*Journal of Environment Pollution and Human Health, 2016, Vol. 4, No. 2, 42-51*
Available online at http://pubs.sciepub.com/jephh/4/2/2

DOI:10.12691/jephh-4-2-2

# The Variability in the Generation, Disposal and Recycling of Mobile Phone E-waste According to Social Classes in Lang'ata Area, Nairobi, Kenya

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**Abstract** The specific objectives of the study were to; a) establish the number of mobile phones operated by urban dwellers within different social classes in the Lang'ata area of the City of Nairobi, b) determine the phone replacement frequency and related driving factors, c) explore the fate of previous mobile phones and modes of disposal for retired phones, and d) assess the level of knowledge and awareness on the importance of mobile phone recycling. Both qualitative and quantitative data were obtained by use of a semi-structured questionnaire administered through informed adult consent. The study sample size comprised 385 respondents distributed proportionally among the three social class zones including the low class zone in Kibera (212), middle class zone in South C, Nairobi West, Madaraka and Nyayo Highrise (131) and upper class in Karen (42). It was established that most of the respondents in their lifetime had owned a total of 7 mobile phones on average. Those in the high class had owned upto 10 phones, while those in the middle and low classes had owned an average of 7 phones. The average number of phones operated at the time of the study was 2 phones per person. It was established that a majority of respondents (52.6%) across the social classes, replaced their mobile phones within a period of 2 years which was shorter compared to the replacement frequency in other parts of the world. The main driving factors for handset replacement were; phone price and functionality, phone brand, phone battery lifetime, internet connectivity, and phone applications. 52.2% of the respondents indicated that they disposed their retired or damaged phones in normal waste bins, while 34.6% gave them out for additional use by other people. 10.1% respondents indicated that they sold them out for re-use. The study established that majority of the handset consumers were largely ignorant about the environmental and human risks associated with mobile phone e-waste hence the casual approach in the disposal of retired handsets. Similarly, the level of education and awareness on the wasted opportunities associated with lack of mobile phone e-waste recycling was quite low and needs to be addressed.

***Keywords:*** *mobile phones, e-waste disposal and recycling, urban social class*

**Cite This Article:** Larry Liza, and Francis Mwaura, "The Variability in the Generation, Disposal and Recycling of Mobile Phone E-waste According to Social Classes in Lang'ata Area, Nairobi, Kenya." *Journal of Environment Pollution and Human Health*, vol. 4, no. 2 (2016): 42-51. doi: 10.12691/jephh-4-2-2.

## 1. Introduction

The use of mobile phones in the world has increased tremendously over the years. In 2014, the total number of global mobile phone users was expected to exceed 5.6 billion [22]. By the end of 2018, this number is expected to increase beyond 6.2 billion with approximately 84% of the world population expected to be using the mobile phone technology [22]. According to the Pew Research Centre [18], cell phones are commonly used in Africa, including Eastern Africa. In 2002, for example, one-in-ten people in Kenya, Uganda, and Tanzania owned a mobile phone. Since then, cell phone ownership has grown exponentially in Africa just as in the United States of America. Cell phone use in Africa is mainly associated with texting, taking pictures or videos as well as for social networking such as through the Whats App. The use of mobile phone banking and money transfer is also very popular in some Eastern and Horn of Africa countries, such as Kenya, Uganda, Tanzania and Somaliland. In Kenya, leading money transfer dealers include the Safaricom M-Pesa, Airtel Money, Orange Money and Yu Cash. Mobile phones are also increasingly being used for internet services and FM radio connections including accessing breaking news [18].

As a result of the remarkable growth in the use of mobile phones, large quantities of electronic waste or e-waste are generated at their end-of-life (EoL). Such e-waste has become the fastest growing solid waste stream in the world. This production is expected to increase die to the digital evolution in the world, including developing countries like Kenya. According to Alam and Khalid [2], global e-waste production is rapidly growing with up to 72 billion tons of waste estimated to be generated annually by 2017. It is estimated that 75-80% of this waste is transferred from the developed to the developing countries especially

in Asia and Africa [21]. Some of the major e-waste recipient countries include China, India, Pakistan, Bangladesh, Ghana and Nigeria. The Bamako Convention was adopted in 1991 as a treaty of African nations that prohibits the importation of hazardous waste including e-waste [14]. The convention which came into force in 1999 is aimed at safeguarding the African environment and people from the hidden dangers associated with hazardous wastes including e-waste.

E-waste has emerged as a major environmental challenge in the world not only because of the increasing quantities of electrical and electronic wastes generated in the modern world but also because of the cocktail of hazardous and toxic ingredients associated with such waste. The waste is considered hazardous due to the presence of toxic substances such as lead, chromium, mercury, cadmium, arsenic as well as flame retardants such as polybrominated biphenyls and polybrominated diphenylethers which pose both environmental, occupational and public health risks [2,19,23]. Both cadmium and antimony are commonly used in the production of mobile phone batteries while lead is used in the solder that joins the parts of the mobile phone. The specific public health impacts of e-waste related toxicants are quite diverse. Empirical research has established that people who interact with e-wastes often suffer nausea, headaches, respiratory and numerous other health problems which are usually associated with other causes [2,21]. Scientific studies have shown that exposure to e-waste toxicants such as lead, cadmium, mercury, chromium and polybrominated biphenyls could lead to brain and central nervous system damage [2,21]. Lead which is an ingredient contained in many mobile phones, is a heavy metal with suspected carcinogenic effects on the central nervous system, immune system, kidneys and the liver. Other common human health problems associated with e-wastes include anaemia, diabetes, cardiovascular complications, birth defects, skin and lung cancers.

Urban areas are considered as the key centres of mobile phone uptake and utilization in the Africa region and are therefore potential hotspots for improper disposal of toxic mobile phone e-waste. In urban areas, e-waste is normally leaked into valued natural ecosystems such as rivers, dams, lakes, agro-ecosystems and livestock grazing areas. The likelihood of such waste eventually becoming assimilated by human beings either directly or through natural transmission along the food chain is very high [2]. Studies have, for example, established that the waste cadmium from one mobile phone battery is enough to pollute upto 600,000 litres of water [9]. Cadmium is associated with deficits in cognition, learning, behavior and neuromotor skills in children. It has also been linked to kidney damage. Consequently, mobile phone e-waste is therefore likely to become one of the fastest-growing environmental pollution problems in the world because of the increasing use of such devices.

Despite the above risks, the safe disposal and management of the toxic e-waste has remained as a major challenge in most countries of the world. In the 1990s, governments in the European Union (EU), Japan, and the United States of America (USA) began to tighten their regulatory frameworks against general e-waste management. The handling and recycling of e-waste in many developing countries is often inappropriate and not compliant to both the Basel Convention of 1992 and the Bamako Convention of 1998 [21]. Parties to the Basel Convention, including Kenya, are obliged to ensure environmentally sound management of hazardous wastes, particularly during disposal. Consequently, Decision VIII/6 on Mobile Phone Partnership Initiative (MPPI) of the Nairobi Declaration on environmentally sound management of e-wastes was adopted during the 8th Conference of Parties to the Basel Convention in 2006 which was held in Kenya. However, e-waste management is still a major challenge in most developing countries due to the inadequate capacity to deal with the increasing quantities of such wastes. At the same time, this challenge has not received adequate scientific attention in the developing countries compared to the bigger problem of general solid waste management especially in the urban areas. The lack of scientific information is likely to slow down the process of timely development of appropriate governance and regulatory frameworks for effectively dealing with the e-waste challenge in a sustainable way.

Kenya has witnessed exponential growth in the use of mobile phones, with the Communications Authority of Kenya (CA) reporting that the number of users in December 2014 was 33.6 million with a penetration of 82.6% which was much higher than the average penetration in the Africa region where the average penetration was estimated at 65% [4]. The above figures indicate that with a national population estimate of about 42 million in Kenya, approximately 3 out of 4 persons in the country own a cellular phone. Under normal circumstances, it is expected that at some point in the course of use, the mobile phone will have to be retired after becoming obsolete or getting damaged. At that point the phone or some of its accessories such as battery, screen protectors or earphones have to be discarded thereby generating e-waste. According to NEMA [14], the current e-waste generated annually in Kenya is approximately 11,400 tonnes including 150 tonnes from mobile phones. An earlier study by Mureithi and Waema [11] had estimated the total e-waste generated each year in Kenya was about 3,000 tonnes.

Kenya has made significant efforts towards the establishment of national guidelines and legal frameworks on the disposal and management of e-waste in the country. In 2010, national guidelines for e-waste management were developed in order to streamline the procedures of handling and disposal of e-waste in various sectors [14]. The guidelines provide a framework for identification, collection, sorting, recycling and disposal of e-waste in line with the provisions of Vision 2030 of ensuring a clean and healthy environment. The guidelines require the establishment of e-waste recycling and treatment facilities in line with the Environment Management and Coordination Act (EMCA) 1999, Environmental Management and Co-ordination (Waste Management) Regulations, 2006. In 2013, Kenya also became among the first countries in Africa to develop e-waste management regulations through the enactment of the Environmental Management and Co-ordination (E-waste management) Regulations, 2013. However, studies have not been undertaken to establish the effectiveness of these frameworks in ensuring the sustainable management of e-waste especially in urban areas.

Studies have established that urban waste management is a complex issue that is influenced by a wide range of social factors. However, the relationship between social stratification and municipal solid waste generation remains unclear especially in the developing countries which are experiencing very rapid and socially stratified urbanization [8,24]. According to Xiao *et al* [24], urban social class, including factors such as residential area, level of education, occupation and level of income can have a significant influence on waste generation, disposal and management. While the rich and affluent may be able to accommodate issues concerning sustainable e-waste management due to their level of education and financial ability, most poor people in the urban areas of Africa are usually restricted to slums and informal settlements where sustainable e-waste management might not be a priority. This issue has not been adequately considered by researchers in Kenya.

This study focused on the generation, disposal and recycling of mobile e-wastes by phone users in the Lang'ata area according to the social classes in terms of the upper class, middle class, and low class. The study sought to determine the social class differences in the generation, disposal and recycling of mobile phone e-waste. The specific objectives of the study were to; a) establish the number of mobile phones operated by urban dwellers within different social classes in the Lang'ata area of the City of Nairobi, b) determine the phone replacement frequency and related driving factors, c) explore the fate of previous mobile phones and modes of disposal for retired phones, and d) assess the level of knowledge and awareness on the importance of mobile phone recycling.

## 2. Research Methodology

The City of Nairobi is located at the edge of the central and rift valley regions of Kenya with an approximate area of 700km$^2$ (Figure 1). It is the capital city of Kenya is one of the largest urban centres in Africa and a key economic hub in Eastern and Central Africa. According to the 2009 national population census, the total population of Kenya was 38.6 million with the City of Nairobi having approximately 3.2 million people [12]. Within the next few decades, the population of Nairobi is expected to reach 10 million. The day-time population of Nairobi City was estimated to grow from 3.2 million people in 2009 to about 5.5 million in 2030 (Nairobi City County 2014). Lang'ata is one of the 17 Sub-counties in the Nairobi City County (Figure 1). Figure 2 shows the administrative divisions in the Lang'ata sub-county which has an area of approximately 106km$^2$ and a population of 355,188 in 2009 which translated to a population density of approximately 3,346 persons/km$^2$ [12].

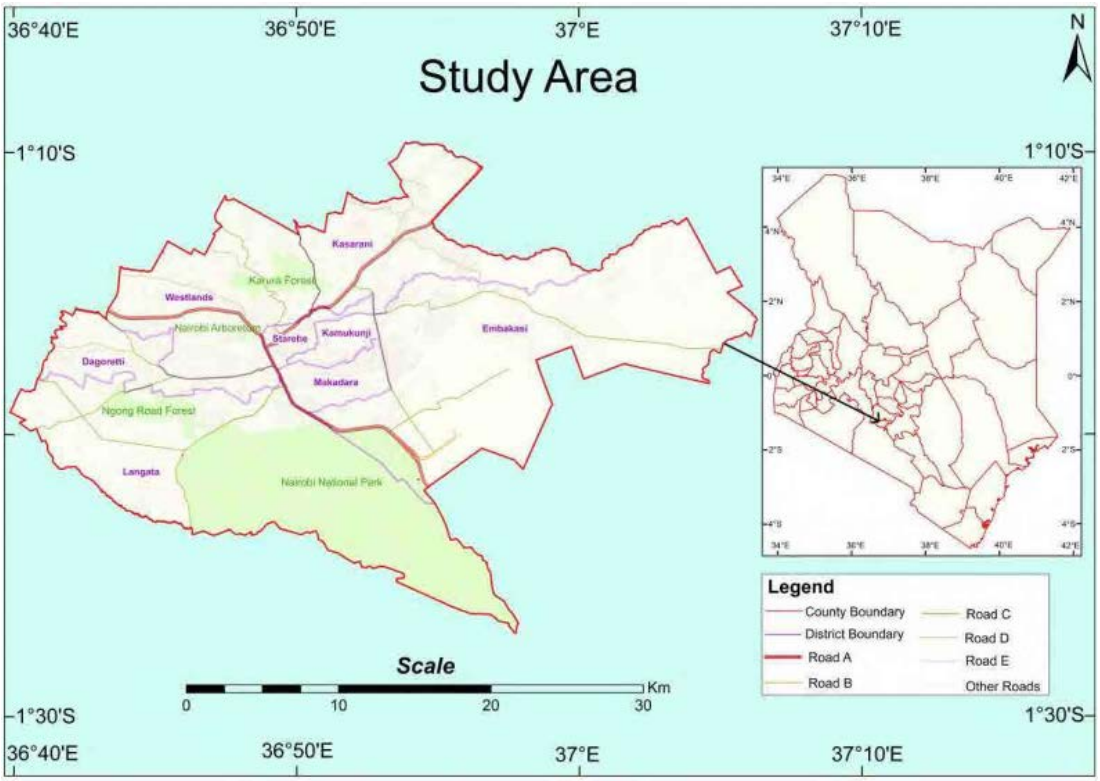


**Figure 1**. The location of the City of Nairobi and Langata area

Lang'ata is a mixed urban residential area dominated by middle class residential estates such Madaraka, South 'C', Nairobi Dam, Airport view, Nyayo Highrise, Southlands, Otiende, Ngei, Onyonka and Jonathan Ngeno. This zone is characterized by flats, maisonettes and bungalows for people who work mainly in the City of Nairobi. The Lang'ata area is also characterized by the high class Karen zone which is associated with low density residential properties characterized by single family dwelling units for wealthy business people and politicians including a significant number of remnant colonial settlers. Finally, Lang'ata is associated with the Kibera Slums, which is one of the largest in Africa and hosts a huge population of unemployed people as well as casual workers who commute daily to the Nairobi industrial area. Lang'ata area is associated with a number of valued ecosystems

such as the Motoine River which originates from the Karen area and flows through Jamhuri Park and Kibera slum eventually discharging into the Nairobi dam near the Wilson Airport. The area is also bordered to the south by the 117 km$^2$ Nairobi National Park with over wildlife 400 species including the endangered black rhino, lions, leopards, cheetahs, hyenas, buffaloes, giraffes, hippos and crocodiles.

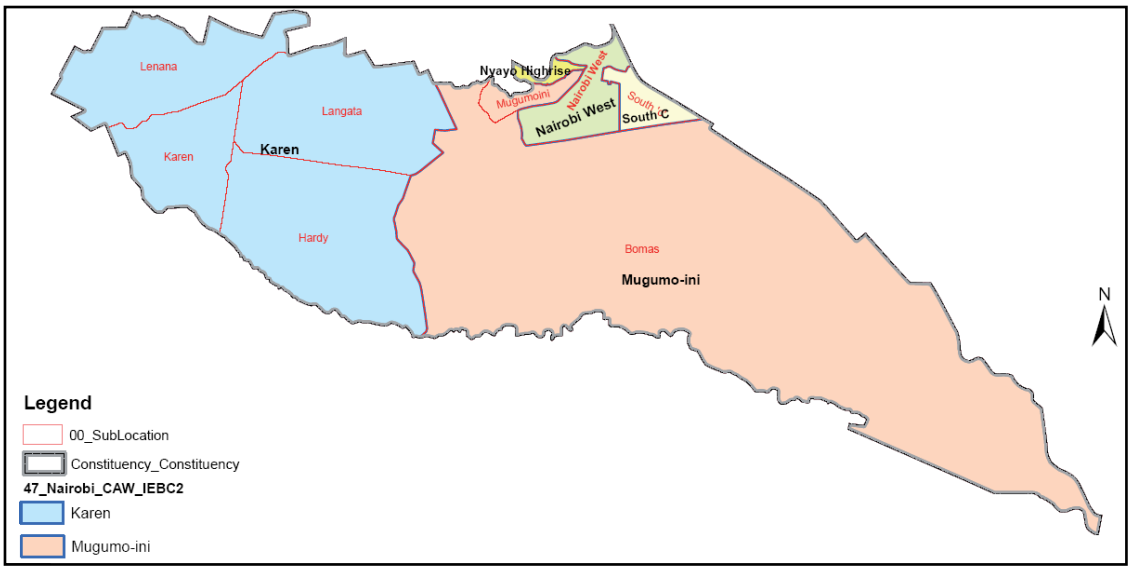


**Figure 2.** Map of the Lang'ata area with key administrative and residential zones

Solid waste management in the City of Nairobi is a growing problem because of rapid urbanization and rural-urban migration. The 45-acre solid waste dumpsite in Dandora is the final disposal site for most of the city which receives over 1.8 million m$^3$ of solid waste against its original capacity of 500,000 m$^3$ annually. Although e-waste is included in the Nairobi City County Solid Waste Management Bill (2014), the framework however does not include such waste in its waste separation portfolio (Republic of Kenya 2014). Sections 20 and 25 of the Bill requires the separation of solid waste including colour coding of waste bins in green for organic waste, blue for plastic and paper waste and brown for other waste [20].

Data collection in the study was undertaken by use of a semi-structured questionnaire administered through informed adult consent. The sampling was structured against the 2009 total population of Langata which was estimated at 355,188 people. The urban household was used as the unit of sampling based on the household framework used during the 2009 national population census. This population was stratified by social strata in accordance with the three types of residential areas as explained above. The sample size consisted of 385 respondents at household level which was distributed among the three social class zones based on the 2009 population structure and in accordance with the statistical procedure by Bernard [3]. The sample size included 55% in the low class, 34% in the middle class and 11% in the upper class as shown in Table 1. The systematic sampling technique was utilized in the identification of target households by considering every tenth household on alternate sides of the street.

**Table 1. Population distribution in sample size**

| Social class | Cluster population | Sample size | Sample % |
|---|---|---|---|
| Lower class | 194,269 | 212 | 55 |
| Middle class | 121,371 | 131 | 34 |
| Upper class | 39,548 | 42 | 11 |
| Total | 355,188 | 385 | 100 |

Exploratory data analysis was undertaken to generate descriptive statistics including percentages, means and standard deviations. Analysis of variance (ANOVA) was used to assess the variance in responses across the social divide using the F-test. Only the tests with P-values of >0.05 were considered as statistically significant. The Statistical Package for Social Sciences (SPSS 21) was used in the data analysis after which the findings were presented in the form of tables, charts, data summary tables and narratives.

## 3. Results and Discussion

The findings showed that majority of the respondents had acquired formal education with up to 50% of the respondents in the middle and high class categories having attained university education compared to less than 2% in the low class category. Only less than 3% of the respondents did not have any formal education (Figure 3).

The study established that most of the respondents owned one or more than one mobile phones with 96% of the phones in a functional state and only 4% as non-functional. For most part, the second phone was retained by the owner for a number of reasons including, sentimental attachment, phone record backup especially phone contacts, hope for future repair, lack of appropriate disposal means or mere hoarding. Table 2 shows the total number of phones owned by urban dwellers across the social strata. It was established that most of the respondents on average had owned a total of 7 mobile phones in their lifetime with those in the high class having owned upto 10 phones while those in the other two social classes had owned upto 7 phones. The average number of mobile phones operated at the time of the study was 2 phones per person (Table 3). There was significant difference between the different social classes in terms of the number of phones ever owned by the respondents as determined by one-way ANOVA ($p = 0.008$). A Turkey

post-hoc test revealed that the number of phones ever owned was significantly smaller for the lower class respondents in Kibera compared to the upper class group in Karen ($p = 0.006$) as shown in (Table 3). The one-way ANOVA also revealed a statistically significant difference between the different social classes in terms of the number of phones operated by the respondents in the course of the study ($p < 0.001$). A Turkey post-hoc test showed that the number of phones in operation was significantly smaller for the lower class in Kibera compared to the middle and the upper class respondents in Karen.

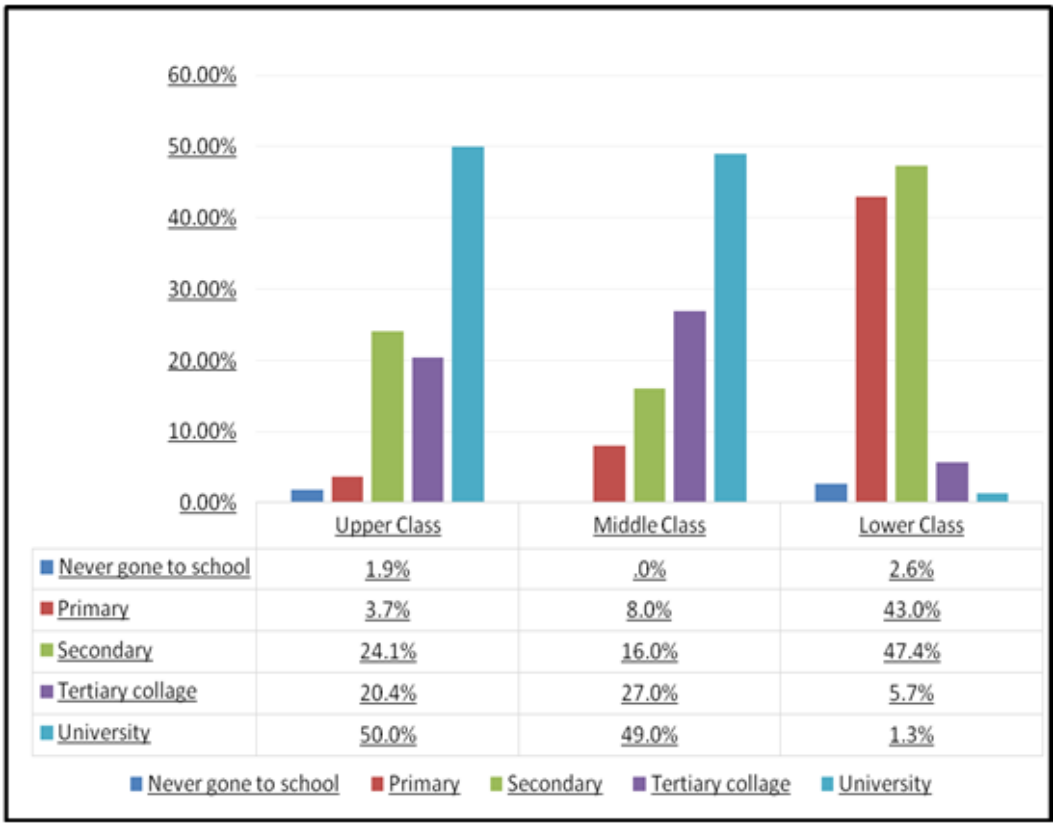


**Figure 3.** Highest education level for the respondents

**Table 2. Comparison of the total number of mobile phones owned by social class**

| Number of phones | Social class | N | Mean | Standard deviation |
|---|---|---|---|---|
| Number of mobile phones owned in entire life | Upper class | 42 | 9.50 | 12.383 |
| | Middle class | 131 | 6.58 | 10.023 |
| | Low class | 212 | 5.35 | 7.171 |
| | Mean | 385 | 7 | 8.941 |
| Number of mobile phones owned at the time of the study | Upper class | 42 | 2.07 | 1.385 |
| | Middle class | 131 | 1.67 | .805 |
| | Low class | 212 | 1.36 | .684 |
| | Mean | 384 | 2 | .881 |

**Table 3. Social class difference on number of mobile phones owned by social class**

| Number of mobile phones | | Sum of squares | df | Mean square | F | p or ∞ |
|---|---|---|---|---|---|---|
| How many mobile phones have you had in your entire life | Between Groups | 773.527 | 2 | 386.764 | 4.948 | .008 |
| | Within Groups | 29861.522 | 383 | 78.172 | - | - |
| | Total | 30635.049 | 385 | - | - | - |
| How many mobile phones owned at the time of the study | Between Groups | 24.635 | 2 | 12.317 | 17.236 | .000 |
| | Within Groups | 272.991 | 383 | .715 | - | - |
| | Total | 297.626 | 385 | - | - | - |

Figure 4 shows that over half of all the respondents in the three social classes replaced their handsets between one and two years. However, the upper class respondents reported a higher rate of phone replacement compared to other two social classes. In Karen, up to 46% of the respondents indicated that they replaced their handsets every year compared to 16.5% in Kibera (Figure 4). It was established that up to 25.4% of the respondents in the low class had retained at least one handset for over 5 years compared to 9.3% and 17.5% in the high class and middle class, respectively. Up to 4% of the respondents had kept the same phone throughout their lifetime compared to less than 2% in the high class. These findings indicated a higher mobile phone throw-away culture among the wealthy urban people than the poor most probably due to the affordability factor.

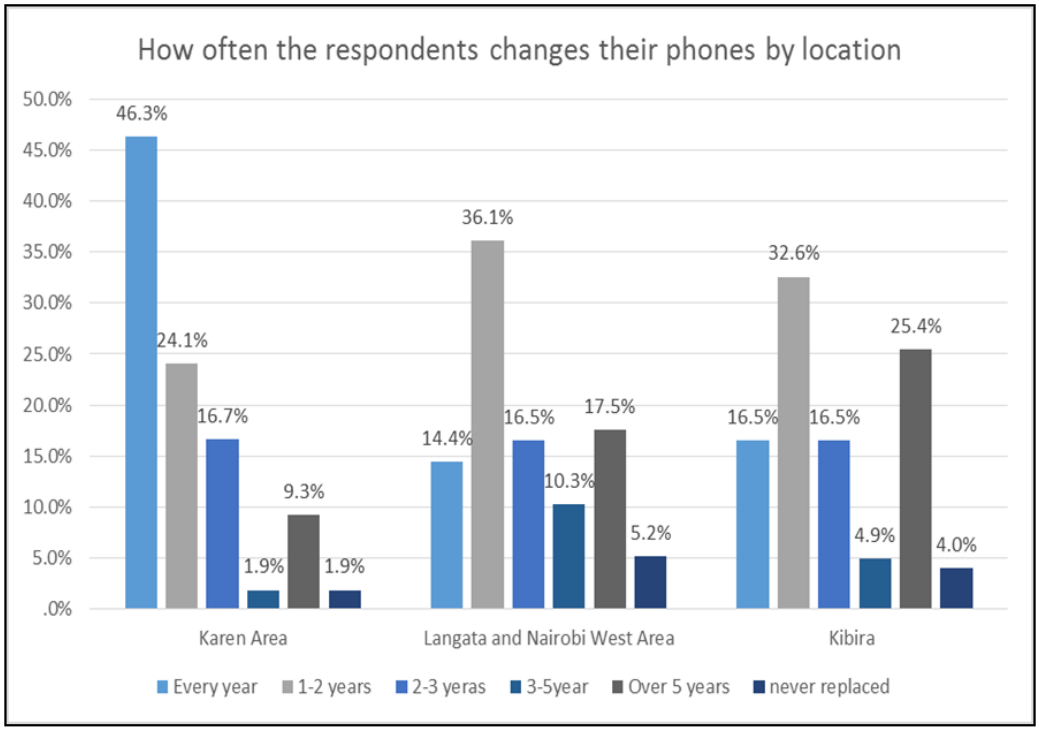


**Figure 4.** Replacement frequency of mobile phones by social class

**Table 4. Key factors of consideration by respondents in the acquisition of new mobile phones and disposal of retired ones**

| Factors of consideration | Upper Class (%) | | | Middle Class (%) | | | Lower Class (%) | | | Average |
|---|---|---|---|---|---|---|---|---|---|---|
| | Low | Moderate | High | Low | Moderate | High | Low | Moderate | High | |
| Functionality | 7.7 | 0 | 92.3 | 6.1 | 1 | 92.9 | 5.2 | 0.5 | 94.3 | 5 |
| Brand | 14 | 6 | 80 | 15.6 | 10 | 74.4 | 29.8 | 3.8 | 66.3 | 4 |
| Look | 21.3 | 12.8 | 66 | 30.4 | 8.7 | 60.9 | 41.6 | 5.3 | 53.2 | 3 |
| Application | 20.4 | 2 | 77.6 | 10 | 7.8 | 82.2 | 36.2 | 8 | 55.8 | 4 |
| Pricing | 22 | 4 | 74 | 12.2 | 12.2 | 75.6 | 9.7 | 2.8 | 87.5 | 4 |
| Adverts | 68.1 | 4.3 | 27.7 | 59.8 | 8 | 32.2 | 70.1 | 10.8 | 19.1 | 2 |
| Design | 34 | 12.8 | 53.2 | 31.5 | 14.6 | 53.9 | 43.6 | 11.8 | 44.6 | 3 |
| Battery | 4.1 | 6.1 | 89.8 | 7.8 | 4.4 | 87.8 | 6.5 | 4.5 | 89.1 | 5 |
| Display | 41.7 | 14.6 | 43.8 | 39.8 | 14.8 | 45.5 | 67.2 | 5.6 | 27.2 | 3 |
| Internet | 13.7 | 3.9 | 82.4 | 6.7 | 6.7 | 86.7 | 40.8 | 14.1 | 45.1 | 4 |
| Camera | 16.7 | 8.3 | 75 | 11.4 | 17 | 71.6 | 40.9 | 12 | 47.1 | 4 |
| Music | 22.4 | 10.2 | 67.3 | 25 | 16.3 | 58.7 | 35.4 | 14.6 | 50 | 3 |
| Warranty | 31.9 | 10.6 | 57.4 | 31.6 | 3.8 | 64.6 | 50 | 6.9 | 43.1 | 3 |

Table 4 shows the results of the analysis of key driving factors associated with mobile phone replacement across the social classes. The respondents were required to rank the replacement driving factors from 1 to 5, with 1 representing the lowest consideration and 5 the highest. In the high and middle class, the top five considerations were associated with handset functionality, battery lifetime, internet connectivity, phone brand and phone applications. In the case of the respondents in the low class the key considerations were phone functionality, battery lifetime, pricing, phone brand, and applications.

The study findings showed that internet connectivity was not an important consideration for the low class people who were more concerned about the price of the handset. The difference can be attributed to the economic status, lifestyle and the kind of business which the people were associated with in their social class. In Kibera, most people are casual workers with simple and sometimes desperate lifestyles and limited savings. They do not deal with daily business that requires internet uses. The high consideration given to pricing by the low class people is likely due to their low purchasing power and hence their greater consideration on phone affordability. The study established that commercial advertisements by mobile phone marketing companies was not among the important considerations by phone users in all the three social classes (Table 4).

The results indicated that socio-economic status played a significant role in determining the disposal method for retired handsets. The upper class, due to their economic capacity, were associated with a higher turn-around time in the use of mobile phones compared to the middle and lower classes. The main reasons for this were attributed to their ability to respond to the introduction of newer and/or more modern handset brands in the market. Such phones were considered to be more convenient both in terms of functionality and applications. The rate of phone disposal in the middle class was considerably lower than the upper

class where the people considered the issues of functionality, battery life and internet connectivity as key reasons to dispose one phone and acquire another better one. The low class on the other hand, had a lower rate of handset disposal. Commercial advertisement did not affect the handset replacement frequency and cannot therefore be considered as a major cause of mobile phone e-waste build-up.

On the disposal of end-of-life (EoL) mobile phones, it was established that the most frequently disposed mobile phone accessories included phone batteries, battery chargers, earphones and phone screens. 52.2% of all the respondents indicated that they disposed their retired or damaged phones and related accessories in normal waste bins, while 34.6% gave them out for use by other people. Only 10.1% of the respondents sold their retired phones for re-use. 1.9% of the respondents indicated that they offered their EoL phones for recycling. In terms of the actual mode of phone disposal, over 55.3% of all low class respondents indicated that they disposed their spoilt phones in regular waste bins alongside other wastes without any separation compared to 50% in the upper class and 46.5% of the middle class. Another 46.5% of the middle class indicated that they usually gave out their spoilt mobile phones to other people, compared to 36.4% in the upper class and 28.7% in the low class. 11.7% of the low class respondents indicated that they sold their spoilt handsets, compared to 9.1% of the upper class and 7% of the middle class.

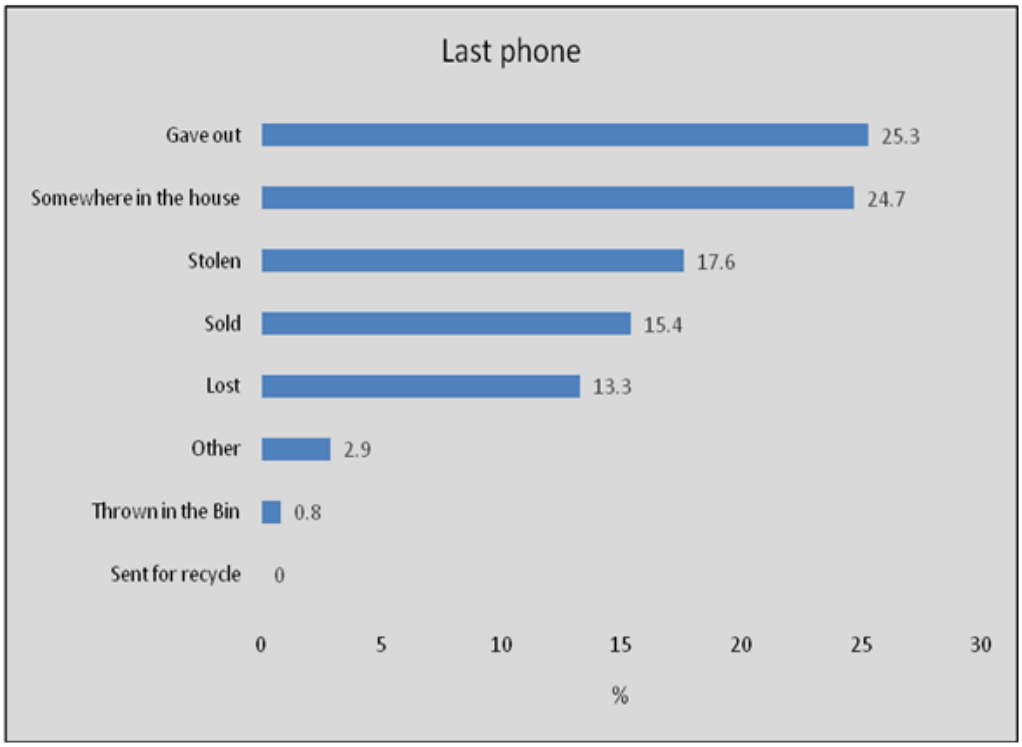


**Figure 5.** Fate of the last phone owned by the respondents

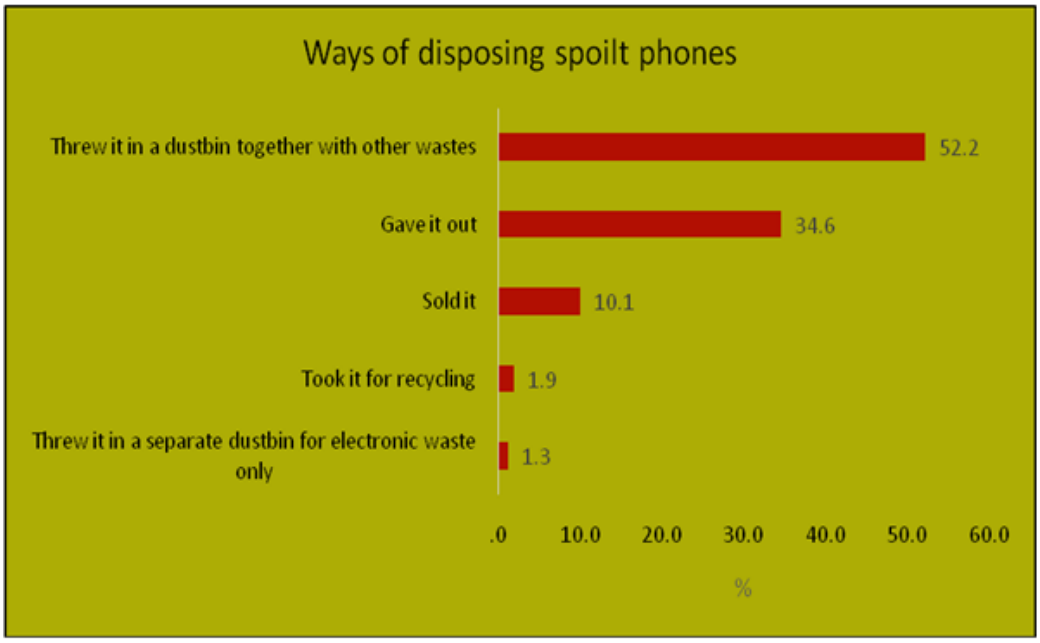


**Figure 6.** Modes of disposal of the last spoilt phone owned by all the respondents

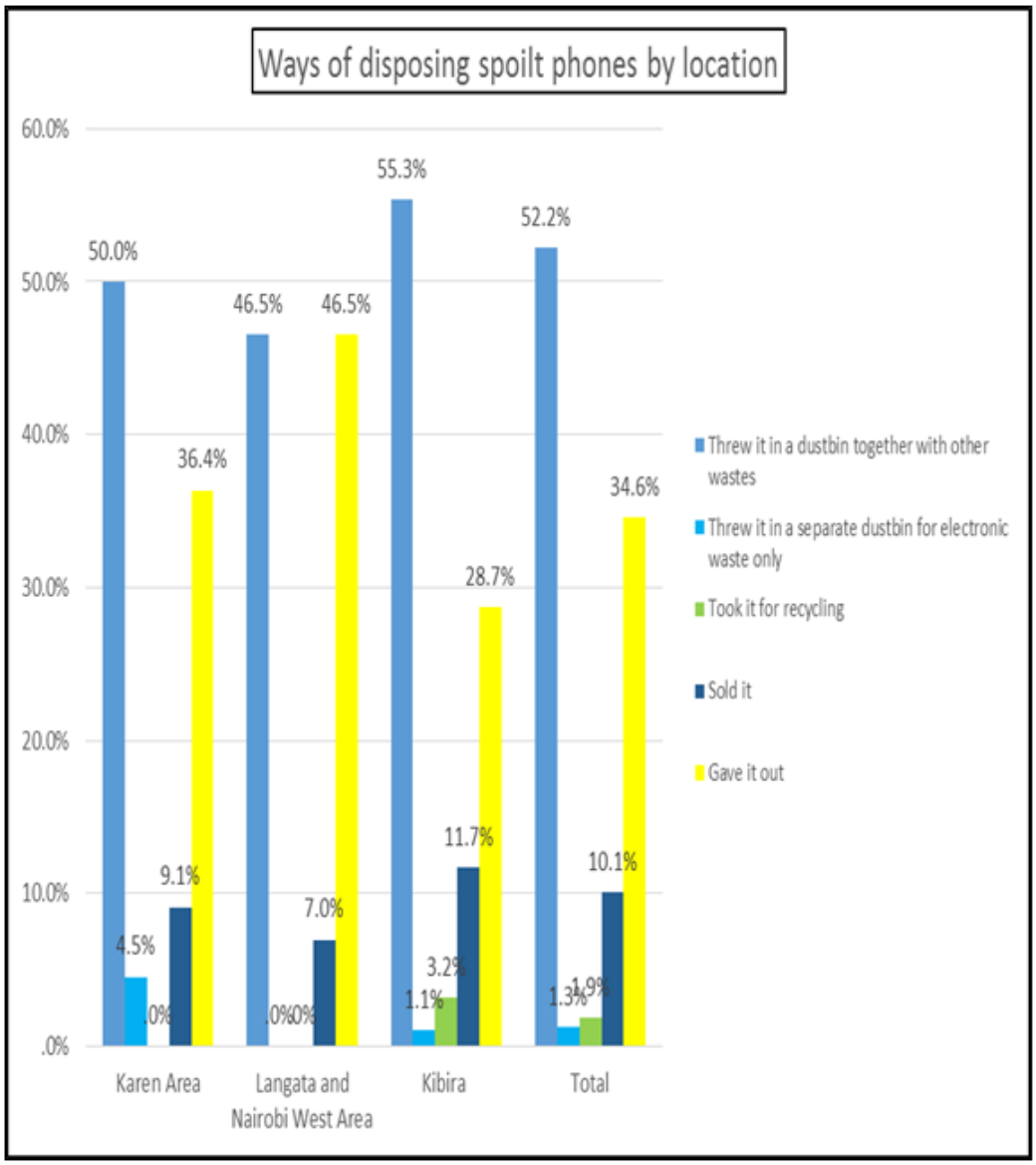


**Figure 7.** Modes of disposal of the last spoilt phone according to social class

On the average, only 1.3% of the phone users indicated that they deposited their retired phones in special e-waste bins. This was higher in the case of the high class respondents (4.5%) compared to 0% for respondents in the middle class and 1.1% in the low class. Similarly, only 3.2% of the respondents in the low class indicated that they were recycling their disposable mobile phones although it was not very clear how this was done. Figure 5 shows the overall statistics on the fate of the last phone owned by the respondents while Figure 6 provides the overall statistics on the modes of disposal of the last spoilt phone owned by all the respondents. Figure 7 provides statistics on the modes of disposal of the last spoilt phone according to social class.

The study sought to know how much the respondents knew about the e-waste management protocol in Kenya especially the National Guidelines for E-waste Management and the Environmental Management and Co-ordination (E-waste management) Regulations, 2013. 46.2% of respondents indicated they knew nothing about those frameworks, while 25.9% and 20.3% indicated that they either knew very little or had moderate knowledge, respectively. Only 7.7% of the respondents indicated that they were fully aware about the e-waste recycling protocol in Kenya. When the e-waste recycling awareness was analysed according to social classes, it was established that over 50% of the low class respondents knew nothing about the importance of e-waste recycling compared 32% in the middle class and 31.5% for the upper class. The proportions of those who knew very little included 26.2% of the low class, and 25.8% and 24.1% of the middle and upper classes, respectively (Table 5).

**Table 5. Responses on knowledge and awareness of the importance of e-waste recycling by social class**

| | | Upper class (%) | Middle class (%) | Lower class (%) | Total (%) |
|---|---|---|---|---|---|
| How much would you say you know about the importance of mobile phone recycling | Nothing | 31.5 | 32 | 55.5 | 46.1 |
| | Very little | 24.1 | 25.8 | 26.2 | 25.8 |
| | Moderately | 37 | 32 | 11.8 | 20.5 |
| | Very much | 7.4 | 10.3 | 6.6 | 7.6 |
| | Total | 100 | 100 | 100 | 100 |

The results showed that the numbers of those who reported knowing very much or moderately on mobile phone e-waste recycling were higher among the middle and high social classes compared to the low class. The proportions associated with high awareness on the recycling of retired mobile phones included 10.3% in the middle class, 7.4% in the upper class and only 6.6% in the low class. Those who reported moderate awareness knowledge included 37% in the upper class, 32% in the middle class and 11.8% in the low (Table 5).

In comparison to other studies, it was established that the overall mobile phone replacement frequency of two years in the Langata area of the City of Nairobi was quite short compared to other parts of the world because most phone users in the rest of the world upgraded their phones within three years [6,17]. But the replacement frequency in Langata was found to be similar to mobile phone consumer behaviour in Europe. AEA [1] reported that in 2006, 27% of European mobile phone users replaced their phones every year while 60% replaced in them in two years. However, Entner [5] has reported that the Germans and Italians retained their handsets beyond four years, more than twice as long as the Americans. Entner [5] showed that people in the USA replaced their mobile handsets after one year and nine months which was also quite frequent in comparison to the Indians who replaced theirs after seven years and nine months. The Brazilians are also known to be quite conservative with a mobile phone replacement frequency of six years and eight months [5].

The finding in this study of inappropriate disposal and management of retired mobile phones in the Lang'ata area in the City of Nairobi was quite similar to the findings in other studies. Li *et al*. [10], for example, also established that most retired mobile phones in China are not properly disposed at their end- of-life stage. Various factors appear to influence this action including sentimental attachment as well as the poor level of knowledge and awareness on mobile phone recycling. Although Nokia East Africa has a mobile phone take back scheme in the region which is aimed at convincing mobile phone users to recycle their EoL mobile phones instead of trashing them, many phone users including the well-educated are not aware about it [15]. The Nokia programme was launched in Kenya in 2008 and covers the Eastern African countries of Kenya, Rwanda, Somalia, Tanzania and Uganda [15]. In Kenya, the programme allows mobile phone users to drop off their EoL handsets at one of their six designated collection centers four of which are located in Nairobi and one each in Kisumu and Mombasa respectively [15]. Thereafter, the retired EoL phones and accessories are then sent to Europe for recycling. By the end of 2008, only 3% phone users recycled their EoL handsets despite the fact that most of them had such phones in their homes which they no longer used. The ignorance and poor level of education and awareness on available EoL mobile phone recycling opportunities was evident in this study.

This study therefore concurs with other studies that the rate of mobile phone e-waste recycling is still low in Kenya just like in the rest of the world [13,17]. Only 1.9% of the respondents in this study indicated that they were recycling their retired mobile phones compared to the global rate of 13% [7]. The rate of mobile phone e-waste recycling is quite low even among some developed countries such as Australia where a low rate 4% has been reported by Jiang *et al.*, [7]. Other studies have shown that monetary incentives might be necessary in order to motivate phone users to participate in phone-take-back schemes for retired phones [10,25]. In this study, 87.9% of the respondents were willing to give out their phones for recycling if a monetary incentive was available.

## 4. Conclusion and Recommendations

It was evident from this study that social-economic status is a key factor in the replacement frequency of handsets which is associated with the generation of mobile phone e-waste. The more economically endowed people in the society have a higher turnover of phones due to their higher purchasing power, and are quicker to replace aging, spoilt or lost phones. Nevertheless, the low cadre of the society also produces substantial e-wastes primarily because of the desire to acquire cheaper phones with short life spans and high disposability. The low class people usually opt for cheaper phones and accessories, thereby leading to high replacement levels, especially for critical accessories such as phone batteries and chargers.

It is evident that e-waste recycling remains low across the urban social classes, including societies with higher level of education and awareness on the environmental and public health impacts of mobile phone e-waste. E-waste recycling in Kenya is still at insignificant levels but is likely to become a rich haven for e-waste recycling initiatives. It is also evident that majority of the mobile phone users in the urban areas of Kenya are largely ignorant about the environmental and human risks associated with mobile phone e-waste hence the casual approach in the disposal of EoL handsets.

Based on the findings of this study, it is recommended that efforts be made to:- a) promote mobile e-waste recycling especially through old phone take-back and recycling opportunities through the establishment of additional disposable EoL phone collection centers which should also be widely publicized at the point of phone acquirement, b) strengthening the level of education and awareness among the mobile phone marketers on the existing e-waste management frameworks especially the National Guidelines for E-waste Management and the Environmental Management and Co-ordination (E-waste management) Regulations, 2013, c) supporting Extended Producer Responsibility (EPR) by focusing on ensuring that mobile phone manufacturers are more responsible for the entire life-cycle of their products, e) introduction of e-waste training modules in schools and universities in order to promote a shift from the throw-away culture of the present to a more sustainable e-waste management culture in the future.

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