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Reducing environmental hazard caused by disposed mobile phones in developing countries

Abstract

The utilization of unused and retired mobile phones in South Africa and other African countries poses a significant environmental hazard. Disposing of retired mobile phones in a safe manner has become an issue of concern in South Africa because of health and environmental hazards associated with it. This study investigates the methods of disposing and recycling of old, unused and retired mobile phones and their associated environmental effect on humans and plants in Africa. A case study approach was used in this paper. Participants were selected from three cities in South Africa, targeting three government institutions and three mobile phone service providers. Semi-structured, open-ended interview questions were used to get evidence from the participants regarding how old, unused and retired mobile phones are disposed and possible effect of these on the environment. The interviews were recorded, transcribed and coded. Findings revealed that most common method of disposing of old, retired mobile phones was donating them as gifts, selling to second-hand shops or storing in homes as spare phones. Based on findings, a proposed framework was developed to guide the collection process, reducing, reusing and recycling of old and retired mobile phones in Africa. The framework will not only assist manufacturers and retailers in selecting a better option of disposing old mobile phones, but also will to improve the hazardous environmental conditions, which affect humans and plants.

Keywords: retired mobile phone, environmental problems, developing countries, toxic metals.
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Introduction

The proliferation of mobile phone networks and other ICT infrastructure has transformed communications in Sub-Saharan Africa making them easier, faster and anywhere. Mobile phones have also allowed Africans to skip the landline stage of development and jump right into the digital age (Cell Phones in Africa, 2015). A survey conducted by Poushter (2016) regarding cell phone ownership in Sub Saharan Africa showed that two-thirds of the population in Africa own mobile phones. It was further established that the ownership of mobile phones in certain African countries like South Africa and Nigeria are very high, where about nine in ten of the population own a mobile phone. Similar growth in mobile phone penetration is seen in all other African countries where survey data are available. Sub-Saharan Africa has the poorest infrastructure projects in the world, with around 29 percent of paved roads, 30 percent accessibility of landline telephones and 25 percent availability of electricity (ITU, 2009). However, accessibility and usage of mobile phones in Sub-Saharan Africa has increased exponentially over the past ten years. It is indicated that availability of mobile phones is ten times as many as landline phones in Sub-Saharan Africa (ITU, 2009). The explosion of mobile phones in Africa has brought new hope in economic development and poverty eradication (Corbett, 2008). Mobile phones have bridged the gap between urban and rural communities, rich and poor and individuals connected to families and to information services (Aker, 2009; Klonner & Nolen, 2008). Aker (2009) further notes that mobile phones have improved agricultural and labor market efficiency and producer and consumer welfare in the Sub-Saharan region of Africa. All these, according to Aker (2009), have been realized through low communication costs of mobile phones, which enables individuals and firms to obtain information quickly and inexpensively on economic and social matters.

Due to the spread of mobile phones in Africa (the words Africa and Sub-Saharan Africa are used interchangeably in this paper), many individuals possess two or more mobile phones – one being a smart phone and the other a normal mobile phone. Smart phones are those mobile phones that can access the Internet and other apps such as iPhone, Blackberry or Android devices. According to Bauer et al. (2005), mobile phones have become the communication tool as a technology of choice for individuals who look for greater interconnectedness. Again, mobile phones are becoming cheaper, easy to use and do not require much literacy or numeracy for its basic use. They can be shared, prepaid, billed in prices per second, depending on the needs and

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abilities of the owner. Mobile phones are also capable of providing a diversity of interactive activities. Applications like text messaging, calling, and Internet browsing are all possible from these small devices. In African social networking, sending and receiving e-mails, instant messaging, and checking facts and definitions are the most common applications of mobile phones used by the population. The use of games, online newspapers, books, radio, and videos are also signs which confirm that the traditional medium of communication is being replaced.

Despite the high rate of mobile phone penetration and the accrued benefit of mobile phones both to individuals and developing countries, the mobile phones cause health hazard and environmental risk to people who use it. The component material these mobile phones are made of are highly toxic and hazardous to the environment (Osibanjo & Nnorom, 2008). The danger of the material component to human beings and the environment becomes more evident when the end of life (EOL) of these mobile phones is reached. With the high proliferation of mobile phones in South Africa and other African countries, the question is how do we reduce the health and environmental hazards caused by these mobile phones when they reach their end of life cycle and are disposed by users?

In this paper, I reviewed how mobile phones could contribute to sustainable economic development and how waste materials generated by these mobile phones, as well as issues regarding the environmental sound management of these obsolete mobile phones are accomplished. Based on the findings, the researcher proposed a Retired Mobile Phone (RMP) framework to manage the health and environmental hazards caused by the disposed mobile phones.

The remaining sections of this paper are structured in this order: literature review, methodology, findings, analysis of results, proposal of EOL and RMP frameworks and conclusion.

1. Literature review

The literature review consists of two main parts: life cycle of mobile phones and waste generated by mobile phones, and e-waste management legislatory framework. The next section focuses on the life cycle of mobile phones and waste generated by mobile phones.

1.1. Life cycle of mobile phones and waste generated by mobile phones. This section, firstly, reviews literature on the economic benefits of mobile phones to consumers and producers in Africa and how this can be used for sustainable development in the African continent. Secondly, the life cycle of mobile phones is considered, and, finally, environmental issues regarding waste generated by these mobile phones is discussed. The next paragraph deliberates on the economic sustainability of mobile phones.

1.1.1. Mobile phones for economic and sustainable development in Africa. The advent of mobile phones in Africa has brought new hope due to its effect on economic development. Policy makers, newspapers and mobile phone companies have publicized mobile phones as devices for poverty eradication (Corbett, 2008). The Sub-Saharan region of Africa has poor infrastructure development. Some recent research indicates that a mere 29 percent of roads in Africa are paved, electricity is accessible to just about a quarter of the population and fewer than three landline phones per 100 people are available (ITU, 2009; World Bank, 2009). However, for the past ten decades, accessibility and usage of mobile phones in Africa have grown tremendously.

Aker and Mbiti (2010) note that mobile phones have bridged the divide between urban and rural communities, rich and poor; and linked individuals to individuals, individuals and information, markets, and services. Again, mobile phones have minimized communication costs, thus, enabling individuals and firms to acquire information directly, quickly and inexpensively on various economic, social and political matters. A growing number of researches show that decreased costs in communication relating to mobile phones have the ability to bring economic growth through the improvement of agricultural and labor market efficiency, as well as producer and consumer welfare in developing countries ((Jensen, 2007; Aker, 2008, 2009; Aker & Mbiti, 2010; Klonner & Nolen, 2008).

Aker and Mbiti (2010) enumerate some economic benefits that mobile phones can provide to consumers and producers in Sub-Saharan Africa. It is indicated that mobile phones can: reduce search costs, improve coordination among firms and improve markets, generate additional employment, increased communication should improve firms' productive efficiency, reduce households' experiences of risks and facilitate financial, agricultural, health and educational services (Aker & Mbiti, 2010). These are briefly expanded below.

First, mobile phones can increase accessibility to and use of information, which, in turn, reduces search costs and increase market efficiency. Flawed and asymmetric information thrives in markets in Africa. Consequently, families, companies and other

businesses use different means to search for information in a number of areas like input and output prices, jobs, potential buyers and sellers for products, natural catastrophes, new technologies, politics and to find out about conditions of friends and family members. Traditional search devices used are mostly personal travel, radio, and less frequently through landline phones, letters, newspapers and television. Of these, personal travel to where the information resides is commonly used, probably due to limited accessibility to the other alternative search devices (Aker & Mbiti, 2010). For example, Aker (2008) found that 89 percent of grain traders who were surveyed in Niger preferred obtaining price information by visiting weekly grain markets instead of listening to the weekly radio program. The introduction of mobile phones can reduce the costs of personal travel, which can be reasonably high when combined with the long distances and poor roads.

This leads to the next economic benefit, which is to improve coordination among firms and improve markets. Improved coordination means better management and synchronization among firms and markets, which allow people in both rural and urban areas to receive information immediately and on a regular basis. In addition, improved coordination permits firms and individuals to become active role players in the search activities, which enable them to ask questions and verify information through various sources (Aker & Mbiti, 2010).

Thirdly, mobile phones can create new jobs to redress demand for mobile-related services and, in this way, provide income generating projects in urban and particularly rural areas. Fourthly, improved mobile phone communication should increase productive efficiency of firms by permitting them to better manage their supply chains. Litan and Rivlin (2001) reported that the Internet improved management efficiency of US firms. Through innovatively improved communication between firms and their suppliers, mobile phones can empower companies and businesses in Africa to manage their supply chains more effectively, restructure their production processes and engage in new activities (Hardy, 1980; Roller & Waverman, 2001).

Furthermore, mobile phones can facilitate communication among social networks in response to shocks, thus, reduce households' exposure to risk. Finally, mobile phone-based applications and development ventures, what Aker and Mbiti (2010) refer to as "m-development", have the ability to advance the provision of financial, agricultural, health and educational services to people in rural and urban areas in Africa.

The next paragraph focuses on the life cycle of mobile phones.

1.1.2. Life cycle of mobile phones. Mobile phones are indispensable tools facilitating everyday life, and our modern societies have experienced tremendous increase in penetration since the implementation of the innovative Global System for Mobile Communication (GSM) standard in the early 1990's (Scharnhorst et al., 2005). Mobile phones when manufactured go through a typical life cycle. The life cycle, according to Huang and Truong (2008), starts when special raw materials like plastics and metals are used in the manufacturing of mobile phones. The mobile phones are purchased and used by consumers and when these mobile phones reach their end of life stage or they are no longer in use, the mobile phones are thrown away, recycled or refurbished for reuse. Sometimes it is recycled and valuable materials are recovered. In some countries, consumers throw away the old mobile phones and they end up in incinerators or landfills.

As mobile phones have become an inherent part of human life, the accrued benefits to individuals and nations as a whole cannot be underestimated. Despite the many advantages from mobile phones in developing countries, mobile phone give off harmful radiation, which affects human health (Sage & Carpenter, 2009). This radiation, according to Suhag et al. (2016), penetrates the human body and affects the cell structure and the DNA. The harmful radiation can cause brain tumor, male infertility, ear hearing impairment, Alzheimer's disease, heart troubles, insomnia and leukaemia (World Health Organization, 2006).

1.1.3. Waste generated by mobile phones. The most dangerous aspect of the mobile phones is the special raw materials, which are used in the manufacturing of mobile phones which include plastics and metals like zinc. These mobile phones consist of many components (e.g., plastic housing, ferrous and non-ferrous metals, liquid crystal display, ceramics and glass, and printed circuit boards) found in other electronic devices. One mobile phone contains more than 30 elements, including precious metals like gold, cobalt, palladium, and rhodium (Schmidt, 2006). These mobile phone devices have rapidly progressed to smaller, lighter models, which weigh less than 100 g. The components in mobile phones vary from model to model, however, as Information Technology advances, changes in the composition material become eminent. A mobile phone with its battery also contains toxic metals and organic chemicals. The metals found in mobile phones include arsenic, beryllium, cadmium, chromium,

copper, lead, mercury, and nickel, as well as organic constituents such as brominated flame retardants (BFRs), polycyclic aromatic hydrocarbons (PAHs), and polyvinyl chloride (Schmidt, 2006). Lead is the most common metal typically found in the lead solder of printed circuit board. Cadmium can be found in batteries, plastic components as a stabilizer and an additional color pigment in some mobile phones. The type of batteries used for mobile phones has rapidly changed over the past decade as a result of the technical development of the battery. The types of batteries that are commonly found in mobile phones include lithium-ion battery using a lithium-cobalt compound or lithium-polymer, nickel-metal hydride battery using a nickel hydroxide compound, and nickel-cadmium battery (Takamoro et al., 2003). The nickel-cadmium battery, an older type of battery, has a lower effect on the environment. Concern over the negative impacts associated with the production, use and end-of life (EOL) of mobile phones is particularly high due to large production volumes and short time scale of technological and stylistic obsolescence (Stutz, Burkhard & Ertel, 2002).

Toxic chemicals found in mobile phones such as arsenic, beryllium, cadmium, and lead are known to bepersistent and bio accumulative hazardous substances. During the recycling and uncontrolled treatment processes of the waste, some chemicals can be released into the environment and may pose a threat to human health. Some brominated flame retardants can form highly toxic dioxins and furans during incineration and recycling (Fishbein, 2002; Scharnhorst et al., 2005). Therefore, it is essential that unwanted mobile phones do not end up in landfills and incinerators. Because mobile phones are relatively small and the impacts resulting from disposal may be overlooked as being minimal. However, the growth in the use of mobile phone has been so rapid that the impacts can become a significant concern. Therefore, proper management of discarded mobile phones is an issue of growing concern around the world (Most, 2003; Skerlos et al., 2003; BAN, 2004; Osibanjo & Nnorom, 2008) and most especially Africa. The next section discusses the management practices and regulatory framework as observed in other countries.

1.2. E-waste management legislatory framework. The use of mobile phones has led to large production of e-waste, which calls for proper management or legislation of the disposal of such waste. Currently legislation on e-waste is developed and enforced mostly by some European Union (EU) countries and their allies, while most developing countries lag behind (Sepúlveda et al., 2010, cited in Coleman, 2016). Currently, the management of e-waste in US and Europe hasled to a remarkable economic effect on global trade as a result of the creation of massive volumes of e-waste. In discussing the disposals of obsolete computers, Coleman (2016) referred to the sixth and ninth Conferences of the Parties to the Basel Convention (2006, cited in Coleman, 2016), which documented that the subject of e-waste recycling demanded obligatory and mandatory, as well as urgent and in-depth supervision in developing countries (Coleman, 2016). The implication is that the issue of e-waste management and recycling is critical to ensure safe and sound environment and this was demonstrated in the adoption of the Nairobi Declaration on the Environmentally Sound Management (ESM) of Electrical and Electronic Waste at the ninth Conference of the Parties to the Basel Convention (2006, cited in Coleman, 2016).

E-waste management in developing countries is a new concept and poses a great challenge to its citizens. Puckett and Smith (2002) reiterate that management of e-waste in developing counties like India and other African countries is at its lowest level. This poor management of e-waste creates hazardous problem in the environment.

In South Africa, e waste management is relatively a new concept and there is no legislation governing it. However, the government of South Africa in partnership with Swiss government has launched an e-waste program called “Knowledge Partnership with developing and transition countries in e-waste recycling” (Lombard et al., 2004). The initiative aims to investigate and assess the management, handling and practices of e waste recycling in South Africa. The program is further strengthened by what South African government terms as “cradle to cradle” approach. This approach system seeks to encourage maximum repair, re-use and reduce the amount of mobile e-waste, which goes to landfill (Lombard et al., 2004). It is based upon these that this paper investigates the disposal of old and unused mobile phones and proposes an environmentally sound management framework to minimize the health and environmental hazards caused by this e-waste.

2. Methodology

The study was conducted through the selection of consumers in South Africa, visits to electronic waste recycling facilities and interviews of mobile retail store managers who are also mobile phone service providers.

The consumers were selected from three cities in South African namely Johannesburg, Cape Town

and Pretoria. A case study approach was used. The consumers were purposefully chosen from three governments owned institutions in three cities. These government owned institutions were selected based on their geographical locations, which span across the entire South Africa and are characterized as urban institution with high number of mobile phone user's. For confidentiality and anonymity requested by these participants, the names of their corresponding institutions are alienated from this research. In addition, three retail stores (MTN, Vodacom and Cell C) managers were interviewed about what customers do with their old phones.

In describing population, Polit and Beck (2008) indicate that it is the aggregate of cases having a common and designated criterion that is accessible as subject for a study. A total of 30 participants, five from each of these institutions and five from each of the three retail stores were selected. The participants were selected based on their status as institutional consumers and managers of mobile phone service providers, which was relevant to the study. The selected participants volunteered to participate in the study on the condition that their identity and their institutions were concealed. Data were collected using semi-structured open-ended interviews questions. The interview questions were:

1. How many mobile phones do you have?

2. Is any of your mobile phone a smart phone?

3. What do you often use your mobile phone for?

4. How frequently do you replace your mobile phone?

5. How do you dispose your old phone?

6. Do you have any alternative means of disposing the old phone?

The interviews lasted for one hour with each interviewee and were audio-recorded and transcribed by the researcher. Another independent researcher checked integrity of data entry from the study. Transcripts were coded using Wolcott's (1994) method of case study analysis techniques. After the initial coding, an independent researcher and the main researcher met to check the consistency of their respective interpretation of the transcripts and the codes. The researcher, then, coded the final transcripts for both consumers and the managers, identified the main themes and traced possible relationships. Some broad categories of themes were identified by searching for patterns in the participants' responses. The different broad categories that were noted are discussed below.

3. Results and discussion

The main categories, which emanated from the interviews, are discussed below.

3.1. Number of mobile and smart phones owned by individuals. The respondents indicated that they own more than one mobile phone. Some of the respondents indicated that they own about three mobile phones. On average, about 95% indicated that they own two or more mobile phone of which one of these phones is a smart phone for browsing on the Internet. One respondent indicated that *"Mobile phones are cheap, easy to use, provide many benefits, and do not require much literacy or numeracy for basic use. Therefore, I keep more than one"*. It was further noted by the respondents that they prefer prepaid mobile phones with billed in prices per second, depending on the needs and abilities of the owner. From the respondents, it became evident that 41% of the users are between the ages of 18-34 years old and own a smartphone, while only 27% of those above 35 years and older own smartphones.

3.2. Purpose of owning a mobile phone. According to the respondents, the most popular activity for owning mobile phones is sending text messages. Over an average of 80% of mobile phone owners say they use their device to send text messages. One respondent said *"I use my mobile phone to go online for Facebook"*. The second most popular activity is taking pictures or videos. Using mobile devices for pictures and videos is most popular among South Africans. Sending WhatsApp messages is also one of the uses of mobile phone according to the respondents.

Other respondents indicated that they are aware of cell phone banking, but they try to avoid it because of security risk. However, there are few of the respondents who indicated that they get political news, access social networking sites, get information about health and medicine, look or apply for a job, or get consumer information such as prices and product availability on their phones. This is affirmed by Arker (2008) that mobile phones have minimized communication costs and, thus, enabled individuals and firms to acquire information directly, quickly and inexpensively on various economic, social and political matters. Again, Arker confirmed that mobile phones have the ability to bring economic growth through the improvement of agricultural and labor market efficiency, as well as producer and consumer welfare in developing countries (Jensen, 2007; Aker, 2008, 2009; Aker & Mbiti, 2010; Klonner & Nolen, 2008).

3.3. Frequency of replacing the old mobile phones and how they are disposed. The respondents indicated that they replace their mobile phones within a one to two years interval because of new technological features, which come to the market. The respondents indicated that because network signals are sometimes weak in certain locations, they purchase a new phone with new network provide like MTN, Vodacom, Cell C or Telkom. In addition, the respondents indicated that owning a sophisticated smart phone among their peers makes them feel socially acceptable and recognizable. Hence, they will prefer to change their phones when a new technology is introduced to the market. The respondents were asked to express how they dispose old mobile phones. The respondents indicated old mobile phones could be given out as donation to others. Other respondents stated their old mobile phones are sold to second-hand shops for money. The respondents suggested that the old mobile phones are sometimes kept so that when the current phone breaks down, one will have a spare phone to use while the original phone is under repair.

In addition to these, the retail store managers who were interviewed indicated that there is no legislation or restrictive law forcing manufacturers or retailers to collect old or retired mobile phones from consumers. Neither is there any prohibiting regulation preventing consumers not to store any old or retired mobile phone at home in South Africa.

4. Proposed Retired Mobile Phone (RMP) framework

From the respondents, it was observed that the only way to dispose of the old mobile phones is to donate them, sell them to a second-hand shop, throw them into the dustbin or keep them somewhere in the house for future use. There is no collection process by which mobile phone suppliers or manufacturers take back old phones from customers. Again, there is no process of refurbishment of these old phones for re-use or exchange for a newer phones. Therefore, the next section proposes a framework based on effective collection process of retired mobile phones in South Africa and other parts of Africa.

Proposed framework.

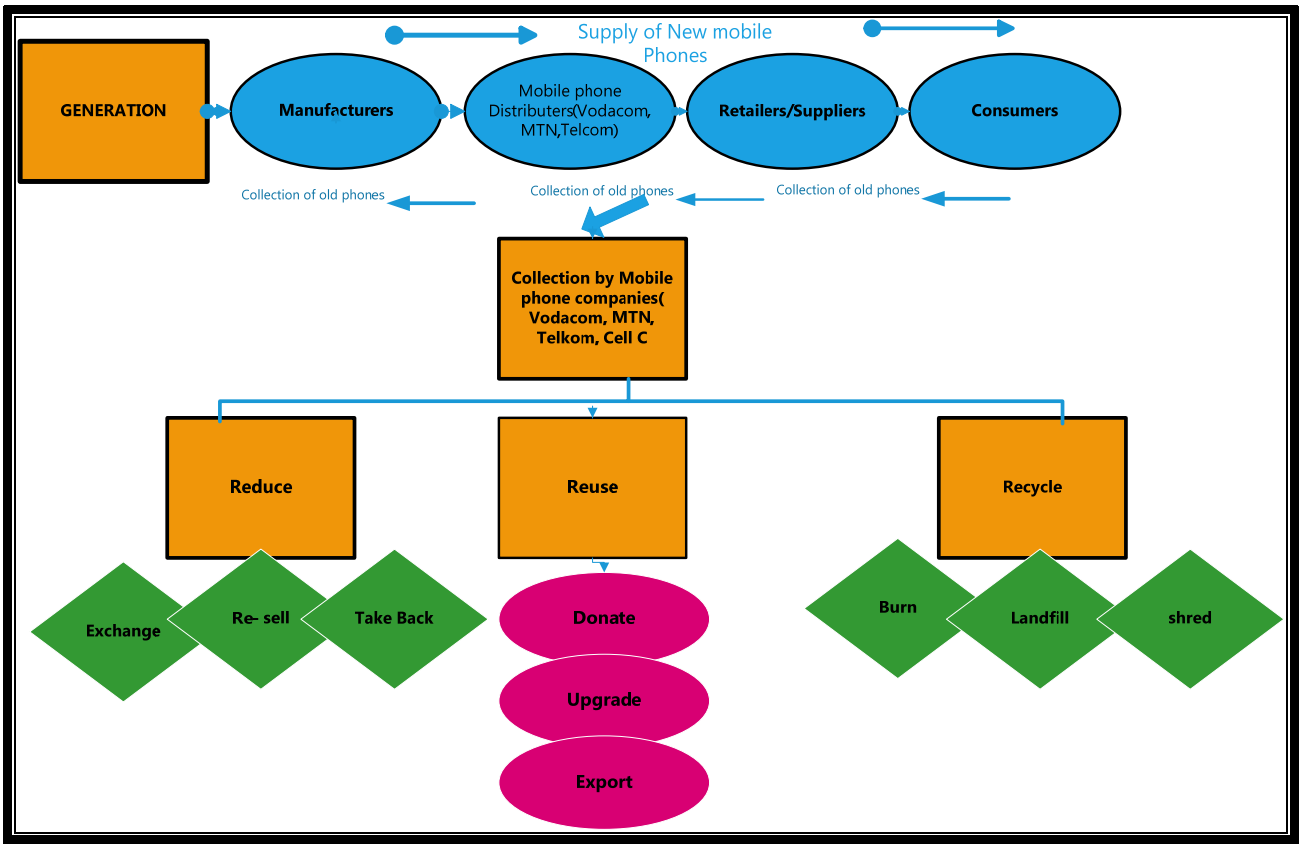

Fig. 1. Retired Mobile Phone (RMP) framework

When the manufacturer in South Africa produces new mobile phones, they move from the manufacturer on the supply chain to distributors (Vodacom, MTN, Telkom and Cell C). These distributors are also network providers in South Africa. These distributors sometimes supply retailers who serve as intermediaries between distributors and consumers.

When mobile phones reach their end of life usage, local retailers nor suppliers of the mobile phones in South Africa neither collect these mobile phones from consumers. The local retailers and suppliers of mobile phones often do not collect the old product from consumers. Consumers stay with these old phones and this poses a major challenge of managing mobile phone waste. This new framework proposes that there should be a collection process from the consumer back to the distributor, then, to the manufacturer. The retailers must take the old phones from consumers by offering economic incentives for the return of their used or retired mobile phones when they purchase a new device. The trade-in price for old and retired mobile phones should depend upon the model of the phones. The local retailers and suppliers send the collected phones to the distributors, then, to the manufacturer for refurbishment, repair, for reuse or recycling, and for final disposal.

4.1. Reduction and reuse. To minimize the quantity of mobile phone waste depends upon the reuse of mobile phones that are outdated (Coleman, 2016). Recycling old phones can be achieved by selling or giving away old phones as gifts, or by up-grading old phones (Williams and Sasaki, 2003, cited in Coleman, 2016). The main idea of reuse is to meet what the user requires by refurbishing the existing phone to extend that phone's life span. Another way of disposing old phones is to resell them. Alternatively, manufacturers can inform customers to bring in their old phones in exchange for new ones. Moreover, the producers can give the users some compensatory amount for their old phones. Sometimes users require upgrade of their phones and such decision must involve the users giving full consent for such upgrade, because full upgrades can sometimes be costly (Coleman, 2016).

4.2. Recycling. Features of new mobile phones change at a faster rate and thereby makes recycling by using landfill methods uneconomical (Coleman, 2016). The discarding of technology devices into landfills is no longer an option for end of life management of obsolete mobile phones because of the high cost involved (Lee et al., 2004). Effective separation of physical components of mobile phones is a major problem facing African nations. Components of mobile phone equipment are usually glued together via weak interfacial bonds such as wrapping, fastening and welding; therefore, intelligent liberation of these materials can occur via low energy methods. Zhang and Forsberg (1999) further indicate that old phones can be disposed of according to its ring shredding. In this case the old phones are broken into smaller particles of clear shapes and sizes, which can be separated and recycled (Coleman, 2016).

Another simple method indicated by the respondents is open burning. Open burning is an alternative for disposing obsolete mobile phones in Africa. This burning produces toxic material,l which is associated with health risks, which is worsened by the high radiation emitted by mobile phones. Combustion from burning mobile phones, according to Coleman (2006), creates fine particulate matter, which is linked to pulmonary and cardiovascular disease.

Conclusion

The research investigated how old and retired mobile phones in South Africa are discarded. It was apparent that the common method of disposing old mobile phones is through storage at homes, selling to second-hand shops or donating them as gifts. These methods were found to create health hazards for children and adults due to high toxic materials released through decomposed parts or leaching. Based on the findings, a proposed Retired Mobile Phone (RMP) framework was developed to guide manufacturers and retailers in the collection process of old and retired mobile phones in Africa for proper and appropriate methods of disposing these mobile phones through the reduction, reusing and recycling of these retired mobile phones. The framework will assist manufacturers and retailers of mobile phones to dispose of obsolete mobile phones in ways that will not pose health risks to humans, plants and the environment.

References

1. Aker, J. C., & Mbiti, I. M. (2010). Mobile phones and economic development in Africa. *The Journal of Economic Perspectives, 24*(3), 207-232. Retrieved from www.cgdev.org
2. Aker, J. C. (2008). Does Digital Divide or Provide? The Impact of Mobile Phones on Grain Markets in Niger. BREAD Working Paper, 177.
3. Aker, J. C. (2009). Mobile Phones and Economic Development in Africa. Invited presentation at the Center for Global Development, Washington, D.C. Retrieved from http://www.cgdev.org/doc/events/08.25.09/Cell_Phone_Survey_CGD_26aug09_Final_Public.pdf
4. BAN (Basel Action Network). (2004). Mobile toxic waste: recent findings on the toxicity of end-of-life cell phones. A report by Basel Action Network.

5. Bauer, H. H., Reichardt, T., Barnes, S. J., & Neumann, M. M. (2005). Driving consumer acceptance of mobile marketing: A theoretical framework and empirical study. *Journal of Electronic Commerce Research, 6*(3), 181.
6. Cell Phones in Africa. (2015). Communication Lifeline. Global Attitude and Trends. Pew Research Canter. Retrieved from www.pewglobal.org/2015/04/15/cell-phones-in-africa-communication-lifeline
7. Corbett, S. (2008). *Can the Cell Phone Help End Global Poverty?* New York Times, April 13, 2008.
8. International Telecommunication Union-ITU. (2008). World Telecommunication Indicators Database. Geneva: International Telecommunications Union.
9. International Telecommunication Union-ITU. (2009). Information Society Statistical Profiles 2009 Africa. Geneva: International Telecommunications Union.
10. Jensen, R. (2007). The Digital Provide: Information (Technology), Market Performance and Welfare in the South Indian Fisheries Sector. *Quarterly Journal of Economics, 122*(3), 879-924.
11. Jensen, R. T. (2007). The Digital Provide: Information (Technology), Market Performance and Welfare in the South Indian Fisheries Sector. *Quarterly Journal of Economics, 122*(3), 879-924.
12. Klonner, S., and Nolen, P. (2008). Does ICT Benefit the Poor? Evidence from South Africa. Unpublished mimeo.
13. Lee, C. H., Chang, C. T., Fan, K. S., & Chang, T. C. (2004). An overview of recycling and treatment of scrap computers. *Journal of Hazardous Materials, 114,* 93-100
14. Litan, R., & Rivlin, A. (2001). Projecting the Economic Impact of the Internet. *The American Economic Review Papers and Proceedings, 91(*2), 313-317
15. Lombard, R., Widmer, & Hecke, J. (2004). Tracing the E-Waste Stream in Gauteng, South Africa, Presentation at WasteCon2004, Biennial International Waste Congress, Sun City, South Africa, October 2004.
16. Most, E. (2003).Calling all cell phones: collection, reuse, and recycling programs in the US. New York: INFORM Inc.
17. Osibanjo, O., Nnorom, I. C., & Ogbonna, K. C. (2008). Modelling waste generation by the telecom sector in Nigeria: the grey side of the impressive outing. *Waste Management & Research, 26*(4), 317-326.
18. Polit, D. F., & Beck, C. T. (2008). *Nursing Research: Generating and Assessing Evidence for Nursing Practice*. Philadelphia: Lippincott Williams & Wilkins.
19. Poushter, J. (2016). Smartphone ownership and Internet usage continues to climb in emerging economies. Pew Research Center. Retrieved from www.pewglobal.org/.../smartphone-ownership-and-internet-usage-continues-to-climb
20. Roller, L.-H., & Waverman, L. (2001). Telecommunications Infrastructure and Economic Development: A Simultaneous Approach. *American Economic Review, 91*(4), 909-923.
21. Sage, C., Carpenter, D. O. (2009). Public health implications of wireless technologies. *Pathophysiology, 16,* 233-246.
22. Scharnhorst, W., Althaus, H. J., Classen, M., Jolliet, O., & Hilty, L. M. (2005). The end of life treatment of second generation mobile phone networks: Strategies to reduce the environmental impact. *Environmental impact assessment review, 25*(5), 540-566.
23. Schmidt, C. W. (2006). Unfair trade: e-waste in Africa. *Environmental Health Perspectives, 114*(4), 232.
24. Sepúlveda, A., Schluep, M., Renaud, F.G., Streicher, M., & Kuehr, R. (2010). A review of the environmental fate and effects of hazardous substances released from electrical and electronic equipment during recycling: Examples from China and India. *Environmental Impact Assessment Review, 30,* 28-41.
25. Skerlos, S., Morrow, W., Chan, K., Zhao, F., Hula, A., Seligar, G. (2003). Economic and environmental characteristics of global cellular telephone remanufacturing. *IEEE international symposium on electronics and environment,* 99-104.
26. Stutz, C., Burkhard, J. E. (2002). Cost element of recycling and the design of mobile phones in the context of WEE. Proceedings of Care Innovation, Vienna. Retrieved from http://aix.meng.auth.gr/lhtee/index.html
27. Suhag, A. K., Larik, R. S., Mangi, G. Z., Khan, M., & Abbasi, S. K. (2016). Impact of Excessive Mobile Phone Usage on Human. *Journal of ComputSciSystBiol, 9,* 173-177.
28. UNEP. (2006). Mobile phone partnership initiative (MPPI). Guidance document: environmentally sound management of used & end-of-life mobile phone. The Basel Convention on the control of transboundary movements of hazardous waste and their disposal.
29. Williams, E., & Sasaki, Y. (2003). Strategizing the End-of-life Handling of Personal Computers: Resell, Upgrade, Recycle. In Kuehr, R. and Williams, E (Eds.). *Computers and the Environment: Understanding and Managing Their Impacts.* London: Kluwer Academic Publishers.
30. Wolcott, H. F. (1994). *Transforming Qualitative Data: Description, Analysis, and Interpretation.* Thousand Oaks, CA: Sage.
31. World Health Organization. (2006). What effects do mobile phones have on people's health?
32. Zhang, S., & Forssberg, E. (1999). Intelligent Liberation and classification of electronic scrap. *Powder technology, 105,* 295-301.