Challenges in E-waste management in Sri Lanka

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13.1 Introduction

Safe management of waste of electrical and electronic waste or E-waste is serious issue of many countries. The alarming rate of electrical and electronic waste (E-waste) generation has become a major global concern (Raghupathy et al., 2010). In particular, it is a great challenge for developing countries due to extensive generation, transboundary movement, and lack of technical expertise (Herat and Agamuthu, 2012). It is estimated that the world generates around 20−50 million tons of E-waste annually, most of it from Asian countries. In this connection, management of electronic waste has become a priority concern in most of the developed and developing nations.

Electronic waste, commonly known as E-waste or waste of electrical and electronic equipment (WEEE), or end-of-life (EoL) electronics, denotes electronic and electrical equipment (EEE), including all components, subassemblies, and consumables, supposed to be out of date, or unwanted by the user.

Electrical and electronic equipment are electronic or electrical equipment that have become unwanted, nonfunctional, or obsolete due to technological advancements or that have reached the end of their useful life called as E-waste or WEEE which stands for waste electrical and electronic equipment. E-waste is mainly consisted of computers, mobile phones, printers, and cathode tubes due to their less life cycle.

There is no universally accepted definition of "electronic waste," or "E-waste," which is used as a general term for old, end-of-life, or discarded, electrical and electronic equipment, and which are supposed to be of no further value to their owners (Widmer et al., 2005).

A more comprehensive definition of E-waste can be observed in the European Parliament Directive 2002/96/EC on Waste Electrical and Electronic Equipment (WEEE). Initially, it defines "electrical and electronic equipment" or "EEE" as "equipment which is dependent on electric currents or electromagnetic fields in order to work properly and equipment for the generation, transfer and measurement of such currents and fields falling under the categories set out in Annex IA and designed for use with a voltage rating not exceeding 1000 Volts for alternating current and 1500 Volts for direct current" (Herat, 2011).

The Waste Electrical and Electronic Equipment Directive (WEEED) of the European Union has identified 10 major categories of WEEE for reporting purpose (Table 13.1).

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Table 13.1 Major categories of WEEE according to WEEED.

Category	Examples
Large household appliances	Refrigerators, ovens, washing machines, dishwashing machines, microwaves, electric heating appliances, electric fans, and air conditioners
Small household appliances	Vacuum cleaners, toasters, irons, coffee machines, appliances used for hair cutting, hair drying, tooth brushing, shaving and body care, clocks, and watches
IT and Telecommunication equipment	Personal computers, mouse, screen and keyboard, laptop computers, notebook computers, notepad computers, printers, copying equipment, electric and electronic typewriters, pocket and desk calculators, fax machines, cordless phones, cellular phones, and answering machines
Consumer equipment	Radio sets, television sets, DVD players, video cameras, video recorders, hi-fi recorders, and musical instruments
Lighting equipment	Lamps and bulbs
Electrical and electronic tools	Drills, saws, sewing machines, equipment used for turning, milling, grinding, sawing and cutting, tools used for riveting, nailing and screwing, tools used for welding and soldering, and tools used for garden activities
Toys, leisure, and sports equipment	Game consoles, electric trains, car racing sets, and video games
Medical devices	Radiotherapy equipment, pulmonary ventilators, and dialysis machines
Monitoring and control instruments	Smoke detectors, thermostats, and heating regulators
Automatic dispensers	Drink and money dispensers

13.2 Global scenario

In a new report on E-waste released by the United Nations University, global electronic waste has reached record high levels. 41.8 million tons of E-waste was generated in 2014, fueling concerns about the growing risks to public health, resource conservation and the environment.

According to the Global E-waste Monitor in 2016, the annual E-waste generation of the world is 44.7 million Metric Tons with an equivalent to 6.1 kg/inhabitant. The report also states that only 20% of the total E-waste generated (8.9 million MT) is documented to be collected and recycled through proper streams. From the remaining 80% of E-waste, 4% of E-waste from higher income countries are thrown into residual waste. The fate of the remaining 76% (34.1 million MT) is not known. It has been predicted that global E-waste generation will reach 52.2 million MT in year 2021 with a per capita generation of 6.8 kg/inhabitant.

When considered the regions in the world Asia is the highest generator of E-waste with 18.2 million MT while Europe and America generate 12.3 million MT and 11.3 million MT, respectively. However, Europe has the highest per capita

Table 13.2 The highest generators of E-waste.

Country	Total generation (million MT)	Per capita generation (kg/inhabitant)
China	7.2	5.2
USA	6.3	19.4
Japan	2.1	16.9
India	2.0	1.5
Germany	1.9	22.8
Brazil	1.5	7.4
Russia	1.4	9.7
France	1.4	21.3
Indonesia	1.3	4.9
Italy	1.2	18.9

Source: Blade, C.P., Wang, F., Wong, J., Kuehr, R., Hulsman, J., 2015. The global E-waste monitor United nations University, IAS- SCYCLE, Bonn, Germany (Blade et al., 2015).

generation of E-waste which is 16.6 kg/inhabitant. Africa is the lowest E-waste generator with 2.2 million MT and 1.9 kg/inhabitant.

Table 13.2 shows the 10 countries that generate most E-waste in the world. It should be noted that only 41 countries in the world has official E-waste statistics.

Sustainable Development Goals outlined by the United Nations Organization aims to achieve balance between economic and technological development in parallel to environmental sustainability. E-waste produces a significant challenge in achieving this balance.

SD Goal No. 3: Good health and well-being, tries to ensure healthy and long lives for all, eliminating or reducing major disease such as cancers, malaria and tuberculosis.

SD Goal No. 6: Clean water and sanitation ensure access to safe drinking water and sanitation for all. Millions of people, mostly children die every year from diseases associated with poor quality water and inadequate sanitation.

SD Goal No. 11: Sustainable cities and communities aims to make cities inclusive, safe, resilient, and sustainable to live. The challenge is to maintain clean cities while allowing them to grow.

SD Goal No. 12: Responsible consumption and production ensures sustainable consumption and production patterns. It tries to reduce future economic and social costs of development efforts, by reducing resource use, degradation, and pollution along the whole life cycle of economic activities. It also encourages customers for sustainable consumption and lifestyles.

Management of E-waste is a worldwide challenge in achieving the sustainable development goals. Several conventions and policies have been introduced from time to time in order to manage E-waste.

- The Basel Convention on the Control of Transboundary Movement of Hazardous Waste and their Disposal in 1989 seeks to reduce hazardous waste generation, restrict their transboundary movements, and promote environmentally sound management.

- The Rotterdam Convention in 2004, promotes shared responsibility between E-waste exporting and importing countries. It provides for obtaining and disseminating information to enable E-waste importing countries to decide whether they are willing to receive E-waste from the exporting countries.
- Waste Electrical and Electronic Directive of the European Union in 2012, aims to protect environment and human health by preventing or reducing the adverse impacts of E-waste by laying down regulations for product design and obligations at the end-of-life of the product. It promotes reuse, recycling, and other forms of recovery of E-waste so as to reduce disposal, and all operations involved in the life cycle, especially treatment of E-waste. This makes manufacturer responsible for collecting, recycling, and disposing of E-waste.
- Restriction of Hazardous Substances (RoHS) Directive in 2011, restricts the use of hazardous substances in the production process and promote environmentally sound recovery and disposal. It restricts the use of six hazardous substances including heavy metals such as lead, mercury, cadmium, hexavalent chromium, polybrominated biphenyl, and polybrominated diphenyl ethers in the manufacturing process of new electrical and electronic equipment.

13.3 Environmental and health hazards of E-waste

E-waste is more harmful than other municipal solid waste (MSW) because they contain heavy metals such as lead, cadmium, arsenic, and mercury, persistent organic pollutants (POPs), flame retardants, and other potentially hazardous substances. It has been predicted that E-waste is growing almost three times the rate of MSW in the world. Table 13.3 illustrates health effects of some elements present in E-waste.

Improper handling of E-waste adds toxic matter to environmental cycles through:

- Leachates from dumping sites
- Particulate matter from dismantling activities
- Fly and bottom ash from burning activities
- Waste water from dismantling and shredding facilities

Emissions during burning of E-waste can give rise to greenhouse gases contributing to global warming. Leachates from dumping sites can cause pollution of water bodies and ground water as well as acidification of soil. Hazardous particles contained in E-waste get accumulated in fauna and flora and can enter human bodies through food chains.

13.4 Sri Lankan scenario

Being the country with a highest literacy in the region the government has identified the need to develop country's capacity in information sector and enhance the

Table 13.3 Negative effects on health by some elements present in E-waste.

Elements	Effects
Arsenic (As)	Carcinogenic substance (skin and lung cancers), cardiovascular disease, and skin lesions
Barium (Ba)	Muscle weakness, damages to heart, liver, and spleen
Cadmium (Cd)	Carcinogenic substance, kidney and lung damage, deficits in learning behaviors, elevated blood pressure, and effects on respiratory system
Chromium (Cr)	Carcinogenic substance, can even cause damages to DNA in cells
Copper (Cu)	Toxic to lungs and mucous membrane, very hazardous if inhaled or contacted with eyes
Lead (Pb)	Causes damage to nervous systems, blood systems, and kidneys, and affects the brain development of children
Mercury (Hg)	Memory loss, sensory impairments, reproductive failure, nausea, vomiting, diarrhea, damages to brain and kidneys, and corrosive to skin and eyes
sulfur (S)	Damages to liver, kidneys, and heart, and suppression of immune system
Silver (Ag)	Damages to eyes through direct contact, repeated exposure may produce general deterioration of health by accumulation in one or many human organs
Zinc (Zn)	Abdominal pain, diarrhea and vomiting, direct contact can cause eye irritation

e-literacy among the citizens. Cumulatively all these reasons lead to boost the generation of E-waste. Like other developing countries in Asia and Africa, Sri Lanka is now confronted with the huge problem of E-waste. Trading of electronic items has become a common practice and the number of sales centers had increased notably within past two decade.

As per the status report on Electronic and Electrical Waste Management in Sri Lanka published by the Central Environmental Authority (CEA) in 2017, total number of EEEs put to the market each year during 2007−15 shown in Table 13.4. As per the said report total number of EEEs put to market increased 22-fold during 2007−15.

13.4.1 Growing demand for electrical and electronic equipment in Sri Lanka

The urbanization rate of Sri Lanka is expected to increase annually by 3%−4% from the current 18.38% of urban population who lives in urban areas and in cities. The urban population contributes for generating MSW which is about 1.0 kg/person/day in Sri Lanka. Although E-waste constitutes about 0.2% of the MSW at present. It is expected to grow with increased urbanization and enhanced quality of life (WRMPP, 2016).

Table 13.4 Summary of total imports in Sri Lanka from 2007 to 2015.

Equipment	Sum of net units (nos.)									Grand Total
	2007	2008	2009	2010	2011	2012	2013	2014	2015	
Air conditioners	**35,555**	**90,582**	**35,378**	**139,768**	**118,455**	**83,639**	**62,450**	**79,496**	**79,529**	**724,852**
Refrigerators	1849	3909	63,606	18,561	49,724	193,413	110,503	130,214	166,566	738,345
Photocopier/Fax		17,372	133,867	146,274	166,194	170,028	139,445	150,841	165,917	1,089,938
Washing machines	20,190	59,216	24,805	42,827	64,822	77,485	28,539	27,587	33,700	379,171
Computers		33,119	202,777	297,192	474,833	519,610	504,848	422,869	401,449	2,856,697
Electric ovens	57,168	82,066	58,226	103,618	142,197	227,357	170,745	138,150	182,960	1,162,487
Mobile phones		225,915	777,143	1,485,248	3,455,947	3,846,712	4,046,694	4,710,247	5,855,551	24,403,457
Televisions	111,950	311,115	163,655	323,689	1,004,838	515,429	442,760	472,529	740,249	4,086,214
Electronic toys	139,377	38,411	2,843,912	3,287,374	3,926,464	3,657,662	419,406	417,566	373,830	15,104,002
Equipment	**Sum of net mass (kg)**									**Grand Total**
	2007	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	
Air conditioners	**5,548,690**	**2,747,642**	**1,807,416**	**3,397,114**	**3,977,590**	**2,877,346**	**3,111,185**	**3,375,921**	**4,282,547**	**31,125,451**
Refrigerators	67,185	219,185	558,925	855,541	2,049,982	6,378,340	4,173,688	4,228,004	6,956,737	25,487,587
Photocopier/Fax		171,275	1,074,835	1,321,872	1,749,705	1,502,970	1,837,318	1,745,852	2,018,322	11,422,149
Washing machines	520,829	1,261,824	766,911	1,229,140	1,731,084	1,639,460	952,895	813,729	1,170,295	10,086,167
Computers		404,336	1,863,687	2,765,118	3,320,947	3,361,109	3,027,080	2,697,920	2,435,755	19,875,952
Electric ovens	420,382	582,770	428,897	806,406	1,126,874	1,132,496	1,070,703	1,066,402	1,373,720	8,008,650
Mobile phones		177,067	442,676	493,764	982,936	13,552,995	1,061,712	1,255,062	1,501,295	19,467,507
Televisions	2,249,845	6,109,928	3,160,094	5,405,772	5,761,944	4,543,958	3,158,345	2,925,134	4,180,156	37,495,176
Electronic toys	95,649	36,678	2,551,423	3,127,996	3,548,467	2,909,016	363,286	334,067	354,289	13,320,871

Source: Sri Lanka Customs.

A noticeable increase was shown in the EEE use in Sri Lanka during the past two decades and with the economic growth of the country EEE use is predicted to grow further in the coming decade. Sri Lanka's EEE manufacturing sector is small and it largely relies on imports to meet the country's demand.

Sri Lanka ratified the Basel Convention on the Control of Transboundary movement of Hazardous Waste and their disposal in 1992. In line with the decision taken at the sixth Conference of the Parties of Basel Convention, a National Implementation Plan and the and the preliminary inventory of electronic waste management was prepared in 2008. The implementation plan recognized the Electronic waste management as a priority issue which needs urgent attention.

Since the adoption of "Free market economy" in Sri Lanka demand for electrical and electronic equipment (EEE) is continuously in the increasing trend. EEE such as mobile phones, computers, televisions, washing machines, and refrigerators has become necessities because of the convenience they give in handling the daily tasks, and the comfort they provide. Among other electronic devices a significant increase in the usage of computers and mobile phones has been observed during the past few years. Table 13.5 shows the growth of telephone penetration per 100 citizens in Sri Lanka from 2013 to 2016.

According to the Telecommunication Regulatory Authority of Sri Lanka, it shows 61.06% of overall mobile connectivity index score. Which means almost 27.38 million mobile connections exists in Sri Lanka, where population of approximately 21 million. Mobile penetration has risen from 126% in 2017 to 131% in 2018 which has been increased by several folds. This indicates that the Sri Lank is with the highest mobile penetration in the South Asian Region.

The records of Department of Census and Statistics of Sri Lanka shows that the percentage of computer owned households has also increased from 22.5% in 2016 to 23.5% in 2017. It is predicted that the demand for EEE, especially mobile phones and computers will be increased at a faster rate in the coming years due to technological advancements that add more attractive features to the items day by day as well as competitive prices and promotional campaigns among importers that operate within the country.

The EEE market in Sri Lanka is dominated by imported items. Imported EEE is responsible for approximately 95% of the market and that importation has been increased during the past few years. However, there are few local producers of

Table 13.5 Telephone usage in Sri Lanka.

Year	No. of cellular phones	Telephone penetration (per 100 citizens)
2013	20,315,150	111.87
2014	22,123,000	119.56
2015	24,384,544	128.71
2016	26,227,631	135.73

Source: Annual Report, 2016. Central Bank of Sri Lanka.

Table 13.6 Local production of EEE.

Year	No. of units	
	Washing machines	Refrigerators
2011	78,000	38,000
2012	86,500	46,000
2013	78,500	43,500
2014	99,000	53,000
2015	130,000	90,000

Source: Ranasinghe (2017).

Table 13.7 Contributors to E-waste in Sri Lanka.

Component	Average lifespan (years)
Personal computers	3–8
Printers	1–8
Televisions	15–20
Mobile phones	2
Refrigerators	15–20
Air-conditioners	5–15
Photocopy machines	5–10
Washing machines	15–20

Source: Development of National Implementation Plan for Electrical and Electronic Waste Management In Sri Lanka Final report, 2008.

equipment such as washing machines and refrigerators, and the local production is also in the increasing trend as shown in Table 13.6.

A survey carried out by the CEA of Sri Lanka in 2008, has revealed that approximately 30% of imported computers are secondhand items. Limited purchasing power of countries such as Sri Lanka has created a growing secondhand market for EEE. There are 140 importers registered with the CEA that import secondhand items. The danger in secondhand or used items and locally assembled equipment is that they possess a shorter lifespan than their original counterparts or reputed brands. Therefore they become unusable within a shorter period and add up to E-waste. It has been estimated that per capita generation of E-waste in Sri Lanka as 4.2 kg/year. Table 13.7 shows electrical and electronic equipment that contribute to E-waste in Sri Lanka and their average life span while Table 13.8 shows the penetration and trend in EEE use in the country.

The census study on computer literacy done in 2015 (DCS, 2015) indicates that at least one computer is available in 25% of households of the country. Overall computer literacy reported in Sri Lanka by 2015 is 26.8% (CEA, 2018). The main contributors to E-waste in Sri Lanka are the households, industries, and the commercial sectors. It has been estimated that per capita generation of E-waste in Sri Lanka as 4.2 kg/year.

Table 13.8 Penetration and trend in EEE use in Sri Lanka.

Census period	Population	Household size	No of estimated households in million	TV (%)	PC (%)	Mobile phones (%)	Washing machines (%)	Refrigerators (%)
2012/2013	20,359,439	3.9	5.22	82.7	18.5	87.6	17.2	46.2
2009/2010	20,675,000	4	5.17	80	12.5	77.1	13.1	39.6
2006/2007	19,773,000	4	4.94	81.3	7	77.3	10.8	35.1
2003/2004	19,232,000	4.31	4.46	70.8	4.1	24,5	7.6	29.7
1996/1997	18,336,000	4.61	3.98	50.61	0.4	4.5	N/A	16.8
1986/1987	15,628,000	5.1	3.06	19.6	N/A	1.4	N/A	8.1
1981/1982	14,846,750	5.2	2.86	1.8	N/A	0.9	N/A	2,9

13.4.2 National electrical and electronic waste management policy in Sri Lanka

Policy on E-waste management was drafted and called for public comments in 2008. As stated in the E-waste policy it is a timely action that has to be taken in managing electrical and electronic equipment in a manner which is sustainable throughout its life cycle and it is also necessary to honor and comply with the provisions of the Basel Convention and other related Conventions ratified by the country in managing E-waste.

The key policy objectives of the National Electrical and Electronic Waste management policy were identified as follows:

- Prevent/minimize negative impacts to the environment and health of the people due to haphazard use of e-products and disposal of E-waste.
- Promote integrated E-waste management by looking at all phases of the life cycle of the product and take action where it is most effective to prevent disposal of E-waste in scattered locations and ensure maximum resource recovery.
- Secure social responsibility toward sustainable production and consumption of e-products.
- Ensure waste treatment and final disposal of E-waste in an environmentally sound manner.

13.5 Analysis of electronic and electrical equipment market in Sri Lanka

Electrical and electronic equipment market of Sri Lanka mainly depends on the imported goods. However, there are few locally manufactured electrical and electronic items available. E-vendors evident that there is a tendency in consumers moving toward locally manufactured products as well.

13.5.1 Electronic and electrical Items manufacturers/assemblers

At present only washing machine, refrigerators, and computers are manufactured and assembled in Sri Lanka. There are only three large scale electronic and electrical assembling industries engaged in manufacturing equipments under brand names. One industry is engaged in assembling computers ranging from tablet PC, laptops, and desktop computers and other two companies are engaged in assembling washing machines and refrigerators. These are vendors who assemble computers mislead by providing rough figures on their manufacturing items to avoid the tax payment. However, the estimates show that local production of refrigerators demonstrated remarkable growth within 2014−15. The production has increased in nearly threefold within last 5 years.

Except in 2013 there is nearly twofold growth in local production of washing machines in 2015 comparing with 2011.

13.5.2 Computer assembling

As per the interviews carried out with the computer assemblers, a prominent tendency of dominating branded products in the market is showed between 2005 and 2014 with respect to 1995 and 2004, where the demand for assembled products were very high as at that time there was a big gap in the cost of assembled and branded products.

13.6 Electronic item importers

Imported electronic and electrical goods are account for nearly 95% of the market share. Table 13.9 shows that import data of other types of EEE 2008−14. When looking through the custom data on importations there is a significant growth in importation of electronic goods.

13.6.1 Secondhand electronic item importers

There are nearly 140 secondhand electronic item importers that have been registered at the CEA as they have to obtain no objection and clearance from the CEA upon importation of used electronic items mainly for used computers, washing machines, and televisions. However, cathode ray tube (CRT) monitors are banned to be imported. These used EE goods generally coming from South Korea, Australia, Singapore, and Japan. This registration mechanism only started in 2014.

These imported computers and washing machines are sold at retail shops in island wide. These vendors directly import used e-items as per the demand.

Inadequacy of import-export regulations allows importation of secondhand equipment with relatively low lifespan, which makes Sri Lanka a dumping yard for low quality and used EEE.

Table 13.10 shows the number of secondhand computers and washing machines which were imported to Sri Lanka in year 2016.

It is inevitable that these computers add into E-waste within 2−3 years. The process becomes more rapid due to high humidity level and high temperature in Sri Lanka. There are huge amounts of unusable electronic items gathered at household level, due to lack of proper island wide efficient collection system. The number of sellers that provide take back offers is also very low.

However, after 2016, government restricted importation of used computers and some other e-items were not allowed. However, importers are tricky enough to import the computers as “knocked down” goods and get those assembled locally as there are no any kind of controls over used parts in the legislation.

Table 13.9 Import data of other types of electronic and electrical equipment 2008–14.

S. No.	EEE Category	2008	2009	2010	2011	2012	2013	2014
		Qty (units)	Qty (units)	Qty (units)	Qty (units)	Qty (units)	Qty (units)	Qty (units)
1	Electric heater	72,783	26,470	52,433	55,739	50,719	37,487	185,931
2	Iron	698,376	358,219	89,012	841,576	683,227	736,822	511,803
3	Kettle	243,484	395,202	556,494	1,228,965	1,105,606	1,021,725	1,028,268
4	Microwave oven	16,387	13,686	20,249	32,280	28,660	26,731	15,640
5	Hair dryer	15,480	11,243	33,323	50,833	34,450	31,139	52,510
6	Vacuum cleaner	12,560	39,800	1732	28,718	35,195	38,570	39,125
7	Rice cooker	275,647	135,679	301,881	1,064,624	882,387	681,832	603,670
8	Electric hay mower	33,342	13,083	15,856	16,354	41,397	8430	19,916
9	CD, DVD, and blue ray player	189,697	149,589	248,647	648,322	614,110	383,352	326,951
10	Camera	49,538	34,816	106,336	239,521	277,758	280,010	266,082

Table 13.10 Importation data of second hand computers and washing machines 2016.

Month	Computers	Laptops	LCD monitors	CPU	Washing machines
January	3491	1076	6313	1913	3361
February	3321	749	6554	3791	4231
March	5347	1603	8470	2314	3953
April	31,738	17,754	57,767	34,027	37,355
May	2407	2537	6157	2640	4880
June	7628	2987	12,459	3724	4366
July	8419	3058	9914	4821	8827
August	5492	1954	15,069	10,943	8360
September	3776	4101	8037	8569	8021
October	2482	2606	6806	2640	4880
November	5103	2331	7253	1811	1327
December	7498	3269	4432	1030	4924
Total	**86,702**	**44,025**	**149,231**	**78,223**	**94,485**

Source: Central Environmental Authority.

13.7 Usage of electronic items in household level: desktop or laptop computers

Table 13.11 shows the percentage distribution of computer owned households by Sector/Province levels. In 2014, at least one computer is available in 22% of households of the country. That is one out of every five households is having a computer. This percentage is about 36% in Urban Sector and Rural and Estate Sector show 20.4% and 4.6%, respectively. The highest availability is in Western province (33.0%) while the lowest availability is reported from North Central province. Over the survey periods from 2004 to 2014 overall percentage has increased sharply from 3.8% to 16.6%.

Table 13.12 illustrates computer owned households in Sri Lanka. By the year of first acquisition of a computer—2014. Accordingly, 65% of the households have acquired the first computer during the last 5 years (2010−14) and the Rural sector shows a higher recent acquisition (68%) than the urban sector (55%).

13.8 Mobile-cellular penetration in Sri Lanka

In 2011, Sri Lanka had an estimated 18,003,447 mobile phone subscribers. By the end of December 2012 the number was 20.3 million. This is for 20.8 million people (International Telecommunication Union, 2015).

Sri Lanka has a relatively high mobile-cellular penetration when compared to the Asia-pacific region. Fig. 13.1 illustrates the worldwide mobile-cellular penetration. By beginning 2012, the country's mobile penetration level was higher than the world and regional averages, which has more than doubled from around 27% in

Table 13.11 Percentage of computer owned households in 2004, 2006/2007, 2009, and 2014.

Sector/Province	Desktop (%)				Desktop or laptop (%)	
	2004	2006/2007	2009	2014	2009	2014
Sri Lanka	3.8	8.2	10.6	16.6	11.4	22.4
Urban	10.5	17.8	23.6	25.8	26.3	35.8
Rural	3.1	6.9	9.2	15.3	9.8	20.4
Estate	0.3	1.1	3.1	2.7	3.3	4.6
Province						
Western	8.4	16.4	19.0	24.5	20.7	33.0
Central	3.3	6.7	9.7	18.0	10.4	23.5
Southern	2.2	4.9	6.6	16.0	7.2	21.0
Northern	NA	NA.	NA	10.8	NA	19.5
Eastern	1.2	3.7	5.8	9.6	5.9	14.7
North-western	3.1	4.8	6.9	14.5	7.1	20.1
North-central	1.4	2.7	6.1	7.4	6.8	10.1
UVA	0.4	2.7	4.6	9.2	4.9	11.1
Sabaragamuwa	2.0	3.3	7.3	13.7	7.5	16.6

NA, not available.

Table 13.12 Computer owned households by the year of first acquisition of a computer—2014.

Sector	Total	Before 2001	2001–04	2005–09	2010–14
Sri Lanka	100.0	5.0	6.6	23.7	64.7
Urban	100.0	6.8	9.8	28.0	55.5
Rural	100.0	4.3	5.5	22.3	67.8

Source: Ranasinghe, A.R.M.W.W.K., 2017. Assessing E-waste management system in Sri Lanka and suggesting mechanism to streamline the existing system. Master Thesis of Environmental Science, The Open University of Sri Lanka.

2006 to over 87% by end 2011. The large majority (around 90%) of mobile cellular subscriptions in the country are prepaid. The percentage of the population covered by a mobile cellular signal stood at 98% by beginning 2011, with virtually by 2019 all Sri Lankans covered by a mobile cellular signal.

13.9 Overview of electronic and electrical waste generation and management in Sri Lanka

According to past evidences, the WEEE management establishments had informally started their operations nearly a decade before. This was done through scrap

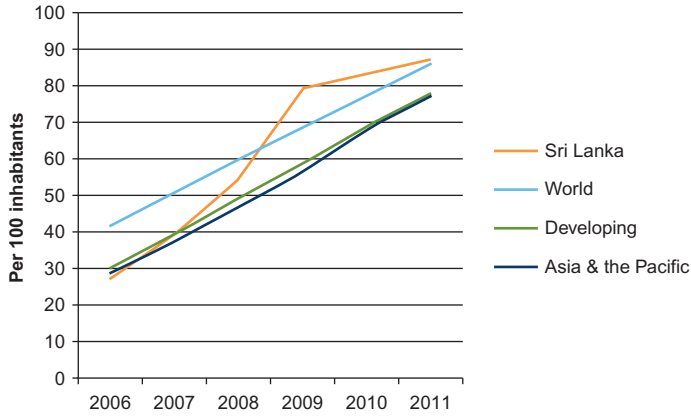

Figure 13.1 Worldwide mobile-cellular penetration from 2006 to 2011. *Source: Ranasinghe, A.R.M.W.W.K., 2017. Assessing E-waste management system in Sri Lanka and suggesting mechanism to streamline the existing system. Master Thesis of Environmental Science, The Open University of Sri Lanka.*

collectors and collecting end-of-life EEEs obtained from corporate sector in bulk when they remove the stock piled E-waste. At the beginning, only two or three E-waste collectors were operated in Colombo distict in Western province, where generation of WEEE was considerably high.

In 2008, certain types of WEEEs had been subjected to regulate under the National Environmental Act by mandating the Scheduled Waste Management license for all E-waste management activities carry out in industrial scale. In parallel to the internal legal framework, government has adopted Basel Conventions' notification procedure for exportation of WEEEs. Currently, it is being strictly implemented and on importing country's consent, exportations are not allowed. Through these procedures, a legal barrier had been set up to control informal exportations.

13.9.1 The stakeholders contribution on waste of electrical and electronic equipment collection

As per the interviews carried out with the "formal E-waste collectors" it was noted that after 2010, formal sector collectors expanded their operations in a more organized way with business agreements with corporate sector. Also they started expanding the collection mechanism throughout the country with their own door-to-door collection. Currently there are 11 E-waste mamagement facilities in operation and all most all are localized to Colombo District.

In 2010, CEA came into a "Memorandum of Understanding" with a telecommunication service provider to establish an island wide collection mechanism for M-waste (waste mobile phone). Through this program, all franchise shops and sales arcades had been converted as collection centers. Under this program there were 47

collection points established to collect waste mobile phones. According to the records this was not very successful as only a very less amount of mobile phones were collected island wide.

In 2011, CEA launched "National Corporate E-Waste Management Program" under a common logo and theme of "ensuring an E-waste free environment." Through this 14 private and public sector partner organizations had signed a "Memorandum of Understanding" with the CEA. Telecommunication service providers, electronic venders, E-waste management companies, and software companies were participated as stakeholders in the national level. The objectives of this program was to establish an island wide collection mechanism, organized drop off events and raising awareness among citizens. This program is still in progress and in 2014 partner organizations have been increased up to 21. Awareness created through this program has boosted the people to enter in to the WEEE business. Even though the main objective of the National Corporate E-Waste Management Program was to establish island wide collection network and it was not sucessfully achieved yet.

When analyzing collection network it was clearly noted that the formal sector collection and storages had been expanded nearly twofold within past 4 years and they do their collection, storage and dismantling practices in more organized way. However currently, only seven formal sector collectors are in operation.

There is a significant tendency for mandating the "Scheduled Waste Management License" as a primary requirement in many public sector and business establishments when they calling tenders to handover their obsolete EEEs. This has induced the informal sector to obtain the license and operate in a formal way.

A recycling facility has been established in the Katunayake export processing zone in 2017 filling the gap of unavailability of a recycling facility in the country. As the current practise only the plastic and metallic components are sold to downstream vendors; recycled internally while all the printed circuit boards are exported. At present, one E-waste management company is in the process of establishing recycling facility (having the processes of metal refining) aimig to cater the entire downstream management of WEEE.

There is a significant expansion of informal sector operations all over the country starting from door-to-door collection and ending up with rudimentary dismantling and metal recovery practices. Mainly scrap collectors are engaged in this business and is operated in domestic level in some localities, which has become a community-based operation.

13.10 Formal sector development in waste of electrical and electronic equipment

Curently there are 10 formal sector collectors bearing "Scheduled Waste Management License" to collect WEEEs are currently in collection operations. Out of these formal sector collectors, all 10 collectors are stationed in Colombo and

Figure 13.2 E-waste collection facilities by mobile phone service providers.

suburbs and five are baring export consents as well. Formal sector development of WEEE is depended on following factors:

1. *Formal sector WEEE management facilities*
   The formal sector collectors ususlly target bulk collections mainly from corporate sector. Modified colletion vehicles with attractive displays are used to collect E-waste in such situations. However the formal sector collectors have stong link with the informal sector as informal sector sell the dismantled parts to the formal sector though there is considrable competition amoung collectors.
2. *E-venders and telecommunication service providers*
   Electronic item venders and Telecommunication service providers who have entered in to a "Memorandum of Understanding" with the CEA had established WEEE collection points in their island wide sales outlets. This mechanism started in 2009 by a telecommunication service provider for the first time. In 2010 and 2014, some other telecommunication service providers and some e-venders joined to the island wide collection network. There are collection centers operate island wide through this mechanism. Normally e-venders collect all most all WEEE devices where as telecommunication service providers collect only mobile phones and batteries. In these sales outlets, a drop-off box had been kept to drop the waste mobile phones. E-waste collection facilities by mobile phone service providers are shown in Fig. 13.2. These collectors having agreements with formal sector WEEE management establishments. CEA monitors this mechanism. However, this sector is not operating in a successful manner as the collection target only their customers. As per the records in some occations, only a very few units have been collected. However, it was noted that state owned mobile service provider has done very significant contribution in raising awareness among citizens and also organizing islandwide drop off events under special programs.
3. *Extended producer responsibility (EPR) of e-vendors*
   E-venders practicing EPR policy also contribute in collection mechanism. Through these mechanisms, consumers can take back waste electronic devices to retail stores that distribute similar electronic items. Because consumers could get back the electronic item at the retail store in reduced price for purchase of a new product. Mainly the refrigerator, TV sets, and air conditioner vendors are engaged in these EPR-based collection mechanism. Basically e-vendor companies practicing this mechanism very active as a very viable strategy to market thier new products. Under this they take the old products

Table 13.13 Exportation of Lexmark torner cartridges.

Year	2013	2014	2015
Number of units exported	5850	11,250	13,840

regardsless of the brand and consessions given to new products. It was revealed that most of these collected WEEE are being directed to the informal collectors.

However, there is a one sucessfull EPR practise being implemented by the local agent of Lex Mark Toner cartridges who collects used cartridges and reexports to the mother company aiming brand protection. Exportation of Lexmark Torner cartridges in 2013−15 are shown in Table 13.13. This is done in complience with the regulatory requirement. Strategies are implemneted for direct taking back from the customers. In addition special drop off events and special promotional programs to collect toners too are carried out.

4. *Nonprofitable agencies/nongovernment organizations (NGOs)*

   Some nonprofitable agencies and NGOs implement collection programs with awareness on WEEE. Currently only one such organization avialble in the country and the amount they collect is very less comparatively. All the collected E-waste are being directed to the licencsed collectors.

5. *Informal sector collectors*

   Informal sector collectors operate their collection activities mainly as door-to-door collection. Their collection mechanisms link with economical mechanism as well. Generally the metal scrap collectors are the key players in this sector. Informal sector collection is distributed throughout the country covering all 25 districts. Unlike the formal sector, informal sector collection operations are distributed within rural areas as well (when comparing with the formal sector, informal sector dominating in rural areas). The collection network of the informal sector may consist of several modes of linkages such as buyers, intermediates, and transporters. This can be considered as the most active collection system in the country. In general small carts and small trucks are used in door-to-door collection. It is extremely difficult to collect the data from informal sector.

6. *E-waste collection through special programs*

Since 2010 the CEA and the partner companies of national E-waste cooperate program held drop off events to collect electronic waste. A drop off event conducted by the CEA is shown in Fig. 13.3. According to the CEA these drop off events mainly aimed to drag the E-waste stagnated in the household level. These drop off events are considered as one of the most sucessfull and effective collection methods.

13.10.1 Sectors engaged in dismantling of waste of electrical and electronic equipments

Dismantling of WEEEs is popular in Sri Lanka as it is required for recycling and recovery as well as for transboundary movements. However, recycling and recovery facilities which operate environmentally unsound manner causing significant environmental and health impacts due to significant amounts of E-waste containing hazardous materials dumped in open-land and waterways (Herat and Agamuthu, 2012). In addition, major environmental and health impacts occur during open burning of E-waste to recover expensive metals. However recycling, dismantling, and recovery

Figure 13.3 E-waste drop off events.

Figure 13.4 Handling E-waste in a formal sector facility.

operations are conducted by mainly informal employment sector in Sri Lanka; however, other sectors where provide significant contribution.

1. *Formal Sector*
   Formal sector dismantling is also carried out by the formal sector collectors which is also an activity covered under the "Scheduled Waste Management License" (hazardous waste management license). General practice in all these formal sector dismantling facilities is manual dismantling to separate printed circuit boards, plastics, and other metal components. Normally 2−20 workers are engaged in dismantling operations in these establishments and some had been provided with adequate trainings. Handling E-waste in a formal sector facility and dismantleing are shown in Figs. 13.4 and 13.5. Such facilties are mainly localized to Colombo and suburbs. Currently there are eight formal sector dismantling facilities in operation.
2. *Electronic item repair shops*
   Some electronic item (e-item) repair shops engage in dismantling operations. E-items that cannot be repaired further are dismantled and components are segregated to be sold out. Mainly removed circuit boards are sold to E-waste collectors.
3. *Informal sector dismantlers*

Generally, the urban poor has engaged in the dismantling of E-waste. Informal sector dismantlers spread all over the country and in most cases operations are going-on in domestic level. Mainly in Colombo district, informal sector operations

Figure 13.5 Splitting cables in a formal sector dismantling facility.

Figure 13.6 Informal sector dismantlers.

are widely found in unauthorized settlements in water body reservations and slums. Usually the scrap collectors are engaged in dismantling of WEEEs. In addition, there are some cottage level establishments dedicated only for dismantling WEEEs. Fig. 13.6 shows an dismantelling operation of PC moniors by informal sector dismantlers. Informal sector collectors sell their E-waste to these establishments is a common practice in Sri Lanka.

Most significant observation made was stockpiled cathod ray tube monitors in large numbers. This was common to all most all of the dismantling facilities. In these places dismantlers simply burn the cables to recover coper which has a comparatively higher economical value. Copper components of the cathod ray tubes are recovered and they openly dump the broken cathod ray tubes which is having lead in the glass. This malpractice will create impacts due to leaching lead in to the environment.

13.10.2 Sectors engaged in treatment and disposal of waste of electrical and electronic equipments

Although there are several sectors involved in E-waste collection in Sri Lanka, there is no formalized country-wide collection system for E-waste. The main E-waste collectors identified as:

1. Formal sector: usually target collection from the corporate sector through predetermined agreements.
2. Telecommunication service providers: have established WEEE collection points in their sales outlets.
3. E-vendors who offer take back services: consumers can get a discount when they purchase a new product if they return the used product such as televisions and refrigerators.
4. Informal sector collectors: usually go from door−to-door and mainly collect household items. They are the most dominating E-waste collectors in the island and their network is distributed in urban, semiurban, and rural areas of the country.

There is a significant link between informal sector and the formal sector E-waste collectors and handlers. Informal sector plays an active role through having island wide collection network and door-to-door collection. Formal sector dominates handling bulk quantities and exportations. Even though there is a control for the formal sector under the Scheduled Waste Management License, the government has no sufficient control over the informal sector.

As informal sector establishments have increased rapidly within the past few years and due to difficulties in accessing them policy makers and relevant regulatory bodies could not able to effectively interfere in streamlining this sector. An integration of all stakeholders such as Electronic item importers, consumers, E-waste collectors, and exporters is at a low level due to insufficient awareness and inadequate use of economic instruments in E-waste management.

13.10.3 Sectors engaged in waste of electrical and electronic equipment treatment

At present the CEA has granted approvals to establish an E-waste recycling or treatment plant at Katunayake Export Processing Zone. This facility will start operations in January 2017. According to the industrialist they developed strategic business agreement with precious metal smelters to refine precious metals by paying a processing fee for the service. We trade refined gold, silver, platinum, lead, copper, and cobalt in metal trade platforms globally.

As the current practice the plastic components and the metallic parts recovered out of WEEE are being recycled locally. Plastic components recovered from WEEEs are crushed in recycling facilities. These recycling facilities are mostly operated as small and medium scale enterprises (SMEs). Recycled plastics are being generally used to manufacture electric switches, plugs, shoe soles and heals. The recovered metal parts are sold to smelters. Out of these recycling/treatment facilities, only few recycling establishments are operated as formal sector.

During the last decade business establishments which are engaged in electronic waste management totally rely on exportation market of electronic waste. At present some large scale electronic waste collectors in informal sector tend to invest on recycling and metal refining facilities. However, there are a considerable amount of E-waste continues to be recycled by the informal sector. All most all of these processes are rudimentary in nature and could be dangerous some processes involve burning, breaking of CRTs and physical processes to recover materials. These result in release of toxic materials to the environment through emissions and effluents. In addition, there is a great potential to cause health impacts to the workers. Fig. 13.7 shows the typical informal sector operations.

Generally the urban poor, localized within Western province has engaged in the trade of waste and recycling which is a most unsafe and polluting livelihood opportunities for survival. Dismantling of electronic items or E-waste is also dominated by the informal sector. Most of the workers involved in such works lives in unauthorized settlements close to marshes and river banks are the urban poor who are unaware or do not bother of the hazards associated with these practices. This makes the situation worse as they do not have the skills and knowledge required in E-waste handling.

13.11 Waste of electrical and electronic equipment disposal and environmental concerns due to heavy metals

In Sri Lanka secured landfill facility is not available to dispose hazardous waste. The only disposal activity that could be observed in relation to E-waste is, open dumping by the informal sector. Fig. 13.8 shows a typical haphazard disposal of E-waste by informal sector. Once they recover the parts, which are having economical value while the rest are dumping in haphazard manner creating several environmental issues.

Figure 13.7 Informal sector operations.

Figure 13.8 Haphazard disposal of E-waste by informal sector.

At present in several municipal dump yards electronic waste are observed. There is a very big possibility of leaching heavy metals contained in these E-waste in to the soil and the ground and the surface water. Several studies done in MSW dump yards indicated metal pollutants in the leachate. Joseph et al. (2018) reported that leachate of active dump site at Karadiyana shows higher concentrations than the stipulated levels of selected trace metals, such as Fe, As, Cu, Ni, Cd, Zn, Pb, and Mn while Wimalasuriya et al. (2011) made similar observation at Gohagoda dumpsite. The both occasions the recorded values are higher than the reported values of Sewwandi et al. (2013). Table 13.14 shows that the heavy metals in leachate of the various dumpsites indicated the presence of metals in higher concentrations which exceeds tolerance limits (Sewwandi et al., 2013).

13.12 Electronic waste exporters

Transboundary movements are taken place by electronic waste exporters. Currently there are seven electronic waste exporters engaged in exportation bearing approvals as per the Basel Convention. Mainly printed circuit boards, batteries and CRTs are exported for the recycling facilities in South Korea, United Kingdom, Singapore, Hong Kong, Japan, the Netherlands, Belgium, and Germany. However, only one company has obtained approvals to export CRT to the Netherland where the cathode ray processing facility is available. Details of formal sector E-waste exporters data following data are shown in Table 13.15.

Although E-waste exporting has become a profitable business, Sri Lanka is yet to tap the E-waste exporting market. There are few companies that export E-waste such as circuit boards and batteries to other countries. But this E-waste is exported without any value addition. The receiving countries are Japan, Singapore, South Korea, Germany, and Belgium.

Table 13.14 Heavy metals in leachate of municipal dump yards.

Sample location	Heavy metals in leachate (ppb)								
	Cr	**Fe**	**Ni**	**Cu**	**Zn**	**As**	**Se**	**Cd**	**Pb**
Bandaragama	329	7167	912	227	5362	722	2607	90	479
Gampola	220	5546	335	734	462	164	461	4	34
Gohagoda	470	77,000	1900	190	6600	170	220	20	500
Rathnapura	439	56,343	1311	627	1685	1551	4922	52	168
Kolonnawa	1968	346,930	4473	55	11,759	705	2443	15	421
Galle	486	15,477	673	564	593	1796	5947	52	169
Wennappuwa	363	2501	399	431	409	939	2812	53	87
Negombo	330	20,111	666	535	2062	846	2184	51	333
Matale	345	60,762	115	573	6876	522	1935	100	1777
Hambanthota	80	5341	226	166	19,909	678	2522	172	492
Kataragama	11	1117	89	58	638	106	400	50	123
Max permissible level	100	3000	3000	3000	5000	200	500	100	100

Source: Sewwandi, B.G.N., Takahiro, K., Kawamoto, K., Hamamoto, S., Asamoto, S., 2013. Evaluation of leachate contamination potential of municipal solid waste dumpsites in Sri Lanka using leachate pollution index. <http://www.sjp.ac.lk/wcup/doc/Kawamoto_MoFA_presentation_041214[1].pdf>.

Table 13.15 E-waste exportations.

Company	Exporting country	E-waste type	Year of commencement	Exported quantity (tons)				
				2011	2012	2013	2014	2015
A	Germany, the Netherland Belgium, UK	Printed circuit boards, cathode ray tubes, batteries, ICT equipment	2010	–	25.6	38.5	73.5	95.5
B	Japan, UK, Hong Kong,	Printed circuit boards, batteries and accumulators	2008		160	120	140	110
C	Japan, Singapore	Printed circuit boards, batteries and accumulators	2007	20		30	20	30
D	South Korea	Printed circuit boards, batteries and accumulators	2011		60	80	110	90
E	Netherlands	Printed circuit boards, batteries and accumulators, telecommunication equipment	2014				50	
F	South Korea	Printed circuit boards, batteries and accumulators	2015					140
G	Japan	Printed circuit boards batteries and accumulators	2015					25
Total exportations				*20*	*245.6*	*268.5*	*393.5*	*490.5*

13.13 Operational system flow diagrams of entire electronic and electrical waste management

Figs. 13.9 and 13.10 show the E-waste management and operational systems in Sri Lanka. Fig. 13.9 illustrates the electronic and electrical waste operational flow in sector wise while Fig. 13.10 illustrates the flow of E-waste which were plotted based on the identifications done through field survey and secondary data of E-waste management.

Flow diagram illustrates in Fig. 13.10 explains the entire downstream flow of electronic and electrical waste. Places where the environmental pollution taken place also identified and marked in the diagram.

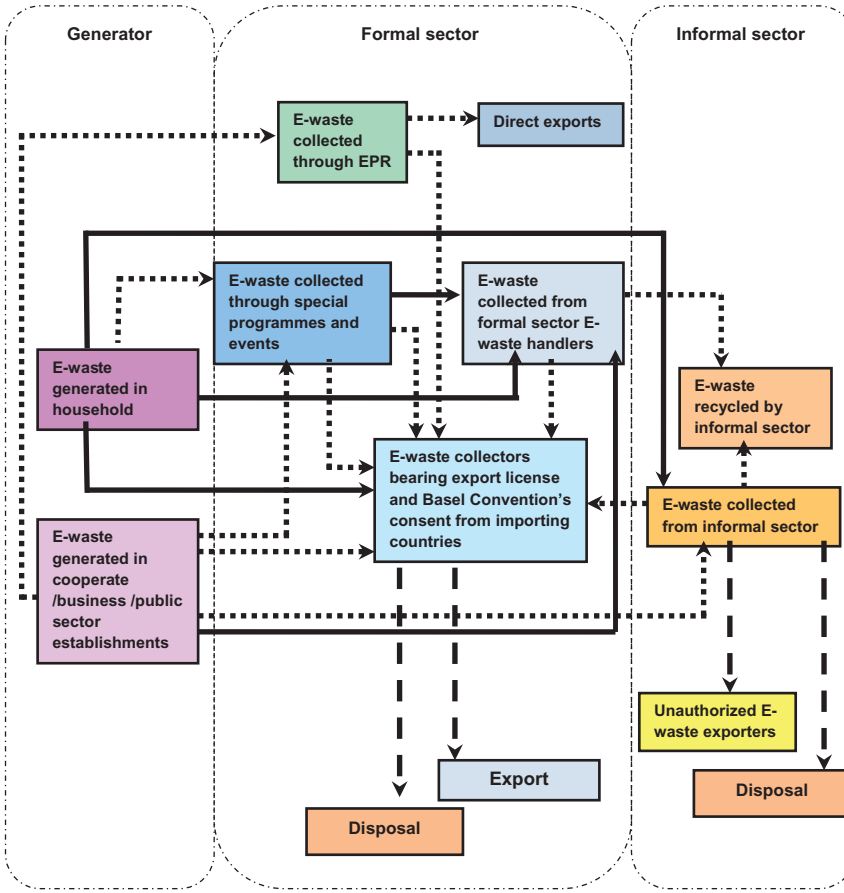

Figure 13.9 Electronic and electrical waste operational flow in sector wise.
Source: Ranasinghe, A.R.M.W.W.K., 2017. Assessing E-waste management system in Sri Lanka and suggesting mechanism to streamline the existing system. Master Thesis of Environmental Science, The Open University of Sri Lanka (Ranasinghe, 2017).

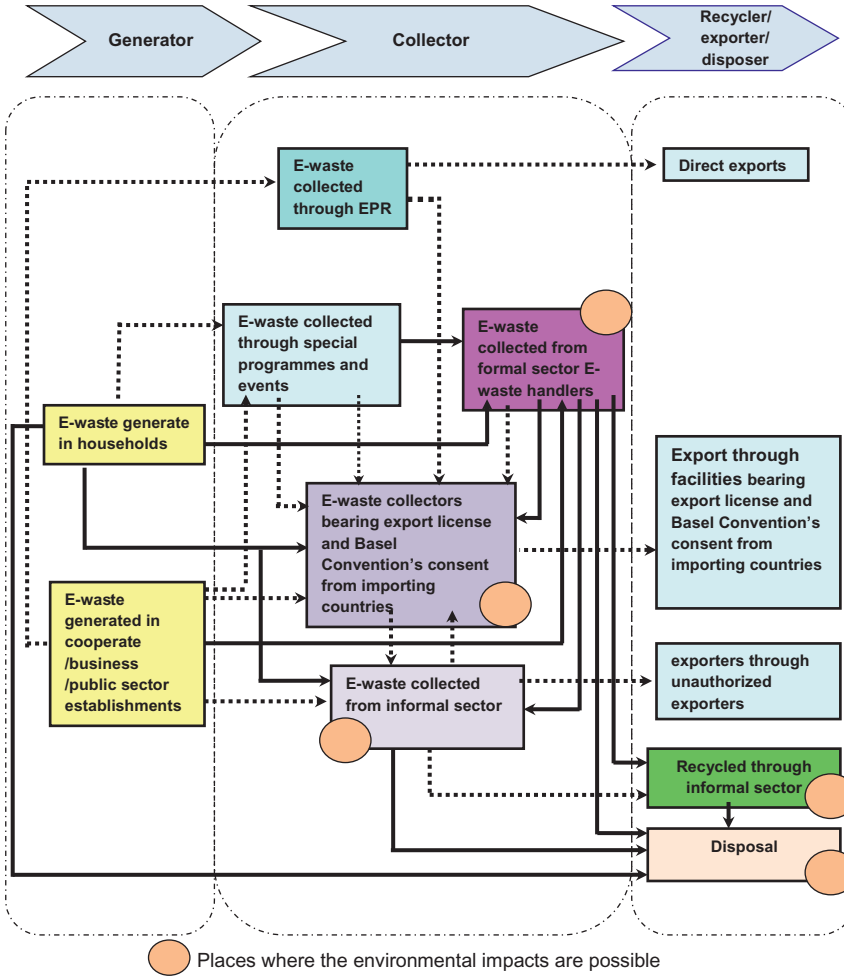

Figure 13.10 Flow of electrical and electronic waste.
Source: Ranasinghe, A.R.M.W.W.K., 2017. Assessing E-waste management system in Sri Lanka and suggesting mechanism to streamline the existing system. Master Thesis of Environmental Science, The Open University of Sri Lanka.

13.14 E-waste management operational system

It can be seen a strong linkage between informal sector stakeholders and informal sector stakeholders. Most of the electronic waste collect from large scale electronic item venders in their promotional take back mechanisms. Generally, E-waste collected through drop-off events and special programs from formal sector follow proper channel to the informal sector for recover valuable parts. These recovery processes involve some risky activities such as breaking glass and burning or it

generates considerable amount of waste or invaluable parts from recovery process. However, there are some illegal exporters in operation. In general, informal sector handles large amount of quantity when compared to the formal sector. Most of the WEEE is passing through informal sector in the downstream management process of E-waste, while some of the formal sector operators engaged in undeclared informal operations as well.

Only a very small quantity of electronic waste is being managed through EPR. Stakeholders involvement and the knowledge on EPR is very low. Most of the electronic wastes generated in household level are managed by the informal sector. E-waste generated from the corporate sector are being managed by the both sectors equally. After recovering valuable parts, haphazard dumping of electronic waste is mainly done by the informal sector through rudimentary operations.

13.15 Identified issues in the downstream management of hazardous waste

The major challenge in E-waste management in Sri Lanka is insufficient awareness among all stakeholders on health and environmental hazards caused by E-waste. This leads to improper handling of E-waste, contributing to severe damages. In addition, there are many drawbacks in legislations and collecting and disposal facilities.

1. *Insufficient legislative framework*

   At present legal provisions are in place only to manage waste mobile phones and computers and accessories under the scheduled waste management license. In addition all types of batteries are also included in this regulation. When considering the generation of electronic and electrical waste other types of E-waste such as washing machines, photo copiers, and fax machines must also be taken in to the regulatory mechanism.

   As the existing regulations and policies are not sufficient to address entire lifecycle management of E-waste and entering of secondhand e-devices in to the country, appropriate legal provisions must introduced to control each and every type of E-waste both locally generated and imported.

   At present only categories types of WEEE including batteries and accumulators addressed under the scheduled waste (hazardous waste) management regulations. All type of WEE should be covered and should be addressed under a separate regulation specifically stipulated for electronic and electronic waste. Ideally the regulation must address the management strategies such as EPR.

   Due to the fact that policies and the legal frameworks are not sufficient to effectively implement the E-waste management system in the country, prioritized attention should be given to develop appropriate policies and legislations specifically to deal with E-waste. In addition to that a well-defined regulatory procedure and adequate measures should be taken to control illegal imports of E-waste and to ensure the environmentally sound management practices in place. Further to this some of the major issues and challenges faced in the implementation process can be attributed to the gaps and overlaps in

the system. First and foremost, the gaps in the legal framework need to be clearly identified and closed.

2. *Inadequate awareness among citizens*

During this study it was clearly noted that awareness among citizens on hazardous nature of the E-waste and its management is extremely poor even among professionals and the educated people. As per these interviews carried out and questionnaires done with the citizens it was clearly noted that the awareness on the electronic waste, legal background, and disposal methods is not satisfactory at all. Even today, though the CEA has mandated that E-waste be given only to authorized collectors, most of the E-wastes are being disposed-off through informal channel in order to earn some quick money. Therefore it is essential that every citizen shall understand that E-waste is hazardous, and it is their responsibility to get it managed in an environmentally sound manner.

Educating the citizens and other stakeholders including public and private sector on the toxicity or hazardous nature of E-waste and importance of directing E-waste in to proper management mechanism must be recognized as prioritized action. Awareness could be implemented regularly and continuously through mass media and as community-based awareness campaigns. Further to that an intensified awareness and training is also provided for the people involved in informal recycling.

3. *Implementing extended producer responsibility (EPR)*

EPR is recognized as one of the most effective ways of dealing with the E-waste issue. Implementing EPR in Sri Lanka has been identified as a big challenge as there is no any legal provision to implement.

Creating financial mechanism to practice EPR is another challenge as some of the e-items are not coming through appropriate paths into the country and the small sop-assembled products also have a considerable share of the market.

Other main issue on implementing EPR is identified as the competition between the formal and informal sectors to gain access to E-waste.

As the actions to be taken to overcome this challenges it is extremely important to identify and specifically address the obstacles related to implementing EPR and develop strategies and introduction of legal framework to effective implementation of EPR mandating producers, importers, retailers with cost of collecting, recycling, and disposal of E-waste.

4. *Unavailability of efficient island wide collection system*

CEA has established an Island wide collection network via partner organizations of the National Cooperate E-Waste Management Program 5 years before. Under this program nearly 300 collection points were established in electronic vendor sales outlets and franchise shops and arcades of mobile network service providers. At present this collection mechanism is not implementing in a satisfactory manner. However, this collection mechanism can be considered as one of the most effective mechanism as it has a widely spread collection points all over the country.

Most of the electronic item vender companies do not provide take back offers through their distributors and channel partners. This also leads to improper dumping through local scrap dealers. Thus, despite having national level management mechanisms, collection of E-waste poses a big challenge, and a synergy and cohesiveness between systems has become the need of the hour.

In order to overcome these issues it is essential to establish infrastructures which sufficiently address collection, storage, transportation, recovery, treatment, and disposal of E-waste at regional and national levels coupled with creating sufficient awareness among citizens enabling them to handover their E-waste to the nearest collection point.

5. *Stagnating E-waste in household level*

   Electronic waste is lying in household backyards as Sri Lankans tend not to throw away their old electronic items even after those become unusable. This is kind of an emotional attachment to used electronic means that most of them are stored. Most of these items were purchased at a high price and hence people are reluctant to dispose of them even after their useful lifetime is over.

   In order to create an effective influx mechanism in to the E-waste management stream, it is an essential action to introduce a financial incentive system to specially for the household electronic waste.

6. *Ad hoc E-waste management system in informal sector collectors and dismantlers*

   In Sri Lanka a considerable amount of E-waste continues to be collected and dismantled through informal sector. Generally, the urban poor, located in unauthorized settlements engaged in collection and dismantling E-waste. Many of these dismantling practices are rudimentary in nature which is a most unsafe and polluting livelihood opportunities for survival. Some processes involve burning, breaking of CRTs, and physical processes to recover materials. These result in release of toxic materials to the environment through emissions and effluents and there is a great potential to cause health impacts to the workers. It is common to see open burning of plastics to reduce the E-waste volumes and copper wires to salvage valuable metals. Such operations have resulted in severe environmental pollution.

   E-waste collection and recycling enables rapid access to cash money. For many collectors and recyclers this rapid-cash-flow is an important reason to engage in this sector, despite unfavorable working condition.

   Role of the informal sector in the value chain of E-waste cannot be neglected due to its potential of generating income to the nonskilled low-income groups. Responsible agencies may pay prioritized attention to integrate the activities of the informal sector into the mainstream management of E-waste through coupling activities of informal and formal sector. Initiating cluster system by entangling formal and informal sector would be an ideal set-up to drive the informal sector in to formalization.

   The process of integrating the informal sector with the formal sector is a significant challenge. On one hand, diversity and the operational mode of the networking of informal sector is not well known. On the other hand, the informal sector operations are extremely diversified with the involvement of multiple stakeholders who are dealing with number of uncertain variables. Such grounds will require a multilevel approaches for streaming informal sector to formal sector.

   Further to that an intensified awareness on hazardous nature of the E-waste, environmental friendly management and safe technical method also be provided to the people who are engaged in the informal sector operations.

7. *Strengthening formal sector*

   There are few formal sector E-waste management facilities are in operation within the country and currently they are in the process of developing their business. Even though these establishments have been recognized as formal sector there are some technical areas yet to be improved. It is a fare argument that these formal sectors would be able to manage E-waste in an environmentally sound manner by using best available technologies (BAT), better working standards leading to better environmental management and enhanced resource recovery. Adequate capacity building, technology transfer, and funding sources based on low interest loan schemes should be available in order to achieve the expected development in the formal sector.

Relevant governmental agencies may take this matter in to a serious note and actions must be taken to introduce policies and market-based mechanisms to support the well-functioning and sustainability of formal sector.

8. *Issue of CRT disposal*

As the recycle value of the CRT tubes are very low. In global scenario the demand for the CRTs are very low. Recycling of leaded glass component in the CRTs is the main issue. Only three facility providers are available and engaged in recycling CRTs which is inadequate. Currently there is only one collector having export approvals for CRTs. The collection is done at a cost. Generally, it costs 2.5$ per kg and due to this reason, there is a big trend of streaming CRT tubes in the informal sector. However, the tubes are simply broken and recover only the copper coil and lead plates while remaining part including leaded glass are subjected to haphazard dumping.

Majority of the informal sector E-waste collection yards are accounted for CRT televisions.

Popular electronic item vendor companies in Sri Lanka implement take back mechanisms as a marketing strategy to attract customers. In this mechanism prize is subsidized when returning an old television regardless of the brand. As these vendors must bear to disposal cost when give out CRTs to the informal sector as an economically favorable alternative they choose informal sector who undertakes the disposal job for "no cost." Recovery process that is practiced by the informal sector is rudimentary in nature and adversely affects the health of the people engaged and to the environment. To divert this mechanism to a formal and environmentally sound way, a kind of an economical mechanism should be introduced to the vendors to cover the disposal cost such as extended producer responsibility system.

9. *Inadequacy of data available on electronic waste and lack of facilities for the research activities*

At present Sri Lanka does not have a comprehensive data base for the generation and lifecycle management of electronic waste. Unavailability of such a data base is a major drawback that could be negatively affected in the planning processes of E-waste management systems and also for the setting up of electronic waste management facilities. Further to that no proper facilities to perform research activities related to electronic waste.

Improving country's ability to gather data and inventory on E-waste generation and lifecycle management and need on the availability of research facilities must be recognized as extremely crucial requirements. To achieve this, necessary funds, infrastructure, expertise, and adequate human resources could be mobilized to setting up research facilities and to create and updating inventories.

10. *Inadequate knowledge among stakeholders*

Knowledge among stakeholders who are actively engaged in E-waste management is not adequate. Hence capacity building of these groups are highly important. Knowledge sharing among neighboring countries is also identified as an important aspect.

11. *Unavailability of financial mechanism to assure the sustainability of downstream management of E-waste*

It has been envisaged that a national level intervention is crucial to achieve the sustainability of downstream management of electronic and electrical waste. However, the unavailability of financial resources for successful implementation of needful actions is the main issue currently confronted with the stakeholder agencies.

Hence it is crucial to introduce some financial mechanisms to assure a *cradle to cradle* approach for responsibly addressing the increasing volumes of e-product scrap.

Ideally the beneficiaries of this mechanism would be the stakeholders who are engaged in the lifecycle management of electronic products starting from the consumer.

12. *Unavailability of a control mechanism for informal sector*

    As the Scheduled Waste Management License is issued upon verifying the destination of the E-waste. For this either the collector should bear the approval to export or to have an agreement with an exporter. However, formal sector companies reluctant to come in to agreements with the informal sector due to the competition in the market. Under this ground formal sector is having monopoly and they have opportunity to demand due to having license.

    Because of this mechanism informal sector operating freely without any control mechanism. Regulatory institutions should take this situation in to a serious note and take actions to subject the informal sector to a control mechanism.

13. *Unavailability of a proper recycling facility in the country*

    Currently all the E-waste collected are exported. Country will be benefitted positively making contributions to strengthen the country's economy as E-waste recycling has been recognized as a lucrative business. Not only that it provides opportunities for the informal sector to get streamline.

13.16 Challenges in E-waste management in Sri Lanka

According to the status report on electronic waste management in Sri Lanka prepared by the CEA, 2016, current annual E-waste generation is estimated at 20,000 MT. Out of which more than 50% is white goods such as refrigerators and air conditioners. Fig. 13.11 illustrates the annual E-waste generation from 2010 to 2030. Accordingly, the annual E-waste release is expected to increase by more than four times from 10,000 MT per year in 2010 to 43,000 MT per year in 2030. In 2014, white goods (6460 MT) continued more than 50% of the total E-waste releases in that year (12,349). Refrigerator E-wastes release show a rapid growth and by 2013 it forms 48% of the white goods (11,648 MT), followed by air conditioners (6122 MT, 25%), and washing machines (3664 MT, 15%) In 2014, in the nonwhite goods segment (5889 MT), TV dominated the composition (81%) followed by computers (8%). However, computer E-waste releases show a gradual increase and eventually becoming the dominant waste component (6067 MT) in 2030. On the other hand, TV shows a decreasing growth due to already saturated Sri Lankan Market, generating 5732 MT in 2030.

According to Fig. 13.11, the profile of accumulated E-waste stock estimated during 2010−16 was 92,000 MT. Readily recyclable white goods continued 53% (48,600 MT) while the rest was nonwhite goods. 38,000 MT (48%) of the total E-waste releases during this period were TVs and computers. Although large in numbers, in terms of weight, mobile phones formed only 3% (2576 MT) of the accumulated E-waste stock for the period 2010−16.

When consider the value of the recyclables the report says that the potential value of the recovered metals from the TV and PC E-waste stocks accumulated during 2010−16 is estimated at USD 31 million. Current annual E-waste generation is estimated at 20,000 MT of which more than 50% is white goods such as

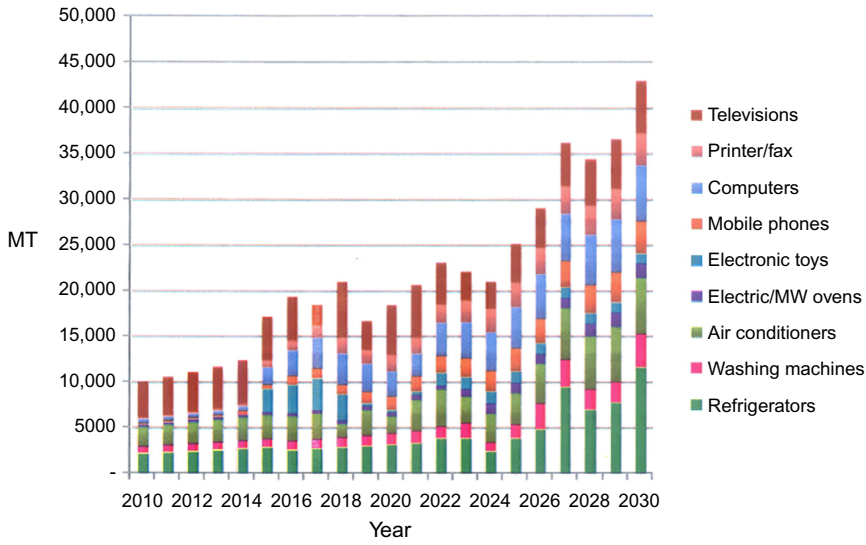

Figure 13.11 E-waste generation in MT per year during 2010–30.

refrigerators and air conditioners. Collection and recycling of white goods is presently being carried out mainly by the informal sector network. Although a few registered recyclers exist to collect and process these wastes, the total amount exported by the registered recyclers accounts for at the most 8% of the nonwhite goods generated per year.

With the increasing knowledge on the importance of E-waste management there is a growing tendency of adopting E-waste legislations in the world. By the end of 2017, the number of countries that have adopted E-waste legislations has been increased to 66, covering 66% of the world population.

However, many countries in the world, especially those are with low or middle-income level status, do not have proper E-waste management regulations. Even if they have E-waste management laws at national level, those are not properly enforced due to inadequate E-waste management infrastructure.

Under the National Waste Management Policy, E-waste management is discussed and yet to be adopted and enforced. As stated in the policy it was designed to provide more detailed focused directions for policy makers and implementers covering vertical and horizontal levels in the administrative and management structures of the country. The multiple challenges faced in the past, facing at present, and also likely to be faced in the future were considered in its design. The time span proposed is up to 2030 under the specific policy statements following statements have been included with respect to the management of electronic waste management.

1. E-waste management shall be considered as part of the integrated solid waste management of the country taking into consideration of the inheriting hazardous characteristics of E-waste.

2. Quantitative and qualitative targets shall be set to promote e-literacy integrating the possible environmental impacts of mismanagement of e-products.
3. Importation of usable used (secondhand) electrical and electronic equipment shall be regulated to prevent and minimize generation of E-waste.
4. Mechanisms shall be developed to prevent outdated/used products reaching Sri Lanka through the mechanisms of gifts, donations, and any other means.
5. A mechanism shall be established to formalize and upgrade the capacities of the informal sector involved in repair and maintenance sector.
6. E-waste collection networks shall be established island wide to prevent haphazard disposal of E-waste and mixed with other waste streams.
7. Infrastructure facilities shall be made available to dispose nonrecyclable E-waste.
8. Resource mobilization strategies shall be developed to ensure efficient E-waste management systems at Provincial and Local Authority Levels covering life cycle management.
9. Importer/producer/agent shall be held responsible for the final disposal of obsolete electronic items.

13.17 Requirements for better E-waste management strategies

At present there is no proper national wide data system on E-waste generated within the country. It is necessary to have access to data such as the amount and nature of E-waste in order to design proper management programs.

13.17.1 Policies, regulations, and legislations

Sri Lanka needs immediate formulation and implementation of proper policies, regulations, and legislations to manage E-waste in the country. The policies and regulations should be sufficient to cover entire life cycle of electrical and electronic equipments that enter Sri Lanka. With special consideration to secondhand items, regulations on importation of secondhand electronic items should address wide range of electronic items including dissembled parts.

As per the current existing legislation only few types of E-waste, for example, waste mobile phones and computers and accessories have been prescribed as hazardous waste. Hence other types of E-waste also be addressed under the legal framework.

The government can provide subsidies for importations environmentally friendly products and increase tax for importation of secondhand products to the country. Importers can be encouraged to abide with the regulations through "business continuation certificates" to ensure importation of high quality products. Simultaneously legislations should enforce to prevent illegal importation of E-waste to the country.

Shared responsibility in E-waste management should be encouraged by the government as an integrated management system for E-waste. Home Appliance Recycling Law (HARL) implemented by Japan in 2001 can be taken as an example in this aspect. The HARL requires producers to replace toxic substances in their

products and increase recyclability, while the consumer pays a fee to recycle the product with government being responsible for collection. At the same time the producer is responsible for recycling of materials and proper dismissal of toxic components.

At least Sri Lanka can promote "eco-design principle" by providing subsidies to industry that adopt waste minimization strategies in their manufacturing process. It requires production and process modification through careful selection of inputs and efficient use of inputs, volume reduction by reducing the volume of waste disposed while removing hazardous portion of waste, and recovery and reuse of waste. It brings several benefits to the industry itself such as elimination of waste disposal cost, reduction of raw materials cost while generating income through waste.

So far Sri Lanka has not fully used economic instruments to manage E-waste. Economic instruments are more effective in influencing people's behavior than the command and control instruments such as policies and standards. Introduction of "Extended Producer Responsibility (EPR)" covering local producers of electrical and electronic equipment, importers, and retailers to take responsibility of total life span management of their items, involving collection and recycle or disposal should be done through relevant legislations. Introduction of deposit refunds and take back offers can be worthwhile practices in this regard.

The government can encourage take back offers by introducing tax incentives for companies that provide the service. Most of the households in Sri Lanka have piles of dispensable EEE due to the reasons that they do not know what to do with them, and also some emotional attachments to these items because they had purchased them at a high price. If take back offers are popularized among the citizens, it will become beneficial to people as well as the vendors because the customers will get a discount for the new product they purchase and the companies will have increased sales. The same incentives can be given to encourage "extended producer responsibility" with local producers as well as importers.

The producers or distributors of EEE can add an "advanced recycling fee" to the product price and charge from the buyer to cover the cost of collecting and recycling the product after its valuable life span. The advanced recycling fee can be used as an indicator of quality and durability of the product.

"Polluter pay" principle can be used to make the polluters be responsible for the pollution they create. It is expected that it will influence stakeholders to choose the less expensive behavior. The government can introduce a fine for citizens who do not properly dispose their E-waste. But this requires proper monitoring also.

It is easy to implement "consumer purchasing policies" for government establishments to go for environmentally friendly products when they purchase EEE such as computers, printers, and photocopying machines.

13.17.2 E-waste collection, storage, and transportation

It is necessary to establish proper infrastructure for collection, storage, transportation, treatment, and disposal of E-waste at regional and national level. It will be more effective to have E-waste management as an integral component of solid

waste management. These activities could be delegated to provincial councils with a central monitoring unit such as the CEA.

Integration of formal sector and informal sector is necessary as the formal sector alone cannot cover the whole island. There should be a proper mechanism to integrate with the informal sector which dominates the collection and dismantling of E-waste. National level information system to monitor and evaluate E-waste management in the country is a major requirement.

13.17.3 Awareness creation

Creating awareness on hazardous nature of E-waste should be given more attention by the relevant authorities as the citizens and especially those who are involved in E-waste collection and dismantling activities do not have sufficient knowledge. Target oriented programs for waste generators (households, industries, and commercial sectors), waste collectors, and the citizens is essential. Mass media has a responsible role to play in this as it can take the message across the country. NGOs and community-based organizations (CBO) can be used to create awareness at community level. School level programs should be organized to create awareness among the younger generation.

Importers of EEE can amalgamate awareness creation on proper disposal of E-waste with their product promotion campaigns and consumer meetings as part of their corporate social responsibility (CSR) programs.

It should be taken into consideration that lack of trained manpower to handle E-waste is an issue in E-waste management, and most of them involved in these activities are from the urban poor and most likely to be uneducated. Therefore it is mandatory to train them in collecting and dismantling of E-waste as most of them do not possess any knowledge on harmful effects and safety precautions. Educating and training of these workers can be done through NGO or CBOs with the support from the government.

13.17.4 Research and development

Capacity development for management of E-waste through research and development should be considered as a priority by research institutes. Development of research facilities and adequate funding to encourage research and development in E-waste management is necessary to develop low-cost, efficient waste treatment methods, technology transfer, and also to establish recycling facilities in Sri Lanka. The government can implement a special funding program through institutions such as National Science Foundation, National Research Council, and the National Institute of Fundamental Studies. Companies who are willing to establish recycling facilities or to adopt modern technologies for E-waste management should be encouraged by providing them loans at low interest rates. Research and surveys relevant to E-waste and development of a national inventory on E-waste are necessary requirements in E-waste management.

13.17.5 Economic aspects of E-waste management

Promotion of "circular economy concept" in E-waste management offers economic development and employment generation rather than the "take-make-disposal" cycle. It aims to redesign products in such a way to ensure minimized input use, waste generation, and to have extended future use. While in use service should be provided to maintain, repair, and upgrade the products to maximize their lifetime. This system can build long-term resilience, generate business, and employment opportunities while providing environmental and social benefits.

E-waste management and exportation is an economically profitable industry; e-wastes contain both hazardous as well as valuable substances and the total value of all raw materials in globally generated E-waste in 2017 has been calculated as Euros 55 billion.

Materials extracted such as glass, plastic, and metal can be inputs to other industries. Important elements in E-waste such as mercury, silver, and phosphorus can be exported to other countries. Asian countries are the recipients of most of the WEEE generated in other countries and China being the largest importer of E-waste in the world. However, Sri Lanka is not yet exporting E-waste to China. There should be a mechanism to encourage value addition to E-waste that are exported by Sri Lanka. It would fetch more foreign revenue to the country while generating more job opportunities.

All stakeholders, the government, mass scale E-waste generators such as industries, mass media, researchers, and the citizens have their own role to play to face and overcome challenges in E-waste management in Sri Lanka.

13.17.6 Integration of the informal and formal sector

In Sri Lanka a considerable amount of E-waste is collected and dismantled through informal sector. As per the Status Report on E-Waste Management (CEA, 2106) there are about 2000 informal sector establishments operate in Sri Lanka. In general, informal sector operators are localized to a particular area and operate as clusters. Mainly the urban low-income groups are engaged in informal collection and dismantling E-waste. Many of these dismantling practices are rudimentary in nature. These practices are very unsafe and create severe environmental pollution. Some processes involve burning, breaking of CRTs, and physical processes to recover materials. These result in release of toxic materials to the environment through emissions and effluents and there is a great potential to cause health impacts to the workers. It is common to see open burning of plastics and cables to reduce the E-waste volumes and to recover valuable metals.

As the informal sector plays a very active role of the electronic waste management system in the country the informal sector is generating income to the unskilled groups. In order to streamline the informal sector proper integration of informal and formal sector is essential but it is very challenging. This could be done through entangling informal with formal sector, formal sector enabling informal sector to operate as a cluster with the formal sector.

13.17.7 Strengthening formal sector

There are few formal sector E-waste management facilities are in operation within the country and currently they are in the process of developing their business. Even though these establishments have been recognized as formal sector there are some technical areas yet to be improved. It is a fare argument that these formal sectors would be able to manage E-waste in an environmentally sound manner by using best available technologies (BAT), better working standards leading to better environmental management and enhanced resource recovery.

Adequate capacity building, technology transfer, and funding sources based on low interest loan schemes should be available to achieve the expected development in the formal sector.

Relevant governmental agencies may take this matter in to a serious note and actions must be taken to introduce policies and market-based mechanisms to support the well-functioning and sustainability of formal sector.

13.18 Conclusion

The rapid increase and changing need of consumers for electrical devices and information technology on a global scale has resulted in a significant rise in electronic and electrical products. In line with the global scenario there is a significant growth and consumption of e-products and thereby generation of E-waste which shows an exponential growth in Sri Lanka.

Current annual E-waste generation is estimated at 20,000 MT, of which more than 50% is white goods such as refrigerators and air conditioners. The balance 50% of nonwhite goods dominated by television (5000 MT/year), specifically TVs and PCs with CRT monitors which are out of markets. With the significant growth in investments, consumption, and exports, the generation of E-waste from general consumption of the techno-products such as personal computers and mobile phones has been drastically increased within Sri Lanka. Although a few registered recyclers exist to collect and process these wastes, the total amount exported by the registered recyclers accounts for at the most 8% of the nonwhite goods generated per year.

E-waste is of concern largely due to the toxicity of the constituent substances if not managed properly. It has been scientifically proven that these substances have a potential of creating both health hazards and environmental impacts. Despite of the toxic nature of the electronic and electrical waste recycling has identified as a lucrative business all over the world. Like other developing countries in Asia and Africa, Sri Lanka is now confronted with the huge problem of E-waste both locally generated and internationally imported.

In such grounds, E-waste management sectors in Sri Lanka have started their business activities both formally and informally. There is a clear evident that the rate of growth in informal sector is moving ahead than formal sector. Formal sector operations generally confined only to the capital city Colombo and the suburbs while informal sector spread throughout the country and their operational system is

far more complicated and creating adverse impacts on the environment and the human health. Hence prioritized attention must be given to identify the system and responsible authorities may mobilize required resources and disseminate appropriate technologies to streamline the informal sector and integrate them with the formal sector. Formal sector operations also yet to be developed; currently it is confined only to collection and dismantling and it was noted that the business ventures have not been made attractive and investments are not sufficient to meet the high-level operations. Even today, most of the E-waste are being disposed-off through informal channel for earning some quick money. Therefore it is essential to aware the people that E-waste is hazardous, and it is their responsibility to get it managed in an environmentally sound manner.

Even though some of the nonwhite goods are collected by the informal network and dismantled to recover components that have economic value, a large percentage of the items, such as CRTs, which cost money to dispose, are left at the site of collection or dumped haphazardly in open dump yards. Cheap, safe, and simple processing methods for introduction into the informal sector are currently lacking. Further there is no single secured landfill to accommodate all hazardous waste including E-waste in Sri Lanka. Therefore it is utmost need to establish a secure landfill for hazardous waste including for E-waste disposal.

When the management of E-waste to be taken on a more serious note, there is a need for dedicated policy and legislative mechanism which should be able to offer clear guidelines for collection, transportation, storage, dismantling, material recovery, preprocessing, and end-processing for final metal recovery. This is important as emerging and developing economies will continuously generate more E-waste in the next 20 years. Even though there are some regulations in place to address the management of electronic waste, some aspects are not sufficiently and effectively addressed and therefore introducing adequate legal provisions are required.

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