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Review Paper

Electronic waste as an emerging waste stream in Nepal: Current status and future prospects of management

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Abstract

In Nepal, the term "Solid Waste" includes waste from any source such as household, industrial, chemical, medical, and electronic sectors. Electronic waste (e-waste) is regarded as one of the fastest-growing waste categories in Nepal due to the annual upsurge in the consumption of electronic appliances. Nepal generated 28 Metric Kilotons e-waste with an average of 900 grams per person. However, Nepal has not drafted a specific national policy for managing such waste. Informal sectors handlea substantial portion of e-waste using conventional methods. Those methods, however, are unsafe and usually lead to contamination of the environment that affects human health and vulnerable populations, including women and children. This paper provides an overview of the current e-waste management status in Nepal with some global exemplary insights, highlights the urgency for the formulation of national e-waste policies, and discusses the necessity for further research to ensure sustainable e-waste management.

Keywords: Contamination, E-waste, Nepal, Policy, Sustainability.

Introduction

Electrical and Electronic Equipment (EEEs) have become essential in our daily lives, from health care to communication to harnessing resources to obtaining and sharing knowledge[1]. Thus, our lives have been made more manageable and comfortable. Nonetheless, as the new EEEs are continually introduced into the marketplace, their short lifecycles, and high rates of obsolescence result in an upsurge in EEEs discarded by users as electronic waste (e-waste). E-waste comprises of electrical and/or electronic equipment and their parts which are discarded by the user without any intention for reuse[2]. E-waste is also considered as waste electrical and electronic equipment (WEEE) or electronic scrap in several regions[3]. The 54 categories of EEE products are divided into six groups corresponding to their management characteristics[4] (Figure-1).

E-waste is among rapidly-growing waste streams, so it is becoming crucial in quantity and toxicity[5]. Several factors contribute to the generation of e-waste. Some of these include human population, living standard, spatiotemporal conditions, and socioeconomic status. Globally in 2019, 53.6 Mt e-waste was generated, tantamount to 7.3kg per person. The upsurge in such waste is primarilydue to the increasing rates of EEEs consumption, shorter life cycles, and only a fewer options for repairing.

The maximum quantity of e-waste was recorded in Asia in 2019 at 24.9 Mt, followed by America, Africa, Europe and Oceania at 13.1 Mt, 2.9 Mt, 12 Mt, and 0.7 Mt, respectively. The global e-waste generation from 2014 to 2030 is depicted in the Figure-2, which is estimated to peak at 74.7 Mt by 2030 reflecting the doubling time of only 16 years[4].

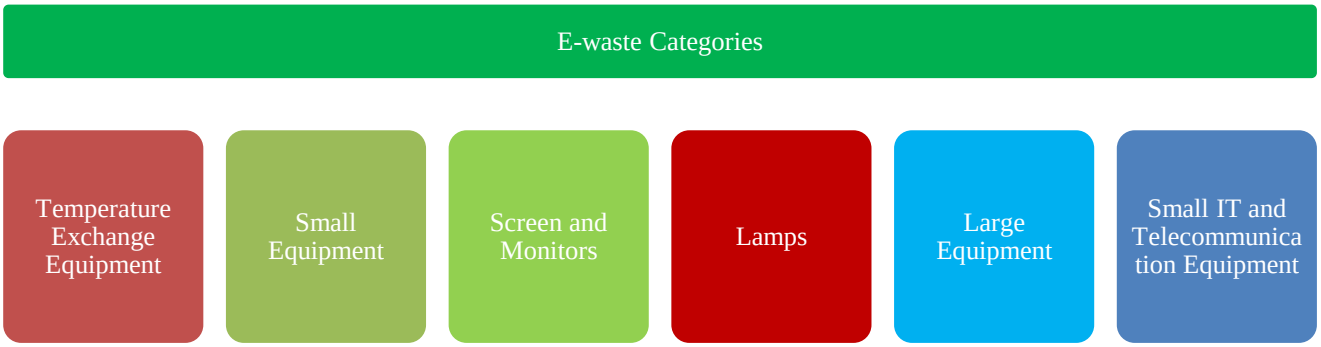

Figure-1: Six general categories of e-waste.

E-waste composition is strongly influenced by the types of electronic devices, model, manufacturer, manufacturing companies, date, and scarp age[6]. Materials found in WEEE can be categorized into five categories[3,7-9]: iron-containing metals, non-ferrous metals, glass, plastic and other materials. The study led by EMPA[10] reported that metals contributed to 60.2%, followed by plastics (15.2%), Metal-plastic mixture(5%), Printed Circuit Boards (1.7%), pollutants (2.7%), cables (2%), Screen (11.9%), and others (1.4%) as shown in Figure-3. The composition of e-waste is complex, which includes a wide variety of metals from hazardous (Cd, Hg, As, Cr (VI), Sb) to valuable metals (Ag, Au, and Pt) and halogens to flammable substances[11]. The presence of harmful constituents has increased the complexity of waste treatment and recovery of valuable materials[12]. Globally, 53.6 Mt of e-waste was quantifiedin 2019, but only 17% was recorded as being collected for recycling. A major fraction of the other 83% is either illegally traded or disposed of in landfills[4].

In developing nations, e-waste is managed by informal sectors, where it is treated using primitive methods (open burning, incineration, acid bath) and the residues are disposed of carelessly. So, toxic substances including heavy metals, dioxins, and furans[13] from e-waste move into the ecosystem to from various sources, including water, air, and soil[14]. Additionally, thousands of workers of diverse ages working in these fields are exposed either through inhalation, dust ingestion, exfoliation, or ingestion of nutritional supplements[15]. For instance, the cadmium used in mobile phone battery can contaminate the 600 m^3 of water[16]. The cathode ray tubes (CRTs) used in TVs, video and monitors of personal computers contain substantial quantities of lead. Chronic exposure to such substances can affect the nervous system, bones and kidney, as well as the endocrine and reproductive systems[17]. An illustration depicting e-waste cycle and potential environmental and human health impact is elucidated by Figure-4.

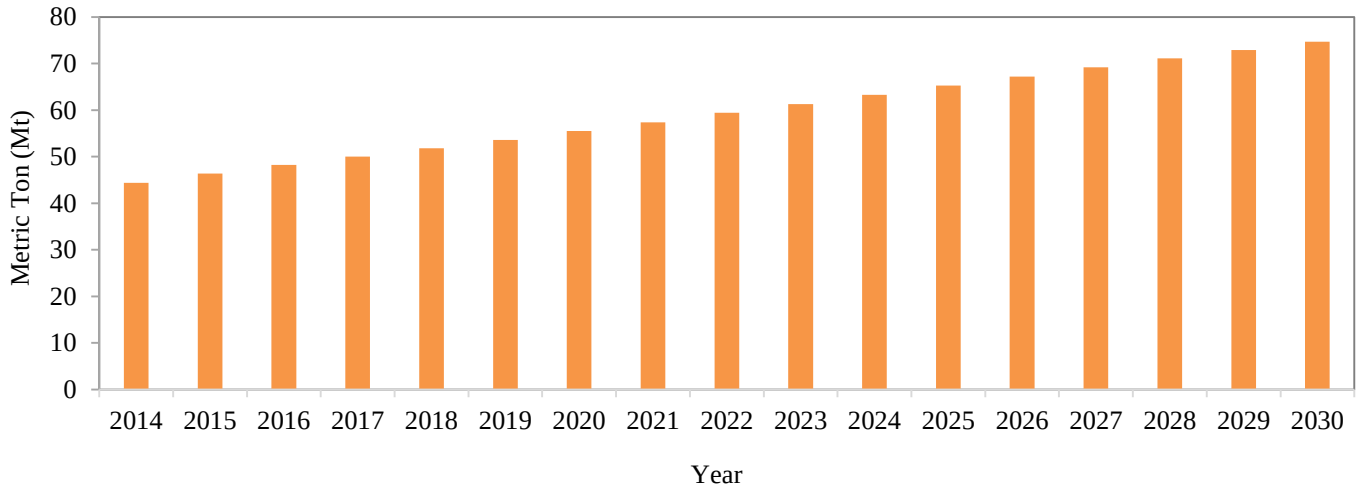

Figure-2: E-waste in Mt between 2014 and 2030 [4].

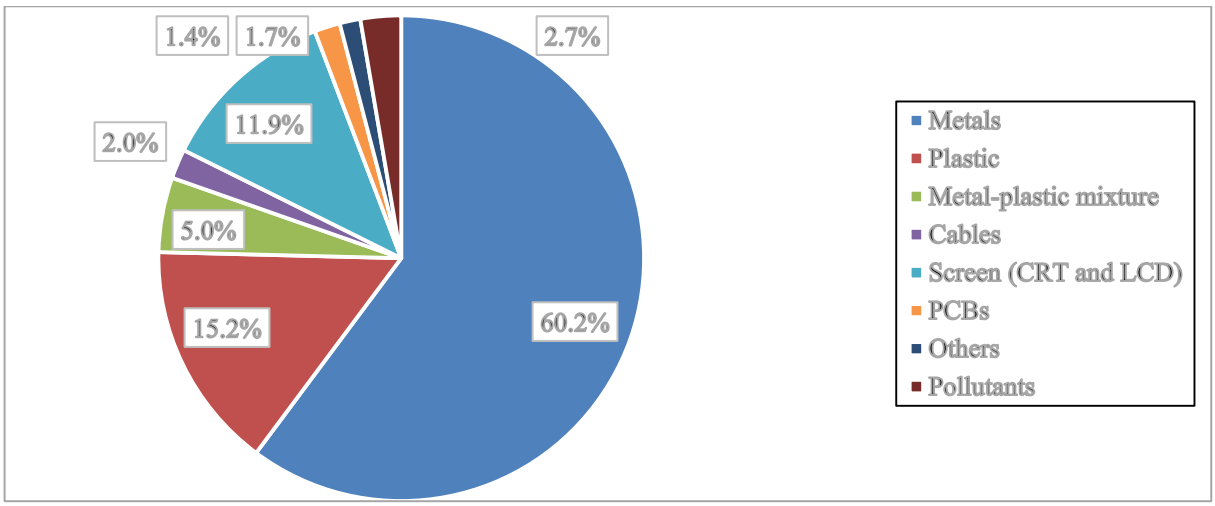

Figure-3: Material composition of e-waste.

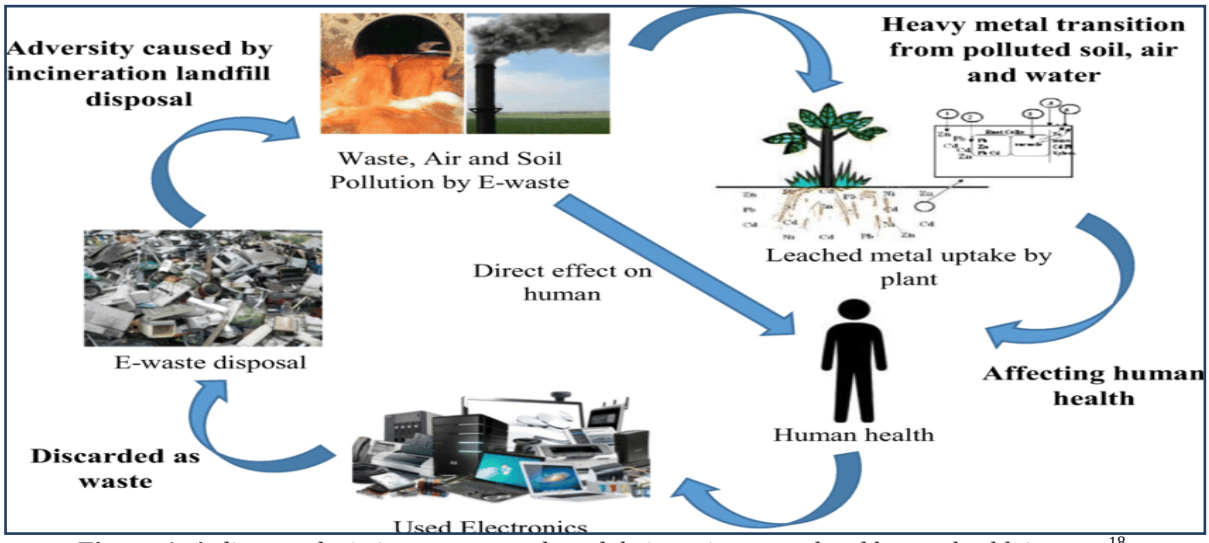

Figure-4: A diagram depicting e-waste cycle and their environmental and human health impacts[18].

Global Perspectives on E-waste Management

As the countries have become more industrial and developed, generation of hazardous waste upsurges significantly. A vehement public stance against poorly managed hazardous waste, including e-waste in developed countries prior to 1990s "Not in My Back Yard" syndrome motivated e-waste to be shipped from developed to developing nations[19]. The waste generated in the countries of origin are not processed or recycled instead moved to the countries of Asia and Africa where environmental standards and laws are less strict and/ or poorly enforced[20]. In the 1970s, developed countries started enacting more stringent laws, such as the "Resource Conservation and Recovery Act" (RCRA) which dramatically rose the hazardous waste disposal cost[19]. So it became more economical to transport to other regions or beyond the boundary than treat them properly in the place of origin[21]. Trans boundary movement of hazardous waste led to severe contaminations in the environment, especially in the regions where conventional recycling and disposal methods were practiced. The effects were further exacerbated by the level of awareness towards environmental protection, controls and regulations[19]. In the meantime, incidents like the Khian Sea disposal in 1986 on the beach in Haiti and the Koko case in 1988 in Nigeria have sparked global concern about the cross-border's movement of hazardous waste.

In response to illegal shipping and disposal of waste characterized by hazardous nature in developing countries, the Basel Convention addressing the trans boundary movement and final disposal of hazardous wastes was enacted in 1992. Along with this, other international conventions, and protocol such as Montreal Protocol, the Stockholm Convention and the Rotterdam Convention came into force. These international regulations have paved the foundation to instrument regional policies and directives to implement measures for protecting both the environment and human health through avoiding or mitigating the possible impacts of e-waste generation. A brief outline of e-waste management policy and practices around the world is presented in Table-1. Even with the implementation of several international regulations and directives, managing e-waste effectively globally remains a great challenge[22].

E-Waste in Nepal

In developing countries, management of e-waste poses a much greater challenge due to lack of proper infrastructure, weak enforcement of laws and a low level of awareness among citizens[3]. In recent years, the rising purchasing power, increasing market penetration of electronic devices, a speedy replacement markets and high rate of EEE obsolescence have made e-waste swiftly expanding waste streams in Nepal. In Nepal, most e-products are imported from original equipment manufacturers of India, China and Europe and sold to end-users through distributors and retailers. As shown in the Figure-5, mobile, desktop, laptops, refrigerators and washing machine account for the majority of EEEs in Nepal. Among the different sources of e-waste, the information and communication technology (ICT) sectors, including telecommunication and household appliances, account for most of the e-waste generation. E-waste includes discarded computers, monitors, televisions, copiers, fax machines, telecommunication instruments, cell phones, and home appliances[23]. During power outages that lasted for almost a decade, Nepal accumulated an approximately 25,000 tons of used-up battery, of which 10,000 were from inverters and 8,000 from solar systems[24]. So, the discarded batteries from solar systems and inverters, mainly containing lead and lithium, account for a major portion of such waste in Nepal. Like other developing countries (Nigeria, Ghana, India, China etc.) Nepal does not import End of Life (EoL) and second-hand electronic products. But in insignificant quantities, Nepal receives second-hand computers and ICT products from donor countries intermittently[25].

Furthermore, the covid-19 pandemic has drastically altered our daily routine. So, during the pandemic, more electronic appliances and gadgets were imported applicable in hospitals, educational institutions, and offices. In fiscal year (F/Y) 2020/2021, Nepal imported 7.03 million sets of mobile phones during the first 11 months of the fiscal year, as against 4.3 million sets for the same period of last fiscal year[26]. Additionally, more than 3 million Nepalese are working abroad as migrant workers and there is no official record for the electronic items they purchase for personal use[25].

Table-1: E-waste management policies, convention and directives around the world.

Convention/Policy/Directive	Practice	Country/Continent
Basel Convention	Control of Tran boundary Movements of Hazardous Wastes and their Disposal.	178 nations of the world
Bamako Convention	Prohibit the import of all hazardous and radioactive wastes and improper management practices.	African Union
EU's WEE Directive	Incorporates all types of electrical goods dividing to 10 categories, with targets set for collection, recovery, and recycling. Free tack back of used products and establishment of collection points.	European Union all members
Restriction of hazardous substances (RoHS)	Limit the use of six specific contaminants: cadmium, hexavalent chromium, lead, mercury, and flame retardants (polybrominated biphenyls and polybrominated diphenyl ethers during the products design.	European Union all members
The 3Rs – Reduce, Reuse and Recycle	Reduce, Reuse and Recycle to prevent the creation of waste.	Japan and for international stage
StEP (Solving the E-waste Problem)	Conduct research and discussion with stakeholders from diverse background to address the e-waste issues through policy, redesign, reuse, recycling, and capacity building.	Around the world
Extended Responsibilities for the Producers (EPR)	Manufacturers and exporters are liable for the sound handling, recycling, and disposal of e-waste.	Switzerland, India, China
Legal to export e-waste for recycling and prefer recycling	50-80% export and rest are land filled or incinerated.	United States of America (USA)
Laws for the Promotion of Effective Utilization of Resources (LPUR) and recycling of specified kinds of home appliances (LRHA)	Consumers are required to work together with retailers to ensure the collection of their WEEE. Consumer are required to pay recycling, transportation fee.	Japan

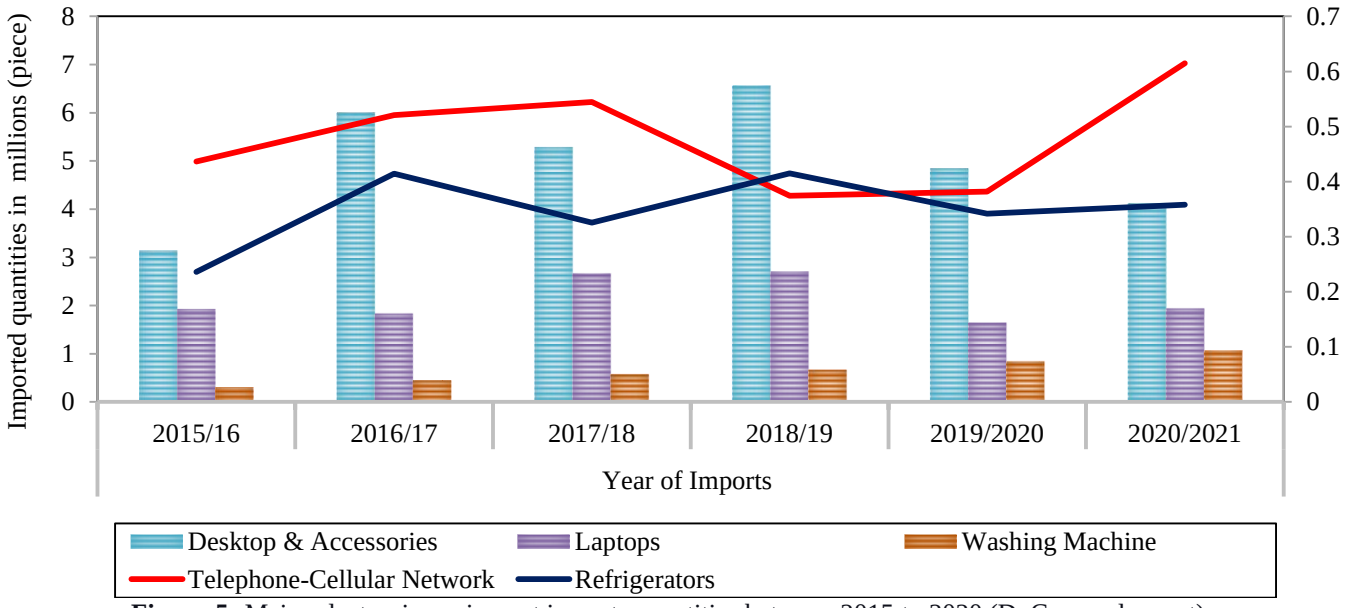

Figure-5: Major electronic equipment imports quantities between 2015 to 2020 (DoC annual report).

In Nepal, as e-waste is a major part of the current waste management chain, and the imported electronic appliances and gadgets that will become obsolete and end up as e-waste could have adverse effects on human health and environment.

E-Waste Management in Nepal

Nepal does not have a long history of solid waste management (SWM) practices. SWM has always remained one of the challenging environmental problems to date, especially in the urban areas[27]. The initiation of collection, segregation at the transfer station, transportation and final disposal in the landfill began in the 1980s after establishing a solid waste management technical support center with the assistance of GTZ[28]. With the upsurge of e-waste generation, few years back various studies have pointed out the establishment of separate e-waste management system. However, there are not any officially authorized systems yet for distinct collection and treatment services for e-waste stream in Nepal. Based on literature review and on the existing current practices, major steps and stakeholders involved in e-waste management are shown in Figure-6.

Generally, when a product ceases to perform, users throw it away or bring it to a refurbishing center. It is still common for EEEs to be repaired and reused which contributes to the increased life spans of EES. At the same time, the repair shop has become the primary repository of obsolete products or components brought in by users[25]. The end of life (EoL) products discarded from users and repairs center follow their route to informal sectors. The informal sectors adopt unscientific and simple procedures of resource recovery referred to as backyard or informal recycling.

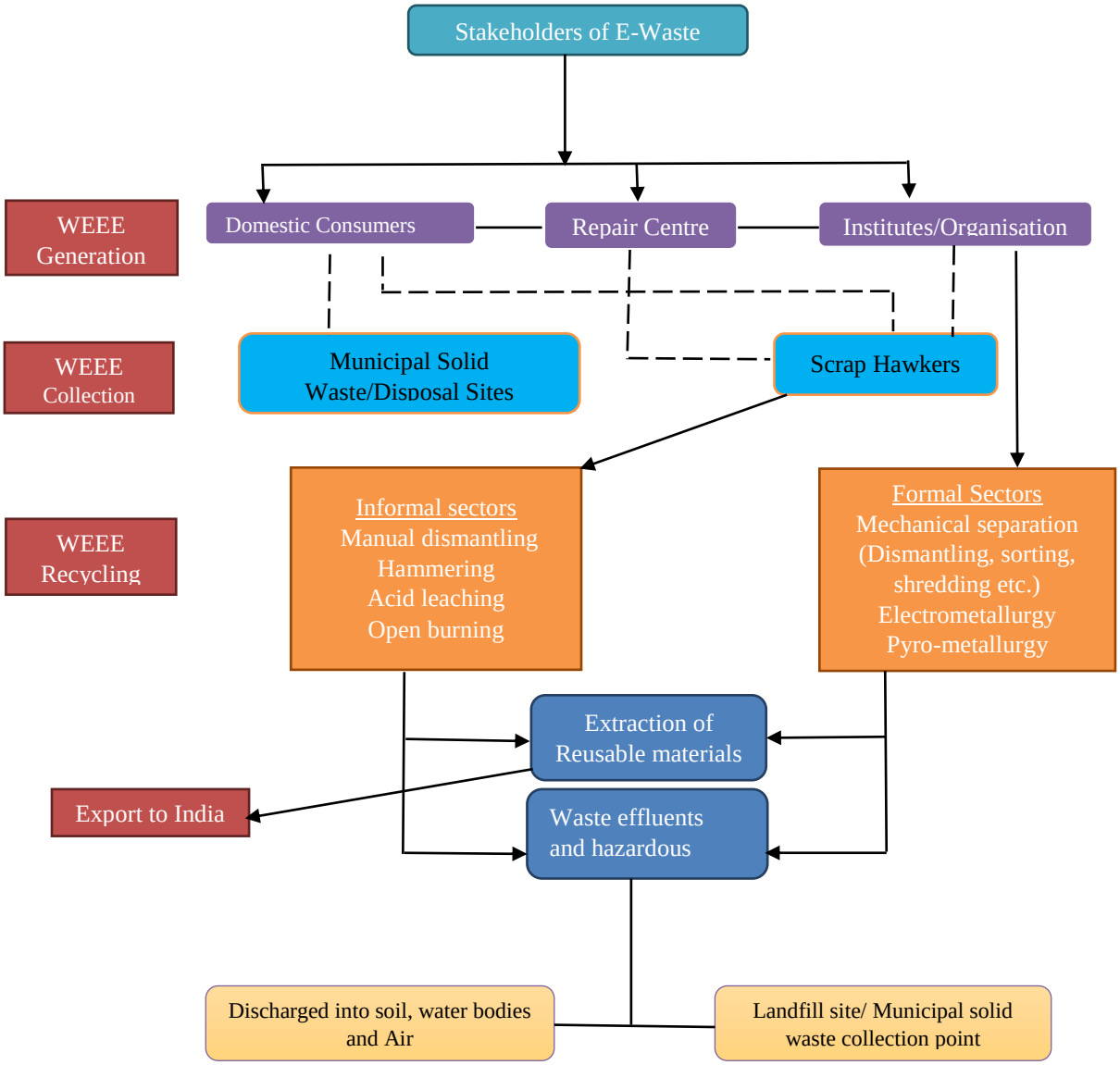

Figure-6: Schematic representation of e-waste management in Nepal.

The management activities include collection, transportation, segregation, dismantling manually by unskilled people in an inappropriate method[29]. The key activities linked with informal sectors are collection and processing. The local rag pickers carry out the collection from house to house, offices, and business centers. E-waste scarps are traded in backyard and slums to those who wish to recover valuable metals. The wastes left over after the recovery of useable materials are disposed of in municipal waste collection centers as well as remained in the waste backyard. The rag pickers play an significant role in mitigating the environmental effects of e-waste[30]. Despite this, an estimated 75% of electronic goods are held at home due to the uncertainty of their managing. E-waste is widely viewed as commodity, causing reluctance to immediate disposal. The electronic wastes are stored in houses, warehouses, offices, etc., which can easily get mixed with household wastes that end up in landfills[31].

Future Strategies for E-waste Management in Nepal

Nepal is a signatory to multilateral environmental conventions and protocols such as the Basel Convention, Stockholm Convention, Rotterdam Convention, Montreal Protocol etc. Still, it is inadequate in the prospect of e-waste management as there are no separate defined framework and collection facilities. On the contrary, various legislative frameworks and management practices have been implemented in the European Union and developed countries such as Switzerland, Japan, Australia, Korea, the United States of America, Canada etc., decades ago. These countries' diverse e-waste management methods could be the basis for setting up national e-waste policies in Nepal. E-waste generation in each country is contextualized by the type of waste it generates. Nepal needs to design a framework that accounts for the types of imported EEEs and their replacement rate. The concept of extended producer responsibility (EPR) has been implemented in many developed for decades. EPR is an environmental policy approach in which a producer's responsibility for a product's life cycle plays a pivotal role[32]. In practice, EPR requires the producer to assure that end-of-life products are collected and sorted. In Nepal, EEEs are imported from the original equipmnt manufacturer from other countries and reach to end-user through local traders and distributors. When a product stop functioning, it is either disposed of in Municipal Solid Waste (MSW) or sold to the scrap collectors. In this context, it would be appropriate to apply the take-back system policy of EPR principle that requires producers to set up formal recycling and safe disposal centers of their products.

Similarly, the management of e-waste depends not only on implementing stringent legislation and the installation of collection centers but also on customer behavior and awareness. In collaboration with distributors, private sectors, media, non-Governmental organizations (NGOs) and manufacturers; government stakeholders need to conduct awareness program and activities for sustainable e-waste management and encourage people to buy the products on a need base. In addition, the informal sectors handle a substantial portion of e-waste generated in Nepal, where different age groups workers are actively involved in extracting valuable resources. Handling, dismantling, and processing e-waste typically occurs on an ad-hoc basis without adequate training and knowledge of occupational health and safety. It is imperative to recognize their contributions and bring them under government jurisdiction to establish them as formal sectors through proper training and information on handling, disposing, and recycling numerous kinds of hazardous materials contained in e-waste.

Perspective on Further E-Waste Research in Nepal

Over the past five years, Nepal has experienced exponential growth in importing EEEs, especially mobile, laptops, desktop and home appliances. The e-waste generation rate has increased steadily and appeared as one of the most important waste forms. In 2019, 28 Metric Kilotons of e-waste was produced in Nepal, with an average of 900 grams per person[4]. Despite the urgent need for e-waste legislation at the national level, it has not yet been on the radar of the government of Nepal (GoN). The hazards and risks e-waste poses to the well-being of humans and the harmful effects it can have on the environmental balance has become a subject of public and academic concern around the world. Thus, as of October 2019, 78 countries have adopted or are implementing national e-waste policies, legislation, and regulation[4].

Furthermore, the number of studies conducted worldwide demonstrates the future potential for research. Studies on e-waste are distributed among generation, composition, resource recovery and improvement of the legal framework, management and its effect on the environment and human health[7,15,20,29,33-36]. On the contrary, there have been few countable studies on different e-waste dimensions in Nepal. There are many potential subjects and area that are uncovered for research that needs to be considered. The major research areas identified are a) hazards of e-waste b) types and composition of e-waste, c) e-waste generation and management practices, d) inventory on flow of EEEs in Nepal e) e-waste policy and framework, f) economic analysis on e-waste recovery and g) international practices and directives. The review of published reports and research papers on e-waste[23,25,37-40] reinforce the need for a comprehensive policy and regulatory framework on e-waste management, a sustainable system for managing e-waste supporting the informal sector, providing well-defined role descriptions for stakeholders, and institutional mechanisms for resource-oriented waste management systems.

Conclusion

Scientific management of solid waste has been a daunting task in Nepal, but in recent years with the proliferation of e-waste, it has become even more difficult. E-waste makes up almost 0.5%

of the total municipal wastes in Kathmandu alone, the central capital city of the country, close to the global average. It contains hazardous constituents that have irreversible effects on the environment and human health. Many countries have shown their concerns for the management of e-waste and enacted national policies, legislations, and/or regulations regarding such waste and the number of such countries has increased from 61 to 78 since 2014. However, knowing the pressing need to have regulatory mechanisms, concerned authority in Nepal has not shown urgency to formulate national e-waste guidelines and policies. E-waste management closely relates to Sustainable Development Goal 11: Sustainable Cities and Communities and 12-Responsible Consumption and Production. Nepal is also a member state of the 2030 Agenda for Sustainable Development Goals, however, increasing amounts of electronic waste compounded by an improper treatment and unscientific disposal to the landfills would threat the living environment, public health, and ultimately hinder target achievement. Given the complexities of e-waste streams, a regulatory framework must be instituted as quickly as feasible to cope with e-waste issues, both on importation and on proper management. As opposed to the conventional linear economy, which has a take, make, and dispose model of production, the circular economy/regenerative movement has been gaining popularity in recent years, and the government of Nepal should explore it as well. Therefore, e-waste collection, exchange, and recycling stations should be established in partnership with private sectors and manufacturers to reduce waste, carbon emissions, and resource consumption.

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