1. Baseline Study

GREATER MONROVIA SOLID WASTE MANAGEMENT BASELINE

This study was conducted within the context of implementation of the project "Delivering Climate Resilient Solid Waste Management Services in Greater Monrovia, Liberia through Community-Based Enterprises"

Title:
Greater Monrovia Solid Waste Management Baseline

1. Baseline Study

Cities Alliance – 2021

Technical coordination and supervision:
Francisco M. Juarez Lopez, Cities Alliance Liberia Country Programme.

Consultancy firm:
Arup Group Limited

Communications Coordination:
Yamila Castro, Cities Alliance Secretariat

Editor:
Juliet Bunch

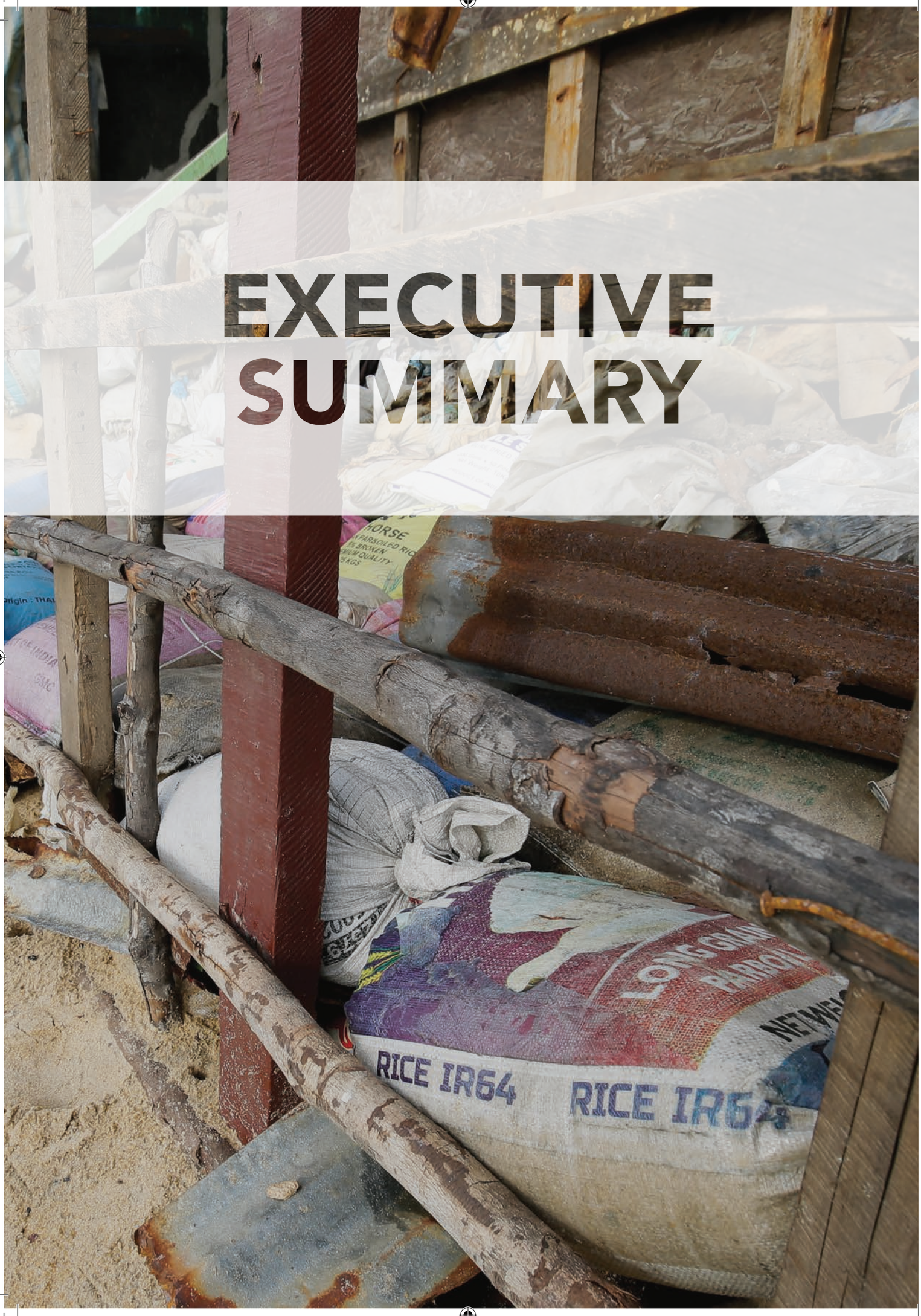
Design:
Creatrix Design Group

Please credit this publication as: Cities Alliance (2021), Greater Monrovia Solid Waste Management Baseline; 1. Baseline Study

CONTENTS

TABLES

ILLUSTRATIONS



EXECUTIVE SUMMARY

Africa is going through an economic boom and cities are at the centre of this pathway to economic prosperity. Liberia as a nation has one of the levels of urbanisation in Africa with just over 50% of the total population living in urban areas[1]. The country's economy is increasingly reliant on the productivity of its urban centres. Greater Monrovia is the clear primate city and as such is critical to the country's growth and development ambitions. Currently, over 26% of the country's total population lives within greater Monrovia and this is estimated to be increasing annually by 3.4%[2]. In this, context greater Monrovia is ill-equipped to mitigate the impending risks associated with urbanisation and population growth, in particular related to solid waste.

Solid waste management is an increasing challenge for African cities, like greater Monrovia, which are expected to double their municipal solid waste generation within the next 15 to 20 years, placing a major strain on already stressed infrastructure (UNEP, 2016). If the growing volume of waste in emerging economies is not controlled, dumpsites are projected to account for 8-10 per cent of global Greenhouse Gas (GHG) emissions by 2025[3].

To address this challenge, the World Bank and the European Union (through the Cities Alliance Liberia Country Programme) are partnering together to support the Government of Liberia (GoL) and the two City Corporations of Monrovia and Paynesville that are responsible for Solid Waste Management (SWM) in greater Monrovia. Both the World Bank and Cities Alliance aim to support an integrated and holistic approach to solid waste management to ensure that waste is viewed as a value chain, from the household to the landfill.

This report examines the institutional and regulatory environment for SWM in greater Monrovia and for the country as a whole, before examining the current waste management operations, followed by a detailed presentation of waste quantity, characterisation, and density. Finally, it presents estimated GHG emissions based on the estimated waste forecast.

INSTITUTIONAL AND REGULATORY ENVIRONMENT FOR SOLID WASTE MANAGEMENT

The draft National Solid Waste Management Policy (2015) is the key policy instrument created in response to the need for strategic coherence nationwide, in line with the decentralisation of certain solid waste management responsibilities. The draft policy sets out the national vision for safe collection, treatment and disposal of solid waste. The policy also outlines linkages between SWM and environmental, public health, economic and gender inclusive outcomes, underpinned by good local governance, public and private sector coordination and technically sound, economically sustainable interventions. Finally, the draft policy sets out roles and responsibilities for key institutions performing SWM functions. The draft policy has been validated in 2017 and now needs to be adopted and implemented.

[1] https://www.statista.com/statistics/455869/urbanization-in-liberia/
[2] https://www.cia.gov/library/publications/the-world-factbook/fields/2212.html
[3] https://www.iswa.org/fileadmin/galleries/About%20ISWA/ISWA_Roadmap_Report.pdf

CURRENT WASTE MANAGEMENT OPERATIONS

A successful waste management system has existed in greater Monrovia as early as the 1980s when the Monrovia City Corporation (MCC) was solely responsible for collecting and hauling for disposal, domestic and commercial solid waste. They were assisted in this by a private waste collection system called "Betty Garbage System". Due to political unrest and conflict, the waste management system has been challenged to breaking point. Over the past decade the international community has been supporting the GoL to re-establish an SWM system in greater Monrovia, and currently the fundamental elements of a waste management system exist, with basic infrastructure such as a landfill, two waste transfer stations, 61 skip buckets and transportation equipment now in place. The private sector is increasingly involved in waste collection through 5 small and medium-sized enterprises (SMEs) and 30 community-based enterprises (CBEs).

WASTE QUANTITY

The waste arising (or production) estimates are based on a per capita waste generation rate and are, therefore, heavily influenced by population estimates. Population estimates are derived from the latest national census data (2008). The data has been projected forward to the baseline year (2018) and then projected forward over a 25-year time horizon (until 2043). The population growth rate for the 10-year period between 2008 and 2018 has generally declined falling from 2.46% per year in 2008 to 2.16% per year in 2018. The population growth rate is projected to continue declining across the projection horizon, falling to 1.37% per annum in 2043. This trend gives an average change in population of 1.95% per year, which is used in the waste forecast.

The waste generation rate used in the model is 0.42kg/capita/day or 0.153tn/capita/year and is the most recent data available (2016). Given the 2018 population, the 2018 baseline position for MCC is an estimated waste arising of **158,278 tonnes.** The 2018 baseline position for Paynesville City Corporation (PCC) is **88,766 tonnes.**

Component	% by weight
Paper	7.0
Glass	1.0
Metals	1.0
Plastics	11.0
Special municipal solid waste	1.0
Combustible waste	14.0
Textiles	5.0
Vegetable/putrescible	43.0
Miscellaneous items	17.0
TOTAL	**100.0**

WASTE CHARACTERISATION

Waste composition in greater Monrovia is as follows, as derived from Pasco (2012):

Applying Net Calorific Value (NCV) data to each component of the baseline waste composition, and taking account of the proportion of each component, the average NCV for greater Monrovia's municipal waste is 8.42[4]. This NCV is within the range required for municipal waste to sustain combustion albeit towards the lower end of the range.

WASTE DENSITY

The waste collected is not subject to more than cursory compaction and can be regarded as un-compacted.

Based on a review of the existing waste density study for Monrovia[5], and using Arup's professional judgement, the density of municipal waste in greater Monrovia is considered to have a baseline value of 261kg/m^3.

ESTIMATION OF BASELINE GHG EMISSIONS

The GHG emissions associated with the waste management systems employed by MCC and PCC have been established using the Waste and Resource Assessment Tool for the Environment (WRATE). WRATE is a software package specifically designed to estimate the life-cycle impacts (LCI) of different waste management systems. It was developed by the Environment Agency in the United Kingdom, principally using data from within the European Union.

Using the WRATE model, the GHG emissions associated with the current Monrovia City Corporation waste management system (at the currently estimated waste collection rate of 40%) is **144m kg CO2-Eq.** The GHG emission associated with the current Paynesville City Corporation waste management system (at a 40% waste collection rate) is **73m kg CO2-Eq.**

These GHG emission results reflect the yearly proportion of the total life cycle emissions of the waste management systems including construction, maintenance, operation and decommissioning of all processes.

[4] World Bank Group, What a Waste 2.0 – A Global Snapshot of Solid Waste Management to 2050, 2018

[5] Pasco Waste and Environmental Consulting, Solid Waste Management – Waste Characterisation on the African Continent, 2012

1. INTRODUCTION

Africa is going through an economic boom and cities are at the centre of this pathway to economic prosperity. Liberia as a nation has one of the levels of urbanisation in Africa with just over 50% of the total population living in urban areas[6]. The country's economy is increasingly reliant on the productivity of its urban centres. Greater Monrovia is the clear primate city and as such is critical to the country's growth and development ambitions. Currently, over 26% of the country's total population lives within greater Monrovia. As it currently stands, an infrastructure services gap exists with urban authoritises struggling to service the urban population, and ill-equipped to mitigate the impending risks associated with further urbanisation and population growth.

Solid waste management is becoming an increasing challenge for African cities which are expected to double their municipal solid waste generation within the next 15 to 20 years, placing a major strain on already stressed infrastructure (UNEP, 2016). If the growing volume of waste in emerging economies is not controlled, dumpsites could account for 8-10 per cent of global GHG emissions by 2025[7].

To address this challenge, the World Bank and the European Union are working together to support the Government of Liberia (GoL) and the two City Corporations responsible for solid waste management in greater Monrovia. The World Bank Liberia Reconstruction Trust Fund (LRTF) is supporting improvements in solid waste management in the Greater Monrovia area, through the implementation of a new landfill – the Cheesemanburg Landfill Urban Sanitation (CLUS) project and strategic investments in the secondary waste collection infrastructure. Cities Alliance with support from the European Union in parallel aims to continue improvements in the operations and functionality of the primary (household level) solid waste collection infrastructure, transport and disposal in Monrovia and the surrounding townships. Together, these two projects aim to support Liberia's Nationally Disclosed Contribution (NDC) to the United Nations Framework Convention on Climate Change by improving the Primary Waste Collection System as well as providing viable alternatives such as waste recycling, composting and exploring opportunities in waste-to-energy solutions.

Both the World Bank and Cities Alliance aim to support an integrated and holistic approach to solid waste management to ensure that waste is viewed as a value chain, from the household to the landfill.

This report summarises the baseline waste management research carried out by Arup for the Cities Alliance Liberia Country Programme to address evidence gaps around waste management in greater Monrovia. The report also provides initial conclusions and recommendations for the greater Monrovia waste management Technical Working Group.

[6] https://www.statista.com/statistics/455869/urbanization-in-liberia/

[7] https://www.iswa.org/fileadmin/galleries/About%20ISWA/ISWA_Roadmap_Report.pdf

1.1 Scope and Purpose

The purpose of the Waste Management Baseline Study is to establish and document the baseline parameters for solid waste management in the Greater Monrovia area (Monrovia City Corporation, Paynesville City Corporation and surrounding townships[8]). The Study collects detailed and accurate baseline information on the current performance of Monrovia's solid waste management (SWM) system and provides the estimated current GHG emissions associated with greater Monrovia's Solid Waste System. This Baseline serves as the foundation for identifying short and long-term opportunities to improve the city's SWM and provide the information necessary to develop an effective, economically viable long term solid waste management plan for the city.

The report examines the institutional and regulatory environment for solid waste management in Greater Monrovia and for the country as a whole before examining the following five areas specifically within greater Monrovia:

- Current waste management operations
- Waste Quantity
- Waste Characterisation
- Waste Density; and
- Estimation of Baseline GHG emissions.

1.2 Approach and methodology

Our approach uses a combination of secondary and primary data collection techniques undertaken over home-country and in-country work periods. The majority of analysis is undertaken in the home-country and involves the analysis of desktop grey, academic and technical data as well as data collected during two in-country missions to greater Monrovia in September and November 2018.

Secondary data collection and analysis includes review of over 45 documents provided by Cities Alliance and those collected in-country. This documentation includes both data concerning both institutional arrangements for solid waste management, technical waste data, data from Community Based Enterprises, and statistical/spatial data.

Primary data collection includes:

- Key informant interviews with main stakeholders responsible for Solid Waste Management in Liberia and Greater Monrovia including:
- Site observations and inspection of waste management practices and infrastructure at key sites around greater Monrovia including the two waste transfer stations, the landfill site and waste vehicle depots.

[8] New Georgia, Garwolon, West Point, Brewerville, Virginia, Congo Town, Johnsonville, Dixville, Caldwell, New Kru Town, Barnersville, and Gardnersville. The Township of Cheesemanburg is the site of the proposed new Cheesemanburg landfill.

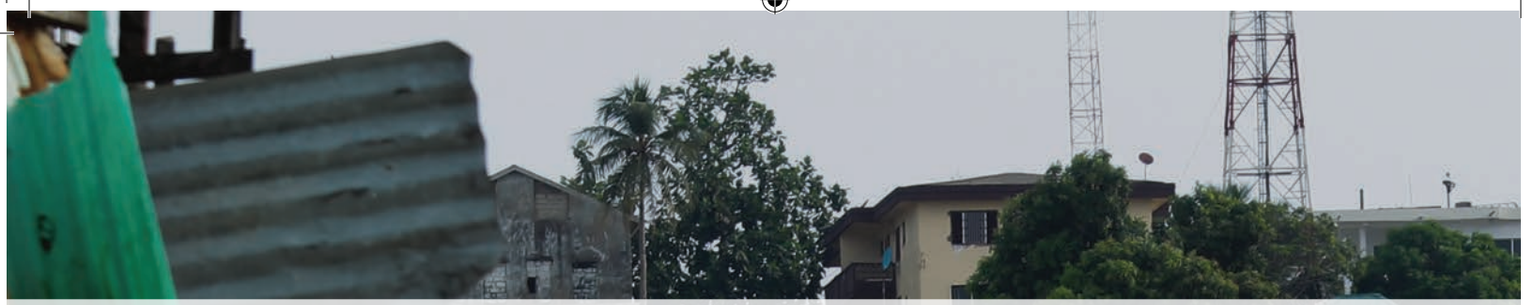
1.3 Data availability

The baseline analysis rests on the reliability and currency of available data. Based on the available information provided by Cities Alliance and collected in-country – there is sufficient data and literature available to establish the current waste management operations, waste quantity, waste characterisation, waste density; and an estimation of baseline GHG emissions resulting from the waste stream.

In cases where data was missing, appropriate proxy data has been used that is applicable to the context of greater Monrovia based on site observations. The use of appropriate proxy data is seen as a practical and efficient approach that enables quality results.

KEY STAKEHOLDERS

1. Cities Alliance Liberia
2. Ministry of Internal Affairs
3. Monrovia City Corporation (MCC)
4. Paynesville City Corporation (PCC))
5. World Bank Project Implementation Unit (PIU)
6. European Union
7. Community Based Enterprises (CBEs) represented by the National Association of Community Based Enterprises (NACOBE)
8. Ministry of Environment
9. Infrastructure operators (waste transfer site, Whein Town Landfill, etc.)
10. Planning / roads / finance department MCC / PCC
11. Statistics / demographics / census department – Liberia Institute of Statistics and Geo-Information Services (LISGIS)
12. Representative of the World Bank Project Implementation Unit (for Cheesemanburgh Landfill Site);
13. Representatives of Liberia's Environmental Protection Agency.



2. CITY OVERVIEW AND BACKGROUND

2.1 Population trends

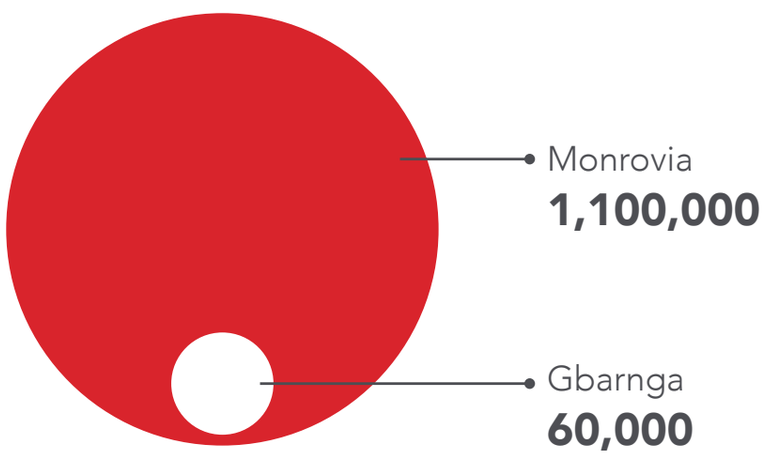
Monrovia, in Montserrado County is the political and economic capital of Liberia. It has an estimated current population of 1,100,000, nearly 20 times the population of Liberia's next largest city Gbarnga, Bong County[9].

The Monrovia population has increased 13-fold over the past 50 years, from 80,000 in the 1960s[10] to its present size. While consistent census data is not immediately accessible, the The wider region of Greater Monrovia including Paynesville has an estimated population of 1.5 million. This accounts for approximately one third of the total Liberia population.

Analysis of census data undertaken by Ngafuan (2010) notes that 29% of Liberians were living in urban areas[11] in 1974, 39% in 1984 and 47% in 2008 with the population of Monrovia also increasing relative to other urban centres[12].

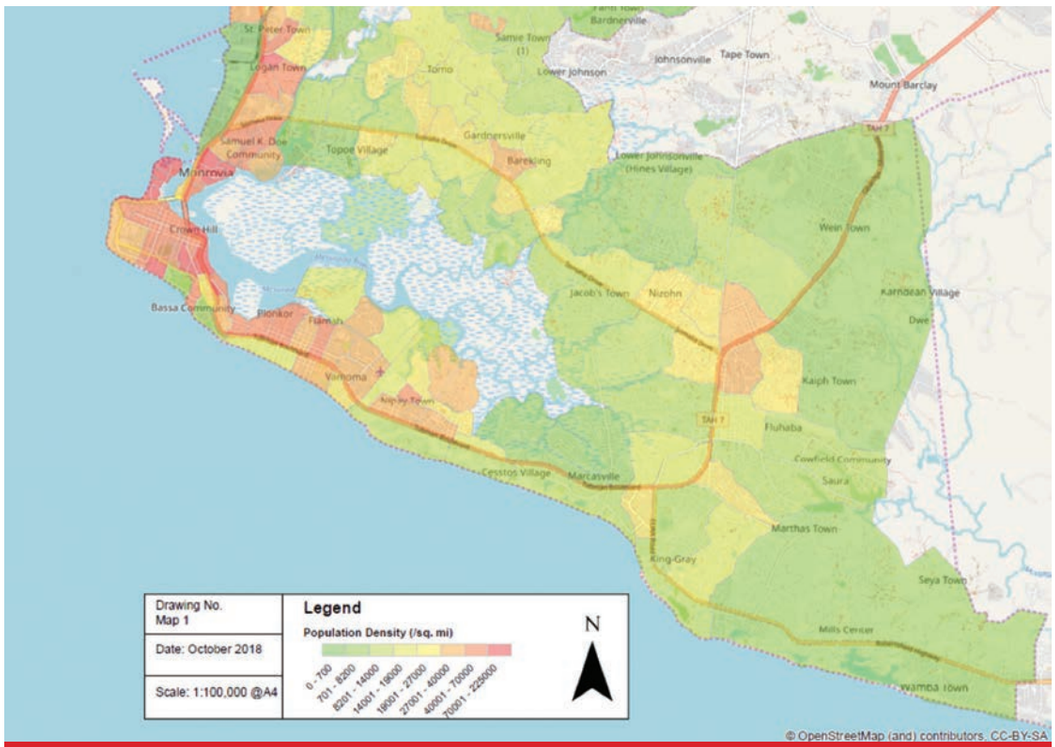
Within Monrovia an upsurge in rural to urban and inter-urban migration, (including during the civil wars where the city was largely under control of peacekeeping forces) has meant that land cover has increased from 100sq km in 1975 to 176sq km in 2013, most notably in the historical centre. Ngafuan suggests that in addition to natural population growth and the relative[13] security offered by Monrovia during civil war, the following factors explain much of the growth of Monrovia:

- Historical and geo-climatic factors (Monrovia was a key trade point even before Americo-Liberian settlement);
- Bias towards Monrovia in economic policy and international development assistance;
- Political centrality and 'urban psyche';
- Superior living standards and educational opportunities; and
- A lack of policy focus with respect to decentralisation and rural-urban migration.



[9] https://eros.usgs.gov/westafrica/case-study/urban-growth-liberias-only-metropolis-monrovia
[10] https://eros.usgs.gov/westafrica/case-study/urban-growth-liberias-only-metropolis-monrovia
[11] In Liberia, all settlements with 2000 or more population are defined as urban
[12] www.theperspective.org/2010/0614201001.html
[13] While Monrovia faced sieges and much destruction it was often safer than rural villages and jungle territory

The city has failed to match this growth with equivalent level of infrastructure development and many poorer neighbourhoods are in slum-like conditions. This has been compounded by significant damage to the city during civil wars and the recent outbreak of Ebola in 2014.



POPULATION DISTRIBUTION (2008)

Population density based on the 2008 Census illustrates the concentration in well-established built-up areas of such as Central Monrovia, Sinkor, and Congo Town. Emerging population hotspots around Redlight market in Paynesville and north of the central business district show the spread of population along Tubman Boulevard.

2.2 Spatial context

Monrovia as a permanent settlement dates back to its founding in April 1822. The original town was laid out on a grid-pattern[14] typical of American towns as seen in Figure 1. This pattern is reflected along southern coastline in present day but along the West coast and further inland a less structured sprawl of discontinuous streets follows major roads.

In 1966 city growth was restricted to south of Mesurado River, which flows parallel to the Monrovia coastline. However, within 20 years the city had expanded beyond this point, growing around the marshlands of the Mesurado. By 2015 this sprawl had continued inland as well as to the North West, beyond the St Paul River.

In 1966 city growth was restricted to south of Mesurado River, which flows parallel to the Monrovia coastline. However, within 20 years the city had expanded beyond this point, growing around the marshlands of the Mesurado. By 2015 this sprawl had continued inland as well as to the North West, beyond the St Paul River.

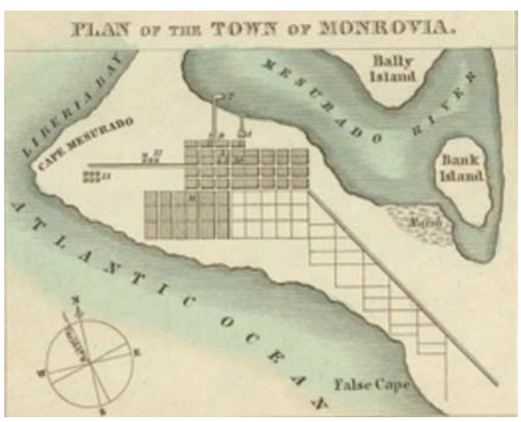
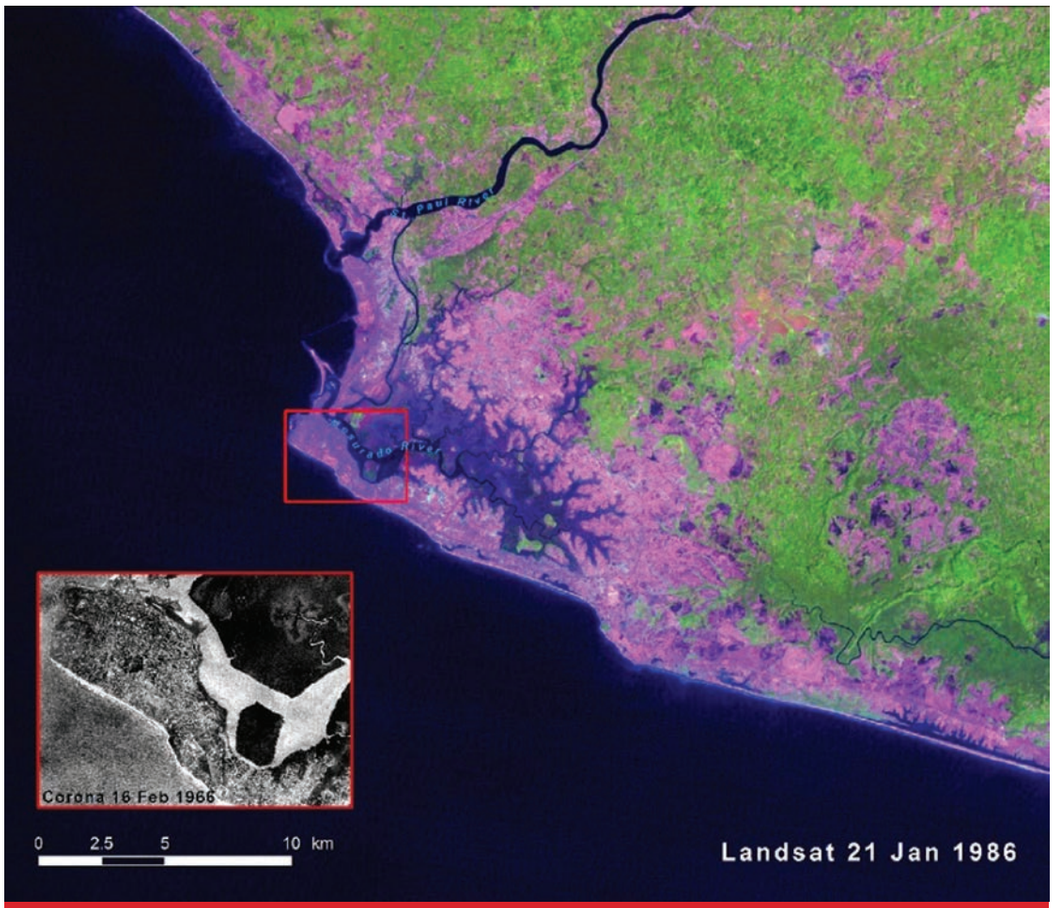


FIGURE 1: Historical plans[15] for the Town of Monrovia, 1832 & 1907 respectively showing the emerging grid/block pattern of urban form.

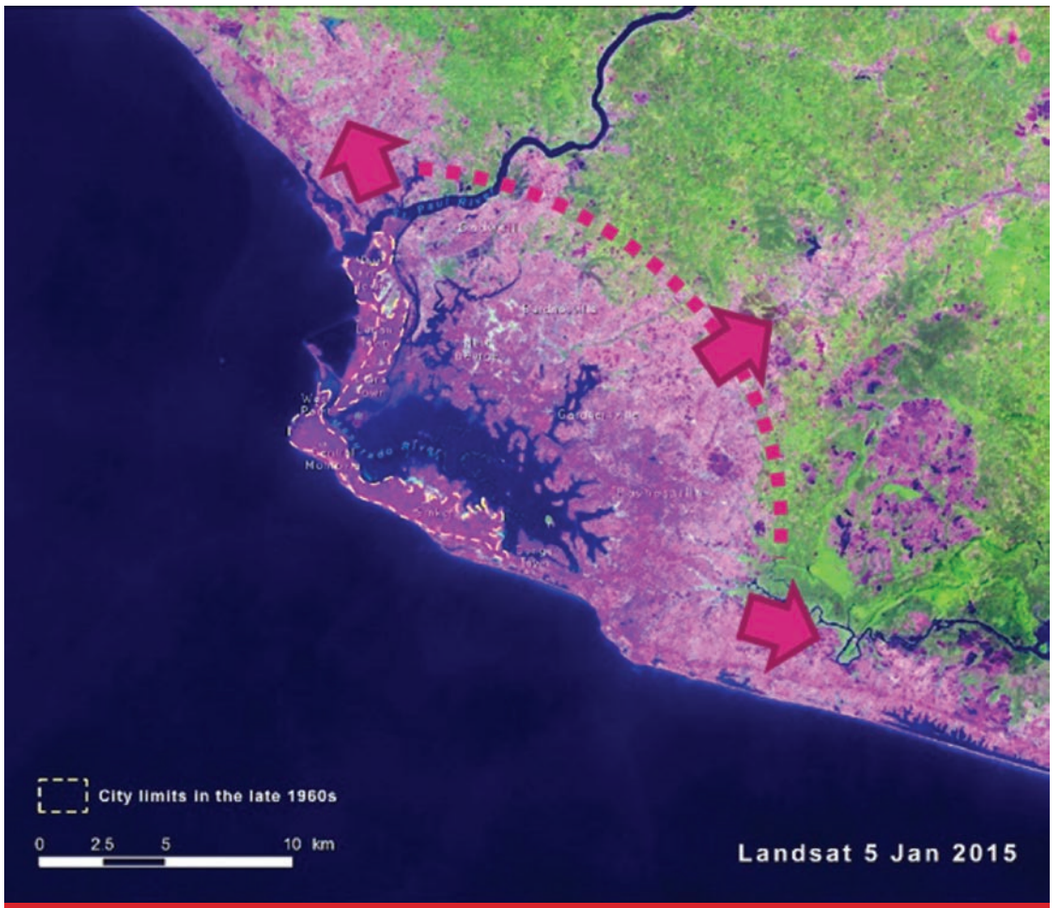
FIGURE 2: Satellite image Monrovia, present day. Google (2018)

[14] https://roomfordiplomacy.com/liberia-monrovia/
[15] Ibid



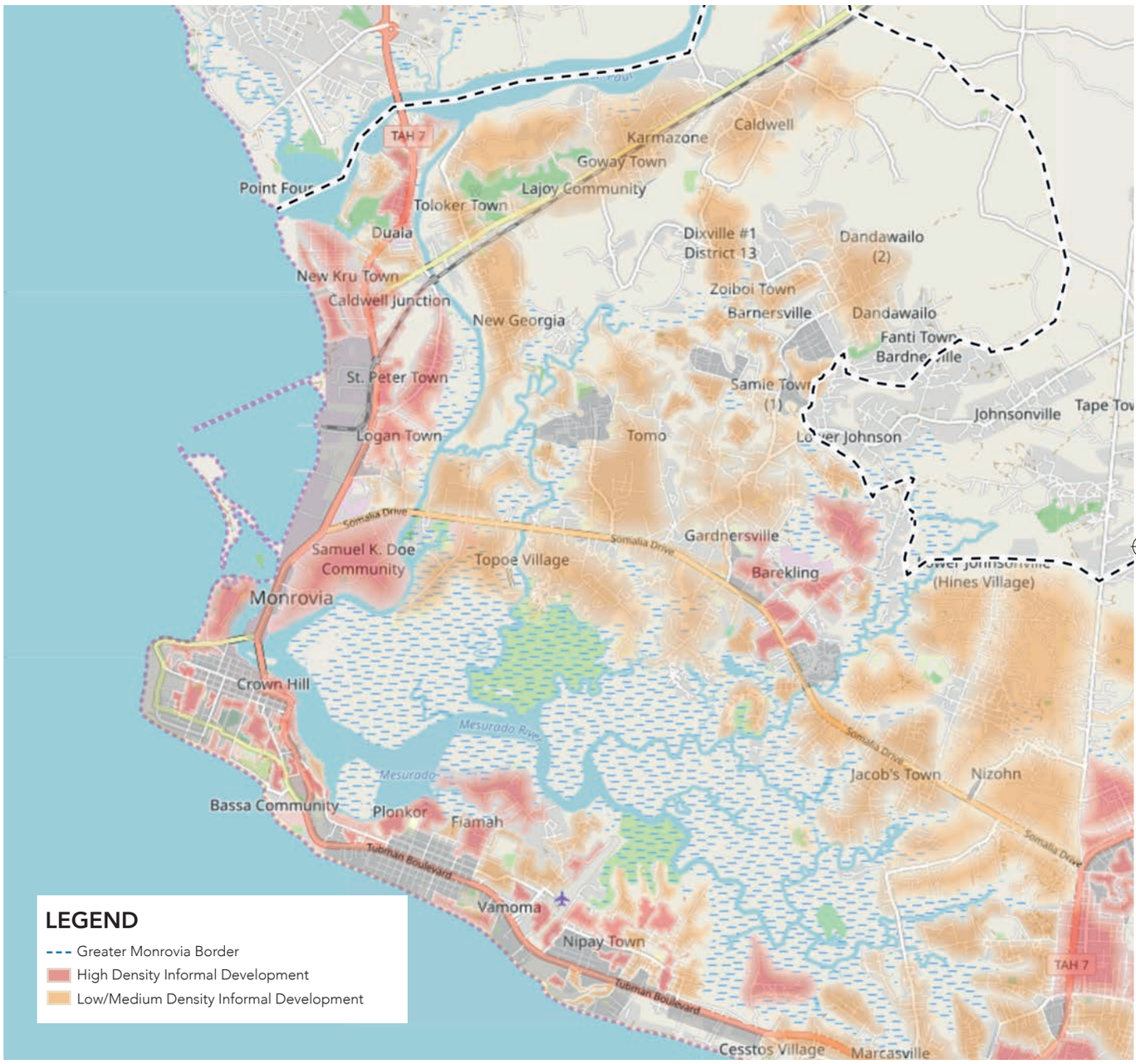
URBAN GROWTH 1966 & 1986

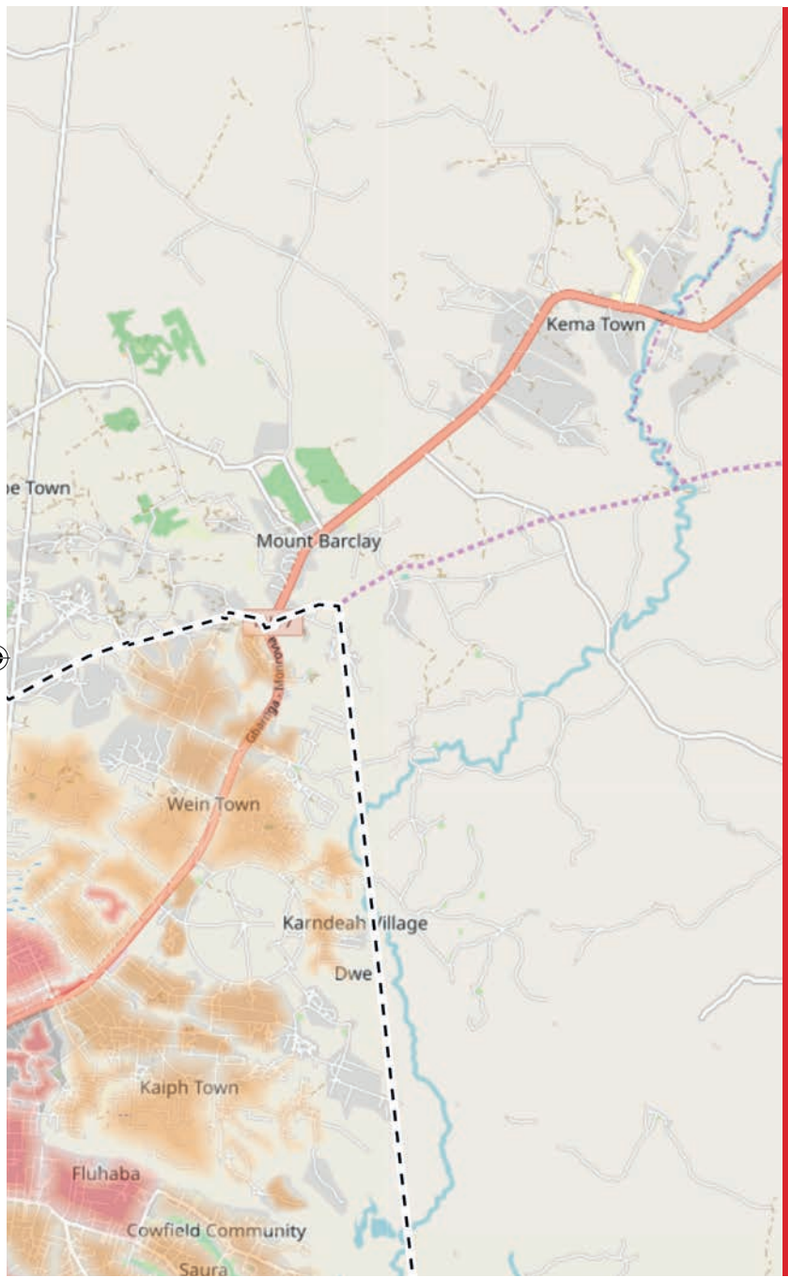
The United States Geological Survey (USGS) has mapped the urban expansion of Monrovia over time based on Landsat imagery. In 1966 city growth was restricted to south of the Mesurado River which formed a natural barrier restricting growth and which flows parallel to the Monrovia coastline. However, within 20 years the city had leapfrogged the River and was rapidly expanding beyond the marshlands of the Mesurado.



URBAN GROWTH 2015

By 2015 urban sprawl has expanded significantly to the North along the coast into St Paul, to the Northeast through Paynesville along the Monrovia-Kakata Highway and to the East along the coast. In addition, general expansion and infill has occurred across greater Monrovia with growth inland taking place concentrically as greenfield land is converted into urban land.


TAH 7
Karmazone
Caldwell
Goway Town
Point Four
Lajoy Community
Toloker Town
Duala
Dixville #1
District 13
Dandawailo
(2)
New Kru Town
Caldwell junction
Zoiboi Town
Barnersville
Dandawailo
New Georgia
Fanti Town
St. Peter Town
Samie Town
(1)
Johnsonville
Logan Town
Tomo
Somalia Drive
Gardnersville
Samuel K. Doe
Community
Topoe Village
Barekling
(Hines Village)
Monrovia
Crown Hill
Mesurado River
Mesurado
Jacob's Town
Nizohn
Bassa Community
Plonkor
Fiamah
Tubman Boulevard
Vamoma
Nipay Town
Cesstos Village
Marcasville
LEGEND
Greater Monrovia Border
High Density Informal Development
Low/Medium Density Informal Development



MAPPING INFORMAL DEVELOPMENT

The scale of informality in urban development and the build environment is significant and widespread. Some suggest that 70% of Monrovia's population lives in slums[16]. The majority of formally planned development is restricted to the old city centre and areas extending out from this centre along the coastline. Levels of informality increase significantly moving inland and particularly to the North of Mesurado River. See Appendix 2 for more detail on the methodology used to map informal development.

[16] https://frontpageafricaonline.com/news/2016news/nha-un-habitat-partner-to-improve-living-conditions-of-monrovia-slums/

2.3 Economic context

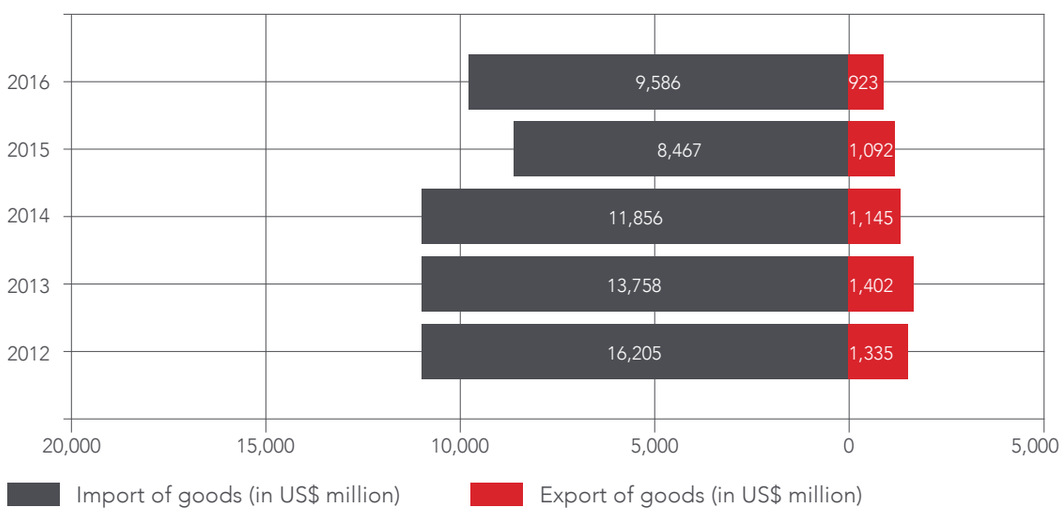
Monrovia is the seat of political and economic power for the country. The city's economy is shaped by its strategic location alongside a natural harbour. It is home to the Free Port of Monrovia, Roberts International Airport and a major national road which connects Liberia to the rest of the world. Highest value Liberian exports include iron ores and concentrates, tankers, other transport vessels, natural rubber, cocoa beans, timber, gold and diamonds[17]. In 2016 the country exported US$ 923 million of goods[18]. Nationally, key GDP sectors are services industry and agriculture[19].

As discussed in section 2.1, socio-economic pull factors have resulted in considerable growth of the urban population. Compared to the rest of Liberia, relative wealth is large and '56.4 percent of Monrovians lie in the highest wealth quintile and only 1 percent of the urban population lie in the lowest wealth quintile, compared to 31 percent of the rural population'[20].

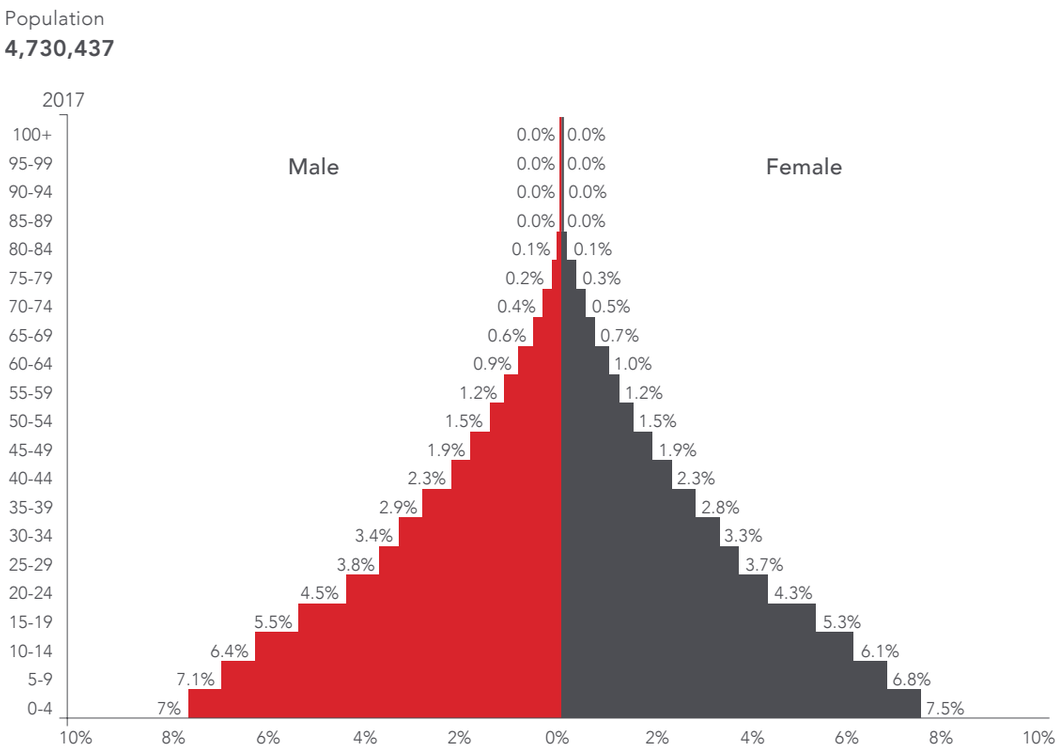
However, Ngafuan (2010) suggests that these pull factors will continue to place strain on Monrovia unless current trends can be reversed with the Monrovian economy growing at a slow pace in comparison to the city's population.

Infrastructure damage and severe disruption to economic growth throughout the country's two civil wars and subsequent Ebola crisis mean that the country is heavily dependent on foreign aid and is playing catch-up in the development of infrastructure and institutions which can facilitate necessary growth. Since the 60s the country has gone through periods of economic growth before these shocks have setback progress. Post-Ebola many investors are still to return.

FIGURE 3: Evolution of the total import and export of goods of Liberia



[17] https://www.worldscapitalcities.com/capital-facts-for-monrovia-liberia/
[18] http://www.intracen.org/country/liberia/General-Trade-Performance/
[19] https://www.gfmag.com/global-data/country-data/liberia-gdp-country-report
[20] www.theperspective.org/2010/0614201001.html



Monrovia and Liberia overall have a highly youthful population as evidenced by the country's a highly expansive population pyramid[21]. They also have a whole generation of Liberians who lost years of education during civil wars and Ebola.

In response to the infrastructure and educational challenges the country faces, President Weah announced plans to invest in Technical Vocational Education and Training programs to build entrepreneurial and marketable skill-sets of the country's youthful population and investment in roads, energy and ports, and agriculture and value-addition activities (across the country) under a Pro-Poor Agenda. The president appealed to bilateral partners, and private investors to support this agenda[22].

2.4 Social context

A growing youthful population without corresponding economic growth has created an environment of few formal sector opportunities. This has led to widespread unemployment and growth of informal sector enterprise. Ngafuan (2010) suggests that one consequence is a growing crime rate and drug addiction in Monrovia, with post-war trauma another contributing factor.

Despite this, poverty is more than two times higher in rural areas (71.6%) than in urban areas (31.5%) and discussed in section 2.3 is lower in Monrovia overall.

[21] https://www.populationpyramid.net/liberia/2017/
[22] https://www.worldbank.org/en/country/liberia/overview

A rapidly growing population has also placed significant pressure on Greater Monrovia to meet other basic needs of its citizens. This includes housing, healthcare, transport, education, water and sanitation, electricity and solid waste. For Monrovia UN-Habitat 2014 assessment suggests Improved Shelter at 67.2%[23], Under-Five Mortality Rate at 12.6%, Literacy Rate at 32.6%, access to Improved Water at 77.4% and internet access at 4.6%[24].

Recent activity to improve infrastructure conditions include:

- An EU funded €18.5million contract, signed in August 2018 to allow the Monrovia electricity grid to absorb more of the electricity from the Mount Coffee Hydro Dam and connect more customers to the grid[25].
- Upgrading projects of major arterial roads Somalia drive and Suakoko Highway funded by JICA[26] and World Bank[27] respectively.
- World Bank Liberia Health Systems Strengthening Project to improve primary and secondary healthcare services[28].

2.5 Environmental context

Inadequate sanitation and solid waste management infrastructure that cannot meet the needs of a growing population is contributing to significant environmental pollution in Monrovia. Beaches and local rivers are littered with garbage and human refuse. In August 2018 the Environmental Protection Agency warned residents against consuming fish from the Mesurado River due to dangerous levels of pollution[29].

Growing urban sprawl has had a significant impact on vegetation levels and deforestation (see section 2.2). In 2010, greater Monrovia had 1.25kha of tree cover, over 7.7% of its land area. In 2017, it lost 6.50ha of tree cover.

2.6 Budgetary context

The Government of Liberia Financial Year runs from 1 July – 30 June of the next year. There are two main parts of Liberia's government budget – recurrent expenditures and the Public Sector Investment Plan (PSIP) expenditures. Recurrent expenditures reflect the ongoing annual costs of government operations. The PSIP reflects capital, project and other special expenditures that will be required for a limited number of years.

Only two Cities in Liberia have separate allocations in the national budget. The first, MCC is the commercial and political capital of the country. The second, PCC, contains the country's largest marketplace, the Red Light market[30]. Each City Corporation submits a budget to the Ministry of Finance and receive fiscal transfers from the national government.

[23] Slums listed at 40%
[24] http://cpi.unhabitat.org/monrovia
[25] https://eeas.europa.eu/delegations/liberia/49303/government-and-european-union-extend-electricity-grid-monrovia_en
[26] newliberiaonline.com/liberia-lacks-behind-in-infrastructure-development/
[27] www.worldbank.org/en/news/feature/2017/02/13/improved-road-network-in-liberia-boosts-trade-and-commerce
[28] http://projects.worldbank.org/P128909/liberia-health-systems-strengthening?lang=en
[29] http://newrepublicliberia.com/avoid-fish-from-mesurado-river/
[30] http://www.citiesalliance.org/sites/citiesalliance.org/files/BB7_Budlender_IEBA_Monrovia_0.pdf

The MCC budget management committee consists of the mayor, director general of internal operations, director general of service programs, the procurement manager, the city planning director, the finance controller and the budget manager. The PCC budget committee includes the mayor, financial analyst, controller, procurement manager and the mayor's special assistant[31].

In FY 2016-2017 the national recurrent budget was US$600m. Municipal governments received 3.8% of the budget, at approximately US$23m. Of this budget, 76% was allocated to the Ministry of Internal Affairs, which oversees local administration. MCC received 14% of the total (US$3.1m), and PCC 5% (US$1m). It is with these funds that the MCC and PCC must deliver all services within their jurisdictions including Solid Waste Management[32].

MCC BUDGET AND EXPENDITURE ON SWM

MCC has XX for FY 2018/19. Of this XX is for capital and XX is for operating expenditure.

The City's principal sources of revenue include… e.g. property rates, tariffs, rental charges…

Reliance on national government transfers…

Allocation to waste management activities as a % of overall budget…

Total MCC Budget (FY17/18) = ?

Total MCC Income = ?

Total MCC Costs (expenditure) = ?

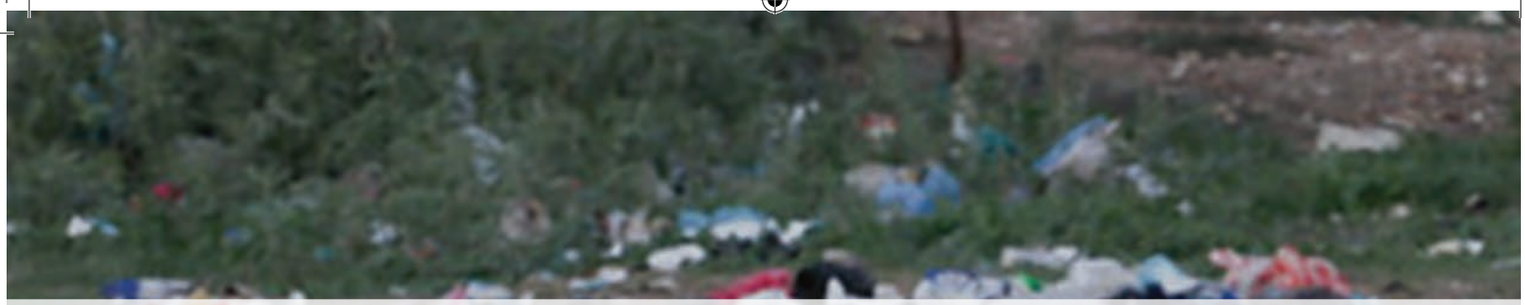
Total MCC Waste Management Costs = ?

PCC BUDGET AND EXPENDITURE ON SWM

The PCC's budget for FY 2018/19 is US$1.8m. This budget comprises US$1.2m (66%) from national government transfers and US$633k (34%) from own source revenue. The City's principal own source of revenues include: market association rates, CBE registration fees, business tariffs, and rental charges. The entire budget went to covering cost of operations within the City Corporation for the year.

According to PCC, 68% of the total budget went to covering solid waste management activities. This budget demonstrates a reliance on national government transfers and the dominance of waste management within the City's activities.

[31] Ibid
[32] Ibid



3. INSTITUTIONAL AND REGULATORY ARRANGEMENTS

3.1 Legislation and regulatory environment

SOLID WASTE MANAGEMENT (SWM) POLICY AND LEGISLATION

The 1986 Constitution provides constitutional basis for environmental law in Liberia, binding the state to adopt an active environmental policy and environmentally sustainable national development plans.

In 2003, three Acts were published granting specific authority for waste management[33]:

- *An Act Creating the Environment Protection Agency of the Republic of Liberia*[34]. This established the EPA as a national monitoring, coordinating and supervisory authority for the sustainable management of the environment
- *An Act Adopting the Environment Protection and Management Law*[35].This provides a legal framework for the EPA. It specifies the agency's role in national waste management as coordinator and monitoring body, setting policies and guidelines and outlines penalisation for improper waste disposal.
- *The National Environmental Policy of the Republic of Liberia*[36]. This includes a chapter dedicated to SWM and recommended policy measures including establishment of landfill sites for all urban areas and coordination of SWM activities across scales including community involvement and sensitisation.

However, over the past 15 years a lack of capacity in key agencies such as the EPA and overlapping jurisdiction across national and local organisations, have contributed to the prevention of the long-term realisation of sustainable solutions[37]. Many duties have been left to Monrovia City Corporation (MCC), (as the local authority under which the majority of the population nationally resides), supported by World Bank investment in infrastructure and capacity building.

In light of this, several recent policy updates have been made in response to evolving needs and practices of SWM nationally and locally:

- *Lift Liberia, the Poverty Reduction Strategy for Liberia (2008-2011).* Post-conflict national development framework. Includes mandated enactment of a national solid waste management policy, strategy and regulation.
- *Monrovia Letter of Sector Policy, 2009*. In the absence of national policy and reflecting the unique challenges of Monrovia, this policy establishes guiding principles for SWM in the capital including affordable service access; SWM cost recovery mechanisms for long-term financial sustainability; and environmentally conscious SWM. The Policy also formalises the growing role of the private sector in MCC waste management since the end of civil war in 2002[38].
- *National Solid Waste Management Policy*. A draft was first created in 2015 by the Republic of Liberia and MCC. This was drafted in response to the need for strategic coherence nationwide in line with decentralisation of certain solid

[33] UNEP, 2007, http://wedocs.unep.org/handle/20.500.11822/17464
[34] https://postconflict.unep.ch/liberia/pdf/EPA_ACT.pdf
[35] www.unesco.org/culture/natlaws/media/pdf/liberia/liberia_act2002_engorof.pdf
[36] http://extwprlegs1.fao.org/docs/pdf/lbr175141.pdf
[37] https://allafrica.com/stories/200805220817.html
[38] http://documents.worldbank.org/curated/en/734831506708143315/pdf/ICRR-Disclosable-P115664-09-29-2017-1506708134222.pdf

waste management responsibilities. A validated policy was presented in April, 2017 but is yet to be formalised. The foundation of the draft policy is the 2009 MCC framework and it sets out the national vision for safe collection, treatment and disposal of solid waste. The draft policy outlines linkages between SWM and environmental, public health, economic and gender inclusive outcomes, underpinned by good local governance, public and private sector coordination and technically sound, economically sustainable interventions[39].

ENVIRONMENTAL PROTECTION AGENCY (EPA)

The EPA, which should be a key organisation in waste management in Liberia only has a budget $115,00 (2007) and only one staff member working on a part time basis was dedicated to waste management issues. Without training and experience in the government entities future waste management initiatives will be undermined, and for example, the EPA is unable to execute its legal mandate. In 2007 there was little appetite to address this capacity gap.

The policy requires that municipal corporations are consistent with ten guiding principles:

In addition to providing greater coordination and nationwide direction and coherence, the draft policy should consider national service coverage/collection which is currently low, a lack of public SWM awareness and education and weak financial and resource capacity, which was further compounded by the Ebola Outbreak of 2014[40].

This review has not found any specific SWM laws beyond the 2003 legislation discussed above. The 2015 draft SWM policy states that a National Solid Waste Management Act shall be passed within three years of implementation of the policy. UNDP also recommend that Guidelines for disposal of wastes from villages and rural communities be developed and the 2015 draft policy mentions the formulation of various bye-laws.

OTHER RELEVANT POLICY AND LEGISLATION

Public Health: The Ministry of Health is mandated through its Environmental and Occupational Health division has the power to conduct sanitation inspection and ensure compliance with the Public health law.

Healthcare Waste: Liberia lacks a legal framework regarding hazardous healthcare waste, and lacks the resource capacity to empower regulatory bodies to monitor and ensure compliance of healthcare waste management sectors[41].

Liberia submitted its contribution to the UN Framework Convention on Climate Change in September 2015, as a platform to integrate its Low Carbon Development

[39] Krah and Nketsia, 2017. PRESENTATION OF THE (Validated) National Solid Waste Management Policy
[40] Solid Waste Management Policy 2nd Edited Liberia NSWMP Final Validated Draft 06 12 15
[41] Beldeh, 2014, Assessing Health Care Waste Management in Liberia

Strategy into the country's long-term sustainable development Vision by 2030. This highlights commitment to reduce greenhouse gas emissions in the energy and waste sectors. Concerning the latter the Government of Liberia commits to: 1) Strengthen institutional & individual capacity for waste management; 2) Develop waste infrastructure; 3) Implement & strengthen policy that promotes private investment in waste management; 4) Capture methane emitted from landfills & used for vehicles, cooking or power.

1. Ensure that all people shall have access to appropriate solid waste management services at affordable cost and at all times.
2. Ensure that solid waste management is conducted in a transparent and accountable manner as an integral part of good governance.
3. Ensure that the solid waste management entities shall establish appropriate cost recovery mechanisms for long term financial sustainability.
4. Ensure solid waste management embraces public and private participation to obtain efficiency gains.
5. Ensure solid waste management is conducted in a gender sensitive manner.
6. Encourage reduction of waste generation through reduction, recycling and reuse, control and regulate generation of waste materials.
7. Comply with national and international standards and regulatory instruments on Hazardous SW.
8. Ensure that standards for occupational health and safety are instituted for all workplaces in keeping with national and international laws.
9. Ensure solid waste management is conducted in an environmentally friendly and sustainable manner to protect human health, natural resources, and the environment in general and global climate change.
10. Ensure accurate information and awareness is provided to the public in a timely, efficient manner.

3.2 Roles and responsibilities description

The 2015 draft solid waste management policy sets out roles and responsibilities for solid waste management:

Monrovia City Corporation (MCC) have a mandate from the national Ministry of Internal Affairs to collect and dispose of solid waste within the Monrovia city limits. Beyond household and business collection, this responsibility extends to the enforcement of ordinances which regulate residential solid waste management practices, as well as education and awareness initiatives. Responsibility also includes the maintenance of public areas including streets and sidewalks. MCC is also responsible for collection and disposal of waste in the surrounding townships[42].

[42] New Georgia, Garwolon, West Point, Brewerville, Virginia, Congo Town, Johnsonville, Dixville, Caldwell, New Kru Town, Barnersville, and Gardnersville. The Township of Cheesemanburg is the site of the proposed new Cheesemanburg landfill.

At the point of collection MCC, according to NACOBE, has 25 contracts with **local community based enterprises** (CBEs) who collect waste door-to-door from households and small businesses. This is a lease model that registers and licenses CBEs to provide primary solid waste collection for a defined area (zone). CBEs a required to pay a fee to MCC for having the right to collect solid waste[43].

Paynesville City Corporation (PCC) have a mandate for the collection and disposal of solid waste within Paynesville city limits. Paynesville has 5 CBEs currently registered with the PCC Solid Waste Management Department. PCC state that CBEs currently have limited technical capacity to reach far into the city[44].

Private Sector: As formalised in 2009 policy, over the past decade large businesses have relied on contracts with private sector suppliers, such as SMEs, who collect and transfer waste directly from large established businesses/institutions to the Whein Town Landfill. Since 2016 the EU suggest that secondary transfer from transfer stations to the Whein Town landfill has now been taken over by MCC[45] via long-haul contractors. World Bank analysis suggests during recent programs some contractors have had failings leading to MCC backstopping and taking over of certain waste transfer operations[46].

Surrounding townships have different arrangements with CBEs and SMEs in their locality with participation varying down to not at all[47].

UNEP[48] note that the Liberia Marketing Association are in theory in charge of waste management in markets and the collection of taxes which are supposed to cover the expenses for these services. This has not historically been realised and LMA has a tense relationship with most municipalities, with LMA retaining taxes but also claiming previous taxes transferred to municipal level were not used for clean-up. UNEP (2007) suggests legal clarification is needed.

SMEs (*international ownership)	Long-haul companies / contractors (*international ownership)
• NC Sanitor • Libra • Hysaa* • Green City • Clean Liberia	• Sandstone* • Nerasa • Libra • Hysaa*

PROPOSED INTERIM TECHNICAL SECRETARIAT

MCC is recognised for its experience and capacity in the management of solid waste. The draft 2015 solid waste management policy proposes MCC act as the Interim Technical secretariat for implementation for a period of two years up to the first

[43] World Bank 2017 Implementation Completion and Results Report, Emergency Monrovia Urban Sanitation Project (EMUS) http://documents.worldbank.org/curated/en/752261498499727624/text/ICR00004138-06202017.txt

[44] Cities Alliance Liberia Country Baseline Report - citiesalliance.org/sites/citiesalliance.org/files/CA-LCP%20BASELINE%20FINAL%20REPORT-21June2017.pdf

[45] Support to the implementation of the EU-Liberia climate change alliance in urban solid waste management and institutional capacity building

[46] World Bank 2017 Implementation Completion and Results Report, Emergency Monrovia Urban Sanitation Project (EMUS) http://documents.worldbank.org/curated/en/752261498499727624/text/ICR00004138-06202017.txt

[47] Solid Waste Management Policy 2nd Edited Liberia NSWMP Final Validated Draft 06 12 15

[48] Assessment of Solid Waste Management

biennial nation-wide consultative meeting. The intention being to kick-start the policy until the national Ministry of Internal Affairs has sufficient capacity. Proposed duties include:

- Put in place a Management Information System (MIS) with a comprehensive spatial data base that will ensure collection and analysis of solid waste management data;
- Develop a sound and internationally accepted Monitoring and Evaluation (M&E) system to track and measure periodic progress at the national and local levels;
- Provide Training and Capacity Building (TCB) support to municipal corporations and other local government;
- Develop a strategic action plan for the effective implementation of the policy with appropriate timelines and milestones, and
- Serve as the learning platform for organized and improved solid waste management.

ENVIRONMENTAL PROTECTION

Nationally, law dictates that the Environmental Protection Agency (EPA) is responsible for developing national solid waste management guidelines and for providing oversight, monitoring and enforcement of environmental regulations related to waste management. In reality MCC appears to share some of this responsibility. The EPA also has national responsibility for environmental quality standards, penalties and fines and controlling pollution. The agency prepares Environmental Impact Assessments and provides permits for landfill sites.

In theory the National government should ensure that local government agencies have adequate budgetary support to fulfil solid waste management responsibilities, through the Ministry of Internal Affairs. In addition to the specific duties outlined below, central government agencies should also facilitate formulation and enforcement of city ordinances; ensure future secondary and final disposal sites are identified and developed; ensure market are designed with adequate waste management facilities; delineate and depoliticize Liberia Market Association (LMA) and encourage cooperation between the LMA and City Corporations; and provide special funding mechanism to support private sector and SME's to start up SWM services.

- **The Ministry of Finance** is responsible for managing all government financial assets and preparing annual fiscal budgets.
- **The Ministry of Public Works** has overall responsibility for the installation of solid waste management infrastructure including transfer stations and final landfill sites in consultation of local authorities. This ministry played an important role in the implementation of the 2009-2016 the World Bank Emergency Monrovia Urban Sanitation (EMUS) programme[49].
- **The Ministry Mines and Energy** evaluates such projects and provides guidance for the geotechnical investigation of engineered landfill sites. The Ministry houses the National Lands Authority.

[49] World Bank 2017 Implementation Completion and Results Report, Emergency Monrovia Urban Sanitation Project (EMUS) http://documents.worldbank.org/curated/en/752261498499727624/text/ICR00004138-06202017.txt

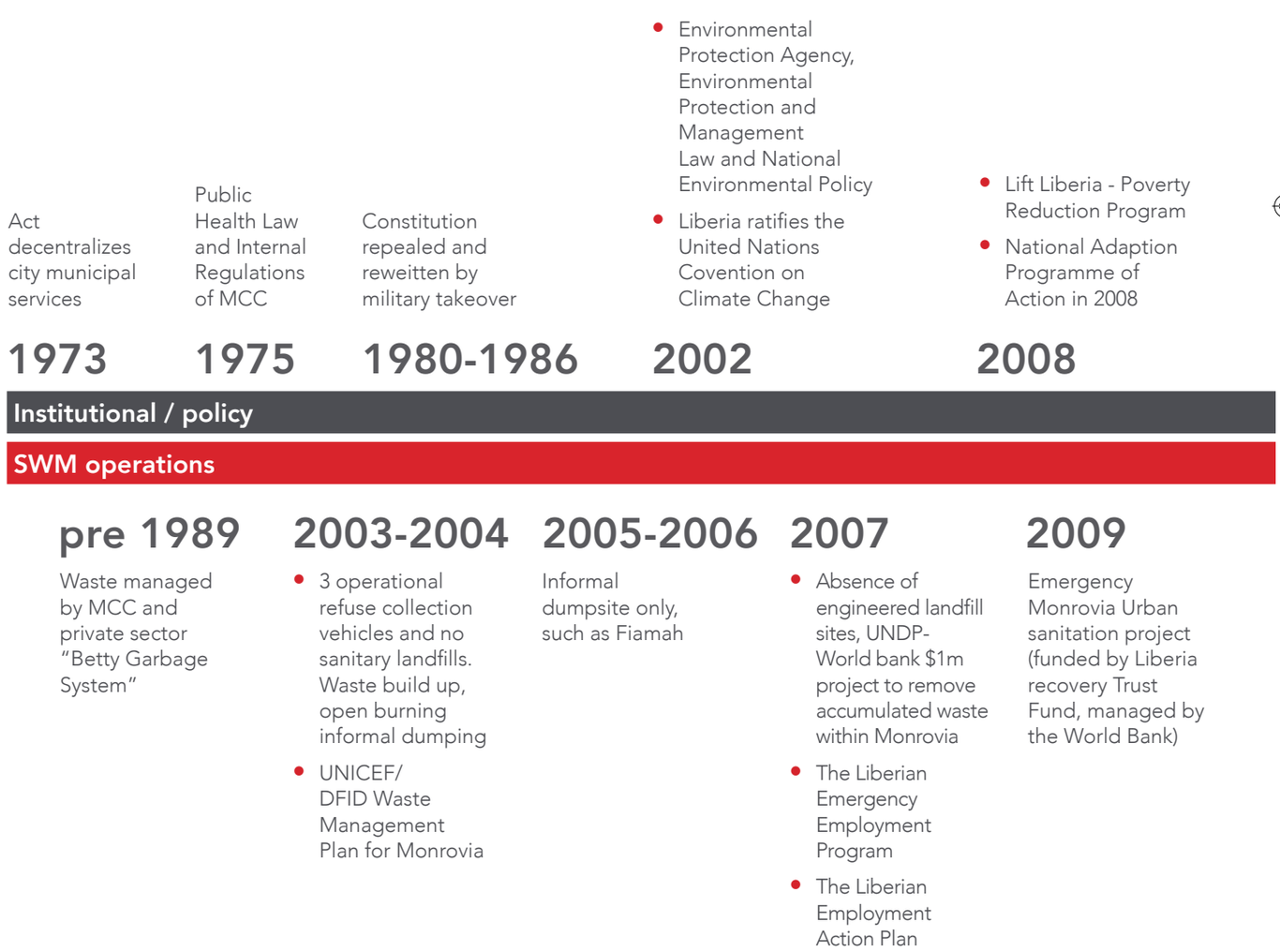
- **The Ministry of Health and Social Welfare** is responsible for assessing the environmental health of the population nationally and the undertaking of site-specific sanitary inspections against public health law[50].

INTERNATIONAL COMMUNITY

In practice, much of the capacity building and responsibility for solid waste management in Monrovia has been undertaken by MCC supported by the international community since the end of civil war in 2002.

In 2010 and 2011 the World Bank Emergency Monrovia Urban Sanitation (EMUS) funded 100% of MCC operations before starting to scale back support to 80% in 2012

FIGURE 4: Timeline illustrating institutional set up and policy formation relating to SWM and the evolution of SWM operations in greater Monrovia



[50] Solid Waste Management Policy 2nd Edited Liberia NSWMP Final Validated Draft 06 12 15

and 60% in 2013. National contributions were being financed through a combination of MCC and specially designated central budget funds. However, since 2014 funding reverted back to 100% after the Ebola crisis[51]. Currently the European Union is supporting the efforts to improve the operations and functionality of the primary solid waste collection infrastructure, transport and disposal in Monrovia and the surrounding townships.

The following organogram outlines the key institutions involved in solid waste management in greater Monrovia and their role and responsibility relating to SWM. In addition, Figure 4 - provides a timeline illustrating the evolution of the SWM institutional set up and policy formation relating to SWM and how SWM operations in greater Monrovia have developed over time.

2009

The Monrovia City Corporation Solid Waste Letter of Sector Policy

2010

Improved Primary Solid Waste Collection in Poor Communities of Monrovia Project (Monrovia Project (IMPAC) funded by the Bill & Melinda Gates Foundation)

2011-2012

- Liberia Rising / Vision 2030
- Agenda for Transformation (2012-2017) (Medium term)
- WASH Sector Strategic Plan (2011-2017)

2011

Fiamah dump site closed

2012

Emergency and temporary (5yrs) Whein Town landfill site completed

2015

National solid waste management policy of Liberia

2016

- GoL & MCC acquire 100 acre land for new Cheesemanbu rg landfill site
- EMUS ended

2018

- Paris Agreement ratified
- Development of a new National Development Agenda for 2018-2024
- Green Climate fund project to advance National Adaption Plan

2017

- Fiamah and Stockton Creek transfer sites exist
- Mayor of MCC pushes for privatisation of SWM operations

[51] World Bank 2017 Implementation Completion and Results Report, Emergency Monrovia Urban Sanitation Project (EMUS) http://documents.worldbank.org/curated/en/752261498499727624/text/ICR00004138-06202017.txt

Environmental Protection Agency

- Solid Waste Management national guidelines
- Environmental quality standards, penalties/fines.
- Pollution control compliance
- Prepare EIAs
- Give licence/permits for engineered landfill sites

The Ministry of Public Works

- Installation of infrastructure for Solid Waste Management delivery e.g. constructing waste collction and transfer stations, and engineered landfill sites

Ministry of Internal Affairs

- Provide MCC/ PCC with annual operating budget
- Mobilises participation of LGAs and citizens in national developments
- Technical Planning Guidance
- Department of Urban Affairs

Ministry of Mines & Energy

- Evaluate urban sanitation projects
- Manage natural resources (including water resources central to WatSap)
- Technical investigation for environmental assessments
- National Lands Authority

Monrovia City Corporation (MCC) and Paynesville City Corporation (PCC) with Township commssioners

- Ensuring clean and sanitary environmental conditions, e.g. street sweeping, collection and disposal of solid waste, and beautification.
- Prohibition of the littering, and requiring residents to clean in front, and around properties up to the sidewalk
- Responsibility for municipal waster disposal sites (skips)
- Responsibility for landfill management and operations (MCC only)

SME's	CBE's	Liberia Marketing Association	Business and Households
(Until recently) Collection services, and operation of transfer stations and landfill facilities	30 contracts for door-door household/small business collection (2018)	Waste management in markets and raising taxes which cover these services in MCC and PCC	Business waste tax. (No tax implemented for household)

Ministry of Finance

- Responsible for managing all government financial assets and preparing annual fiscal budget

Ministry of Health & Social Welfare

- Responsible for environmental health nationally
- Conduct sanitary inspections to evaluate compliance with Public health diagnostics

Nat'l Public Health Inst.

- Expand, conduct, coordinate public health and medical research to inform public health policies
- Develop/strentghen the laboratory system and public health diagnostics

Water, Sanitation & Hygiene Commission

- Promote and regulate the development and management of water, sanitation and hygiene services (WASH)
- Serves as the principal government entity on WASH and provides on waste disposal affecting water sources

International Community

Emergency clean ups,funding for waste infrastructure and operations, supporting development of plans/ documents

4. CURRENT WASTE MANAGEMENT OPERATIONS

A successful waste management system has existed in greater Monrovia as early as the 1980's. The Monrovia City Corporation (MCC) was solely responsible for collecting and hauling for disposal, domestic and commercial solid waste. They were assisted in this by a private waste collection system called "Betty Garbage System". In 1990, the population was 300,000 with an annual growth rate of 7 per cent, garbage collection and disposal in accessible areas was 85% effective in Monrovia, though it only reached accessible areas with most informal settlements remaining uncleared[52]. Due to the political unrest and conflict the system has been challenged to the breaking point. Over the past decade the international community has been supporting the GoL re-establish a SWM system (Figure 5).

4.1 The City Corporations

As described above City Corporations are responsible for the collection and disposal of solid waste from households and businesses within the Monrovia city limits – this responsibility is currently divided between Monrovia and Paynesville City Corporations. MCC and PCC are also responsible for the enforcement of SWM ordinances and education / awareness raising initiatives and the maintenance of the public realm within their administrative boundaries. City corporations are responsible for all street cleaning. Market waste collection and disposal is undertaken with the support of Market Associations.

As previously described, at the household level, the City Corporations have contracts in place with CBEs who collect waste door-to-door on behalf of MCC and PCC and some townships. The following sections describe current operational activities for both MCC and PCC.

MONROVIA CITY CORPORATION

MCC utilise CBE's to carry out primary waste collection, with the collected waste being deposited in bulk containers (skips). MCC have vehicles capable of lifting the skips, which are transferred to one of two waste transfer stations for emptying. The waste deposited at the transfer stations is then loaded into bulk haul vehicles for transfer to the Whein Town landfill site. Transfer to the landfill site takes place at night due to traffic congestion during day-time hours.

A summary of MCC's past and current assets, resources and facilities is provided below:

The waste transfer stations are currently owned and operated by MCC and receive waste from CBEs, MCC and third parties. Each transfer station serves a distinct geographical area – north and south of the Mesurado River delta. The sites consist of administration buildings, a weighbridge facility (not working) and a Dutch Barn style tipping hall. The tipping hall includes a ramp providing access to an upper tipping level. However, the only tipping activity seen took place in the lower level. There is some evidence of rudimentary recycling operations but it was not established if the activity is entrepreneurial or approved by MCC. Both tipping halls show damage caused by poor operational practices and appear poorly maintained (Figure 6). At Fiamah waste transfer station waste was observed being tipped into standing water as the site-wide drainage system appears to be blocked (Figure 7).

See Appendix 3 for the current MCC Organogram and numbers of staff.

[52] UNEP, Desk Study on the Environment in Liberia – 2004 https://bit.ly/2EDybKR

FIGURE 5: Timeline of the Solid Waste Management system in Monrovia

2003-2004

- 3 operational refuse collection vehicles and no sanitary landfills. Waste build up, open burning informal dumping
- UNICEF/DFID Waste Management Plan for Monrovia

2007

- Absence of engineered landfill sites, UNDP-World bank $1m project to remove accumulated waste within Monrovia
- The Liberian Emergency Employment Program
- The Liberian Employment Action Plan

2010

Improved Primary Solid Waste Collection in Poor Communities of Monrovia Project (Monrovia Project (IMPAC) funded by the Bill & Melinda Gates Foundation)

2011

Fiamah dump site closed

2012

Emergency and temporary (5yrs) Whein Town landfill site completed

2016

- GoL & MCC acquire 100 acre land for new Cheesemanbu rg landfill site
- EMUS ended

2017

- Fiamah and Stockton Creek transfer sites exist
- Mayor of MCC pushes for privatisation of SWM operations

Monrovia City Corporation		
Year	1990[53]	2018[54]
Population estimate	300,000	827,622
Facilities	• 1 transfer station • 20 primary collection stations (skips)	• 1 landfill • 2 transfer stations • 52 skips • RC sites[55]
Equipment[56]	• 8 dump trucks • 3 garbage compactors • 1 front end-loader • 5 pick-up trucks • 20 utility management operational vehicles	• 10 large tipper/dump trucks • 5 skip trucks (IVECO) • 4 mini trucks • 5 front-end-loaders (1 damaged) • 1 bulldozer • 5 tricycles • 3 pickup trucks • 3 motorcycles
Community based enterprises	An organized private collection system (CBE's)	An organized private collection system through CBE's (25 registered with NACOBE)

Both sites contained waste at the time of the visit but the stockpile at the Fiamah waste transfer station appeared to be larger and older than that at the Stockton Creek waste transfer station, perhaps suggesting transfer operations (to the landfill site) were not as efficient and/or it was operating beyond design capacity.

The Whein Town landfill site (Figure 12) while located within the administrative area of PCC is owned and operated by MCC on conclusion of the World Bank EMUS project. The tipping now occurring in the landfill appears to be unmanaged due to the lack of functioning equipment. There is no evidence of the use of landfill cells or daily cover. Instead, waste tipping operations resemble a 'stack of pancakes', which causes concern for the long term stability of the site. There has already been some slippage on one of the slopes. The site was designed as a sanitary landfill site with a liner system and leachate control system. The functionality of the leachate control system was not established. The site is worked by one group of scavengers, who are a family unit, and collect recyclable materials such as metal, glass and plastic from the surface of the landfill site.

[53] UNDP, State of the Environment Report for Liberia – 2006
[54] Interviews with WB PIU, August 2018
[55] MCC has several RC sites which are reinforced concrete (RC) U-shaped walls where waste is collected in communities, e.g. Fish Market. The exact number of these sites could not be determined during this baseline study.
[56] Source: WB PIU – Equipment Purchase Plan for CLUS Project

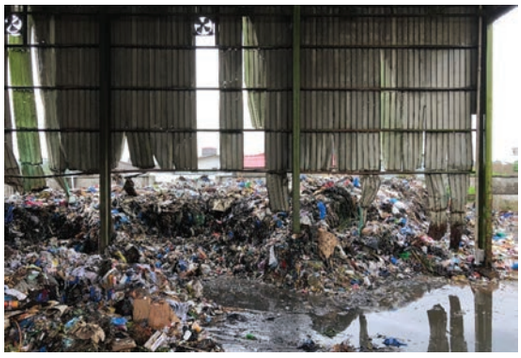


FIGURE 6: Fiamah waste transfer station with blocked drainage

FIGURE 7: MCC skip truck dumping waste outside covered transfer site

FIGURE 8: Stockton Creek transfer station

FIGURE 9: Somalia Drive – existing road condition

FIGURE 10: MCC skip buckets

FIGURE 11: RC site known as Fish Market in MCC

FIGURE 12: Whein Town landfill

FIGURE 13: Whein Town landfill equipment

FIGURE 14: Whein Town landfill former equipment

FIGURE 15: Whein Town landfill abandoned equipment and non-engineered slopes prone to slide

PAYNESVILLE CITY CORPORATION

PCC also utilise CBEs to carry out primary waste collection but not all of the waste collected by CBEs is deposited in bulk containers (skips). PCC do not have vehicles capable of lifting skips. Therefore, in order to empty the containers, the skips are tipped over onto their sides (see Figure 15) and the waste is then loaded onto tipper vehicles, with these vehicles delivering directly to Whein Town landfill site, located within the PCC administrative area. Secondary waste collection and deposit at the landfill also takes place at night due to day-time traffic congestion.

A summary of PCC's current assets, resources and facilities is provided below:

Within PCC a site of significance is the informal dump site serving the Redlight Market. This is an open air dumpsite (see Figure 16). However, it is the recognised point of disposal for waste from the market. The site is cleared as and when it is possible, with clearance operations taking place at night as the area is heavily congested during the day (Figure 17). Fly-tipping is common along major roads (see Figure 18). PCC primarily uses rented equipment to empty skips but has been donated two waste compactor trucks from Turkey which are not functioning (see Figure 19). PCC has also recently purchased 3 tricycles (see Figure 20) to augment / replace the existing old tricycles.

Paynesville City Corporation	
Year	2018
Population estimate	440,424
Facilities	7 skips
Equipment[53]	• 1 front end-loader • 2 large tipper/dump trucks • 2 skip trucks • 1 mini truck • 2 waste compactor trucks (not in use due to inappropriateness for existing waste system) • 4 tricycles (3 new, 1 old) • 1 pickup truck • 2 motorcycles
Community based enterprises	5 Organized private collection system (CBE's)

FIGURE 16: PCC skip buckets tipped over for emptying

FIGURE 17: Redlight Market informal dumpsite

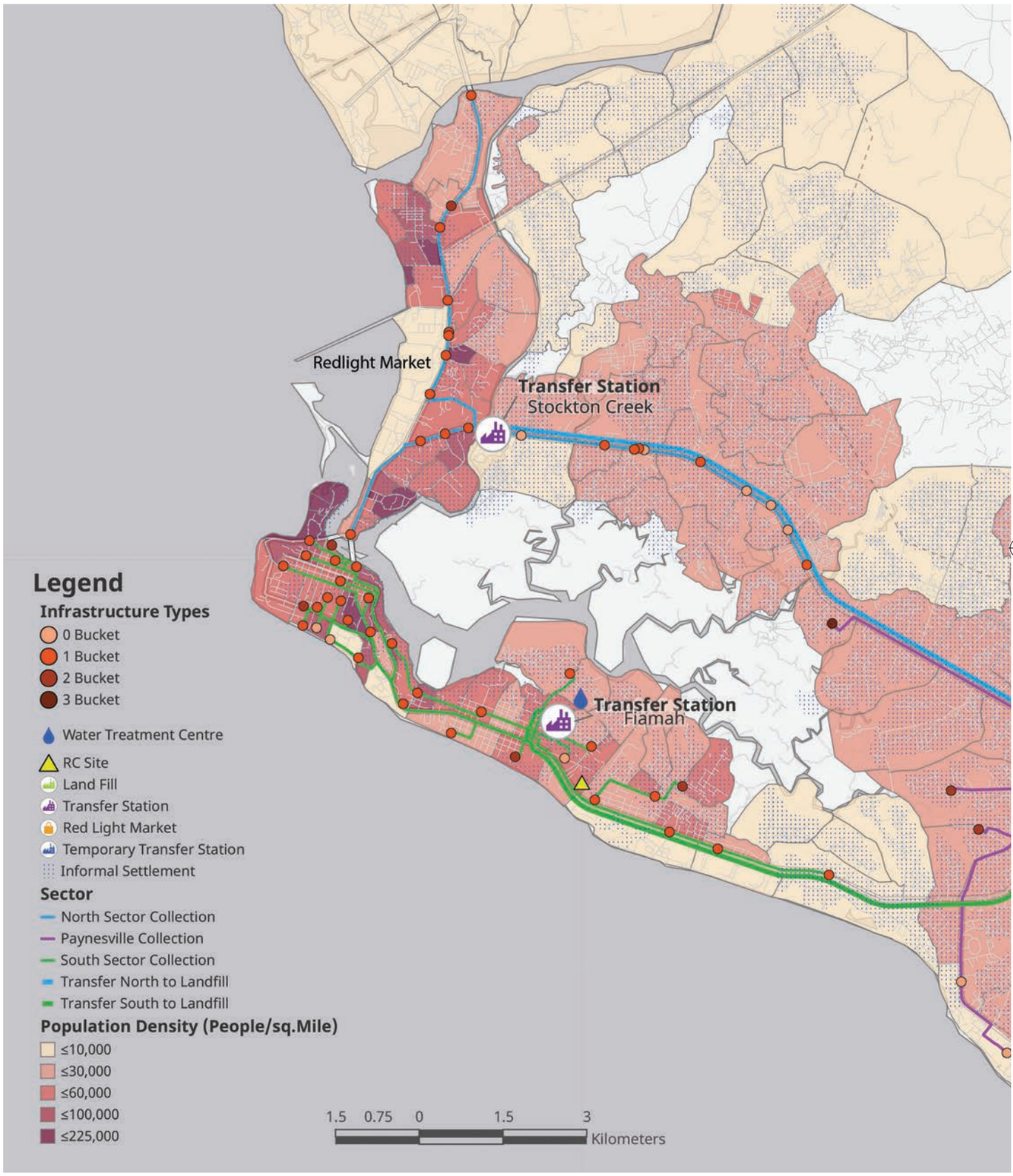
FIGURE 18: Fly-tipping is common in both Monrovia and Paynesville

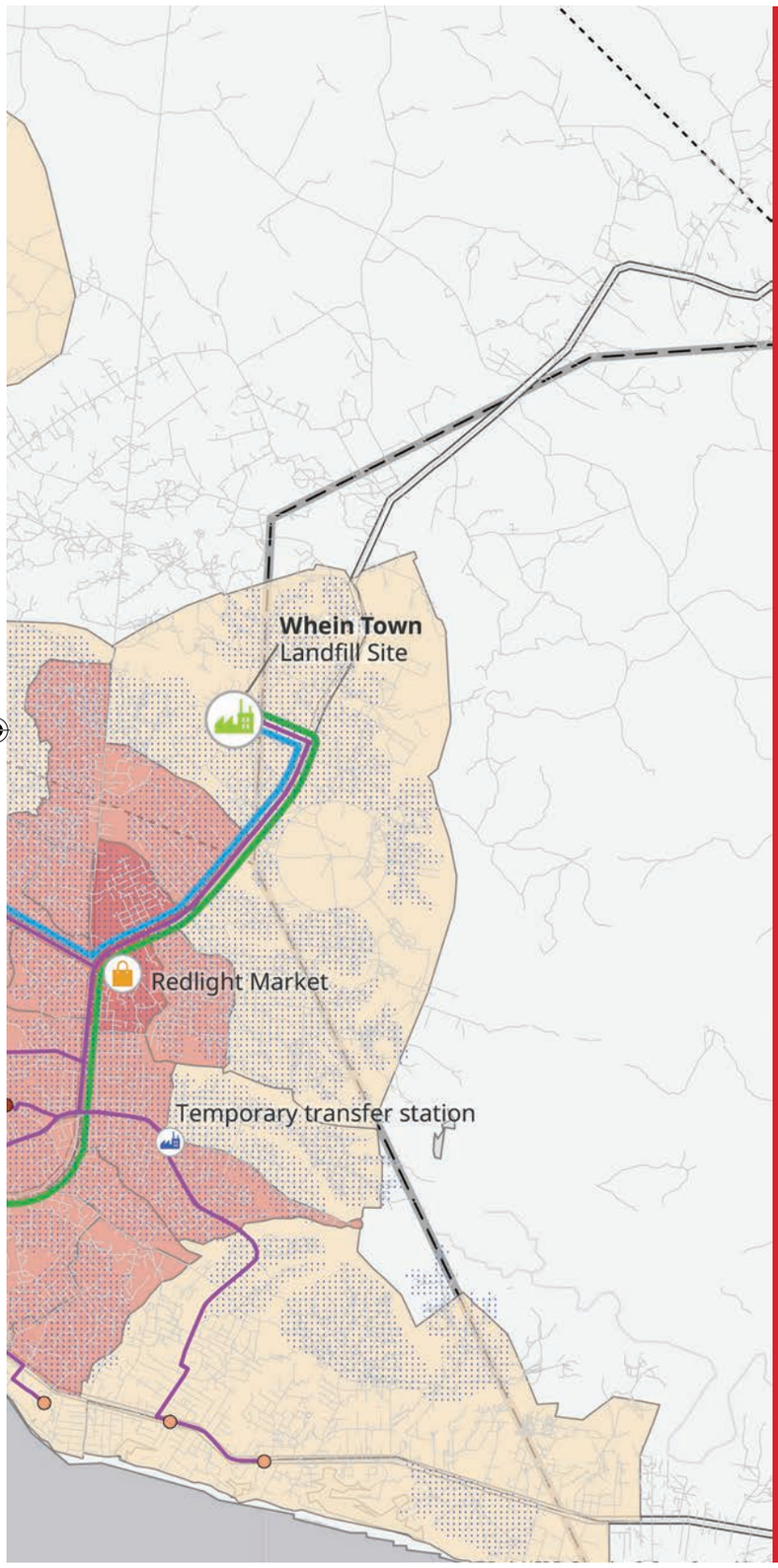
FIGURE 19: Access route to Redlight Market dumpsite

FIGURE 20: Donated waste compacting trucks to PCC are not being used due to inappropriate equipment for existing waste system (waste type and collection method)

FIGURE 21: Newly purchased PCC equipment – when heavily loaded can be prone to tipping

4.2 Existing infrastructure and route map





WASTE MANAGEMENT INFRASTRUCTURE AND ROUTING STUDY

This map illustrates the existing infrastructure in greater Monrovia including all skip locations, locations of transfer sites and Whein Town landfill and the secondary waste collection route study.

The secondary collection of waste is divided within Monrovia City Corporation into two parts, north and south of Mesurado River. Skips to the north are serviced by vehicles traveling to the Stockton Creek Transfer Station. Waste from skips to the south of the River is transferred to Fiamah Transfer Station. For the purposes of this study, the distance to Transfer Station was the determining factor between the north and the south of the city.

Secondary collection of waste by the Paynesville City Corporation is currently reliant on 7 skips as indicated on the adjacent map. Waste is carried directly from the skips to the landfill at Whein Town.

Primary collection of waste is carried out within each zone by designated CBE's as described in Section 4.4.

4.3 Material recycling in greater Monrovia

We have observed small scale material recycling activity at the landfill site and transfer stations, where plastic and metals are collected. It may be that similar activity takes place elsewhere within the waste management chain but there is no evidence of any formal organised material recycling. It is our view that any recycling activity that takes place is informal and small scale, carried out by individuals with and without official access to waste arisings.

There is a local market for plastics with two companies - Duplast and Green City – known to buy plastic 'at the gate'. We believe the purchased plastic is recycled into the products the two companies produce. It has not been possible to quantify the amount of plastic waste recycled in this way but there will be a limit to the amount of recycled plastic that can be added to their products. What is clear is that the waste stream contains far more plastic than both companies are able to process.

Anecdotal evidence and our own observations suggest that plastic bottles, in particular, are reused a number of times before finally being discarded, with this reuse activity possibly competing with their recycling.

We understand there is also a growing scrap metal industry but have seen no evidence of organised metal recycling within the greater Monrovia area. However, the fact that metals are recovered from waste deposited at the transfer stations and landfill site indicate that there are local buyers for the material, who it is assumed consolidate the material for sale into the international scrap metal market.

The evidence available to us would suggest there is limited material recycling occurring in the greater Monrovia area. A proportion of the plastic waste can be recycled on a closed loop basis but access to this system would appear to fluctuate depending on production requirements. It is not clear what happens to any excess plastic waste recovered from the municipal waste stream. Nor, is it clear what happens to metal recovered from the municipal waste stream.

4.4 Community Based Enterprises

At the household level, the city corporations have contracts in place with community based enterprises who collect waste door-to-door. National Association of Community Based Enterprises (NACOBE), is the national umbrella organisation representing the 30 CBEs across greater Monrovia.

Community Based Enterprise (CBEs) play a critical role in the waste management system as they are the only licenced operators that can collect waste from individual households and businesses. CBEs have the ability to employ youth and generate income through recycling leading to positive environmental impacts.

PCC state that CBEs currently have limited technical capacity to reach deep into the city[57].

[57] Cities Alliance Liberia Country Baseline Report
citiesalliance.org/sites/citiesalliance.org/files/CA-LCP%20BASELINE%20FINAL%20REPORT-21June2017.pdf

CBE's are licenced and registered with the relevant city corporation (MCC or PCC). CBE's pay a fee to the city corporation for having the right to collect solid waste in a particular zone. MCC has 25 contracts[58] with local CBEs and Paynesville has 5 CBEs registered with the PCC Solid Waste Management Department[59]. Consultation with NACOBE indicate that of the total 30 registered CBEs, only 14 have a valid licence and are currently active in collecting waste – an indication of the precarious financial situation of these community based enterprises. In a Cities Alliance Survey, however all the waste collectors said that they had paid tax in the previous 12 months[60]. This discrepancy may be due to the precarious nature of the CBE business model.

The households and small businesses that receive the service are expected to pay fees to the CBEs. The fees charged vary according to factors such as the volume, frequency of garbage collection, and the households "ability to pay" which is subjectively defined by the CBE and also varies by zone. The CBEs pay a portion of the fees as an annual tax to the City. The amount to be paid to the City varies according to the number of households served.

CBEs typically collect waste on a daily basis and use tricycles and carts to collect waste. CBEs operate in defined zones and have dedicated areas typically based on the number of households. CBEs see benefit commercially from recycling waste and with their strong community links are able to influence waste management behaviours within communities and neighbourhoods. The average CBE employs 10 people (70% male and 30% female).

Aside from licenced CBE's there are unlicensed operators, sometimes individuals that collect solid waste from households for a fee. This unregulated collection system is undermining the local contracts in place and can lead to fly-tipping of waste[61]. Informal collection is recognised as a key risk to CBE's. Ineffective enforcement against 'moonlighters' undercut CBEs and operate without a licence and oversight. The lack of enforcement impacts on CBE's commercial business.

Below is a full list (active and inactive) of the registered CBE's with NACOBE:

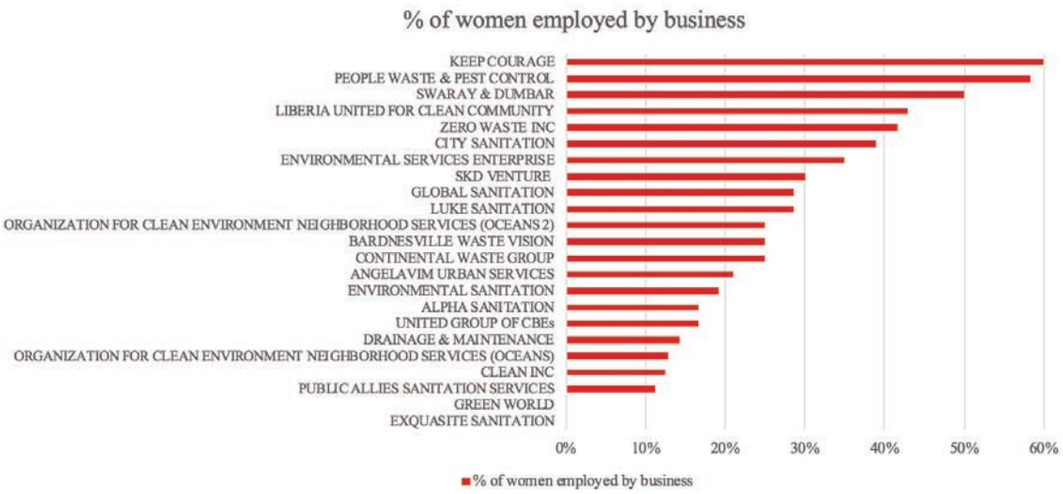
Zone	#	Community Based Enterprises	Holding a permit as of 13 Dec 2018	Total employees	Male employees	Female employees	# households served
ZONE 100 CBEs (NEW KRU TOWN)	1	Zero Waste Inc.	Yes	12	7	5	368
	2	Swaray & Dumbar	Yes	12	6	6	420
	3	Continental Waste Group		8	6	2	105
	4	Keep Courage		10	4	6	120
ZONE 200 CBEs (LOGAN TOWN)	5	Unique Sanitation		n/a	n/a	n/a	n/a
	6	Fombaco		n/a	n/a	n/a	n/a

[58] Interview with National Association for Community Based Enterprises, 13 Sept 2018
[59] Ibid
[60] citiesalliance.org/sites/citiesalliance.org/files/BB7_Budlender_IEBA_Monrovia_0.pdf
[61] Interview with National Association for Community Based Enterprises, 13 Sept 2018

Zone	#	Community Based Enterprises	Holding a permit as of 13 Dec 2018	Total employees	Male employees	Female employees	# households served
ZONE 300 CBEs (CLARA TOWN)	7	Drainage & Maintenance		7	6	1	120
	8	Skd Venture		10	7	3	150
	9	Exquasite Sanitation	Yes	6	6	0	245
	10	Liberian Youth	Yes	n/a	n/a	n/a	n/a
ZONE 400 CBEs (WEST POINT)	11	United Group of CBEs		6	5	1	150
ZONE 500 CBEs	12	Org. for Clean Env. N/hood Services (Oceans)	Yes	39	34	5	900
	13	Luke Sanitation		7	5	2	160
	14	Green World	Yes	12	12	0	240
ZONE 600 CBEs	15	People Waste & Pest Control	Yes	24	10	14	420
ZONE 700/ 800 CBEs	16	Public Allies Sanitation Services	Yes	9	8	1	315
	17	Environmental Sanitation	Yes	26	21	5	1100
	18	Environmental Services Enterprise	Yes	20	13	7	450
ZONE 900 CBEs	19	Alpha Sanitation	Yes	12	10	2	300
	20	Angelavim Urban Services	Yes	19	15	4	588
ZONE 1000 CBEs	21	City Sanitation	Yes	18	11	7	700
ZONE 1200 CBEs	22	Liberia United for Clean Community		7	4	3	n/a
ZONE 1300 CBEs	23	Global Sanitation		7	5	2	113
	24	Clean Inc.		8	7	1	n/a
ZONE 1400	25	Bardnesville Waste Vision		8	6	2	200
Paynesville City Corporation							
	26	Via Sanitation	Yes	n/a	n/a	n/a	n/a
	27	Joe Coal		n/a	n/a	n/a	n/a
	28	N. Joe Sanitation		n/a	n/a	n/a	n/a
	29	Org. for Clean Env. N/hood Services (Oceans)		12	9	3	450
	30	Angelavim Urban Services		n/a	n/a	n/a	n/a

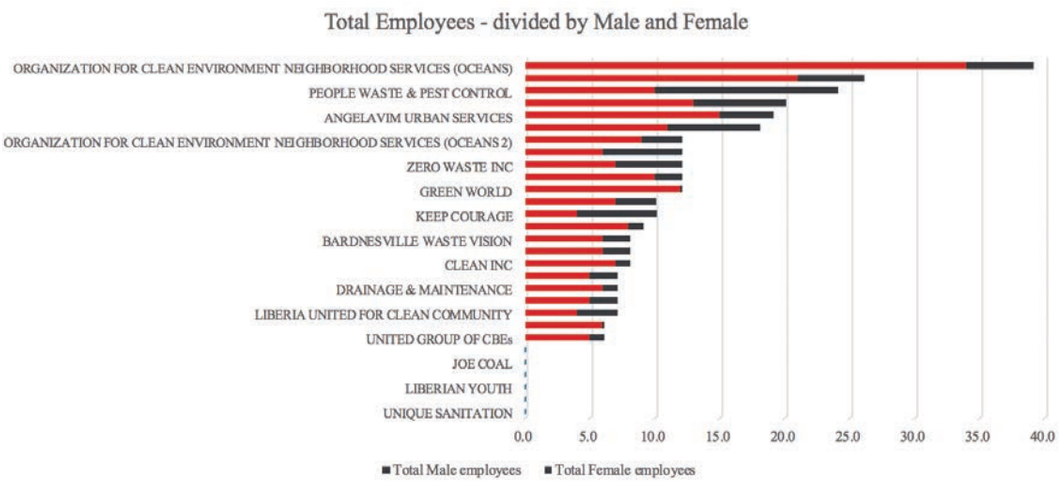
CBE's employ men and women in varying degrees. The below graph illustrates the variation from majority-women led CBE's to those with no women in employ.

FIGURE 22: 11 out of 30 CBE's employ women, with some CBE's such as "Keep Courage" reporting 60% women employees in their workforce.



CBE's also vary in size, from just 6 employees to just under 40.

FIGURE 23: Graph that illustrates the variation in size of CBE's and their split between male and female employees



CHALLENGES

Some of the key challenges faced by the CBEs in greater Monrovia include: difficulty in finding people prepared to do the work, customers not paying, limited access to quality equipment, competition from unlicensed waste collectors and City Corporations, limited business-related skills, and difficulty accessing small/reliable business improvement loads with reasonable payback periods[62]. According to a Cities Alliance survey, 92% of waste collectors said that some of their client households had not paid fees in the past 6 months, nearly two-thirds complained about the high cost of equipment, and 28% indicated that they had been unable to collect waste from at least one household because the waste had been collected by another waste picker (including those with and without authorization for collection)[63].

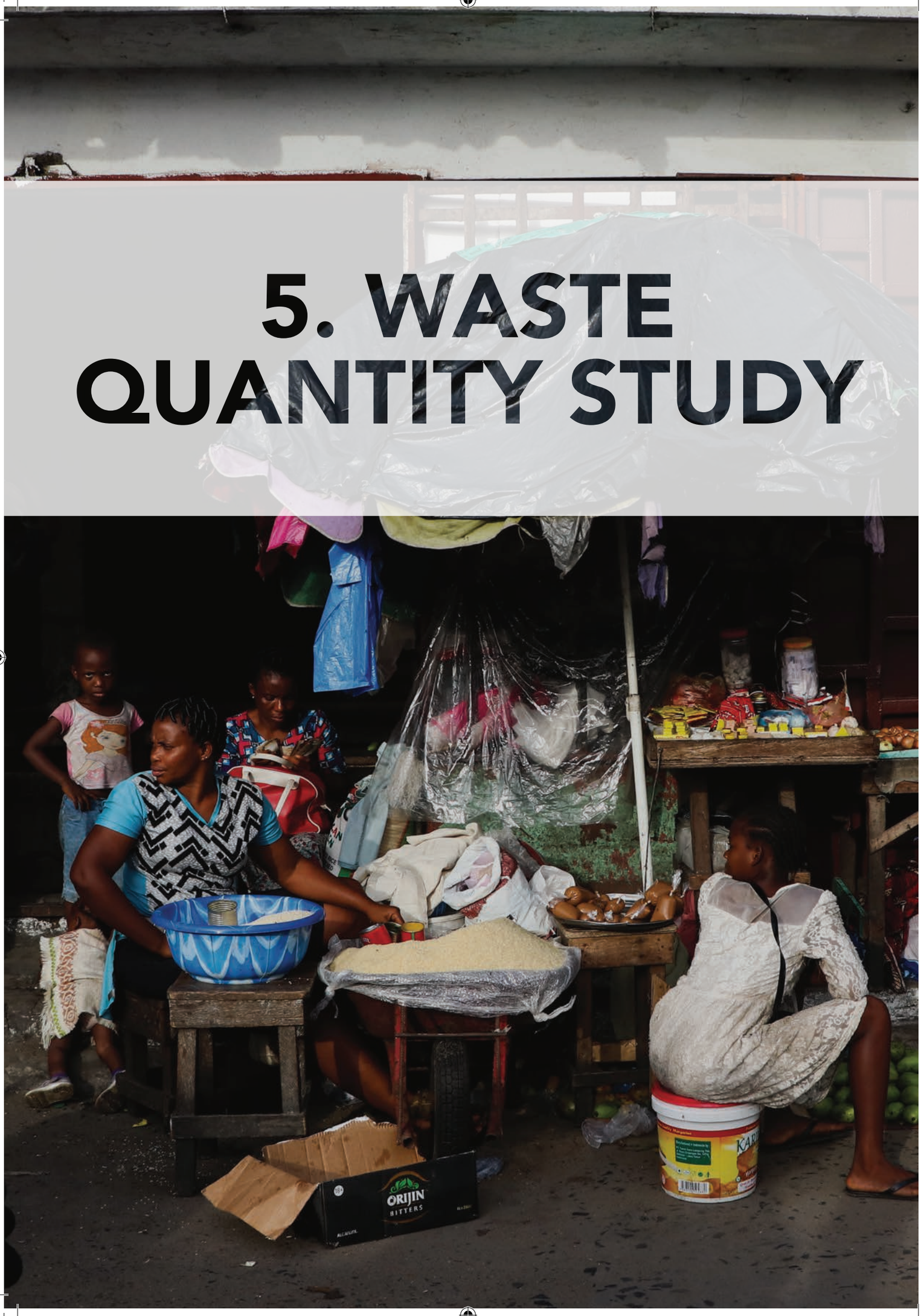
FIGURE 24: CBE equipment in Paynesville

[62] Consultations with NACOBE, September 2018
[63] citiesalliance.org/sites/citiesalliance.org/files/BB7_Budlender_IEBA_Monrovia_0.pdf

FIGURE 25: CBE equipment (source: NACOBE)

FIGURE 26: CBE equipment in compound (source: NACOBE)

5. WASTE QUANTITY STUDY



5.1 Waste Forecast

The waste forecast is an MS Excel™ based model that estimates waste arising from a 2018 baseline to 2043, utilising a variety of data sources and trends including historical census data.

5.2 Waste generation rate

The waste generation rate used in the model is 0.42kg/capita/day[64] or 0.153tn/capita/year and is the most recent data available (2016).

The majority of waste is biodegradable with plastics forming the 11% of the waste stream

[64] World Bank Group, What a Waste 2.0 – A Global Snapshot of Solid Waste Management to 2050, 2018

5.3 Population estimates

Population estimates are derived from national census data obtained in 2008[65]. The data has been projected forward to the baseline year (2018) and then projected forward again to 2043. Table 1 gives the 2008 census population data for each zone within greater Monrovia and the 2018 baseline population estimate.

Population growth for the period between 2008 and 2018 is generally declining falling from 2.46% per year in 2008 to 2.16% per year in 2018. The decline in population growth continues across the projection horizon, falling to 1.37% per annum in 2043. This trend gives average change in population of 1.95% per year, which is used in the waste forecast.

TABLE 1: Population estimates 2008 and 2018

Zone	2008 population estimate	2018 population estimate
New Kru Town	73,379	92,074
Logan Town	58,168	72,988
Clara Town	55,462	69,592
West Point	29,516	37,036
Central Monrovia A	42,139	52,875
Central Monrovia B	40,688	51,054
Sinkor	43,780	54,934
Lakpazee	42,045	52,757
Old Road	48,274	60,573
Congo Town	25,217	31,642
Paynesville	350,998	440,424
Gardnesville	80,397	100,880
New Georgia	54,188	67,994
Bardesville	35,224	44,198
Johnsonville	4,514	5,664
Caldwell	26,586	33,359
TOTAL Greater Monrovia	**1,010,575**	**1,268,046**
TOTAL Paynesville	**350,998**	**440,424**
TOTAL Monrovia	**659,577**	**827,622**

[65] 2008 National Liberia Census, LISGIS

5.4 Results

The waste forecast based on the application of the above waste generation rate and population growth change to the 2018 baseline population data is set out in Figure 27.

It should be noted that the waste forecast relates to waste arising estimates at the point of production. For this reason, the assumed waste collection rate was set to 100%.

The waste forecast estimates for each zone can be found in Appendix 4.

Waste characterisation data, as determined by Pasco (see Section 6)[66], was applied to the waste forecast to provide a quantitative estimate of the principal waste fractions for each year of the forecast– see Figure 28.

The 2018 baseline position for Monrovia is estimated arisings of 158,278 tonnes. The 2018 baseline position for Paynesville is estimated arisings of 88, 766 tonnes.

FIGURE 27: Waste forecast estimate (tonnes per year displayed in 5 year intervals)

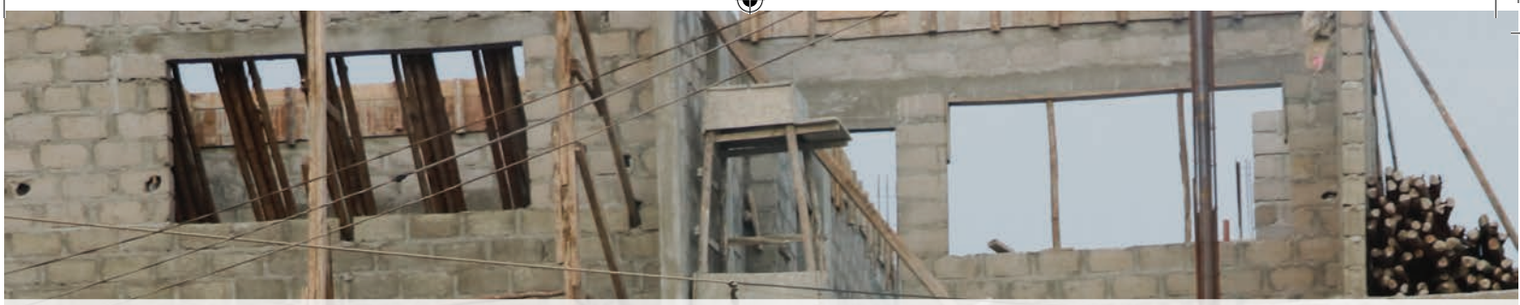
Year		2018	2023	2028	2033	2038	2043
Zone							
New Kru Town		18,557	20,450	22,349	24,248	26,147	28,046
Logan Town		14,710	16,211	17,716	19,222	20,727	22,232
Clara Town		8,460	9,322	10,188	11,054	11,920	12,785
West Point		7,464	8,226	8,990	9,753	10,518	11,281
Central Monrovia A		10,657	11,744	12,834	13,925	15,015	16,106
Central Monrovia B		10,290	11,339	12,392	13,445	14,498	15,551
Sinkor		11,072	12,201	13,334	14,467	15,600	16,733
Lakpazee		10,633	11,717	12,805	13,894	14,982	16,070
Old Road		12,208	13,453	14,703	15,952	17,201	18,451
Congo Town		6,377	7,028	7,680	8,333	8,986	9,638
Paynesville		88,766	97,819	106,903	115,987	125,071	134,155
Gardnesville		20,332	22,406	24,486	26,567	28,648	30,729
New Georgia		10,744	11,840	12,939	14,039	15,138	16,238
Bardesville		8,908	9,817	10,728	11,640	12,551	13,463
Johnsonville		1,142	1,258	1,375	1,492	1,609	1,725

[66] Pasco Waste and Environmental Consulting, Solid Waste Management – Waste Characterisation on the African Continent, 2012

Year		2018	2023	2028	2033	2038	2043
Zone							
Caldwell		6,723	7,409	8,097	8,785	9,473	10,161
TOTAL	Greater Monrovia	247,044	272,238	297,520	322,802	348,085	373,367
TOTAL	Paynesville CC	88,766	97,819	106,903	115,987	125,071	134,155
TOTAL	Monrovia CC	158,278	174,420	190,617	206,815	223,013	239,211

FIGURE 28: Waste forecast by principal fraction (tonnes per year displayed in 5 year intervals)

WASTE COMPOSITION		2018	2023	2028	2033	2038	2043
Paper	7%	17,293	19,057	20,826	22,596	24,366	26,136
Glass	1%	2,470	2,722	2,975	3,228	3,481	3,734
Metals	1%	2,470	2,722	2,975	3,228	3,481	3,734
Plastics	11%	27,175	29,946	32,727	35,508	38,289	41,070
Special MSW	1%	2,470	2,722	2,975	3,228	3,481	3,734
Combustible	14%	34,586	38,113	41,653	45,192	48,732	52,271
Textiles	5%	12,352	13,612	14,876	16,140	17,404	18,668
Vegetable/ putrescible	43%	106,229	117,062	127,934	138,805	149,676	160,548
Miscellaneous items	17%	41,998	46,280	50,578	54,876	59,174	63,472
TOTAL		247,044	272,238	297,520	322,802	348,085	373,367



6. WASTE CHARACTERISATION STUDY

Our determination of waste characterisation is based on observations, previous studies and professional judgement gained from work in other African countries and elsewhere.

Our research shows that two previous waste characterisation studies have been undertaken in Liberia. The first around 2004 by UNICEF-DFID[67] and the second around 2012 by Pasco Waste and Environmental Consulting[68], hereafter referred to as Pasco, (on behalf of the Bill & Melinda Gates Foundation).

The results of the UNICEF-DFID study appear in the UNEPS 'Assessment of Solid Waste Management in Liberia' report but we have been unable to find any information relating to the study methodology.

The results of the waste characterisation study undertaken around 2004 are given in Table 2.

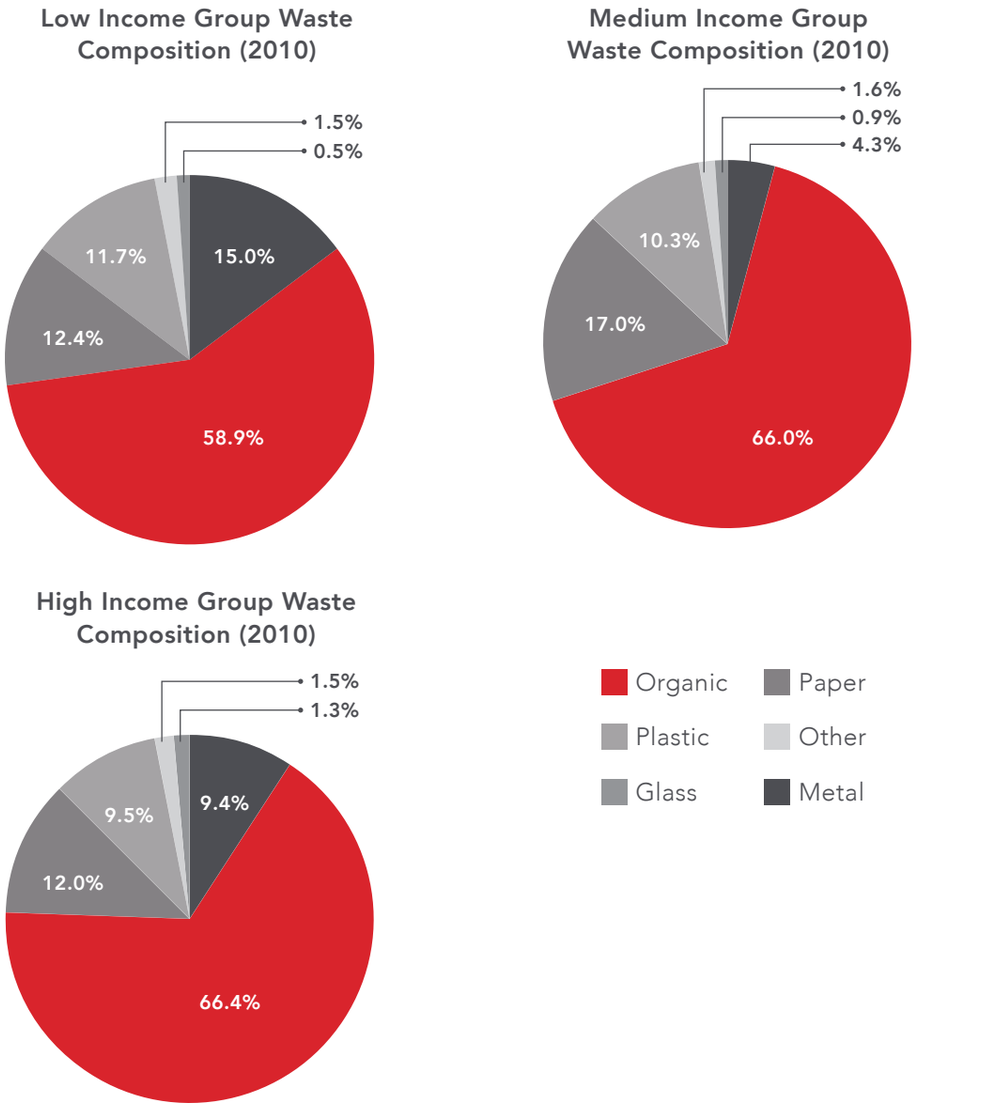
TABLE 2: UNICEF-DFID waste characterisation for Monrovia

Component	% by weight
Paper	10.0
Glass	1.2
Metals	2.0
Plastics	13.0
Leather, rubber	0.2
Wood, bones, straw	4.6
Textiles	6.0
Vegetable/putrescible	43.0
Miscellaneous items	20.0
TOTAL	**100.0**

The Pasco study considered United States Environmental Protection Agency guidance in determining sample size, frequency of sampling etc. to ensure the study would be representative of Monrovia. The study methodology - Monrovia was one of five cities sampled in the study – called for sampling by socio-economic group. However, it was not possible to achieve this level of stratification with the Monrovia sample because there was no town planning structure in place, effectively mixing up the socio-economic groups within the city. The sample obtained whilst still representative of Monrovia could, therefore, be said to represent the 'average' socio-economic group in Monrovia.

[67] United Nations Environment Programme, Assessment of Solid Waste Management in Liberia, 2007
[68] Pasco Waste and Environmental Consulting, Solid Waste Management – Waste Characterisation on the African Continent, 2012

FIGURE 29: The effect of income levels on waste composition in Kenya



For our previous work in Kenya[69] data on waste composition by socio-economic grouping from the Japanese International Co-operation Agency (JICA) was analysed. The results are shown in Figure 29.

This shows that differences in income levels do not, in general terms, affect waste composition. There is some variation in the proportion of components – the most notable, in this case, being metals – but at any reasonable scale of waste collection this variation is likely to get lost.

For our work in Kenya we also evaluated data on waste generation rate by socio-economic grouping from the African Development Bank (AfDB), UNEP and JICA. This confirmed, not surprisingly, that higher levels of waste generation are associated

[69] Arup, KenGen: Feasibility Study for Nairobi Urban Waste to Electricity Plant – Waste Forecast Model v1.5, 2011

with higher incomes. However, the highest rate of waste generation was associated with the middle income group. For that particular data set it was established that compared to the low income group:

- the Low to Middle Income group produced 1.2 times the tonnes per capita per annum;
- the Middle Income group produced 1.7 times the tonnes per capital per annum; and
- the High Income group produced 1.6 times the tonnes per capita per annum.

In our view waste in Liberia will also experience some small variations in composition associated with different socio-economic groupings. It is also our view that the general correlation between waste generation and income will be as true for Liberia as it was for Kenya. However, the actual impact of the different socio-economic groups within Greater Monrovia on variation in waste composition and waste generation rate does remain unquantified.

The sampling methodology employed by Pasco is commonly known as the 'quarter and cone' technique and is used throughout the world when characterising waste using bulk samples.

The paper fraction identified by Pasco consists of 1% w/w paper; 4% w/w cardboard and 2% w/w composite packaging e.g. Tetrapak.

The combustible waste fraction identified by Pasco consists of 12% w/w contaminated organic waste such as wood, straw and bone and 2% w/w other combustible waste.

The vegetable/putrescible fraction identified by Pasco consists of 13% w/w clean organic waste; 15% w/w soil like organic matter smaller than 20mm in diameter and 15% w/w other organic matter smaller than 20mm in diameter.

TABLE 3: Pasco waste characterisation

Component	% by weight
Paper	7.0
Glass	1.0
Metals	1.0
Plastics	11.0
Special municipal solid waste	1.0
Combustible waste	14.0
Textiles	5.0
Vegetable/putrescible	43.0
Miscellaneous items	17.0
TOTAL	**100.0**

The nature of the waste observed in greater Monrovia, particularly at the transfer stations and landfill site, does not contradict the findings of either of the two waste characterisation studies. It is evident that there is almost no metal or glass in the municipal waste stream, with dense plastic (plastic containers) being the most identifiable component. The 'paper' content is dominated by cardboard. The remainder appears to be a mixture of food and kitchen waste and miscellaneous items. Our observations would suggest food and kitchen waste is in relatively high proportions, as it appears to be 'smeared' throughout the waste mass.

Whilst the two studies were not identical the waste fractions identified are similar enough to allow comparison. The studies indicate little change in composition over an 8 year period. There has been a small decrease in what can be described as dry recyclable materials (paper, glass, metals and plastics); a possible increase in contaminated organic waste (suitable for combustion) – wood, straw and bone - but no change in the putrescible fraction.

Our data for East and Central Africa[70] indicates higher proportions of vegetable and putrescible waste than are present in Liberia and comparable levels of dry recyclable materials, albeit that the 'mix' differs. However, the combustible contaminated organic waste identified by Pasco can also be said to be putrescible and if added to the separately identified vegetable/putrescible fraction the total proportion of putrescible waste increases to 55% by weight and is more comparable with the levels of vegetable/putrescible waste indicated by our data for East and Central Africa.

Data for Mali indicates comparable levels of dry recyclable materials but a lower proportion of vegetable/putrescible waste. Data for South Africa, as might be expected, is more characteristic of developed countries.

The World Bank report 'What a Waste 2.0: A Global Snapshot of Solid Waste Management to 2050'[71] provides a generic waste characterisation for sub-Saharan Africa countries and is shown in Table 4.

TABLE 4: World Bank waste characterisation (sub-Saharan Africa)

Component	% by weight
Paper	10.0
Glass	3.0
Metals	5.0
Plastics	8.6
Wood	0.4
Vegetable/putrescible	43.0
Miscellaneous items	30.0
Miscellaneous items	17.0
TOTAL	**100.0**

[70] Arup, Waste Forecast Tool version 2.3 - composition tab, 2016

[71] https://openknowledge.worldbank.org/handle/10986/30317 (Accessed 8th November 2018)

The two waste characterisation studies undertaken in Liberia are comparable with the generic waste characterisation for sub-Saharan Africa. The delta values (Δ) associated with the two Liberian waste characterisation studies, compared to the generic waste characterisation are given in Table 5.

An analysis of the delta values suggests:

- Dry recyclable materials, in the waste stream, appear to be declining;
- (That said) the glass and metal components appear relatively stable based on the difference in delta values;
- The vegetable/putrescible component, within the waste stream, is stable; and
- The difference in miscellaneous items is due to the studies targeting different waste fractions. (This component (and similarly named fractions e.g. residual waste) are generally used to balance the waste composition.)

The waste characterisation data indicates that Monrovia's waste is of relatively low value compared to generic sub-Saharan Africa waste having a declining proportion of materials with a recycling value. The reasons for this declining proportion of recyclable materials may be attributable to the general socio-economic conditions in Liberia, as there was no evidence of anything other than small scale entrepreneurial recycling activity. We also received anecdotal evidence that plastic containers tend to be reused a number of times before finally being disposed of and this may account for the decline in the plastic component.

The fact that there has been no change in the vegetable and putrescible component suggests that food purchasing, preparation and eating habits are, currently, uninfluenced by convenience (packaged) food and supermarket shopping. Ironically, any shift towards convenience foods could increase the 'value' of Monrovia's waste as the proportion of dry to wet components would shift in favour of dry components. Such a shift might also be accompanied by an increase in waste generation rate.

TABLE 5: Difference in waste composition (compared to the 'average' for sub-Saharan Africa)

Component	WB % by weight	2004 study Δ (as % by weight)	2012 study Δ (as % by weight)
Paper	10.0	0	-3.0
Glass	3.0	-1.8	-2.0
Metals	5.0	-3.0	-4.0
Plastics	8.6	4.4	2.4
Wood	0.4	N/A	N/A
Vegetable/ putrescible	43.0	0	0
Miscellaneous items	30.0	-10	-13
TOTAL	**100.0**		

HAZARDOUS WASTE

There are, undoubtedly, components within the municipal waste stream which are hazardous. Based on the waste characterisation study undertaken by Pasco these components are likely to be 1% by weight of the total municipal waste stream. This is not significantly different to the quantity of hazardous waste found in the municipal waste stream of countries with mature waste management systems. For example various research relating to the composition of the UK municipal waste indicates the proportion of hazardous waste (in the UK residual municipal waste stream) at around 1.5% to 2% by weight[72].

No readily identifiable hazardous components were observed during our site visits and management of these components on the basis of the 'dilute and disperse' principle (within the larger municipal waste body) is acceptable given the existing waste collection arrangements.

Hazardous waste also arises from other sources including industry and hospitals. From discussions with James Strother - President of the Liberian Business Association and owner of NC Sanitor an SME with waste management interests we have established that hospitals in the greater Monrovia area dispose of their waste using on-site incineration or the services of the aforementioned SME, who, ultimately, also incinerate the hospital waste they collect. We cannot comment on the 'robustness' of the incineration processes used and assume that the residual waste from these processes is ultimately landfilled, as the Whein Town landfill site offers the only disposal option. It has not been possible to gather data in relation to the management of hazardous waste arising from industrial processes.

[72] Envirocentre, Residual Waste Report, 2007 and Enviros, Guidance on the Kerbside Collection of Household Hazardous Waste, 2009

6.1 Conclusion

Based on research and professional judgement the Pasco waste characterisation study is regarded as being representative of the waste composition in greater Monrovia and provides an appropriate baseline.

NET CALORIFIC VALUE

Applying Net Calorific Value (NCV) data[73] to each component of the baseline waste composition and taking account of the proportion of each component, the average NCV for Monrovia's municipal waste can be estimated – see Table 6.

This NCV is within the range required for municipal waste to sustain combustion albeit towards the lower end of the range. As previously noted Monrovia's municipal waste is relatively wet with a high proportion of vegetable/putrescible and other organic waste. Moving forward it may be beneficial to consider one or more means of reducing the moisture content of the waste, as this would increase NCV.

TABLE 6: Estimated NCV of Monrovia's municipal solid waste

	a	b	c = a x b
Component	**WB % by weight**	**2004 study Δ (as % by weight)**	**2012 study Δ (as % by weight)**
Paper	7%	11	0.77
Glass	1%	0	0
Metals	1%	0	0
Plastics	11%	24.86	2.73
Special municipal solid waste	1%	0	0
Combustible waste	14%	14.06	1.97
Textiles	5%	14.33	0.72
Vegetable/ putrescible	43%	3.59	1.54
Miscellaneous items	17%	2.57	0.44
Proposrtion contributing to NCV	97%		8.17
	e		d
Average NCV MJ/kg	8.42	f=d/e	

[73] NCV data taken from the UK Waste and Recycling Environmental Assessment Tool for the Environment (WRATE). For further information, see wrate.co.uk

7. WASTE DENSITY STUDY

Our determination of the density of waste in greater Monrovia is based on site observations, previous studies and professional judgement. No new measurements have been undertaken as part of this baseline study.

Based on observation and the method of waste collection employed by MCC/PCC the waste collected is not subject to more than cursory compaction. Neither the primary or secondary waste collection system provides for the mechanical compaction of waste prior to deposit at the transfer stations, or direct to the landfill in the case of PCC. Based on discussion the transfer operation does not provide for the mechanical compaction of waste either. The only compaction is that resulting from the loading of the bulk haulage container. On this basis, when considering waste density, the waste collected by MCC/PCC can be regarded as un-compacted.

Similarly, based on the method of waste collection employed by PCC the waste collected is not subject to more than cursory compaction, resulting from the loading of the bulk haulage container prior to transfer to the landfill site. On this basis, when considering waste density, the waste in PCC can also be regarded as un-compacted.

Waste density is influenced by the composition of the waste – more specifically its absorption capacity - and its method of storage and the prevailing climatic conditions. Waste with a high absorption capacity stored in open containers in an area of comparatively high rainfall will have a higher bulk density value than, say, waste of the same absorption capacity stored in closed containers in the same environment.

Our research shows that two previous waste characterisation studies undertaken in Liberia have also considered waste density. The first around 2004 by UNICEF-DFID[74] gives waste density as 250kg/m^3 and the second around 2012 by Pasco Waste and Environmental Consulting[75], hereafter referred to as Pasco, (on behalf of the Bill & Melinda Gates Foundation) gives waste density as being between 242kg/m^3 and 280kg/m^3.

There is no information on the methodology used in the 2004 study but the 2012 study employed the cone and quartering technique, which is used internationally to determine waste characteristics from bulk samples. The 2012 study also took account of the distinct 'wet' and 'dry' seasons experienced in Liberia. Taking account of the seasons the study suggests that the median waste density for waste arising in Monrovia is around 261kg/m^3.

As stated above there are a number of factors that influence waste density so direct comparison with other municipal waste density data is of limited value. However, bulk density data for the different components found in Monrovia's municipal waste can be used to provide an estimated waste density for the municipal waste stream as a whole; which in turn can be used to sense check the waste densities determined by the earlier studies.

The components found in Monrovia's municipal waste have been allocated a bulk density value derived from an empirical study undertaken in 1993[76] and referenced in Arup's Waste Forecast Tool version 2.5. Wherever possible, the bulk density value

[74] United Nations Environment Programme, Assessment of Solid Waste Management in Liberia, 2007

[75] Pasco Waste and Environmental Consulting, Solid Waste Management – Waste Characterisation on the African Continent, 2012

[76] Tchobanoglous, G., Theisen, H., Vigil, S.A, Integrated Solid Waste Management - Engineering Principles and Management Issues. McGraw-Hill Inc. 1993

chosen is for material found in un-compacted residential waste. We have used professional judgement to assign bulk density values where there is no matching component data – these instances are identified as comments in Figure 28 on the following page. Figure 30 provides an estimate of waste density where the bulk density value assigned to the vegetable/putrescible component is 0.291 tonnes/m^3.

The use of this value gives an estimated waste density less than that reported in the two earlier studies. As this could be attributable to the value used not fully accounting for the moisture content of residential waste in Monrovia a comparison calculation was undertaken using a bulk density value for the vegetable/putrescible component of 0.540 tonnes/m^3 and representative of wet food waste from commercial sources. The estimated waste density from this calculation is shown in Figure 31.

This calculation gave a waste density estimate slightly higher than the upper value reported by Pasco.

FIGURE 30: Calculation estimate of waste density where the bulk density value for vegetable/putrescible component is 0.291 tonnes/m^3 (dry waste)

	a	b	c = a x b	
Component	% by weight	Assigned bulk density tn/m3	Bulk density as proportion of composition	
Paper	1%	0.089	0.0009	
Cardboard	4%	0.05	0.0020	
Composites	2%		0.0	
Glass	1%	0.196	0.0020	
Metals	1%	0.089	0.0009	
Plastics	11%	0.065	0.0072	
Special municipal solid waste	1%		0.0	
Wood, straw etc.	12%	0.101	0.0121	
Combustible waste	2%		0.0	
Textiles	5%	0.065	0.0033	
Vegetable/putrescible	43%	0.291	0.1251	
Miscellaneous items	17%	0.131	0.0223	
	100%	Σc	0.1757	tn/m3
	d			
Proportion contributing to density	95%	Σc/d=	0.1849	tn/m3
			185	kg/m3

Assigned value for un-compacted residential yard waste

Assigned value for un-compacted residential residual waste

0.291 0.54 tn/m3

Value for uncompacted residential mixed food waste

Value for wet food waste (commercial origin)

FIGURE 31: Calculation estimate of waste density where bulk density value for the vegetable/putrescible component is 0.540 tonnes/m^3 (wet waste)

	a	b	c = a x b	
Component	% by weight	Assigned bulk density tn/m3	Bulk density as proportion of composition	
Paper	1%	0.089	0.0009	
Cardboard	4%	0.05	0.0020	
Composites	2%		0.0	
Glass	1%	0.196	0.0020	
Metals	1%	0.089	0.0009	
Plastics	11%	0.065	0.0072	
Special municipal solid waste	1%		0.0	
Wood, straw etc.	12%	0.101	0.0121	
Combustible waste	2%		0.0	
Textiles	5%	0.065	0.0033	
Vegetable/putrescible	43%	0.54	0.2322	
Miscellaneous items	17%	0.131	0.0223	
	100%	Σc	0.2827	tn/m3
	d			
Proportion contributing to density	95%	Σc/d=	0.2976	tn/m3
			298	kg/m3

Assigned value for un-compacted residential yard waste

Assigned value for un-compacted residential residual waste

0.291 0.54 tn/m3

Value for uncompacted residential mixed food waste

Value for wet food waste (commercial origin)

7.1 Conclusion

Based on a review of the existing waste density study for Monrovia and professional judgement the density of municipal waste in greater Monrovia is considered to lie in the upper half of the range reported by Pasco, with a suggested baseline value of **261kg/m^3.**

8. ESTIMATION OF BASELINE GREENHOUSE GAS (GHG) EMISSIONS

8.1 Introduction

The GHG emissions associated with the waste management systems employed by MCC and PCC have been established using Waste and Resource Assessment Tool for the Environment (WRATE). WRATE[77] is a software package specifically designed to estimate the life-cycle impacts (LCI) of different waste management systems. It was developed by the Environment Agency in the United Kingdom principally using data from within the European Union. As such some processes within WRATE cannot be amended to directly correspond to waste management practices in Greater Monrovia.

A 'best-fit' approach has, therefore, been adopted where necessary, utilising the knowledge and experience gained from other WRATE LCI assessments. It is acknowledged that this approach may lead to a more beneficial output than is actually the case but for an initial baseline estimate the output is considered representative of GHG emissions associated with waste collection and disposal in MCC and PCC.

The principal reason for using WRATE is that it is specifically designed to determine the life-cycle impacts of waste management systems. The system boundary is defined by the user, based on current and/or proposed waste management systems. The waste management system is represented by a user entered process flow diagram, utilising icons to represent specific processes within the waste management system. The validity of the waste management system (process flow diagram) entered is determined by mass balance.

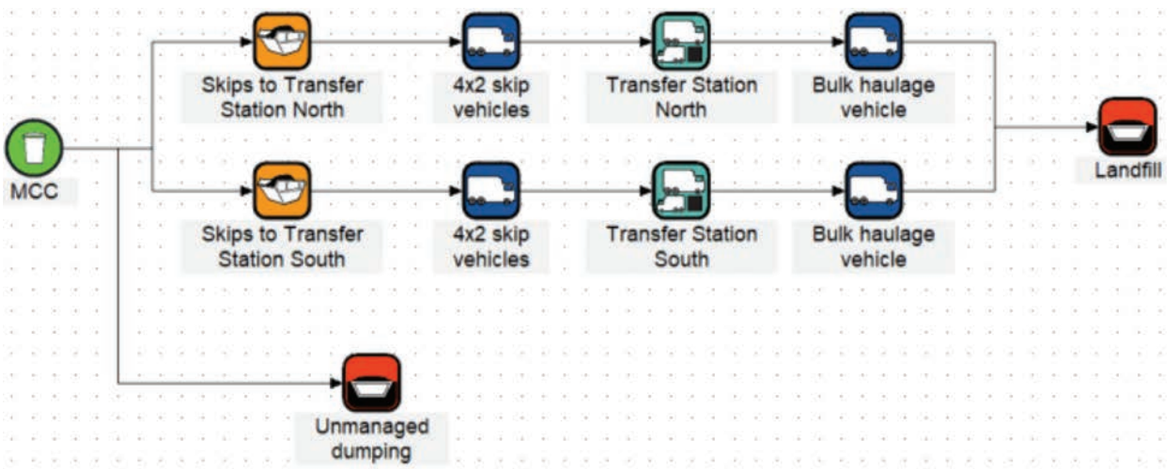
In this particular case two separate waste management systems were modelled and the GHG emissions for each determined.

[77] www.wrate.co.uk

8.2 MCC Waste Management System

The waste management system for Monrovia City Corporation is represented by the process flow diagram set out in Figure 32 below.

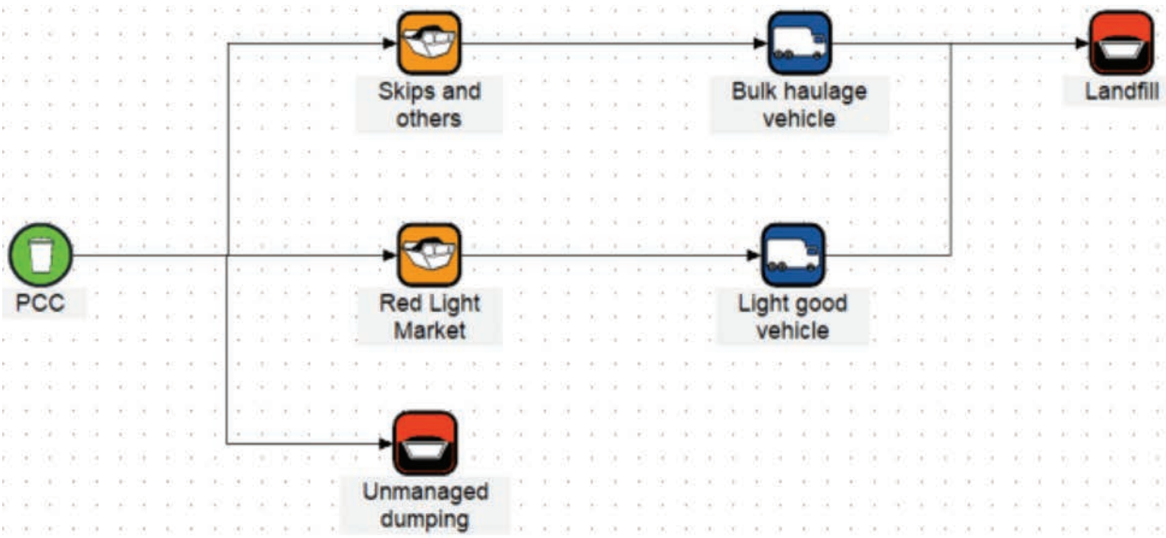
FIGURE 32: WRATE representation of MCC waste management system



8.3 PCC Waste Management System

The waste management system for Paynesville City Corporation is represented by the process flow diagram set out in Figure 33 below.

FIGURE 33: WRATE representation of PCC waste management system



8.4 Limitations and assumptions

The limitations and assumptions used in the determination of waste management GHG emissions for MCC are:

- The emissions associated with primary waste collection are not included, as the majority of primary waste collection is not mechanised.
- Vehicle allocations within the WRATE model are best fit.
- Vehicle emissions are those associated with Euro IV compliant vehicles. The skip vehicles observed in Monrovia and Paynesville were of Chinese manufacture and a search of manufacturer's website produced a technical specification which indicates the vehicles comply with Euro II standards, however default vehicle process emissions within WRATE are compliant with Euro IV. It was assumed that the larger bulk haulage vehicles met the same standard as the skip vehicles (i.e. Euro II).
- The transfer stations are of 'Dutch Barn' design consisting principally of concrete and steel.
- The landfill site is lined with natural material and includes a leachate collection system but no landfill gas capture.
- The limitations and assumptions used in the determination of waste management GHG emissions for PCC are:
- The emissions associated with primary waste collection are not included, as the majority of primary waste collection is not mechanised.
- Vehicle emissions associated with the plant used to empty skip containers and load bulk haulage vehicles are not included as there is no comparable vehicle data within the model. These emissions are regarded as being de minimis with regard to the overall assessment.
- Vehicle allocations within the WRATE model are best fit.
- The landfill site is lined with natural material and includes a leachate collection system but no landfill gas capture.

8.5 Energy grid mix

In determining any GHG emission estimate the model takes it account the energy grid mix used to produce power so that any energy recovery processes within the system boundary can be off-set against the emissions associated with the chosen energy mix.

Information from the Liberia Electricity Corporation indicates that the Mount Coffee hydroelectric facility is now producing 20MW of electrical energy, with the remainder of the country's electrical energy produced by high speed diesel (HSD) generators (totalling 22MW of output, of which 16-18MW is available) and three heavy fuel oil (HFO) fired power stations with a combined output of 38MW. As HFO predominates and HSD does not feature in the energy grid mix selection available in WRATE the energy grid mix chosen was 75% oil/25% hydroelectric, on the basis of best-fit for both MCC and PCC.

8.6 Modelling methodology

The total quantity of waste arising in both MCC and PCC has been estimated using 2018 population data for each city corporation area[78] and a common per capita waste generation rate[79]. For MCC this data gives the 2018 estimate of annual waste arisings as 155,278 tonnes and for PCC the data gives the 2018 estimate of annual waste arisings as 88,766 tonnes. However, within the PCC area there is the Redlight Market which contributes additional waste arisings. These have been estimated as a percentage uplift of the per capita total. The uplift applied is 7%[80] making the estimated waste arisings from Redlight Market 6,213 tonnes per year, which increases the total waste arisings in the PCC area to 94,979 tonnes per year.

Data supplied by MCC relating to inputs into the Whein Town Landfill Site indicate that around 3% by weight of input is from private waste producers/contractors. However, there is no information relating to the original source or routing of these inputs so any split between MCC and PCC would be arbitrary.

From these annual tonnages the proportion of each component within the waste arisings was estimated based on the waste characterisation reported by Pasco Waste and Consulting Limited[81] and the waste characterisation variables available within the WRATE model e.g. Pasco identified that the paper fraction consists of 1% paper, 4% cardboard and 2% composite packaging. This has been translated (within the WRATE model) into 1% unspecified paper. 4% card and 2% other card.

TABLE 7: MCC and PCC estimated waste arisings (by type)

Component	% by weight	MCC tonnes/year	PCC tonnes/year
Paper and card	7.0	10,869	6,649
Glass	1.0	1,553	950
Ferrous metals[82]	0.5	776	475
Non-ferrous metals	0.5	776	475
Plastics[83]	11.0	17,081	10,448
Special municipal solid waste[84]	1.0	1,553	950
Combustible waste	14.0	21,739	13,297
Textiles	5.0	7,764	4,749
Clean organic[85]	13.0	20,186	12,347

[78] Arup, Monrovia Waste Forecast Model – Population Data, 2018 (MCC population is 854,520; PCC population is 440,424)
[79] Arup, Monrovia Waste Forecast Model – Waste Forecast, 2018 (0.153 tonnes/capita/year)
[80] Arup estimate based on ratio of market waste to household waste in Nairobi, Kenya
[81] Pasco Waste and Environmental Consulting, Solid Waste Management – Waste Characterisation on the African Continent, 2012
[82] Allocated equally within WRATE between unspecified ferrous metal and unspecified non-ferrous metal
[83] Allocated within WRATE to dense plastics only
[84] Allocated within WRATE to household hazardous waste

Component	% by weight	MCC tonnes/year	PCC tonnes/year
Fine material	15.0	23,292	14,247
Non-combustible waste[86]	32.0	49,689	30,393
TOTAL	**100.0**	**155,278**	**94,979**

The split between ferrous and non-ferrous metal is arbitrary as there is no data available on the ratio of ferrous to non-ferrous metal in the Greater Monrovia waste stream. Whilst an accurate split would increase confidence in the GHG emission estimate the overall quantity of metal in the waste stream does not merit the expense involved in separately identifying the two types.

Discussion indicated that around 36%[87] of the wastes arising are collected via the secondary waste collection system leaving 64% uncollected and unmanaged. Table 8 sets out the quantity of waste assumed to be collected by each city corporation and ultimately disposed of to landfill and the quantity assumed to be left uncollected and informally disposed of through uncontrolled activities.

As mentioned above the landfill also receives inputs from private companies equivalent to around 3% of the total annual input. The estimated total amount of waste collected and landfilled by the city corporations (in 2018) is 90,087 tonnes. Assuming this amount represents 97% of the annual input into the landfill than the estimated input (in 2018) from private companies is 2,786 tonnes.

As described in Figure 30 the waste collected by MCC is firstly transported to one of two waste transfer stations, which, in general terms, can be said to be north and south of the Mesurado River. Spatial data prepared by Arup, based on information supplied by LISGIS, was used to identify the location of each waste collection point. Each waste collection point was allocated to either Fiamah Waste Transfer Station (south of the river) or Stockton Creek Waste Transfer Station (north of the river) and the travel distance between the collection point and waste transfer station estimated. The estimated travel distance takes into account network constraints and that only one container can be collected at once by each of the five vehicles employed and that each container needs to be returned to its collection point following emptying.

TABLE 8: MCC and PCC collected and uncollected waste estimates

Waste arisings	MCC (tonnes/year)	PCC (tonnes/year)
Est. total waste	155,272	94,976
Collected and landfilled	55,898	34,191
Uncollected and not managed	99,380	60,785

[85] From vegetable/putrescible component reported by Pasco Waste and Environmental Consulting

[86] Consists of soil like material in vegetable and putrescible component and miscellaneous items reported by Pasco Waste and Environmental Consulting

[87] Technical Working Group, December 2018

The estimated travel distance involved in collecting waste and delivering it to Fiamah Waste Transfer Station is **1,407,594 kilometres per year.**

The estimated travel distance involved in collecting waste and delivering it to Stockton Creek Waste Transfer Station is **634,241 kilometres per year.**

A detailed breakdown of the waste collection points allocated to each waste transfer station can be found in Appendix 5 to this section of the report.

The estimated travel distance between each waste transfer station and the landfill site at Whein Town is then estimated, taking into account network constraints and that only one container can be collected at once by each of the two bulk haulage vehicles servicing the transfer stations and that each container needs to be returned to its collection point following emptying.

The estimated travel distance involved in transferring waste from Fiamah Waste Transfer Station to Whein Town landfill site is **59,130 kilometres per year.**

The estimated travel distance involved in transferring waste from Stockton Creek Waste Transfer Station to Whein Town landfill site is **54,488 kilometres per year.**

As described in Figure 34 the waste collected by Paynesville City Corporation is delivered to directly from the point of collection to Whein Town landfill site. Spatial data prepared by Arup, based on information supplied by LISGIS and PCC, was used to identify the location of each waste collection point. For each waste collection point the travel distance between it and the landfill site was estimated. The estimated travel distance takes into account network constraints and that only one container can be collected at once and needs to be returned to its collection point following emptying.

The estimated travel distance involved in collecting waste and delivering it to Whein Town landfill site is **449,795 kilometres per year.**

Further information on the waste collection points used to estimate travel distance can be found in Appendix 5 to this report.

In addition, PCC also undertake an informal waste transfer operation from the site of the Redlight Market 'transfer station' to Whein Town landfill site. The estimated travel distance involved in transferring waste between these two points is **1,412 kilometres per year.**

Data in relation to the quantity of waste arising, its method of collection and the infrastructure used in its management are all combined by the tool to produce an estimate of the GHG emissions associated with that particular waste management system. The GHG emissions associated with any uncollected portion of the waste arisings cannot be ascertained directly but indirect measurements, based on changes in the waste collection rate, can be made.

8.7 Results

The GHG emissions associated with the current Monrovia City Corporation waste management system (at a 36% waste collection rate) are 108,566,713kg CO2-Eq.

The GHG emission associated with the current Paynesville City Corporation waste management system (at a 36% waste collection rate) are 66,661,144kg CO2-Eq.

These results reflect total life cycle emissions (apportioned to an annual basis) of the waste management systems including construction, maintenance, operation and decommissioning of all processes.

Sensitivity analysis indicates that a 10% increase in collection rate increases GHG emissions by around 0.4-0.5%. This means that if waste collection rates increased to levels approaching those in countries with mature waste management systems, say 90%, but the methods of waste collection and infrastructure used remained the same then the associated estimated GHG emissions would be in the order of 111,851,748kg CO2-Eq for MCC and 67,964,017kg CO2-Eq for PCC. Therefore, ironically, any improvement in waste collection rate, all other things being equal, will result in an increase in GHG emissions. The same is true in relation to any overall increase in transport distances between the waste collection points (including the waste transfer stations) and the final point of disposal.

A more efficient waste collection system in terms of number of containers serviced per tip, payload capacity, engine emission standards etc. will all help mitigate any increase in GHG emissions associated with higher rates of waste collection and/or longer travel distances to the final point of disposal.

The GHG emissions associated with waste collection vehicles are underestimated in the model due to software limitations. However, in total, vehicle emissions only form around 1-4% of the estimated GHG emissions. Table 9 sets out the estimated GHG emissions associated with the collection and transport of waste.

The majority of estimated GHG emissions arise from the use and operation of the landfill site, principally as a result of zero landfill gas capture, which allows (along with the informal disposal of the majority of Greater Monrovia's waste arisings) the release of methane to the atmosphere – which is a potent GHG.

TABLE 9: Estimated transport related GHG emissions

Characterised result	MCC (40% collection rate)	PCC (40% collection rate)	MCC (90% collection rate)	PCC (90% collection rate)
climate change: GWP 100a kg CO2-Eq	1,946,572	868,494	4,865,568	2,171,214

Methane is one of the principal components of landfill gas, with a Global Warming Potential 25 times that of carbon dioxide. The methane within landfill gas is combustible and, as a result of the combustion process, can be converted into less potent forms of GHG. The combustion process can simply burn-off the methane, commonly known as flaring, or, where the landfill gas yield is/will be high enough the combustion process can be used to generate energy. The production of energy from landfill gas not only lowers the potency of the residual GHG emissions but allows for some off-setting of the energy grid mix.

Greater Monrovia's GHG emissions could be significantly reduced through the installation of a landfill gas recovery system at the proposed new landfill site in Cheesemanburg, perhaps to the degree that any increased transport related GHG emissions are mitigated.

We have provided a specific estimation of the current waste quantities in Whein Town landfill and their associated GHG emissions in Appendix 6. However, it should be noted this estimate is based on ground level methane flux rates and takes no account of life cycle impacts. It is a separate estimate that has no relationship to the modelling methodology described above.

9. CONCLUSIONS AND RECOMMENDATIONS

9.1 General

A functioning waste management system was in operation before the start of civil war and this is re-emerging once again. Currently, the fundamental elements of a waste management system exist for greater Monrovia.

All the key actors involved in solid waste management recognise the system needs to be improved and are actively striving to improve. This includes government structures at the national level that facilitate local governments (City Corporations) who are responsible for secondary collection and private sector (SMEs and CBEs) that are a key part of the primary waste collection system.

The method of waste collection in some parts of greater Monrovia is shortening the life of limited assets. A reconciliation of equipment, in particular containers and type of collection vehicle, is required. The use of a properly aligned container and vehicle system would bring efficiencies with regard to service times, health and safety and operating costs.

The existing Whein Town Landfill is unstable and unmanaged which is leading to outbreaks of fire and slides that are hazardous to those managing the site. A detailed survey of the landfill is required and possible re-engineering necessary in order to accept further inputs.

The road network and traffic congestion is impacting the ability of the existing actors to collect, sort, and dispose of waste efficiently. Existing road conditions, particularly of Somalia Drive further hinder the transport of waste to Whein Town landfill. Finally, the increasing volume of traffic within greater Monrovia limits how efficiently waste can be managed.

9.2 Waste management policies and regulations

There are existing policies that clearly define roles and responsibilities for waste management, such as the draft 2015 National Solid Waste Management Policy. This Draft Policy should be adopted and implemented, with the SWM Technical Working Group taking the lead in championing this implementation and providing the necessary coordination across agencies. In addition, the following policy actions are suggested:

- The Liberia Marketing Association (LMA) are responsible for waste management in markets and the collection of taxes from local businesses in order to cover the expenses for this service. Legal clarification of the LMA's responsibility is needed in coordination with the City Corporations.
- The National government should ensure that local government agencies have adequate budgetary support to fulfil solid waste management responsibilities, through the Ministry of Internal Affairs.
- National government agencies should provide the enabling environment to facilitate formulation and enforcement of city ordinances; ensure future secondary and final disposal sites are identified and developed; ensure

markets are designed with adequate waste management facilities; delineate and depoliticize Liberia Market Association (LMA) and encourage cooperation between the LMA and City Corporations; and provide special funding mechanism to support private sector and SME's to start up SWM services.

- Finally, there is a need to include a charging mechanism (possibly within the draft 2015 SWM Policy) as described in Section 9.8 below that provides a requirement for each household to contribute a minimum amount to support the solid waste management system. This would allow waste management businesses to have greater certainty over their revenue streams and would enable further access to finance, for example through the form of business loans.

9.3 Private sector

Community based enterprises (CBE's) provide a fundamental part of the household and small business primary waste management system in greater Monrovia. SME's also provide crucial services in waste collection from larger businesses and in the transportation of waste from transfer stations to Whein Town landfill site.

Aside from licenced CBE's there are unlicensed operators that collect solid waste from households for a fee. This unregulated collection system is undermining the local contracts in place with CBEs and can lead to illegal tipping of waste as there is no accountability to local authorities through a licencing mechanism.

Informal collection is recognised as a key risk to the financial viability of CBE's. Ineffective enforcement against 'moonlighters' is undercutting CBEs who are paying for an operations licence. Enforcement and policing of informal collectors is needed to protect the legal rights of CBE's.

CBEs also do not have exclusive rights to operate in particular zones and compete with City Corporations for key clients that are typically the businesses that can afford to pay.

A detailed business survey of CBEs should be carried out to understand the specific needs of these types of companies and detailed information on the spoilage rates of equipment for example.

Models of partnership in scale between CBE's and SME's can be trialled whereby CBE's and SME's partner to deliver a complete waste management solution for a specific area. This partnership could result in waste being dealt with quickly and efficiently from source to final solution (e.g. recycling or depositing in landfill).

9.4 Financing Waste Management

There does not appear to be any sources of sustainable funding for the waste management system in the greater Monrovia area. All parts of the waste management chain, including CBEs, would benefit from proper budgets. A significant part of securing sustainable funding is ensuring the appropriate revenue-raising

powers exist and that all those who should pay do pay. The fees levied also need to be affordable for those paying them.

In this section we outline the different ways in which charges might be structured and collected. In doing so we have assumed that MCC and PCC are ultimately given the power and means to collect their own revenue and that they duly distribute said revenue through the waste management chain i.e. CBEs no longer collect their own fees but instead receive payment from MCC or PCC.

The diagram[88] on the right outlines the components that might be included in any waste charge.

A flat rate fee would need to reflect both the fixed and variable costs associated with the waste management system, however it is challenging to recover all variable costs. Flat fee charges can be varied to reflect income levels, however this type of fee structure also tends not to promote the 'polluter pays' principle.

Multiple component waste charges generally consist of a basic fee element to recover the fixed costs associated with the waste management system and a rental/service fee element to recover the variable costs associated with the waste management system. These types of charges have the potential to achieve greater cost recovery but tend to have higher administration costs (compared to single component charges). They also promote the 'polluter pays' principle as the total charge paid is dictated by the payee's waste management behaviour – this type of charging arrangement is commonly called 'Pay As You Throw' (PAYT).

PAYT charging schemes can be based on volume or weight. Volume based schemes include:

- Full-unit pricing: users pay for all the waste they want collected in advance by purchasing a tag, custom bag, or selected size container;
- Partial-unit pricing: the local authority or municipality decides on a maximum number of bags or containers of waste, with collection paid for by taxes. Additional bags or containers are available for purchase should the user exceed the permitted amount; and
- Variable-rate pricing: users can choose to rent a container of varying sizes, with the price corresponding to the amount of waste generated.

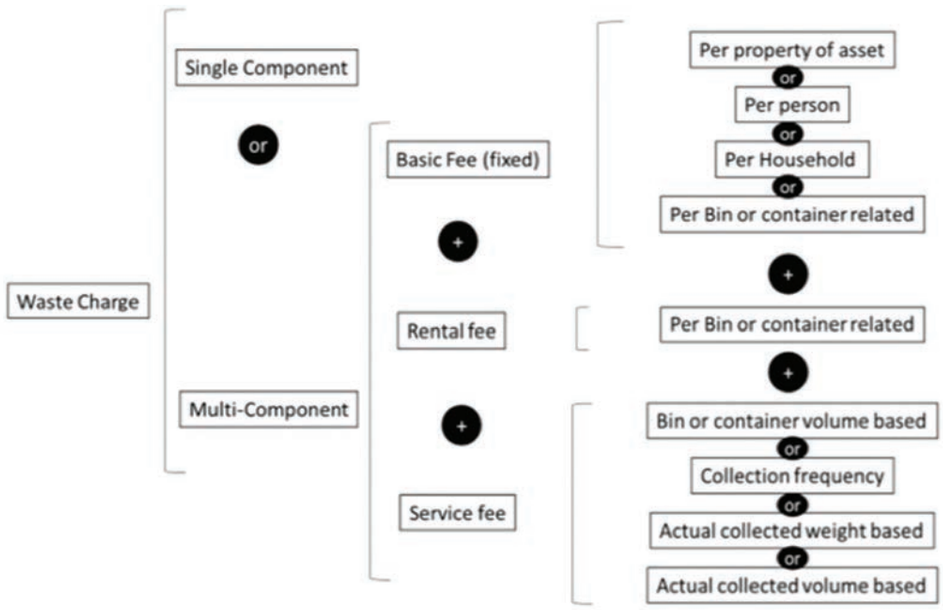
Weight based schemes require that each resident's container can be identified at the point of collection and weighed on-board the collection vehicle.

The complexities of PAYT schemes mean they are not appropriate for greater Monrovia for the foreseeable future.

A single component charge is more appropriate as it can be levied on property, people or service assets like containers. It can be collected in the form of local taxes; as part of another utility payment or deposit/rental payment (service assets only). However, such a charge could not be implemented until the necessary regulatory and governance arrangements are in place to support revenue collection by the city corporations.

[88] Full reference to be cited in issue version – working assumption

FIGURE 34: Possible waste fee components



9.5 Waste reduction

Reducing the amount of waste that is generated per capita requires direction and action by the national government through activities such as[89]:

- Waste education and sensitisation programmes
- Take-back schemes (in partnership with sellers/producers)
- Fiscal measures, such as specific product taxes on products that a highly polluting or are expensive for the government to manage.

9.6 Waste re-use

There is a well-understood culture of re-use in greater Monrovia and is widely practiced informally for key materials, such as plastics. This culture may provide an opportunity for the CBEs in particular to establish more formal re-use initiatives, whereby materials that might be useful in, say, house maintenance can be separated and stored for use within the local community.

[89] Taken from https://research.bangor.ac.uk/portal/files/17730411/2017_Impact_of_pay_as_you_throw.pdf

FIGURE 35: Selling waste for re-use

9.7 Waste recycling

Recycling opportunities in greater Monrovia are very limited due to the size of the market. Separate but related actions are required to develop the internal market for recycled materials and to gain access to the wider regional marketplace. These should be considered as part of a specific Waste Recycling Study.

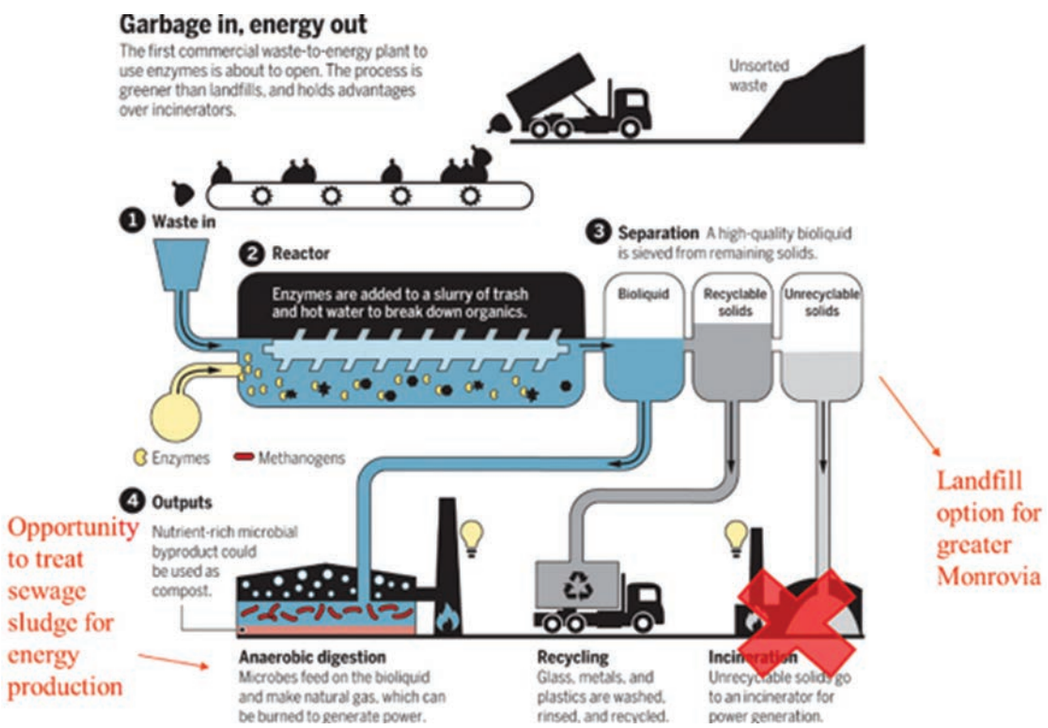
Given that the majority of waste is compostable, a home and community-level composting system may provide a viable solution for addressing some of this waste that is currently being directed toward landfill. Currently there is no evidence of a local market for compost, but this is something that could be promoted if there is sufficient demand. This should be considered as part of a specific Waste Recycling Study.

Plastic is a relatively high value recyclable material with a global market. The current plastic generation rate is low by international standards, but if organised, plastic recycling could generate a source of income and remove approximately 10% of the current waste stream.

9.8 Waste recovery

Waste recovery technologies need to be able to treat non-segregated waste

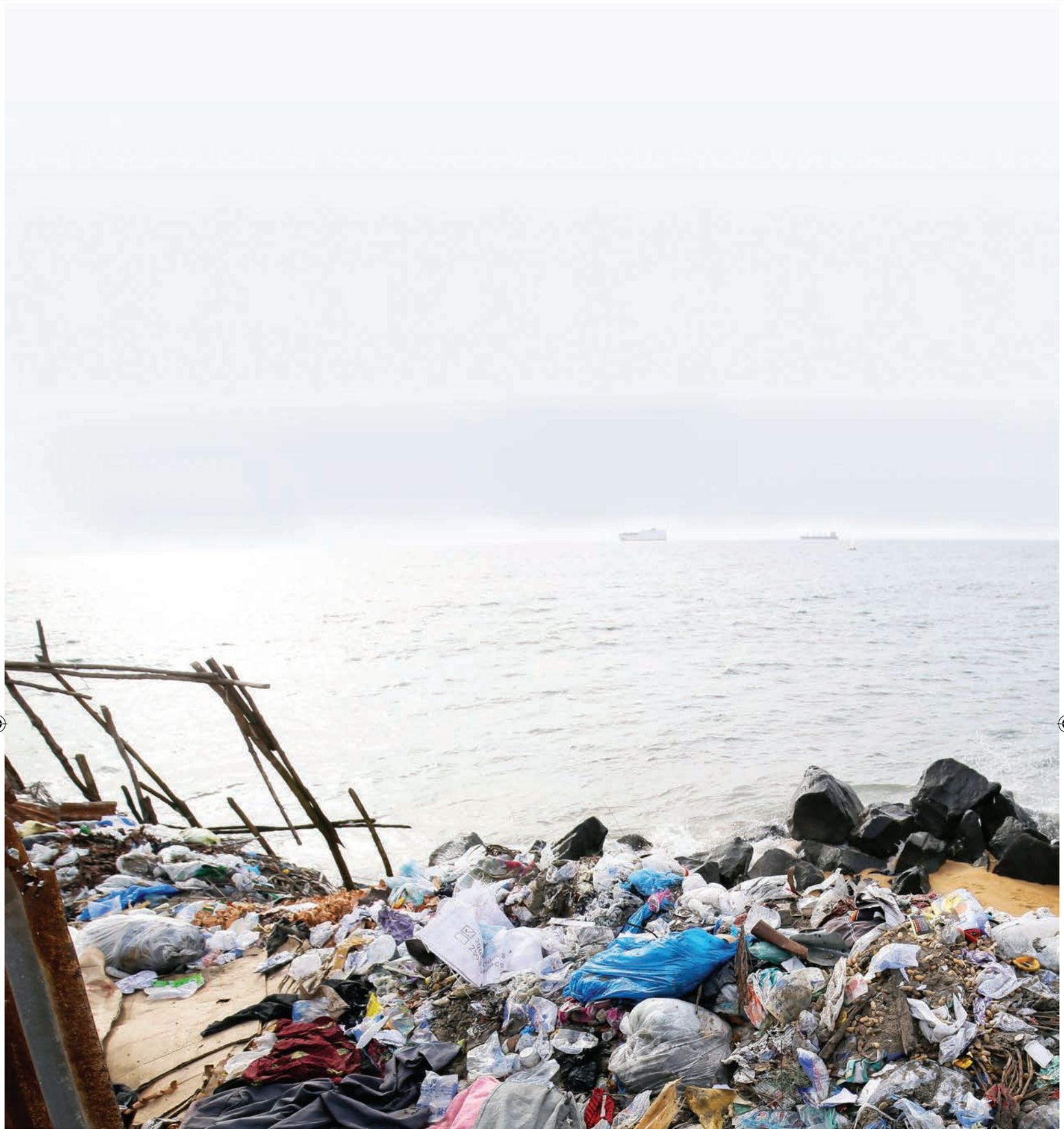
- The typical incineration plant for municipal solid waste is a moving grate incinerator. The moving grate enables the movement of waste through a combustion chamber to be optimized to allow a more efficient and complete combustion. Moving grate incineration would undoubtedly work in greater Monrovia – we have established the waste is of sufficient minimum net calorific value but it is likely to be too costly and may be an inappropriate technology with regard to the skill base required to operate and maintain such technology.
- Mechanical Biological Treatment may be a more appropriate large scale solution but the limited quantity of higher value recyclable materials in the waste stream and lack of local markets for the outputs may impact on its economic viability.
- Modular and scalable solutions may be a better approach. e.g. the REnescience process shown in Figure 36 which digests unsorted waste using a slurry containing specific enzymes. The digested waste slurry can then be separated out for anaerobic digestion, remaining solids recycled separated for recycling and any residual waste (minimal) sent to landfill. To a degree the level of investment can be tailored to the available funding. The process can be 'tested' before large scale investment is made. Such solutions might be able to operate at the community level which would address the waste transportation issues associated with traffic congestion in the greater Monrovia area. Depending on the solution adopted other benefits might accrue at the community level such as local energy grids.



“

It always seems impossible until it’s done. „

– Nelson Mandela



Cities Alliance
Cities Without Slums

HOSTED BY
UNOPS