Clean City Mobile Application

"Pay as you trash"

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Introduction

Urbanization in Kenya has made it increasingly difficult to manage the ever-growing volumes of solid waste and heaps of wastes have become a common site in Kenyan urban towns (Mwangi & Mburu, 2016). The result, Nairobi is a filthy city. It has lost its glory of being the "City in the Sun" to hold the unenviable title of the "City of Garbage in Africa" (Odenyo, 2017). As you walk around the estates in different parts of the city, there are piles of solid waste everywhere (examples in *Figure 1* in the appendix). This is especially evident in the middle and low income estates. The situation is so dire as to pose a big threat to the health of Nairobi residents (Mugumura, 2015). The author goes on to state that waste causes a myriad of problems, from pollution, to blocked drainages and also negatively impacts on the public health of Nairobi residents.

The solid waste generated in Nairobi can be categorized as domestic waste, construction and demolition waste, biomedical waste, chemical waste, municipal waste, industrial waste, hazardous waste, electronic waste, motor waste (including oils and tyres) and sewage sludge (National Environment Management Authority [NEMA], 2015).

This paper notes that solid waste management in Nairobi has been a social responsibility of the corporate world or one of the services provided by the municipality or county government and a non-priority for the national government of Kenya. The corporate world organizes events for clean-up activities varying times in the year by involving their staff and only in selected locations. City residents on the other hand are only involved in collection of their own individual refuse or waste with minimal interaction with the collectors. This paper focuses on finding a solution to involving residents and the Nairobi County Council (NCC) in proper waste management by proposing a mobile application that will help digitalize the collection and transportation of solid waste in Nairobi. The paper looks at the current situation, together with previous research done on waste management in trying to find a lasting solution to eradicate the piles of garbage seen in estates and commercial zones within Nairobi and its environs.

Situation Analysis

The rate of urbanization in Kenya outpaces the rate of growth in the total population; in turn, the urbanization process is highly skewed in favor of one city, Nairobi (Mwangi & Mburu, 2016). The authors continue to assert that, consequently, Nairobi is now estimated to be four times the size of the next large urban area, Mombasa. Alongside this growth, Nairobi is generating waste exponentially. Waste generation is growing in tandem with the increasing urbanization (Mwangi & Mburu, 2016). However, NCC, which is charged with waste management is unable to collect waste regularly and has therefore contracted private companies to do so on its behalf[1]. These companies seem to compete for businesses individually as there is no coordinated mechanism through which they can synchronize their collection for designated regions of operation. That notwithstanding, NCC continues to levy monthly fees for garbage collection for the little or non-existing service. According to NEMA (2015), the challenges encountered in waste collection and transportation include low coverage of waste collection services, irregular waste collection, inadequate refuse transportation trucks and unregulated collection fees. These challenges can in turn be respectively attributed to lack of zoning of waste collection areas, poor scheduling of waste collection, low government budgetary allocation for waste collection coupled with little investment in acquisition of proper waste trucks due to low and unpredictable returns and lack of a clear policy on waste management services (NEMA, 2015).

After conducting secondary research from the NCC website, we established that currently, there are 27 listed refuse collectors in Nairobi County in the Business List directory[2]. These are limited liability companies which also engage in landscaping and a myriad of cleaning services for their clients. Some of the companies already have websites with contact details provided. However, they do not engage with their clients through social media platforms which would bolster the companies' engagement with their stakeholders. Other than contacting each organization directly whenever there is a need, and only then, there is hardly any interactions between all the players involved in waste management in a given platform, either online or offline.

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[1] Information obtained from Nairobi County Council website www.nairobi.go.ke
[2] Available at www.businesslist.co.ke

Literature Review

The rapid urbanization and population growth trends that are being realized in much of the developing world including Kenya have precipitated a dramatic increase in municipal solid waste (Mwangi & Mburu, 2016). The need for a proper waste management strategy is therefore inescapable if the society is to address the challenge of ever increasing municipal solid waste. Bamodu (2013) observes that while conventional waste collection methods were successful for garbage collection, the surge in waste generated, as well as the increase in people requiring garbage collection services, have proved the traditional method inefficient. The author observes further that the current garbage situation especially in major cities, has precipitated the adoption of IT and mobile technologies in a move to address the challenges being encountered in waste management.

Mavropoulos, Tsakona and Anthouli (2014) opine that the digital evolution and mobile developments, which have facilitated information flow and interconnectivity have created opportunities for novel means of collecting waste. In their article, Mwangi and Mburu (2016) observe that mobile technological applications are currently being adopted in the management of solid waste in most countries. According to the authors, some of the most common applications are the Radio-frequency identification (RFID) which is being used together with the global positioning system (GPS), the global system of mobile communication (GSM) and the geographical information systems (GIS). A similar observation is made by Thyberg and Tonjes (2015) when they observe that GIS is currently being used in several municipal waste management systems. Bamodu (2013) singles out "Fleetlink" (an application for tracking garbage trucks) and the "Recycle T" (for alerting refuse collectors) as some of the apps that are currently in use.

Mavropoulos, *et al.* (2014) conducted a study on the use of mobile apps in waste management and found that the apps had a positive impact on municipal waste collection, transfer and disposal. The study further found that the mobile apps facilitated the logistics of waste collection and disposal as people were able to use the available apps to communicate to garbage collectors. This is a good finding and as Oteri, Kibet and Ndung'u (2015) note, the penetration of the mobile phone technology in Kenya has made it a potentially important tool in establishing a sustainable waste management system.

According to the 2017 quarterly sector statistics report by the Communications Authority of Kenya (CAK), mobile penetration stood at 88.1% in the year's first quarter with 37.8million subscribers up from 36.1 million in 2016. Oteri, *et al.,* (2015) had given the mobile penetration level in Kenya as of 2014 at a high of 78%. The figure keeps changing as mobile telephony costs have gone down significantly. This implies that the mobile technology has potential for use in waste management. Nonetheless, when examining RFID use in municipal waste management, Mwangi and Mburu (2016) found that while the use of RFID technology in waste management has been adopted in Kenya, this is still at the testing stage and has not precipitated any real results that would indicate its effectiveness in municipal waste management. This in line with a similar assertion made by Mavropoulos, *et al.* (2014) where they note that mobile applications use in municipal waste management is still in its infancy stage.

Therefore, while scholars and existing studies reveal that the use of mobile apps in waste management has been on the increase elsewhere, studies that would inform on the current situation in Kenya is limited. Furthermore, even for the few studies concerning the use of mobile technology in waste management, such as that by Mwangi and Mburu (2016) do exist, their treatment of the situation is inconclusive and does not capture the value (or potential value) of mobile apps use in waste management in Kenya. However, it is apparent that a well-designed refuse management system would highly enhance the process and will prove sustainable.

In addition, after grappling with the problem of solid waste for many years, this paper notes that the Kenya national government has with effect from September, imposed a ban on the production, importation, distribution and usage of the non-biodegradable plastic bags mostly used for packaging of finished products by industries and carrying shopping from retail outlets. This is presumably because they form part of the waste lying all over the city. Although the ban is expected to take effect progressively, it faces strong opposition from manufacturers and is reminiscent of two previous unsuccessful bans implemented in 2007 and 2011.

Data Collection

The data presented in this chapter was obtained through a combination of primary and secondary data collection methods. This data is the basis of the analysis of the solid waste

problem in Nairobi and forms the justification for the mobile-phone application proposed as a solution for solid waste management (SWM) in Nairobi.

Secondary data is information that has already been collected and recorded by a third party, for another reason, (Blumberg, Cooper & Schindler, 2014). For secondary data, the researchers conducted searches in peer reviewed and non-peer reviewed sources. The search for peer reviewed sources was conducted in the journals subscribed to by the United States International University-Africa Library. These are Africa Online Journal, BioOne, Business Monitor International, Cambridge Journals, Cochrane Library, Directory of Open Access Journals, EBSCOhost, Edinburgh University Press, Emerald, HINARI, IEEExplore, JSTOR, Keesings, Kenya Information Preservation Society, Lyell Collection, Mary Ann Liebert Online, Nature Publishing Group Journals, Oxford journals, Sage Journals, Taylor and Francis Online, and Wiley InterScience.

This however was not sufficient as there was additional information that was not reported in peer reviewed literature. To ensure all relevant information was captured, the search was extended to non-peer reviewed sources including the Encyclopaedia Britannica, the World Bank and World Health Organization archives, Japanese International Cooperation Agency (JICA) report and news sources indexed and retrievable from Google search engine (news option). This additional criterion brought up web based information from opinion pieces and newspaper articles. Primary data used is in the form of photographs taken during observatory field visits around Nairobi (as seen in *Figure 1*). The photographs demonstrate extent of the solid waste problem.

By its own account, the Nairobi City County (NCC), is unable to perform adequate solid waste management (Mwololo, 2017). This waste includes food scraps, expired drugs, and chemicals, raked leaves, crop residues, animal manure, sewage sludge, old newspapers, cans and bottles, worn-out furniture, abandoned cars, food processing waste, mining waste and construction waste (Muthiani, 1991). According to Koigi (2017), Nairobi generates more than 3,000 tonnes of solid waste daily. This volume is higher than a JICA (2010) projection on solid waste for the period between 2010 and 2030 (see *Figure 2*).

In a bid to stem the solid waste tide, in 2015, the NCC invited foreign companies to assist in the management of the waste (Mutavi & Wachira, 2015). The authors continue to state that

even with the said intervention, the problem has degenerated into a crisis of unprecedented proportions and note that NCC has been accused of allowing Nairobi to degenerate into a 'budding dumpsite' (p.5). In 2016, the Government of Kenya launched an initiative to ensure that county governments undertook the following:- conducted zoning of waste collection areas; ensured timely and regular collection of solid waste, either through door-to-door collection or from centralised collection points; ensured that collected waste is transported using NEMA-licensed vehicles to designated disposal sites and to ensure that designated dumping sites were secured with a fence and a gate manned by a county government official to control dumping and prevent spread of waste outside the disposal site (Koech, 2016). This paper notes that NCC has not implemented these measures.

Today, most streets and residential areas have piles of garbage that have remained uncollected for weeks on end, thereby limiting passage through the streets and emitting a stench that fouls the air while plastic paper bags litter the streets (Muraya, 2017). From the Kenya Law Reports (KLR) we note that in 2011, Phillip Kisia, the then NCC Town Clerk, was charged in court for failing to ensure collection of domestic waste from 13th June to 28th September, 2011 (*Republic -versus- National Environmental Management Authority parte Phillip Kisia*, 2011).

NCC has also been accused of collecting waste from one area only to dump it in another as seen in the case against Mr. Kisia, where he was charged with failure to comply with an order directing him to stop illegal dumping of solid waste along roads in the city (*Republic -versus-National Environmental Management Authority parte Phillip Kisia* - KLR, 2011).

Poor waste handling leads to pollution of water sources such as the Nairobi River since waste is dumped without protecting groundwater (Kariuki, 2017). Another indication of this can be inferred from the frustrations cited by the Japan International Corporation Agency (JICA) report in their 2012 partnership with the Nairobi City County to manage solid waste. The two had entered into a partnership for the management of the solid waste problem but JICA reported that the partnership had failed to bear fruit because the Nairobi City County lacked both the capacity and the political will to do so ("World Economic Outlook", 2010). JICA (2010) also proposed alternative SWM sites and zoning around Nairobi but NCC failed to endorse (See *Figure 3*).

In addition, corruption at the NCC has been cited as a hindrance to the collection of garbage (Oteri, *et al.,* 2015). For instance, in 2014 Nairobi City County tendered for private companies to provide solid waste collection services. Although many qualified companies submitted their bids for offering the services, the tender was un-procedurally awarded to one company thereby resulting in an acrimonious court case (Oteri, *et al.,* 2015). The authors contend that the initiative ended up failing: only about 5% of the targeted households signed up for collection by the single company; the rest of the residents have continued to contract garbage collection to their regular collection companies.

The uncollected solid waste has been the source of ecological, economic, social, environmental and health challenges, ranging from air pollution as well as clogged drainages and sewers to waterborne diseases such as typhoid, cholera and diarrhoea as well as respiratory diseases and malaria (Muigua K., Wamukoya D., & Kariuki F., 2015). For instance, in Ongata Rongai, a town in Kajiado County, the drainage system is in a deplorable state and is permanently clogged with garbage leading to stagnation of waste water and the overflow of raw sewage unto the streets (Muigua *et. al*, 2015). As a result, home owners and landlords have been using the cover of darkness to empty raw sewer into the roadside storm water drainage system. Unbeknown to them, the drainages eventually empty into the rivers that pass through the Nairobi National Park thereby impacting negatively on wildlife (Otieno, 2017).

Despite the fact that Nairobi City County and its predecessor, the City Council of Nairobi, have been collecting levies, rates, fees and other charges without fail, the management of waste by private entities has been going on for over 30 years, as seen in the case of *Waste and Environment Management Association of Kenya -versus- Nairobi City County, 2015* (KLR, 2015). Aggrieved by this practice of collection of revenue without service delivery, several groups of Nairobi residents have attempted to stop Nairobi City County from collecting revenue. Many of these attempts have yielded no fruit as illustrated by the case of *Ibrahim Hussein -vs- Nairobi City County 2015* where the High Court declined to grant an order barring the NCC from collecting property rates, fees and charges imposed for business permits and licenses for Eastleigh area of Nairobi (KLR, 2015). The application was grounded on the fact that NCC had failed, among other things, to regulate and manage environmental pollution as well as refuse removal and solid waste disposal and sanitation management services in Eastleigh.

The role of the private sector in waste management cannot be overlooked. Indeed, Kenya's Vision 2030 recognises the need for multi-sectoral coordination and cooperation in pollution control and waste management (Government of Kenya "Vison 2030," n.d)

Product Justification

According to Ochieng (2016), a mobile technology-enhanced waste-management system that addresses structural inefficiencies in the waste management would be a panacea for Nairobi's solid waste problem. Such a system would include: firstly, the segregation and differentiation of solid waste into organic, metals and glass, paper and plastic waste at source. The author also asserts that digital geo-spatial mapping including digitized zoning of waste segregation centres, transit points and disposal points to ensure accurate output projection, tracking and traceability of waste along the entire value chain. He contends that the creation of strategic partnerships between Nairobi City County and both informal waste collectors and private entities will ensure higher logistical strength that would require involvement of the mapping of transit routes for waste (Ochieng, 2016).

This corroborates the results of a recent empirical study reported by Kariuki (2015) which has demonstrated that the use of mobile technology can provide a solution to the management of solid waste in Nairobi. In an IBM funded trial, 10 waste collection trucks belonging to the Nairobi City County were fitted with mobile phones that were modified with a gyroscope and an accelerometer. The trial demonstrated that with accurate data on variables such as the location of each truck at any time, the amount of fuel used by each truck, the distance covered, and the routes used by each truck, it was possible to have an efficient waste management system, (Kariuki, 2015).

Over the past decade, the theme of sustainable environmental conservation has gained prominence around the world and Kenya is no exception (Makenzi, 2015). According to the author, one of the biggest environmental sustainability problems in Africa is the management of solid waste which he states has resulted from fast economic growth, exponential population growth and rapid urbanization coupled with the discouragement of common waste management practices by environmental lobbyists due to the dire negative impact on the environment. Kenya is no different.

It is against the backdrop elucidated above that we found a need to come up with an app to consolidate collection efforts. The other reasons justifying the need of the app this paper notes are:- (1) there is no mobile app currently available in Kenya that provides an avenue to coordinate collection efforts by private firms and therefore there is certainly a gap (2) the mobile app will attempt to organize and cluster all the stakeholders in one common platform to ensure all areas in the city are properly covered and served (3) The app will help improve environmental sustainability by involving all citizens in waste management and (4) with a waste recycling option, citizens will be involved in helping NCC in its implementation of recycling efforts to reduce large amounts of recyclable waste at the dumpsites.

The proposal is for the NCC government, which oversees waste management, purchase the app from the developers to help streamline waste collection and thereby improve operational efficiency not only in collection but also in disposal in the dumpsites. NCC can also develop the app further to include areas of reporting other services such as broken sewers, blocked drains and burst water pipes.

The name of the proposed app is Clean City; choice of name reflects the overarching goal of this app – to ensure we can restore the cleanliness in Nairobi city.

Benefits and Foreseen Challenges

The primary goal of waste collection management planning is to prepare the society or citizenry to effectively manage home or office refuse (Odenyo, 2017). The author continues to assert that most human activities both at home, in residential houses, or commercial organizations generate waste every day and while the amount of waste varies, proper coordination of collection can infer many benefits to all. This paper notes that Clean City's benefits will be diverse both to NCC and Nairobi residents. NCC and garbage collection companies' benefits are:- (1) the app will allow more efficient and effective waste management activities, (2) it will save valuable time and resources garbage trucks spend driving around homes on scheduled days whether there is waste to collect or not and (3) will encourage stakeholders (e.g. consumers, collectors and City Council) to work together to make the town garbage free.

The benefits of the app for residents/consumers will be (1) they will enjoy structured refuse collection and have their trash collected as and when they want. (2) they will only pay for trash when it is collected and therefore enjoy massive savings when away from home and need not pay for trash when not necessary; (3) the app may also help minimize garbage dumps sometimes occasioned by non-collection by the City Council and thereby make Nairobi City clean again.

This paper also notes the opportunity to develop the mobile app further to include other services as mentioned earlier, i.e. to report blocked sewers or drainage systems, burst water pipes among others offered by NCC and thereby include all services that will make Nairobi city clean again. Another opportunity noted is the option of using the app as a business model that can be adopted in other counties in Kenya to harmonize collection efforts all over the country.

On the challenges, this paper notes that despite the proposed app being noble, acceptance by a rigid NCC government may be slow and even when done, NCC may not be willing to pay the developers for coming up with the app and instead develop their own; especially due to the corruption cartels mentioned earlier in this paper. Acceptance by consumers may also take a while as we do not anticipate behavior change will be instant. This is especially so for residents in low income areas who are so used to dumping without paying anything for their trash. It is hoped that NCC can introduce penalties for dumping to discourage the trend. Another challenge noted is that since the application is hosted on smartphones, some consumers may not necessarily have them and hence will not be able to participate on this platform. It is envisaged that NCC can introduce surveillance cars or individuals as done with parking attendants compelling residents to use the app either through the surveillance teams' mobile phones or those of their friends or neighbors.

The threats that we foresee that would affect implementation is that stable Internet connection may not be available in every part of the city and this may create delays in reporting and subsequent collection. It is hoped that with the introduction of 4G connection by mobile providers, the threat may subside progressively. Affordability of Internet charges may also make some residents shy away from downloading the app and therefore, sensitization of the charges vis-à-vis the benefits to the masses should be undertaken either by sustained marketing and/or advertising campaigns.

How the Mobile Application will work

The Clean City mobile application will be hosted on the Google Play Store or Apple Store so that members who would like to sign up for the service can easily locate it to enable them download the app to their smartphones upon request. Once the app is downloaded on the mobile phone, a shortcut icon will be created on the mobile phones and it will be activated upon one selecting the icon and access the other services. Downloading the app will be quick and easy as illustrated in *Figure (i)* below:
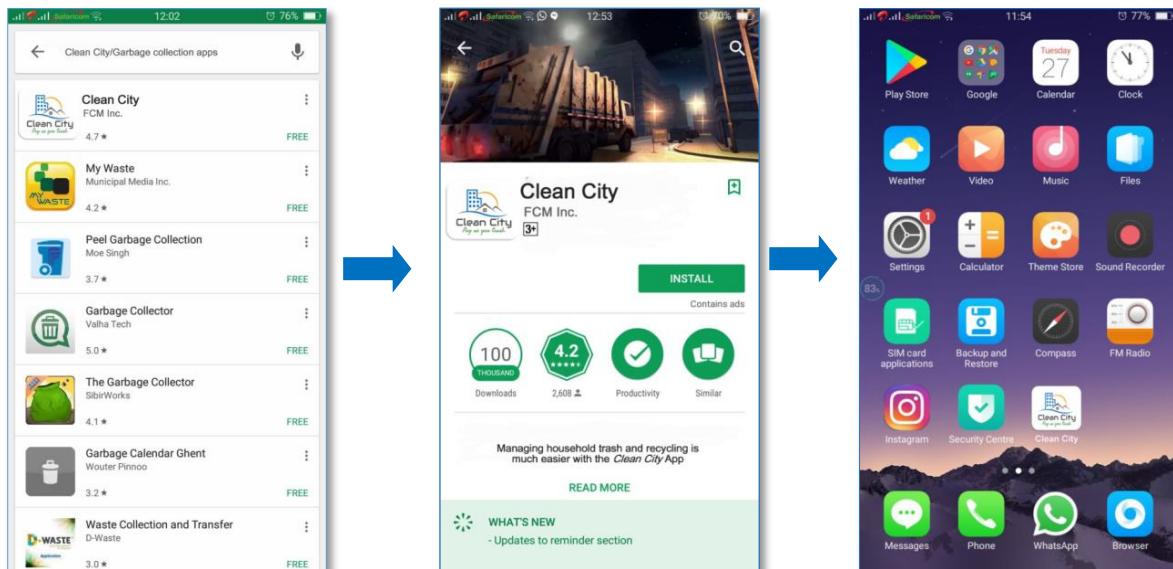
Figure (i): Downloading the App from the App Store

The mobile app will provide an easy to navigate waste collection time showing the dates and types of waste to pick up. One will also be able to set alerts and reminders to keep up to date with waste collection. The app contents should integrate the waste calendar to interface directly with that of the smartphone. The main objective of the app will be to provide a 'pay as you trash' service so that one only needs to pay for garbage collected and earn some cash from recyclable trash. No monthly or ledger fees will be necessary or levied. The app will provide a waste and recycling feature that will allow one to see what materials may be recycled, thrown away or composted. The proposal is to also have the app provide users with information on how to dispose of garbage that they have in their homes as well as get the most out of this service. Further, it is proposed that NCC provides well labeled dustbins for this purpose. (Figure 4 in the appendix shows examples of labelled bins)

For this app to work effectively and efficiently, we will have three categories of operators including subscribers, collectors, and the NCC. The NCC will run the back end of this application ensuring that all requests are attended to allocated collector. The subscribers will use the app to request garbage collection services whereas the collectors will work to respond to these requests.

A. Subscribers

Subscribers to the Clean City garbage collection service will have the opportunity to request for garbage collection through their mobile phones and pay for the same once the trash is collected. A problem for most of our subscribers now is that existing garbage collection services do not offer this service as frequently as is needed and most people have to store up their garbage for weeks before it is collected or get rid of the trash themselves without seeking the services of a collector. To subscribe to this service, users will be required to download the app and register for this service by providing the following details as illustrated in *Figure (ii)*:

1. User name
2. Email Identification
3. Mobile Number
4. A password which will be used to log in to the application when using it
5. Once all these details are provided the users will receive a notification with an OTP (one time password) that will be sent through mobile phone short message service (SMS) for verification purposes

Once the app is open, subscribers will be able to request for the desired service, which, as will be illustrated later, can be either for waste pick up booking, reporting unattended waste, providing recycling items information, write, or call to make inquiry to the designated city council official who will be available all day. The sign up process is illustrated below.
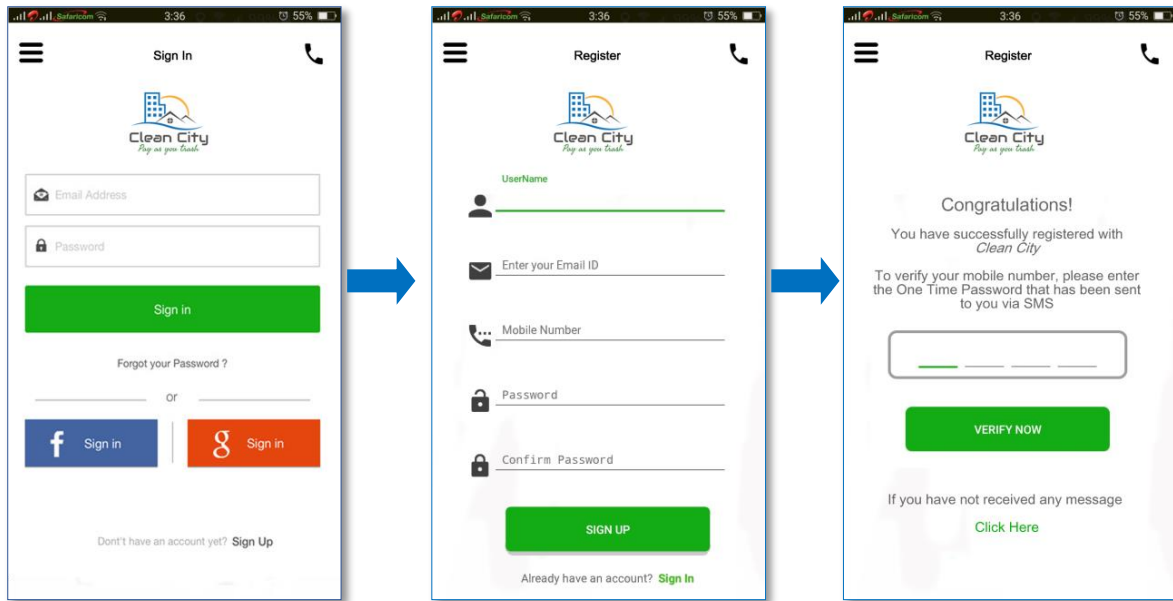
Figure (ii): Signing Up

B. Collectors

Licensed garbage collectors who wish to participate in the waste collection platform will be free to do so, however they will need to get clearance from NCC to ensure they meet the waste collection and disposal requirements. Once NCC approves their participation, the steps for signing up are as follows:-

1. Sign up your truck online - this is through the City Council website. Licensing and certification will not be done via the mobile phone as there is need to upload other documentation and to ensure monitoring of their activities which is more practical to do via website and/or email.

2. Upload documentation: Driver identification (ID), truck registration, business permit, required licenses etc.

3. Go through screening for eligibility and certification

4. Once certified, get listed and activated as a clean city garbage collector.

5. Collectors will then use the app to collect garbage from as many users as possible as illustrated in *Figure (iii)* below
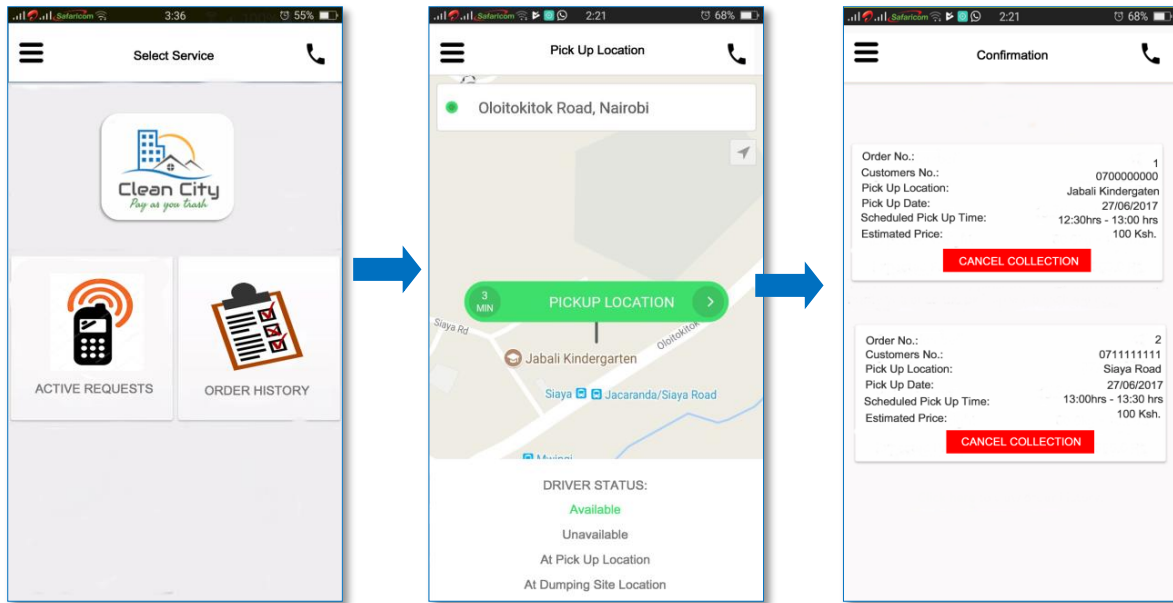
Figure (iii): Collector's pick up Interface

C. Nairobi City Council (NCC)

Being the main operators of this application, NCC will have an interface of their own where they will be able to track the garbage collection activities that are happening on the Clean City platform. The City Council will also be able to answer any queries coming from the subscribers and collectors as well as address any complaints that may arise about the Clean City App. From their end, NCC will receive compliments, suggestions or complaints about the app, which they will use to make improvements on the app. What will be key for NCC will be the collection of unattended waste once reported and the verification of users to ensure that no unlawful activity occurs under the pretext of using the app. NCC will also be able to use this app to evaluate the services that are offered within the app and the customer's level of satisfaction. Further, NCC will also coordinate all stakeholders on the platform and maintain harmony amongst the licensed collectors. They will also be charged with the responsibility of sensitizing the public through marketing campaigns to ensure as many residents as possible download and use the app.

The Clean City App will, primarily, be used to provide three key services including requesting or booking garbage collection, reporting unattended waste and recycling. The decision to have these three key services was based on the problems identified when conducting the situational analysis and the possible needs that we anticipate from our consumers when using the services.

When conducting the situational analysis, we found that consumers would like to have their garbage collected as frequently as possible to avoid storage of trash within the households, which in turn attracted pests and rodents. Accordingly, heaps of unattended waste have been identified as being a bigger problem for the communities at large as they pose as environmental hazards. Lastly, the need to recycle was also identified as an important aspect for our consumers with very little recycling activities being carried out by the existing garbage collectors. As a matter of fact, home owners know and do very little when it comes to recycling their trash with the only access they have to recycling being "*mali kwa mali*" (Swahili for recyclable item collectors) who go door-to-door collecting any little recyclables that homeowners have in their homes. Through recycling, subscribers will be able to earn money from their recyclables and will become more aware of the recycling process allowing them to separate their recyclables before requesting or booking for waste pick up.

1. *Requesting Garbage Collection*

With one click of your cellphone, requesting or booking garbage collection is easy on the Clean City App. When a subscriber needs their trash to be collected, all they need to do is input details of where they require the trash to be collected from and a collector will respond by scheduling and picking up the trash. During the initial stages of the app, we expect a slight delay in securing a garbage truck to pick up trash – but not longer than one day. This is because the number of registered trash collectors currently is less than 30 collectors and this is the group we propose NCC to target the roll out with at first before we can get more trucks registered as collectors later. The objective is to provide subscribers with more trucks and ensuring that these trucks pick up as much waste as possible within a day. By ensuring that the trucks leave with as much waste as possible, Clean City aims to make the process of garbage collection more efficient and less wasteful. As illustrated in *Figure (iv)*, the subscriber will request garbage collection through the steps below:

1. Activate the Clean City app by clicking on the icon
2. Select request garbage collection
3. Input and confirm pick up location
4. One will then receive a confirmation message detailing the order number, pick-up date, estimated pick up time, registration number of the garbage truck and the price to pay - this is crucial information for ensuring a smooth process

5. The app will notify the person requesting for collection service when the collector arrives at designated location and the resultant price estimate.

6. The subscriber will have two payment options, including cash or via mobile money.
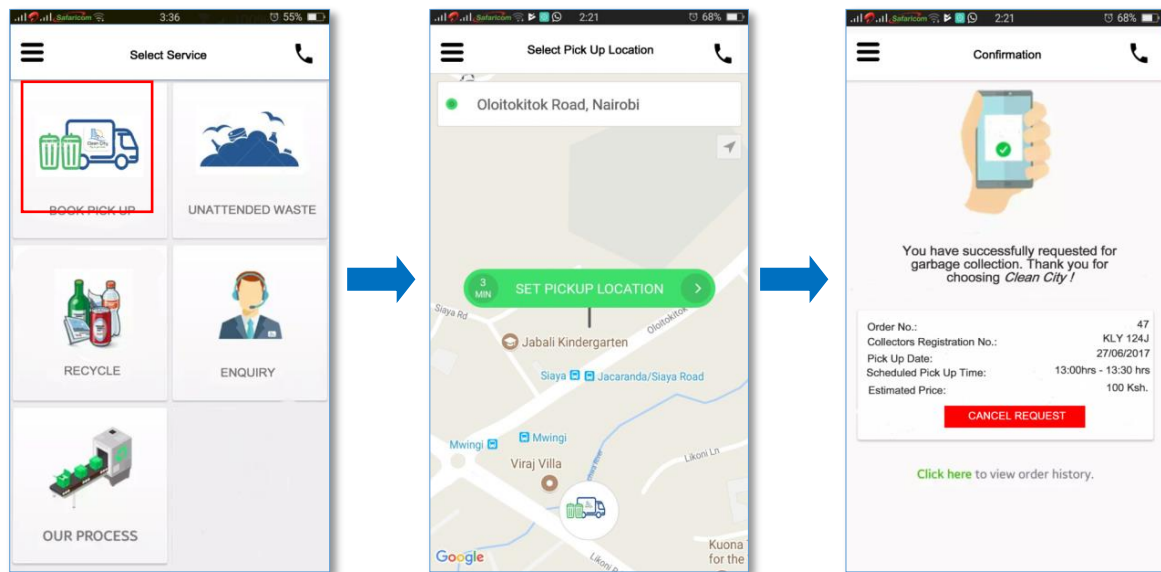

Figure (iv): Requesting/Booking Garbage Collection

2. *Reporting Unattended Waste*

Piles of uncollected garbage are key concerns for the city and we hope that through the Clean City App we will be able to solve this problem for city residents. Users will be able to report unattended waste that they come across in the estates or in the streets and pose an environmental problem. All they need to do is input details of the uncollected waste then report it and the app will geolocalize this giving the exact location through google maps. This interface will also enable the person reporting to upload pictures of the garbage heaps after capturing the same with their mobile phones and notify the garbage collectors to plan for the collection. The pictures will enable the collectors monitor whether it is a first-time report of the same unattended waste to avoid sending more than one collector to one place to collect the same garbage. An alert message will then be sent to the NCC with this photo of the unattended waste and the location of the waste to which they will respond by collecting the waste. This will allow for more accountability on the garbage menace so as to ensure that the authorities tasked with garbage collection are doing their part in reducing this problem. On the Clean City App, subscribers will be able to report unattended waste in their community and thereby request for collection to weed off piling of garbage as indicated in *Figure (v)* below. The steps for reporting unattended waste will be as follows:-

1. Take a picture of the unattended waste then go to 'report unattended waste' on the app
2. Enter the location
3. Fill details of the unattended waste: upload the image of the unattended garbage for ease of identification and click 'report'
4. This information will be sent to the Collectors interface for collection scheduling.
5. The app will notify you once the unattended waste is collected by NCC
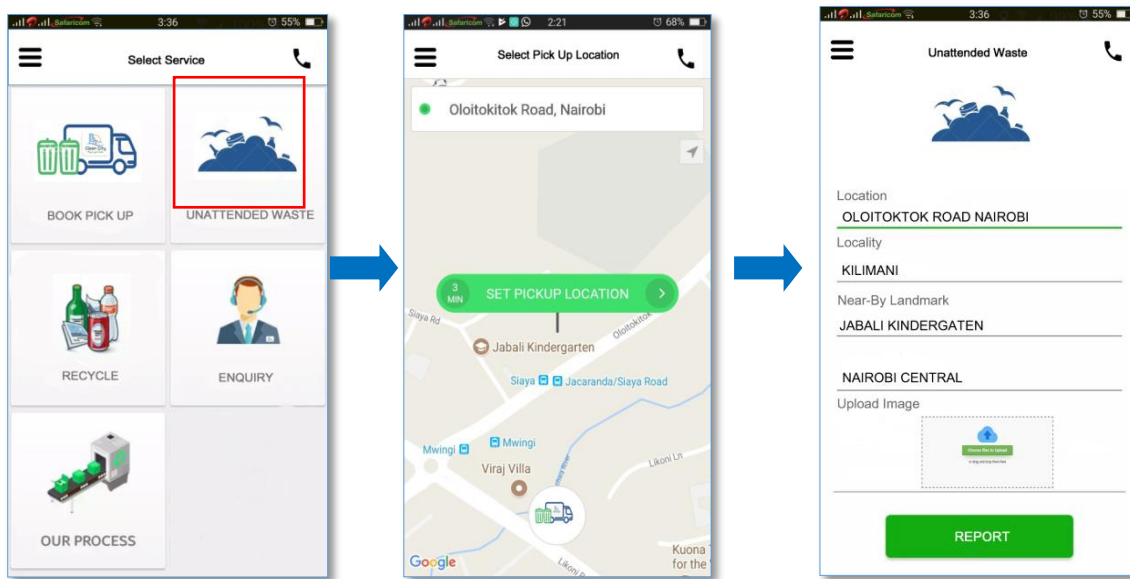
Figure (v): Reporting Unattended Waste

3. *Recycling*

Recycling is an important aspect of the Clean City App as it helps in ensuring that trash that would otherwise end up in a landfill is delivered to appropriate recycling centres. The recycling section of the app will allow subscribers to manage their waste through this medium. The app will also provide weekly notifications to users reminding them to recycle and taking them through which items can be recycled. Direct end consumers will group recyclables into four main categories including paper, glass, plastics, and metal but with an inclusion for any other recyclable trash that subscribers may have at their disposal. Users will find buyers for their recyclables and will be able to earn some money depending on the amount of recyclable trash they have for selling. Buyers, on the other hand, will be able to locate nearby users for pick-up of recyclables. The app will also allow buyers to contact sellers directly and organize pick-up/disposal of their recyclable trash. As indicated in *Figure (vi)* below, subscribers can recycle their trash in these easy steps:

1. Go to recycle on the app

2. Select whether you are a buyer or seller

3. Select what you want to recycle - indicating the quantities and amount

4. Sell/buy your recyclables to an open market

Figure (vi): Recycling waste

Proposed Garbage Collection Pricing

Downloading the app will be free for subscribers and therefore, there will be no need to make payment or charge monthly fees. The only fees payable are those related to garbage collected. On the pricing, this paper notes that the ability to pay for any product or service may be pegged

directly proportional to the level of income of the customers. The higher the income, the higher the ability and conversely, the lower the income, the lower the ability to pay. In the case of SWM, it is important for the proposed solution be priced in a way that makes it both affordable to the customers and commercially viable to contractors. According to JICA (2010), we find that, on average, the private companies contracted by households and private corporations to perform SWM charged Kshs. 200 per month for low income areas, Kshs. 400 per month for middle income areas, Kshs. 600 per month for high income areas and Kshs. 1,000 per month to business establishments. JICA (2010) examined the financial statements of the companies and concluded that they were profitable.

JICA (2010) also found a large disconnect between the affordability to pay (ATP) and the willingness to pay (WTP) for SWM by Nairobi residents. According to JICA (2010), in slum areas and other informal settlements, the ATP was estimated at Kshs. 89.7 per month while the WTP was Kshs.77.7 per month. Other areas the report notes are - in low income areas, the ATP was Kshs.152.9 per month while the WTP was Kshs. 31.9 per month. In the low-middle income areas, the ATP was Kshs.328.6 per month while the monthly WTP was Kshs.35.3. In the case of middle income areas, the ATP was Kshs.768.8 per month while the monthly WTP was Kshs. 96.2. In the high-income areas, the ATP was Kshs.1,017.40 per month against a WTP of Kshs. 193.0 per month. On the other hand, the ATP for businesses was estimated at Kshs. 20,197 per month while the WTP was estimated to be Kshs.692 per month.

Using these two sets of variables, this paper posits that the proposed solution would work best with the low-middle, middle and high income residents and among business establishments. The proposed charge per trip should be Kshs.100 per collection trip in the low-middle income areas and middle income areas, Kshs.200 per trip in high-income areas and Kshs. 1,000 per trip for businesses.

Conclusion

This paper notes that the rapid growth in population that is attributable to a high birth rate together with rural- urban migration will make SWM more and more challenging for cities such as Nairobi. However, in the same way that technology provides a solution for many other challenges, the application of technology to SWM can form part of the solution for these cities. This paper considered the implementation of a mobile phone based application, Clean City, for

the delivery of SWM services. As illustrated in studies such as Bamodu (2013) as well as Mavropoulos, Tsakona and Anthouli (2014) highlighted in this paper, mobile applications of this nature can infuse efficiency and effectiveness into non-performing SWM systems.

Developers of Clean City contend that the app is intended to provide an intelligent consumer-centric waste transport management system that integrates the traditional waste-truck fleet management system with a modern on-demand waste collection service. The paper envisages a situation where the Nairobi City County government partially divests from SWM in favour of private entities through a Public-Private Partnership (PPP). Under this arrangement, the Nairobi City County government can provide a designated waste dumping site and engage in SWM in public areas and in the Central Business District while private entities can provide SWM in middle-income and high-income residential areas, commercial establishment as well as industries. Additionally, community based organizations can be involved in SWM in the low-income areas and informal settlements.

The developers opine that the implementation of Clean City requires the demarcation of Nairobi into waste collection zones and then enrolling private SWM service providers across the demarcated areas. It also involves the enrolment of customers who download the application and use it to request for their waste to be collected at their own convenience. The deployment of the waste collection trucks would be guided by the requests made by the customers to ensure that collection is done as soon as practicable taking into consideration the road traffic situation.

This paper found that cities which adopted similar technology in SWM reported reduced expenditure on SWM as well as efficiency (Bamodu, 2013, and Mavropoulos, Tsakona & Anthouli, 2014). Accordingly, the benefits of Clean City, if implemented under a PPP arrangement would include higher frequencies of waste collection, a wider waste collection route coverage as well as more efficient and effective use of waste collection trucks. Clean City customers can experience on-demand services with guaranteed waste collection in a welcome shift from the current situation where for many Nairobi residents waste collection remains a remote possibility. Private businesses will benefit from a cleaner ambience which is key in attracting and retaining customers in addition to a reduction in the cost and effort of SWM. For the Nairobi City County government, an efficient and effective SWM system will result in a cleaner city and in turn lead to greater satisfaction by residents.

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Appendices

Figure 1:
Source: Pictures taken by this paper authors in various estates in Nairobi – Woodley, Eastleigh, Ruai and Kangemi
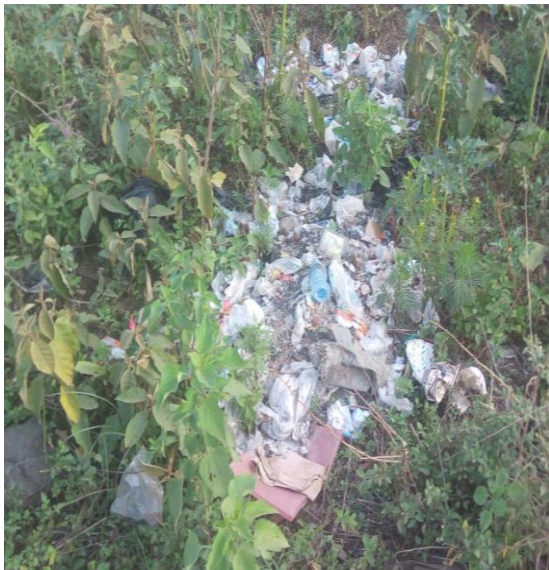
Figure 2

**Population and Solid Waste Generation Projections for Nairobi**

Year	2009	2010	2015	2020	2025	2030
Nairobi Population ('000)	3,040	3,150	3,760	4,420	5,150	5,940
Waste Generation (ton/day)	1,848	1,924	2,353	2,831	3,378	3,990

Source: Central Bureau of Statistics Kenya (CBSK) and *"World Economic Outlook"*, 2010, IMF, and the JICA Survey Team

Figure 3

JICA (2010) Solid Waste Management Map highlighting proposed alternative SWM sites around Nairobi
Source: JICA (2010)
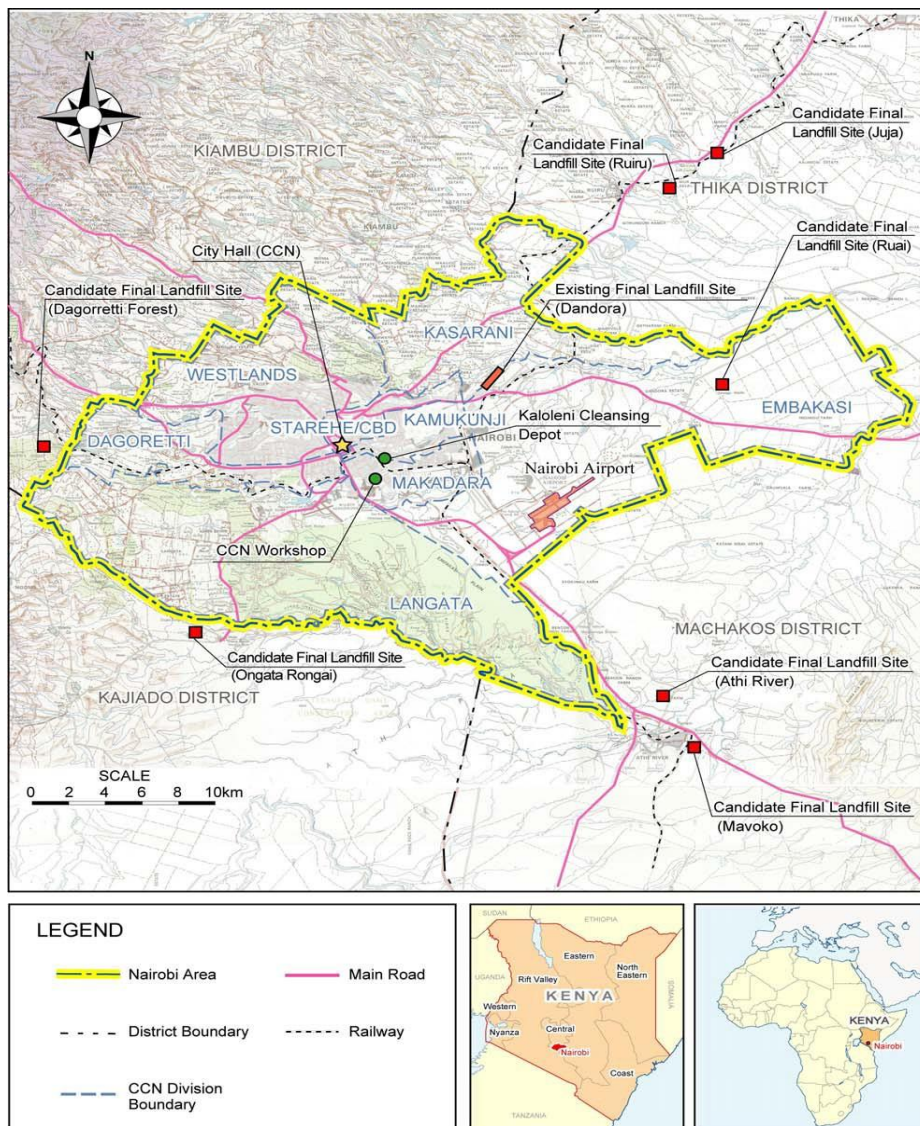
Figure 4 – Samples of proposed labelled dustbins

Source: http://photobucket.com/images/dustbin