

# Sustainability Assessment of Material Recovery Facilities (MRFs): The Case of Ubungo and Kigamboni Municipality

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**Abstract:-** This study assesses the factors affecting the sustainability of Material Recovery Facilities (MRFs). It is motivated by the fact that Tanzania through Vice-President's Office-Division of Environment is in the process of establishing three Pilot MRFs as part of Open Burning Project. However, there has never been adequate studies to inform on necessary factors for MRFs sustainability.

The study conducted in Ilala city, and Kigamboni and Ubungo municipalities. The choice of study area based on existence of MRF in Ilala city and proposed MRFs in Kigamboni and Ubungo municipalities. The study variables include SWM administration; waste collection services and segregation practices; reliable market for the recyclables waste; waste characterization; land availability; technology and human resources; financial viability; legal framework; community economic status and awareness level.

Interviews, different types of observations, and documentary review formed the research data collection techniques. The study used descriptive analyses for its variable analysis.

The findings show that there is supportive legal framework; enough and right waste composition; reliable land; and economic viability for the MRFs establishment. Parallel to that, the study areas found with ineffective SWM administration; inadequate waste characterization studies, segregation practices, human skills and community awareness. Further, there were untapped waste market potential, poor technological application and moderate waste collection services.

To this end the study recommends; setting attractive prices for the recyclables in the MRFs; incentivising communities to use the MRFs; Intensifying community Awareness campaigns on the use of MRFs; and application of Public Private Partnership model in operating the MRFs.

**Keywords:-** MRFs, Material Recovery Facilities, Sustainability, Solid Waste Management, Recycling, and Tanzania.

## I. INTRODUCTION

A Material Recovery Facility (MRF) is a place where solid waste are delivered to be separated, processed and stored for later use as raw materials for remanufacturing and reprocessing (Dubanowitz, 2000). According to Feria (2023), MRFs and Waste Transfer Stations are often used interchangeably. Both sites have similar layouts, equipment, and staff. However, MRFs will go that step further as they are more suited to recycling as separation happens at Waste Transfers Station too.

Tanzania is implementing an Open Burning Project, whereas the establishment of Material Recovery Facilities (MRFs) is among the project's components. Although, the existing legal framework in the country has never specifically mentioned MRFs, but existence of clauses in several legislations on Waste Transfer Stations set up a legal basis for their establishment.

The establishment of a Waste Transfer Station in Tanzania is governed by the Environmental Management Act, 2004, the Public Health Act, 2004, and the Solid Waste Management Regulations of 2009.

Also, waste separation to recover the recyclables is the requisite of The Public Health Act, 2009 which call for Local Government authorities to ensure the collected waste is separated at source whereas the Act requires the Local Government Authorities to prescribe for the separation at source, of different types or kinds of waste or garbage.

Despite the presence of solid legal framework there has never been adequate MRFs in Tanzania. The Vice President Office- Division of Environment is currently involved in the establishment of pilot MRFs in the two municipalities (Ubungo and Kigamboni) in Dar es Salaam city under the Open Burning project.

Therefore, taking into cognizant the absence of adequate MRFs as well as studies on sustainability of MRFs in Tanzania, this study developed to fill that gap by informing on important factors to be considered for MRFs ' sustainability.

### ➤ Objectives

- To assess and inform on the sustainability factors for establishment of Ubungo and Kigamboni MRFs

**II. LITERATURE REVIEW**

➤ *Community Involvement for Successful MRFs Operations*

In Indonesia, CdMRFs (Community Material Recovery Facilities) are well-known as waste banks that have customers or members from surrounding neighbourhoods and are managed by the community or local leaders (Raharjo et al., 2015). CdMRF members are encouraged to perform waste segregation at the household and collection sites. At CdMRFs, recyclable waste collected by the community is weighed and valued according to the type and classification of the waste (Soesanto et al., 2021a). CdMRFs record all transactions and balances (deposited money from selling their waste) of all members. Members may withdraw their money from waste sales at any time once the balance fulfils the minimum amount of cash regulated by the CdMRF (Soesanto et al., 2021b).

A CdMRF is typically preferred by communities over other informal recyclers when the former offers fairer prices than the latter (Chalcharoenwattana & Pharino, 2015). Many researchers have demonstrated the potential of a recycling system through a CdMRF project (Singhirunnusorn et al., 2012; Wijayanti & Suryani, 2015). Although CdMRFs seem to be promising, the development of CdMRFs depends on the active participation of all community members (Singhirunnusorn et al., 2012).

The establishment of a CdMRF as a form of Community Based Solid Waste Management in neighbourhoods, hamlets, and urban villages was proven to trigger community participation in solid waste recycling (MacRae & Rodic, 2015). A CdMRF illustrates the effort of a community to support sustainable solid waste management practices while educating the public and improving recycling practices and general welfare (Purba et al., 2014). CdMRFs also improve the surrounding community because they increase awareness of appropriate solid waste management, knowledge of the impacts of unmanaged solid waste, and public concern about solid waste and build caring and mutually beneficial community enthusiasm (Indrianti, 2016).

➤ *Household Awareness and MRFs Performance*

In Semarang City, the capital of Central Java Province, Indonesia, the maximum actual recycling activity of CdMRFs accounts for 5% of the total generated solid waste (Raharjo et al., 2015). This percentage is low because of limited environmental knowledge of the community, which leads to low awareness and participation in recycling activities (Singhirunnusorn et al., 2017). Sekito et al. (2013) found that up to 33% of the waste generated in Semarang City could potentially be recycled through informal sectors. However, households' waste separation practices are not performed properly because of low public awareness, an insufficient number of separated waste collection bins, and the unavailability of separate (organic and recyclable) waste transport facilities (Fatimah et al., 2020).

➤ *Effective Recycling*

Manda, T.A. (2005) has identified 12 factors affecting recycling sector. The identified factors include; Government policy, Government Finances, Waste characterization, Waste collection/Segregation, Household education, Household economics, Municipal Solid Waste Management (MSWM) administration, MSWM personnel Education, MSWM Plan, Local-Recycled Material Market, Technological and Human Resources and Land availability.

Table 1 Describes the Factors in Detail.

Title	Description
<i>Government Policy</i>	Presence of regulations, enforcement of laws, and use of incentive schemes.
<i>Government Finances</i>	Cost of operations, budget allocation to MSWM, stability/reliability of funds.
<i>Waste Characterization</i>	Assessment of generation and recovery rates, and composition of waste stream
<i>Waste Collection and Segregation</i>	Presence and efficiency of formal or informal collection and separation by either scavengers, municipality, or private contractors.
<i>Household Education</i>	Extent of knowledge of waste management methods and understanding linkages between human behavior, waste handling, and health/sanitation/environment within households.
<i>Household Economics</i>	Individuals' income influencing waste handling behavior (reuse, recycling, illegal dumping), presence of waste collection/disposal fees, and willingness to pay by residents.
<i>MSWM Administration</i>	Presence and effectiveness of private and/or public management of waste (collection, recovery, disposal).
<i>MSWM Personnel Education</i>	Extent of trained laborers and skilled professionals in MSWM positions.
<i>MSWM Plan</i>	Presence and effectiveness of an integrative, comprehensive, long-term MSWM strategy.
<i>Local Recycled-Material Market</i>	Existence and profitability of market systems relying on recycled-material throughput, involvement of small businesses, middlemen, and large industries/exporters.
<i>Technological and Human Resources</i>	Availability and effective use of technology and/or human workforce and the safety considerations of each.
<i>Land Availability</i>	Land attributes such as terrain, ownership, and development dictating MSWM.

Source: Manda, T.A. (2005)

➤ *Waste Management Planning*

Effective MRFs requires the availability of data and information necessary for planning and operation. The presence of Waste Management profile may best present the rich information to guide the sustainability of MRFs. Omar (2022) highlighted some of the important data to be included in the MRFs. The data include:

- Population and local Government authority data;
- Waste quantity and composition data;
- Waste polices and legislation;
- Institutions in place;
- Costs and financing of the waste management system (WMS);
- Technologies in use; and
- Stakeholder identification and participation.

**III. SUSTAINABLE MRF CONCEPTUAL FRAMEWORK**

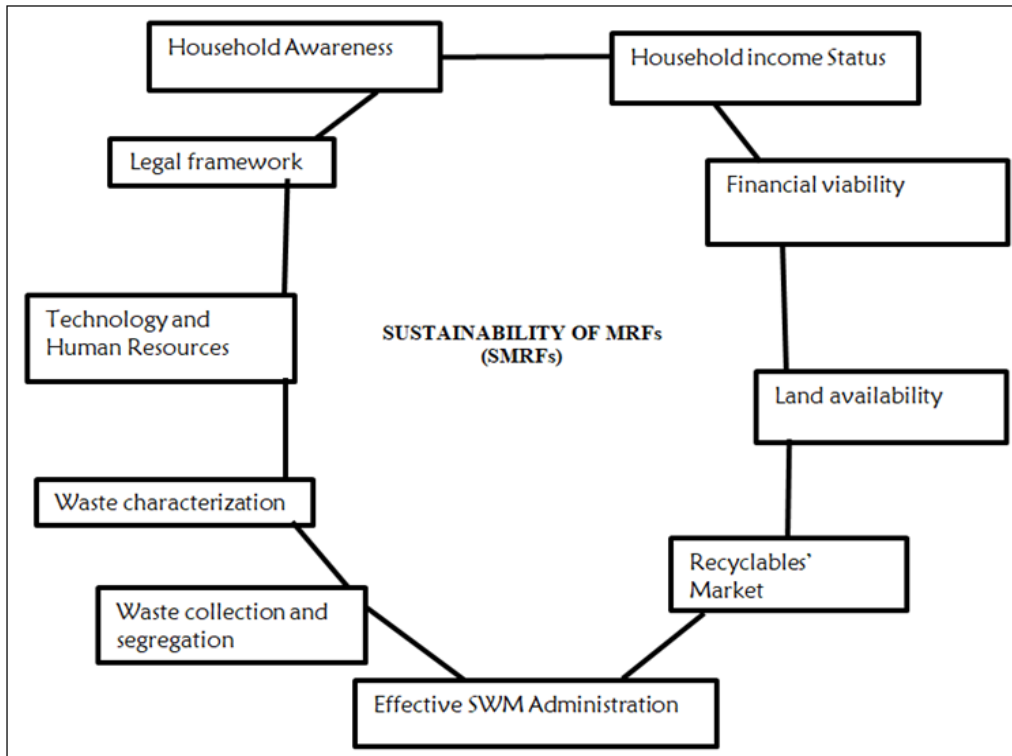


Fig 1 Sustainable Material Recovery Facilities’ (MRFs) Framework  
Source: Own Construct, 2023

The sustainability of MRFs depend on various factors. As indicated in Figure 3.0 the factors include Effective SWM administration whereas, relevant stakeholders and their roles are clearly identified and fulfilled; Availability of waste collection services and segregation practices; Presence of reliable market for the recyclables waste; and Presence of reliable waste characterization data for determining the volume of recyclables and possible revenues MRF can generate,

Further, availability of Land free from disputes; the use of right technology and capable human resources in managing MRFs; Financial viability of the MRFs whereas, the revenue must exceed the operational cost; Presence of supportive legal framework that back up the establishment of the MRFs; Understanding of the economic status of the community for determining a proper plan for community engagement in the use of MRFs and high level of awareness to the community on the use of the established MRFs are very essentials in ensuring sustainability of the MRFs.

**IV. METHODOLOGY**

The study methodology involved a purposeful selection of 3 Local Government Authorities (Ilala City, Kigamboni and Ubungo Municipalities). The choice of Ilala

city was informed by the presence of MRF in Bonyokwa Ward. On the other hand, the choice of Kigamboni and Ubungo Municipalities was influenced by the inclusion of the two municipalities in the Open Burning Project for the establishment of pilot MRFs.

The study also, involved Focus Group Discussions (FGDs) as part of data collection protocols. Members of the conducted FGDs included 3 Head of Environmental departments and 3 Environmental officers each from Ilala, Kigamboni and Ubungo Municipalities; A representative from PO-RALG responsible for Local Government Authorities coordination; 3 representatives from Vice President Office Division of Environment and representatives from waste collection service providers.

Further, interviews, were conducted to representatives from Mtaa Chairperson of the Bonyokwa sub-ward; a Sampled 20 Households at Bonyokwa sub-ward and 3 representatives from the established MRF at Bonyokwa sub-ward and 3 representatives from the NGO that supporting the establishment of the MRFs (NIPE FAGIO). The study also involved a documentary reviews as part of data collection tools and the collected data analysed using descriptive analysis.

## V. RESULTS AND DISCUSSION

### ➤ *Legal Framework;*

Tanzania has a robust legal framework for supporting the establishment of MRFs. The supporting pieces of legislations include, the Environmental Management Act, 2004, Public Health Act, 2004, and the Solid Waste Management Regulations of 2009.

### ➤ *Waste Characterization Studies*

The quantity and composition of generated waste can be considered as backbone in the establishment of MRFs. Quantity information can include both the weight and volume of generated waste in an area expected to be served by the established MRF. Also, Waste quantity include the projection on the future waste generation. These are the quantities that will be used to estimate the size of the required MRF and associated management cost. For example, in Bonyokwa's MRF in Ilala city, that serves a total of 10,4000 population and 3000 households, a total of 47.94 tons of waste is received every month out of which clear plastic is 0.440 tons; coloured plastic is 0.344 tons; HDPE plastic is 0.520 tons; other wastes including paper and leather is 0.896 tons; Hazardous waste is 1.072 tons, and organic waste is 44.668 tons. This provides the basis for estimating the amount of money that can be generated from the MRFs through selling of the recyclables. This call up on the two municipalities of Ubungo and Kigamboni to conduct thorough waste characterization study before the establishment of the MRFs.

### ➤ *Swm Administration*

In Ilala city the established MRF in Bonyokwa Sub-Ward, found to have involved several stakeholders. For example, NIPE FAGIO (NGO with SWM focus) has provided the expertise, start-up capital and 3 bins at each household in project area. The NIPE FAGIO has also being involved in awareness creation to community on the sustainable use of MRF. However, the situation is different in Kigamboni and Ubungo municipality whereby, the

process is Government dominated. In the two municipalities there is inadequate involvement of Private sector (including waste collection service providers), NGOs with SWM focus as well as recyclers and informal waste collectors. This may affect the off-taking of the recyclables, supply of technical know-how and effective operation of the MRFs.

Further, Ilala city enjoys the support of local leaders especially, *Mtaa* chairperson, unlike Kigamboni and Ubungo municipalities whereby the process of MRFs establishment is controlled at municipal level with less ownership at local level. This may affect the sustainability of the proposed MRFs.

The political will of Local leadership in Ilala city has proven to be pivotal for successfulness of MRFs. Local leadership at Bonyokwa sub-ward have been very instrumental in mobilising community in waste sorting as well as abiding to waste collection schedules. This also, involved organizing waste collection schedules for the residues at the MRFs as well as identification of the customers for the recyclables.

### ➤ *Market For Recyclable Waste*

The presence of reliable off-takers of the collected recyclables is very vital for the sustainability of the MRFs. In Dar es Salaam, there is a reliable market for recyclable waste, especially plastic and paper as shown in plate 1.0. However, in Ilala city (Bonyokwa sub-ward) the established MRFs found not to have specific contract with off-takers of the recyclables waste. This may jeopardize the sustainability of the MRFs in a long run.

This also applies to Kigamboni and Ubungo municipalities whereby, there were no pre-planning arrangements for off-taking of the recyclables from the MRFs. There must be a clear arrangement with recycling companies or aggregators for off-taking the collected recyclable at the MRFs to enhance sustainability.



Plate 1 Recyclables Market Opportunities in Dares Salaam  
Source: Omar (2022)

Further, as organic waste consist higher proportion of the generated waste, presence of market for by product of organic waste is vital for sustainability of MRFs. For example, the market for Maggots and organic Fertilizer is among the low hanging fruits for sustainability of MRFs. *Hermetia illucens* or Black soldier Fly (BSF), an insect native to Tanzania, has a spectacular ability to convert waste into protein and is renowned for easy handling. The fly can consume as much as 70% of its own body weight in waste every day. For every kilogram of organic waste that it consumes, nearly 50 grams of protein are produced that can act as a feed supplement for commercial livestock such as

poultry or fish. There is a continuous demand for fish and chicken in the country, but the production costs at the moment are very high, amongst others due to the expenses related to feeds as indicated in several studies. The project areas (i.e. Ubungo and Kigamboni municipalities) are also known to have commercial livestock and vegetable growers which provide assured market organic waste products especially, maggots . maggots and high-nitrogen organic fertilizer. The best practice from the existing MRF in Ilala municipality has proven high demand for both maggots and fertilizers in the local community.



Plate 2 Black Soldier Fly Value Chain  
Source: Mukonoweshuro et. al., (2023)

➤ *Financial Sustainability*

The interview with Ubungo environmental officer revealed that the planned MRFs are expected to serve 7,013 and 26,000 population for Kinzudi and Mavurunza sub-ward respectively. Based on the UN-Habitat Study of 2018 the per capita waste generation in the two municipalities is 0.67kg/day. Impliedly, in Ubungo municipality the proposed MRF in Kinzudi sub-ward is expected to serve 4.7 tons per day while the one in Mavurunza sub-ward is expected to serve a total of 17.42 tons per day. However, the study conducted by the Vice-President-Division of Environment in 2020, have indicated the average composition of MSW includes garden and wood waste to be (30%), food waste (37%), papers (11%), plastic (7%), glass (4%), metal and tin (1%), textiles (2%) and ash (8%). Further, the same study by the Vice-President-Division of Environment in 2020, indicated the recovery rate for plastic and paper to be in the range of 20-30%. Other studies including UN-Habitat (2021) indicated the metal recovery rate to be as high as 60%. Based on that the income necessary for running the MRFs can be established.

• *Income from Selling Recyclables and Recovered Organic Waste*

Sustainability of the proposed MRFs in Kigamboni and Ubungo municipalities at large extent depend on the amount of recyclables that can be retrieved from waste stream for sale. Table 2.0 and 3.0 shows the estimated recyclables to be collected and their expected revenues respectively based on the waste composition and recovery rate highlighted in 5.3.3.

Table 2 The Estimated Recovered Recyclables and Organic Waste for sale from MRFs

S/No.	Waste Type	% Composition	Amount generated (tons/year)	% Recovered	Recovered amount (tons)
Kinzudi MRF	Organic waste	39	657	10 (Maggots)	65.7
				40 (compost)	262.8
	Plastic	16	274.480	20	54.89
	Paper	11	188.705	20	37.741
	Metal	5	85.775	60	51.46
Mavurunza MRF	Organic waste	39	2479.74	10	247.97
				40	991.89
	Plastic	16	1,017.33	20	203.46
	Paper	11	699.41	20	139.88
	Metal	5	317.92	60	190.75

Field Survey: 2023

Table 3 Expected Revenue for the MRFs in Ubungo Municipality

MRF	Waste Type	Recovered amount (tons) annually	Price per Ton (Tshs)	Total Expected Revenue (Tshs) annually
Kinzudi MRF	Organic waste	65.7 (Maggots)	2,000,000 (maggots)	131,400,000
		262.8 (compost)	100,000 (compost)	26,280,000
	Plastic	54.89	500,000	27,445,000
	Paper	37.741	300,000	11,322,300
	Metal	51.46	600,000	30,876,000
	<b>Waste Collection Charges</b>			
	<b>Waste generator</b>	<b>Number</b>	<b>Price per Household</b>	
	Households	7,013	3000	21,039,000
<b>Total</b>				<b>227,323,300</b>
Mavurunza MRF	Organic waste	247.97	2,000,000 (maggots)	495,940,000
		991.89	100,000 (compost)	99,189,000
	Plastic	203.46	500,000	101,730,000
	Paper	139.88	300,000	41,964,000
	Metal	190.75	600,000	114,450,000
<b>Total</b>				<b>853,273,000</b>

Field Survey: 2023

- Operational Cost based on the Best Available Practice from the Existing MRF in Dares Salaam

The operational cost includes supplying the storage equipment for waste segregation, collection of the segregated waste from households, transportation of the residual waste to the dump site, wages, and water bills.

Table 4 Operational Cost

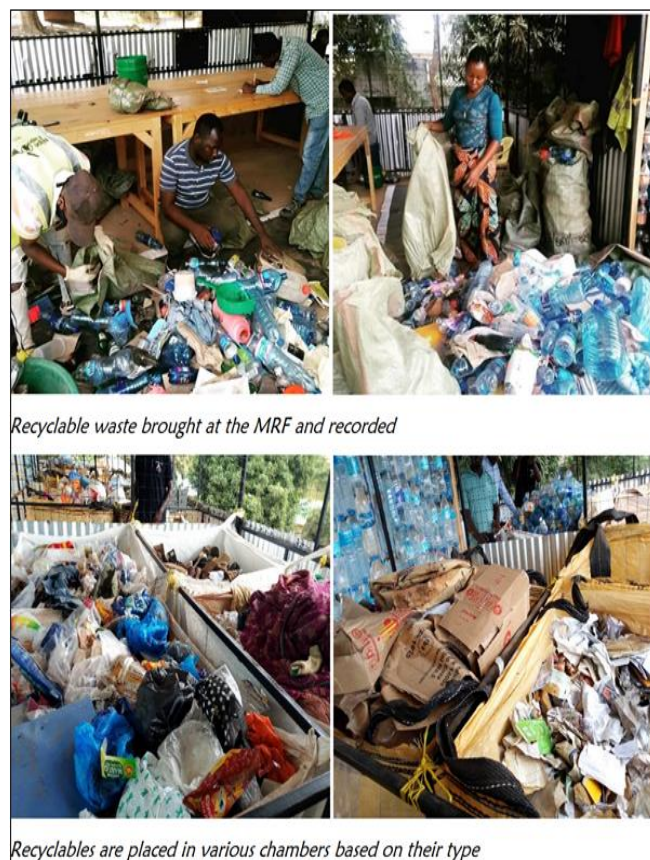
MRF location	Item	Unit	Unit cost (Tshs)	Annual Cost (Tshs.)
Kinzudi	Storage Equipment	42,408 pc	500	21,204,000
	Collector’s Wages	10 Person	5000	18,000,000
	Watchmen Wages	1 person	5000	1,800,000
	Water bills	Lump sum	30,000	360,000
	Residual waste Transportation	24 Trips	400,000	9,600,000
<b>Sub-total</b>				<b>50,964,000</b>
<b>Buying of Recyclables</b>				
	Plastics	54.89 tons	300,000	16,467,000
	Papers	37.74 tons	150,000	5,661,000
	Metals	51.46 tons	500,000	25,730,000
<b>Sub-total</b>				<b>47,858,000</b>
<b>Sub Total</b>				<b>98,822,000</b>
Mavurunza	Storage Equipment	181,872 pcs	500	90,936,000
	Collector’s Wages	20 persons	5000	36,000,000
	Watchmen Wages	1 person	5000	1,800,000
	Water bills	Lump sum	60,000	720,000
	Residual waste Transportation	48 Trips	400,000	19,200,000
<b>Sub-total</b>				<b>148,656,000</b>
<b>Buying of Recyclables</b>				
	Plastics	203.46	300,000	61,038,000
	Papers	139.88	150,000	20,982,000
	Metals	190.75	500,000	95,375,000
<b>Sub-total</b>				<b>177,395,000</b>
<b>Total</b>				<b>326,051,000</b>

Field Survey: 2023

Therefore, based on table 3.0 the expected revenues for the Kinzudi and Mavurunza in Ubungo municipality are 227,323,300Tshs and 853,273,000Tshs respectively. However, the operational costs for Kinzudi and Mavurunza MRFs are expected to be 98,822,000Tshs. and 326,051,000Tshs. respectively. This implies that there are nearly 150% and 135% profits for Kinzudi and Mavurunza respectively if the MRFs are managed well. This will guarantee the sustainability of the proposed MRFs.

➤ *Technology and Human Resource*

At Material Recovery Facility (MRF) it is expected for waste to be received, separated, and recyclable materials prepared for marketing to end-users. This requires use of technology and equipment to sort and process recyclable materials, which increases the efficiency of the recycling process. The operational of such equipment require capable human resource. However, in interview with project coordinator at the Vice-President office –Division of Environment and Head of Departments at both Ubungo and Kigamboni Municipalities it was clearly indicated that the waste brought at the MRFs will be manually sorted. “There will be no use of automated machines for enhancing sorting Efficiency”... indicated by Project Coordinator. This has also, been observed for the existing MRFs in Bonyokwa Ward as shown in Plate 3.0.



Recyclable waste brought at the MRF and recorded

Recyclables are placed in various chambers based on their type

Plate 3 Waste Sorting at Bonyoka MRF in Ilala City

### ➤ *Household Awareness*

Community awareness on the existence of the MRF in their locality and their role is vital for the sustainability of the MRFs. For example, Bonyokwa sub-ward through local leaders especially Mtaa chairperson and members of Sub-ward committee have reached out the community to sensitize them on the use of MRFs and the benefit attached to it. This has been witnessed during the study whereby, local leaders used different approaches in sensitizing community. The applied approaches include provision of waste segregation bins/sacks to encourage sorting practice, provision of waste segregation equipment, free waste collection charges for the households that perform well in waste sorting and regular community meetings.

### ➤ *Waste Collection And Segregation*

In Ilala city (Bonyokwa sub-ward) found to have well established waste segregation plan. Through NIPE FAGIO-NGO households in the project area supplied with 3 waste storage equipment. Further, there was planned waste collection schedules, whereby, group of youth contracted for waste collection in a project area. There was also established incentives mechanisms for households that adhered to waste segregation practices. The incentives include free waste collection charges. This was also found to have been considered in the designing of the proposed MRFs and Ubungo and Kigamboni municipalities whereby, some funds allocated for sensitization of waste segregation practices including provision of segregation equipment.

### ➤ *Household Income Status*

As indicated by Fadhullah, et. Al., (2022), low income areas with predominantly rural characteristics with high proportion of low income earners tend to exhibit less waste segregation practices compared the high income status neighbourhoods. This fact has also proven to be true in the study area. In the interviews with local leaders and municipal officials it was clearly stipulated that appetite of waste segregation is low in the Bonyokwa sub-ward in Ilala municipality as much of the area is composed of low and middle income earners. However, it was also highlighted that buying of the recyclables at MRFs motivate the low income earners to segregate waste as oppose to middle and higher income families. The motivation of waste segregation to higher income households found to be motivated by exposure which also linked with education and economic status.

Likewise, Kigamboni and Ubungo municipalities have indicated the higher income households are engaged more in waste segregation practices compared to their counterpart in low income areas. The project area in both municipalities highlighted to have a mixture of low and medium income neighbourhoods. This call for introduction of incentives for both low and income households for sustainability of the MRFs.

### ➤ *Land Availability*

The sustainability of MRFs is also very much depends on the land ownership. In Bonyokwa sub-ward the Land for the establishment of MRF found to be offered by

Government. This found to guarantee security for the investment as well as resource mobilisation from several stakeholders.

Likewise, in Ubungo and Kigamboni municipalities the two municipalities have offered land for the establishment of the MRFs. For the case, of Kigamboni the area was demarcated for the establishment of Waste transfer station prior the introduction of Open Burning Project. The Municipality has already started investment in the area which make it is to fit the MRF purpose.

For the case of Ubungo municipality the 2 areas (Kinzudi and Mavurunza) located for establishment of MRFs found to have been acquired through a participatory approach between the municipality and local leaders. This found to guarantee security of investment and in turn sustainability of the MRFs.

## VI. CONCLUSION

Sustainability of MRFs is associated with many factors. However, the ten (10) factors identified in this paper are the core from which the sustainability of the proposed MRFs in Ubungo and Kigamboni municipality advised to consider. The important of these sustainability factors anchored on the fact that the two MRFs under the Open Burning project are expected to be the model MRFs whereas, its failure my discourage future investment in the establishment of MRFs. In turn, this may defeat the good purpose of MRFs as not only waste management strategy but also livelihood opportunity for urban poor.

## RECOMMENDATION

- The prices for the recyclables in the MRFs should be made attractive compared to other buyers to entice waste pickers to bring the recyclables to the MRFs.
- The community must be incentivized in the use of MRFs. Some of the incentives may include reduction of waste collection charges for the households that demonstrate effective waste segregation practices.
- Continuous awareness campaigns on the use of MRFs by community members.
- The operation of the MRF should apply Public Private Partnership model whereby, Waste collection Service provider operating in that locality must also run the established MRF.

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