A MICRO-LEVEL ANALYSIS ON THE STATUS OF ELECTRONIC WASTE GENERATION AMONG HOUSEHOLDS OF TRIPUNITHURA MUNICIPALITY

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Executive Summary

Waste Electrical and Electronic Equipments is growing rapidly due to large number of equipments being launched in the market on day-to-day basis; thanks to the advancement in technology. Taking the global and national perspective, we can see that huge quantities of ewaste end up in the waste stream every year and are not managed properly. Even the advanced nations find it difficult to properly dispose and recycle ewaste due to high labour cost because of which they illegally export it to developing nations where the labour costs are cheaper. In developing nations, informal sector dominates and handles the ewaste collected and is managed in a risky manner posing hazards to humans and environment. This situation can be clearly witnessed in India where hazardous methods are used by the informal workers to extract metals from ewaste components and the residues are incinerated. Incineration and acid bath of discarded electronic components by the informal sector workers to extract precious metals such as gold, silver, palladium and other metals like copper, aluminium etc. without any safety measures is dangerous to both human health as well as the environment. Through these unsafe methods, toxic chemicals percolate into the ground contaminating the soil and the groundwater. Incineration emits obnoxious gases into the atmosphere causing air pollution. Hence, proper collection and management of ewaste generated is of prime significance to avoid the negative externalities.

A micro-level study in Tripunithura Municipality of Ernakulam district was conducted in 2017 by taking 10 per cent of the total households from four wards using simple random sampling. The objectives of the study was to examine the socio-economic background of the inhabitants of the study area, to forecast the WEEE that will be generated among the households in the coming years, quantify ewaste discarded in last three years and to evaluate the volume of operational and non-operational EEE stored by the households. The study showed that approximately 3.37 metric tonnes of ewaste was generated in the last three years from the study area disposed by 46 per cent of the households. Majority of them disposed working electronics due to frequent need for repairing, to be in trend, high electricity consumption and lack of modern features. Households had disposed their working and non-working equipments with the informal scrap-dealers and had received returns between Rs 0 to Rs 1000. 39 per cent of the ewaste generated were discarded with the informal scrap-dealers. 1.87 metric tonnes of non-working products had been stored by the respondents in their home for repairing, exchanging, disposing with the scrap dealers and also due to lack of time, returns and collection centre. A total of 106 working gadgets had been stored at home by 39 per cent respondents which are used occasionally or not used at all. The reason for non-usage of working EEE stated are high electricity consumption, lack of time, electrical circuit problems, for exchange and for no specific reason. Majority of them only exchanged their electronic products followed by disposal with the scrap dealers. Majority of the respondents were unaware of the existence of authorized ewaste collection centres in the district, harmful substances and the latest Ewaste Rules of the Central Pollution Control Board.

From the study conducted, it can be concluded that consumers are ignorant of the adverse impacts that can cause from disposing obsolete electronics with the informal scrap dealers. Also, the lack of proper collection mechanism is making the consumers to dispose it with the informal centres. Since end-of-life electronic products are different from that of other household wastes, consumers assign value to their electronics, irrespective of it being in working condition or not. Again, the behaviour of consumers to dispose working gadgets for latest ones also escalates the issue of ewaste. The State Pollution Control Board, in its ewaste collection and disposal orders put forth in 2014, had strictly mentioned the registration of ewaste dismantling/recycling facilities operating in the State. This should be extended to the all the informal units in the State collecting ewaste as well.

Hence, the following recommendations are being put forward for sound ewaste management:

1. Consumer awareness regarding adverse impacts of ewaste and disposal of ewaste with authorized ewaste collection centres/take-back system of producers.
2. Proper collection system should to be implemented by the Urban Local Bodies (ULBs) and collected electronic products must be channelized to registered ewaste collection centres.
3. Storage space to be setup by the ULBs to store the collected electronics before sending it to registered centres.
4. Informal ewaste collection centres/scrap-dealers and its workers must be empanelled and should focus on collection, segregation and sorting of the products.

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Chapter – 1: Introduction

Waste Electrical and Electronic Equipments (WEEE) or Ewaste which are the most commonly used terms has not been defined in a standard manner. The European Union's WEEE Directive and the Basel Convention were the first to define it and later several other agencies and conventions such as Solving the Ewaste Problem (StEP), Organization for Economic Co-operation and Development (OECD) and Basel Action Network (BAN) provided their own definition for Ewaste. According to the EU's WEEE Directive, "*Electrical or electronic equipment (EEE) including all components, sub-assemblies and consumables which are part of the product at the time of discarding is considered as Ewaste.*" StEP has defined ewaste as "*The reverse supply chain which collects products no longer desired by a given consumer and refurbishes for other consumers, recycles or otherwise processes waste.*" OECD defines ewaste as "*Any appliance using electric power supply that has reached its end-of-life.*" (United Nations Environmental Programme, 2007)

Hence, Waste Electrical and Electronic Equipments (WEEE) or Ewaste is a term used to cover all electrical and electronic equipments and its components that has reached its end of life and is not intended for reuse. It includes products with circuitry or electrical components with power or battery supply (Baldé, 2015). So, Ewaste includes televisions, computers, laptops, notebooks, mobile phones, refrigerators, air conditioners, washing machines, printing and copying machines, dish washers and small equipments like lamps, Compact Fluorescent Lamps (CFLs), calculators, telephones, vacuum cleaners, oven, radio, cameras, electronic toys, medical devices and monitoring and control equipments that has completed its life cycle and has been discarded (Shunichi Honda, 2016). The electrical and electronic equipments (EEE) can be categorized into six groups which are shown in Chart 1.

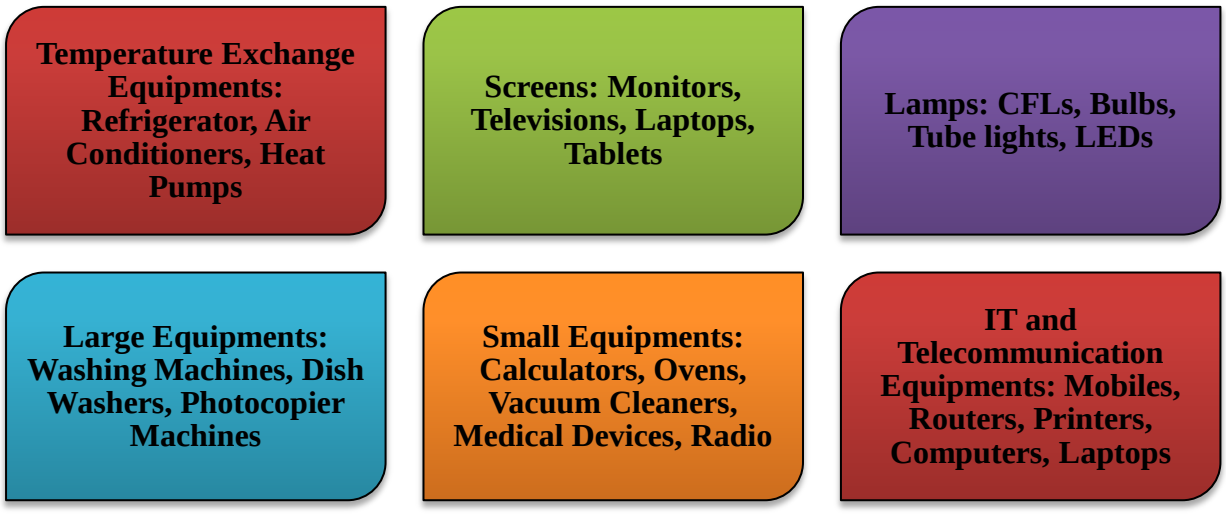


Chart 1: Categories of EEE
Source: Baldé, 2015

Increasing sales of EEE is directly proportional to the accelerating menace of Ewaste. The electronics industry has been growing rapidly since 2000 when access to internet and telecom dissemination gained momentum. Of the total electronics produced globally in 2008, China was the highest producer with 26 per cent share in total world production, followed by Europe with 22 per cent, North America with 18 per cent and the rest of Asia and Pacific with 16 per cent of total production. In the Asia-Pacific region, Japan, China, Taiwan, India and Singapore are the chief EEE manufacturing hubs (Export-Import Bank of India, 2011). It was estimated in the Regional Ewaste Monitor Report that globally, the amount of EEE in the market was 51.33 million tonnes in 2007 which would increase to 56.56 million tonnes in 2012. Asia is the largest EEE consumer with 20.62 million tonnes in 2005 which increased to 26.69 million tonnes in 2012. Therefore, it can be stated that the electronics industry worldwide is burgeoning rapidly which will pave way for an ever-increasing volume of ewaste in the coming years (Shunichi Honda, 2016).

Global Outlook on Generation of WEEE

Urbanization and growing consumerism has generated a new form waste stream into the already existing ocean of waste, the Ewaste. Innovation of new products, changing technology, declining prices and increasing demand has also contributed to the mounting menace of Ewaste. In 2014, approximately 41.8 million tonnes of ewaste was generated worldwide (Baldé, 2015). Table 1 shows the WEEE generated per category of ewaste, continent and per inhabitant in 2014.

It is anticipated that the Ewaste would mount to 49.8 MT by 2018 worldwide. Asia is the highest contributor to the global Ewaste stream accounting for 16 MT while the highest Ewaste generated based on per inhabitant basis is in Europe with 15.6 kilograms per inhabitant in 2014. The top three Asian nations with the highest volume of Ewaste generation in the year 2014 were China with 6 MT, Japan with 2.2 MT and India with 1.7 MT (Baldé, 2015).

Continent	Category of WEEE (in Metric Tonnes)							WEEE per Inhabitant (in Kg)
	Small Equipments	Large Equipments	Temperature Exchange Equipments	Screens	Small IT	Lamps	Total	
Africa	0.6	0.5	0.3	0.3	0.1	0.1	1.9	1.7
Americas	3.6	3.3	2	1.7	0.8	0.2	11.7	12.2
Asia	5.1	4.1	2.7	2.5	1.1	0.5	16	3.7
Europe	3.3	3.6	1.9	1.7	0.9	0.2	11.6	15.6
Oceania	0.19	0.14	0.08	0.1	0.05	0.01	0.6	15.2
TOTAL	**12.79**	**11.64**	**6.98**	**6.3**	**2.95**	**1.01**	**41.8**	

Table 1: WEEE generated per Continent, Category and Per Inhabitant
Source: Baldé, 2015

Figure 1 represents the global quantity of ewaste being generated category-wise in the year 2014.

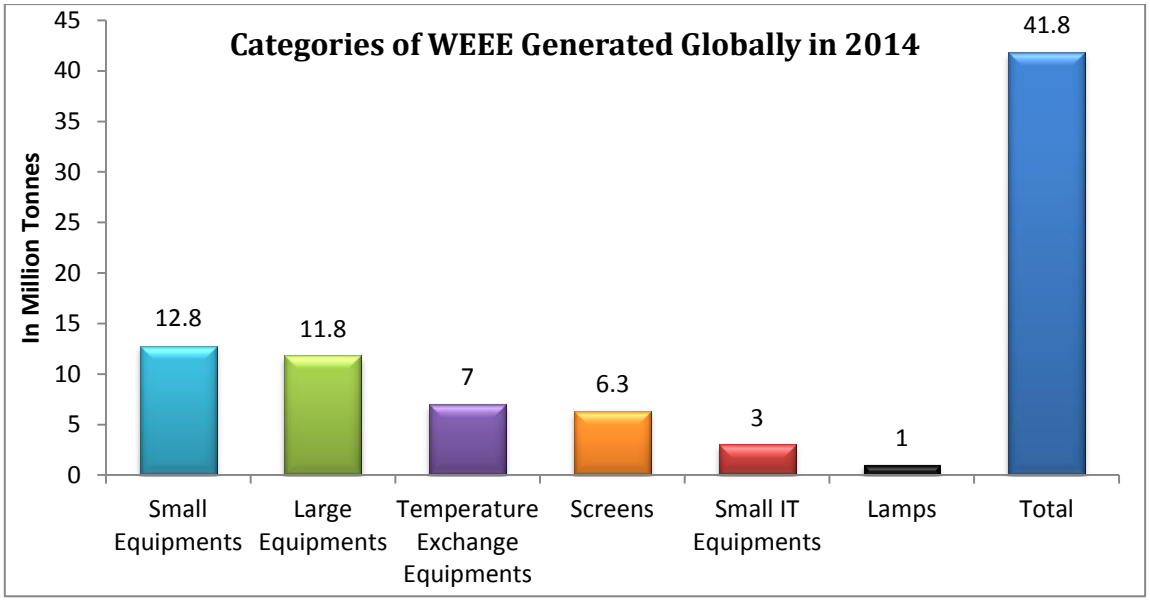


Figure 1: Global Generation of WEEE Categories in 2014
Source: Baldé, 2015

Components in Ewaste, Effects and its Management

Electronic waste contains many hazardous substances which are harmful to both humans and the environment (See also Five Winds International, 2001, Lines, 2016, Puckett, 2002).

Toxic Metals	EEE Components	Effects
Mercury	Fluorescent lamps, flat screen laptop displays, batteries, CRT (Cathode Ray Tube) monitors and mobile phones	Affects the central nervous system leading to mental retardation, deafness, blindness, speech impairment. Affects cardio-vascular system leading to blood pressure, heart diseases. Cognitive deficits in children, immunity and reproductive issues and even death
Arsenic	Light emitting diodes	Skin diseases, lung cancer and impairment of nerves
Barium	Spark plugs, fluorescent lamps	Swelling of brain, muscle weakness, heart, liver and spleen damage
Lead	Solders, CRT monitors, personal computers (PCs), cabling, batteries in laptops, printed circuit boards (PCBs), motherboards, fluorescent tubes, printers and capacitors	Impairment of psychological and neuro-behavioural functions, kidney damage, reproductive issues, less immunity, death
Nickel	Batteries, CRTs, PCBs and computer housing	Lung issues and lung cancer, bronchitis, allergy
Cadmium	PCs, batteries in laptop and computers, CRT monitors, cabling, motherboards, PCBs and plastic computer housings	Kidney damage, skeletal damage, cancer

Beryllium	Motherboards, connectors, printed board assembly, finger clips, PCs, monitors, relays, switches and laser printers	Lung cancer, Beryllicosis – a disease affecting lungs and skin diseases
Hexavalent Chromium	PCs, monitors, cabling, motherboards and hard discs	Respiratory and circulatory problems, liver and kidney damage, death from lung cancer
Brominated Flame Retardants (BFRs)	PCBs, plastic computer casings, motherboards, keyboard buttons, connectors and cabling	Combustion of BFRs releases poisonous gases which can cause hormonal disorders
PolyVinyl Chloride (PVC)	Monitors, keyboards, cabling, plastic computer housings, cellular phone windows,	Incomplete combustion of PVC releases hydrogen chloride gas which turns to hydrochloric acid when combined with water. It can cause respiratory issues
PolyChlorinated Biphenyls PCBs)	Capacitors and cabling	Cancer and liver damage
Chlorofluorocarbons (CFCs)	Cooling units and insulation foam	Affects ozone layer leading to skin cancer

Table 2: Presence of Toxic Metals in Various EEE Components
Source: Five Winds International, 2001, Holm, et al., 2002, Puckett, 2002 and Kiddee & Naidu, 2013

Table 2 shows the toxic metals present in various EEE components. Ewaste components, along with toxic metals, contain precious metals like gold, silver, palladium and platinum that can be recycled. It also contains plastics, glass, wood, printed circuit boards (PCBs), concrete, ceramics and rubber. 50 per cent of ewaste is comprised of iron and steel, 21 per cent by plastics and 13 per cent by non-ferrous metals (United Nations Environmental Programme, 2007). Thus, from the 'resource' point of view, ewaste acts as an urban mine as well as toxic mine with a combination of precious and toxic metals respectively. The precious metals, if recycled, can be reused in the manufacture of new products and thus can reduce the use of virgin materials leading to energy efficiency. Of the 41.8 million tonnes of ewaste generated globally in 2014, approximately 300 tonnes of gold (10,400 million Euros), 1000 tonnes of silver (580 million Euros) and 100 tonnes of palladium (1800 million Euros) was present which amounts to 12,780 million Euros. But for extracting these metals, proper collection and channelization of ewaste generated is crucial along with state-of-the-art technology. Hence, appropriate handling and management of WEEE is of utmost importance (Baldé, 2015).

An Overview of Consumer Electronics & WEEE Generation in India

In India, the electronics industry started to witness growth from 1980s with the manufacture of colour televisions, initiation of computers and telecommunication equipments. India's electronics industry is bifurcated into consumer electronics, industrial electronics, computers, communication and broadcasting equipment, components and strategic electronics (Export-Import Bank of India, 2011).

Although 70 per cent of ewaste generated is by the government, public and private sectors, 15 per cent by individual households and the rest by manufacturers, comparatively, it can be said that household sector's contribution might be small but in absolute terms, their contribution is large which is reflected in their consumption of huge quantities of consumer durables (Research Unit (LARDDIS), 2011). Figure 2 shows the production of consumer electronics (refrigerator, washing machine, air conditioner and microwave oven) and mobile phones in India from 2003-2004 to 2016-2017 in crore rupees. Figure 3 represents the total sales of PCs, with focus on sales of desktops and the units of desktops sold to the household sector.

Figure 2 and 3 showcases the fact that Indian electronics industry has been burgeoning rapidly with respect to the demand from household sector. The technological advancement along with rising consumer demand, large middle class population and increasing disposable income has led to an increase in the production and consumption of electronic products (Export-Import Bank of India, 2011).

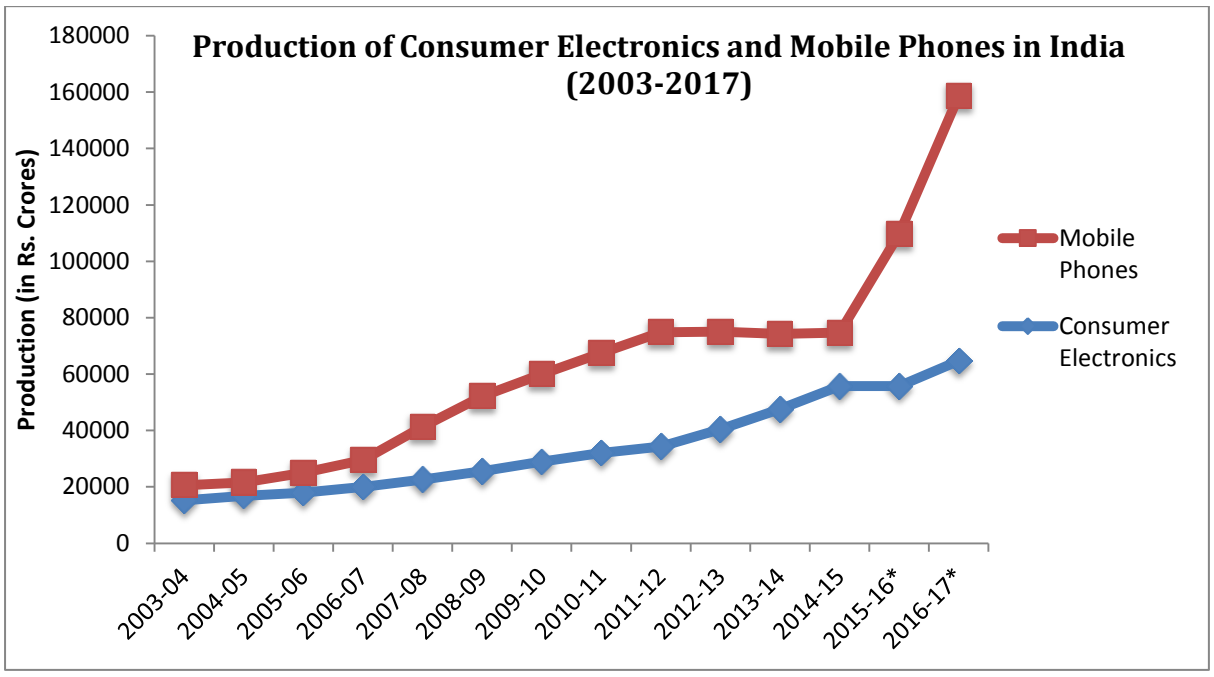


Figure 2: Production of Consumer Electronics and Mobile Phones in India (2003-2017)
Source: Ministry of Electronics & Information Technology (MeitY), Annual Reports, 2008-2017

Some of the other growth drivers boosting the EEE industry are organized retailing which facilitates high-end and branded products, increasing demand in rural markets advocated by increasing rural electrification, urbanization and brand awareness, product innovation and narrowed price gap[1] (Ernest & Young and FICCI, 2015). The demand for low-cost products has led to short life span of the gadgets (Shunichi Honda, 2016) which is a factor contributing to ewaste generation. Consumers hardly take their non-working electronics for refurbishment as replacement is much

[1] Air conditioners, high-end TVs which were considered as luxury goods is now available at cheaper price as many financing options are put forward by the retailers, thus, reflecting the narrowed price gap (Ernest & Young and FICCI, 2015).

cheaper, thus, increasing obsolescence rate of EEE is another factor leading to ewaste generation (Puckett, 2002). The average life cycle/ obsolescence rate of a product is the period after which the EEE has reached its end-of-life. It can be divided into three stages:

1. Active Life: Number of years an equipment can be effectively used
2. Passive Life: Refurbishing and reusing a product for a period after its active life.
3. Storage: Storage time before disposal and storage at repair shops before dismantling.

In developing countries, the lifespan of an EEE is the sum of active life, passive life and storage (United Nations Environmental Programme, 2007). The life cycle of EEE is represented in Chart 2.

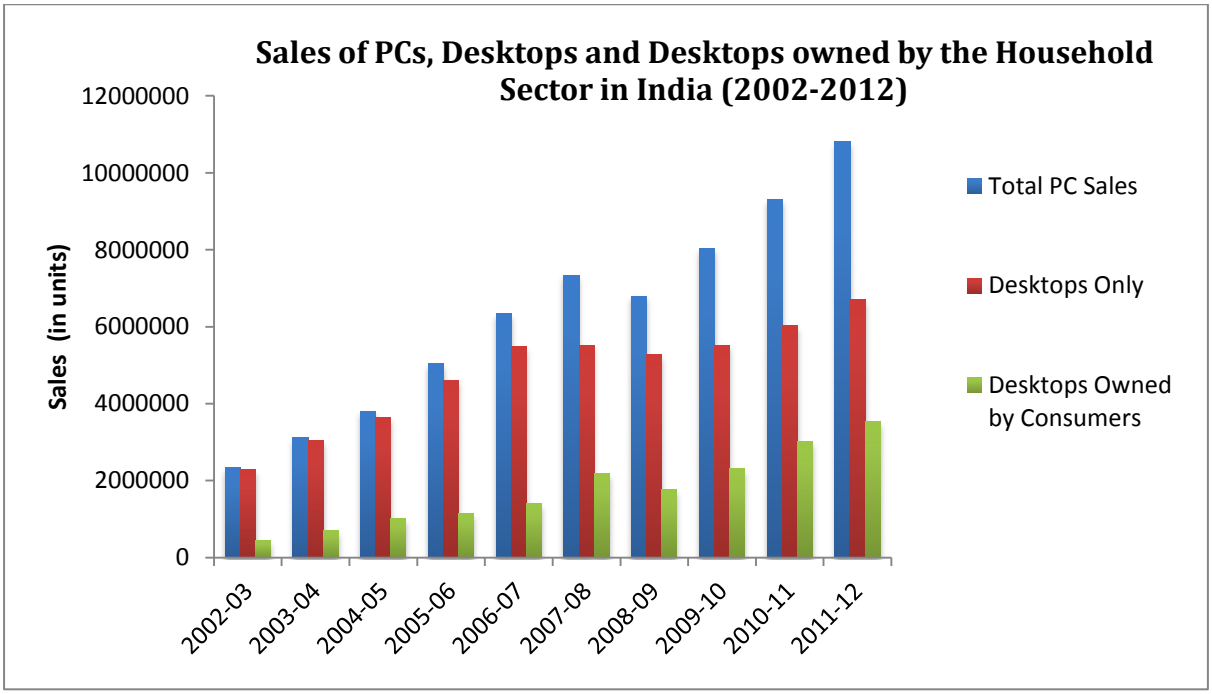


Figure 3: Sales of PCs, Desktops and Desktops owned by the Household Sector in India (2002-2012)
Source: MAIT-IMRB, 2012 & MAIT-IMRB, 2008

The high demand for cheaper gadgets and increasing obsolescence rate has caused the frequency of product replacement among consumers and producers share of market to upsurge respectively. Thus, increase in production, sales and consumption of EEE has the darker side in the form of escalating ewaste. Hence, proper management of electronic waste is of prime significance (Shunichi Honda, 2016).

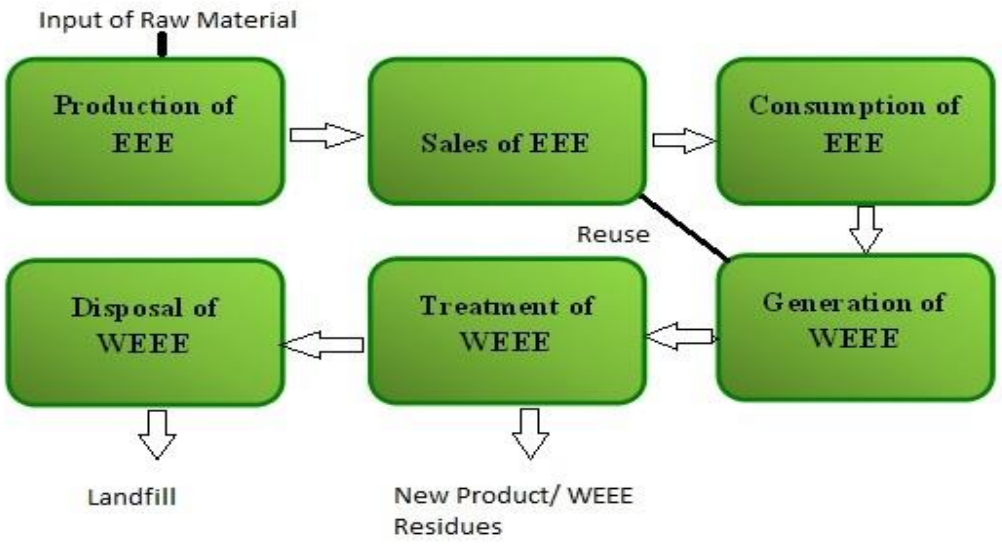


Chart 2: Life Cycle of Electrical and Electronic Equipment
Source: United Nations Environmental Programme, 2007

Many independent studies have been conducted regarding Ewaste issue in India but the lack of official data persists as a problem to quantify the actual amount of Ewaste generated. In 2005, the Central Pollution Control Board (CPCB) estimated that about 1.47 lakh tonnes of WEEE were generated in India. A study conducted by the Electronics Industry Association of India (ELCINA) anticipated Ewaste generation of about 4.34 lakh tonnes by 2009. The CPCB further estimated that the WEEE in the country would accelerate by more than 8 lakh tonnes by 2012 (Research Unit (LARDDIS), 2011).

According to the study conducted by The Associated Chambers of Commerce and Industry of India (ASSOCHAM), India's ewaste is estimated to amount to 30 lakh metric tonnes by 2018 from the present level of 18.5 lakh metric tonnes (ASSOCHAM-Frost and Sullivan, 2016). The top 10 e-waste generating States of India are Maharashtra, Tamil Nadu, Andhra Pradesh, Uttar Pradesh, West Bengal, Delhi, Karnataka, Gujarat, Madhya Pradesh and Punjab (Research Unit (LARDDIS), 2011). The top Indian cities which generate the highest amounts of WEEE are represented in Figure 4.

Ewaste management can be classified into four main stages:

1. Proper collection mechanism, which includes either take-back system, collection points in municipalities or door-to-door collection.
2. Dismantling of WEEE parts manually to remove the hazardous components.
3. Sorting and segregation to separate ferrous and non-ferrous metals.
4. Material and energy recovery to extract raw materials and precious metals (Shunichi Honda, 2016).

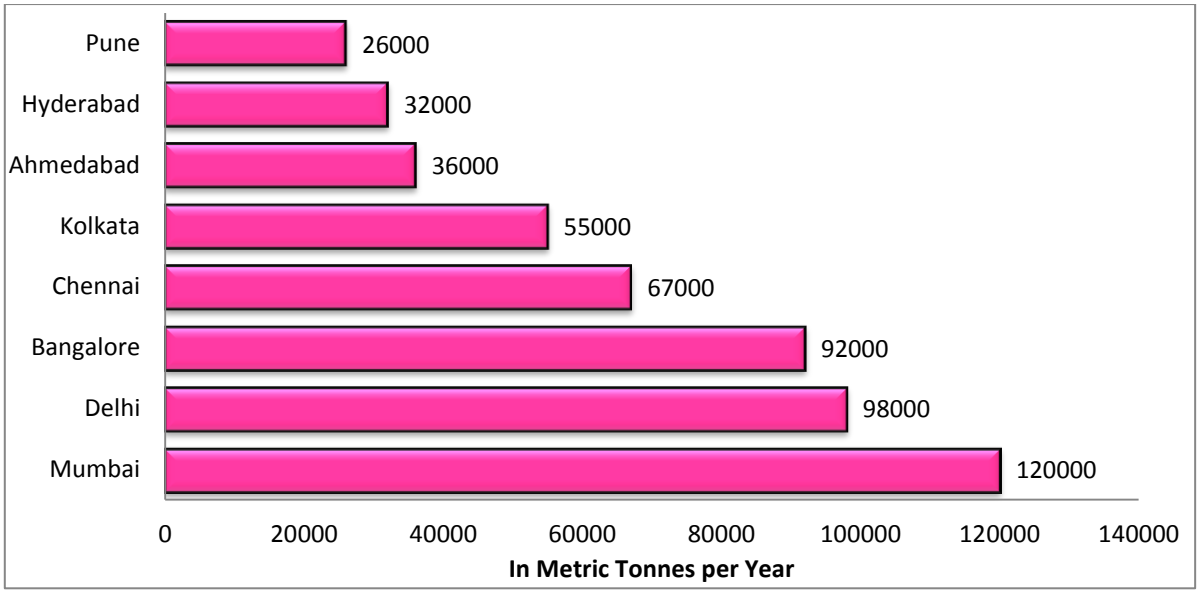


Figure 4: Top Indian Cities generating Highest Volume of Ewaste
Source: ASSOCHAM-Frost and Sullivan, 2016

In the reverse supply chain of ewaste management, the basic collection mechanism is always the weakest link in developing countries, so is the case in India. In developing countries, informal waste pickers usually collect, sort and dismantle the ewaste collected for recovery of metals without any safety measures and that too in a hazardous manner (Lines, 2016). In India, WEEE is handled by informal and formal sectors. The unskilled workers in the unorganized sector engage in the task of segregation, dismantling, shredding and open burning of ewaste parts without any gloves or masks and acid bath for metal recovery. They risk their lives along with their families as it is their only source of livelihood. They pose danger to themselves, their families and environment. This form of recycling is more harmful than favourable (Research Unit (LARDDIS), 2011).

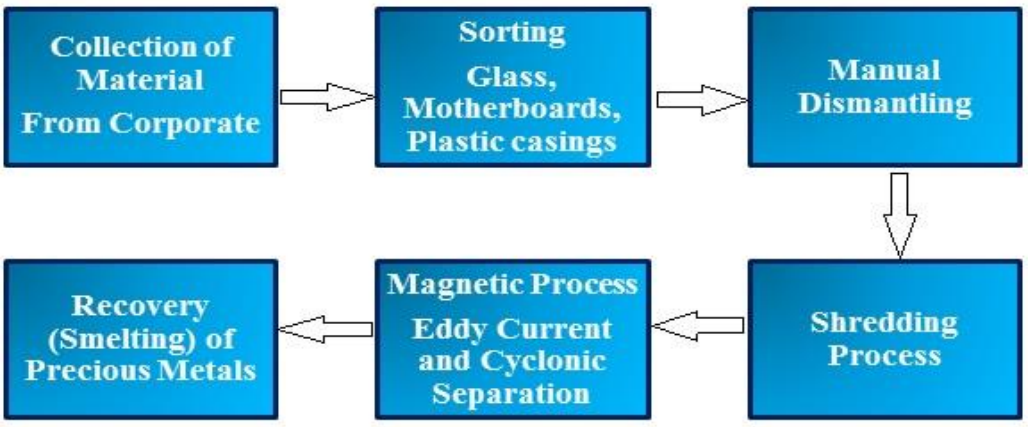


Chart 3: Process followed by Formal Recyclers in India
Source: Khattar, 2007

On the other hand, formal sector collects, dismantles and recycles the ewaste in an eco-friendly manner using state-of-the-art technology and also ensures worker safety (Research Unit (LARDDIS), 2011). Chart 3 shows the process of ewaste recycling adopted by the formal sector in India.

India presently does not have the technology for smelting, that is, for the extraction of precious metals from the residual mixture obtained after the shredding process. Currently, this mixture is sent to Umicore Refinery in Belgium which has the premium technology for metal recovery (Khattar, 2007). As on 29th Dec 2016, there are 178 formal ewaste recycling units in India with an approximate capacity of 4,38,086 metric tonnes per annum registered with the Central Pollution Control Board spread across 14 States (Central Pollution Control Board, 2016). But it is found that only 5 per cent ewaste is recycled by the formal sector while 95 per cent of ewaste generated is recycled by the informal sector. Hence, absence of proper collection system, channelization and a stringent legislation is the main reason for growing informal ewaste sector in India (Research Unit (LARDDIS), 2011).

Ewaste Policy in India

Electronic waste in India was initially managed under The Hazardous Waste (Management & Handling) Rules, 2003 due to the presence of hazardous components in the EEE. The mounting ewaste menace in the last decade forced the Government to implement a specific Rule for sound management of Ewaste. Thus, India got its first Ewaste (Management & Handling) Rules in 2011 which prioritized Extended Producer Responsibility[2] (EPR). Though the Rule was implemented, it had lot of drawbacks like complicated procedures for registration of ewaste collection centres etc. (Central Pollution Control Board, 2011). The shortcomings led to revision of the Rule and the revised Ewaste (Management) Rules, 2016 were implemented on Oct 26th, 2016 with the objective to check the leakage of ewaste to informal sector and to manage the ewaste generated in the nation in a sound manner. The Ewaste (Management & Handling) Rules, 2011 was applicable to producers, consumers/bulk consumers, collection centres, dismantlers and recyclers while the new rule has widened its applicability to manufacturers, dealers, refurbishers and Producer Responsibility Organization (PRO) as well (Central Pollution Control Board, 2016).

The new rules have also taken into consideration EEE components, spares and parts, Compact Fluorescent Lamps (CFLs) and mercury containing lamps which was ignored in the previous rules. Collection of ewaste under the new rules is the prime obligation of the producer for which the producers can set up collection centres or arrange take-back mechanism without separate authorization. Consumers/bulk consumers have to channelize the ewaste generated by them to authorized collection centre/dismantler and should not mix it with municipal solid waste. They also have to

[2] Extended Producer Responsibility (EPR) – It is the responsibility of every producer of EEE for channelization of e-waste to an authorized dismantler/recycler to ensure environmentally sound ewaste management (Central Pollution Control Board, 2016).

ensure safe disposal of fluorescent and other mercury containing lamps with registered ewaste collection centre/recycler. The role of Urban Local Bodies (ULBs) is to collect and channelize the ewaste generated to authorized dismantlers/recyclers. The new rules also charges for the damage done to the environment due to improper ewaste management and also levies penalty for violation of the rules. The new rules have also simplified many procedures so that the management of ewaste can be hassle-free (Central Pollution Control Board, 2016).

Hence, with the Ewaste (Management) Rules, 2016, the formal ewaste recycling sector will start to grow which is a boon for them but a bane for the informal sector. The ewaste generated will now be channelized to authorized recyclers which will reduce the amount of raw materials for the informal recycling sector and will have adverse repercussions for individuals engaged in ewaste recycling in the sector. As a remedy to this problem, Toxics Link, an Indian research NGO has developed some hybrid models stimulating formal-informal sector linkage so that they can be regarded as a 'package' rather than alternatives for ewaste management. The models that they have developed, though largely theoretical, make the informal sector workers to undertake the task of collection, sorting and dismantling of ewaste and channelizing the materials to the formal sector for further processing. In this way, the livelihood of the informal workers will be secure and the formal sector will get the required raw materials for their operations, which altogether will lead to sound ewaste management (Lines, 2016).

The new rules have also provided non-compulsory provisions like setting up of Producer Responsibility Organizations[3] (PRO), ewaste exchange and Deposit Refund Scheme[4] for easy implementation of Extended Producer Responsibility by the producers for proper ewaste channelization (Central Pollution Control Board, 2016). In India, consumers tend to assign value to their end-of-life products and expect some reward for discarding the appliances (Lines, 2016). Nokia initiated the first mobile phone recycling campaign in Uganda in 2010 which was a success as Nokia provided small gifts, for instance, a recycled bag, to the consumers who brought their mobile phones for recycling. They also provided the consumers an opportunity to win a Nokia N8 mobile phone via lucky draw. In 2008, Nokia started a programme to take-back and recycle mobile phones in India with the aim of consumer awareness and to make recycling easy for which they committed to plant a tree for every mobile phone discarded for recycling. They collected more than 50 tonnes of old phones and accessories in the first 2.5 years of their agenda and in return, Nokia planted more than 90,000 trees. This shows that people are inclined to recycle if they are given proper information as well as easy access to recycle. Along with the implementation of an

[3] Producer Responsibility Organization – It is a body of producers/manufacturers responsible for collection, transportation and recycling of WEEE based on fundamental principles of EPR both legally and operationally (United Nations Environmental Programme, 2007).

[4] Deposit Refund Scheme – The Producer charges an additional amount as a deposit at the time of sale of the EEE and returns it to the consumer with interest when the EEE has reached its end-of-life and is returned (Central Pollution Control Board, 2016).

effective legislation, consumer awareness is also significant for recycling (Tanskanen, 2012).

WEEE Generation: Scenario in Kerala

The role of urbanization has a great impact on consumerism in Kerala. There has been high growth of the urban population in the State due to a three-fold increase in the number of towns. Urbanization in Kerala had increased from 25.96 per cent in 2001 to 47.72 per cent in 2011. Kerala is ranked 9th in Census 2011 in terms of urbanization and Ernakulam leads as the most urbanized district (68.1 per cent) (Kerala State Planning Board, 2017). According to Census 2011, Kerala has 93.91 per cent of literate population and thus, is enriched with abundant human resource (Government of Kerala, 2017). This acts as a driving force for Information Technology (IT) investments into major IT hubs of the State, that is, Technopark in Trivandrum and Infopark in Kochi which has world-class IT infrastructure facilities (Department of Information Technology , 2007).

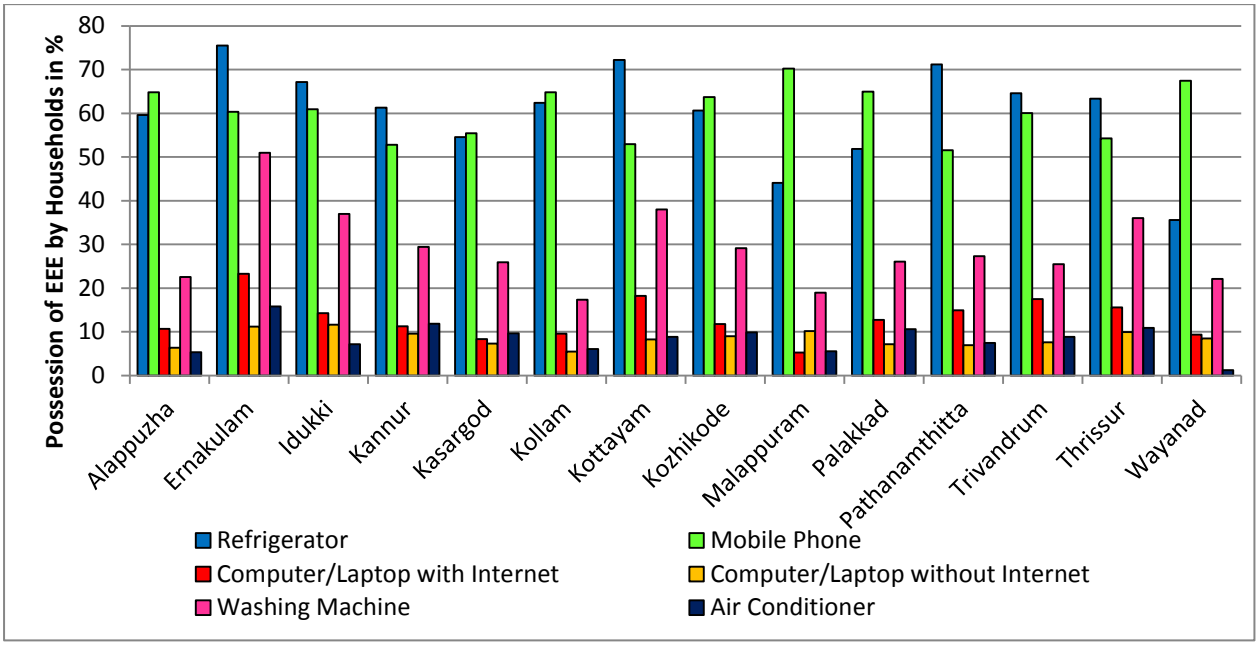


Figure 5: Percentage of Households Possessing EEE in Districts of Kerala
Source: Socio-Economic and Caste Census, Government of India, 2011

In Kerala, there are 13,79,341 urban households in total out of which 8,76,488 households have refrigerators (63.54 per cent), 8,33,500 have mobile phones (60.43 per cent), 2,06,671 have computer/laptop with internet (14.98 per cent), 1,20,446 have computer/laptop without internet (8.73 per cent), 4,31,704 households with washing machines (31.30 per cent) and 1,37,755 households with air conditioners (9.99 per cent) (Ministry of Rural Development, Government of India, 2011). Figure 5 depicts the district-wise percentage of households in Kerala that possess refrigerators, mobile phones, computer/laptop with and without internet facility, washing machines and air conditioners.

With the demand for and consumption of EEE increasing in Kerala, it is obvious that the amount of WEEE generated will also be increasing. So, managing the ewaste generated must be one of the important agenda among other waste-reducing initiatives of the Government. There is no apt collection system for ewaste in the State due to which informal sector dominates which is similar to the national scenario (Government of Kerala, 2014).

In 2012-13, there were three authorized ewaste collection centres in Kerala and a total of 69.738 tonnes of ewaste was collected in the year. In 2013-14, one more ewaste collection centre was given approval by the Kerala State Pollution Control Board, thus, making the total collection centres to be four and a total of 265.559 tonnes of ewaste was collected in that year (Kerala State Pollution Control Board, 2012-13 & 2013-14). Currently, there are 9 ewaste collection centres in the State, one in Palakkad District and rest in Ernakulam District (Kerala State Pollution Control Board, 2017). There is no authorized ewaste dismantling/recycling facility in the State and thus, the collected ewaste is disposed through authorized recyclers outside Kerala (Kerala State Pollution Control Board, 2012-13 & 2013-14). As per the Ewaste (Management & Handling) Rules, 2011, the State's WEEE from government departments/institutions, other organizations and individuals are currently handed over to the Clean Kerala Company Limited (CKCL) in Trivandrum formed under the Local Self Government Department at a rate of Rs. 10/- per kilogram (Government of Kerala, 2016).

The Clean Kerala Company Limited currently collects ewaste, along with tube lights and CFLs, and sends it to the Earth Sense Recycling Private Limited Recycling Plant in Hyderabad where it is scientifically processed. The company also has data on the amount of ewaste collected by them till now. As on 8th October, 2017, a total of 353.5 tonnes of ewaste has been collected by the Company. 2 tonnes of ewaste which was pooled in by various government departments was collected by the company on 24th January, 2017 from Ernakulam Collectorate. The CKCL's special drive called IT@School was inaugurated by collecting ewaste from 5 districts amounting to a total of 12,437 kilograms (Trivandrum – 2730 Kgs, Alappuzha – 2027 Kgs, Thrissur – 1900 Kgs, Kozhikode – 2292 Kgs and Kannur – 3488 Kgs) (Clean Kerala Company Limited, 2017).

Consequently, it can be said that the WEEE generated and disposed in the State will be higher than the available data but lack of proper collection system and official reporting makes it impossible to analyze the actual quantity produced. As regards the authorized ewaste collection centres are concerned, there are presently 9 out of which 8 are in Ernakulam district as on March 2017; hence, what happens to the ewaste generated in other districts of the State remains unanswered. Since there is no proper ewaste collection mechanism in the State, it is affirmative that huge volume of ewaste generated from household sector end up either with the informal sector or being stored at house.

Conclusion

One man's waste is another man's resource, thus, terming obsolete EEE as waste is not apt as it contains many components which can be extracted and recycled leading to conservation of resources and energy. But the term is universally used and has no alternative, thus, the terms 'Ewaste' and 'WEEE' have been used interchangeably in the study. India lacks proper ewaste collection and disposal mechanism, proper channelization and official recording of ewaste generated. The same issue can be witnessed in Kerala as well. Hence, the generation, management and handling of WEEE are of crucial importance.

Chapter – 2: Methodology and Analysis of Data

Research Problem

Electronic waste is an emerging concern of the 21st century. Day-by-day people are conspicuously consuming electronic products as a status symbol and urbane lifestyle. Thanks to the erudite technology, there is no limit to the multiplicities of appliances being launched in the market. People generally have a tendency to be in fad due to which they are ready to purchase a new gadget even though they own the same sort in working condition. This trend of disposing or non-usage of the working electrical and electronic equipments and replacing it with new ones possessing latest features have given rise to escalating quantities of ewaste .

As regards WEEE management, there is no proper collection and disposal mechanism for discarded EEE in India. Majority of disposed EEE end up in landfills and for incineration harming the health of living beings and the environment. The discarded EEE is gathered mostly by the informal sector and is dismantled and shredded without any safety measures. Though there are formal ewaste recycling centres in India that are authorized to collect and process the discarded EEE, they do not receive the raw materials due to lack of proper channelization of resources. The e-waste generated is not even recorded due to which actual volume is unknown. This has significantly affected the sound management of ewaste (See also Research Unit (LARDDIS), 2011).

In case of Kerala, the ewaste generated is collected (not completely) and sent-off to recyclers outside Kerala as there is no adequate facility to dismantle or recycle ewaste in the State (See also Kerala State Pollution Control Board, 2012-13 & 2013-14). Due to the absence of apt ewaste collection and record-keeping, the quantity of ewaste generated from the household sector is unknown. Of the nine authorized ewaste collection centres, eight are in Ernakulam district but still consumers are clueless regarding disposal of ewaste. It is not feasible for consumers to transport their WEEE from long distance and dispose at the authorized collection centres in the State. Hence, they either opt to store the non-working EEE at their house or dispose it with informal scrap dealers who are near to their locality. Thus, the amount of ewaste disposed as well as stored by the consumers in their houses is a matter of concern to be examined. A micro-level analysis among households in a local urban area can put forth the basic issues that individual consumers have to deal with end-of-life EEE since they too are creators of ewaste. The following questions are raised:

1. What is the stock of electrical and electronic equipments among the households in the study area?
2. How much quantity of ewaste has been discarded by the households in the study area in the last three years?
3. What are methods adopted by the households for discarding their end-of-life EEE?

4. What is the amount of non-used but functional EEE stored by the households in their house?
5. What is the volume of non-functional EEE stored by the households in their house?

Research Objectives

To answer the above questions, the following objectives have been set for the current study:

1. To examine the socio-economic background of the inhabitants in the study area.
2. To analyze and quantify the household stock of EEE in the study area.
3. To evaluate the quantity of discarded EEE in last three years and to identify the disposal methods adopted by the respondents in the study area
4. To study the volume of non-used but functional and non-functional EEE stored by the households.

Research Method

The area taken for the study is Tripunithura Municipality because it is a suburb of Cochin Corporation with growing number of apartments, electronics showrooms and technical institutes along with rising standard of living among the households. The Municipality has 49 wards. The total wards are categorized into three strata on the basis of an estimated monthly income of the households. This information is collected by interviewing a few Ward Councillors and Junior Public Health Nurse of the Municipality. Of the total wards, 33 wards consists majority of low income households, 12 wards with majority of middle income households and 4 wards with majority of high income households. Since the wards with low income households is high, 2 wards representing low income and 1 ward each representing middle and high income households are selected for the study through simple random sampling. The four wards of the municipality selected are Market, Mekkara, Palliparambukavu and Kannankulangara representing two low income wards and one middle and one high income ward respectively. The sample drawn is 10 per cent of the households from each ward using simple random sampling, constituting to a total of 180 households. The primary data is collected from the households with a structured schedule and from Municipality officials via personal interview. The secondary data is collected from various journals, global and national reports, policy documents and internet sources. The period of study is 2017.

The electrical and electronic equipments (EEE) taken for the current study are television, refrigerator, washing machine, air conditioner, computer, mobile, laptop, tablet, mixer and grinder, radio, DVD player, oven, induction cooker, water heater, tube light, CFLs, ceiling fan, stabilizer and inverter (excluding battery). All these EEEs have been incorporated so that the study stands unique among other ewaste related studies as well as to know which all products in the household sector contribute the highest to the ewaste stream so that the products can be narrowed down for further studies among the households.

Significance of the Study

This study will help identify the magnitude of ewaste problem in a local urban area with which the ewaste dilemma on a broader perspective can be understood. The study will also throw light on the role played consumers in the generation of Ewaste and the extent of knowledge and awareness they have on its disposal and management. Further research can be conducted among bulk consumers, that is, public and private institutions and commercial establishments to analyze the dilemmas regarding WEEE management.

Limitations

The study is limited to a single municipality and only a small percentage, that is, 10 per cent of households are chosen from the four wards taken for the study as sample. A few respondents were reluctant to disclose their monthly income range but it is estimated by the researcher by taking the respondents' occupation as a proxy for assessing their monthly income range. Regarding consumer EEE such as Television, Computer, Refrigerator, Water Heater and Grinder, features like type and size of screen, single or double door, volume etc. have not been taken into account for calculating the ewaste generated. The average lifespan of certain EEE is unavailable.

Profile of the Area of Study: Tripunithura Municipality

Ernakulam District in Kerala is situated on the coast of Arabian Sea. It is the most industrially advanced and flourishing district of the State comparatively (The District Administration, Ernakulam). There are 13 Municipalities in the district, Tripunithura being one of it (Government of Kerala). Tripunithura Municipality is a suburb of Cochin Agglomeration with an area of 29.17 square kilometres. There are 49 wards in the Municipality. The Municipality has 1 taluk hospital, 8 primary health centres, 16 private hospitals, 1 Ayurveda medical college, 39 schools, 68 anganwadis, 2684 commercial establishments, 2 veterinary hospitals, 1 slaughter house, 16 colonies, 5 cluster areas and 6058 BPL families (Government of Kerala).

Map 1: Tripunithura Municipality
Source: Government of Kerala

Through personal interview conducted with the Senior Clerk of the Primary Health Standing Committee of the Municipality, it is known that the Municipal Solid

Waste (MSW) collected is segregated and the degradable ones are sent to Brahmapuram Waste Treatment Plant, non-degradables are given to scrap dealers and plastic waste is sent to Kerala Enviro Infrastructure Ltd in Ambalamedu, Kochi. When asked whether ewaste was found among MSW, the Senior Clerk replied that since no collection mechanism is present in the Municipality, people have no other option other than to dump it along with MSW and that they receive e-scraps occassionally (Primary Survey, 2017).

The first-of-its-kind ewaste collection drive was conducted in August 2017 in the Municipality organized by Suchitwa Mission in association with the Clean Kerala Company as part of the Independence Day Programme. During the drive, many consumers disposed obsolete EEE such as television, computer, mobile phone, camera and other accessories amounting to a total of 350 kilograms of ewaste. An amount of Rs. 3500/- will be paid at a rate of Rs. 10 per kilogram to the Municipality (not paid at the time of collection), however, the consumers were not paid any returns at the time of disposal (Primary Survey, 2017).

When asked about future proposals for WEEE management, the Senior Clerk replied that plans are being suggested for a Material Recovery Facility[5] (MRF) and SWAP Shops[6] for reuse of second-hand EEE under the Haritha Keralam initiative. Though one SWAP shop is currently present in the Municipality, the initiative is not functioning as desired. The present SWAP shop, introduced in December 2016, has been able to collect many used clothes and one television set. The MRF initiative is on hold as the Municipality is facing hurdle connected with storage space (Primary Survey, 2017).

Socio-Economic Background of the Respondents

Qualification, Occupation and Monthly Income Range of the Respondents (in %)

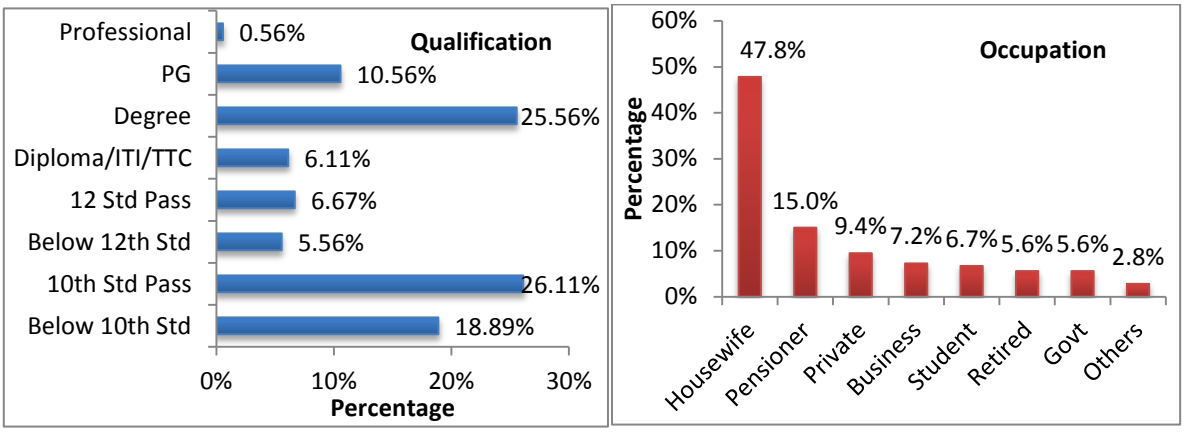


Figure 6: Qualification and Occupation of the Respondents
Source: Primary Data, 2017

[5] Material Recovery Facility (MRF) - It is a specialized plant that separates and prepares materials for remanufacturing and reprocessing. MRFs act as temporary storage and segregation area before transporting the materials for recycling (Suchitwa Mission, 2017)

[6] SWAP Shop - It is set up for promoting 'reuse' of materials by providing a public system for exchanging reusable goods that could be useful for others (Suchitwa Mission, 2017)

Of the 180 respondents interviewed, 26.1 per cent have primary schooling and 25.6 per cent are graduates which together constitutes 51.7 per cent of the total respondents. As regards the occupation of the respondents, majority interviewed are housewives as the earning members were not present at home at the time of the interview. The occupations that fall under the 'other' category include domestic work, social work and temple priests. Majority of the respondents interviewed are dependent population (respondents who are housewives, retired persons without pension and students) and independent population constitutes 39 per cent of the total respondents (Figure 6). Of the independent population interviewed, 33 per cent are earning less than ₹ 30000 as monthly income (Figure 7). Average age of the 180 respondents interviewed is 51.96 years.

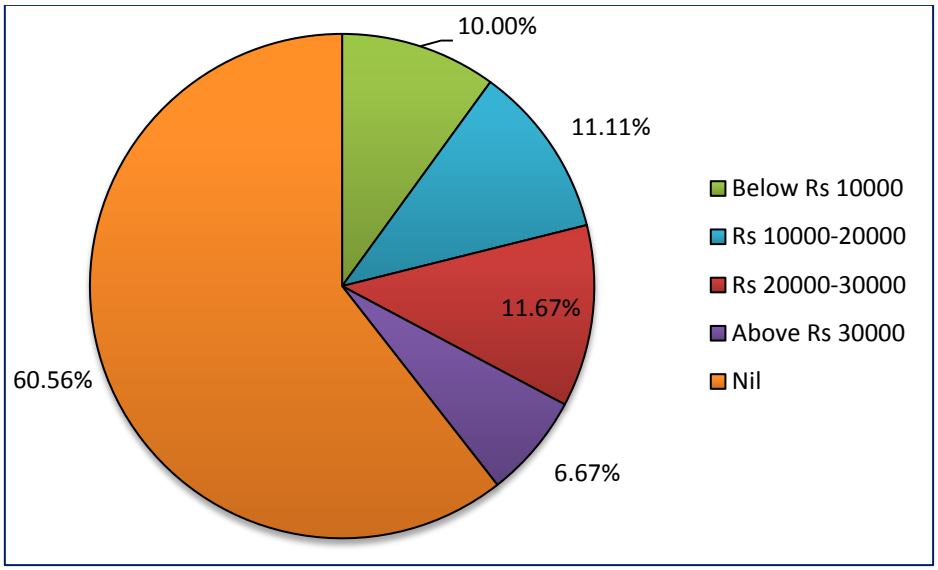


Figure 7: Monthly Income Range of the Respondents
Source: Primary Data, 2017

Religion and Family Details of the Respondents

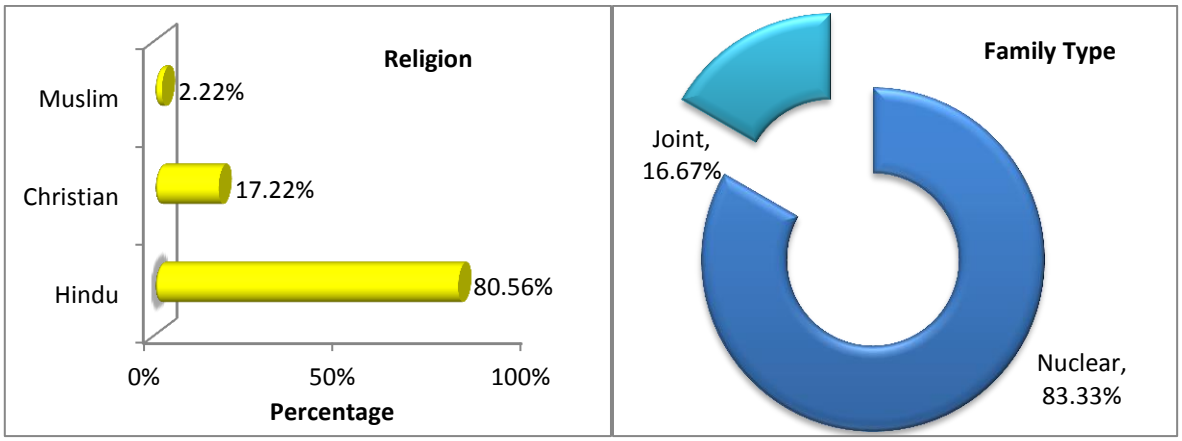


Figure 8: Religion and Family Type of the Respondents
Source: Primary Data, 2017

From the study, it is found that Hindus dominate the study area accounting for 80.56 per cent followed by Christians and Muslims. Majority of the families are nuclear

(Figure 8). Majority of the households have three members accounting to 40 per cent excluding the respondents. The average household size is 3.49 persons per household. It is calculated by dividing the total population in the four wards by the total households in the four wards taken for the study.

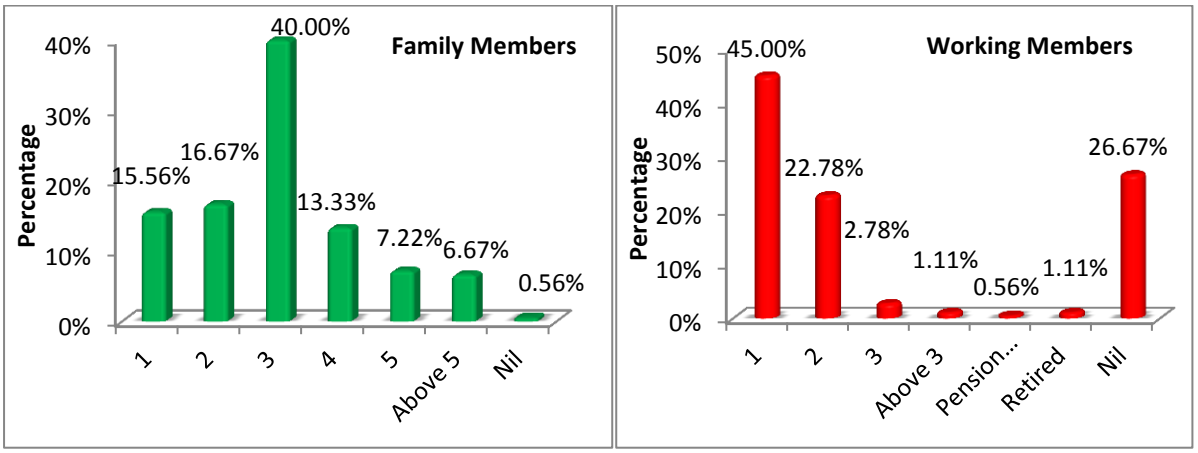


Figure 9: Number of Family Members and Working Members
Source: Primary Data, 2017

45 per cent households have only one working member, 23 per cent households have two working members and 27 per cent households have no working members (Figure 9). The highest range of monthly income earned by the respondents' family members ranges between ₹ 20000- ₹ 30000 which accounts to 21.11 per cent. Only 8.89 per cent of working family members earn an income of ₹ 40000 and above per month. Majority of the respondents have their own house and 15.56 per cent are staying in rented houses (Figure 10).

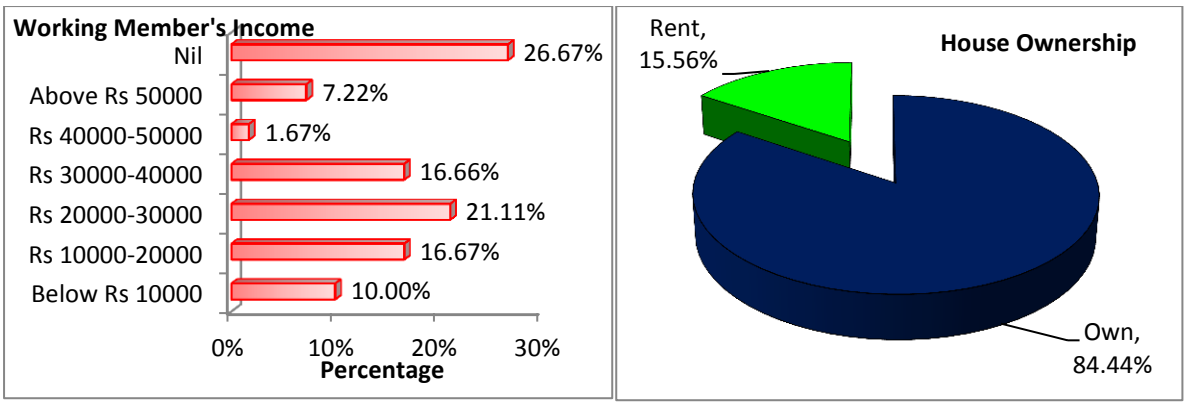


Figure 10: Monthly Income Range of Working Members and House Ownership
Source: Primary Data, 2017

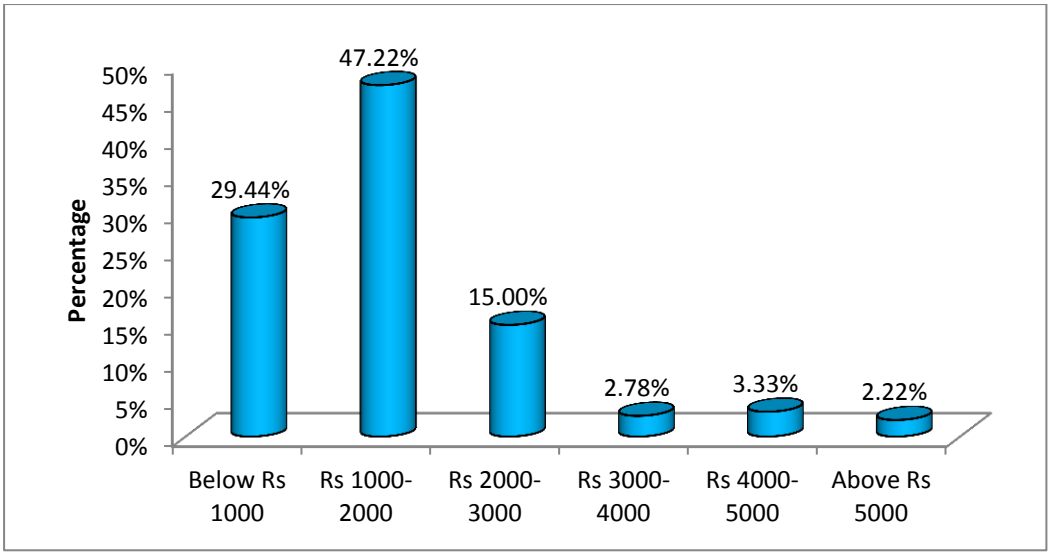


Figure 11: Average Electricity Consumption in Rupees
Source: Primary Data, 2017

47.22 per cent households consume electricity ranging between ₹ 1000- ₹ 2000 (Figure 11).

Household Stock of EEE in the Study Area

Figure 12 shows the data regarding the percentage of urban households in the Municipality possessing specific consumer durables – Refrigerator, Mobile phone, Computer/Laptop with and without internet connection, Washing Machine and Air Conditioner, accessed from the Socio-Economic and Caste Census 2011, Ministry of Rural Development, Government of India.

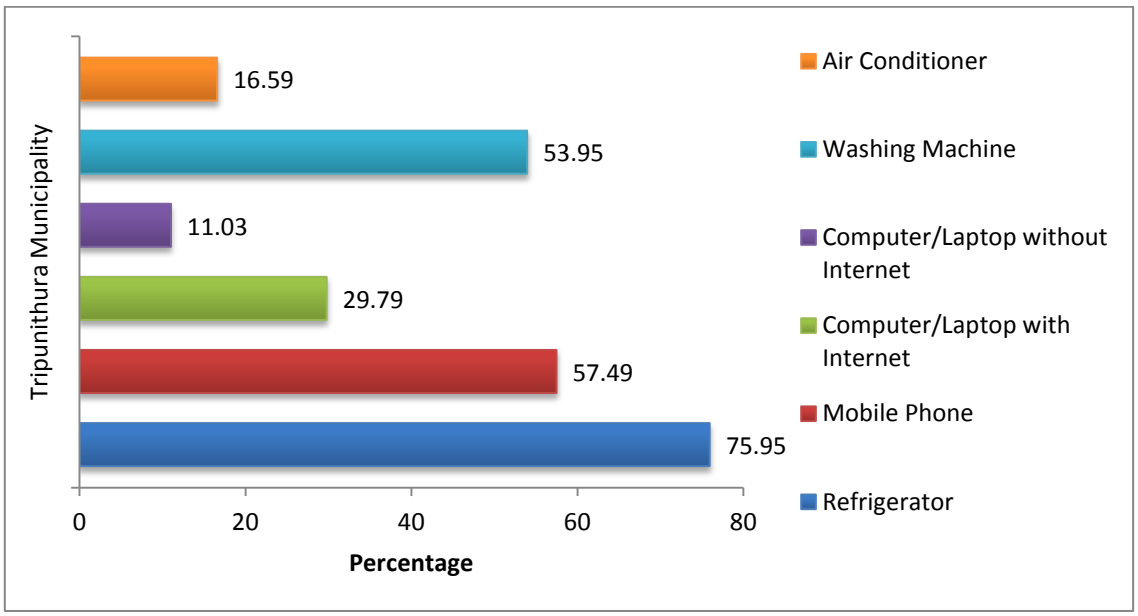


Figure 12: Percentage of Households Possessing EEE in Tripunithura Municipality
Source: Government of India, 2011

Figure 13 shows the in-use electrical and electronic products among the respondents interviewed in the four wards taken for the study. From the below figure, it

can be pointed out that income is not a constraint for the consumption of electronic goods.

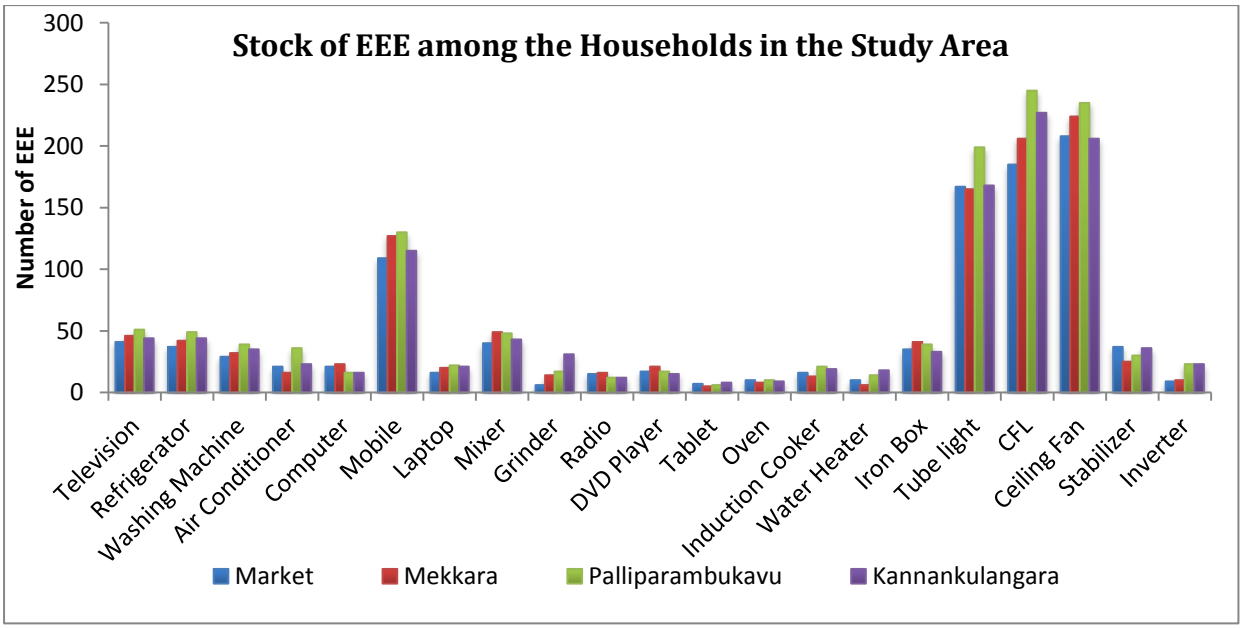


Figure 13: Stock of EEE among the Households in the Study Area
Source: Primary Data, 2017

The four wards showcase the fact that consumption of electronic gadgets will increase irrespective of individual's income as day-by-day new appliances with latest features are being launched. It can also be seen from the study that respondents in the middle income ward, that is, Palliparambukavu ward, possess the highest number of major electrical and electronic equipments (Television, Refrigerator, Washing Machine, Air Conditioner and Mobile, though computer is an exception). This can be related to the Export-Import Bank of India (2011) study which reports larger middle class population as a factor making a positive impact on the electronics industry.

Forecasting the Volume of Ewaste Generation based on Household Stock of EEE

The volume of ewaste that will be generated in the study area is calculated with the currently used products in the area with the assumption that all the EEE will end-up in the waste stream after it has completed its lifespan. For this study, the average weights of the products have been used to estimate the volume of ewaste that will be generated in the study area. The formula used for calculating the ewaste generated is:

Ewaste Generation (in Kgs) = Number of Product X * Average Weight of Product X

With the above formula, the quantity of WEEE from the four wards that will enter the ewaste stream in the coming years is estimated in Table 3 (The respondents were not sure of the exact year of purchase of EEE due to which the year of disposal of each product could not be estimated). In case of Inverter, the weight of battery has not been taken into consideration as some respondents stated to use solar panels. The capacity of Water Heaters and Grinders has not been mentioned by the respondents due to which the average weights of the lowest capacity of Water Heater (Capacity of 1 Litre

= 2 Kgs) and Grinder (Capacity of 1¼ Kgs = 25 Kg) are taken for calculating ewaste generated from it. In case of Stabilizer, its average weight differs according to the type of EEE with which it is used (Average weight of a Stabilizer used for Television and Refrigerator = 3 Kgs and for Air Conditioner = 7 and above Kgs). Hence, the average weight of a Stabilizer is assumed as 5 kgs in this study.

EEE	Average Lifespan (years)	Average Weight (in Kilograms)	Number of Products in Use in the Study Area	Estimated Ewaste Generation in Kilograms**
Television	9	36.5	182	6643
Refrigerator	10	48	172	8256
Washing Machine	9	65	135	8775
Air Conditioner	10	46	96	4416
Computer	6	27.2	76	2067.2
Mobile Phone	5	0.102	481	49.06
Laptop	5	2.5	79	197.5
DVD Player	4	5	70	350
Tube Light	2	0.2	699	139.8
CFL	2	0.08	863	69.04
Oven	NA	15	37	555
Mixer	NA	2	180	360
Radio	NA	2	55	110
Iron Box	NA	1	148	148
Tablet*	5.1	0.125	26	3.25
Induction Cooker*	NA	1.25	69	86.25
Water Heater*	NA	2	48	96
Grinder*	NA	25	68	1700
Ceiling Fan*	NA	2	873	1746
Stabilizer*	NA	5	128	640
Inverter* (excluding Battery)	NA	8	65	520
TOTAL			**4550**	**36,927.1**

Table 3: EEE - Average Lifespan and Average Weight
Source: Central Pollution Control Board, 2016, Huisman, Magalini, & Kuehr, 2007, United Nations Environmental Programme, 2007, IMRB International, 2010, IRG Systems South Asia Pvt. Ltd., 2007, Taylor, 2015, * Primary Data, 2017, ** Calculated by the Researcher.

The above table shows that from the present household stock of EEE in the study area, 36,927.1 kilograms (36.9271 metric tonnes) of EEE (4550 products) will end up in the ewaste stream in the coming years.

Refurbishment of Electrical and Electronic Equipments by the Households

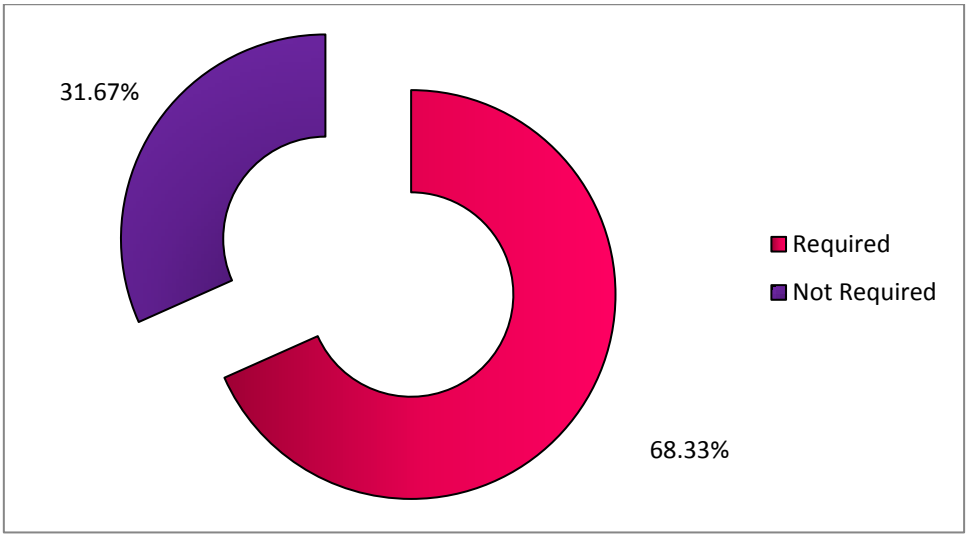


Figure 14: Requirement of Refurbishment
Source: Primary Data, 2017

68.33 per cent respondents stated that they have repaired their electronic products and are reusing it (Figure 14). Major electronic products that are repaired and reused are Television, Refrigerator, Washing Machine, Computer and Mixer (Figure 15).

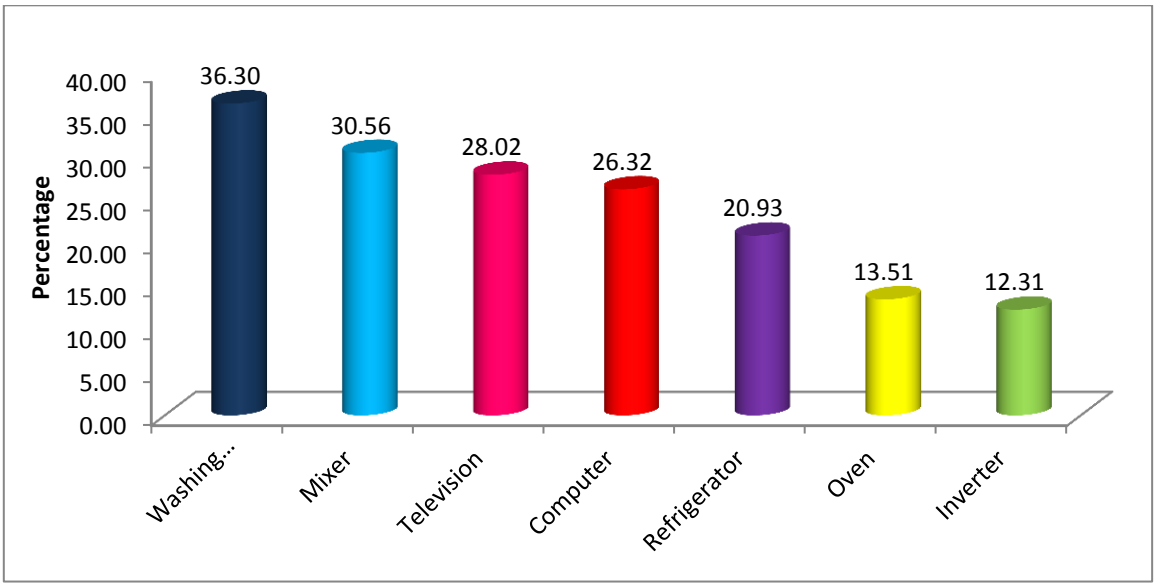


Figure 15: Percentage of Type of EEE Refurbished
Source: Primary Data, 2017

Thus, majority of the consumers have extended the lifespan of their products (passive life) currently in use through refurbishment and have curtailed its early entry into the ewaste stream.

Details of Electrical and Electronic Products Disposed in 3 Years

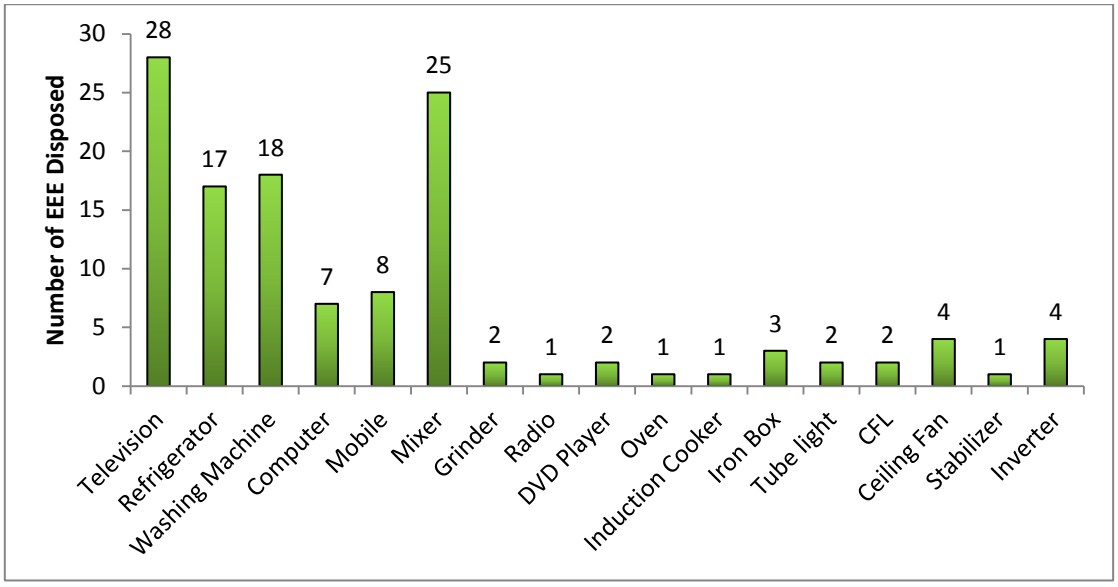


Figure 16: EEE Disposed in 3 Years (in Numbers)
Source: Primary Data, 2017

From the interview conducted, it is found that 46.11 per cent of the households have disposed multiple electronic products. The major electronic gadgets discarded in the four wards are televisions, refrigerators, washing machines, computers, mobile phones and mixers (Figure 16).

Quantity of Ewaste Discarded in the last 3 Years

The volume of ewaste that has been discarded in the last three years is calculated with the same formula used for estimating the ewaste quantity that will be generated in the coming years. Table 4 represents the quantity of ewaste produced in the last three years from the study area.

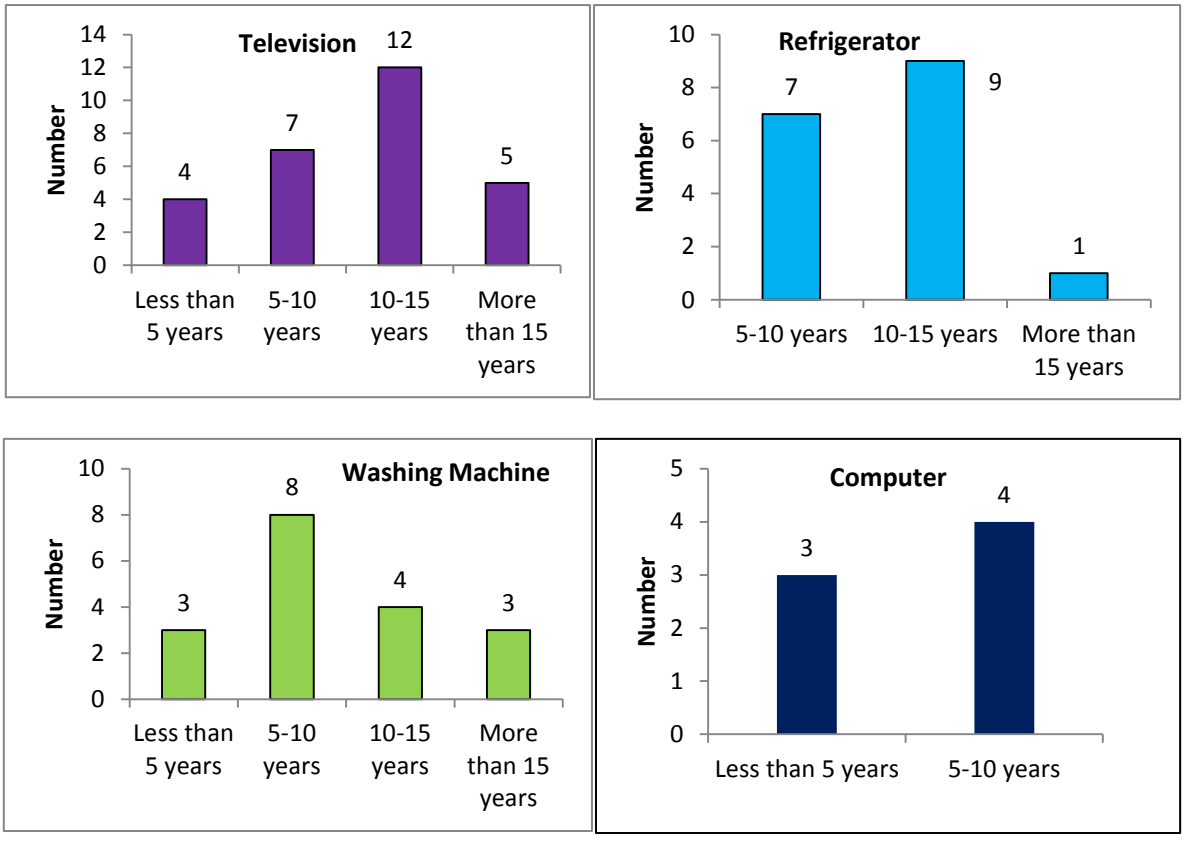
EEE	Average Weight (in Kilograms)	Number of Products Disposed in the Study Area	Ewaste Generated in Kilograms
Television	36.5	28	1022
Refrigerator	48	17	816
Washing Machine	65	18	1170
Computer	27.2	7	190.4
Mobile Phone	0.102	8	0.816
DVD Player	5	2	10
Tube Light	0.2	2	0.4
CFL	0.08	2	0.16
Oven	15	1	15
Mixer	2	25	50
Radio	2	1	2
Iron Box	1	3	3

Induction Cooker	1.25	1	1.25
Grinder	25	2	50
Ceiling Fan	2	4	8
Stabilizer	5	1	5
Inverter	8	4	32
TOTAL		**126**	**3376.026**

Table 4: Volume of Ewaste Disposed in 3 Years
Source: Primary Data, 2017

It can be found from the study that a total of 3376.026 kilograms (126 products) (3.37 metric tonnes) of ewaste has been generated from the study area in the last three years. This finding clearly showcases the accelerating volume of ewaste and the significance of WEEE management as pointed out in the literature review.

Lifespan of Major Disposed Products (in Numbers)



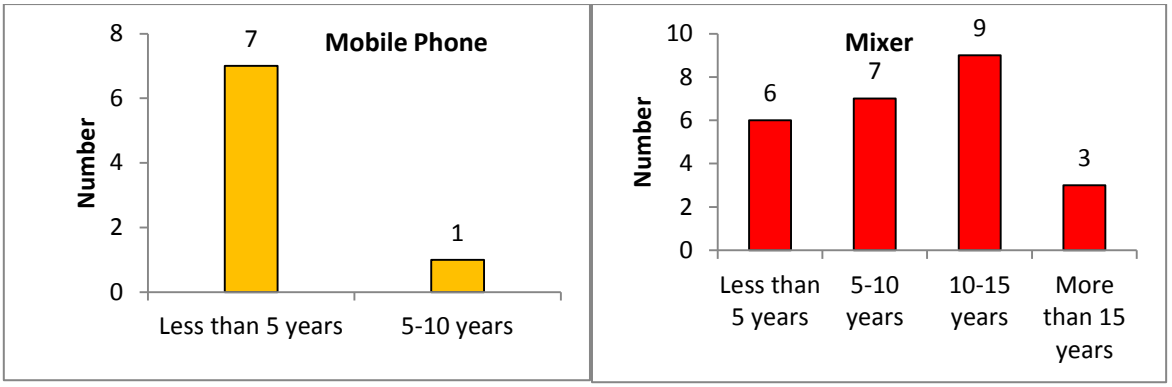


Figure 17: Lifespan of Major Disposed Products
Source: Primary Data, 2017

The figures indicate that major consumer electronics were used by the respondents beyond its lifecycle before disposing it. Refurbishment of the EEE plays a significant role in extending the lifespan of these products before disposal. These electronic gadgets were disposed after the completion of its active life and passive life.

Condition of the Disposed EEE and Reason for Disposal

Of the total 83 households that disposed have EEE in the last three years, 51 per cent stated that they have disposed their working appliances (Figure 18). The reasons they cited are frequent repairs, high electricity consumption, to be in fad and lack of modern features. Majority claimed to have to repair their appliances frequently due to which they disposed it.

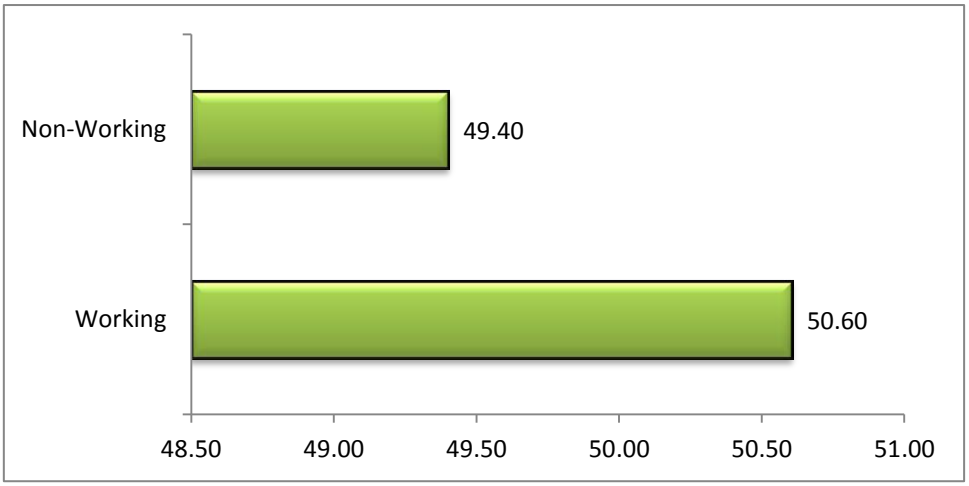


Figure 18: Condition of Disposed EEE
Source: Primary Data, 2017

23.81 per cent respondents reported to have no specific reason for disposing their gadgets (Figure 19). This behaviour of the consumers of disposing working products without any specific reason will aggravate the issue in the coming years. Hence, consumer awareness regarding the significance of reuse of EEE and ewaste management is necessary.

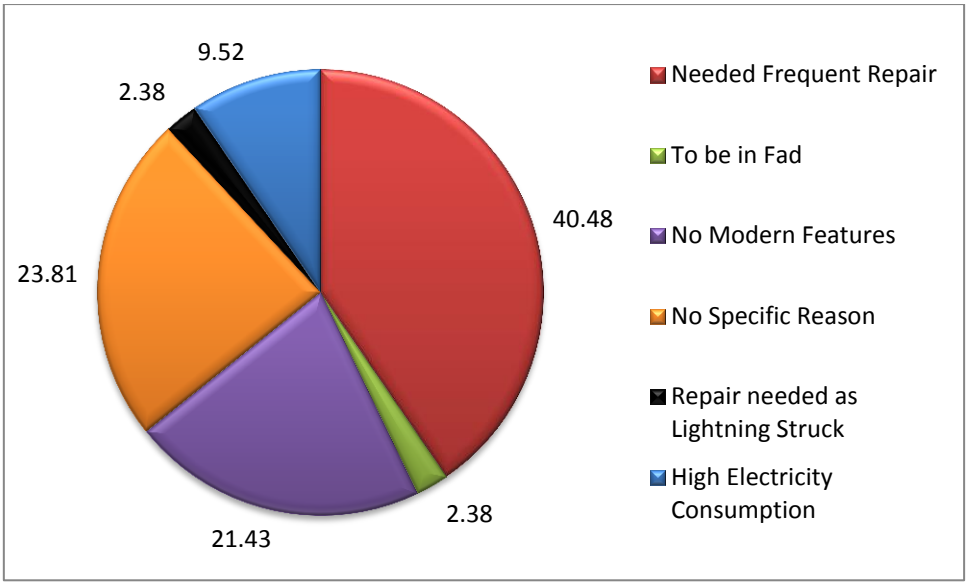


Figure 19: Reason for Disposal of Working EEE
Source: Primary Data, 2017

Method of Disposal Adopted

From the survey conducted, it is found that 52 per cent households exchanged their old products for new ones. This displays that people are more inclined to receive something in return rather than freely dispose their non-working appliances. That is why majority of the respondents opted to exchange their products. It is followed by 39.76 per cent of respondents who reported to have given their old products to scrap dealers (Figure 20).

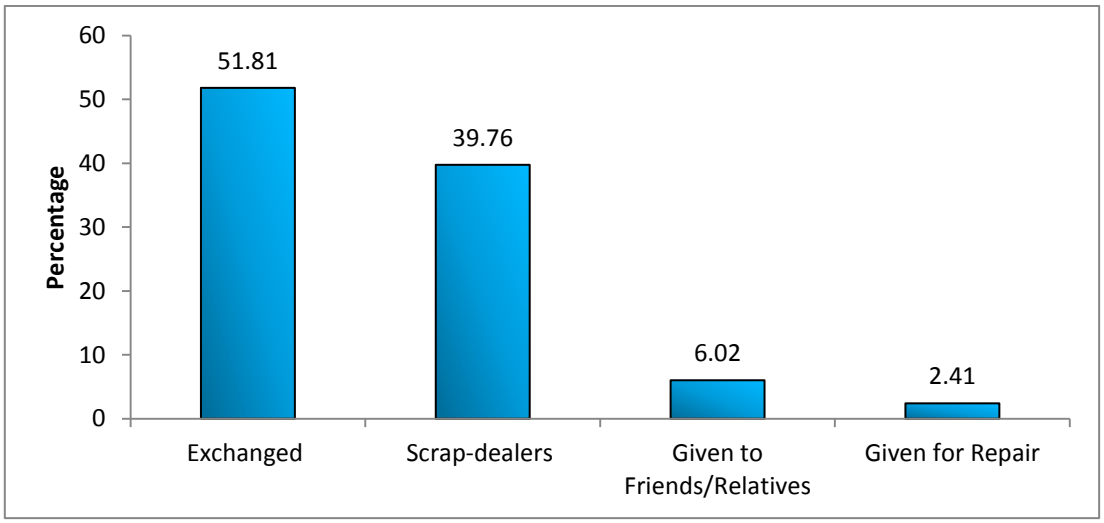


Figure 20: Method of Disposal
Source: Primary Data, 2017

64 per cent respondents have exchanged their working products for new ones while 24 per cent have given their working electronics to scrap-dealers (Table 5). The working products disposed with the informal sector may make its entry into the second-hand market and the non-working ones may either be refurbished or will be recycled using unsafe methods by the informal workers.

Content		F	%
Working Products	Exchanged	27	64.29
	Scrap Dealers	10	23.81
	Friends/Relatives	5	11.90
TOTAL		**42**	**100**
Non-Working Products	Exchanged	16	39.02
	Scrap Dealers	23	56.10
	Repair	2	4.88
TOTAL		**41**	**100**

Table 5: Disposal of Working and Non-Working EEE
Source: Primary Data, 2017

Table 5 also shows that 12 per cent of the respondents have given their working products, which they do not use/want, to friends/relatives; thus, reuse of EEE is taking place. Here, exchange of electronic product is assumed to be a disposal method since there is no ewaste collection mechanism in the study area and thus, the respondents find it as a means to dispose their electronic products.

EEE/Content	Working EEE Disposed	Non-Working EEE Disposed	Total Number of EEE Disposed with Scrap Dealers	Ewaste Disposed with Informal Scrap Dealers (in Kgs)
Television	3	9	12	438
Refrigerator	3	6	9	432
Washing Machine	1	3	4	260
Computer	0	5	5	136
Mixer	2	7	9	18
Mobile Phone	1	0	1	0.102
Radio	1	0	1	2
DVD Player	1	1	2	10
Iron Box	0	1	1	1
Tube Light	1	0	1	0.2
CFL	1	0	1	0.08
Ceiling Fan	2	2	4	8
Stabilizer	0	1	1	5
Inverter	0	1	1	8
TOTAL	**16**	**36**	**52**	**1318.382**

Table 6: WEEE Disposed with Scrap Dealers
Source: Primary Data, 2017

The above table (Table 6) shows that 1318.382 kilograms of EEE, both working and non-working, was disposed by the respondents in the study area with the informal scrap dealers. That is, of the 3.37 metric tonnes of ewaste generated in the last three years from the study area, 39 per cent of the ewaste was discarded with the informal sector. This reflects the national scenario of ewaste market being dominated by the informal sector as pointed out in studies of Lines (2016) and Research Unit (LARDDIS), (2011) wherein they focus on lack of proper channelization and collection system as the

reasons for disposal of ewaste with the scrap dealers. This creates negative externalities creating social cost. It is unknown whether the working EEE disposed with the scrap dealers has been refurbished and entered the second-hand market as the study was limited to consumers. Of the total respondents who gave their working as well as non-working electronic products to the scrap dealers, more than half of the respondents received returns less than Rs 500/- for their products (Figure 21).

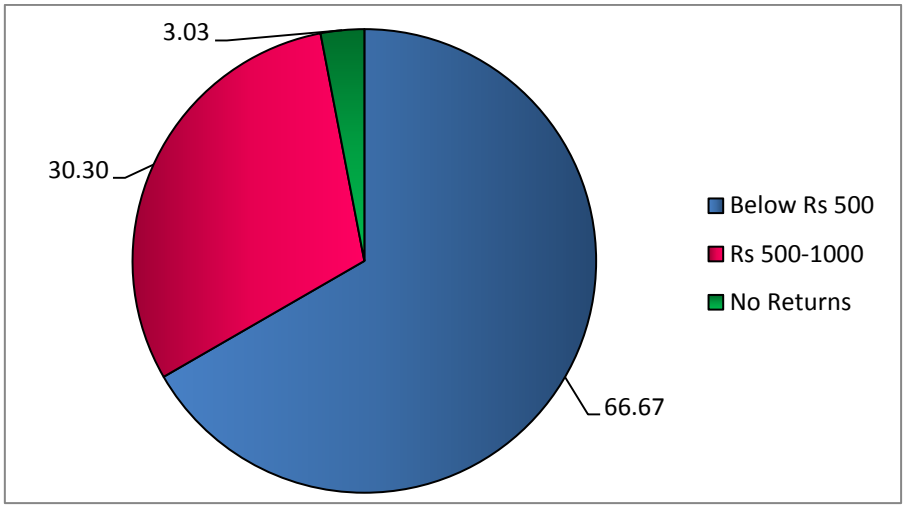


Figure 21: Returns Received from Scrap Dealers
Source: Primary Data, 2017

From the study, condition of the EEE can be seen as a decisive factor for the respondents to choose between exchange of the products and disposal with the scrap-dealers. It can be seen from Table 5 that 64 per cent of the respondents chose to exchange their working equipments as they reported that working products have comparatively more exchange value than non-working products. 56 per cent respondents chose to dispose their non-working equipments with the scrap-dealers as the exchange value will be low for non-working EEE while they may get a higher value for the same from the scrap-dealers.

Replacement of the Appliances

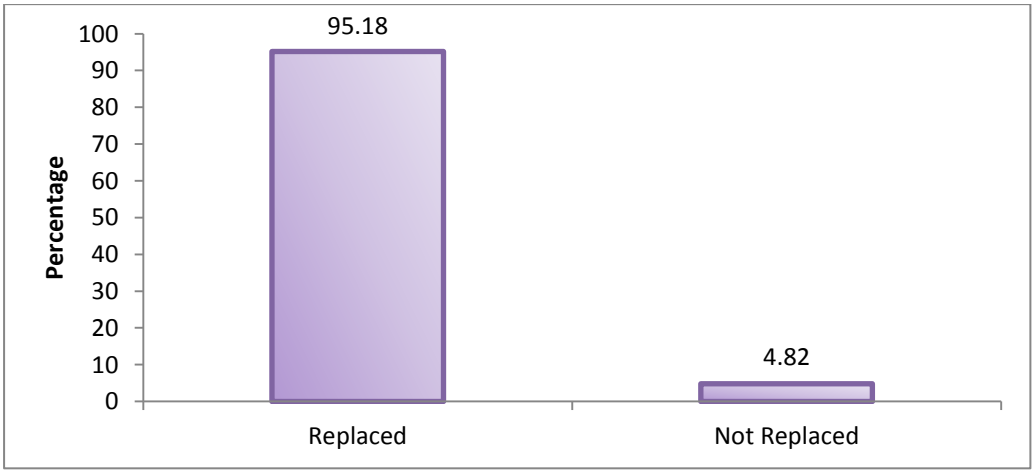


Figure 22: Replacement of Discarded EEE
Source: Primary Data, 2017

Of the total 46.11 per cent households who reported to have disposed their EEE, 95 per cent have replaced their disposed products with new ones (Figure 22). This finding point out that lower replacement cost, in the form of low-cost EEE, makes consumers to purchase new products than repairing their existing appliances making the obsolescence rate of the EEE to increase. This finding is advocated by what Puckett had stated in his 2002 study that consumers find it easier to replace than repair non-operational EEE. One thing to be noted here is that not only the availability of low-cost products contributes to replacement of EEE but factors such as lack of modern features, recurrent repairing and higher electricity consumption also affects the consumers' decision to replace an EEE as it can be found that working gadgets have also been disposed and replaced.

Details of Non-Working EEE Stored at Home

From the primary data collected, it is found that 29 per cent have stored non-working electronic products at home with varying duration of storage. The quantity of end-of-life electronic products (in kilograms) stored at home is represented in Table 7.

EEE	Average Weight (in Kilograms)	Number of Non-Working EEE in the Study Area	Ewaste Stored at Home (in kg)
Television	36.5	12	438
Refrigerator	48	8	384
Washing Machine	65	8	520
Computer	27.2	10	272
Mobile Phone	0.102	9	0.918
Laptop	2.5	1	2.5
Mixer	2	9	18
Grinder	25	4	100
Radio	2	1	2
DVD Player	5	1	5
Oven	15	6	90
Induction Cooker	1.25	5	6.25
Iron Box	1	2	2
Tube light	0.2	1	0.2
Ceiling Fan	2	4	8
Stabilizer	5	1	5
Inverter	8	3	24
TOTAL		**85**	**1877.868**

Table 7: Number and Volume of Non-Working EEE Stored at Home
Source: Primary Data, 2017

The above table shows that 1877.868 kilograms of WEEE has been stored by 29 per cent households in the study area. They have stored it in their houses due to lack of collection centres, no desired returns and for refurbishment and exchange of the same in the future.

Duration of Major Non-Working Equipments stored at Home (in Numbers) and Reason for Non-Disposal

Figure 23 represents the duration of storage of major non-working products at home by the respondents. 29 per cent respondents cited that the products need to be refurbished due to which they have stored it at home, 21 per cent respondents are waiting for festivities to exchange their products when good offers are available, 15 per cent have reported to store their non-working equipments at home due to lack of ewaste collection points in the locality and 13 per cent respondents expect good returns for their product and the lack of it made them to store the equipments at home (Figure 24).

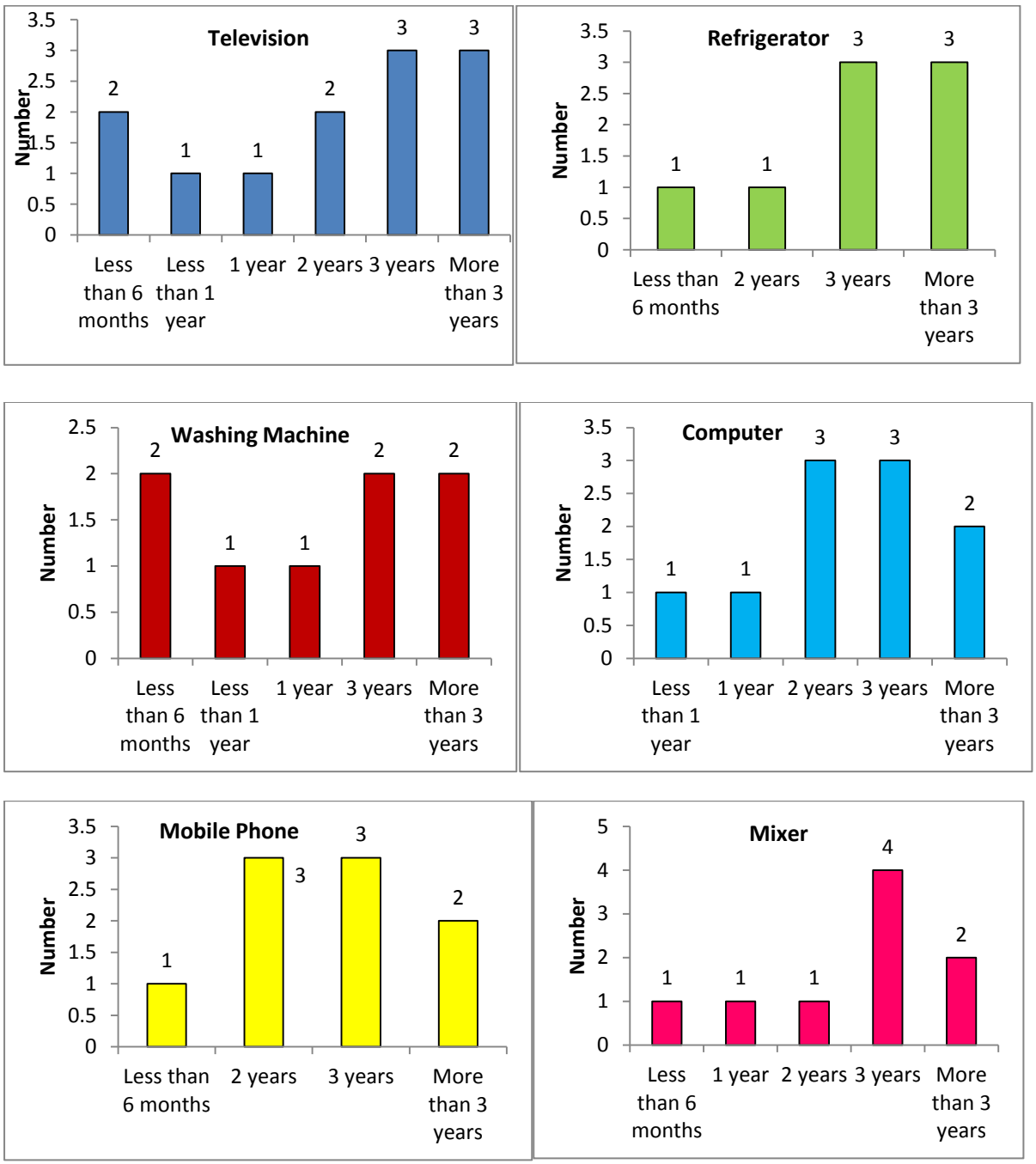


Figure 23: Duration of Storage of Major Non-Working EEE at Home
Source: Primary Data, 2017

One respondent stated that they dispose the accessories of non-working mobile phones like earphones and chargers along with the municipal solid wastes while others have also stored these accessories at home.

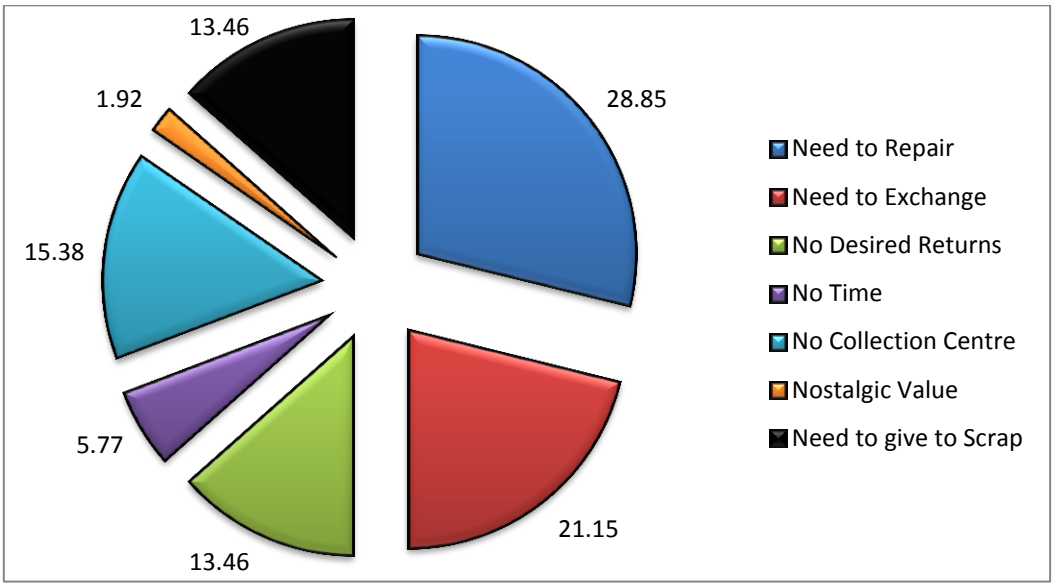


Figure 24: Reason for Storage of Non-Working EEE at Home
Source: Primary Data, 2017

Since 29 per cent respondents have been storing various non-working equipments at their house for three or more years, it shows that these end-of-life products have crossed over its active life and passive life and is currently stored preventing its inflow in to the ewaste stream, hence, not getting recycled as well. This is due to lack of apt system for collecting end-of-life EEE in the study area. Thus, if proper collection mechanism and awareness is created among the households, consumers will come forward to discard the EEE which they have stored in their house.

Details of Unused Working EEE Stored at Home

The primary survey conducted among 180 households in the study area reveals that 39 per cent respondents have stored their working electronic appliances at home without completely or occasionally using it. Table 8 shows the number of EEE being stored at home without using it or only occasionally using it.

EEE	Number of Working EEE Unused
Television	9
Refrigerator	1
Washing Machine	8
Air Conditioner	5
Computer	7
Mobile	3
Laptop	2
Mixer	5
Grinder	8

Radio	5
DVD Player	11
Oven	11
Induction Cooker	24
Iron Box	7
TOTAL	**106**

Table 8: Number of Unused EEE Stored at Home
Source: Primary Data, 2017

Duration of Major EEE being Kept Unused/Occasionally Used

The numbers of major electrical and electronic products which have been kept unused for varying duration or used occasionally are represented in Figure 25.

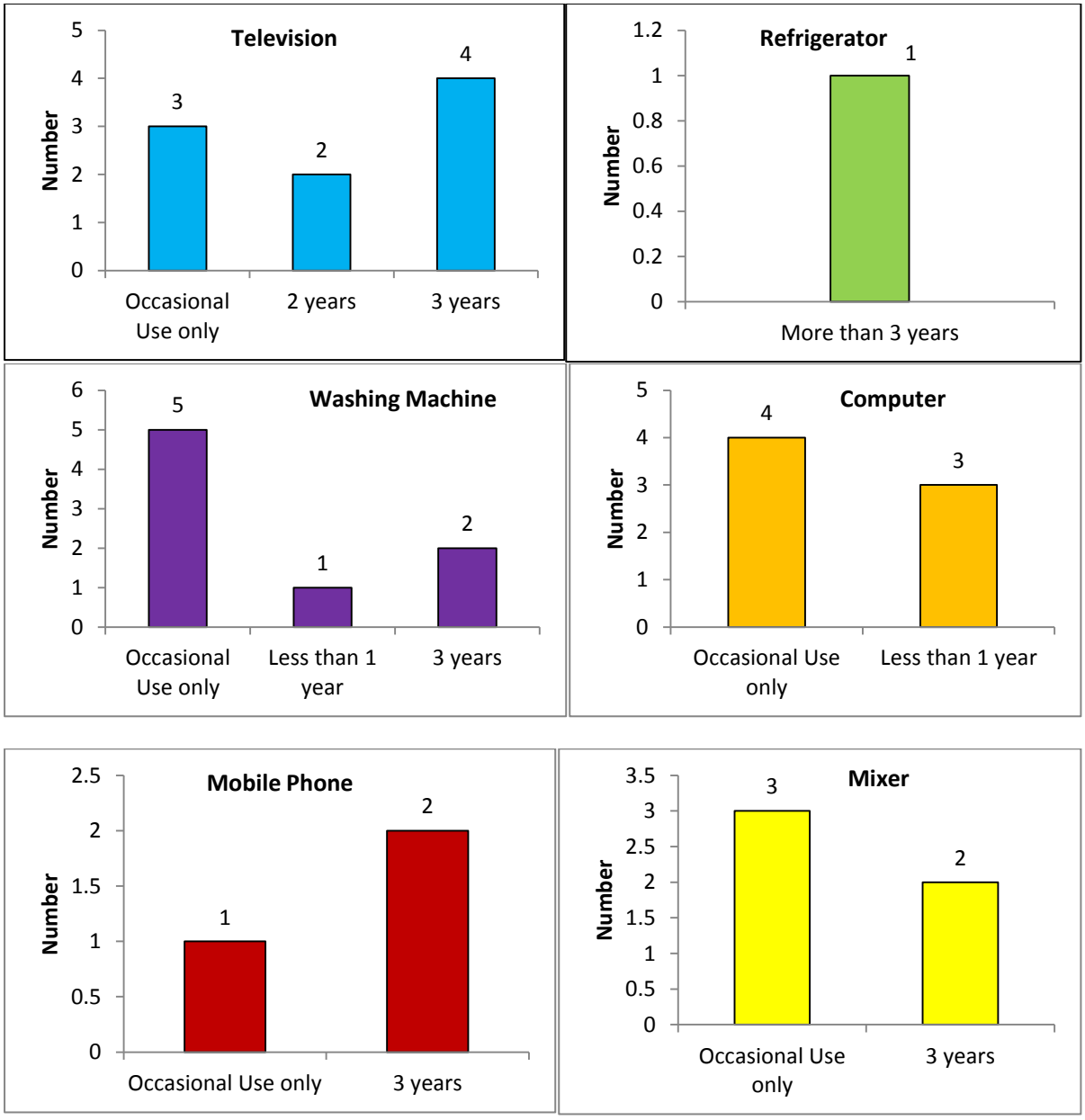


Figure 25: Duration of Storage of Unused EEE at Home
Source: Primary Data, 2017

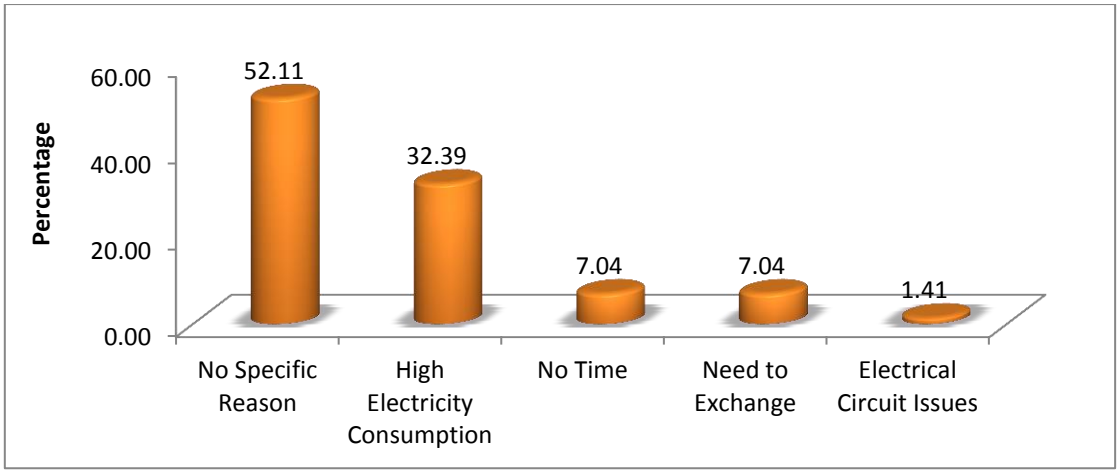


Figure 26: Reason for Non-Usage of EEE
Source: Primary Data, 2017

Majority of the respondents reported to have no specific reason for not using their working electronic gadgets while the second highest reason reported is high electricity consumption for non-usage of their working electronic products (Figure 26). When asked whether the products are currently in working condition or not, 96 per cent respondents stated that their unused products are still in working condition while only 1 respondent (1.41 per cent) stated that their unused product is currently not working. 3 per cent respondents do not know whether their unused EEE are currently working or not. The respondents owning air conditioners reported that they only use it during summer season and that too occasionally due to consumption of high electricity.

A Comparison of Non-Working and Working but Non-Used EEE Stored at Home (Individual Product Level)

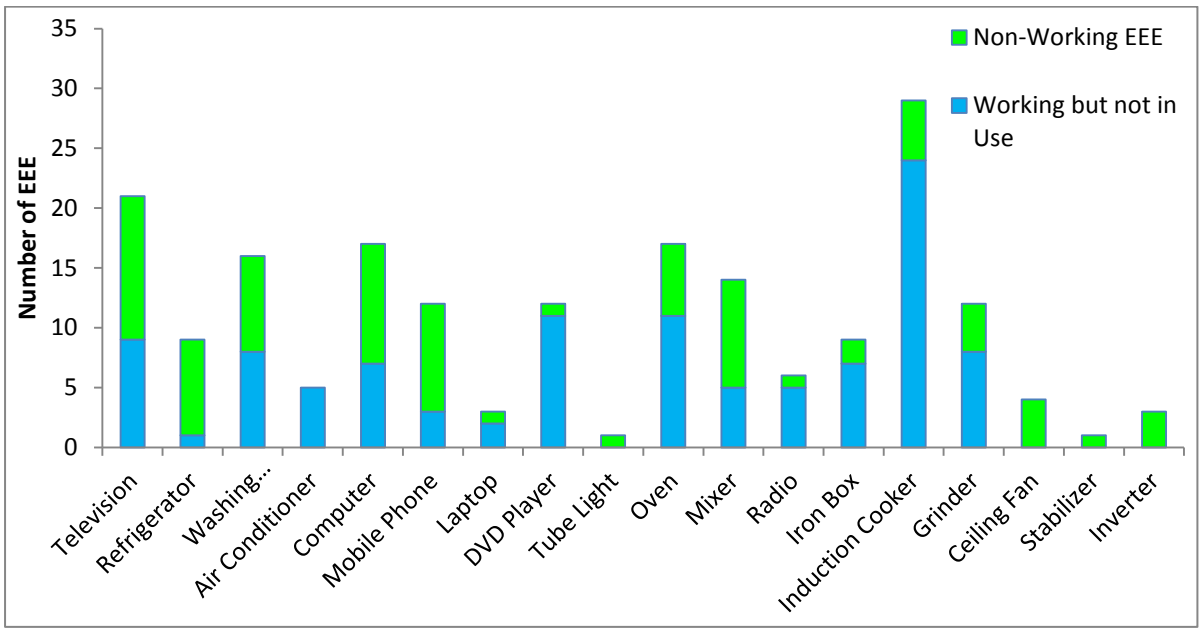


Figure 27: Storage of Non-Used but Working & Non-Working EEE
Source: Primary Data, 2017

The above figure (Figure 27) depicts the number of working EEE but unused and non-working EEE stored at house by the households in the study area. The lack of awareness on how to dispose the WEEE, lack of time and desired returns and to repair or exchange in future can be attributed to this behaviour among the households.

Owning Second-Hand Products and Purchase of New Products by the Respondents

It is known from the study that only 4.44 per cent, that is, only 8 respondents own second-hand products (Figure 28).

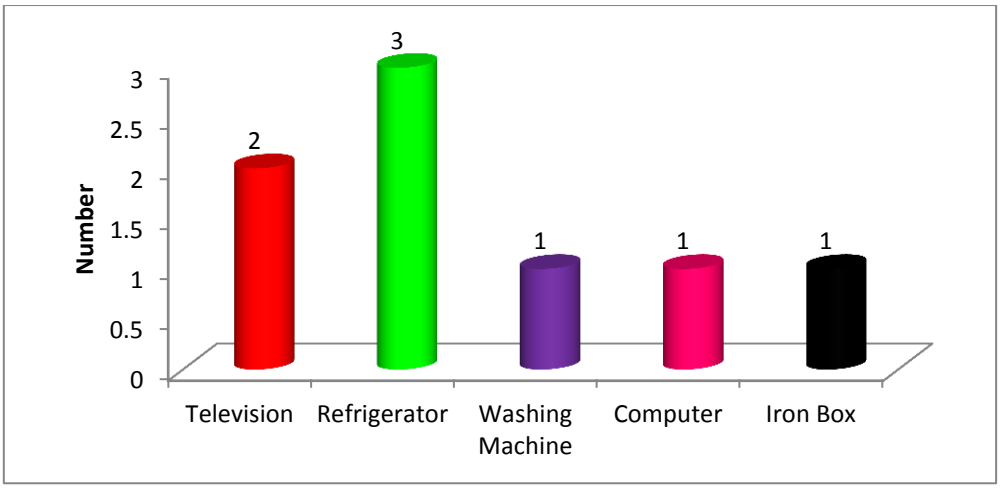


Figure 28: Owning Second-Hand EEE
Source: Primary Data, 2017

The study reveals that comparatively people prefer to purchase a new product rather a second-hand one as they stated that new EEE are available presently at affordable prices and that price of new equipment would only be slightly higher than that of a second-hand product. Also since there is the issue of asymmetric information in case of second-hand products, people openly disclosed their preference to purchase only new EEE if they are planning to purchase one.

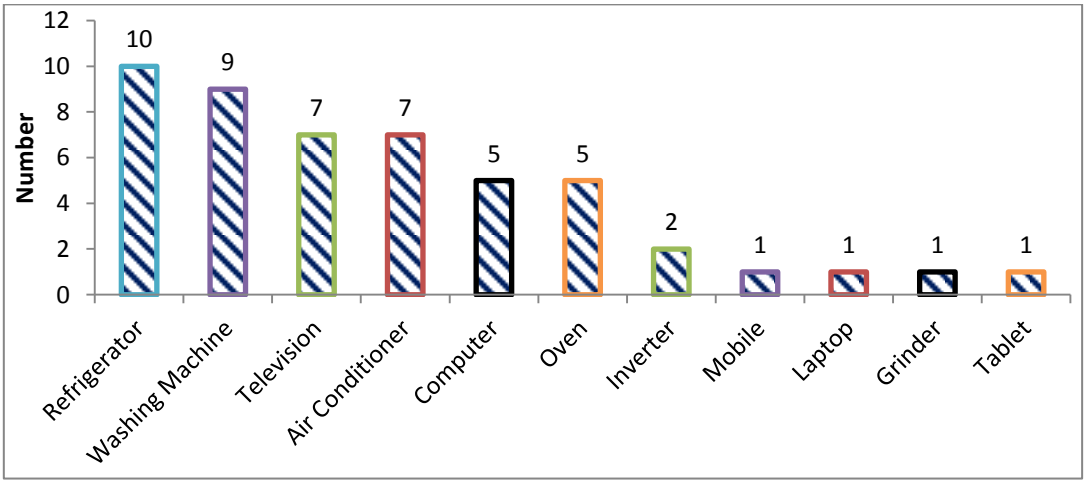


Figure 29: Plan to Purchase New EEE
Source: Primary Data, 2017

26.11 per cent respondents are planning to purchase new products which are represented in the above figure (Figure 29).

Respondents' Awareness on Ewaste Disposal and Management

From the study, it is found that 14.44 per cent of the respondents know about scrap-dealers who collect ewaste from the locality while only 0.56 per cent is aware of the registered ewaste collection centres present in the District. The respondents reported that they will choose to dispose their ewaste with the scrap dealers (23.89 per cent) as they get returns, even if a meagre amount, for the products while 51.67 per cent respondents will choose to only exchange their products (Figure 30).

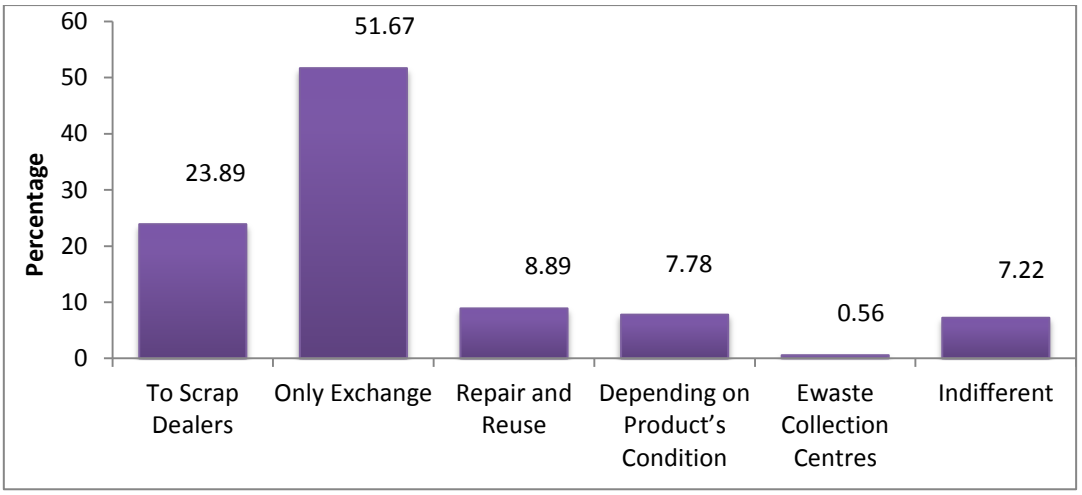


Figure 30: Current WEEE Disposal Methods
Source: Primary Data, 2017

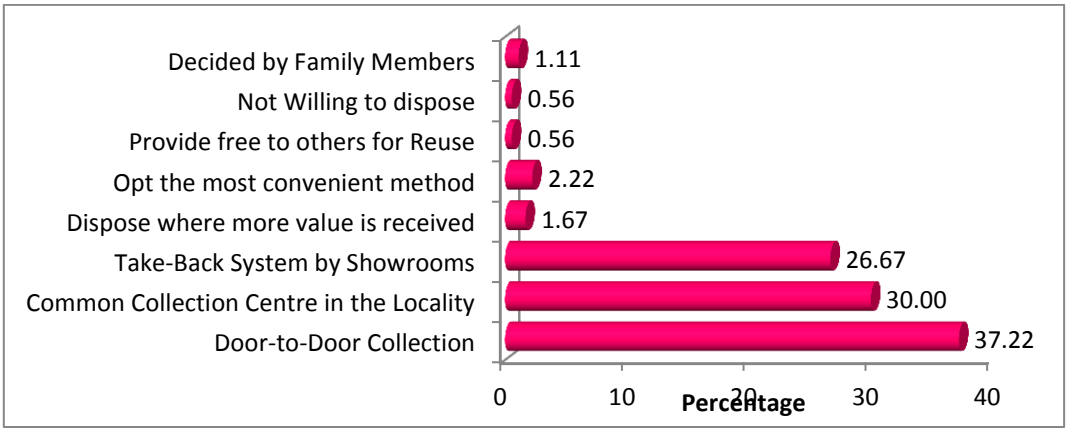


Figure 31: Preferred WEEE Disposal Methods
Source: Primary Data, 2017

When the respondents were asked about their preferred way to dispose ewaste, 37.22 per cent cited door-to-door collection as a convenient way to dispose ewaste, 30 per cent responded with the option of setting up a common collection centre in the locality and 26.67 per cent opted for take-back mechanism (Figure 31).

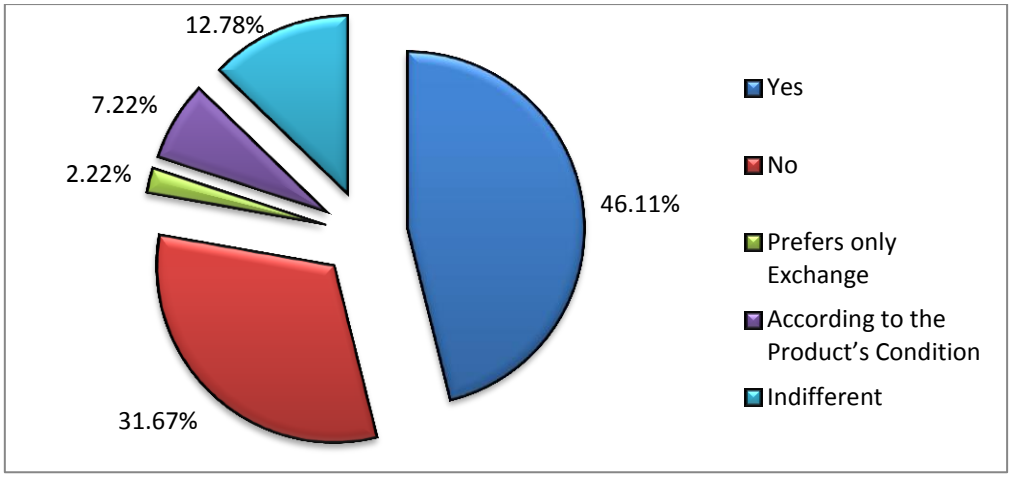


Figure 32: Expectation of Returns from WEEE Disposal
Source: Primary Data, 2017

It is also found that 46.11 per cent consumers expect return value for the product disposed. Hence, it can be understood that majority of the consumers are not willing to dispose their electronic products without receiving any returns (monetary gain or exchange), irrespective of the product being working or not (Figure 32).

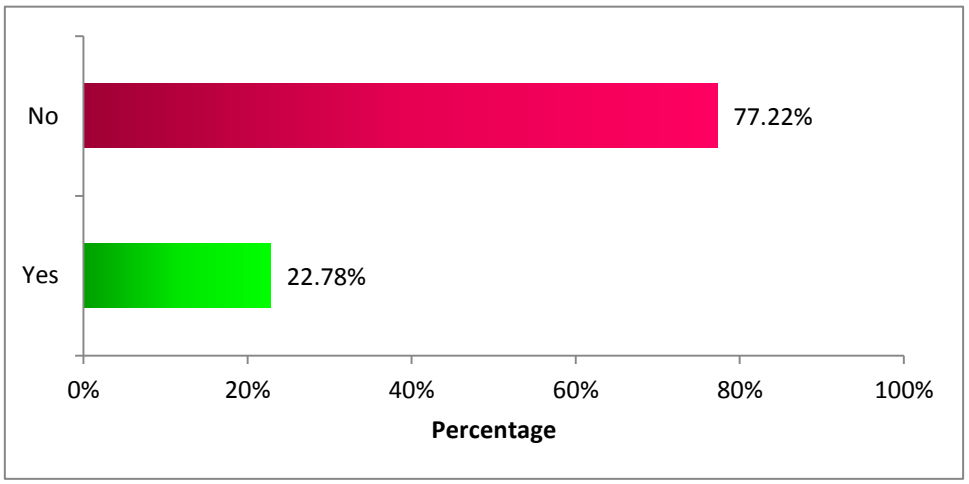


Figure 33: Awareness of Latest Ewaste Policy
Source: Primary Data, 2017

It is also found that majority of the respondents have no knowledge about the presence of harmful substances in the electronic parts (58.89 per cent) and have not even heard or read about the latest Ewaste Policy implemented by the Central Government (77.22 per cent) (Figure 33). 86 per cent respondents have no awareness regarding ewaste collection centres or scrap-dealers in the study area or nearby. Thus, it can be said that consumers' knowledge regarding Ewaste, its hazardous nature, collection centres and the latest Ewaste Rules implemented is minimal.

Chapter – 3: Summary, Recommendations and Conclusion

Waste Electrical and Electronic Equipments is growing rapidly due to large number of equipments being launched in the market on day-to-day basis; thanks to the advancement in technology. Taking the global and national perspective, we can see that huge quantities of ewaste end up in the waste stream every year and are not managed properly. Even the advanced nations find it difficult to properly dispose and recycle ewaste due to high labour cost because of which they illegally export it to developing nations where the labour costs are cheaper. In developing nations, informal sector dominates and handles the ewaste collected and is managed in a risky manner posing hazards to humans and environment. This situation can be clearly witnessed in India where hazardous methods are used by the informal workers to extract metals from ewaste components and the residues are incinerated (See also Baldé, 2015; Research Unit (LARDDIS), 2011; Lines, 2016).

Awareness among the population regarding WEEE and its consequences can create a significant impact on their attitude towards its management. People usually consider ewaste as harmless because unlike biodegradable waste, ewaste generated can be stored for longer duration as it is non-perishable. But the presence of heavy metals makes it harmful and the lack of information is making people to assume it as harmless. This supposition makes people to store their obsolete EEE at home or at office or wherever they get free space for long period of time.

To understand the above dilemmas in detail, analysis in a local area has been conducted with the objectives to examine the socio-economic background of the inhabitants of the area taken for the study, to forecast the WEEE that will be generated among the households in the coming years, quantify ewaste discarded in last three years and to evaluate the volume of operational and non-operational EEE stored by the households. For this purpose, Tripunithura Municipality, an urban centre in the Ernakulam district of Kerala has been chosen for the study. Four wards – Market, Mekkara, Palliparambukavu and Kannankulangara, have been selected randomly based on low, middle and high-income households respectively. From each ward, 10 per cent of the total households were selected randomly amounting to a total sample of 180 households. Structured schedule was used to interview the respondents. Unstructured schedule was used to interview the Municipality officials. Arithmetic Mean, Percentage, Tables, Figures and Charts have been used to analyze the data collected. The major findings from the study are pointed out below:

Socio-Economic Profile of the Respondents

- Average age of the respondents is 51.96 years.
- Of the total respondents interviewed, 26 per cent have basic schooling and another 26 per cent are graduates. Respondents with post-graduation constitute only 11 per cent.

- Majority of the respondents interviewed are housewives (48 per cent) as the earning members were not present at home at the time of interview. Respondents with government and private employment accounts to 6 per cent and 9 per cent respectively.
- 10 per cent respondents earn a monthly income below Rs. 10000 and only 7 per cent earn above Rs. 30000.
- 81 per cent respondents follow Hindu religion and 83 per cent have a nuclear family system.
- Average household size is 3.49 persons per household.
- 40 per cent households have three family members (excluding the respondent).
- 45 per cent households have one working member.
- Among the working family members, 21 per cent earns a monthly income ranging between Rs. 20000-Rs. 30000.
- 84 per cent households have their own house while 16 per cent live in rented house.
- 47 per cent of the households pay an electricity bill ranging between Rs. 1000-Rs. 2000 and only 2 per cent pays electricity bill above Rs. 5000.

Details of EEE, Ewaste Discarded and Working/Non-Working EEE in the Study Area

- Households of Palliparambukavu, the middle income ward, possess the highest number of consumer electronics such as Television, Refrigerator, Washing Machine, Air Conditioner and Mobile Phone.
- Based on in-use EEE in the study area, 36,927.1 kilograms of ewaste is estimated to be generated in the coming years.
- 68 per cent respondents reported to have repaired their EEE.
- 46 per cent households have disposed EEE in the last three years and the volume of WEEE discarded amounts to 3376.026 kilograms.
- Of the 46 per cent households, 51 per cent households have discarded working electronics and 49 per cent have discarded non-working ones.
- The reasons cited for disposal of working electronics are frequent repairing, to be in trend, high electricity consumption, lack of modern features and for no specific reason.
- 52 per cent have opted to exchange, 40 per cent gave to scrap dealers, 6 per cent gave for reuse to friends/relatives and 2 per cent have given their obsolete EEE for refurbishing.
- 67 per cent received returns below Rs. 500 by discarding WEEE with scrap dealers, 30 per cent received returns between Rs. 500-Rs. 1000 and 3 per cent received no returns at all.
- 95 per cent households replaced their disposed EEE with new ones while 5 per cent have not replaced yet.
- A total of 85 non-working EEEs have been stored by 29 per cent households at their home which amounts to 1877.868 kilograms of ewaste not entering the waste stream.

- The reasons reported for storing non-operational EEE at home are to repair, exchange, need to give to scrap dealers, lack of time, returns and collection centre and due to nostalgic value.
- A total of 106 operational EEEs have been stored at home by 39 per cent respondents which are used occasionally or not used at all.
- The reason for non-usage of working EEE stated are high electricity consumption, lack of time, electrical circuit problems, for exchange and for no specific reason.
- 4 per cent of the total respondents interviewed own second-hand EEE.
- 26 per cent households are planning to purchase a new appliance.
- Majority of the respondents preferred door-to-door collection, a common collection centre and take back system for disposing ewaste.
- 46 per cent respondents expect some returns for the product disposed, 7 per cent take into account product's condition to determine the returns while 13 per cent are indifferent towards returns.
- 86 per cent have no knowledge regarding the existence of authorized ewaste collection centres in the district.
- 41 per cent are aware of harmful substances in WEEE while 59 per cent have no knowledge about it.
- 23 per cent respondents have either heard or read about the ewaste policy while 77 per cent have no idea about the ewaste rules.

Thus, it can be concluded from the above study that various types of ewaste has been generated in last three years in the study area. People have stored equipments at home that have completed its lifespan. They have also working equipments which are not being used completely or used occasionally. Electronic products when kept unused for a longer duration become non-operational. The behaviour of the respondents in the study area with respect to non-usage of working products for a long period of time can stop the functioning of EEE. It will then either be refurbished or disposed, thus, entering the ewaste stream before reaching its lifespan, if disposed. The absence of proper collection mechanism is making the households in the study area to store their end-of-life EEE at home.

One of the respondents during the interview stated that they dispose small electronic equipments such as mobile chargers, adapters, earphones etc. along with the municipal solid waste. When asked whether the respondents were facing any health issue due to storage of ewaste in their house, no one reported to have any sort of health problems and a few of them were of the opinion that storage of ewaste has not caused any problems to them till now and will not cause any issues in future as well. This attitude of the respondents reflected that they were unaware of the harmful substances present in the EEE components. They were also surprised when the researcher mentioned about the presence of harmful as well as precious metals in the EEE.

Though there are 8 authorized ewaste collection centres in the district, 86 per cent of the respondents in the study area were unaware of the fact. Therefore, the first and the foremost requirement in the study area is consumer awareness regarding ewaste management followed by an appropriate collection mechanism for the ewaste being generated and channelizing it to the authorized centres present in the district. The Municipality can conduct an awareness programme to educate the households about electronic waste and its impacts by conducting workshops or classes through residents association in all the wards. The Municipality can also conduct ewaste collection drive once in every six months and the collected ewaste can be recorded and transported to the authorized centres in the district. The respondents interviewed had expressed their preference for a door-to-door collection, a common collection centre in the locality and take-back mechanism for ewaste disposal. Thus, if the Municipality conducts a collection drive on a regular basis, they will be successful in collecting a large volume of ewaste that will be currently piled up in numerous houses.

Since, majority of the households prefer exchange of their products or want to give to scrap dealers expecting some returns, the Municipality can make arrangements to provide some gifts in the form of cloth bags or plant saplings or can even conduct a lucky draw contest wherein the winner can get a small cash award as done by the Nokia Company in their ewaste collection drive in India (See also Tanskanen, 2012). However, a recent ewaste collection drive conducted by the Municipality gathered only 350 kilograms of WEEE. Lack of information, returns and transportation may be attributed as the reason for low turnout of WEEE. Waste is referred to something which has no use value. Thus, in the case of discarded/obsolete EEE, terming it as Ewaste should be avoided and rather calling it as E-Residue would acceptable as it can be reused and recycled and is definitely not a waste.

Hence, the following suggestions are put forward for ewaste management in the study area:

1. Consumer awareness by organizing discussions via residents associations and neighbourhood groups. Educating the ward councillors about WEEE and its consequences can ensure the spread of information among the households of the respective wards.
2. Proper collection mechanism – a collection drive, door-to-door collection and/or a common collection centre to be set up.
3. Collection of ewaste once in every six months from consumers.
4. Transportation of the collected ewaste to the nearby authorized collection centre in the district or associating with Suchitwa Mission so that the collected ewaste can be handed over to the Clean Kerala Company.
5. Returns to the consumers in the form of recycled products, seeds or saplings at the time of disposal.
6. Informal ewaste collection centres and the workers must mandatorily be empanelled and should focus on collection and segregation of ewaste collected.

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Annexes

Annexure I: Table Showing the Production of Consumer Electronics and Mobile Phones in India from 2003 - 2017

Year	Consumer Electronics Production	Mobile Phones
2003-04	15200	5350
2004-05	16800	4800
2005-06	18000	7000
2006-07	20000	9500
2007-08	22600	18700
2008-09	25550	26600
2009-10	29000	31000
2010-11	32000	35400
2011-12	34300	40500
2012-13	40447	34600
2013-14	47599	26650
2014-15	55806	18900
2015-16*	55765	54000
2016-17*	64752	94000

Source: Ministry of Electronics & Information Technology (MeitY), 2008-2017
***estimates**

Annexure II: Table showing the Sales of PCs, Desktops alone and Desktops owned by the Household Sector in India from 2002 - 2012

Year	Total PC Sales	Desktops Only	Desktops Owned by Consumers
2002-03	2344617	2293643	435792
2003-04	3124422	3035591	698186
2004-05	3809724	3632619	1017133.32
2005-06	5046558	4614724	1153681
2006-07	6341451	5490591	1406394
2007-08	7344306	5522167	2183752
2008-09	6796107	5279648	1783498
2009-10	8034556	5525992	2320988
2010-11	9314934	6030418	3014555
2011-12	10817709	6711911	3537159

Source: MAIT-IMRB, 2008 & MAIT-IMRB, 2012

Annexure – III: Ward Names, Population and Household Units in Tripunithura Municipality

Ward No.	Name of the Wards	Household Units	Ward-Wise Population
1	Attaprayil	500	1723
2	Puthankulangara	485	1654
3	Vadake Veimeedi	431	1535
4	Traco	468	1638
5	IOC	478	1673
6	Irumpanam	502	1744
7	Post Office	480	1644
8	Puliyannoor	489	1736
9	Elumana	447	1583
10	Iyirettil	502	1762
11	Ilamanathope	488	1674
12	Makaliyam	470	1645
13	Chithrapuzha	468	1638
14	Hillpalace	511	1789
15	Kyomtha	472	1652
16	Karingachira	520	1820
17	Chathari	498	1739
18	Njanamthuruthu	470	1680
19	Pallipparambukavu	479	1667
20	Railway Station	443	1713
21	Market	403	1525
22	Changamputha	473	1646
23	Thiruvankulam	443	1550
24	Thiruvankulam Temple	490	1715
25	Chakkuparambu	435	1533
26	Gandhipuram	446	1544
27	Mekkara	479	1528
28	Choorakad	527	1830
29	Puthiyakavu	584	2044
30	Pavamkulangara	549	1833

31	Valiyathara	468	1606
32	Ammankovil	522	1830
33	Vellakkinakkal	510	1801
34	Panackal	425	1509
35	Thoppil	448	1581
36	Kannankulangara	438	1552
37	Statue	473	1647
38	Ambalam Ward	485	1637
39	Chakkamkulangara	478	1663
40	Thamaramkulangara	505	1762
41	Thevarakkavu	453	1581
42	Pottayil	460	1594
43	Thondoor	452	1509
44	Pereekkad	484	1614
45	Nannappilly	451	1680
46	Pisharikovil	445	1548
47	Mathoor	469	1634
48	Illickapady	482	1654
49	Maramkulangara	507	1762
	TOTAL	**23,385**	**81,621**

Source: Tripunithura Municipality, 2010

Calculation

Market Ward = 403 HH (10 per cent = 40.3 = 40 HH)

Mekkara Ward = 479 HH (10 per cent = 47.9 = 48 HH)

Palliparambukavu Ward = 479 HH (10 per cent = 47.9 = 48 HH)

Kannankulangara Ward = 438 HH (10 per cent = 43.8 = 44 HH)

Total Sample Households = 180 HH

Annexure – IV: Percentage and Number of Urban Households possessing Major Consumer Durables in Tripunithura Municipality

Municipality	Total House-holds	Refrigerator		Mobile Phone only		Computer with Internet		Computer without Internet		Washing Machine		Air Conditioner	
	Number	Number	%	Number	%	Number	%	Number	%	Number	%	Number	%
Tripunithura	16,881	12821	75.95	9705	57.49	5029	29.79	1862	11.03	9108	53.95	2800	16.59

Source: Socio-Economic and Caste Census, Ministry of Rural Development, Government of India, 2011

Annexure V: District-Wise Percentage and Number of Urban Households possessing Major Consumer Durables in Kerala

State/District	Total House-holds	Refrigerator		Mobile Phone only		Computer/Laptop with Internet		Computer/Laptop without Internet		Washing Machine		Air Conditioner	
	Number	Number	%	Number	%	Number	%	Number	%	Number	%	Number	%
India	65133952	31484705	48.34	51911934	79.70	6233219	9.57	4145060	3.36	16050349	24.64	6285809	9.65
Kerala	1379341	876488	63.54	833500	60.43	206671	14.98	120446	8.73	431704	31.30	137755	9.99
Alappuzha	80187	47795	59.60	51965	64.80	8589	10.71	5074	6.33	18072	22.54	4308	5.37
Ernakulam	247201	186692	75.52	149201	60.36	57495	23.26	27606	11.17	126010	50.97	39166	15.84
Idukki	12058	8098	67.16	7346	60.92	1717	14.24	1402	11.63	4460	36.99	862	7.15
Kannur	78277	47998	61.32	41333	52.80	8839	11.29	7522	9.61	23033	29.42	9269	11.84
Kasaragod	33739	18399	54.53	18708	55.45	2821	8.36	2463	7.30	8753	25.94	3257	9.65
Kollam	112674	70311	62.40	72997	64.79	10801	9.59	6196	5.50	19509	17.31	6853	6.08
Kottayam	54247	39172	72.21	28710	52.92	9878	18.21	4484	8.27	20601	37.98	4796	8.84
Kozhikode	155609	94317	60.61	99135	63.71	18320	11.77	14034	9.02	45361	29.15	15314	9.84
Malappuram	86600	38151	44.05	60840	70.25	4560	5.27	8808	10.17	16444	18.99	4776	5.52
Palakkad	58765	30454	51.82	38165	64.95	7476	12.72	4232	7.20	15307	26.05	6254	10.64
Pathanamthitta	30572	21754	71.16	15755	51.33	4574	14.96	2127	6.96	8348	27.31	2284	7.47

Thiruvananthapuram	265540	171518	64.59	159456	60.05	46493	17.51	20280	7.64	67734	25.51	23481	8.84
Thrissur	156749	99294	63.35	85084	54.28	24443	15.59	15614	9.96	56495	36.04	17049	10.88
Wayanad	7123	2535	35.59	4805	67.46	665	9.34	604	8.48	1577	22.14	86	1.21

Source: Socio-Economic and Caste Census, Ministry of Rural Development, Government of India, 2011

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