Reverse Logistics Activities for Household E-Waste Management: A Review

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***Abstract*— Recently, with the advancement of technologies in all fields of life, the competition has increased among manufacturing companies and industries. Reverse logistics is one of the significant and well-known activities to improve the business processes from the point of origin to destination. Reverse logistics activities have implemented in different business operations in which one of the significant areas is household e-waste management. With the passage of time, different types of household products have been piling up and cause for environment and waste issues. To tackle this mounting waste issues, reverse logistics activities are promoting product recovery and strategies for e-waste management. This review points out the fundamental of reverse logistics and looks into the existing activities for e-waste management. The main objective of this paper is to highlight the recent growing concern to controlling rising global pollution by household waste. Through this literature review, this paper concludes the gap and recent activities in the field of household e-waste. This paper offers deeper understanding of various benefits and issues with regards to household e-waste.**

***Keywords*—** *Reverse logistics, e-waste management, environment, pollution, review paper*

1. Introduction

Reverse logistics is one of the significant and effective flow products and it's all processes from point of origin to the point of consumption. Different types of processes have been applied for reverse logistics such as planning, controlling and implementing.

Reverse logistics is well known and one of the broad domain and has advance features. Reverse logistics also used in solid waste management and recycling the products. In supply chain management, revers logistics has gained a prominent role due to its professional and significant key competence [12], [14], [16]. According to [31], reverse logistics are used to handle the products, materials, transportation, distribution, storing, moving and controlling the materials. Due to advance processes, company sustain in market by their conversion processes. Companies can manage their waste processes with conversion methods and enhance their economic growth and development.

2. Reverse Logistics Benefits

In e-waste management, the concept of reverse logistics has implemented and drastically changed traditional methods into new and advance operation. The benefits of reverse logistics have multiple benefits if all the processes manage properly and adopt advance tackling methods. Recently, all stakeholders involved in reverse logistics and they realize its importance through theoretical information due to its supply chain management steps and its innovative services to achieve the companies' targets. The effective and well-established reverse logistics operations have positive impact on organisation growth such as for its internal cost, inventory management, expanding its revenue, environmental cost reduction, competitive advantages, customer satisfaction and all its services [3], [5].

Cost reduction is one of the significant benefit which minimizes the company risks and increases the revenue [6]. The effective reverse logistics

practices significantly enhance the organisation profit and if these processes are not well defined it may cause of loss in organisations. If tangible or intangible resources are targeted the effective reverse logistics practices, this can have a positive impact on organisation sustainability and growth. According to one study based on USA in 2010, more than 160 organisations survey, it is observed that 87% organisations have strong believe on reverse supply chain management and its effective practices [25]. Best reverse logistics practices have reduced the inventory carrying costs, waste disposal costs and transportation costs. In addition, the best practices also reduce costs of product before product purchasing.

Another main benefit of reverse logistics is waste and environmental management due to its processes such as refurbishment, remanufacturing, reuse, recycling and asset recovery. By practicing the reverse logistics operations, the organisations will be more environmental friendly and reach a certain level of green processes. In addition, the concern of environment is recognized as one of the main facts which forces the companies to make their processes according to environmental friendly parameters such as marketing, remanufacturing processes, refurbishing and overstock processes. Reverse logistics can help the organisations and companies to be more ecologically friendly and cost effective by extending the traditional product life cycle. In addition, the good practices of reverse logistics can decrease the cost by reusing the products, materials and components instead of disposing or landfill which has negative effect on environment [7].

Customer satisfaction is another significant benefit of reverse logistics which can provide the opportunities to organisation for better marketing practices. Marketing and packaging decisions making also supported in reverse logistics practices and increase the customer satisfaction. High quality reverse logistics promote and build long term relationship between organisation and customer and motivate for repurchasing the products. Reverse logistics is a vital tool for supporting the brand initiative and marketing strategies. With advance reverse logistics practices, organisations compete the market by increasing their product demands and capture larger market [15]. It is clear that reverse logistics have various advantages for organisations and industries. Recently, reverse logistics also involved in other services including household waste management, e-waste management.

This paper reviews the most recent reverse logistics approaches for household e-waste management, their benefits and current challenges. This review helps the new researchers to explore the revers logistics filed for household e-waste management.

The rest of the paper is organised as follows: Section 3 presents the methodology of the paper followed by the household management concept in Section 4. Section 5 discusses the most recent studies in the field. Section 6 illustrates the challenges and solutions to adopt the reverse logistics activities in household e-waste management. Section 7 concludes the paper with future direction and suggested research.

3. Research Methodology

The search for related publications available was mainly conducted through major online databases such as provided by Emerald, Elsevier, ProQuest, Springer and Wiley. Google Scholar was also used as a tool to help finds related articles. Keywords such as reverse logistics, electronic waste (e-waste), household electronic waste (e-waste) and recycling. A total number of 80 articles ranging from year 2005 – 2019 were reviewed.

4. Household E-waste Management

Electronic waste refers to obsolete or unwanted all components including electronics, electrical by a user [20]. This field is also known as waste of electronic equipment or end-of-life electronics. However, this e-waste is misleading due to its characterization categorically as waste. In the waste material, some items will be reusable and available through secondary markets. With advancement of new technologies, we observed the rapid growth of electronic devices worldwide such as mobile phones and computers. However, with the increment of this growth' the e-waste and its management has not corresponded to growth in processes in terms of equipment recycling, collection and reuse. According to USA. EPA in 2007, 9% of electronics sold between 1980 to 2004 in USA and still 180 million units are still waiting for disposal activities [29]. In order to address the challenge of e-waste management, reusability and recycling' different types of approaches have been designed. Figure 1 shows the e-waste types.

Figure 1. E-waste Types

There are many reasons behind the growth of waste during past decade such as increasing demand of appliances and devices and more attractive feature of hi-tech products. New smart cell phones are another cause of e-waste due to its easy availability and usage. Electronics devices have lowest consumer recycling rates of any solid waste stream. The recycling programs have not effective because they rely on consumer return. With increasing trend of e-waste, number of different programs are available for consumers for electronic disposal. The electronic products are harmful for human and environment due to its circuit boards and processors which have serious impacts on human health. These components are based on mercury, brominated flame retardants and cadmium and some other persistent organic compounds. These electronic wastes are harmful and cause of various skin diseases, cancer, mental disorders and other health issues.

E-waste also has various health effects on environment. According to [27], 820,000 tons copper was observed during e-waste operations. On the other hand, Polybrominated diphenyl ethers (PBDEs) also cause of endocrine disruption due to its fat-soluble nature and it is not easily breakable and adjust in natural food chain. In developed countries, where e-waste management is one of the main issue, there are different recycling methods and policies have implemented for toxic material [23]. European Union developed an agreement in 2007, in which they mentioned to deal with electronic waste and contains some recycling methods for waste management.

5. Recent Challenges and Solutions

In order to control e-waste, there are various practices have adopted around the globe. Basically, e-waste practices are categorized into proper or improper management. In proper management technologies, detoxification, refining and shredding are included. On the other hand, in improper e-waste management, open burning, land filling and wet chemical washing are included [26], [30]. Improper e-waste management is still in practicing in developed countries and one of the country is USA where 70% heavy metals found from landfills. In addition, some other methods in developed countries are illegally shipped the e-waste and legally donated or sold in local markets is another serious matter. In some cases, after dismantling the products are separated into parts for material recovery such as sliver, metal and cooper. After these practices, the leftover plastics, contaminants and heavy metals left in piles around working areas [21]. Many workers have involved in these practices and their health is also on danger during these operations.

Different types of tools and method have been designed by researchers and developers for effective household e-waste managements. The methods are life cycle assessments [11], system approach [28], economic and environmental modelling and measuring carbon impacts [13] are the examples. According to [17], that 20% households do not obtain any involvement to use recycling collection services. Another factor reported is collection complexity and simple and easy waste collection systems are better and attractive selection for household. In another study by [4] discussed that householders are confused about the concept of separation of materials from different containers and produced residual waste. Well operated household waste collection is another significant factor which increases the recycling level. In this section, different types of existing frameworks and models discuss.

Ref. [4] and [9] investigated the household waste systems and recycling behaviour within the reverse logistics domain. Authors adopted the multi method approach based on consecutive inductive and deductive investigations. This study was based on qualitative and qualitative methods where explanatory findings broaden the better understanding of the phenomenon. This study

revealed that there are identical interactions are existing between situational and personal factors. In addition, demographic factors affecting the household recycling behaviour with key factors including convenience, availability, engagement and accessibility. This study indicated the existence of symbolic effects between personal and situational factors. The proposed model is more effective to manage and enhance the recycling and sustainability. Author also introduced the recovery support and positive impact of communication and education to effect in design of model.

Subsequently, [18], [19] proposed a mix methodology based sequential exploration design model to make relationship between householders and the municipalities. This study revealed the factors which are associated with symbiotic element which are situational and personal factors. This study also designed a framework and encapsulated a symbiosis effect and provides empirical evidence about reverse logistics and its behavioural aspects. Household consumers are addressed in this study by occupied the pivot point where the first tier is supplier in reverse logistics systems. The findings of this study suggested that personal factors interact with situational factors and transformed based on effective factors including availability, engagement and convenience. On the other hand, the personal factors revealed from this study were knowledge, self-awareness, self-efficacy, household dynamics and social norms.

Additionally, [22] identified the correlation between community participation in recycling programs and their attitude and knowledge or solid waste management. This study revealed that the community attitude is significant in Putrajaya area in Malaysia about recycling program. In addition, community also adopted educational tools including internet, reading materials as an input. The distances from houses towards the recycling and collection centres, limited space are the major factors that prevent the community towards the recycling program. These findings are utilized on stakeholders to improve the implementation policies of the program. The action plan for proper e-waste management for households in Malaysia need to increase awareness to avail the sustainability of waste management and achieve the better results from community.

Furthermore, [2] analysed the collected data about public attitudes on waste management source recycling and separation. The results revealed that most of the respondents have inadequate knowledge and practice. Most of the respondents are not satisfied with available waste collection services in their areas and less willing to pay services charges. This study highlighted that there is need to provide a better infrastructure and improving the recycling programs. In addition, local government also provides an infrastructure and ends with citizens separating the waste and putting in right containers. The majority of respondents in this study were unsatisfied, these results indicated that there is need to improve the recycling services where government and other stakeholders should be clear in terms of their responsibilities and services.

Ref. [1] investigated the rate of participation for sustainable waste and environment management activities. This study is based on mix method and conducted a survey to gather the data and then analysed. The results of this study revealed that most of the respondents believe about waste has some value and agree to conduct the recycling and waste separation. On the other hand, few have explained some reasons for low level waste recycling and separation. The reasons behind low waste separation can be attributed with two main reasons, the lack of incentives in area and unavailability of recycling programs. The results of this study indicated that higher public environment sanitation and waste management is ensured the health environment. Authors suggested that adequate measures should be taken by the environmental protection board and ensure the high level of public participation.

Consequently, [24] developed a framework for reverse logistics of e-waste which contains recycling. In this study, authors described the behaviour of decision makers, consumers, sources of recycling processes and market demand for the products. These authors constructed the multitier e-cycling network equilibrium model and established the variation inequality formulation. This solution yields the material flows and prices. The numerical results of this study solve the proposed algorithm. The proposed model also provides the qualitative aspects of the equilibrium flows. The proposed framework will help the e-waste management processes and better solutions.

Table 1. Selected studies on Reverse Logistics

S/No	Author and Year	Research Methodology	Major findings	Description
1	[4]	Predicting the individual waste management behaviour and develop a model	Study revealed various organisational motivations and barriers involved in promoting the individual waste management behaviour	Authors investigated the household waste systems and recycling behaviour within the reverse logistics domain.
2	[18]	Author adopted semi-structured interview and thematic data analysis to achieve the study objectives.	There are symbiosis effects are existing between two major factors which are driving the councils for recycling the performance	This study proposed a mix methodology based sequential exploration design model to make relationship between householders and the municipalities.
3	[22]	Author conducted a detail survey to determine the participants and community awareness about recycling program.	The distances from houses towards the recycling and collection centres, limited space are the major factors that prevent the community towards the recycling program.	This study identified the correlation between community participation in recycling programs and their attitude and knowledge or solid waste management.
4	[2]	Author conducted a detail survey to determine the respondents' knowledge about e-waste management practices.	The results revealed that most of the respondents have inadequate knowledge and practice.	This study analysed the collected data about public attitudes on waste management source recycling and separation.
5	[1]	This study is based on mix method and conducted a survey to gather the data and then analysed.	The results of this study indicated that higher public environment sanitation and waste management is ensuring the health environment.	This study investigated the rate of participation for sustainable waste and environment management activities.
6	[24]	Author conducted a detail survey to determine the participants and community awareness about recycling program.	Authors described the behaviour of decision makers, consumers, sources of recycling processes and market demand for the products.	Authors developed a framework for reverse logistics of e-waste which contains recycling.

6. Discussion

Reverse logistics has gained more attention of researchers and academic due to its stretching and worldwide supply chain management operations. Reverse logistics is used for management of hazardous materials, logistics recycling and waste disposal. It also related with all logistics activities carried out in source reduction, disposal, reusing of materials and recycling. Recently, the global attention and commitment to environmentally friendly operations encompass the reverse logistics. Reverse logistics is more than handling the returns, and recovering/reusing discarded parts; it also used to extend the design and other elements of the product's life cycle [10]. In the context of household management, poor service quality of refuse collection affects the quality of lives of the people and communities. The recycling is the process of systematically collecting, sorting, decontaminating and returning of waste materials to commerce as commodities for use or exchange. Poor services in waste management always leads to effect the health of people, pollution, irrespective socio-economic status and various other social issues. In Malaysia, the waste management issue is raised due to poor services, lack of e-waste programs and effective participation of municipalities because household waste in many countries had been always under the responsibilities of local councils or local authorities.

It has been seen from literature, that public ignorance on the relationship between active public participation in waste management in Malaysia due to lack of involvement of community in waste management, lack of availability of programs recycling centers, unawareness of participants, distance between houses and recycling centers and behavioural attitudes. Some other factors contributed to slow public participation in waste management in Malaysia are their ignorance due to lack of involvement in community. Some other weaknesses in waste management are increasing population and excessive waste generation in the region. The household recycling rates depends as much on the recycling systems provided by the councils as well as the participation of households. These all revealed factors indicated that there is a need to develop a framework to address these issues in Malaysia and provide better solutions and framework to all stakeholders in community [8].

7. Conclusion

In this review, we discussed e-waste management, recent challenges and its solutions. Reverse logistics provides different types of activities to address the e-waste issues. Reverse logistics activities have implemented in different household e-waste operations. All reverse logistics activities have designed to solve the e-waste issues which are causing for environment and health waste issues. This review points out the fundamental of reverse logistics and looks into the existing activities for e-

waste management and highlights the recent growing concern to controlling rising global pollution by household waste. Through extensive literature review, this paper concludes the gap and recent activities in the field. This review is a mile stone for new researchers who are working in this field. In future, an e-waste model would be developed in order to address the waste issues through reverse logistics activities. Since this paper only focuses on issues and benefits, it is suggested that future research would emphasise on other aspects of reverse logistics and household e-waste such as policy and regulations, success factors and operational governance.

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