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# OPEN MAPPING FOR PRODUCTIVITY AND POLLUTION IMPACTS IN DUALA MARKET

## FINAL ANALYSIS REPORT

DEVELOPED BY



**Humanitarian  
OpenStreetMap  
Team**



WITH SUPPORT FROM



**THE WORLD BANK**

# TABLE OF CONTENTS

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<b>1   Introduction</b>	<b>1</b>
Key Findings	2
Recommendations	3
Methodology	5
<b>2   Market Assessment</b>	<b>6</b>
Glossary of Actors & Stakeholders	7
Management & Relationships	
Vendor Fee Collection Structures	8
Solid Waste Management Structure	9
Traffic and Road Network	11
Vendor & Product Overview	12
Layout & Infrastructure	14
Water, Sanitation & Hygiene Infrastructure	15
Drainage Infrastructure	17
Storage Infrastructure	19
<b>3   Food Loss &amp; Waste</b>	<b>20</b>
Sold, Wasted, & Stored for Next Day	21
Daily Losses from Stored Food	25
<b>4   Health &amp; Sanitation</b>	<b>26</b>
Vendor Sick Days	27
Access to Toilets & Community Burden	28
Contamination and Exposure Potential of Toilet Facilities	29
Contamination and Exposure Potential of Solid Waste Sites	30
Solid Waste Composition in the Expanded Market	31
Waste Collection Challenges	32
<b>5   Traffic &amp; Congestion</b>	<b>33</b>
Vehicle Congestion in the Expanded Duala Market	34
Product Delivery on UN Drive	37
Pedestrian Movement and Traffic in Duala Market	38
Vendor Travel to Duala Market	39



# INTRODUCTION

Duala Market is one of the most important economic zones in Liberia, and specifically, the Greater Monrovia Metropolitan Area. The market serves as a critical food hub bridging agricultural activities in outer counties, such as Bomi and Nimba, with Monrovia's urban food system. Situated in an area with high population and structural density, Duala faces extensive congestion challenges compounding the pressure on the fragile ecosystem and inadequate infrastructure, and dramatically increasing risks of public health emergencies.

Devastated by the 2014 Ebola outbreak, the Duala community once again faced a public health emergency with COVID-19 at the conclusion of this study. From the pandemic to the increasing impact of flooding due to climate change and urbanization, the challenges Duala Market and the local community face are complex and interconnected with the pollution and productivity issues investigated during this study. Lessons learned from COVID-19 and flooding in 2019 were incorporated into this study, revealing and re-iterating the vulnerability of market infrastructure and services. These experiences highlight the negative impact major disruptions like these have on market activities and services including daily wages, productivity, and the overall impact on city's economy. This study further emphasizes the urgency of improving market infrastructure and services to build resilience, and the need for a participatory process to resolve existing issues of management, operation and inadequate infrastructure.

The **Open Mapping for Productivity and Pollution Impacts in Duala Market** project was led by the Humanitarian OpenStreetMap Team (HOT) and iLab Liberia. This project supports the World Bank's efforts to analyze problems affecting the lives of Monrovia residents due to the challenges of poor market infrastructure, pollution, and food system vulnerabilities. The data developed through this project worked to:

- Help unravel the complex and intermingled issues and problems in Duala market of Greater Monrovia
- Explore the management of pollution vectors, in particular food loss and waste and the relationship with market performance/productivity.

This investigation, completed from October 2019 through May 2020, was conducted through a series of participatory efforts - mobilizing local community members to conduct geospatial, qualitative, and quantitative surveys. Stakeholders from government, management organizations and agencies, private business, community-based enterprises and organizations, vendors and other informal roles within the Duala Market system were included in primary data collection. In addition to identifying key challenges and recommendations for solutions, this report provides an overview and analysis of the data collected covering topics of market management, layout and infrastructure, food loss and waste, health and sanitation; as well as traffic and congestion.

# KEY FINDINGS

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## Management, Layout, & Infrastructure

- Over time, Duala Market has **expanded by 11.8x in size** beyond the official boundaries. This area now incorporates three additional sub-markets: Kuwait, Saturday, and Karngar Building Markets.
- Across the expanded market, **a lack of clarity of organizational structure** has led to conflict and gaps in management of vendors and facilities, impacting factors such as public health, sanitation, and waste.
- An estimated **72-89% of vendors operate informally**, outside of the official boundaries.
- Informal vendors contribute significantly to burden on facilities but do not pay into association fees. Inclusion of informal vendors could account for a **2.6 to 7.9x increase in market revenue**.
- The **drainage network is highly fragmented and ineffective**. Nearly all drainage, where it exists, have no outflow or are too blocked by debris to drain.
- Lack of cold storage for frozen and perishable goods and limited warehouses reduces the scalability and growth of market activities. **Storage warehouses only accept non-perishable products and only a few iceboxes are available for rent**.

## Food Loss & Waste

- A high rate of perishable products is wasted on a daily basis, with vendors reporting **5.6% daily product is wasted**.
- Daily food loss & waste accounts for **8.8% and 9.1% daily loss of potential gross profit** for fruit/vegetable vendors and meat vendors, respectively - as reported by surveyed vendors.
- Despite lack of proper storage facilities, **97.5% of fruit/vegetable vendors and 80% of meat vendors** report that they store or save product on a daily basis.
- Perishable product vendors reported that between **9-9.4% of stored stock is lost daily**.

## Health & Sanitation

- Nearly all **vendors self-reporting illness work within the official market**, both those coming into work and those staying home, showing a high risk of disease spread within the official market boundaries.
- Vendors and customers place a significant burden on toilet and water facilities that the community & residents rely on. **Each facility may serve between 2,000-10,000 users**.
- Open waste sites, toilets and water points are in close proximity of wetlands and are extremely exposed to flooding, posing additional epidemiological risk. Of the existing facilities, **93% of toilets are within 100 meters of wetland** without proper infrastructure to prevent contamination.

## Traffic & Congestion

- Traffic flows show peaks at the beginning and ends of the day, with the **highest cumulative traffic between 8-9am and at 5 pm**. This represents both market and non-market rush hour traffic sharing the same road network.
- On average, **vendors travel 50 minutes** to reach the market, often using multiple modes of transit.
- Bringing product to the market, **taxi drivers and delivery trucks make multiple stops** along UN Drive, stopping and unloading where possible - interrupting traffic movement.
- Vendor and delivery **travel behavior poses significant public health risks** in event of an outbreak.



## RECOMMENDATIONS

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Duala Market is a critical hub of economic activity for Liberia with a significant daily inflow of vendors, customers, transporters, and other market actors. It is geographically placed within a dense residential and commercial area, along a critical national artery for transportation, and atop a precarious natural environment. These factors, and others discussed in this report, makes Duala Market a high risk hotspot for disease and epidemic outbreak while playing a critical role in the Liberian economy. To reduce this risk while addressing other challenges the market faces in terms of congestion and the overuse of existing facilities, **our overall recommendation based on the findings of this study is to stagger flows into the market while increasing access to hygiene facilities.**

Further recommendations include:

### MANAGEMENT, LAYOUT & INFRASTRUCTURE

- **Prioritize reaching an agreement** over organization, management, and jurisdiction of responsibilities between market actors.
- **Reorganize internal and external market areas**, and develop agreements between formal and informal market stakeholders through participatory process.
- **Divide market area by product** to reduce conflict between vendors, regulate pricing, improve efficiency of customer traffic, and improve waste management.
- **Stagger opening hours for different vendors** to reduce the burden on congestion, market space, sanitation facilities, and to reduce public health risks

### FOOD LOSS & WASTE

- **Construct, improve cold and dry storage facilities** to allow vendors to safely store their goods on site and reduce the loss from produce waste and increased transportation burden.
- **Improve reliability of electricity to storage facilities** to ensure that existing cold storage sites are safely able to store food.
- **Improve highway conditions** along highest volume routes to reduce produce damage and decrease the farm to market transport time for products coming into Montserrado County.
- **Re-organize distribution of roadside vendors** to improve traffic flow and reduce burden on waste management and sanitation facilities

## HEALTH & SANITATION

- **Increase the number of sanitary facilities** to have even distribution and access across the expanded market area, as well as to reduce the burden on community facilities. Consideration should be made to locate facilities, equidistant for majority of vendors, in relatively open areas, and away from residential areas.
- **Install hand washing stations** with soap dispensing stations at each toilet
- **Relocate toilet facilities and water points** away from solid waste sites and swamp areas, improving facilities with lights, locks, and other privacy/safety features.
- **Consider community operation/private sector ownership and management** for toilet and water facilities.
- **Provide solid waste collection workers with effective tools and financial incentives** to increase their waste collection including trucks or motorized carts. Promote involvement of private sector in waste management.
- **Re-organize, rehabilitate, and add new waste collection sites** to make waste consolidation easier as well as to prevent waste from entering wetlands.
- **Reach an agreement on clear flow of waste management responsibilities** for both formal and informal parts of expended market between varied market stakeholders.

## TRAFFIC & CONGESTION

- **Build or rehabilitate existing sidewalks** to allow pedestrians to safely navigate UN Drive while reducing impact of pedestrians on vehicular traffic flow.
- **Re-organize or relocate roadside vendors** to reduce roadside congestion, create safer passage for pedestrians, and encourage buyers to enter the market instead of stalling traffic to purchase along the main road.
- **Improve the market infrastructure and services for both formal and informal vendors**, as well as allocate more land to formal loading and unloading zones.
- **Implement driving education programs** to improve driving skills and reinforce traffic laws.

## OTHER

- **Support development of educational and daycare facilities** for formal and informal marketeers<sup>1</sup> and their children to improve access of learning facilities for families dependent on market livelihoods.

1 | Of 403 vendors surveyed that provided gender, 383 (95%) were women.



# METHODOLOGY

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This study is based on primary geospatial, qualitative, and quantitative data collection conducted over a five month timeframe in Monrovia, Liberia. Data collection activities included:

**Participatory Mapping/Ground Truthing:** To capture the official and unofficial boundaries of the market with key officials and stakeholders, boundaries were denoted using GPX tracking and cleaning in QGIS, followed by confirmation from stakeholders.

**Focus Group Discussions (FGDs):** A series of four FGDs were held with multiple stakeholder groups to gather qualitative information on the structure and interactions between market actors, vendors, and understanding of market conditions as well as potential improvements.

**Infrastructure & Services Mapping:** A geospatial survey was conducted using OpenMapKit (OMK) to capture the market infrastructure, activity distribution, and features such as businesses, solid waste sites, and drainage, based on the area determined through participatory mapping. This data was uploaded to OpenStreetMap following data capture and cleaning.

**All-Product Vendor Survey:** Using OpenDataKit (ODK), information was collected from market vendors on products sold including hours of opening, busiest times of day, customer demographics, interruption of work due to illness. All vendors in the main market building were surveyed. Outside of the main market building, surveyors used a transect survey method, surveying every 4th vendor in parallel to UN Drive.

**In-depth Perishable Product Vendor Survey:** A second vendor survey was conducted focusing exclusively on perishable product vendors with additional questions regarding vendor travel, safety and security, and food loss estimates. All perishable product vendors in the main market building were surveyed. Outside of the main market building, surveyors used the transect survey method, surveying every 4th perishable product vendor in parallel to UN Drive.

**Product Delivery Survey:** Using OpenDataKit (ODK), surveyors stationed at the Duala Market Building and at Saturday/Farmer's Market conducted sampled surveys of product delivery vehicles including delivery trucks and taxis. Surveyors conducted surveys with every delivery truck that unloads within sight. When not surveying a delivery truck, surveys were be conducted with each taxi delivering closest to the standing location. Surveys were conducted across one weekday and one weekend day from 7 am to 6 pm.

**Traffic Census:** A photo census and delivery truck count were conducted from vantage points at the Duala Market Building and at Saturday/Farmer's Market. Surveyors counted the total number of delivery trucks passing over the course of 11 hours and captured north-south photos on an hourly basis. These photos were used to count traffic by type (including pedestrians). Surveys were conducted across one weekday and one weekend day from 7 am to 6 pm.

**Waste Collection Monitoring & Survey:** Mappers coordinated with waste collection groups to shadow their work for one day. Two GPX tracks were collected one showing the track of workers during waste collection until their cart was full, and a second showing the track workers take to empty their buckets.



# MARKET ASSESSMENT

The following section provides an assessment of the overall market, both original and expanded boundaries covering:

- **Actors, Management & Governance** - a glossary of actors and stakeholders and management relationships for economic activities, solid waste, and traffic.
- **Vendor & Product Overview** - a breakdown of product categories by location and estimated revenue potential
- **Layout & Infrastructure** - a quantitative and qualitative assessment of boundaries and existing infrastructure such as water, sanitation, and drainage

The data visualized in these sections were gathered through focus group discussions, vendor and product surveys, and field mapping activities.



# GLOSSARY OF ACTORS & STAKEHOLDERS

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## Key Management Stakeholders

The following stakeholders maintain responsibilities across multiple management categories such as waste, traffic, and economic activities. These stakeholders include government and private entities.

**Liberia Market Association (LMA):** LMA is charged with coordinating the activities of all markets within Liberia in a structural and orderly manner. LMA operates all facilities within the original Duala Market boundaries as well as Kuwait Market.

**Monrovia City Corporation (MCC):** MCC is the local authority overseeing the city of Monrovia. MCC currently oversees waste management activities outside of the original Duala Market boundaries, including community and roadside waste collection.

**Borough of New Kru Town:** The Borough of New Kru Town has jurisdiction over the Duala Community and its surroundings, as well as direct management of the Kangar Building Market within the expanded market boundaries.

**Afrindo Shopping Center / Saturday Market:** A private market within the expanded boundaries popular for its sales of vegetables and fruits as well as offloading of the trucks that usually bring in produce.

## Governmental Stakeholders

Government (local and/or national) entities that play a role in the management of activity within the expanded Duala Market boundaries, focused on a particular management category (i.e. waste, traffic, economic activity).

**Liberian National Police (LNP):** LNP is the recognized institution responsible for regulating road traffic in and around Duala Market.

**Liberia Land Authority:** LLA oversees how land is developed, controlled and managed, including access to public land.

## Private Stakeholders

Private entities or businesses that play support in the management of activity within the expanded Duala Market boundaries, focused on a particular management category (i.e. waste, traffic, economic activity).

**Duala Brothers Association (DBA):** DBA consists of several businesses operating warehouses in Duala Market and its expanded areas.

**J.J. Menscole Property:** A private property currently occupied by a portion of the main Duala Market.

## Organizational/Union Stakeholders

Local and/or national organizations that play support in the management of activity within the expanded Duala Market boundaries, focused on a particular management category (i.e. waste, traffic, economic activity).

**Federation of Petty Traders (FEPTIWUL):** FEPTIWUL is a newly established governing body responsible for regulating Petty Traders in all markets across the city, as well as advocating for, representing, and negotiating on behalf of petty traders and informal workers with authorities.

**Federation of Road Transport Union:** The union manages parking sites, levies taxes (tickets) on vehicles, and coordinates passengers and vehicle movement between markets and cities across Liberia.

# MANAGEMENT & RELATIONSHIPS: VENDOR FEE COLLECTION STRUCTURES

While the LMA maintains a straight-forward payment system between formal vendors and management original Duala Market boundaries, the expansion of the market has led to a complex structure of sub-market management and multiple fee collecting entities.

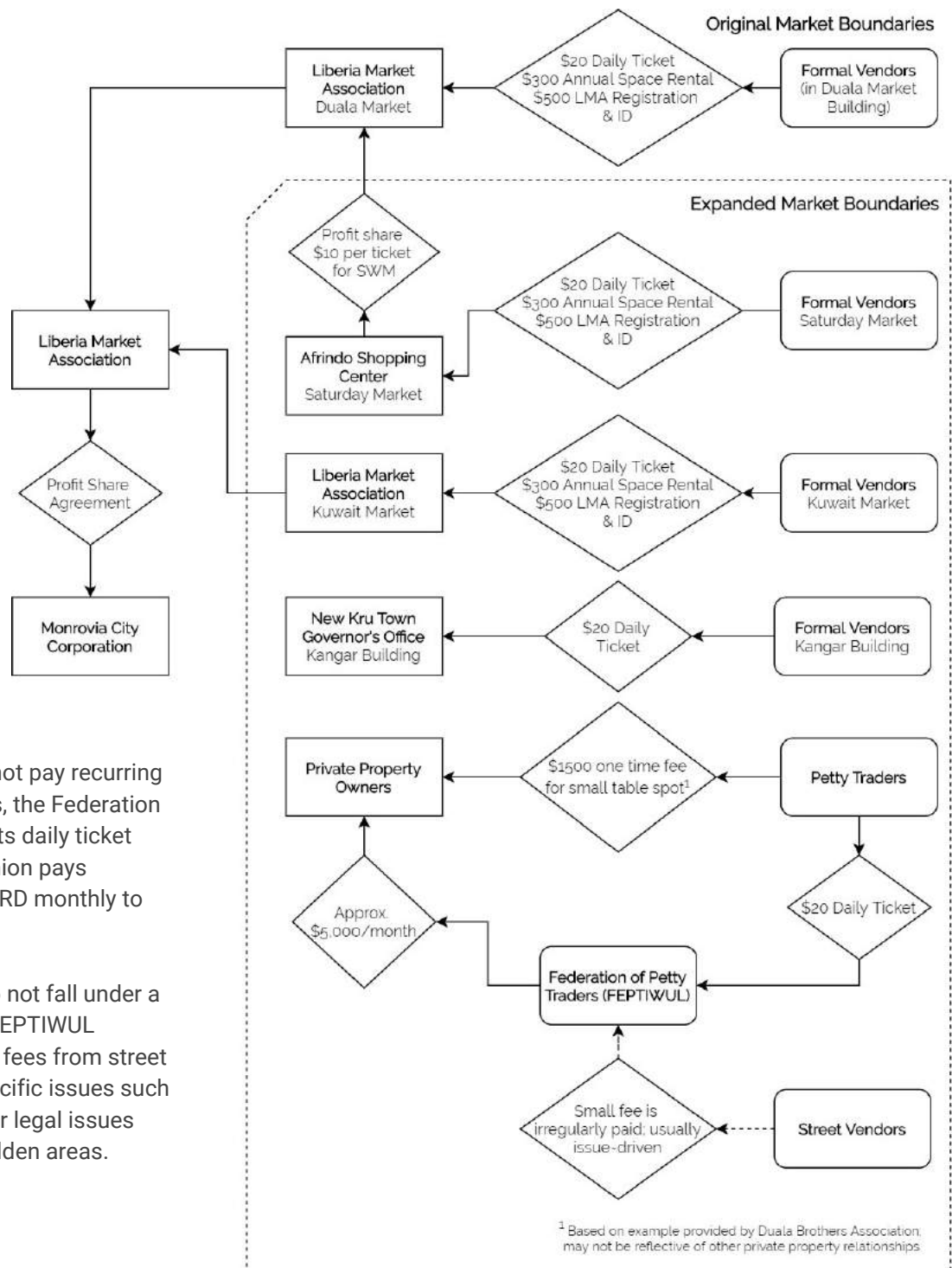
According to the LMA director, formal vendors within the original Duala Market boundaries (and Kuwait Market in the expanded boundaries) pay a \$20 LRD flat daily ticket rate. However, \$300 LRD dollars is paid annually per table within the original market areas. While an additional \$500 LRD is paid for LMA registration and ID annually.

The Saturday market, though operated by a private individual, maintains a profit share relationship with LMA, Saturday Market vendors are charged LMA daily tickets, with half or \$10 LRD per ticket provided to LMA to cover solid waste management.

Property owners charge petty traders a one-time fee for a small spot to build a table. The Duala Brothers Association identified this fee to be \$1500 LRD, though this may vary.

While petty traders do not pay recurring fees to property owners, the Federation of Petty Traders collects daily ticket fees of \$20LRD. The Union pays approximately \$5,000 LRD monthly to the property owners.

While street vendors do not fall under a particular jurisdiction, FEPTIWUL collects irregular, small fees from street vendors to address specific issues such as dealing with police or legal issues such as selling in forbidden areas.



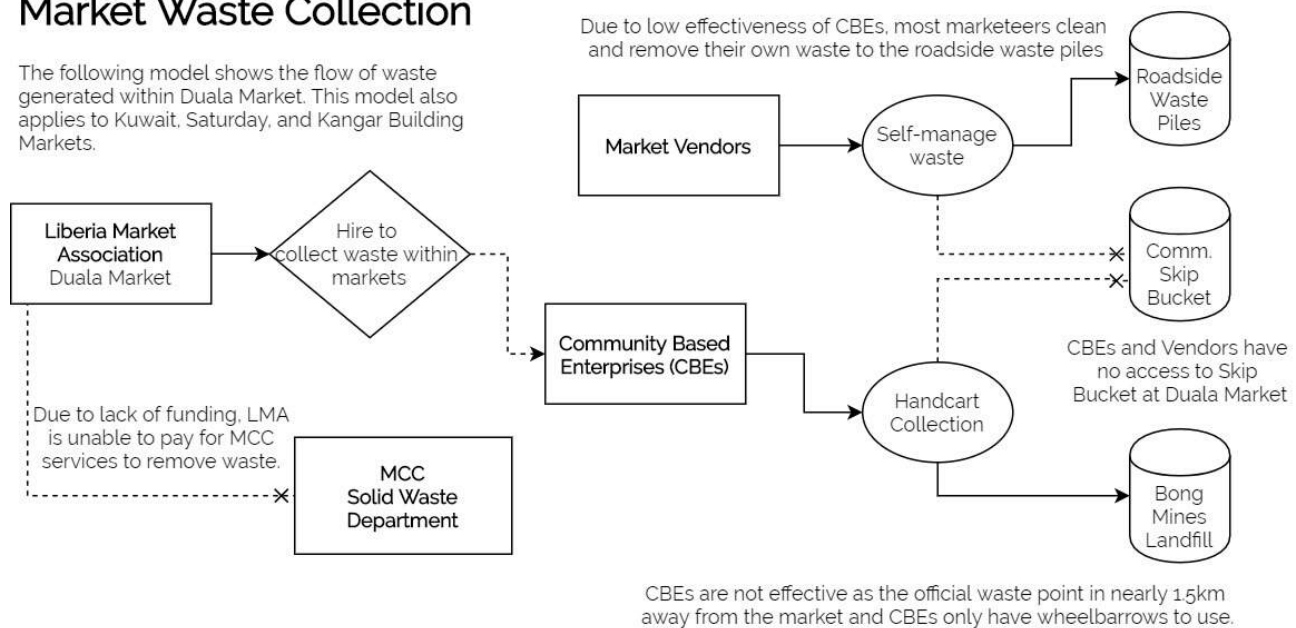
# MANAGEMENT & RELATIONSHIPS: SOLID WASTE MANAGEMENT STRUCTURE

Solid Waste Management activities for the original and expanded Duala Market boundaries can be categorized into three areas:

- **Market Waste Collection** - removal of market-generated waste from within markets
- **Roadside Waste Collection** - removal of market and non-market related waste from roadside piles
- **Direct Business Collection** - paid services for waste removal between private entities

## Market Waste Collection

The following model shows the flow of waste generated within Duala Market. This model also applies to Kuwait, Saturday, and Kangar Building Markets.



For waste generated within the market, LMA contracts CBEs to collect waste from within the market. These CBE workers use handcarts to collect and transport waste from Duala Market to the Bong Mines landfill, nearly 1.5 km from Duala Market. This according to the CBEs, makes their work more difficult and not profitable. With distance, time, and volume restrictions, CBEs are not as effective as needed to keep up with the waste generated in the market (see the Health and Sanitation section for more detail on this waste movement.) As a result, most marketeers clean their own spots, tables, or shops - bringing waste to the roadside. Once at this point, the market waste falls within the perimeters that MCC is responsible to clean.

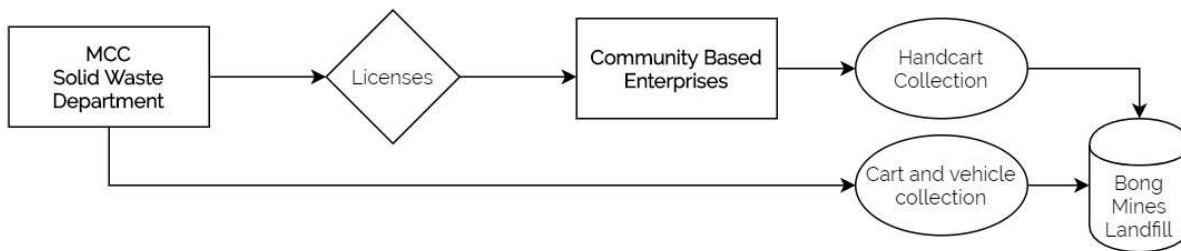
During focus group discussion, participants shared that LMA should be paying fees to MCC to clean the waste. However, LMA representatives indicated that due to lack of funding they are unable to pay for MCC services. As a result of the lack of support from LMA, MCC only cleans along the roadside and not within the original Duala market or any of the expanded sub-markets (Saturday, Kuwait, or Kangar Building Markets).

Solid waste is a major issue not solely for Duala Market, but is faced across jurisdictions. The sub-markets within the expanded market boundaries (Saturday, Kuwait, and Kangar Building Markets) face these same issues, and market-generated waste is similarly managed. However, lack of clarity over management structures and movement of vendors and customers between jurisdictions (between and within formal and informal market areas), ownership of the excessive waste is a point of contention between management parties. While all markets are contributing to the waste issue, it was agreed that the market management was not solely responsible for waste issues in and around the market. Participants acknowledged that informal vendors operating outside of, and not paying dues to, Duala Market or the sub-markets contribute significantly to solid waste as well.

# MANAGEMENT & RELATIONSHIPS: SOLID WASTE MANAGEMENT STRUCTURE

## Roadside Waste Collection

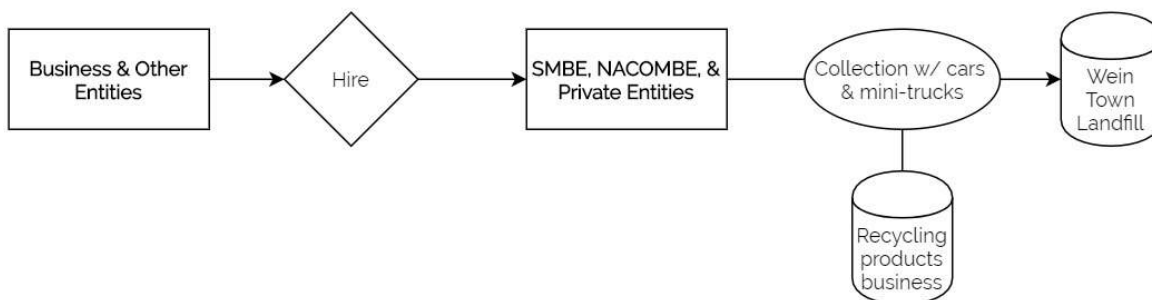
The following model shows the flow and collection of roadside waste piles through the original and expanded market boundaries.



Waste piles along UN Drive (from Caldwell Junction to Club Breweries) fall under the responsibility of the MCC Solid Waste Department to manage and collect. MCC provides licenses to various CBEs to collect roadside waste using handcarts. Similar to the challenges faced by waste collection CBEs hired by LMA, roadside collection CBEs are not allowed to use the skip buckets and must transport all waste by foot to the Bong Mines Landfill, 1.5 kilometers away from Duala Market. MCC also contribute directly to roadside waste collection using both carts and vehicles to transport waste to the Bong Mines Landfill.

## Direct Business Collection

The following model shows the relationship between private entities for direct hire waste collection services.



In addition to the organization-managed waste collection, private entities have filled gaps in waste services by directly providing paid waste collection services to business owners. Businesses (stores, banks and other shops) hire SMBEs, CBEs, NACOMBE & other private entities to manage their waste. This waste is collected using cars and mini-trucks to be transported to the Wein Town Landfill. To operate, these entities pay license fees and registration to MCC on an annual basis.

## Skip Buckets

The only community skip bucket present in both the original and expanded market boundaries is located within the original market boundaries behind the Duala Market building. This skip bucket is restricted to only be used by the surrounding community and is not available for market vendor or customer use - anyone found dumping waste from the market in the community skip bucket is fined \$50 USD.

# MANAGEMENT & RELATIONSHIPS: TRAFFIC AND ROAD NETWORK

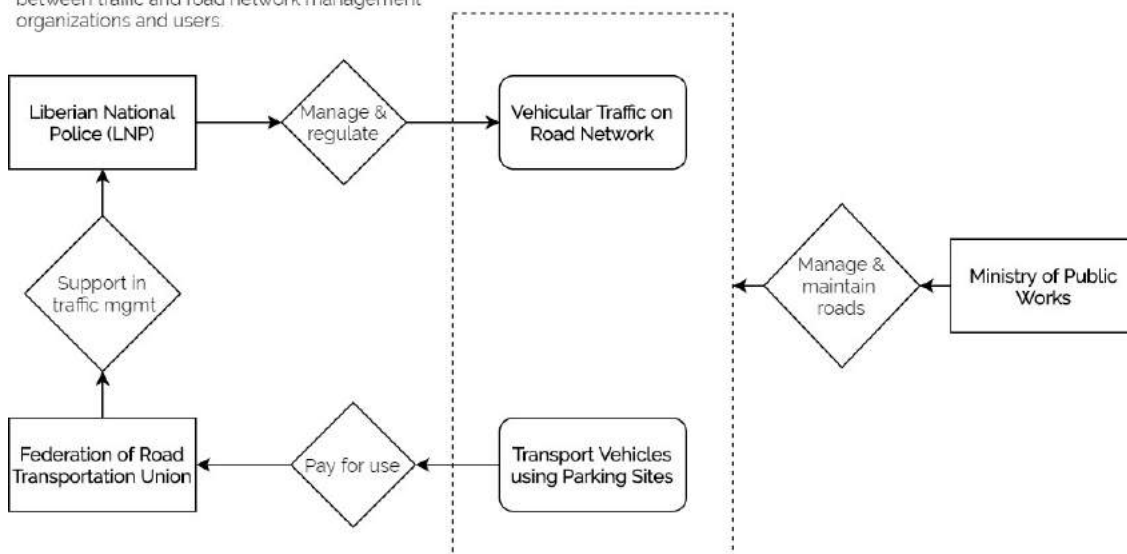
**Traffic management is overseen by the Liberian National Police (LNP) with the support of the the Federation of Road Transportation Union. Road network maintenance and development is separately managed by the Ministry of Public Works**

Currently, the Liberian National Police - Duala Detachment has a daily routine for deploying traffic officers at each junction and particular points where traffic is prone. However, the LNP is currently understaffed and unable to single-handedly manage traffic flow in the expanded boundaries, chiefly along UN Drive. Therefore, LNP coordinates with the Federation of Road Transport Union (vehicles, motorcycles, and tricycles/kehkehs) for supervising the daily flow of traffic. LNP does not provide financial incentive for this support. While the Liberian National Police have established rules and regulations to improve traffic congestion, the overwhelming numbers of pedestrians, drivers, marketers not following laws of the road make it difficult for LNP to manage traffic.

The Monrovia City Police, managed by the Monrovia City Corporation, does not manage traffic along UN Drive.

## Traffic & Road Network

The following model shows the relationship between traffic and road network management organizations and users.



In addition to supporting the LNP with traffic management along UN Drive, the Federation of Road Transportation Union manages formal parking sites throughout the expanded Duala Market boundaries. Transportation vehicles using Union managed parking sites pay fee for use. This management serves as the revenue stream for the union's operations, including support to LNP.

The Ministry of Public Works, while not being involved in direct traffic management, plays a key role through the management, development, and maintenance of the road network throughout Liberia. Focus Group Discussions focusing on the issues of traffic management noted construction and maintenance of roads as a significant contributor towards traffic issues through the expanded market boundaries. The roads surrounding Duala Market were designed, projected and built for limited uses and cannot accommodate the present increase in population and growing economic activities. The Ministry of Public Works was not represented during these discussions, and further discussions in regards to traffic flow and management should include their participation.

# VENDOR & PRODUCT OVERVIEW: ORIGINAL MARKET BOUNDARIES

**\$8660 LRD**<sup>1</sup> Expected daily revenue from official vendors based on 20 LRD daily ticket rates

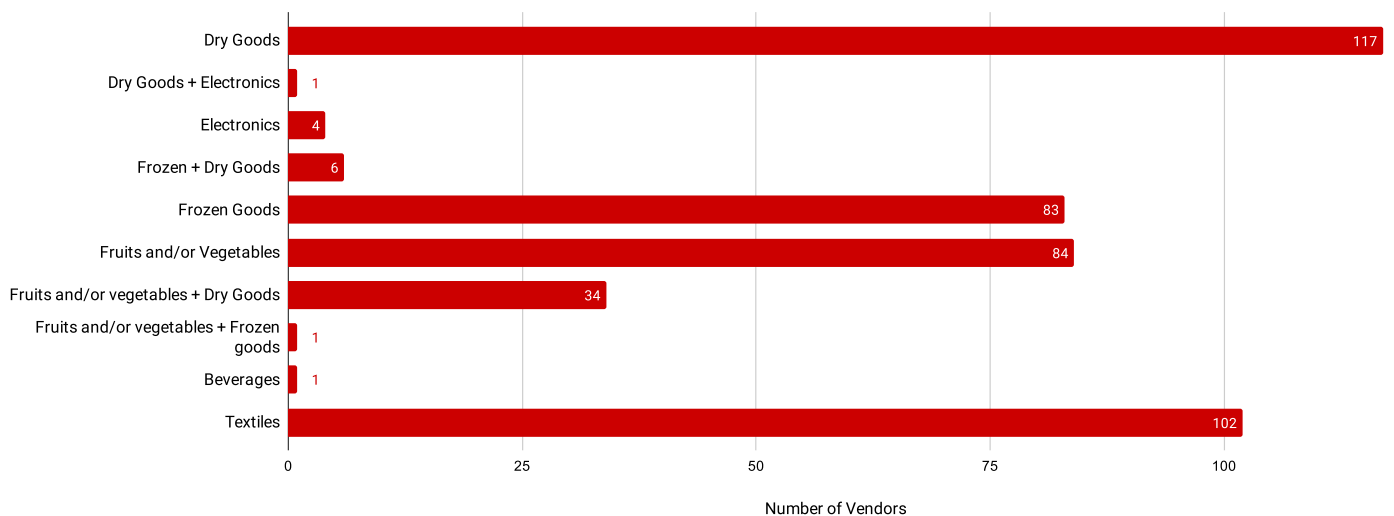
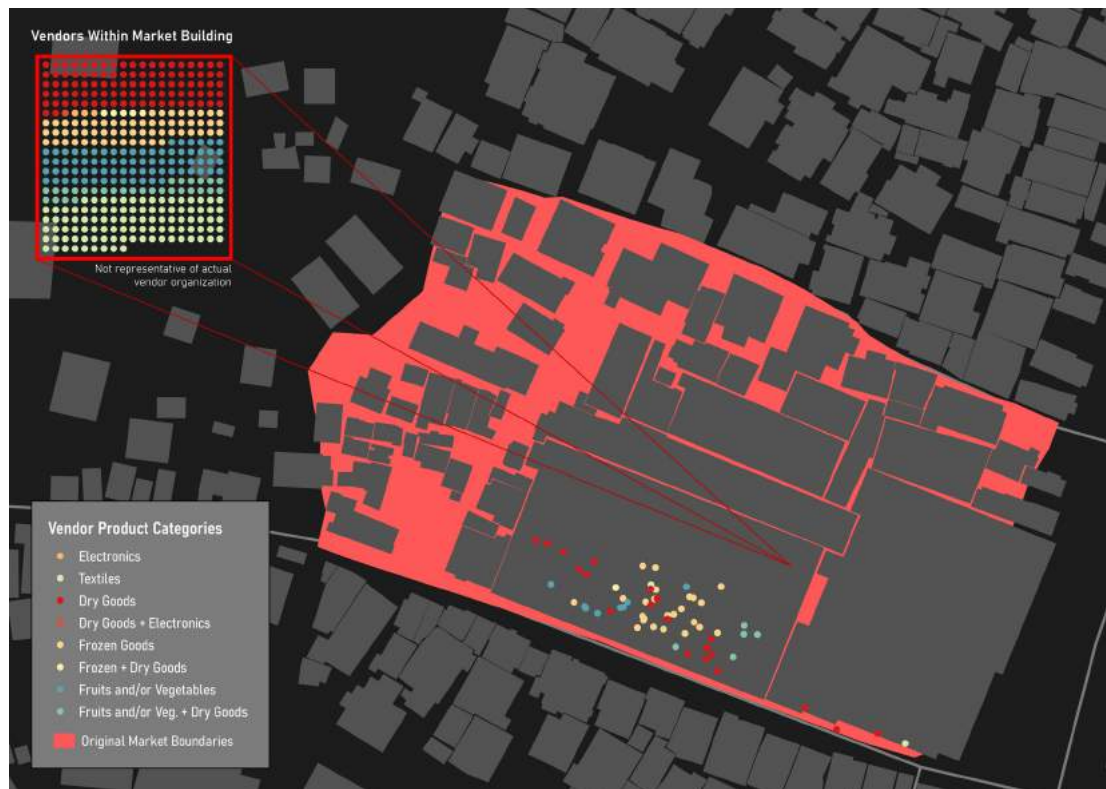
To operate within the official Duala Market boundaries, marketeers are charged a daily ticket fee issued by the Liberia Market Association (LMA).

**~433**

## vendors operating within official market boundaries

The majority of all vendors within the original market boundaries sell dry goods (27%) or textiles (23.6%). These are followed by fruits and/or vegetable vendors and frozen goods vendors with nearly equal portions at 19.3% and 19.2%, respectively.

Currently, there is no formal organization of product categories.



1 | \$43.73 USD, as of 29 May, 2020 exchange rates via XE.com

2 | \$0.10 USD, as of 29 May, 2020 exchange rates via XE.com

# VENDOR & PRODUCT OVERVIEW: EXPANDED MARKET BOUNDARIES



## \$22,400 to \$67,200 LRD<sup>1</sup>

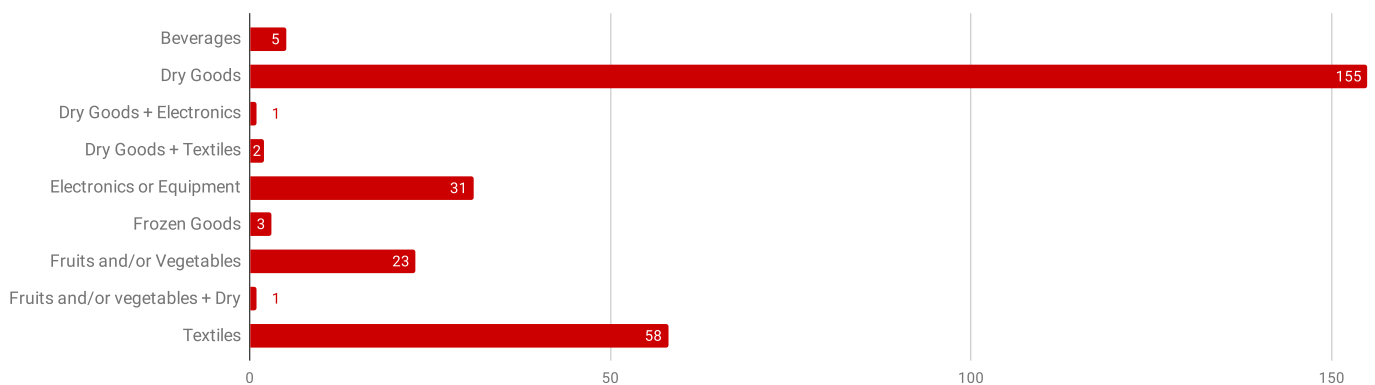
**Potential additional daily revenue**  
if street vendors paid daily ticket rates

While vendors outside of the official Duala Market boundaries may pay fees to the Sub Market manager, private property owners, or others<sup>2</sup> to sell their products within the expanded market boundaries, there is potential to consolidate and regulate prices throughout the entire expanded area.

## ~1,120 - 3,360

**vendors operating outside of official market boundaries**

Similar to within the original market boundaries, the majority of vendors selling product outside are dry goods<sup>3</sup> and textiles vendors. Perishable goods vendors - those selling fruits, vegetables and/or frozen products - are significantly lower outside of the original market buildings. Those that do sell perishable goods tend to congregate around Kuwait and Saturday Market, where many of the perishable products are delivered daily. All other, non-perishable products are sold throughout the expanded market area along UN Drive with little segmentation according to product type.



1 | \$113.42 - \$340.24 USD, as of 29 May, 2020 exchange rates via XE.com

2 | See Section "Management & Relationships: Vendor Fee collection structures" for detailed fee information

3 | Dry goods include products such as rice, cassava flour, dried beans, pasta, etc.

4 | 279 vendors surveyed, representing a sample (between 8% and 25%) of the total vendors

# LAYOUT & INFRASTRUCTURE: EXPANDED MARKET BOUNDARIES

## 11.8x

### expansion of Duala Market beyond original boundaries

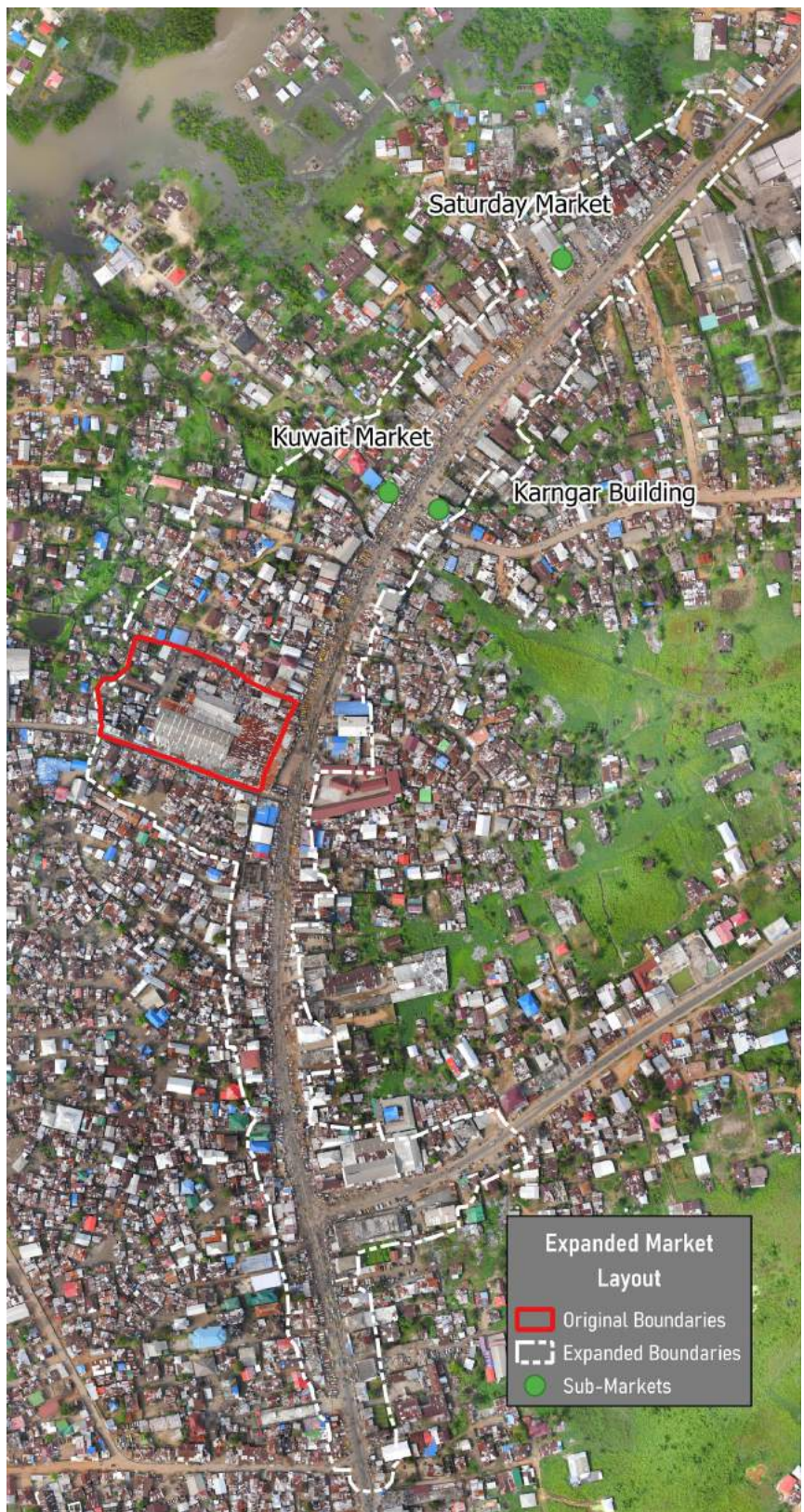
Over time, the informal market surrounding Duala Market has grown from an area of 0.017 square kilometers to 0.201 square kilometers - an increase of 1182%.

Three sub-markets have developed within the expanded, unofficial boundaries:

- Kuwait Market - managed by LMA, under a separate market superintendent.
- Saturday Market (also known as Afrindo Shopping Center Market) - operated by a private entity.
- Karngar Building - operated by the Governor of the Borough of New Kru Town.

Informal marketeers and petty traders line the streets between these markets, blurring the lines between market boundaries as well as management responsibilities. Conflict and lack of clarity exists in which authorities are responsible for services, such as waste management.

According to the LMA, the market boundaries have changed naturally, as the vendors grow in population so does the space it covers. Some private landowners have turned their land adjacent to the markets into selling spots. While this is generating revenue for them, these landowners recognize that it is not sustainable as challenges of the market are spreading into their homes. Some property owners are in court as petty traders have encroached on their properties and they do not have any means of easily keeping them away.





# WATER, SANITATION, AND HYGIENE INFRASTRUCTURE: ORIGINAL MARKET BOUNDARIES



## 1 designated waste site

One official solid waste site containing a community skip bucket is owned and operated by MCC. While in close proximity to the main market building, market generated waste is not permitted and can result in fines if used improperly. Waste removal by MCC is infrequent and inconsistent - which is not sufficient enough for the amount of waste generated.

## 2 water points

On the original market grounds, two private water points are available and operational. Both pumps are identified as not safe for drinking. These are within close proximity of toilets and the solid waste dumping site. One water point is located on the edge of swamp increasing likelihood of contamination, especially during flooding.

## 3 toilet facilities

Within the main building, there is one general "paid-per-use" toilet operated by the market authority and two additional "paid-per-use" toilets operated by private individuals or businesses. The cost per individual use of both public and private toilets is between \$10 and \$20 Liberian dollars.

# WATER, SANITATION, AND HYGIENE INFRASTRUCTURE: EXPANDED MARKET BOUNDARIES

## 6 unofficial waste sites

Six unofficial waste dumping sites, large enough to be seen easily in drone imagery, exist either within or on the edge of the expanded market boundaries. All of these sites exist where built up zones meet swamp area, creating potential for pollution and health issues, especially during the rainy season when flooding frequently inundates these areas. No skip buckets exist in the expanded boundary.

## 17 water points

All but one of the seventeen water points mapped within or on the edge of the expanded market boundaries are operational. Four water points are community managed, two are managed by religious institutions, and ten are privately owned and operated. Only one of the water points are government owned - operated by the Liberia Sewer and Water Corporation (LWSC). Only one tap requires a fee for use.

## 12 toilet facilities

Three public or community toilets are present within the expanded market area. In addition to these, six toilets are operated by private individuals and three are operated by religious or school facilities. Due to the lack of sufficient official market facilities, toilets throughout the area are used by marketeers and customers.



# DRAINAGE INFRASTRUCTURE: EXPANDED MARKET BOUNDARIES

## 1.3 km of drainage within the expanded market

The drainage network within the expanded market area is completely fragmented and ineffective. Drainage structure is inconsistent in material, size, design, and maintenance - with most segments disjointed from outflows. **Nearly all channels have no existing outflow or are too blocked by debris to drain.**

The largest contiguous segment of drainage, running along the east side of UN Drive, is 300 meters in length. Though it is designed to drain into the swamp area to the northeast of the main market, the majority of the drain is blocked by waste and debris (see image top right).

An additional 88 meters of drainage exist underneath the eastern edge of the main Duala Market building (see image bottom right). As the building has expanded over the top of the drain, the drain has become completely dysfunctional, filled with waste and disrupts the flow of pedestrian traffic within the building.

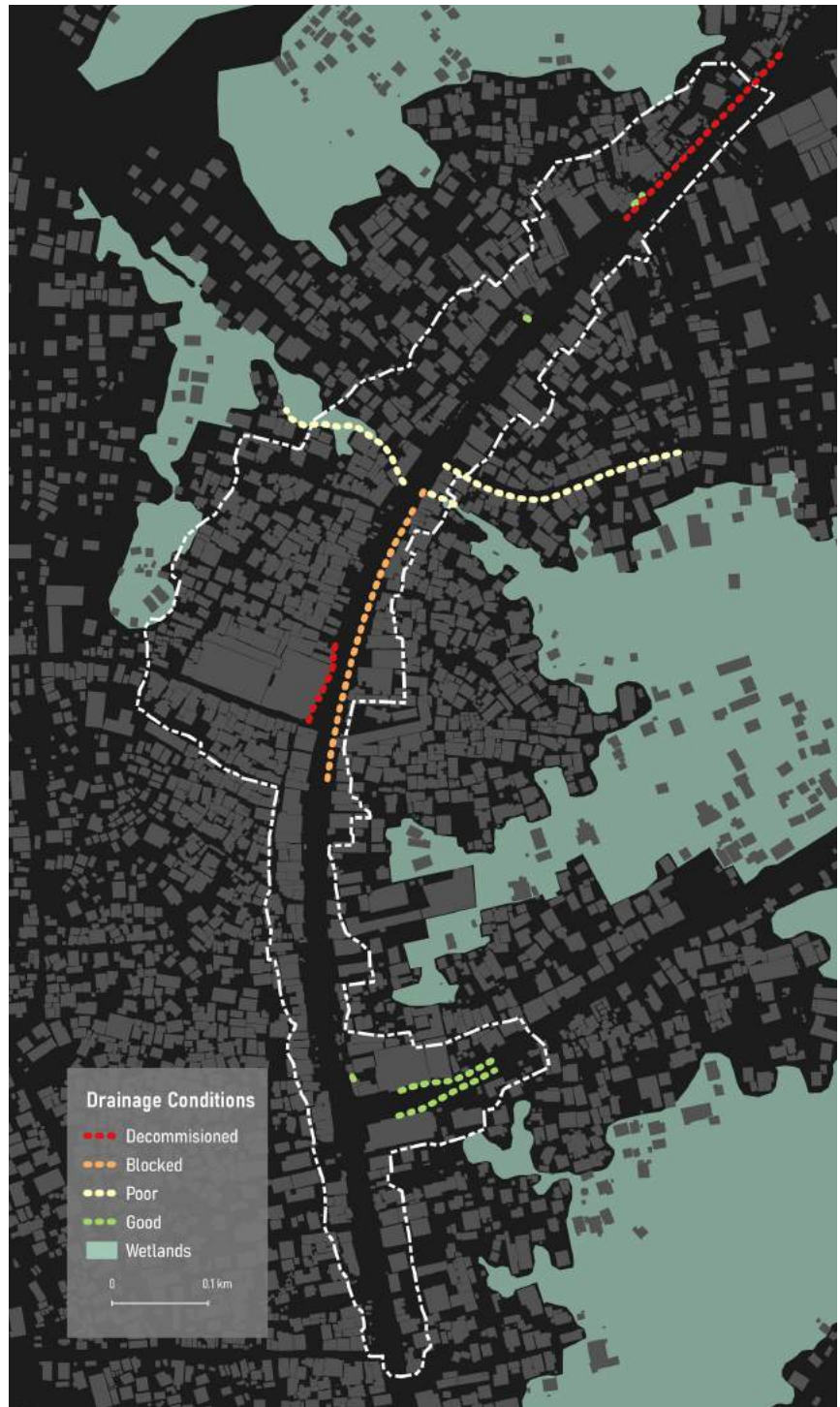
**Focus groups identified the drainage network as one of the most significant infrastructure challenges the market faces.** Vendors and other stakeholders expressed concerns that the state of the drainage network leaves the entire market area muddy, especially during the rainy season, largely from pools of waste.

The representative of Kuwait Market explained that customers are now going to markets in Brewerville and Caldwell due to the smell and pollution. Participants also explained anecdotally that children who accompanied their parents to sell are known to frequently become ill from malaria, dysentery and diarrhea from year round pollution.

The representative from the Ministry of Public works recognized that an absence of proper maintenance service is a significant contributor to these issues - as no entity can be identified as being currently responsible for cleaning and maintaining drainage.



# DRAINAGE INFRASTRUCTURE: EXPANDED MARKET BOUNDARIES



While all existing drainage is fragmented, the conditions of the drains vary. Drains along Caldwell Junction are in good repair with no apparent blockage. Drainage near Kuwait Market, allowing for the flow of water between wetlands across UN Drive is functional but in poor condition. Drains along UN Drive all are reported to be blocked or decommissioned (filled in). With the compounding impacts of traffic and flood along UN Drive, cleaning and/or fixing these drains is a priority.

# STORAGE INFRASTRUCTURE: EXPANDED MARKET BOUNDARIES

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Duala Market and Saturday Market manage smaller warehouses that are able to store only dry goods, textiles, and other non-perishable items. The two storage areas within the main Duala Market building offer a limited number of formal Duala Market vendors, as well as others from outside the main building, a place to store their products. These facilities only store dry goods as there is no electricity, cooling, or any other storage feature other than an open space and security.

Several private warehouses can be found across the expanded market. The majority are located outside the original market area, largely clustered near Saturday Market. Similar to the market-managed facilities, these structures are concrete or metal buildings that offer only security. Marketers store their goods in the warehouse only for security purposes as no other amenities such as cooling or heating are available.

The **Duala Business Association**, a group of businesses operating warehouses in the Duala Market and its expanded areas, owns several of the warehouses. These facilities, typically metal structures, only store dry goods, textiles, electronic and non-perishable goods. This is due to the lack of cooling systems, electricity and a lack of proper equipment to handle frozen and perishable goods.

Dry goods storage  
could cost a vendor

**\$250 LRD  
per month**

According to Wallace Boye of the Duala Brothers Association, storage cost varies based on the volume of goods to be stored. Payment is done on a membership basis per month. For example, goods from a dry-goods table can cost \$250.00 per month.

In all non-perishable storage facilities, products are placed in bags, tied, and locked in boxes. Items are assigned areas of the warehouse for easy reference over time. Goods are transported at the beginning or end of the day on carts/wheelbarrows rented by the owner of the goods. When products are broken into and stolen, the facility is responsible to handle the cost. For this reason, goods brought in and out are inspected by the facility supervisor and the owner. The floors of the storage facilities are concrete with pallets or tarpaulins to keep the products protected from the cold or flooding during the rainy seasons. The storage facilities' supervisors have an inventory of all costumers, type, and quantity of goods. The supervisor monitors who have collected or deposited their goods daily and collects the warehouse fees monthly. A marketer in arrears to the warehouse will not get his/her goods out until the fees are fully paid or an arrangement is reached.

In the original Duala Market building, a few individuals operate ice boxes, used for the storing of perishable goods and fresh produce. Of the three informal markets currently forming the expanded Duala Market, there is not a single cold storage warehouse facility. Therefore, vendors from the other expanded market areas must transport their perishables to the original Duala Market buildings to use the iceboxes which are not secure or sufficient. Given the limited amount of iceboxes available and unstable power, many goods are prone to get damaged on a daily basis.

For frozen goods and vegetables, some marketers that can afford to will return product to the stores where they were purchased for daily storage. Daily storage fees at these stores with cooling facilities varies based on the volume of the goods but are very high. Most marketers cannot afford the cost thereby taking their goods home and using home-made preservation techniques such as keeping the vegetables underground, while frozen food like fish and meat have to be dried.



# FOOD LOSS & WASTE

The following section covers the perishable food products, specifically analyzing reported rates of food sales, loss, and storage:

- **Sold, Wasted, & Stored For Next Day** - a quantitative assessment, based on vendor reporting, of rates of percentage sold, wasted, and stored for perishable products, categorized by fruit/vegetable and meat products. This section also provides a further breakdown by specific product type.
- **Daily Losses from Stored Food** - a quantitative assessment of losses vendors experience from food storage, by category and item type.

# FRUITS & VEGETABLES: SOLD, WASTED, & STORED FOR NEXT DAY

On average, fruit and vegetable vendors experienced a daily loss of 2.4 pounds (lb) of food product accounting for a loss of 291 LRD or 8.8% of potential gross profit.

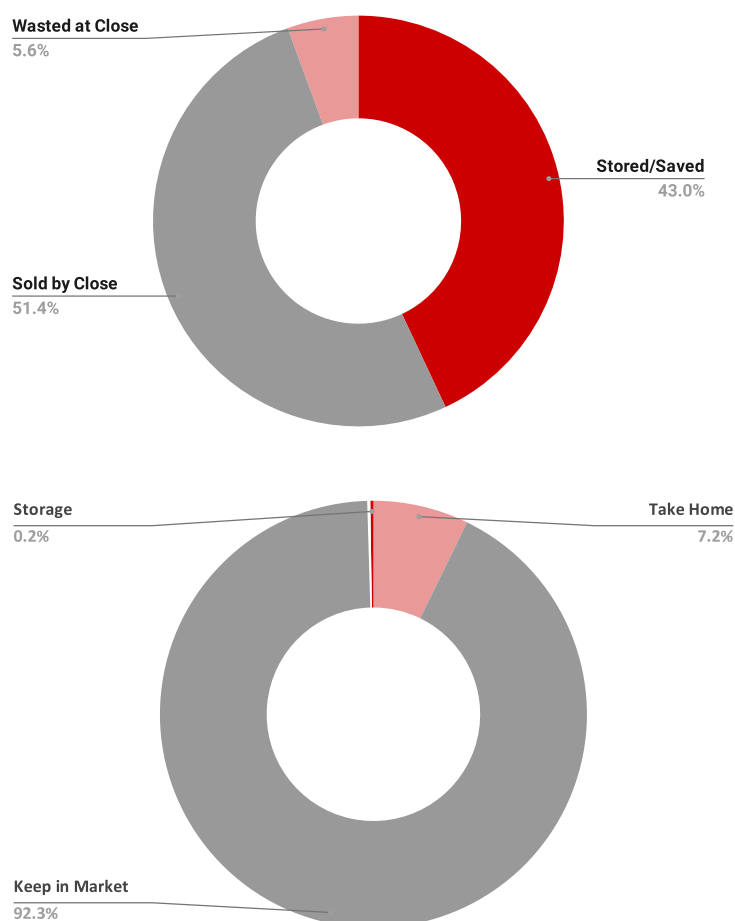
In total, 287 fruit and vegetable vendors were surveyed for product sales, waste, and storage ratios across the Expanded Duala Market boundaries. This survey provided product information for 440 items across 42 fruit and vegetable types. Of these, vendors reported that 51.4% of fruit and vegetable products are sold by close of business on an average day. For the unsold product, 43.0% is stored or saved and 5.6% of product is wasted in some form.

Of the product stored or saved, vendors reported 92.3% of products are kept in the market for the next day's sales and 7.2% of products are taken home. One vendor (0.2%) reported using dry storage for their pepper product and another (0.2%) reported leaving their product with boys to sell by the next day.

Tomatoes and yams accounted for the highest percentage of daily waste, with 15.8% and 15.0% of daily product being wasted respectively. Daily, average vendors lose 1287 LRD to tomato product waste and 2723 LRD to yam product waste, with yams accounting for the highest daily LRD loss for any product. These products were followed by cassava leaves and peanuts/groundpeas (10% daily waste each), cabbage (9.4%), pumpkin (9.3%), pawpaw (8.3%), water leaves (7.4%), lettuce (7.4%), and potato (7.1%).

The only products to report zero daily waste were fever leaves, plum oil, palm oil, and coconut. However, only two vendors reported selling coconut and the other three products only being reported by one vendor.

The following page provides a complete graph of sales/waste/storage ratios for all 42 products available.

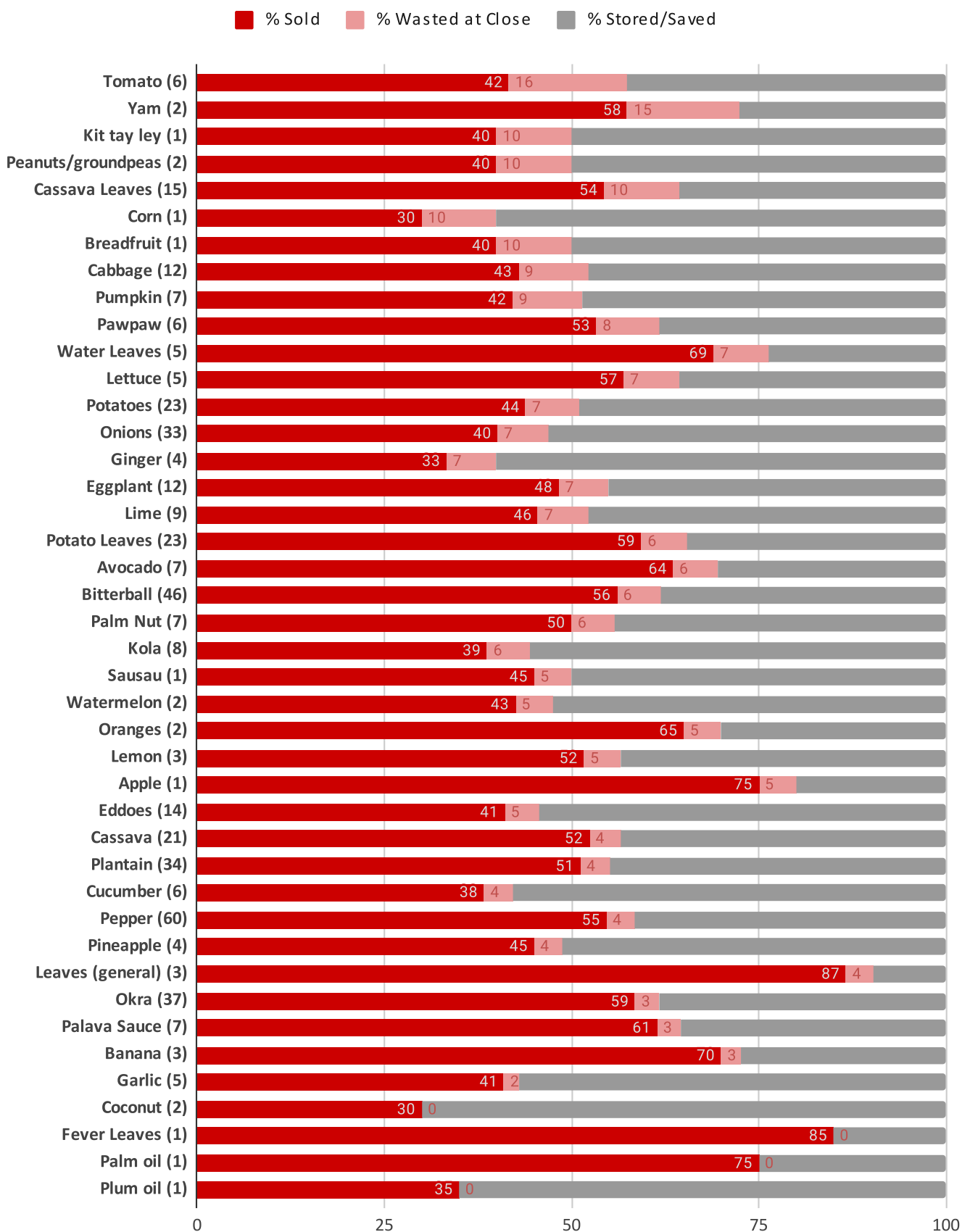


## PRODUCTS WITH HIGHEST ESTIMATED DAILY WASTE\*

Product	Avg. lb carried	% Loss	Avg. LRD loss
Tomato	88.7	15.8%	1287 LRD
Yam	82.5	15.0%	2723 LRD
Cassava Leaves	72.2	10.0%	517 LRD
Peanuts/groundpeas	80	10.0%	1200 LRD
Cabbage	128.8	9.4%	2000 LRD
Pumpkin	141	9.3%	1945 LRD
Pawpaw	141.7	8.3%	885 LRD
Water Leaves	36	7.4%	152 LRD
Lettuce	24	7.4%	236 LRD
Potato	83.2	7.1%	962 LRD

\*Products reported by more than one vendor

# FRUITS & VEGETABLES: SOLD, WASTED, AND STORED FOR NEXT DAY



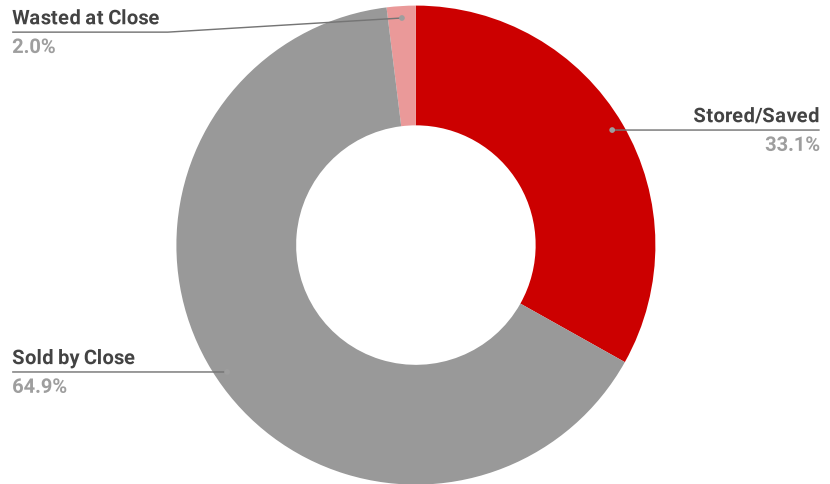
The table above shows the average percentage of product wasted, sold, and stored/saved by close of each day, as reported by individual vendors and categorized by product. The total number of vendors identifying as selling each product are provided in parenthesis, percentage sold and wasted is labeled.



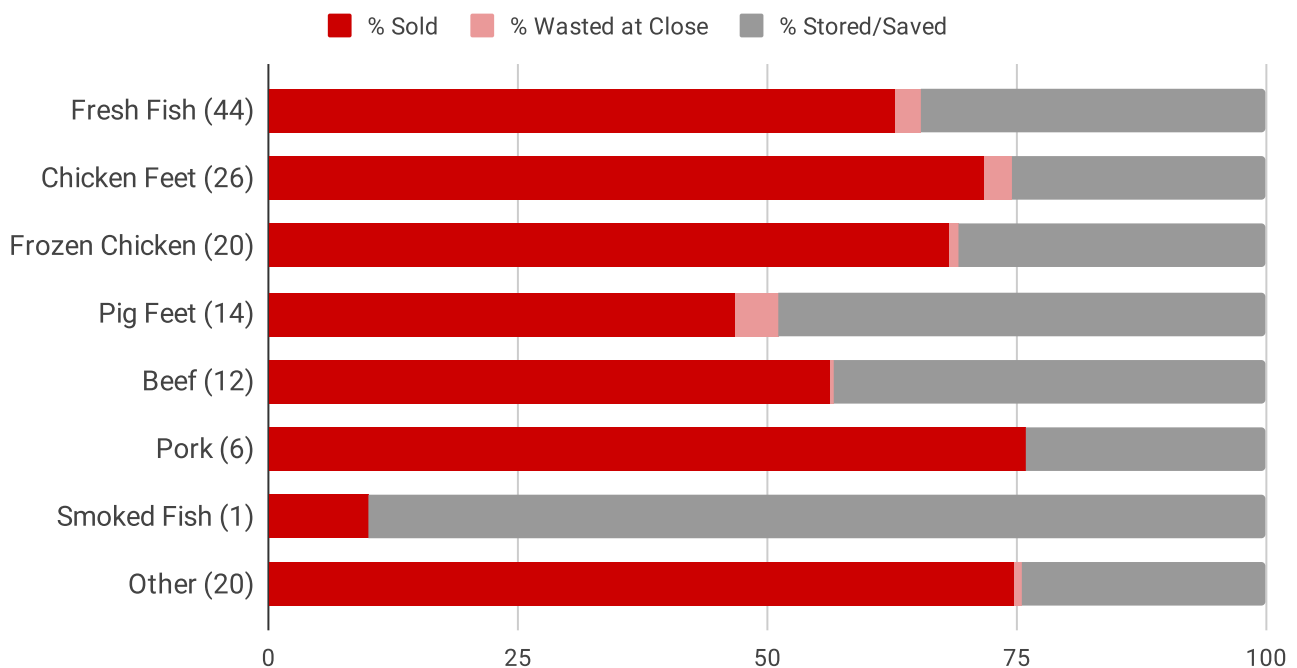
# MEAT PRODUCTS: SOLD, WASTED, & STORED FOR NEXT DAY

On average, meat product vendors experienced a daily loss of 1.4 pounds (lb) of food product accounting for a loss of 178 LRD or 9.1% of potential gross profit.

Of vendors surveyed, 116 reported selling meat products, providing information for 7 product types such as fresh and smoked fish, chicken feet, frozen chicken, pig feet, beef, and pork. Vendors indicated that the majority of meat products (64.9%) are sold by close of the business day. While 2.0% of product was reported as being wasted in some form over the course of the business day, and the remaining 33.1% of unsold product being stored or saved.



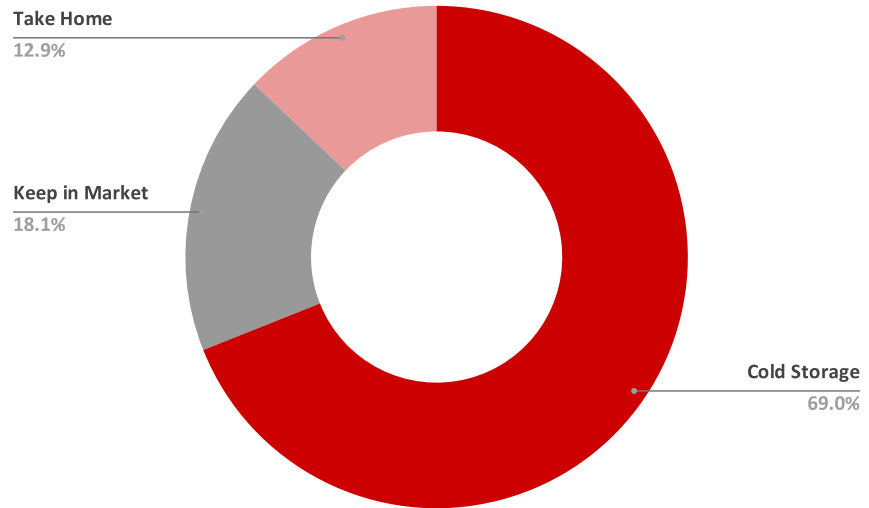
Out of the product types surveyed, pig feet had the highest average daily waste percentage (4.3% wasted, 46.8% sold, 48.9% stored). Chicken feet had the second highest waste percentage (2.7%) and second highest percentage sold (71.7%), with 25.5% sold the next day. Fresh fish vendors reported an average of 2.5% wasted, 62.8% sold, and 34.7% stored or saved. Frozen chicken vendors reported an average 1.0% wasted daily, 68.2% sold, and 30.9% stored or saved. Beef vendors reported only 0.4% of product wasted daily on average, 56.3% sold by end of day, and 43.3% saved.



The table above shows the average percentage of product wasted, sold, and stored/saved by close of each day, as reported by individual vendors and categorized by product. The total number of vendors identifying as selling each product are provided in parenthesis.

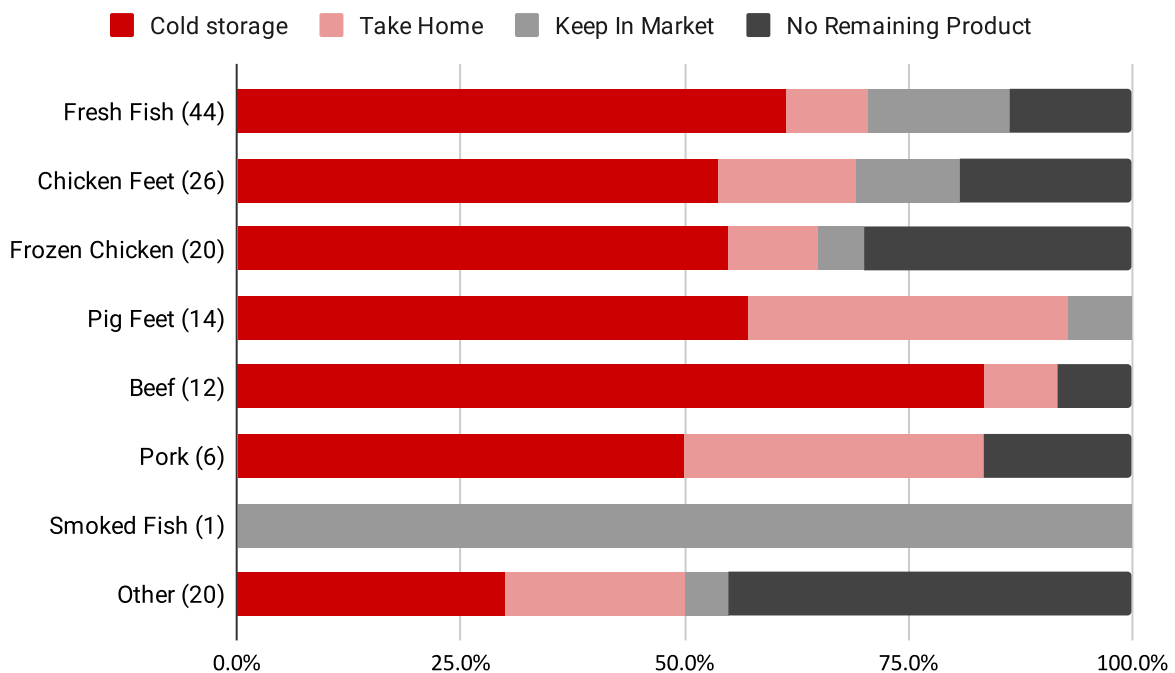
# MEAT PRODUCTS: SOLD, WASTED, & STORED FOR NEXT DAY

Pork products reported zero waste percentage, with 75.8% daily product sold and 24.2% stored or saved. Smoked fish had no reported waste percentage, with 10% of product sold daily and 90% stored or saved for the next day. However, smoked fish was only reported by one vendor, potentially skewing these results. Additionally, an "Other" category was reported for 20 product surveys. These individual product names were not captured due to survey form error.



For meat products saved or stored, 69% of products are placed in cold storage options. The remaining product is either kept in the market (18.1%) or taken home (12.9%).

Smoked and fresh fish have the highest portion of product being kept in market, with all smoked fish vendors and 15.9% of fresh fish vendors reporting product being kept in market. Pork and pig feet have the highest ratio of vendors taking product home - 35.7% and 33.3% respectively. Beef vendors reported the highest ratio of using cold storage, at 83.3% of vendors using the option.

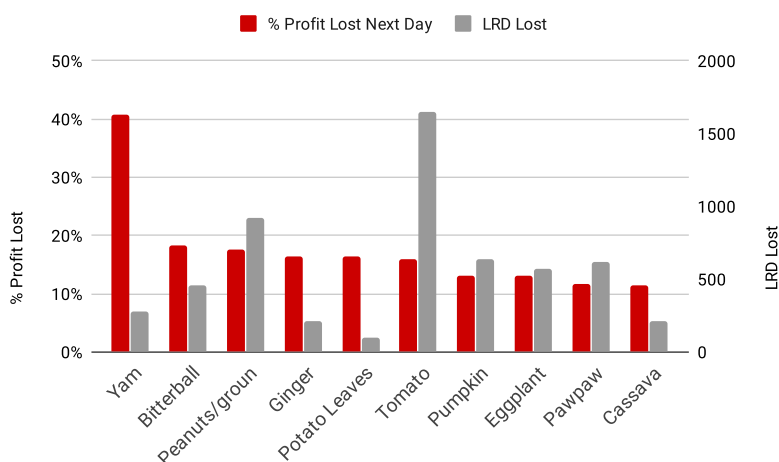


# DAILY LOSSES FROM STORED FOOD

## 97.5%

Fruit and vegetable vendors store or save product daily

9.4% stored/saved fruits and vegetables are wasted



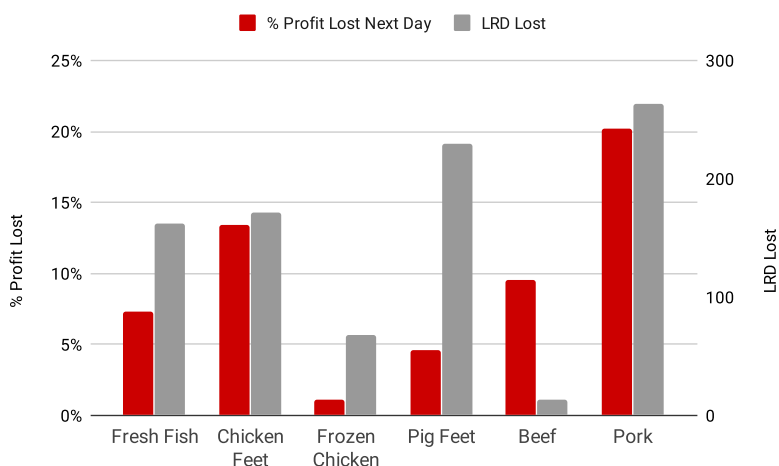
On average, 2.4 pounds (lb) of stored food is wasted by the next day for fruit & vegetable vendors. This loss accounts for 9.4% of fruit and vegetable vendors' stock on average. Of the vendors surveyed, 291 Liberian Dollars (\$1.47 USD<sup>1</sup>) are lost per vendor from stored food, accounting for 8.8% of potential gross profit.

Of the 42 fruit and vegetable products sold by surveyed vendors, yams accounted for the highest portion of potential profit loss due to product waste while in storage. Bitterball, peanuts/groundpeas, ginger, potato leaves, tomato, pumpkin, eggplant, pawpaw, and cassava follow yams as the top ten products in storage profit loss. Overall, tomatoes had the highest estimated loss in LRD due to loss, damage, or spoilage in storage, with an average of 1648 LRD (\$8.34 USD) per vendor selling tomatoes.

## 80%

Meat product vendors store or save product daily

9.1% stored/saved meat products are wasted



The average meat product vendor reported a loss of 1.4 pounds (lb) daily due to damage, loss, and spoiling in storage. This waste accounts for an average 9% of stored stock. The average vendor surveyed loses 176 LRD (\$0.89 USD) per day due to storage product loss, accounting for 9.1% of potential gross profit.

Pork products had the highest total LRD lost on average as well as the highest ratio of potential profit lost the next day. On average pork vendors lose 263 LRD (\$1.33 USD) on product wasted in storage, accounting for 20% of the potential gross profit they could have made from their stored product stock. While the average beef vendor had a much lower total loss in LRD than other products, this loss accounts for 10% of the next day's potential gross profit.

1 | Exchange rates listed accurate as of 29 May, 2020 exchange rates via XE.com



# HEALTH & SANITATION

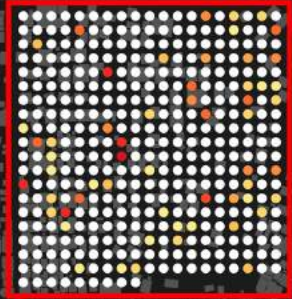
The following section covers the health and sanitation issues, including waste, impacting the expanded market with an emphasis on market vendors:

- **Vendor Sick Days** - spatial analysis looking into geographic patterns in vendor reported sick days gathered through qualitative and spatial vendor surveys
- **Access to Toilets & Community Burden** - qualitative and spatial assessment of the proximity of vendors to toilet and estimated burden on the community through overuse of facilities.
- **Contamination & Exposure Potential of Toilets and Waste Sites** - qualitative and spatial assessments of the proximity toilets and solid waste sites to wetlands and flooding exposure.
- **Solid Waste Composition in the Expanded Market** - qualitative assessment based on observations and focus group discussions of the composition and sources of waste in the market.
- **Waste Collection Challenges** - a spatial overview of waste management providing insight into capacity issues, gathered through shadowing waste collection workers during their daily work.

# VENDOR SICK DAYS

## DAYS COMING INTO THE MARKET WHILE SICK

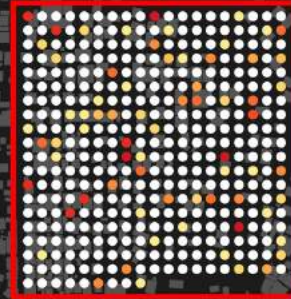
Vendors Within Market Building



Not representative of actual vendor organization

## DAYS AWAY FROM MARKET DUE TO SICKNESS

Vendors Within Market Building



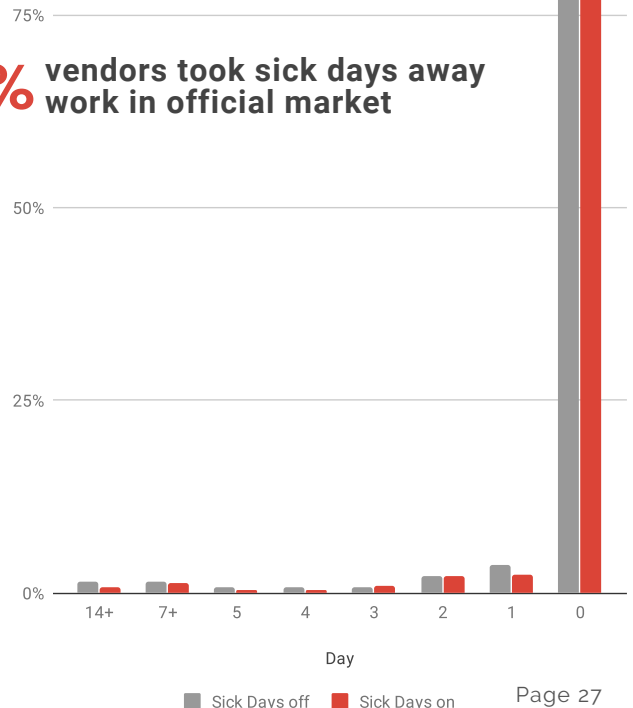
Not representative of actual vendor organization



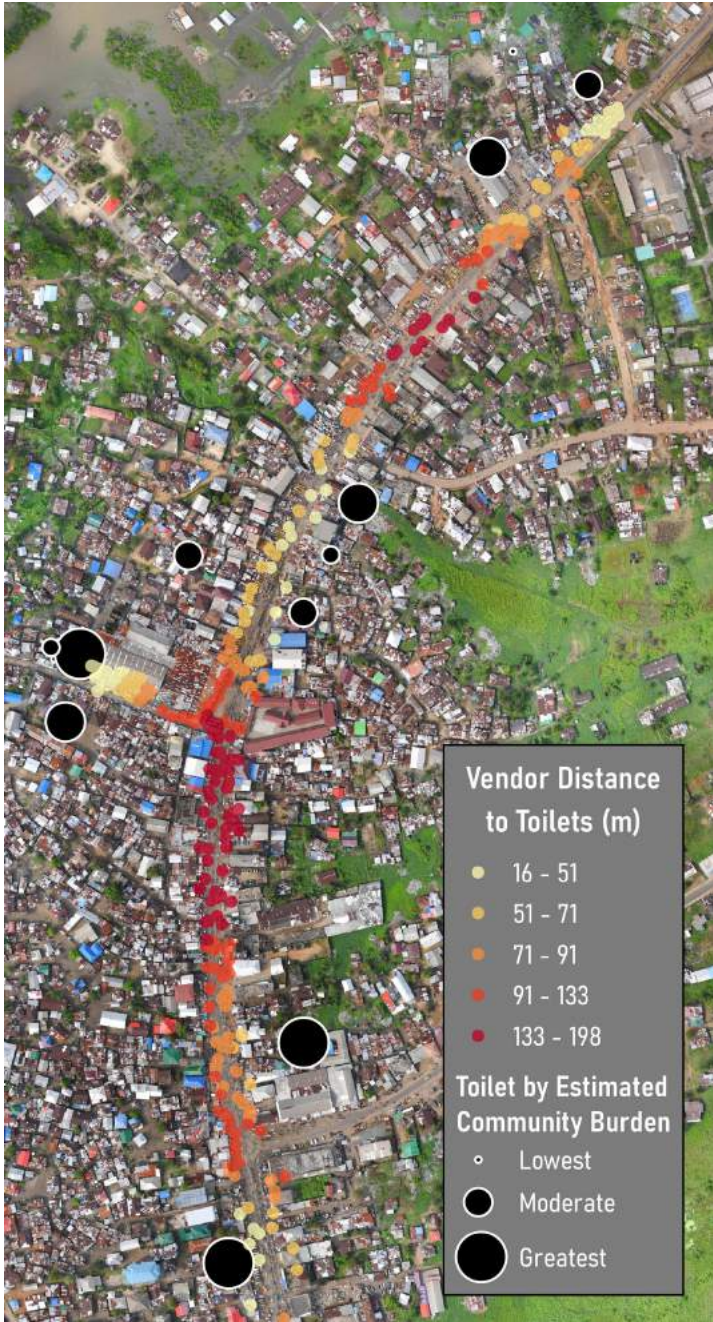
**95.7%** vendors coming in sick work in official market

**92%** vendors took sick days away work in official market

Overall, 89% of vendors reported that they had not taken a single day off in the past month due to illness, and 91% reported that they had not worked while sick during the past month. While the majority of the 704 vendors who answered the survey did not report sick days, the majority of those that did report having sick days (whether staying home or coming in) were vendors working within the original market boundaries. 62 out of the 65 vendors that reported coming into the market while sick work within the official boundaries and 81 of the 88 who reported illness keeping them from coming into the market also work within these boundaries.

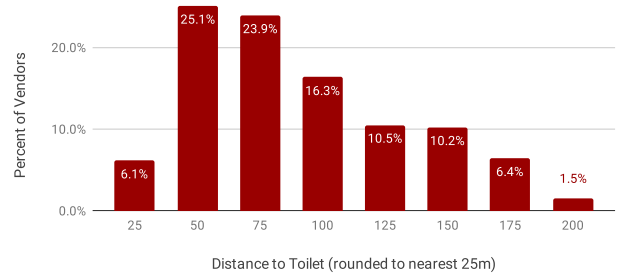


# ACCESS TO TOILETS & COMMUNITY BURDEN



Estimated Community Burden was calculated by combining total closest vendors with total closest buildings within 100m catchment areas.

On average, vendors outside of market buildings are 90m away from the closest toilet facility.



During focus group discussions on the layout and management of the market, toilet quality and access was identified as one of the key challenges to the market operations.

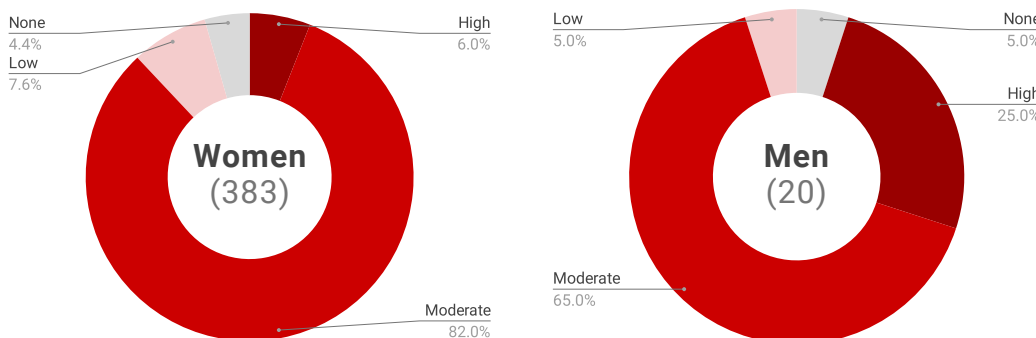
**~2.2-9.5k potential users per toilet facility**

Based on Facebook Population data

Most street vendors typically use nearby communities' public and private toilets. Within the main Duala Market building, there is one general "paid-per-use" toilet operated by the market authority and two additional "paid-per-use" toilets operated by private individuals or businesses. Saturday Market has two private toilets. The cost per individual use of both public and private toilets is between \$10 and \$20 Liberian dollars. Most toilets are separated by gender but because the service is first-come-first-serve and demand is high, there is no restrictions on gender usage - men may often be found using female toilets and vice versa.

Many of these toilets are located within close proximity to nearby swamps. As there is no proper sewer system, these toilets create significant issues with respect to pollution despite efforts to keep them clean. Additionally, due to their proximity to the swamps, many of these toilets are not easily accessible during the rainy season, and of course, not designed for people with disabilities.

What is your level of concern for your health and safety when using public services such as toilets?



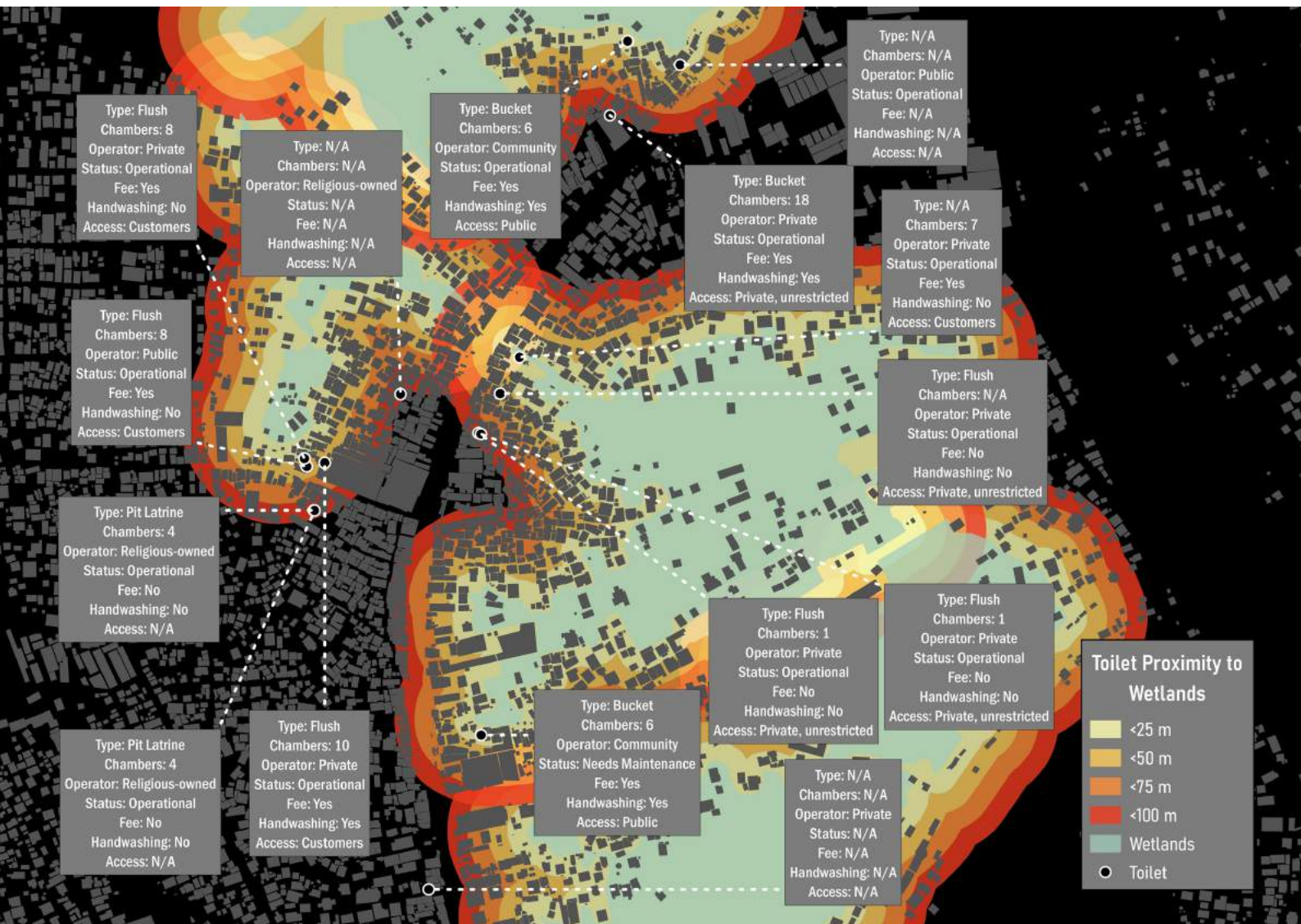
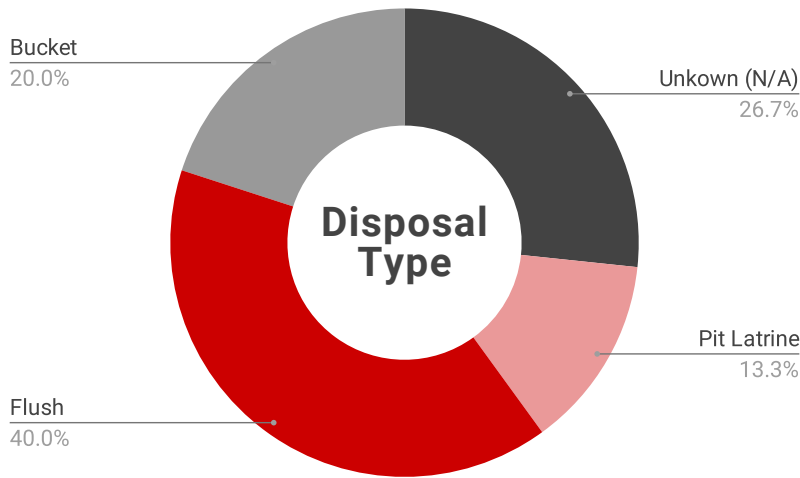
**81%**

of vendors use these toilets because they have no other option despite feeling concerned for their health and safety

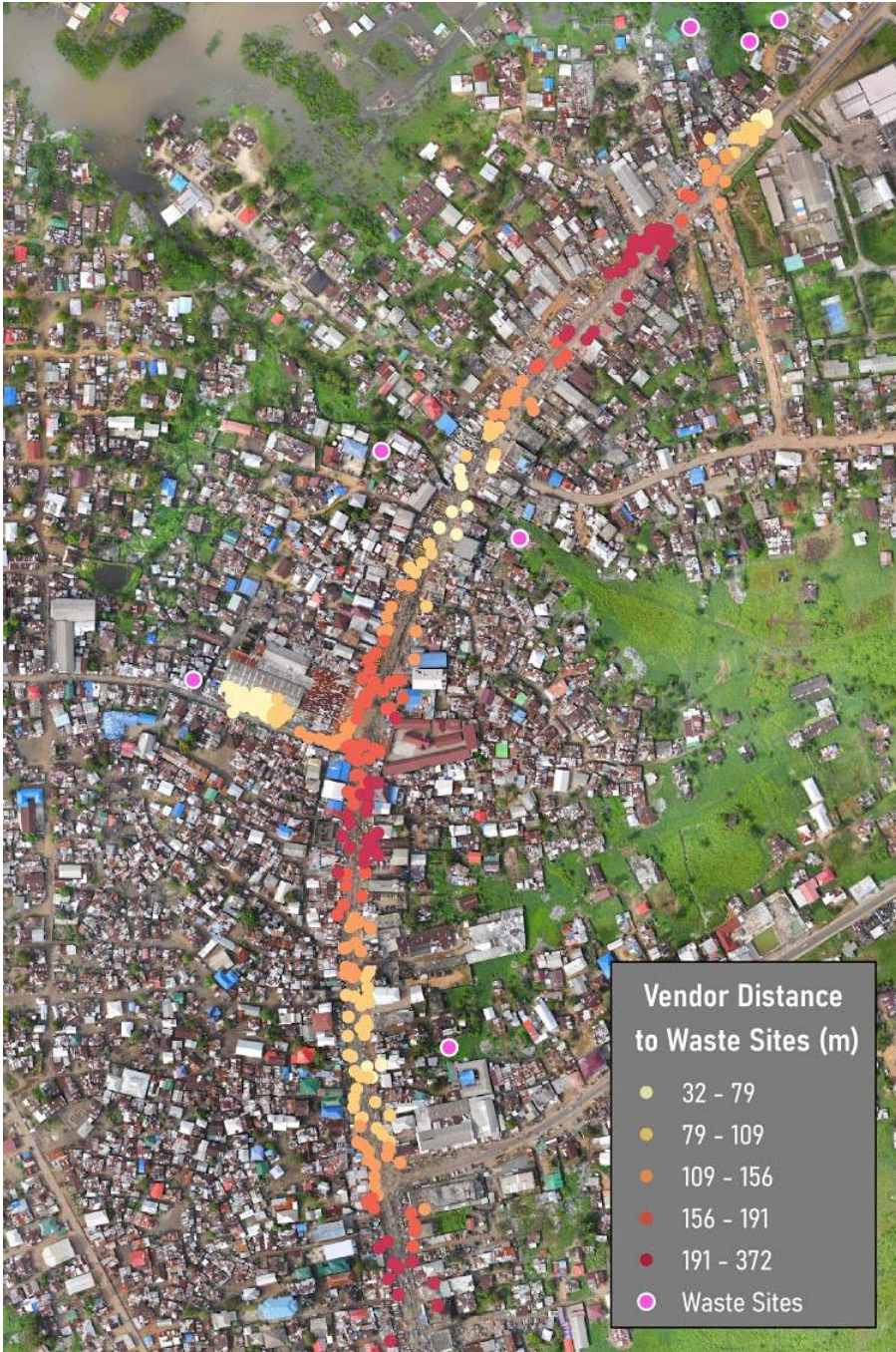
# CONTAMINATION AND EXPOSURE POTENTIAL OF TOILET FACILITIES

## 14 out of 15 toilets are within 100 meters of wetlands

The close proximity of toilets to these natural bodies of water creates a high risk of water contamination with potential for spreading disease and illness. With inconsistent maintenance and plumbing structure, these toilets pose risk in the best of conditions. During the rainy season with flood waters frequently overflowing wetlands onto the road network and into homes, the current locations of these toilets pose an even greater risk towards public health.



# CONTAMINATION AND EXPOSURE POTENTIAL OF SOLID WASTE SITES



**Proximity of large unofficial dumping areas to water sources and human activity poses a significant health risk. With the added threat of regular flooding, these sites have potential to be epidemic hotspots.**

With official and unofficial waste sites few and far between, roadside dumping is persistent along UN Drive. On average, vendors are 136.98 meters to the nearest large waste site within the expanded market. All but one waste site identified are unofficial sites where dumping is occurring straight into the swamp. **These six unofficial sites cover more than 2,500 square meters either adjacent to or in the swamp.**

As land reclamation is commonly conducted in Liberia by filling swampland with waste and burning the rubbish, the intentions behind the sites chosen for dumping may be a mix of convenience, lack of other available land, and intentional filling of swamp. Regardless of intention, these identified waste sites encroaching on swamp and wetlands poses significant health and sanitation issues for both those living and working nearby.

The one official waste dumping site is located on the grounds of the original Duala Market behind the market buildings. This site shares an area of approximately 65 square meters with two toilets and within 100 meters of two water points.

## Close-ups of the largest sites

Left - a dump site located at the junction of UN Drive and Monboe Town East Road covering an area of ~509 sq meters.

Right - two sprawling sites between the wetlands to the north and UN Drive covering a combined area of ~1517 sq meters.





# SOLID WASTE COMPOSITION IN THE EXPANDED MARKET

Stakeholders identified charcoal, plastic packaging, and organic/food waste as the most significant contributors to solid waste. Monitoring activities shadowing CBE waste collection teams observed that waste removal almost exclusively focuses on plastic waste removal.

Due to the lack in suitable storage facilities within the market as well as the lack of consistent power supply at these facilities, perishable products are a significant contribution to the solid waste at Duala Market. Charcoal is also noted for being one of the highest contributors to the solid waste within the market resulting from its processing, packaging and repackaging for retail purpose, and disposal after use. Plastic generated from the dry goods sold mainly by street vendors, hawkers and traders are also noted for contributing greatly to the waste in the market. As plastic does not decompose, the **MCC pointed out plastic waste as being one of the most challenging waste types they are faced with removing.**



Participants determined that **vegetables and fruits, both when they are being transported to the market from the farms or other surrounding markets and when on sale, are noted for producing the most waste within the market.** When being transported to the market, some produce is damaged and abandoned by the sellers. When being sold, these products get damaged and disposed of after a few days due to lack of proper storage. On the other hand, frozen food and its accompanying packaging materials are also noted for being one of the major contributions of solid waste within the market also due to the limited access to storage facilities within the market. When stored in those limited storage facilities, they are also prone to get damaged due to the uncertainty of the power source and supply to those facilities.



# WASTE COLLECTION CHALLENGES



**1.5 km** from Duala Market to official dump site

**With current limitations, MCC & CBE waste collectors can only collect up to 2 cubic meters of waste per day.**

As the skip bucket and waste site behind the Duala Market buildings is reserved for community use only, MCC and CBE waste collectors are mandated to transport any waste collected to the Bong Mines Dump Site by foot, over 1 kilometer away.

The map to the left shows the average route taken by MCC & CBE waste collection staff during their daily shifts. The collection period represents an example of one crew's transect walked before the cart was filled. This route takes approximately 2 hours to complete during their three hour shift from 6-9 am. With these constraints, the average work day only allows workers to collect the amount of waste that will fit into a single cart load. Evening rounds are not realistic due to a lack of street lights.



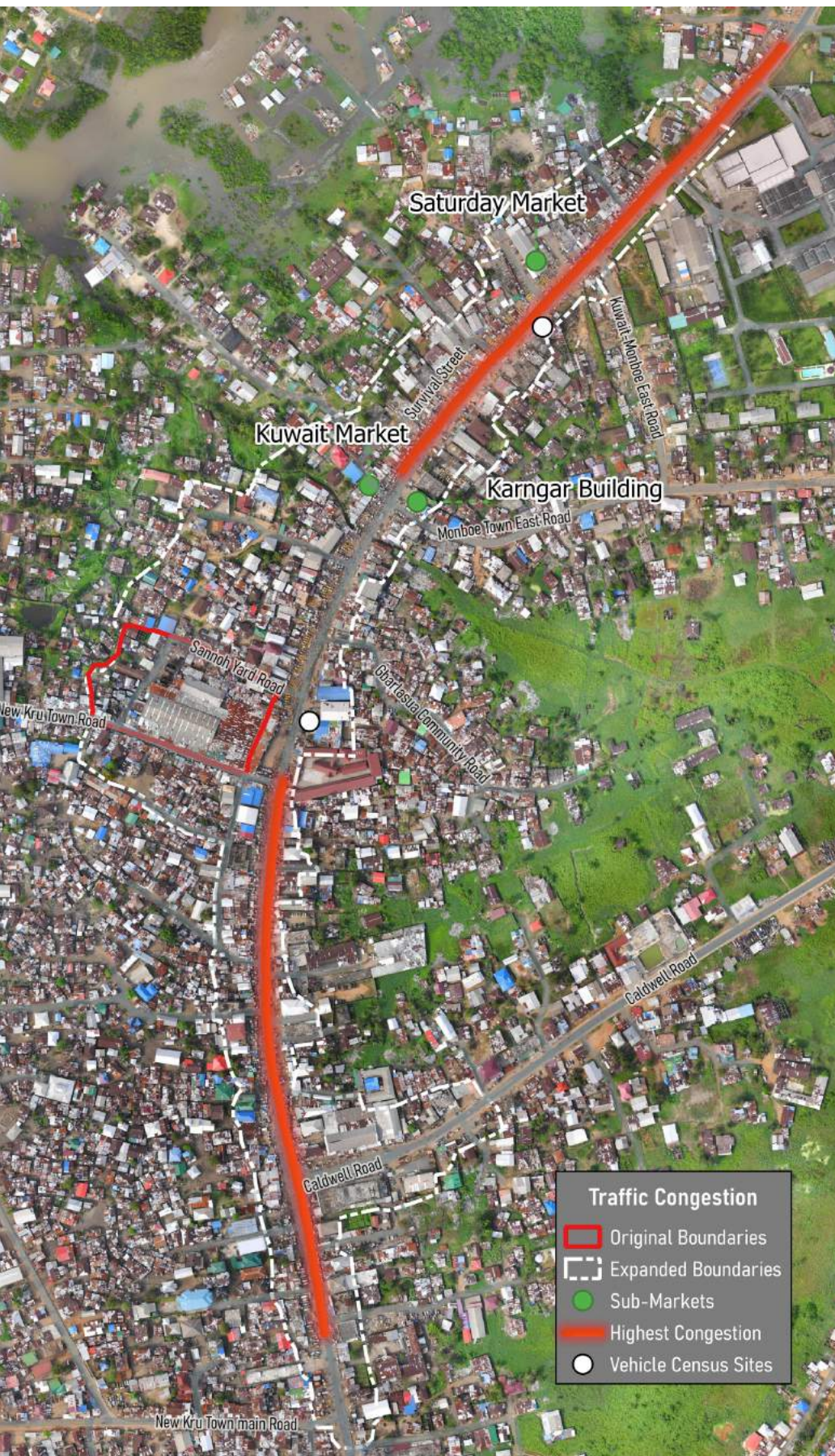


# TRAFFIC & CONGESTION

The following section provides an assessment of traffic and congestion issues in the expanded market boundaries including:

- **Vehicle Congestion** - an assessment of traffic by vehicle and hour to understand temporal and spatial dimensions of congestion using photo census surveys
- **Product Delivery** - a look at product delivery impacts of taxis and delivery trucks in contributing to traffic including unloading time, distance, and number of stops along UN Drive
- **Pedestrian Movement & Traffic** - a comparative temporal and spatial assessment of pedestrian traffic using photo census and vendor survey data
- **Vendor Travel to Duala Market** - an overview of vendor travel by mode, duration, and distance gathered through vendor surveys

# VEHICLE CONGESTION IN THE EXPANDED DUALA MARKET



Through structured observations, two stretches of the road network surrounding Duala Market were identified as having the heaviest vehicular congestion causing regular traffic jams. These sections are south-bound from north of Saturday Market to Kuwait Market, and northbound from south of Caldwell Road to the original market boundaries at the main Duala Market Building.

Southbound traffic coming from the north contributes to a high number of vehicles entering Bushrod Island through the only southbound route onto the island. Vehicles intending to reach any of the areas submarkets (Duala, Kuwait, Karngar, and Saturday) or for other business on the island must pass through this area.

Similarly, vehicles traveling northward towards any of the sub-markets or to exit Bushrod Island to the north are likely to be stalled at Duala Market.

Following the traffic jam survey, vehicle and pedestrian census counts were conducted at two sites - across from Duala and Saturday Markets. This data is explored in detail on the following page.

**Overall, the busiest times of day with the highest total vehicle counts were at 8 am for the Duala Market census site and 6 pm for the Saturday Market census site.**

# VEHICLE CONGESTION IN THE EXPANDED DUALA MARKET

Traffic on UN drive becomes worse during the rainy season and it is not uncommon for roads on Bushrod Island, including major thoroughfares to become inundated with water.

Nearly all the drainage networks along UN Drive are non-functional and as a result, flooding occurs on the main streets. The segment of the UN Drive passing the main Duala Market is on a higher elevation and further from wetlands than many other areas, therefore flooding does not tend to occur on that area of UN Drive. However, segments of UN Drive along Via town, Clara town, Freeport, and Logan town communities are often flooded at waist level during the peak of the rainy season.

With development encroaching the extensive wetlands present across Bushrod Island, infrastructure is highly exposed when waters rise. Taking into account proximity of roadways to wetland areas, the most exposed sections of road network in the expanded market boundaries are north of Saturday Market, the junction at Kuwait Market, as well as between Caldwell Junction. Additionally, New Kru Town Road and Sannah Yard Road at the rear of the main Duala Market building have a high exposure potential due to proximity to wetland.

A culvert beneath UN Drive near Kuwait Market allows for the flow of water between the main wetland areas. However, waste and debris can easily block this channel.

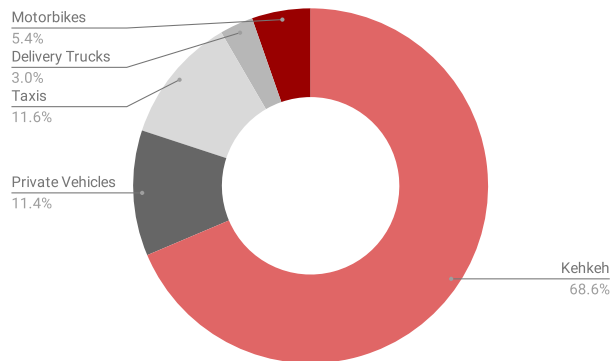
Note: the map at right does not account for elevation, only distance to water features.



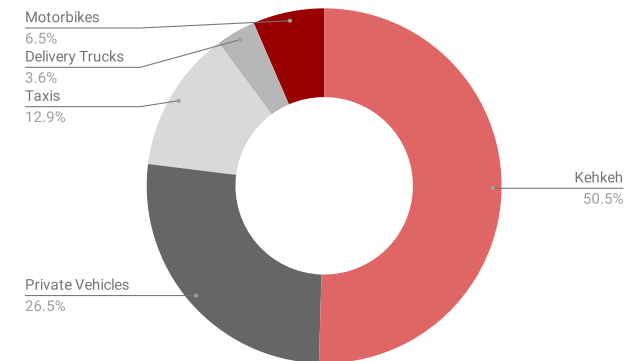
# VEHICLE CONGESTION IN THE EXPANDED DUALA MARKET

## Duala Market

### Total Observed Vehicles

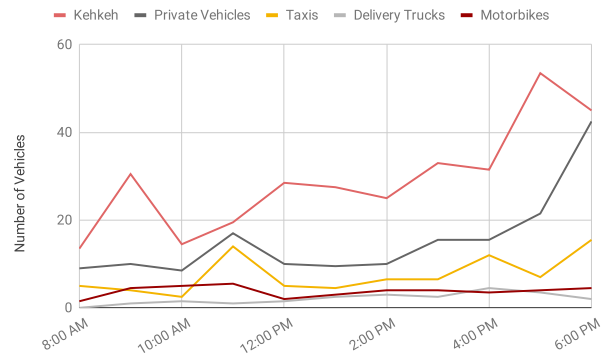
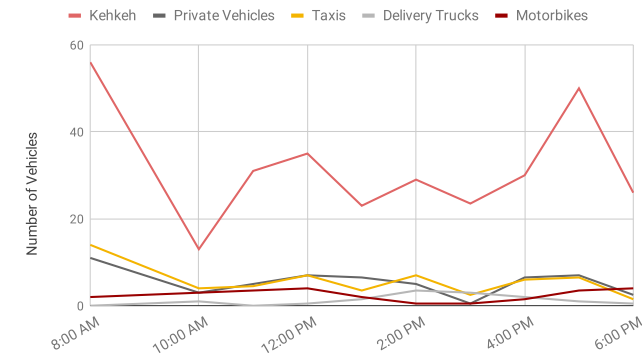


## Saturday Market



## Hourly Vehicle Count

### Average of weekday and weekend surveys

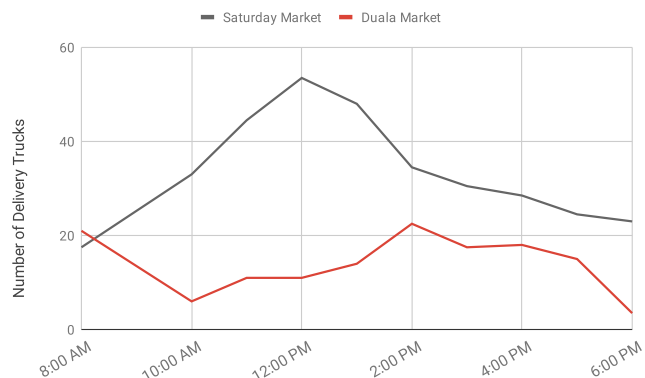


**While kehkehs (commercial tricycles) had the most significant presence, their small size allows for a higher number to share the road at a single time. Conversely, the presence of taxis and private vehicles appear to contribute to more significant traffic jams.**

On average, kehkehs accounted for the highest proportion of vehicles present near the main Duala Market building with 68.6%. This ranking held true across all observed hours between 8 am and 6 pm on the Friday and Saturday surveys were conducted. At the Duala Market main building, the presence of kehkehs experience two peaks - first around 8 am and at rush hour, 5pm. Similarly, at the Saturday Market observation point, kehkehs had the largest presence accounting for 50.5% of observed vehicles. At Saturday Market, kehkehs had two peaks as well, though the first occurred earlier in the morning at 9 am with the second at 5 pm. In total, 322 kehkehs were observed per day at the Duala Market site and 254 per day at the Saturday Market observation site.

Taxis and private vehicles had nearly equal presence, as observed at the Duala Market site, with 11.6% and 11.4% respectively. At the Saturday Market site, private vehicles accounted for a significantly higher presence at 26.5% whereas only 12.9% of vehicles observed were taxis. Notably, private vehicles and taxis spiked at 11 am and 6 pm - with the 6 pm spike having a significant impact on traffic at the Saturday Market site.

In addition to the hourly vehicle census, delivery trucks were specifically counted in total across two days. These included both delivery trucks stopped to unload as well as those passing through. Saturday Market had an overall higher presence of delivery trucks throughout the day, with a peak of 56 on average passing at noon. At the Duala Market observation site, the highest number of delivery trucks observed were at 8 am and 2 pm.



# PRODUCT DELIVERY ON UN DRIVE



**18 minutes:** average time delivery taxis spend unloading on UN Drive

**14 minutes unloading on average**      **1+ stops to unload on UN Drive on average**

An equal number of taxi driver surveyed reported spending 1 hour and spending 2 hours traveling to their destination at the market, with 33.3% each. Taxi drivers spending 3 hours accounted for 26.7% of those surveyed. Those reporting 3 hour travel times originated in Grand Cape Mount and Bomi counties as well as Red Light Market. Bomi County accounted for the most common origin, with an average travel time of 2 hours. Despite these long travel times, 51.3% of drivers reported coming from within the city of Monrovia. 93.3% of taxi drivers were transporting perishable goods such as vegetables and frozen goods.

Following Duala Market, 26.7% of taxi drivers' next stop was in Bomi County and 20% were heading to Red Light Market.

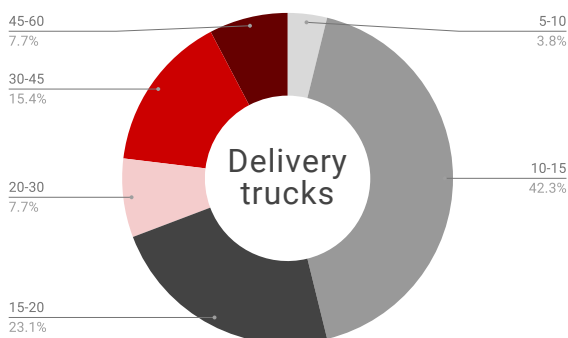


**69 minutes:** average time delivery trucks spend unloading on UN Drive

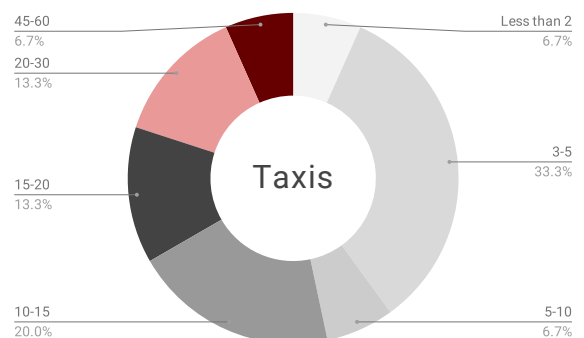
**21 minutes unloading on average**      **3+ stops to unload on UN Drive on average**

On average, 61.5% of delivery truck drivers reported taking 1 hour to reach their destination, the second most common time reported being 2 hours with 23.1%. These delivery trucks are typically originating in Central Monrovia (34.6%), Clara Town (30.8%), or Logan Town (15.4%). Of those surveyed, only a small number of delivery trucks originate outside of Montserrado County with one driver each from Grand Cape Mount and Bomi Counties. The majority of trucks surveyed (69.2%) carried dry goods, with only 11.4% carrying perishables.

The majority (76.9%) of delivery trucks unloading in the market do not leave empty with 90% of trucks still containing 25-75% of their arrival inventory. The next destination for delivery varies with nearly equal distribution between Bardnesville, Caldwell, Clara Town, Central Monrovia, Gardnersville, Logan Town, New Kru Town, Red Light Market, and elsewhere in Montserrado County.



**Unload Time (min)**



# PEDESTRIAN MOVEMENT AND TRAFFIC IN DUALA MARKET

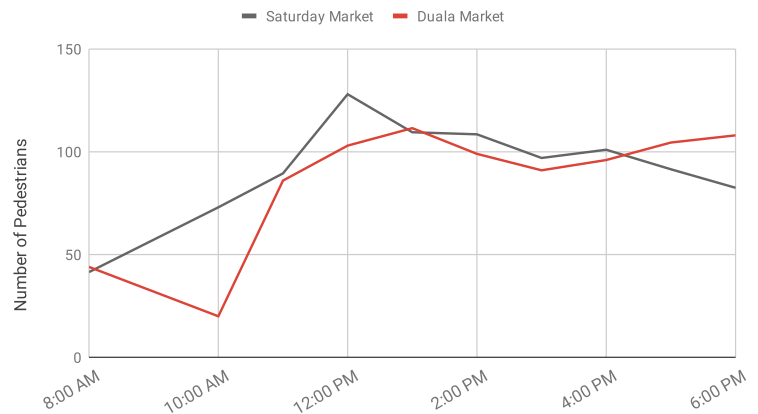


With a lack of sidewalks and vendors selling into the roadway, pedestrian traffic contributes to not only congestion within the market itself, but within the roadway. Additionally, with all vehicle types parking to load and unload people and products wherever they can find a location, pedestrians are forced to move into traffic to navigate the expanded market and UN Drive.

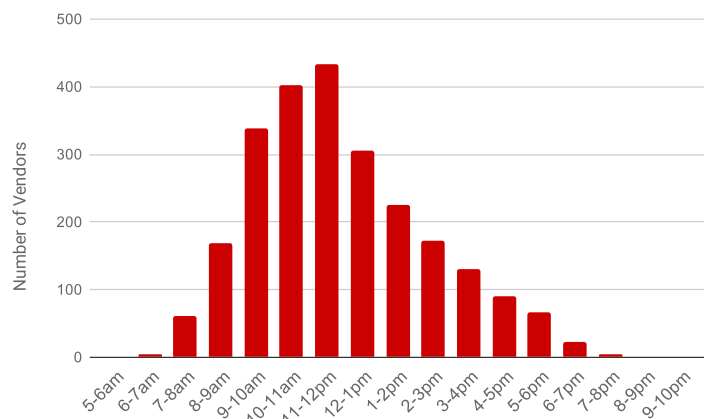
Using hourly photo census, example at left, at the Saturday and Duala Market observation sites, pedestrians were observed in highest concentrations between 12 and 1 pm for both markets. This observational data coincides with vendor survey data identifying 12 pm as the busiest hour for customers throughout the expanded market.

Following the rise in foot traffic at 12 pm, the observed number of pedestrians steadied at both locations around 100 per hourly census. This stabilization is notably different from the decrease in customers observed by vendors, indicating foot traffic in the afternoon is not necessarily related to market business.

Hourly Pedestrian Count



Vendor survey (within market building and street vendors):  
What is your busiest hours with customer traffic?

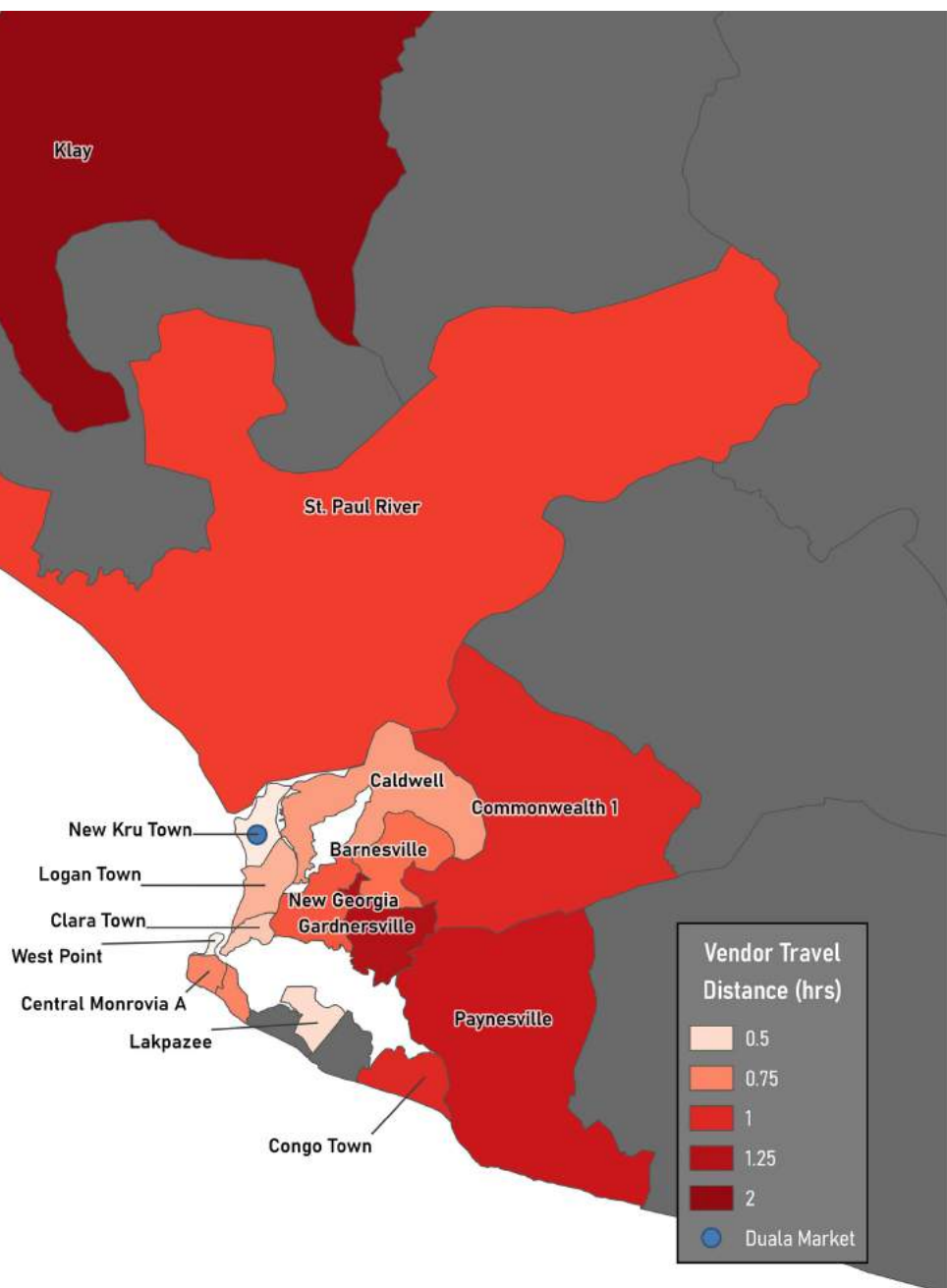




# VENDOR TRAVEL TO DUALA MARKET

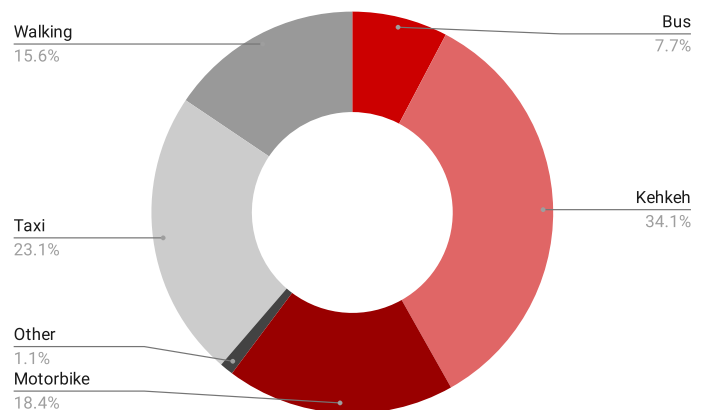
**50 minutes**  
average vendor travel time

The highest proportion of surveyed vendors identified Caldwell (28.6%) and New Kru Town (27.1%) zones as their point of origin before traveling to the market on a daily basis. Of the vendors surveyed, 84.4% came from within Greater Monrovia, and 96.8% of vendors coming from outside of the Greater Monrovia district originate from St. Paul River District. St. Paul River District was the third most common origin for vendors. Despite the proximity and access from St. Paul River District communities through UN Drive, most vendors originating from the District require nearly 2 hours to travel to the market on a daily basis.



Despite this high travel time, 76.9% of vendors reported that they do not make a stop on the way into Duala Market. Of those that did report making a stop, 33.3% stopped at Red Light Market or another location in Paynesville. Additionally, 30.1% made a stop elsewhere in New Kru Town zone.

On average, vendors use more than one mode of transportation to reach Duala Market (1.46 modes on average), with some vendors using as many as four different modes of transportation. Kehkeh, taxis, and motorbikes were identified as the most common modes of transportation - all significant contributors to traffic on UN Drive.





## Acknowledgements

A special thank you to the community members, vendors, and all others that welcomed HOT, iLab, and the World Bank team into the Duala Market and surrounding area to conduct this research. Their support and assistance was critical to the completion of this work.

Additionally, we would like to thank all of the participants who attended the information sessions, participatory mapping, focus group discussions, and all other participatory activities completed.