Title Page

Assessing the Side-Effects of ICT Development: E-waste Production and Management. A case study about cell phone end-of-life in Manado, Indonesia

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***Highlights (for review)**

- More than 9500 tons of E-waste per year is produced in Indonesia from cell phones alone.
- E-waste management is largely absent even from a city that is considered as an example of successful waste management in Indonesia.
- Collection of discarded phones from users by producers performed weakly, and did not account for users' behavior and awareness.
- Over 80% of cell phone users interviewed in this study owned at least one retired cell phone.
- The recovery rate of E-waste in Indonesia is estimated at less than 1%, indicating a large waste of resources and high potential for environment.

Assessing the Side-Effects of ICT Development: E-waste Production and Management

A case study about cell phone end-of-life in Manado, Indonesia

Abstract

The rapid evolution of ICT devices, together with an increasingly wide spread of the internet and features such as social networks, results in a tremendous increase in the number of discarded cell phones. While the number of cell phone users is increasing very fast in Indonesia, the fate of phones once they are not used anymore is largely unclear. This study aimed at obtaining an overview of E-waste management in Indonesia using a critical case study approach, assessing the cell phone life cycle. The study was carried out in Manado, a medium-sized provincial capital in Indonesia, which has received government awards for its waste management. Yet, the study found indications that E-waste is ending up in landfills, and that dedicated legislation and monitoring systems for E-waste were lacking. As a result, there was little take-back action by producers, consequently leading to a lack of user awareness regarding E-waste disposal. The problems the Indonesian government is facing are twofold: first, E-waste is smuggled into the country in the form of used devices; second, a large number of second-hand devices with unknown sources are circulating within the country uncontrolled. From the current number of subscribers, it is estimated that more than 9.500 tons of waste are produced annually in Indonesia from cell phones alone, and the amount is steadily increasing. While the current study focused on the life cycle of cell phones, the situation for other electronic devices is likely to be very similar. Sustainable management of E-waste generated from the use of cell phones as well as other ICT devices is required not only to provide economic benefits from recycling of the valuable substances they contain, but most importantly for environmental protection. The results of this study indicate that an incentive system should play a key role in any take-back system for cell phones.

Keywords

E-waste management, electronic waste, end-of-life cell phone management, EPR, green IT, Indonesia

1 Introduction

In recent years, concurrent with the worldwide increase of ICT usage, society has become dependent on the availability of electronic devices. ICT devices have spread to both developed and developing countries, bringing advantages in many aspects of life such as education, communication, banking, entertainment, or navigation, through the widely increasing availability of internet access. This has consequences for the abundance of retired devices known as electronic waste (E-waste). According to the OECD (Organization for Economic Cooperation and Development), electronic waste or E-waste is defined as any household appliance consuming electricity and reaching its end of life [1].

Due to the high cost of recycling in an environmentally sound way in industrialized countries, much of the E-waste is sent to poorer countries, even though this practice is banned by the Basel Convention and the European directive on Waste for Electrical and Electronic Equipment (WEEE) [2, 3]. The global E-waste generated per year amounts to approximately 20-25 million tons, most of which is being produced in rich nations like the U.S. or European countries. Based on the number of discarded ICT devices collected in Europe, computers, cell phones, fixed-line telephones, televisions and radios are the major electronic products, and together they amounted to 11.7 million tons in 2007 [3]. In the United States alone, 130,000 computers and more than 300,000 cell phones are disposed each day, and an estimated 80 percent of the generated E-waste is sent to less-developed countries [4]. China is among the biggest receivers of E-waste sent by wealthier countries, along with countries such as Peru, Ghana, Nigeria, India and Pakistan [5, 6, 7]. Singapore is one of the known destination countries of E-waste in Southeast Asia, while neighboring countries such Malaysia, Vietnam, Philippines and Indonesia are suspected to receive a large share of this waste through illegal imports [4].

E-waste frequently contains valuable as well as potentially toxic materials. These materials require a special treatment when the devices reach their end of life in order to avoid environmental contamination and accumulation of hazardous substances in the human body [7]. Hazardous materials contained in cell phones include brominated flame retardants, arsenic, antimony, beryllium, cadmium, copper, lead, mercury, nickel, and zinc. In the Resource Conservation and Recovery Act (RCRA) of the U.S. , these materials are categorized as persistent bio-accumulative toxins. They have a long life-span and they can accumulate in animal tissues, increasing their amount in the body over time and thus leading to contamination through the food chain. In humans, they can lead to cancer as well as reproductive, neurological and development disorders [7, 8, 9]. In addition, special treatment of E-waste should be considered to prevent wasting valuable and rare elements. Materials such as gold and palladium can be mined more effectively from E-waste compared to mining from ore [10]. Among ICT devices, cell phones and computers contain the highest amount of precious materials. Because cell phones have a small size, as well as the shortest life-span among ICT devices, they are easily being thrown in the garbage or end up in landfills undetected. Therefore, it is important to avoid obsolete cell phones from being kept at home, as it is usually just a matter of time for them to end up in landfills [10, 11]. While the amount of cell phones in industrialized countries has begun to level off at around 115 per 100 inhabitants, ownership in developing countries is still increasing rapidly and currently lies at about 70 per 100 inhabitants [12]. If ownership there reaches 100%, the vast majority of cell phones will be located in developing countries, where recycling is still far from adequate [12, 13]. The problem faced by developing countries stems not only from the transboundary movement of E-waste but also from domestically-generated waste as result of local use.

In the following section, the concept of a take-back system as the underlying approach of E-waste management in developed countries is described, followed by the research questions on potential E-waste in Indonesia resulting from the use of cell phone.

2 E-waste management approach

In most industrialized countries such as the OECD member countries, including all of the European Union, E-waste management is implemented quite effectively on the basis of Extended Producer Responsibility (EPR), to cope with the pollution and waste generated [14]. EPR is defined as "an environmental policy approach in which a producers' responsibility for a product is extended to the post-consumer stage of a products' life cycle including its final disposal" [15]. In other words, EPR refers to the responsibility of any producer for his products when they become obsolete or are discarded by the users. This includes both financial as well as physical responsibility for collection and recycling. In this context, 'producer' means any manufacturer or brand including the importer or exporter, as well as persons distributing under the brand's name [8, 15]. Take-back programs, where the producers are collecting their devices for their final treatment, are often said to be the purest kind of EPR. Most of the OECD member countries have implemented take-back policies either as mandatory or as voluntary programs. In mandatory take-back programs, governments usually set their own recycling target for a producer to achieve. For example, a government sets a goal of a 75 percent recycling rate for a producer, based on the quantity of electronic devices from this producer entering the market [16]. Voluntary take-back programs are usually initiated by the producers without regulation by the government. The producers agree to take back their obsolete electronic products independently and to manage them in an environmentally sound way. However, experiences from Europe indicate that the lack of a mandatory take-back system leads to a poor performance by the producers, underlining the important role of regulation in Europe. A Producer Responsibility Organization (PRO) is usually formed to manage the E-waste recycling in order to meet the EPR recycling target [14, 15].

In Germany, the volume of the devices which enter the German market (in kg) is reported to the EAR (Elektro-Altgeraete Register), a PRO, by the producers every month. The EAR then calculates the total market volume share and notifies each of the producers to retrieve their E-waste from collection sites managed by the municipalities. Nokia, for example, collaborates with recyclers for the actual recycling process. Reports of total recycled E-waste are sent to Nokia and the EAR [17]. In Korea, the EPR regulation for electronic devices has been implemented in 2003, covering television sets, personal computers, refrigerators, washing machines, and air conditioners. In 2005, cell phones, including the batteries and chargers, as well as fax machines, printers, and audio equipment, were included in the EPR regulation. The retailers are usually gathering the old phones by offering incentives associated with the purchase of new phones. Since January 2008, the government requires that the materials contained in the electronic devices are reported when the devices enter the market in order to control the amount of hazardous materials. Also since 2008, the retailers and suppliers are obliged by law to accept old cell phones returned by the users without charge. The old cell phones are then recycled and valuable materials such as cobalt, copper, aluminum and iron are recovered [11]. Besides Germany, which has been pioneering take-back policy in 1991 with its packaging ordinance, other OECD countries such as Australia, Canada, various EU member states, Japan, Norway and the United States are also including take-back programs in their waste management systems [15]. The local government has a crucial role to play in the EPR implementation, as it has to coordinate and regulate all of the actors, ranging from the importers to the end users, in the cell phone life cycle [15]. Consequently, if government effectiveness and performance is poor, EPR implementation is likely to be poor as well.

While on the one hand developed countries in the OECD have implemented take-back systems to address the problem of generated E-waste, on the other hand this organization's member countries are the main suppliers of E-waste to non-OECD countries. The U.S, Australia, Japan, and some European countries are countries identified as sending E-waste to non-OECD countries such as China and India [4]. The movement of E-waste in the form of second-hand devices or declared as material aid is sometimes used to transfer the responsibility of costly recycling to less-developed countries [4, 18]. Globally, the amount of E-waste is increasing rapidly. The situation of E-waste generated in less-developed countries is more complex, as it is often illegally imported, but is also being generated locally as a result of domestic use. Since the movement of ICT devices affects both developed and less-developed countries, the EPR approach should be applied globally [14]. The Indonesian government has adopted the EPR approach. However, it is still in the preliminary stages of implementation, and further studies are needed to assess its suitability and performance within the local context [19].

3 Potential E-waste in Indonesia

The launching of new ICT devices such as tablets and smart phones are highly anticipated events reported in the international media, and these products compete in providing features that are more convenient and more attractive for the end users. New technologies with better features for the end users are launched continuously, with product form and functions evolving. As a result, old devices which are still functioning may be perceived as outdated. Besides for their utility, these devices are also being used to display social status or as part of fashion, especially in less-developed countries. This results in a fast turnover as people aim to constantly have the newest version of a device [13, 20, 21]. Moreover, obtaining new ICT devices is often more affordable and convenient than upgrading old ones [20] .The number of cell phone subscribers has surpassed land line phone users in 2002, and with the spread of social networks such as Facebook, cell phones are perceived not only as a technological object but also as a "social object" [21]. With 2 years, cell phones have the shortest average lifespan among all ICT devices, followed by portable computers with 5 years [22]. Besides having the shortest life span, cell phones and mobile computers are devices that have the fastest-growing market globally [3, 13, 23].

Indonesia is the largest country in Southeast Asia, with a total population of more than 240 million people. According to the OECD, Indonesia, along with China, India, Russia and South Africa, has the potential to create an enormous amount of waste in the future due to economic improvement and rapid urbanization. The management of municipal waste, including E-waste, is predicted to be one of the biggest challenges in the coming decades [1].

ICT development has been particularly rapid in Indonesia. Licenses for using 3G (third generation technology), which can support full motion video, music streaming, 3D gaming, and high-speed internet access, have been issued to several cellular operators in the country beginning in 2006 [24]. The number of cell phone subscribers has since increased rapidly, as cell phones became a means to access the internet. While internet penetration in Indonesia is still the lowest among Southeast Asian countries, the percentage of Indonesian internet users that access the net using their cell phone (48%) is the highest in Southeast Asia [25]. On the one hand, Indonesia is known to be one of the target countries of E-waste from industrialized countries, while on the other hand the extent of E-waste produced from local usage is still unknown. There are few studies about cell phone management in Indonesia, and the effect of an increasing spread of the internet on cell phone usage has not been examined yet.

This study aimed at giving an overview of E-waste management in Indonesia, with a particular focus on cell phone end-of-life management as an example representative of small electronic devices. It explores the cell phone life cycle with a focus on key actors, from an Extended Producer Responsibility (EPR) point of view. As most of the industrialized countries implement their E-waste management system on the basis of EPR, the practices were assessed against this principle. The following aspects were examined: 1) How is the current situation of E-waste generated from cell phone usage? 2) What is the role of the government and producers regarding the post-consumer stage of cell phone devices, and what consequences does this have for end user awareness? 3) Which attributes of the users drive the abundance of obsolete cell phones?

4 Methodology

As studies on the end-of-life management of cell phones in Indonesia are virtually absent, this study was conducted using an explorative research approach, in which a new field is explored to obtain an in-depth understanding of the examined case [26, 27]. Field research was conducted using a critical case study approach in a medium-sized provincial capital in Indonesia. Cell phones were chosen as the focus of this study, as they constitute one of the most rapidly spreading ICT devices in Indonesia, reaching even remote areas [28]. According to Flyvjberg [29] a ‘critical case’ can increase the generalizability of the study by the strategic selection of the case: “A critical case can be defined as having strategic importance in relation to the general problem”. The study site, Manado, has been promoted as an exemplary city in terms of good waste management by the national government. It was thus assumed that the city would provide an example of the best possible case of E-waste management in the country. The predominant research strategy was the use of a qualitative, inductive approach [30]. The study was carried out using a combination of qualitative approaches and employed triangulation of results for cross-checking information obtained from the key actors. The life cycle of the cellular phones, starting from the retailers and following the cycle until the devices’ end of life, was explored in order to show whether the system works in a sustainable way or not.

The field study was conducted from mid-September 2011 to the end of October 2011. Interviews with key informants were chosen to retrieve data in an explorative way and to frame the current situation in the absence of official data. The targeted interviewees (n=13) were owners of retail stores, refurbishing/service points, distributors, a recycling point, and service providers, as well as representatives of government bodies responsible for the trade (Chamber of Commerce and Customs Department in Manado) and the management of waste (e.g., Ministry of Environment Jakarta, Department of Cleaning and Gardening in Manado). These key respondents were chosen to get an overview of the cell phone life cycle and of the situation of cell phones when they become obsolete, with the aim of assessing the extent of a potential take-back system for obsolete cell phones.

In addition to key informant interviews, a questionnaire was distributed to cell phone users (n=110) as a qualitative informative element to understand their perspective about E-waste and to obtain information on user preferences regarding cell phones. The questionnaire was addressed only at people who owned cell phones and who were over 17 years of age, having their own income. Snowball sampling was used as sampling technique during the survey, where additional respondents were recruited based on references using social networking [26]. In the questionnaire, the users’ attitudes toward the use of cell phones and their awareness of E-waste take-back systems were assessed. The shortcoming of this sampling is that it is not representative of the population; however, since the sampling frame is unknown, this method was most suitable regarding the particular situation, available time, and financial resources [26, 31]. In addition to the collection of data in the field, a complementary desk-based review of policy documents, government data and information from cell phone producers and network operators was done. Both qualitative and quantitative approaches were used for data triangulation, were results from different sources are combined for cross-checking of results [30].

5 Results

5.1 Extent of cell phone usage in Indonesia

By 2011, the number of subscribers of the three largest GSM cellular network operators had reached more than 190 million (out of the total Indonesian population of 245 million). This indicates that the total number of cell phones currently used in Indonesia is potentially more than 190 million, as each subscription represents one SIM card, which is usually used in one particular cell phone and is not shared. Thus, when assuming an average life span of 2 years a weight of 0.1 kg per unit [22], it can be estimated that at least 9,500 tons of potential E-waste are generated per year in Indonesia from cellular phones alone. This does not yet include the amount of cell phones that have become obsolete since cell phones first entered the market in 1995. These three largest GSM cellular operators comprise up to 85 % of the total cellular connections, with an average growth of 21% per year [32].

5. 2 Role of the key actors in the cell phone life-cycle regarding E-waste management

There is no regulation yet for managing the E-waste generated at home, neither at the national nor at the regional level. In the view of a representative of the Ministry of Environment in Jakarta, the main institution responsible for waste management in Indonesia, the problem of E-waste lies in the control of the trans-boundary movement of E-waste. Indonesia comprises many small islands, making it difficult to control the import of E-waste. In many instances, smuggled E-waste was discovered by the government which had been illegally imported using various methods, such as being declared as raw materials, as materials for reconditioning/reuse, or for charity. The EPR approach has been adopted by the central government since 2008, however it was still in the process of drafting of regulation at the time of this study. By the time this study was conducted, the focus of the national government regarding E-waste was more in handling the illegal transportation of E-waste to the ports or remote islands in Indonesia (H.A., Telephone Interview, 26 Sept 2011).

In an interview held with the head of the provincial Cleaning and Gardening Department in Manado, it was confirmed that E-waste management and regulations did not yet exist within the region of Manado, nor was there ever an initiative from the local government to handle electronic waste produced by the local community. According to the informant, the waste generated from the community, whether from households or business centers, consists of two kinds, organic or dry waste. According to this definition, E-waste is more likely to be discarded as dry waste. E-waste did not exist as an official category of waste (J.O., Interview, 11 October 2011). Cell phones have been on the market for at least one decade and most of the cell phones sold in the early years of the trade have already reached their end of life. According to the head of Cleaning Department in the region of Manado, E-waste such as discarded electronic components including cell phones had been observed in landfills by the local department responsible for managing the domestic waste in the region, and since incineration in Indonesia is regulated by law and must not pollute the air, all of the waste that cannot be reused or recycled any more ends up in the landfill (J.O., Interview, 11 October 2011). By the time the study was conducted, the destiny of E-waste in Indonesia, and in Manado in particular, was to end up in landfills in an unknown quantity, due to an absence of E-waste management legislation.

Based on the interviews and questionnaires conducted, an overview of the E-waste management system in Manado can be drawn (Fig. 1). The government is shown as a separate entity, as no rules for domestic E-waste management exist yet, and government thus does not play a direct role in the current local cell phone life cycle.

New branded cell phones are imported by the main distributors from the producers through the main ports in Indonesia (Batam, Medan, Jakarta, Surabaya, and Makassar). There are local distributors which are mainly centered in the provincial cities, such as Manado, who distribute the items to retailers where the users get access to them. These retailers are normally small-scale businesses that operate independently. Besides getting access to devices through these retailers, users also can obtain the devices directly from the service providers. The distributors and retailers were found to not play any role in the collection of retired cell phones, which bridges the end users and producers. Their roles are in the distribution of products to the end users, but not in the take-back of used devices.

At the level of the end users, the cell phones are first circulating among the users, either by being sold on the second hand-market or by being passed on directly to other people. From the questionnaire conducted, 61 % of the users prefer to keep their obsolete cell phones at home, due to the low price used cell phones fetch on the second hand market (Fig. 2). Another reason why obsolete cell phones are kept at home instead of being passed to friends and families is because obsolete cell phones are usually perceived to be old-fashioned, cheap, and with outdated technology which people are not interested in anymore. Therefore, the users are reluctant to pass their phones to friends or family, as owning or giving away an old cell phone is frowned upon. Remarkably, not a single respondent would bring their obsolete cell phone to the recycling center in Manado. The reason for this is that respondents didn't know about the existence of the recycling center. When asked about their awareness of recycling centers available in the city, only 2 among 110 respondents had ever heard about such centers. This agrees with the lack of awareness reported by the key actors interviewed. When the respondents were asked whether they have obsolete cell phones with them, 80% of the respondents answered to own at least one obsolete cell phone, most of which are kept at home.

Service/Refurbish centers, where the broken cell phones are repaired, are available at strategic places throughout the city. However, similar to the end users, their broken cell phone components end up in the garbage, heading to the landfill. Obsolete cell phones accumulate not only with cell phone users, but also at the service centers/refurbishing points, which had a high amount of obsolete components left over from service.

A collection center is available through the representative offices of the brands. Fig. 1 shows the path via collection centers that obsolete cell phones would have to take in order to avoid them from ending up in landfills. According to the manager of the Nokia Care center Manado, per month, usually 10-15 pieces are collected from a recycling box in the office, and these usually consist of batteries. The returning of old/obsolete cell phones depends on the user willingness (H. pers. comm. 23 Sept 2011). Data obtained based on interviews with one main distributor and collection center of Nokia shows that the number of collected items for recycling was less than 1% of the total monthly sales (S.S., Interview 2011; H., Interview, 2011). This is not including other brands yet.

The input and output shown in Fig. 1 refers to the devices entering the market, and to those leaving it as obsolete devices, respectively. The extent of the E-waste production is difficult to determine from the key actors mentioned, due to a lack of recorded data.

5. 3 User attributes contributing to turnover of cell phones

According to the questionnaire survey, the life-span of cell phones in the selected region appeared to be shorter than the typical life-span of cell phones, which is two years. The survey of 110 respondents yielded an average life-span of 19 months, calculated from the number of cell phones bought in the last four years by each respondent. Cell phones are often used by people for fashion reasons. According to several respondents, the newer the technology of cell phones, the better they were perceived to be. This is in accordance with the survey result, where the most important aspects for the respondents when purchasing a cell phone were its “Technology” (46% of the respondents), followed by “Brand” (18%), “Price” (13%), “Operating system” (13%), and others (10%). The government of Indonesia arrives at a similar conclusion regarding an observed decrease in the life span of cell phones, which it attributes to advances in technology and associated fashion/lifestyle aspects [33].

The users often use more than one active cell phone at the same time. More than half of the respondents used one active cell phone and the remainder of the respondents used between one and five cell phones (Fig. 3). The use of more than one cell phone was found to be triggered by the presence of different providers on the market, which offer different services. The users preferred using more than one cell phone at a time as a result of various bonus options offered by different cell phone operators.

As a very low return rate of obsolete cell phones was observed, a number of scenarios regarding hypothetical incentives for returning cell phones were offered in the questionnaire survey. Incentives included direct or indirect benefits such as cash-back, coupon or discount options, or donations for humanitarian purposes for each phone returned. While the latter option was ranked as most preferable, this might reflect the wish of the respondents to please the interviewer. Bonus and discount programs were ranked next. Unsurprisingly, the option ‘no particular program’ was ranked as least favorable (Table 1).

6 Discussion

Since the ratification of the Basel Convention in 2005 (it was signed in 1993), the national regulation prohibits the import of any hazardous waste into Indonesia [34]. Despite its being banned by law, a high amount of smuggled E-waste is still found, sent by wealthier countries to some remote and difficult-to-control islands in Indonesia, where they are usually declared as useful materials. Potential E-waste in the form of scrap materials or second hand devices arrives at Indonesian islands via the nearest ports such as Singapore and several cities in Malaysia [33]. There are two areas in particular which have been discovered to be gateways for E-waste entering Indonesian territory: Batam (East Sumatra) and the Wakatobi Islands (Southeast Sulawesi). E-waste is suspected to enter the southern part of Indonesia through Batam, while E-waste in the eastern part of Indonesia supposedly enters via Wakatobi [19, 33]. Once it has passed the international ports, onward transport to other regions usually proceeds unobstructed. Indonesia consists of thousands of islands, and interisland shipping is highly difficult to monitor, as controls are not effective in most ports, and boats frequently connect villages and small cities, bypassing regulated ports. Consisting of more than 17.000 islands, Indonesia is particularly susceptible to the illegal spread of E-waste due to its geography.

One origin of illegal of E-waste imported to Indonesia has been pointed out in a recent study, in which Indonesia is mentioned as one of the countries suspected as receiving E-waste from European countries and the United States [4]. Another recent study lists the main European ports in Germany, the Netherlands, Belgium and the United Kingdom as responsible for most illegal transports [2]. Anderson [4] points out that even the so-called green recycling in the US has been found to contribute to the under-cover market of E-waste in Asia. In 2008, a broker in Hongkong was discovered to buy so-called green E-waste from companies in five big cities in the U.S, where 42 out of 43 E-waste recyclers were ready to ship their waste abroad [4]. Once in the main ports in Asia, these items can easily enter Indonesian territory via international ports or through its islands. There are several reported cases of E-waste being shipped to Indonesia. In early 2012, around 113 containers of toxic waste (including E-waste) sent from the Netherlands and the United Kingdom were found in the Jakarta port [35]. In 2010, nine containers filled with E-waste and bound for Indonesia were returned to Massachusetts, USA [4]. This is one of the big challenges faced by the government regarding the illegal import of cell phones and other electronic devices. The global movement of E-waste from developed countries has begun to reach even the remote islands of Indonesia.

Based on the observations and interviews conducted in Manado, besides devices from the official brands, cell phones sold constitute a mix between replicas and second-hand devices with unknown sources (usually sold on the black market). The interviewed retailers confirmed that not all of the cell phones being sold on the market are original ones, as the components often are of mixed origin. For example, the battery included in a cell phone may not be the original one from the brand producer. These non-brand products are suspected to originate in China and enter via Singapore, which makes their price very cheap compared to the original brands sold by the official retailers. The government concedes that there are many illegal imports of second-hand electronic devices into Indonesia, which reduce the domestic market. In total, around 40 percent of the electronic devices sold in Indonesia are illegal imports [33].

In Indonesia, there was no specific definition yet under the national legislation about what constitutes domestic E-waste at the time this study was conducted. E-waste is recognized as a new kind of waste, and regulation was still in the process of implementation after being adopted in 2008. Infrastructure and an information system to quantify, monitor and handle E-waste are lacking, and efforts to set up such infrastructure are time-consuming. According to official statements by the Government of Indonesia, none of the more than 300 landfill sites under its management contain any discarded cell phones or other electronic devices [33]. However, E-waste was found as ending up in landfills in Manado in the present study, both from households and from service centers. Even though the quantity of the E-waste in Manado was stated to be quite small, it is nonetheless alarming that the obsolete devices are slowly beginning to be discarded.

Cell phone producers have set up collection points in almost all of the Indonesian provincial cities including Manado, as a kind of voluntary take-back option without regulation from the government. These collection centers are mainly provided by internationally recognized brands. However, the representative offices are the only key actors of the cell phone life cycle that seem to operate in a manner conducive to proper cell phone recycling. In Manado, a recycling box was provided by Nokia in their representative office, giving users the possibility to return their E-waste to the producer. The main distributors and retailers, who are the actors in direct contact with the end users, have no options for offering take-back systems or approaches to inform users about proper recycling. As a result, the awareness of end users regarding proper treatment of E-waste is low. This has led to the observed low rate of collection by the recycling centers, estimated at less than 1%, since the passive approaches they take are not suited to the situation and conditions in the city. While cell phones have been increasing tremendously in numbers in the past years and thus constitute the largest proportion of potential E-waste in terms of numbers, the low collection rate of other ICT devices implies that their situation is similar in the absence of E-waste regulation. Taking an example from one of the OECD countries, the overall rate of recovery of ICT devices (including cell phone) in Germany has reached more than the 75% target rate set by the government. In 2008, the rate was as high as 95% of the number of devices entering the market [16]. This number is far different for the situation in Indonesia, a country of more than 240 million people. Since the collection centers rely on a voluntary approach, efforts of taking back old devices and reaching out to the customers remain half-hearted. A combination of a lack of regulation by the government and missing initiative by the distributors and retailers resulted in the users not being aware of the existence of recycling centers. One potential way forward would be to learn from industrialized countries such as Germany, where the producers have a certain target rate of recycling. The quantity of cell phone devices entering the market has to be reported to a registration agency by the producers for further calculation of the target recycling rate that is their responsibility [16, 17]. Another lesson could be provided by the Netherlands, where the government obliges the producers to prepare proposals on how they would manage their electronic devices at the post-consumer stage including take-back, recovery and funding mechanism. These proposals must get an approval from the government before their products are allowed to enter the market [15]. However, the country-specific differences in geographical setting, infrastructure, legislation, social-cultural context and end user behavior, an implementation of EPR requires further assessments to match the local context.

The present study indicated that there is a fast turnover of cell phones in the study region, as shown by their short life-span of 19 months. The type of life-span calculated here denotes how long a single user owns or uses a product [36]. This short duration in the study region is identified to be driven by a number of factors, including fashion, affordable prices, and the wide spread and usage of social media that allow people to communicate virtually. Cell phones are used to display social status, as use of the latest technology is perceived as fashionable. The drop in prices of cell phones as a result of competition between official brands, availability of black market phones or devices from Chinese producers, which have become increasingly abundant over the last two years, enable even people with a very low income to own cell phones. Concurrently, the different providers are competing in offering various affordable services, causing people to own and use more than one device at a time. The new features that are launched continuously encourage people to discontinue using their old and still functioning cell phones and strive to own the latest versions, with new interfaces e.g. for social networking. In addition, in the case of broken cell phones, people tend to buy new devices instead of repairing their broken ones, as the price of new devices is often less than the cost of reparation. Similar patterns regarding a fast turnover of cell phones for reasons of fashion and low prices are also mentioned in other studies [13, 20, 21]. This trend is leading to a high abundance of potential E-waste, resulting in a higher latent danger of E-waste ending up in landfills.

In the study area, similar to other studies, the users preferred to keep their obsolete cell phones at home [37, 38]. Thus, a potential way for re-collecting obsolete devices from users is in encouraging and informing them in an effective way regarding recycling. The interview results indicate that the users prefer to return their obsolete devices if an incentive system exists. A combination of an incentive system and an information system for raising awareness of the end users might lead to a more effective collection of E-waste.

While these results should be treated as a preliminary indication, they nonetheless underline the general importance of having an incentive system in place. A similar notion was expressed in the interviews with key actors in the cell phone market (distributors and retailers), who stressed that in order to collaborate with the producers in the establishment of a take-back system, there would have to be advantages on their side as well. In the absence of a strong and enforced legal regulation, the collection of retired, obsolete and broken cell phones thus appears most likely to succeed if driven by an incentive system.

6 Conclusion

As the technology of cell phones is becoming more advanced over time and as an ever increasing number of electronic devices are entering the market in the country, regulations on E-waste take-back systems are needed to prevent toxic materials contained in those devices from ending up in domestic backyards and landfills. The effective collection of E-waste does not only avoid the risks posed, but also brings economic benefits from the recovery of precious materials. From the estimated amount of cell phone waste produced annually in Indonesia, more than 3.500 kg of gold could potentially be recovered. Our results show that in Indonesia, specific policies for E-waste management are absent, that take-back performance by producers is weak, and that awareness regarding recycling and proper waste treatment among the key actors of the cell phone life cycle is extremely low, leading to an unsustainable outcome of the cell phone life cycle. More research is needed to develop a framework for an effective E-waste management which builds on the participation all of key actors in the devices' life cycle. Without neglecting the problem of the imported E-waste and the black market, the government should also pay attention to the official producers (brands) that currently are present in Indonesia, since immense amounts of E-waste are being generated in Indonesia as a result of the local use of cell phones officially bought on the domestic market. The producers should set their recycling target rate based on the quantity of their devices entering the market, which has to be regulated by law through mandatory or voluntary take-back initiatives. An information system is needed for quantifying the cell phones entering and circulating within the country, beginning with information from the importers. The central government of Indonesia plays an important role in setting up this legislation for further protecting its regions from the risk posed by E-waste. While EPR has been adopted in Indonesia, further studies are needed to enable the government to adapt the implementation to the situation and the context in Indonesia, learning from other countries which have successfully implemented this system. Emphasis should be placed on the raising of end user awareness to treat their obsolete cell phones properly, for example by returning them to official collection centers. At the same time, the infrastructure for an effective overall E-waste management system needs to be set up. In the face of weak implementation and enforcement of regulatory measures by government authorities, more attention has to be paid to appropriate incentives for recycling. For the development of management strategies, economic assessments such as consumer preference studies and cost-effectiveness analyses should be considered.

While this study was concerned with cell phones only, the results indicate that other electronic devices in domestic use in Indonesia have a similar fate of ending up in the landfills, as no management systems and regulation for E-waste exist in the country. However, differences in consumption habits are likely to exist for different devices. The limited survey of cell phone owners, while not allowing for a general empirical analysis due to the small sample size, nonetheless provides some qualitative information on potential underlying user attitudes and preferences, and should be followed up by a larger-scale quantitative study.

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Figures:

Fig. 1 Overview of cell phone life cycle in Manado

Fig. 2 Attitude towards cell phones not in use anymore

Fig. 3 Percentage of respondents owning different numbers of active cell phones

Table:

Table 1 Different scenarios for incentives offered in return for users returning their old cell phones. Respondents (n=110) were asked to rank the likelihood of responding to each scenario from 1 (very likely) to 5 (highly unlikely).

Figure 1
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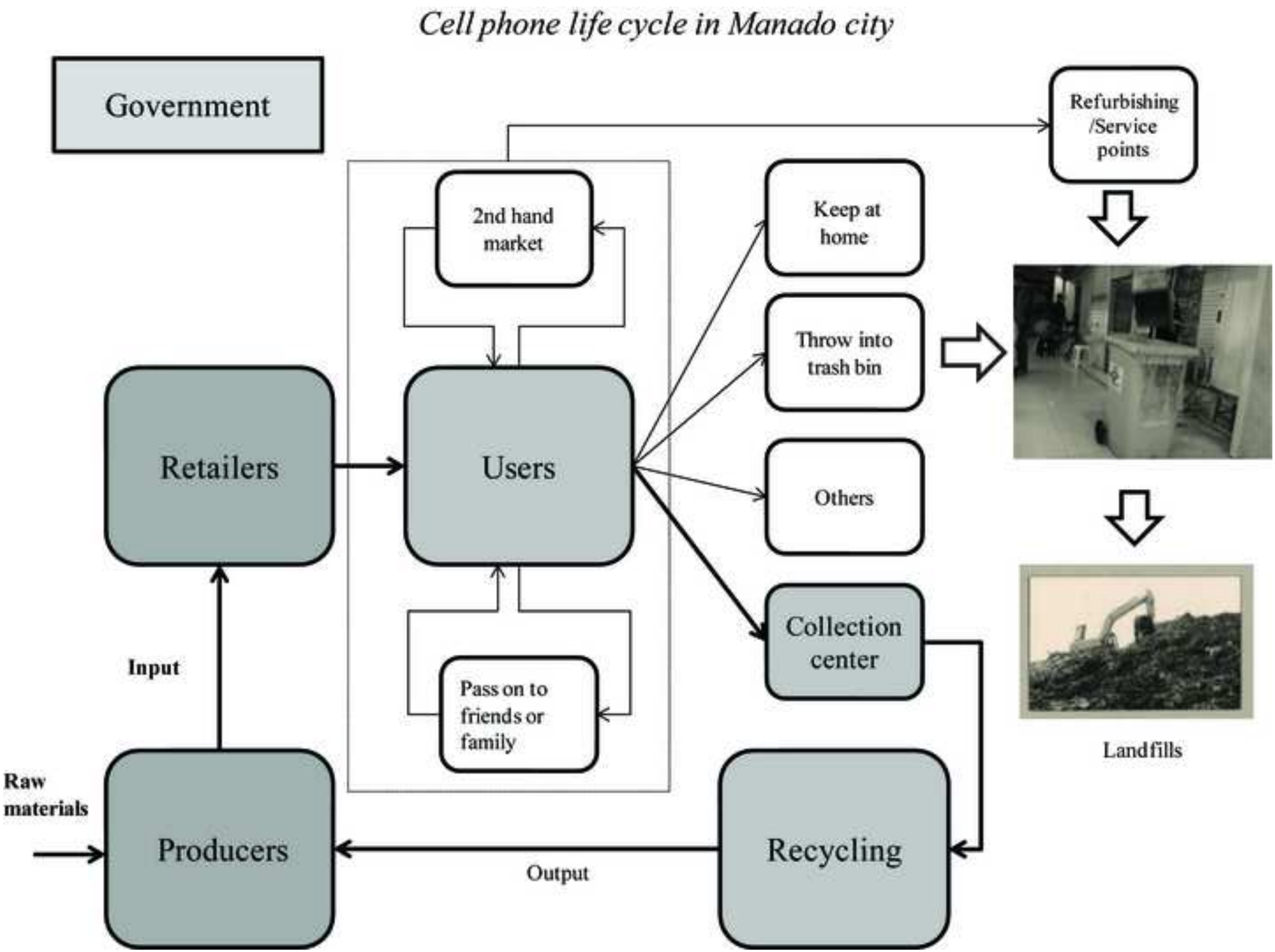

Figure 2

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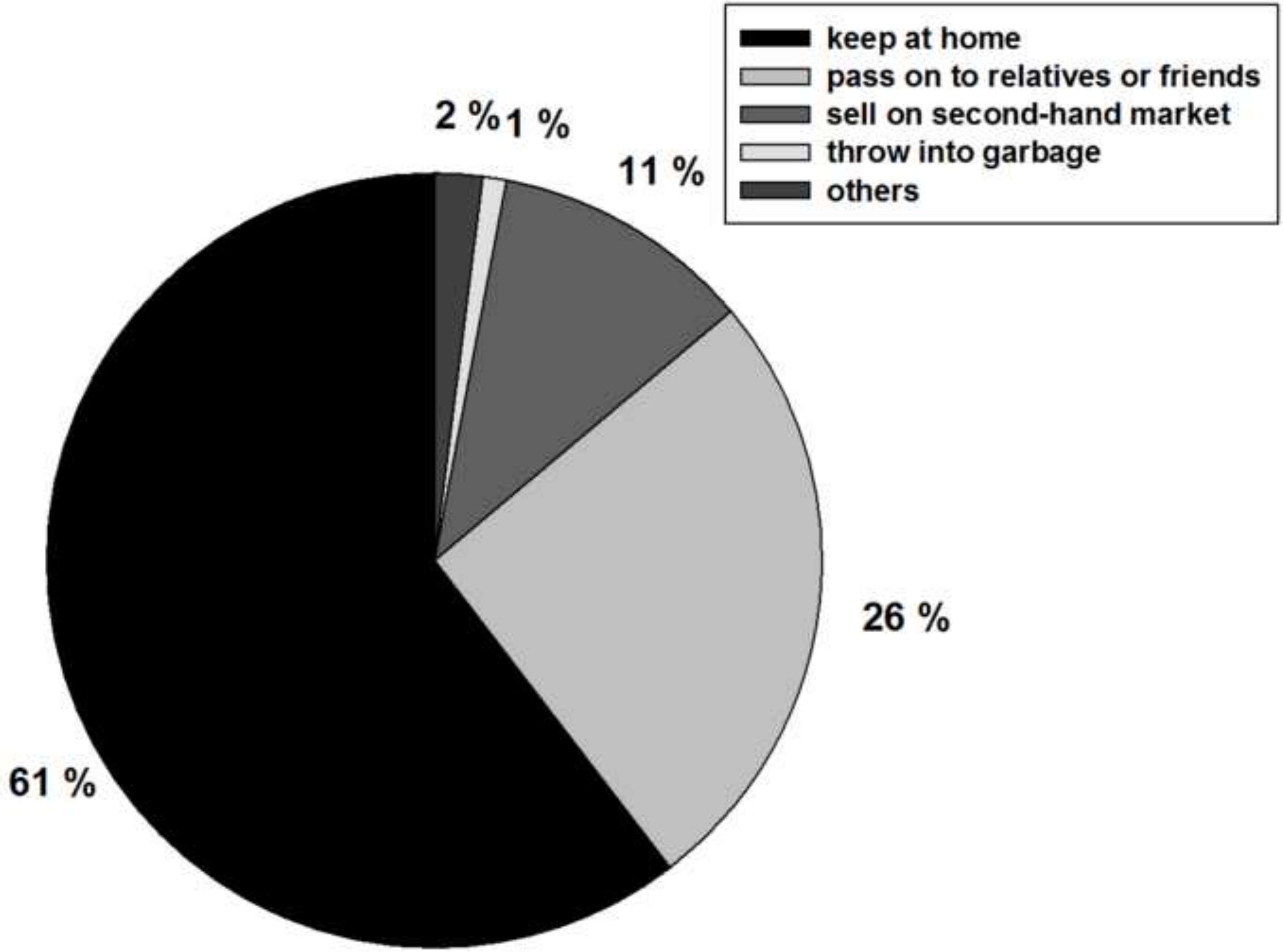

Figure 3
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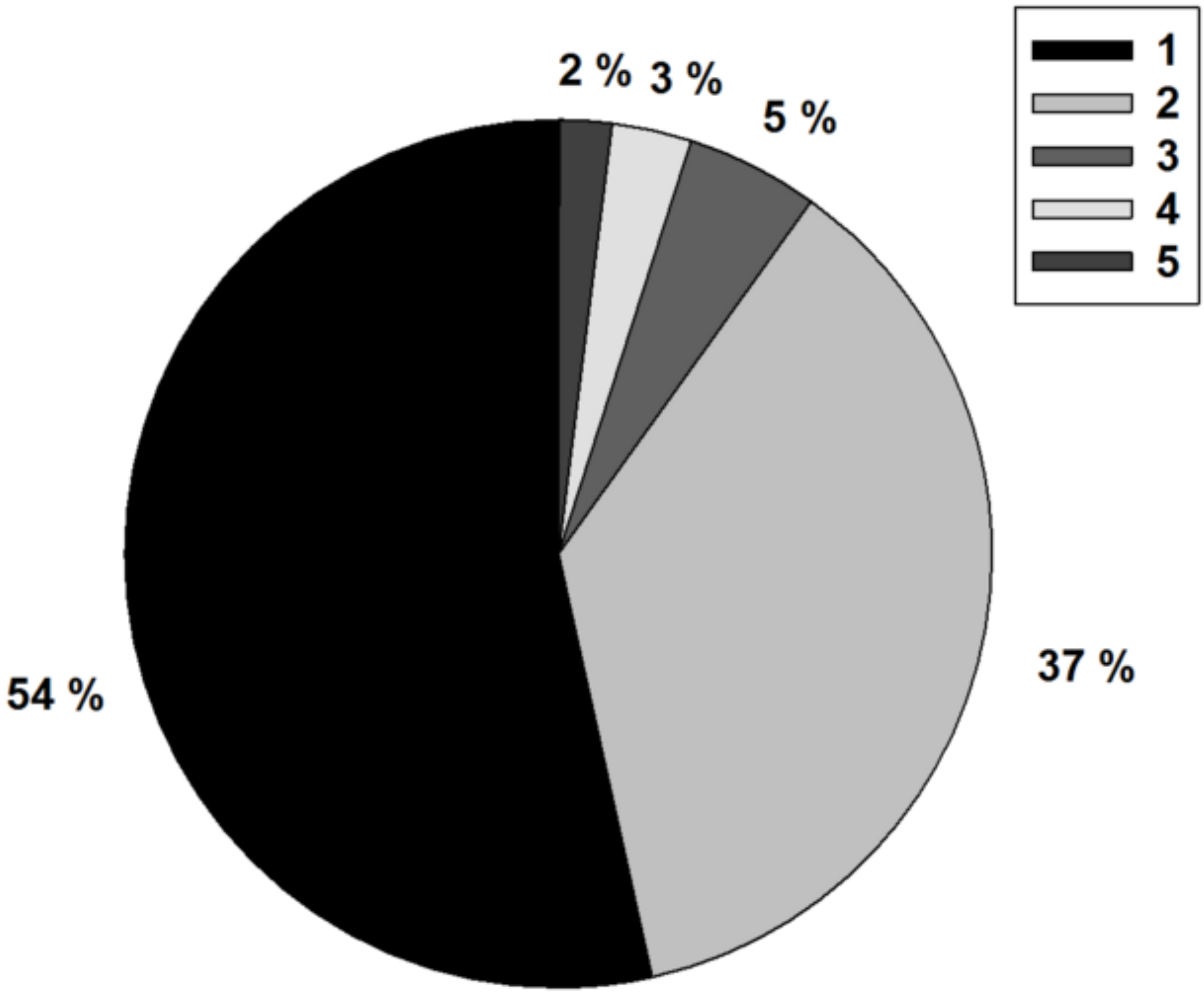

Table 1

N=110	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
	There is a program which allows users to exchange old cell phones for new ones at a discount	There is no particular program	Some money is paid for every returned old cell phone, according to the functions that are still working	There is a program that helps growing trees for each phone returned	The yields from the program are used for humanitarian purposes (e.g. helping poor people)	Bonus from the cell phone shop, e.g. vouchers
Mode	2 (Likely)	4 (Unlikely)	2 (Likely)	2 (Likely)	1 (Very Likely)	2 (Likely)
Sum	214	368	243	253	186	230