-up and scheduling of the organization.

Some new half-time officers will have to be recruited at each sector level, i.e. 35 persons to be recruited or appointed. They will take care of the good implementation of the plan on the sector level which lacks of specific workshop to ensure all its roles.

- Technical ministries:

Some additional full-time inspectors in the technical ministries (Infrastructure, Health, Agriculture, Trade and Industry) will have to be recruited. They will be dedicated to the working monitoring of the treatment tools.

2.5.4.2 Training

The whole personnel involved in solid waste management will have to be trained initially and all along the program. Four different target groups should be distinguished.

- City of Kigali:

The first group will be of the officer responsible of solid waste management at the City of Kigali and the three district officers, so that they will communicate together. They will have tuitions from an international trainer at the start of the program, reminded every three year, and make some visit to a more advanced country.

Then, they will be in charge of training the sector officers. This training will be on the possible options to manage collection coverage and advertisement to population within the plan.

- Technical ministries:

The third group will be the one of the inspectors in the technical ministries will have a similar training program together. This program will be very focused on the type of treatment concerned and could be performed by a technical centre if not the supplier.

Then, they will then have the charge of training the private operators contracted by the City of Kigali at the landfill site, the incineration tool, the composting facility and the sorting facility. This training will be less technical and concern the way to operate the equipment.

Table 13: Training investment costs

Public	Type	Schedule	Unit	Number	Unitary cost (EUR)	Cost (EUR)	Cost (RWF)
CoK & districts	Tuitions	Program start	day	5	1 500	7 500	6 000 000
	Visit	Visit	person	4	2 500	10 000	8 000 000
	Training	Every 3 year	day	10	1 500	15 000	12 000 000
Technical ministries	Tuitions	Program start	day	5	1 500	7 500	6 000 000
	Visit	Visit	person	4	2 500	10 000	8 000 000
	Training	Every 3 year	day	10	1 500	15 000	12 000 000
Chief of sector	Tuitions	Program start	day	70	100	7 000	5 600 000
	Training	Every 3 year	day	10	100	1 000	800 000
Private operators	Tuitions	Program start	day	8	300	2 400	1 920 000
	Training	Every 3 year	day	10	300	3 000	2 400 000
Total						70 900	56 720 000

2.5.5 Incentives

2.5.5.1 To private operators of treatment

As written before, there will have to be some incentive from the government to make waste treatments at the landfill and at the incinerator more profitable for the private operators. The amount of this incentive to working cannot be calculated yet but does not constitute a part of the investment costs since it will be part of the operational budget.

2.5.5.2 To the users of compost

There should be a support to the use of compost in the horticulture under the form of a free delivery to farmers. The transportation might be paid by the Ministry of Agriculture but does not constitute a part of the investment costs either.

2.5.5.3 To recycling companies

- Investment in recycling:

Some investment incentives should be planned to help the industrial companies to invest into the appropriate machines enabling them to manufacture recycled materials. It is advised to allocate them the amount of 10% of the necessary investment directly by the Ministry of Economic Planning and Finances.

The average investment should be around 100 000 EUR for 5 already existing companies to get a recycling line and 200 000 EUR for 5 new recycling companies to settle. The total amount of investment would be of 150 000 EUR.

- Tax exemption:

Finally, some other incentive to all private operation involved in the valorisation of solid waste is the tax exemption that will have be approved by the government. However, it will not constitute a part of the investment costs since it will be part of the operational budget.

2.5.6 Communication

2.5.6.1 To the waste producers

The communication to waste producer should be large. It should start as soon as the global system has been adopted and then be pursued all along the program.

The budget should be differentiated by targets as in the following table. The need is more important for households because they are more numerous and not professional.

Table 14: Communication investment costs

Target	Type	Schedule	Unit	Number	Unitary cost (EUR)	Cost (EUR)	Cost (RWF)
Households	Flyers; Advertising	Program start	number	1	60 000	60 000	48 000 000
	Flyers; Advertising	Regular basis	number	10	20 000	200 000	160 000 000
Hospitals	Visits	Program start	number	1	20 000	20 000	16 000 000
	Visits	Regular basis	number	10	5 000	50 000	40 000 000
Businesses	Visits	Program start	number	1	20 000	20 000	16 000 000
	Visits	Regular basis	number	10	5 000	50 000	40 000 000
Industries	Visits	Program start	number	1	30 000	30 000	24 000 000
	Visits	Regular basis	number	10	5 000	50 000	40 000 000
Total						480 000	384 000 000

2.5.6.2 To the waste recyclers

This other type of communication will be done through the communication campaign scheduled towards the industries. For this reason, it was not budgeted additionally.

- Interest of using recycled materials:

To foster the use of recycled materials in the country, the companies potentially concerned by the use of recycled materials should be visited in order to sensitize the manager and its personnel of the economic interest of such a practice for appropriate products that could be targeted. Indeed, the recycled materials are usually more than twice less expensive than the virgin materials that have to be imported.

- Incentives to the recycling companies:

The information of the two incentives to recycling listed above should be communicated to the local industry at the occasion of visits. This should be combined with the visits about the interest to use recycled materials.

NB: Full schedule presented in Appendix 8, with active stages in bold cases and action follow-up in hatched cases

3. Strategic plan for solid waste management

3.1 Endorsement of the strategic plan

A workshop has been organized and held on Wednesday the 14th of March at the town hall of the City of Kigali in the presence of:

- the vice-major in charge of environment,
- the officer responsible for solid waste management,
- many institutional stakeholders,
- a few private companies,
- a few representatives of the civil society,
- some other consultants.

Further to a presentation of the strategic plan guidelines, some questions and remarks have been brought and discussed.

After some explanations about points of methodology, the main comments were about some institutions to involve, some incentives to add and some investments to include. They came to enrich the draft of strategic plan that had been prepared.

Unfortunately, it was not possible to make the necessary choice between the two proposed sorting options during the workshop. It was requested to compare the advantages and drawbacks of the two options to help the City of Kigali make the decision shortly and finalize the plan on that point.

3.2 Proposed strategic plan

The draft of strategic plan has been adapted by taking into account to the relevant remarks and comments gathered during the workshop: it is presented in [Appendix 9](#). Actually, it should be seen as a document to be revised by the steering committee of the program itself, in order to be further amended or precised.

The proposed strategic plan includes a part about the expected impacts, environmental on the one hand, social and economic on the other hand. This will help the City of Kigali make further decisions and give it arguments to apply for funding of the necessary investments.

3.3 Comparative assessment of the two sorting options

3.3.1 Environmental standpoint

3.3.1.1 Transportation involved

Transportation has direct consequences on the environment through the greenhouse gas emitted and also the nuisance generated such as noise and smells. It is therefore interesting to consider it because it will be affected by the choice of sorting option.

In the case of the sorting facility (Option 2), the recyclables will have to be transported by the trucks up to the landfill site at about 12 kilometres as in the case of Option 1 they will probably remain in the city.

Additionally, the expected amount of recyclables to be collected in Option 2 will be of 21 503 tons per year compared to 12 902 tons per year in the case of Option 1.

Globally, the transportation of recyclables up to the sales will be much higher in the case of Option 2 than in the case of Option 1 and the difference can be calculated at about 200 000 tons kilometres with the hypothesis of 4 kilometres in the case of Option 1. Since the final treatment will be sanitary and therefore less impacting to the environment, it has to be considered as a negative impact.

3.3.1.2 Quality of sorting

The quality of sorting is usually better closer to the source, so it will probably be better in the case of Option 1 than in the case of Option 2. As a consequence, the cleaning will not be so important and the involved water will be reduced.

However, Option 1 presents the risk of some emission of undesirable waste at the location of the sorting that could pollute the immediate environment. This seems to be the only environmental drawback.

3.3.2 Social and economic standpoint

3.3.2.1 Diversion from treatment

Final treatment will be better but more expensive to the community, so all waste that could be diverted from it to be valorised will result in a public saving. It is worth to compare the diversion in the case of each option.

In the case of Option 2, 21 503 tons will be diverted each year compared to only 12 902 tons per year for Option 1. If Option 1 is chosen, there will be 8 601 additional tons per year to be treated at a price of about 5 000 RWF per ton for an annual cost of 43 million RWF.

3.3.2.2 Amount of waste valorised

The waste valorised will result in the availability of secondary raw materials for the local industry that would be able to replace virgin imported materials. Economically, this is an opportunity for the economic activity and it worth to measure it.

As seen above, the difference is 8 601 tons per year. Considering that the recycled materials are usually sold about half price compared to virgin materials and an average price of 200 EUR per tons of recycled materials, the additional value would be of 1 720 000 EUR per year in the case of the sorting facility (Option 2).

3.3.2.3 Employments created

Another social and economic difference between the two options is about the employment created. At first, it might be observed that in the case of Option 1, the only difference from the current situation is that the dealers have to be registered.

Secondly, the sorting facility (Option 2) will create some 27 steady employments to the local population. This will allow to 27 families rely on a fixed salary that will not be minimum and this is a gross difference.

3.3.3 Conclusion

Globally, it seems that Option 1 of sorting at transit shows less environmental impacts than Option 2 of sorting facility. Even if Option 2 suffers from an implementation delay of about one year compared to Option

1, the social and economic impacts are largely in favour of Option 2 especially with a higher amount of recycled materials and created employments.

Aware of these differences of impacts and in order to contribute to the development of the country through solid waste management, it is advised to choose Option 2 of sorting facility. This comforts the detailed study that should be carried out.

APPENDICES

Appendix 1:

List of reference documents

1. Environmental Law of Rwanda – The Republic of Rwanda (May 2005)
2. Economic Development and Poverty Reduction Strategy – The Republic of Rwanda (September 2007)
3. The Third Integrated Household Living Conditions Survey – National Institute of Statistics Rwanda (January 2012)
4. National Policy and Strategy for Water Supply and Sanitation Services – Ministry of Infrastructure (February 2010)
5. Standards on the Management of Waste Disposal Sites – Rwanda Utilities Regulatory Authority (November 2009)
6. National Strategic Plan for the Management of Healthcare Waste – Ministry of Health (February 2011)
7. Five-year Operational Plan for Healthcare Waste Management in Rwanda – Ministry of Health (February 2011)
8. Strategic Health Development Plan for the City of Kigali (December 2011)
9. National Industrial Policy – Ministry of Trade and Industry (April 2011)

Appendix 2: List of encountered persons

- City of Kigali / Mr. John Mugabo, Responsible for Waste Management
- City of Kigali / Mrs. Elizabeth Nahimana, Solid waste consultant
- City of Kigali / Mr. Geoffrey Cyatura, Responsible for Environment
- City of Kigali / Mr. Pascal Nahimana, Responsible for Agriculture and Livestock
- Ministry of Health / Mr. Joseph Katarwa, Head of environmental health department
- Ministry of Environment and Natural Resources – REMA (Rwanda Environment Management Authority) / Mr. Remy Duhuze, Director
- Rwanda Development Board / Simeon Ntuye, Environmental analyst
- Ministry of Infrastructure – EWSA (Energy, Water and Sanitation Authority) / Mr. Fidèle Nteziyaremye, Engineer
- Ministry of Trade and Industry / Mr. Alex, Engineer
- Ministry of Finance and Economic Planning / Mr. William Furaha, Environment sector specialist
- Rwanda Resource Efficient and Cleaner Production Centre / Mr. Steven Niyonzima, Coordinator
- Ministry of Agriculture / Mr. Charles Murekezi, Programme Officer
- RURA (Rwanda Utilities Regulatory Authority) / Mr. Jacques Nzitonda, Director of Waste and Sanitation
- COOCEN / Mr. Célestin Habumugsha, Director
- COPED / Mr. Paulin Buregeya, C.E.O.
- ECO-PLASTICS / Mr. Wenceslas Habamungu, Managing Director
- District of Gasabo / Mrs. Emmerence Uwantage, Hygiene and Sanitation Officer
- District of Kicukiro / Mrs. Béatrice Mukamana, Hygiene and Health Officer
- District of Nyarugenge / Mrs. Rosine Nishimwe, Environment Officer
- SUPA / Mr. Jean, Technical Manager
- ROTO / Mr. Shiva, General Manager
- K.S.A.W. / Mr. Rajni Patel, Managing Director
- MIRONKO / Mr. Jean-Pierre Mironko, Managing Director
- Sector of Rwezamenyo / Mr. Alexis Semitari, Chief of sector
- National Agricultural Export Development Board / Mr. Epimaque Nsanzabaganwa, Head of Horticulture Division
- AMIZERO / Floride Mukarubuga, Executive Secretary

Appendix 3: Visit report of COOCEN

Date: 23-02-2012

Place: Nyakabanda Sector, Nyarugenge District

Contact: Célestin Habumugsha, Director

Report:

COOCEN is a cooperative that collects household waste by little trucks of 10 m³ and wheelbarrows at about 4 000 households of the three quite poor sectors of Kimisangara, Nyakabanda and Nyamirambo on a basis of twice a week. These sectors are actually shared with another cooperative.

Since 2002, it has tried to valorise the organic part of waste that is the most important. Apart from 50 persons for the collection and 20 persons for the payment, it employs 20 persons for the manufacturing.

The amount of waste collected is evaluated at 90 tons per month, which corresponds to a very low ratio of 0.2 kilogram per inhabitant and per day. Of this waste, the organic fraction is separated if this has not been done at the household level and the recyclable items (mostly of plastics and metals) are also sorted to be sold to local buyers.

The organic part is then dried during about one day in the sun, before being stored. The process consists in a quite fine shredding (400 kg/h x 3) and then to a compacting (800 kg/h x 2) able to produce plain cylinders that are cut to get the final product called "briquette".

The "briquettes" are used as a combustible in replacement of the charcoal made of wood and its combustion power is said to be good (being evaluated by IRST). COOCEN has already got some markets in the local prison that buy the "briquettes" at the price of 70 RWF per kilogram by order of 300 tons which seems to be low compared to the price of 200 RWF for charcoal.

Pictures:



Appendix 4: Visit report of ECO-PLASTIC

Date: 28-02-2012

Place: Mageragere Sector, Nyarugenge District

Contact: Wenceslas Habamungu, Plastic Plant Manager

Report:

The ECO-PLASTIC factory is located in a rural part of the City of Kigali. This quite remote location was required by REMA which was afraid of the possible nuisance of a plastic recycling factory.

Only soft plastic waste like commercial packaging PE film is collected by informal ways. They are brought directly at the site or in the town and paid to the collectors between 250 and 500 RWF per kilogram after weighting.

The first step is the further sorting upon the material (LDPE, HDPE, others) and pollution. Then the manager will be able to make mixtures of various categories.

The plastic waste is then washed manually with some liquid detergent in bowls alimented by water that is recovered in decantation basins. The plastic material is then dried at the sun like clothes.

After drying, the transformation first consists in shredding and extruding with a 50 kg/h capacity machines manufactures in India. They are both estimated at about 40 000 USD and represent the recycling workshop able to convert the waste in a raw material allowed to be transformed.

The production of plastic bags, made of 80% to 100% recycled material with the desired pigments, uses a blowing extrusion machine (0.7 or 1.4 m of width) followed by an appropriate folder. Then the plastic bags can be printed.

The total capacity is limited by the washing at 100 kilogram per hour. The global capacity of the plant is therefore of about 240 tons per year.

Pictures:



Appendix 5: Visits report to local industry

Date: 02-03-2012

Place: mostly Kicukiro District

Contact: various (see list of encountered persons)

Report:

Some short visits were made without appointment to a few factories of Kigali potentially able to recycle materials present in the household waste. The companies have been targeted in order to meet the main materials: paper, plastics and aluminium and are presented below.

- Paper:

SUPA manufactures hygienic paper from rolls of recycled paper bought in Moshi (Tanzania). It would like to implement a local paper factory, but the local availability of water does not seem to be enough as the need would be of major importance.

- Plastics:

ROTO is the Rwandan branch of the major regional group specialized in manufacturing tanks and tubes by of HDPE. Although, the products and process allow the use of recycled material, the management is not ready to accept any change in their specifications even for a much cheaper raw material. MIRONKO Plastic Industry is one of the main factories oriented to injection moulding of consumer products in HDPE and has been restarted quite recently. It is currently studying the idea of using materials coming from household waste for which it has carried out some trials from recycled plastics coming from household and bought to dealers.

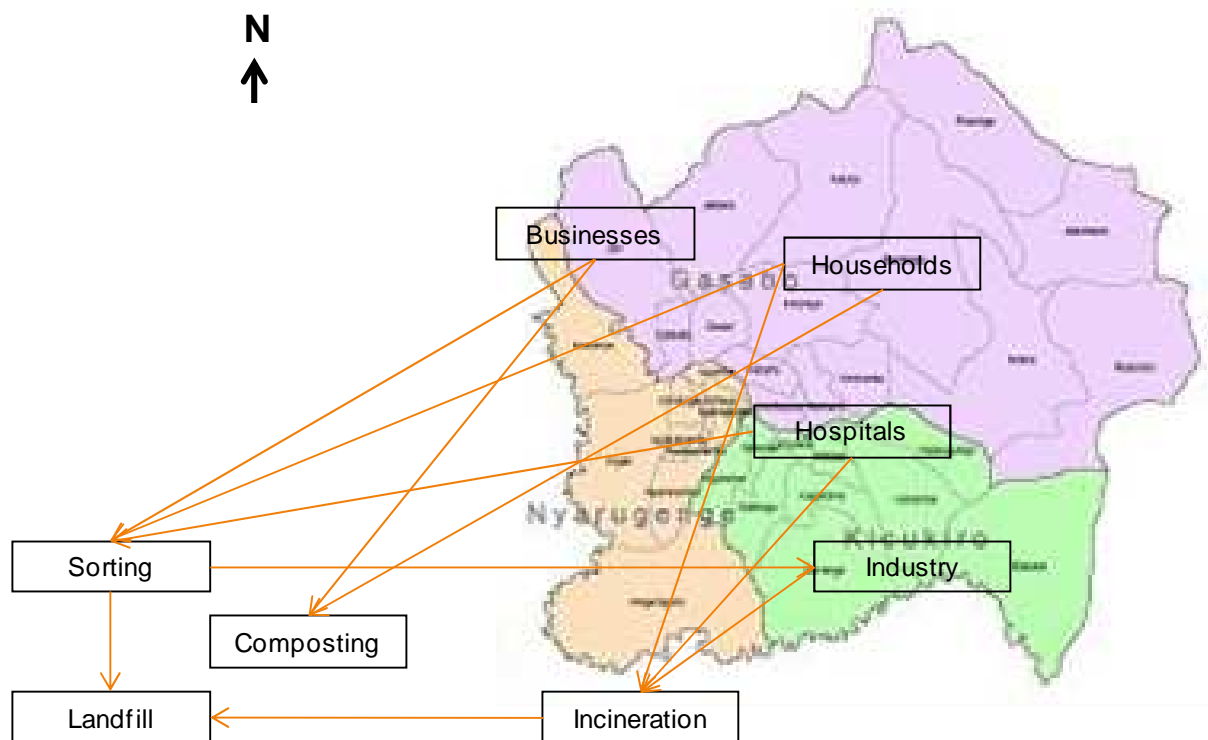
- Aluminium

K.S.A.W. (Kigali Steel and Aluminium Works) is a multinational company specialized in the manufacture of aluminium products by compression of sheets 100% recycled coming from another factory in Uganda. The plant is also recovering and compressing 30 to 40 tons per months of aluminium cans from households that it buys at the price of 1.1 USD per kilogram.

Pictures:



Appendix 6: Site localization



Appendix 7: Public investments involved

COMPONENT	Object	Cost (EUR HT)	Cost (RWF HT)
I : COLLECTION	Collection	0	0
II : VALORISATION	Composting facility	1 780 000	1 424 000 000
	Sorting facility	1 560 000	1 248 000 000
III : TREATMENT	Temporary landfill site	1 500 000	1 200 000 000
	Landfill sites rehabilitation	1 080 000	864 000 000
	Sanitary landfill	4 052 000	3 241 600 000
IV : EMPOWERING	Empowering	70 900	56 720 000
V : INCENTIVES	Incentives	150 000	120 000 000
VI : COMMUNICATION	Communication	480 000	384 000 000
TOTAL		10 672 900	8 538 320 000

Appendix 8: Schedule of components

N°	COMPONENT	Sub-component	2012				2013				2014				2015				2016				2017				2018				2019				2020				2021				2022																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																					
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Appendix 9:

Draft of the proposed strategic plan



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