



# A Study on the E-waste Collection Systems in Some Asian Countries with Special Reference to India

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## ABSTRACT

Safe management of waste electrical and electronic equipments is becoming a major problem for many countries in the world. Due to the advancement in technology, increased market penetration of electrical and electronic equipment and high rate of obsolescence, there is an increased generation of electrical and electronic waste (e-waste). E-waste being a post-consumer waste needs to be collected from the various sources of its generation. Subsequently, establishment of collection centres is necessary to channelize such wastes for environmentally sound recycling. A number of methods are adopted for the collection of e-waste in different countries all over the world. This paper is an attempt (a) to study existing collection systems in some Asian countries including Bangladesh, Burma/Myanmar, China, Hong Kong, Indonesia, Japan, Malaysia, Philippines, South Korea, Taiwan and India; and (b) to formulate a sustainable model for collection systems for the developing nations.

## INTRODUCTION

With the advancement in technology around the world along with the continuous up-gradation in design, the rate of obsolete electrical and electronic equipment has been significantly increased in the electronics sector. Another reason attributed to the less life of electronic items is the economic growth and market penetration. Particularly in China, 83 million units of electronic and electrical equipment (EEE) were scrapped in 2007 that reached to 227 million in 2012 with an average annual growth of 19.9% (Veenstra et al. 2010). In another instance, over 3 million computers and 15 million mobile phones reached their end-of-life in Korea during 2004 (Hyunmyung & Yong-Chul 2006). In the year 2008, around 12.9 million units of EEE were collected at the specified collection points by Japan (Ministry of Environment, Japan 2010). As per the United Nations Environment Programme (UNEP) report the waste from mobile phones would increase by 18 times by 2020.

Wastes from electronic products contain toxic substances which lead to adverse effects on health and environment when such wastes are processed in the unorganized sectors without following adequate health and safety norms. The presence of precious metals (PMs) such as gold (Au), silver (Ag), platinum (Pt), gallium (Ga), palladium (Pd), tantalum (Ta), tellurium (Te), germanium (Ge) and selenium (Se) makes recycling of e-waste attractive economically

(Raghupathy et al. 2010). The e-waste management needs segregation, collection, transportation, storage, treatment, recovery of valuable materials and final disposal of residue. However, the developing countries are facing problems not only due to the high rate of e-waste generation and collection, but also due to the imports of obsolete electronic products and e-waste. Particularly in India, the management of e-waste still remains one of the biggest tasks, not only due to rising demand of electronic products, but also due to growing imports of electrical and electronic products from developed nations. Given the gravity of the situation, this study was undertaken on the prevailing "collection systems" for e-waste in some Asian countries namely, Bangladesh, Burma/ Myanmar, China, Hong Kong, Indonesia, Japan, Malaysia, Philippines, South Korea, Taiwan and India. The outcome of this study may provide clues important for devising future studies on the subject.

## METHODS

The trends in the e-waste production have been significantly changed with the changing economy of the developing countries (Robinson 2009). The consumers are one of the key stakeholders in any e-waste system as they are the buyers of the product in the first place; they are also the users and they are the ones who decide whether to store, exchange, repair, refurbish or dispose of the products after use. The outlook of the population of the less developed nations is

also one of the major factors that influence the consumers to purchase new electronic products (Skovgaard et al. 2005, Bandara et al. 2007). As post-consumer waste, the e-waste needs to be collected from the end user to be channelized for environmentally sound management, thereby requires a system for its collection. A number of methods are adopted for the collection of e-waste in different countries the world over. This study pertains to the practices prevailing in some countries in the Asian region. The information on e-waste management in Asian countries was collected from various sources such as published reports, journals, e-books and respective websites.

## RESULTS AND DISCUSSION

In most of the countries taken up for study, e-waste is collected and treated majorly by the informal sector. There is a preference for the reuse of electronic equipment, only 20% to 30% are recycled while the rest is disposed of in Bangladesh (Ha et al. 2009, Ahmad 2011). However, in Myanmar, there is a tendency to carefully reserve the damaged equipment or parts so that the same can be utilized for repair (Aung & Myint 2010). In China, both formal and informal collectors are involved in e-waste collection and most of the e-wastes collected from the urban areas are sent for recycling; whereas, those collected from the rural areas are traded to the local second-hand market (Kim et al. 1996, Tong & Wang 2004, Hicks et al. 2005, Streicher-Porte & Yang 2007, Yang et al. 2007, Chi 2011, Li 2011). Hong Kong has also faced a lot of problems due to the excessive generation of e-waste; however, the government has taken some considerable steps to control the problem of e-waste like setting up recycling facility along with proper collection system (Chung et al. 2011). Additionally, Hong Kong has also proposed to setup many collection points and recycling centres across the country. At present there are approximately 100 sites that are used for storing discarded electrical and electronic items. Most of these sites are the old scheduled agricultural areas which are privately owned. In Indonesia, there are eight industries involved in the collection and dismantling of e-wastes (Gaidajis et al. 2010, Panambunan-Ferse & Breiter 2013). According to the Indonesian Ministry of Environment, e-wastes are imported under false declaration as metal and plastic scrap for recycling in countries like Indonesia (Hanafi et al. 2011 and Meidiana & Gamse 2010). The e-waste recycling is mostly carried out by the informal sector (Andarani & Goto 2012). Dumping of e-waste is a major problem in Indonesia, which includes disposal in landfills (Gaidajis et al. 2010, Hanafi et al. 2011, Meidiana & Gamse 2010, Panambunan-Ferse & Breiter 2013). In Japan, approximately 85% of e-waste is recycled and rest 15% is discarded into landfills. A large number of

collection points (500 in numbers) have been setup as a part of Extended Producer Responsibility (EPR) and Advanced Recycling Fee (ARF) (Jimlynch 2013). Malaysia has the facility for collection as well as processing unit for precious metal recovery. There are 146 e-waste recovery facilities in Malaysia with the total capacity to manage more than 24,000 metric ton of e-waste per month. Precious metals recovery is limited to only on wet chemical processes and electrolysis (Agamuthu et al. 2009, Awang 2010). Collection centres are managed by the solid waste concessionaries or local authorities and export of e-waste is not allowed because of the presence of the facilities to process and recover useful materials from e-waste in the country. Kuala Lumpur has concessionaries and in Pulau Pinang the collection involves local authority or NGO or waste generators or recyclers (Betts 2008).

Philippines has important collection, recycling and refurbishing facility for e-wastes. The two main environmental laws define the overall framework for managing e-wastes: (a) the Ecological Solid Waste Management Act of 2000 (RA 9003) and (b) the Toxic Substances & Hazardous & Nuclear Wastes Control Act of 1990 (RA 6969). The objective of RA 9003 is to follow the 3R concept; reduce, reuse and recycling prior to collection, treatment and disposal (The Philippines Government 2000, Peralta & Fontano 2006). In Philippines, the waste collection is mainly carried out by municipality, in which e-waste may be classified under RA 9003. In case e-waste is disposed along with municipal waste, then there is no provision of treating the e-waste separately (Peralta & Fontano 2006). However, the Materials Recovery Facilities (MRF) are available only at a few locations. Notably, South Korea has Producer Recycling (PR) Rule for the management of e-waste and the recycling rate for IT equipment and appliances combined is 82% which is highest in the world, with as many as 500 collection points (Jimlynch 2013). In 1998, Recycling Fund Management Committee (RFMC) system was introduced in Taiwan to encourage recycling (Kyogikai 2000). As per the RFMC procedures, the producers pay the charges for collection and recycling of e-waste. The Fee Rate Reviewing Committee (FRRC) decides the collection and recycling charges and these charges are revised annually on the basis of factors like London Metal Exchange (LME) rates (Chung & Murakami 2008). In India, the collection of e-waste is mainly done by recyclers including both formal and informal sectors, wherein 90% of e-waste is recycled in the informal sector while the formal sector is able to collect only 10% of the total share of the e-wastes. As per the published information, India has 134 authorized collection centres in 19 States by MoEF (2014-15). India has notified the e-waste Management and Handling Rules, 2011 based on EPR, wherein the producers are

responsible for establishing collection centres and organizing collection of e-waste. However, no effective collection systems have been put in place by the producers other than storing the obsolete products in their warehouses. Most of the used electronic items are refurbished and repaired a number of time and many of them are sold in the thriving secondary market. Due to the gap in collection systems, only 40% of the total e-waste is channelized for recycling while the rest 60% remains untraceable (Secretariat 2011). In many developing countries there is also a tendency for selling the used equipment from the cities to the countryside and villages because of the lack of ownership of Waste Electrical and Electronic Equipments (WEEE) in those regions. In many cases the equipments are reused and those that are beyond repair are discarded indiscriminately thereby making e-waste collection a difficult task. The findings, which have been described above are summarized in Table 1.

The details about the different systems being practiced for collection of e-waste in the Asian countries reveal that each country has adopted these practices according to their requirements. However, there is a need to evolve an efficient system for the collection of e-waste through authorized collection centres, collection point, drop boxes, door to door collection, including the take back system organized by the producers or manufacturers of particular brand in order to channelize these for environmentally sound recycling. Such establishments may be setup by anyone or stakeholders in the e-waste value chain such as manufacturers, producers, dealers, recyclers either individually or collectively in association with other stakeholders or other agencies.

Collection centres could also be an independent unit/entity as a business activity.

China, Japan, South Korea, Taiwan and India have notified e-waste policy and regulations, while all other countries in the region do not have an e-waste policy or regulations. In Bangladesh, Myanmar and Philippines, e-waste is collected by informal sector and the waste is disposed in open areas, landfills or dumped along with garbage. In Hong Kong, the majority of the WEEE is transported overseas for recycling and some remaining e-waste is disposed along with garbage. In India, the e-waste rules provide for a collection system, however, only a few authorized collection centres have been setup to date. The collection systems are essentially devised by the recyclers rather than the producers as mandated in the e-waste rules. In China, both formal and informal collectors are involved in e-waste collection (Tong & Wang 2004, Yang et al. 2007, Streicher-Porte & Yang 2007). In Malaysia, there is no direct channelization of waste, but it is managed by NGO/local authorities. In Taiwan, the producers are made responsible to pay for collection and recycling of e-waste and the charges for collection and recycling are decided by reviewing committee.

Since different operations already exist in countries taken up for study, there is bound to be a difference in the establishment of the collection system. The following discussions provide an insight in the prevailing system in different countries with a view to evolve a model. The model/system is intended to provide linkages between various stakeholders in order to facilitate the collection of e-waste.

Table 1: Summary of e-waste collection system in Asian countries.

Country	Collection system	Law/Regulations	Recycling Formal/Informal
Bangladesh	Disposed in to landfills, rivers, ponds, drains, lakes, channels and open spaces. The e-waste is mainly recycled by the informal sector located in Dhaka and Chittagong	None	Informal
Burma/ Myanmar	No Information	No information	No information
China	Old for New Rebate Program" (also known as "Old for New Program") or exchange programs	Yes	Both
Hong Kong	Presence of eight collection points and three recycling centres	None	Both
India	Collected by formal and informal sector	Yes	Both
Indonesia	Eight industries involved in collection and dismantling	None	Both
Japan	Five hundred collection points have been set up as a part of Extended Producer Responsibility (EPR) and Advanced Recycling Fee (ARF).	Yes	Both
Malaysia	146 e-waste recovery facilities. Collection centres are managed by the solid waste concessionaires/local authorities.	None	Formal
Philippines	Collection, recycling and refurbishing facility.	None	Both
South Korea	Recycling rate is 82 % along with five hundred collection points	Yes	Both
Taiwan	Under RFMC producers pay the charges for collection and recycling of e-waste.	Yes	Both

**Collection of e-waste by producer:** According to the EPR system, the management of e-waste generated by the end of life products goes to the producer. Essentially, the producer uses the dealers, distributors, retailers or any other agency to collect the e-waste those may be provided certain incentives. Producer may also organize a direct take back system for their brand of products from the identified consumers. Take back system may also require an agreement between the consumer and producer to ensure that the end of life product is returned to the producer. Countries including Bangladesh, Myanmar, Malaysia and Indonesia do not apply EPR, adopt various methods for collecting e-waste and these methods include repair, refurbish, reuse and/or disposal. Additionally, the repair shops and service centres also generate e-waste which may be the whole product or components which are no longer fit for use and are discarded. In such cases, these wastes would require a dedicated collection system to deposit such wastes and subsequently channelize them for recycling.

**Collection of e-waste by recycler:** The e-waste collection by recyclers is also very important where recyclers play a vital role in managing and reduce e-waste through the recycling and recovery operation. In fact, e-waste recycling has become a lucrative business venture which is further regulated by the policy and regulations framed in most of the countries taken up for the study. In most cases, it is purely a business venture due to the presence of valuable materials in the e-waste that can be easily recovered by recycling. According to the EPR system, producers are required to collect and channelize e-wastes for recycling and recovery. However, in view of the business interest, recyclers collect e-wastes from consumers either directly, through hawkers or through auction and subsequently recover the material to be sold in the market as a resource. In developing nations, the informal sector has a vital role to play in the e-waste recycling. They also tend to compete with the formal recyclers and in some cases, they complement the activities. The mutual support system that integrates operations in the informal and formal recycling units is ideal for developing economies and the relation between these two sectors is essential for the success of e-waste management (Raghupathy et al. 2010). The role of informal sector in e-waste recycling has been considered important not only in India, but also in other Asian countries of this region. In most of the countries taken up under this study, e-wastes are mainly treated by the recyclers in the informal sectors; however in some cases, the formal sector is also involved as prevalent in India and China. While engaging informal sector, it is essential to identify and authorize such units to be linked with the producer and the formal recyclers.

**Collection of e-waste by collection centres:** Consumers

using electrical and electronic equipment/appliances have to ensure that e-wastes generated by them are channelized through collection centres. Notably, the collection centres play a vital role in the collection of e-wastes from consumers. Collection centre can reach out to the consumers by organizing door-to-door collection of e-wastes and providing incentives including the certificate of receipt, discount coupons on the purchase of new products or direct cash. Collection centres may even operate through dealers or distributors or retailers or other agencies, wherein a box or a bin is provided for the e-waste. E-waste can also be collected from the service centres and re-furbishers where, the repaired or refurbished products will go back to the consumer and the discarded components and non-repaired products are sent to the collection centre or to the recycler. In India, hawkers also known as 'kabadiwalas' contribute majorly in the collection of recyclables including e-wastes from consumers in exchange of money. The e-wastes, thus, collected are sold to the informal sector without any accountability. Therefore, the kabadiwalas may be included and motivated, and informal sector to be a part of e-waste value chain by organizing them, to participate in the e-waste collection process.

The studies on the practice for e-waste collection prevalent in the countries taken up for the study revealed that e-waste is collected by the informal sector and traded into the local second-hand market (Kim et al. 1996, Tong & Wang 2004, Hicks et al. 2005, Yang et al. 2007, Streicher-Porte & Yang 2007, Li 2011, Cheng & Chang 2017). However, the mechanism of collection and transfer varies in each of these countries. In China, the formal collectors pay tax and give away the collected e-wastes to authorized recyclers for environmentally-sound treatment. In Japan, the retailers take back home appliances only upon the request of consumers and these are transported to the collection site. The manufacturer organizes the transportation of the e-wastes to the collection site in collaboration with the retailers. In South Korea, there is producer recycling (PR) rule for the management of e-wastes wherein, the consumer buys any new product by depositing the old equipment against it. In Taiwan, consumers surrender their used equipment via retailers, municipal collection, private collectors, or donations to charities who in turn, hand over WEEE to licensed recyclers. There is also introduction of RFMC, where producers pay the charges for collecting and recycling of e-waste (Cheng & Chang 2017).

**Channelization of e-waste to collection centre:** Collection centre can collect the e-wastes through different sources such as household, schools and educational institutions, commercial establishments, service centre and re-furbishers and also through the producer-organized system such as

take back. In case of household e-waste, the collection centre has to be from door to door. For school and educational institutions, bins could be provided and a collection drive could be organized so that the staff and students of the group can collect the e-waste from the institutions and from their household as well. Bulk consumers, who are the major generators, may establish their own collection centres or channelize the waste to designated collection centres. Such bulk consumers may also directly send their waste to authorized dismantlers or recyclers. However, the bulk consumers also dispose their e-wastes through auctions and the collection centres may participate in such auctions to channelize the e-waste for authorized recycling. On the other hand, the producers may organize the collection through the dealers or distributors or retailers under the take back program or exchange of the used products for new products and channelize the e-waste either to authorized collection centre or to the authorized recyclers. The electronic and electrical products, which come to the service centres or refurbishers, may be repaired or refurbished and handed over to the consumers. Additionally, the components or products not repaired can be collected by the collection centres or by the recyclers. An overview of the channelization of e-wastes to collection centre is presented in Fig. 1.

**Role of an independent agency in the e-waste collection system:** The collection of e-waste is a critical activity in the whole e-waste management system and irregularities in the collection channels need to be rectified to make the whole process effective. The product, which is no longer in working condition, is handed over to a service centre, repair shop or a refurbishment unit where the product is made functional. Those products, which are not repairable and non-usable reaching the end of life, are channelized to dismantler or recycler. The producers invariably set up such service centres or they enter into collaboration with the producer. However, the tracking of the large number of unauthorized service centres and repair shops that prevail in most of the Asian countries is difficult. The exchange schemes though enable a huge collection of the used electrical and electronic equipment, but these are not channelized due to lack of coordination between the various agencies. In such cases, an independent organization or agency may facilitate in the process. In fact, an independent agency is required to establish the linkages between various stakeholders and to carry out the transactions required for collection and channelization of e-waste. Fig. 2 provides a model/system for such centres.

The facilitation counter set up in the collection centres would provide a platform for such transaction between consumers and collection centres to help in channelizing the e-waste from different sources to the collection centres. Such

collection centres would also collect the e-waste from household consumers on the exchange rates that may be decided by the product, its quality and condition. Such transactions may be monitored to enable reliability and transparency. The independent collection agency would also indulge in conducting awareness programs to sensitize the society to understand the function of facilitation counters and also organize collection drives.

Channelization of e-waste from consumers to facilitation counter can be done by various methods such as direct collection by deposition of e-waste by consumers, or through collection points, collection bins, drop boxes, vans etc. Collection points can be from the residential areas, commercial areas, and educational and other institutions. The collection bins can also be placed in public places like restaurants, malls, offices, post offices, market places, etc. Mobile vans can also be used for door-to-door collection of e-waste. Components and defective products from service centres/re-furbishers can be transferred to the facilitation counter to channelize the waste to collection centres. Such system requires support from the Government as well as other participating agencies.

**Proposed system of e-waste collection and channelization:**

The approach of the study was to provide a model/system for e-waste channelization. The overall material and financial flow details have been summarized in Fig. 3. The electrical and electronic products are used by the consumers and are returned after the end-of-life. The dealers, distributors or retailers also facilitate the producers in the collection of e-waste under the take back or buy back scheme through exchange of used products when the consumer buys the new product. It is required to channelize the wastes generated during manufacture of electrical and electronic products to the authorized recyclers. E-waste can also be collected from the service centres or re-furbishers, wherein the repaired product is given to the consumer and the defective products or components are sent for recycling. Collection centres are required to channelize the e-waste to the authorized recyclers for environmentally sound process.

The transactions were involved in the e-waste collection in most of the countries considered in this study. Therefore, an understanding of the financial flow in the e-waste management system is necessary in order to facilitate the collection of e-waste. Moreover, while purchasing any product, the consumer is required to pay an amount in advance towards the "Deposit Refund Scheme" (DRS), which is refundable when the product is returned at the end-of life. The interest earned from this deposit is to be used for recycling of the product purchased. Producers may financially support the dealers or distributors or retailers to organize the take back or buy back schemes. Collection

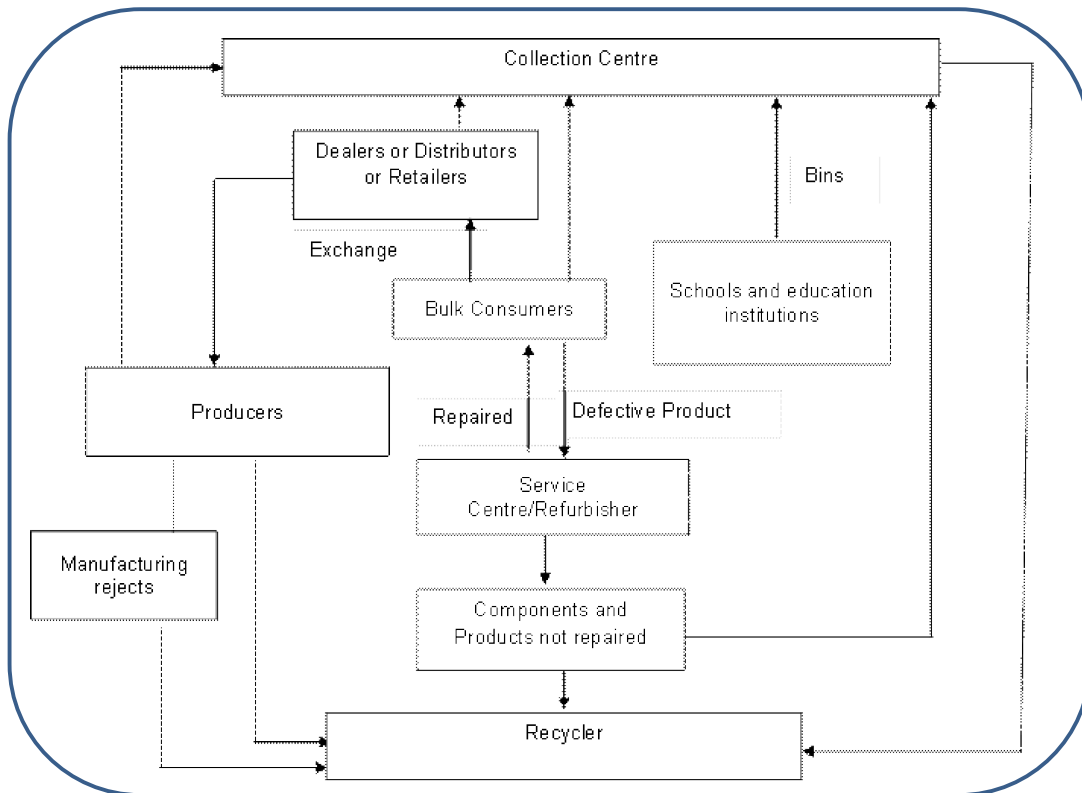


Fig. 1: E-waste collection centre.

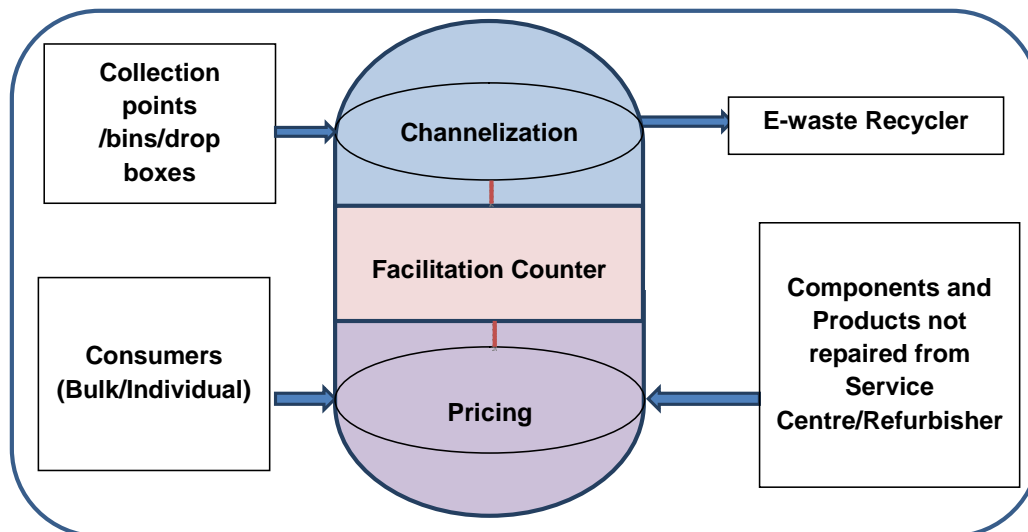


Fig. 2: E-waste collection through independent agency.

centres can facilitate e-waste collection from household consumers on the basis of e-waste exchange rates. Because collection centres provide an important link in the e-waste management system, these need to be financed by producer, government, recycler or any combination of these

stakeholders. However, there is a chance of the collection centre to be an independent entity on its own, and also create necessary linkages between the various stakeholders to channelize e-waste to authorized recyclers as well as to make it into a profitable business venture. However, effort

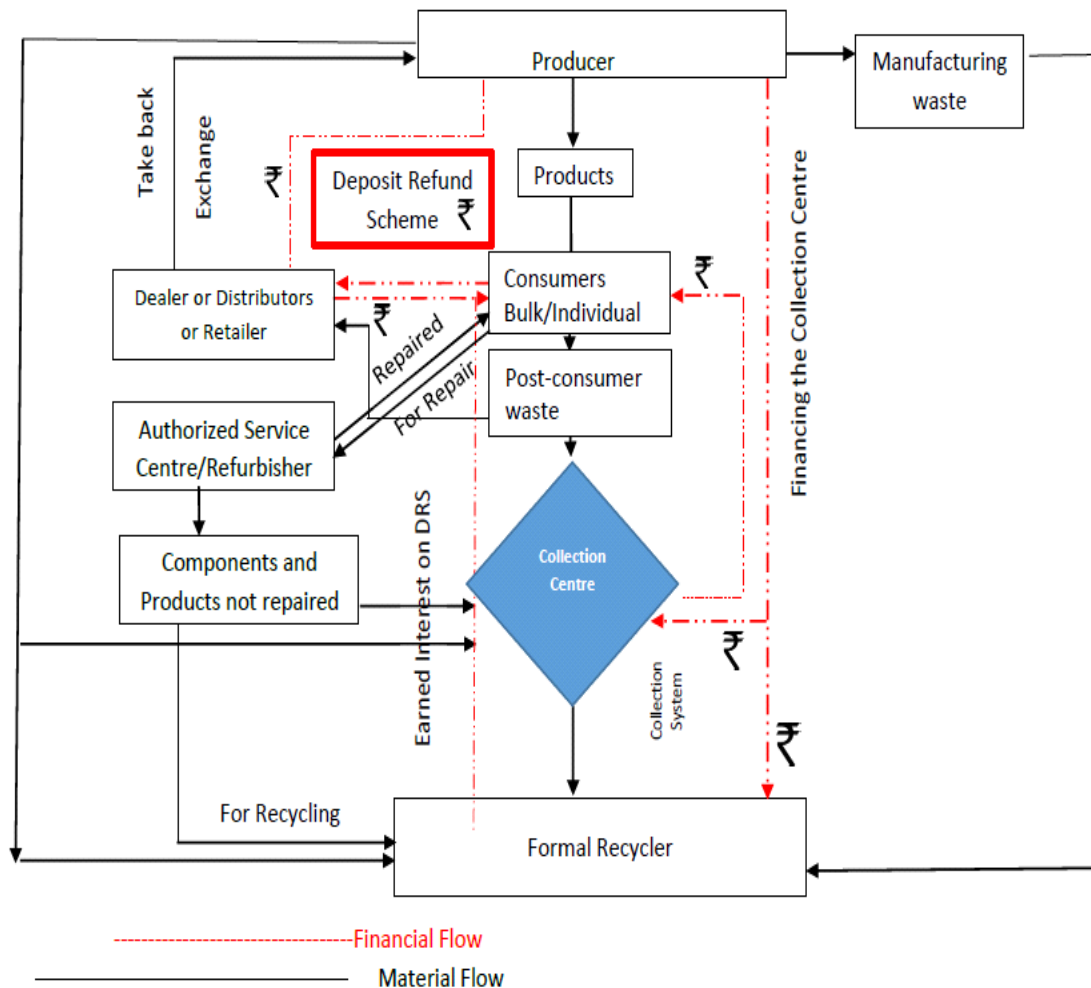


Fig. 3: The model for e-waste collection and channelization.

is required to monitor the activities and provide guidance for channelizing e-waste for environmentally sound management.

## CONCLUSIONS

The study illustrated that although the Asian countries are known to recycle e-waste, however, disposal into landfills or dumping in open spaces cannot be ruled out. The need of the hour is to improve the efficiency in the collection systems. In order to start corrective actions on policy and implementation, collection and maintenance record of e-waste is of utmost importance. Formulation of standards and specifications for processing and recycling e-waste and regular assessment of e-waste generation is required for e-waste management. The authorities and the entrepreneurs are responsible agencies need to play an important role in

improving e-waste management at present as well as future. They need to increase public awareness about e-waste and the role of facilitation counter to promote the collection and channelization of e-waste. Doing this will bind them into the process through appropriate extended producer responsibilities. The proposed system provides all these in the system for effective channelization of e-waste.

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