E-Waste Management: Developing a Model for Effective Take Back System in India

Dr. Rajeev Srivastava,
Associate Prof, IMS Unison University,Dehradun

Abstract

The electronics industry is the world's largest and fastest growing industry. Last decade has seen tremendous growth in the field of information technology all over the world, especially in developing countries like India. This growth has brought a new kind of waste known as electronic waste or e-waste that is very harmful for human health and environment. Since this waste has very complex characteristics and requires an equally complex set of efficient technology and processes to deal with it. This study strives to develop a valid and reliable model for effective e-waste management in Indian context. Total 495 respondents participate in the survey. A multiple regression analysis was employed and the, 'Collection and Recycling' appeared as the best predictor, followed by 'Rules and Regulation', 'Awareness', 'Responsibility' and 'Initiatives'. The e-waste management model developed in this research may be utilized for effective e-waste management in an organization.

Keywords: Recycling, e-waste, Reuse, Collection, Disposal.

1. Introduction

Electronic waste, e-waste, e-scrap, or Waste Electrical and Electronic Equipment (WEEE) are different names for discarded electrical or electronic devices. Based on data gathered by United Nations organizations, governments, non government and science organizations in a partnership known as the "Solving the e-waste Problem (StEP) Initiative (www.unu.edu), it was forecasted that by 2017, the global volume of discarded refrigerators, TVs, cellphones, computers, monitors and other electronic waste will weigh almost as much as 200 Empire State Buildings .

MoEF (2012) report says that Indian electronic waste output has jumped eight times in the last seven years i.e. 8,00,000 tones now. In parallel, life of electronic and electrical products is constantly reducing. High consumerism of these products, low recycling rates and illegal transboundary movement from developed to developing countries (Puckett and Smith, 2002; Brigden et al., 2005) is creating issues in e-waste management. The number of electronic devices used per capita at the global scale will continue to increase; while their size will further decrease and microprocessors will invade more and more everyday objects. Experience shows that the miniaturization of devices is usually counteracted by the growing numbers of devices produced. On average, each person on the planet produced seven kilograms of e-waste in 2012, that is 48.9 million tonnes in total, and StEP estimates that this will rise to 65.4 million tonnes in 2017 (www.unu.edu).

Solutions have been proposed from the perspective of new industrial product designs, manufacturing and recycling philosophies (e.g. the extended producer responsibility, EPR) and green procurement policies. In the European Union, the WEEE is more commonly used and specifically defined as electrical and electronic equipment which consumers dispose of or is required to dispose of pursuant to the provisions of national law, including all components, sub-assemblies and consumables. Management of electronic waste is a much more formidable challenge in developing countries on account of lack of proper infrastructure, poor legislation and awareness among citizens. Also at stake are the livelihoods of a large number of urban poor involved in processing and recycling of e-waste. According to a report from Center for Science and Environment (2011), India is generating 350,000 tonnes of electronic waste (e-waste) every year and imports another 50,000 tonnes. Out of this mammoth e-waste pile, only 19,000 tonnes are recycled. Some of the top generators of e-waste in India are Maharashtra, Tamil Nadu, Andhra Pradesh and Uttar Pradesh.

2. Review of Literature

The electronics industry is the world's largest and fastest growing industry and is recognized as one of the engines of economic development in India. The last decade has seen tremendous growth in the field of information technology all over the world, especially in developing countries like India. This growth, combined with rapidly increasing product obsolescence and consumer choices, has brought in a new kind of waste–electronic waste or e-waste. This ever-increasing waste has very complex characteristics and requires an equally complex set of efficient technology and processes to deal with it. Inadequate technical infrastructure for handling and managing the waste (Nguyen, 2009), movement of e-waste dismantling from the formal to the informal sectors (Jain and Sareen, 2006) are important drivers of inappropriate e-waste management. Lack of relevant information as support to the disassembly (Zhiduan, 2008), information about recycling services (Huang and Truong, 2008), and an ambiguous responsibility for e-waste recycling among consumers, retailers, and manufacturers (Jinglei et al., 2009) are also an important factor for e-waste management.

Limited literature was found in Indian context about the e-waste management. Therefore it was fascinating to know about the e-waste management in Indian context.

An extensive review of literature was carried out in the area of e-waste management as discussed above. The important factors related to e-waste management were identified and organized in a research model. The factors are described as follows:

i) Collection and recycling: Collection and recycling means collecting back used electronics devices for the purpose of recycling, reuse and safe disposal of e-waste .Buy back system is an important factor for e-waste management (Jinglei et al., 2009).Time delay (Lafir Ali, 2008), lack of collection points (Shih, 2001) and cost of collection (Wei Shanshan, 2008) are main drivers for collection of e-waste. An efficient take back system is dependent on accessibility, collection facilities, adequate and consistent information to the users (Brussels, 2008).Complexity of take-back system is also one of important factor (Zhiduan Xu, 2008). A paper discussed that real quantity of discarded e-waste in urban China is not recycled or disposed by formal recyclers (Hao Liu et al., 2007*)*. High recycling cost (Marie-Claude Nadeau), low recycling rate (Brian K. Gullett, 2007) are main drivers of formal recycling. The most challenge faced by formal e-waste recycling sectors is that they do not get sufficient e-waste to maintain normal operations (Jinglei et al., 2009). Due to high costs of recycling and lack of consumer incentives, only very small fractions (Hyunmyung Yoon, 2006) reach for formal recycling. Trans-boundary system for the 3R (Reduce, Reuse and Recycle) management of electronic waste (Masachika Suzuki, 2008) is important driver for reuse. e-waste management can be improved by donating e-waste to charities or schools, remanufacturing and by use of upgradeable electronic devices (Kristin Hanks, 2008).

ii) Rules and regulations: Rules and regulations refer to the legal system required for effective e-waste management. Adequate rules and regulations is one of the important factors in management of e-waste. By making final treatment and landfill last stage of the disposal process (Shih, 2001) e-waste management can be improved. In the absence of legislation, e-waste recycling systems have been limited to private recycling of high-value waste with only limited consumer participation (Susan et al., 2008). Trans-boundary movements of huge amount of e-waste from developed counties to developing countries (Wen, 2006), lack of legislation around e-waste (Roa, 2007), dumping e-waste into landfills, terrible working conditions for workers (Hanks, 2008), rigorous controls to prevent the illegal import and export of e-waste (Sinha-Khetriwal et al.,2005) and lack of relevant laws to adjust or control the selling behaviors of waste electric & electronic equipment (Wen, et al. 2006) are some important rules and regulations related issues in proper management of e-waste.

iii) Government support: Government support refers to the **s**upport required from the Government at various levels for effective management of e-waste. It is suggested that recycling facilities to manage e-waste should be supported by the Government (Cobbling, 2008). Informal sector as a crucial and emerging issue, which is needed to be well understood and better governed (Tienhua and Yenming, 2008) by the government. Inadequate technical infrastructure for handling and managing the waste and movement of e-waste dismantling from the formal to the informal sectors (Jain and Sareen, 2006) are important drivers in improper e-waste management. e-waste can be a potential product for secondary markets (Kahhat et al., 2008) so government need to develop second hand markets for electronics devices. The system creates incentives for collectors and recyclers to over-report the amount of collected e-waste in order to gain extra subsidies (Kojima et al., 2006). Under the support of government, e-waste generated from government agencies must be made mandatory to send to formal recyclers (Hao et al., 2007).

iv) Awareness: Making the end user of electronics devices aware about various activities and services of e-waste. Lack of relevant information as support to the disassembly (Zhiduan, 2008), information about recycling services (Huang and Truong, 2008), consumer awareness regarding environmental issues (Sinha-Khetriwal et al., 2005), and lack of programs that will enable consumers to reduce, reuse and recycle greater volume of this growing category of waste (Carolyn, 2005) are some important barriers for effective management of e-waste.

v) Initiatives: Initiatives refer to programs or schemes required to promote effective collection, recycling and disposal of e-waste. It is important for government and manufacturers of electronics devices to take various types of initiatives to promote e-waste management. Several initiatives have also been launched by electronic product manufacturers or government to collect WEEE (Jinglei et al., 2009). They have begin efforts to collect (e.g., free e-waste collection events) and recycle the e-waste from

residential and business sectors (Kahhat et al., 2008), enterprises and individual consumers choose to send owned e-waste to formal recyclers (Hao, 2007) and promoting renewal and reuse (Hanks et al., 2008). The Legislation and various initiatives intended to help and manage these growing quantities of e-waste are the drivers for effective management of the e-waste.

vi) Responsibility: Responsibility means all stakeholders of e-waste should understand and play their role in responsible manner so that e-waste can be managed properly. It is important to clarify the roles and a clear demarcation of responsibilities (Sinha-Khetriwal et al., 2005). If consumer take responsibility to bring their e-waste to designated drop off collection points of e-waste (Susan et al., 2008) and manufacturer take responsibility to reduce toxicity in material used for making electronic equipments (Thiel and Neeli, 2008), e-waste management can be improved. While manufacturers are responsible for collection and disposal, other participants in the lifecycle of electronic products, such as consumers and government, should also take responsibility for e-waste management. By providing financial incentive to consumer for returning their e-waste to authorized collection centers, management of e-waste can be improved (Kahhat et al., 2008). Thus responsibility is an important driver for effective e-waste management. An ambiguous responsibility for e-waste recycling among consumers, retailers, and manufacturers (Jinglei et al., 2009) is also an important factor. These issues are summarized in Table 1.

Table 1
Factors responsible for e-waste Management

No.	Issues	Literature Support
1.	Collection and Recycling	Ali et al.,2008; Jinglei et al.,2009 ; Rolf et al., 2008; Shanshan and Kejing, 2008;Shih, 2001; Brian et al., 2007; Hao et al.,2007; Jinglei et al.,2009;Marie-Claude et al.,2008; Yoon and Jang, 2006; Hanks et al.,2008; Suzuki M., 2008;Huang and Truong ,2008; Kojima et al.,2006;Tong,2004;
2.	Rules and regulations	Hanks et al.,2008; Roa,2007; Shih,2001; Sinha-Khetriwal et al.,2005; Wen et al.,2006;
3.	Government support	Cobbling , 2008; Hao et al.,2007; Jain and Sareen, 2006;Kahhat et al., 2008; Kojima et al.,2006; Nguyen,2009; Tienhua and Yenming ,2008;
4.	Awareness	Carolyn,2005; Huang and Truong,2008; Sinha-Khetriwal el al.,2005; Zhiduan, 2008
5.	Initiatives	Hanks et al.,2008; Hao et al.,2007; Jinglei et al.,2009; Kahhat et al., 2008;
6.	Responsibility	Jinglei et al.,2009; Kahhat et al.,2007; Kojima et al.,2006; Sinha-Khetriwal et al.,2005; Susan et al., 2008;Thiel and Neeli,2008;
7.	Effective e-waste Management (Dependent factor)	Hanks et al., 2008; Huang and Truong, 2008; Kahhat et al., 2008; Liu, 2006; Nguyen,2009; Roa,2007; Thiel and Neeli,2008; Wang and Chou,2009;

The aim of this paper is to identify the variables responsible for growing volume of e-waste and to arrive at a Research Model of effective e-waste management The Research Model was designed with identified variables which have come out from the various literatures. Hypotheses were generated to validate the variables of the research model.

3. The Research Model and Hypotheses

On the basis of the literature review few variables were identified. It was hypothesized that these variables will influence the effective management of e-waste. From the existing literature six variables were identified. These variables are 'Collection and recycling', 'Rules and Regulations', 'Government support', 'Awareness', 'Initiatives' and 'Responsibility'. These were the independent variables which may influence effective management of e-waste. The variables and items identified from existing literature are summarized in Table 2.

Table 2:
Variables and items

Sl. No.	Variables	Items
1	Collection and recycling	Complex Collection process, Cost effective collection, Easy accessibility of collection points Latest recycling technology, Cheaper recycling cost, Low recycling rate, Environment friendly recycling, Increase in life time of electronic devices, Donate, Upgradeable, Recoverable.
2	Rules and regulations	Illegal import, Safe disposal, Working conditions of workers, Restrict dumping, Selling behaviors of e-waste
3	Government Support	Control informal recycling, Enforcement and supervision, Subsidy to formal recyclers, Proper Infrastructure, Develop secondary markets
4	Awareness	Collection facilities, Recycling services, Improper disposal impact.
5	Initiatives	Buy back schemes, Promoting reuse, Promoting repair
6	Responsibility	Producer, Manufacturer reduce toxicity, Manufacturer give incentive to consumer, Retailers and repair shops to accept discarded appliances, Enterprise and individual consumers to bring their e-waste to formal collection points

On the basis of literature study six variables are identified and from these variables Research Model was developed. This Research Model is shown in Figure 1. In the Research Model it was hypothesized that all identified variables may be predictor of the effective e-Waste management. The related hypotheses are mentioned below:

H1: Effective e-Waste management is affected by Collection and Recycling.

H2: Effective e-Waste management is affected by Rules and Regulations.

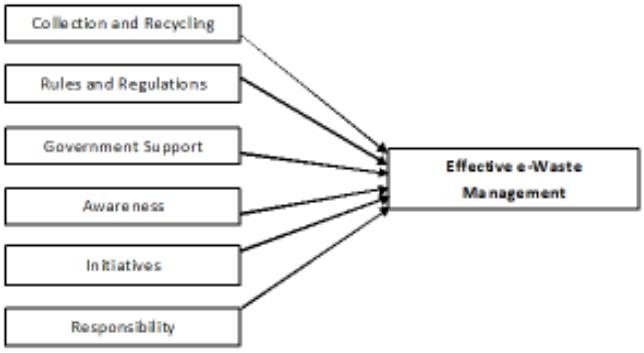
H3: Effective e-Waste management is affected by Government Support.

H4: Effective e-Waste management is affected by Awareness

H5: Effective e-Waste management is affected by Initiatives

H6: Effective e-Waste management is affected by Responsibility

Figure 1:
Research Model for Effective e-waste Management



4. Data Collection and Result Analysis

Questionnaire was designed with the objective to collect data which is necessary to test the hypotheses formulated for the study. Questions related to the test of hypotheses were in the statement format, which seeks opinion in terms of level of agreement or disagreement of the respondent. The items of the variables given in Table 2 were considered to prepare the questions of the questionnaire. Some questions were also prepared on the basis of the literature study related to the variables. The questions in the questionnaire were multiple choice types and seven point Likert scale was used.

The intervals used were 'extremely disagree', 'disagree', 'partially disagree', 'neutral', 'partially agree', 'agree', and 'strongly agree'. This justifies that the answers of the categories is mutually exclusive so that respondents had to select only one choice against a question.

Personal search was made at various websites related to the service sector. Information was provided about the use of electronic equipments and it was found that software industries and the higher education institutes used large amounts of electronic equipments in their organization as compare to other service sectors. So software industries and institutes providing higher education constitute the population of the study. Out of the total population 600 was taken as the sampling frame. This sampling frame was the target respondent.

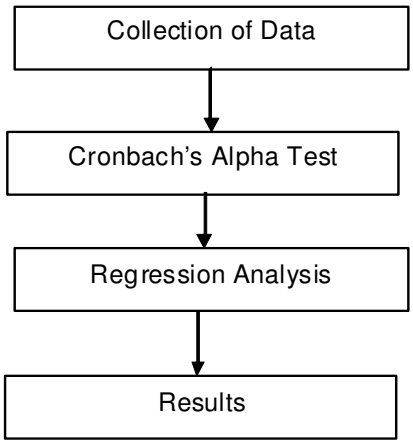
An effort was made to get the responses from the target respondents. For this purpose structured questionnaire was mailed and personal visits as well as telephonic request were also made to get the questionnaire filled up.

From the defined sample frame 558 responses were received. Further these samples were scrutinized to check the usability of the responses. It was found that some of the responses were partially filled; these responses were not considered for the further analysis. Out of the received sample, 495 responses were found usable responses. These responses were used for the further analysis.

A questionnaire based approach was used for obtaining data from the Top managers, software developers, Directors, and Professor of the software and education industries. In this process the questionnaire was used as a tool for getting the responses. The questionnaire was validated through different stages of validation. Then pre testing of the questionnaire was done through pilot study.

Data collection and analysis was carried out to validate the Research Model through survey. The hypothesized Research Model (Figure 1) was validated through multiple regression analysis. Regression coefficients (beta value) show the degree of association between dependent variable and independent variable. Flow Chart of data analysis is shown in Figure 2.

Figure 2
Data Analysis Flow Chart



4.1 Construct Validity: Cronbach's Alpha

Construct validity was conducted to know the convergent validity of the items used for the different variables. For this purpose the Cronbach's Alpha Test was conducted by dropping and retaining the different combination of items (Table 2). The combination having highest value of reliability coefficient i.e. alpha was considered as the best combination of items for the further study. The value of alpha for the best combination of items for a given variable is shown in Table 3

Table 3
Cronbach's Alpha Test

Factor	Alpha Value
e-waste Management (Dependent Factor)	.779
Collection and Recycling	.810
Responsibility	.803
Awareness	.757
Rules and Regulations	.814
Initiatives	.638
Government Support	.848

4.2 Regression Analysis

The hypothesized research model (Figure 1) was validated by multiple regression analysis. The regression analysis was done at 90% of level of significance. The analysis enabled to predict the variability in dependent variable based on its covariance with all independent variables. The coefficient of determination (R Square) indicates that the research model shown in Figure 1 explains 65.7 percent variation in effective e-waste management (Table 4).

Regression coefficients (beta value) show the degree of association between dependent variable and independent variables. The value of adjusted R Square was found 0.653. The standard error of estimate is the square root of the residual mean square in ANOVA (Table 4). In this case, standard error is equal to 0.58067 and measures the spread of the residual error.

The standardized coefficients (beta values) show the degree of association between dependent variables and independent variables (Table 5).

Table 4
Model summary for effective e-waste management as dependent

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.811	.657	.653	.58067

a.Predictors : (Constant),Responsibility,Initiative,Awareness,Government Support ,Rules and regulations

Table 5
Multiple regression analysis results

Item	Standardized Coefficient	P- value	Relative importance
Constant		0.0001	
Collection and Recycling	0.421	0.000	I
Rules and Regulation	0.322	0.000	II
Government Support	0.002	0.965	VI
Awareness	0.131	0.000	III
Initiatives	0.052	0.091	V
Responsibility	0.074	0.046	IV

Note: Depended Variable: Effective e-waste Management; *Significant at 0.10 level (2- tailed);
R= 81.1 percent

4.3 Comparative Significance of Dimensions

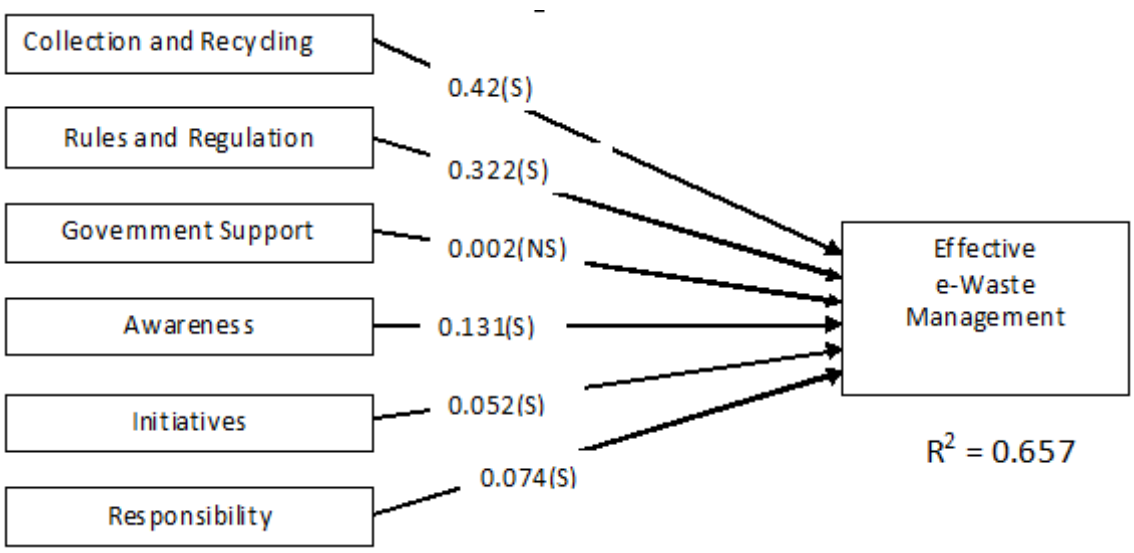
In research model there were 6 hypotheses of effective e-waste management, five of them have been accepted. One of the hypotheses could not be supported in the study, that is- H3 (Table 5). 'Government support' is not supported in the study as the predictor of effective e-waste management. The hypotheses H1, H2, H4, H5, and H6 are supported in the study (Table 5). Thus 'Collection and recycling Attributes', 'Rules and regulation Attributes', 'Awareness Attributes', 'Initiative Attributes', and 'Responsibility Attributes', are the predictor of effective e-waste management (Figure 3)

Table 6
Summary of Research Hypotheses

Hypotheses		Result
H1	Collection and recycling Attributes → Effective e-waste management	Supported
H2	Rules and Regulations Attributes → Effective e-waste management	Supported
H3	Government Support Attributes → Effective e-waste management	Not Supported
H4	Awareness Attributes → Effective e-waste management	Supported
H5	Initiatives Attributes → Effective e-waste management.	Supported
H6	Responsibility Attributes → Effective e-waste management	Supported

Level of Significance: 90%

Figure 3:
Model for effective e-waste management



5. Discussion

Data collection and analysis was carried out to validate the Research Model. Convenience sampling was done from the defined population to get the responses from the Top managers, Directors, Professors, and software developers of Software and education sector. Questionnaires were used to get the responses. 495 usable responses were received for the analysis. Construct validity was conducted to know the convergent validity of the items used for the different variables. For this purpose the Cronbach's Alpha Test was conducted by dropping and retaining the different combination of items. The combination having highest value of reliability coefficient i.e. alpha was considered as the best combination of items for the further study.

The hypothesized Research Model was validated through regression analysis. The analysis enabled to predict the variability in dependent variable based on its covariance with all independent variables. Regression coefficients (beta value) show the degree of association between dependent variable and independent variable. There were 6 hypotheses of effective e-waste management; five of them were accepted at 90% level of significance. Thus 'Collection and Recycling Attributes', 'Rules and Regulation Attributes', 'Awareness Attributes', 'Initiative Attributes', and 'Responsibility Attributes', support as the predictor of the effective e-waste management. One of the hypotheses could not get supported in the study and 'Government support' is not supported as the predictor of effective e-waste management. While at level of significance 95% four of them were accepted. Thus 'Collection and Recycling Attributes', 'Rules and Regulation Attributes', 'Awareness Attributes', and 'Responsibility Attributes', support as the predictor of the effective e-waste management. Two of the hypotheses could not get supported in the study and 'Initiative Attributes' and 'Government support' are not supported as the predictor of effective e-waste management, as shown in Figure 3.

6. Recommendations and Future Direction

This study strives to develop a valid and reliable model for effective e-waste management in India. A total of 495 respondents participated in the survey. A multiple regression analysis was employed and the, 'Collection and Recycling' appeared as the best predictor, followed by 'Rules and Regulation', 'Awareness', 'Responsibility' and 'Initiatives'.

Therefore, these five factors can be treated as key factors for effective e-waste management. On the basis of above discussion, we can identify all the five factors to be important (although in varying degrees) for the purpose of successful implementation of effective e-waste management. In this research only six e-waste management factors have been used to develop the model. But more e-waste management factors can be included to develop the relationship among them using the multiple regression analysis methodology. Scope for future work in this area is abundant, because e-waste have significant contribution in the growth of the Indian economy and it is a new sector defined by the Government of India. The Model for effective management of e-waste in service industry developed here can be further validated for other sectors. The model evolved in the research is able to explain 65.4% variation of effective e-waste management. This can be further improved by adding few more variables. Longitudinal study may also be conducted to further validate the model and the recommendations made in this research. The future research in this area may have the following directions:

1. The Acceptance of Model developed here can be further validated for other sectors to test the effective management of e-waste and consolidate the model for wider acceptability.

2. The model evolved in the research is able to explain 65.4% (R-square=0.657) variation of effective e-

waste management. This can be further improved by adding few other variables.

3. Effective e-waste management in Indian context is a new area of research. Hence further investigations are required to discover other significant variables which might affect the e-waste management.

4. Longitudinal study may be conducted to further validate the model and the recommendations made in this research.

7. Concluding Note

The main purpose of this study was to assess the factors influencing the effective e-waste management. Six variables were identified with the help of literature study which may influence the effective e-waste management. Then these were tested through survey study. It was found that five variables named 'Collection and Recycling', 'Rules and Regulation', 'Awareness', 'Responsibility' and 'Initiatives' influence the effective e-waste management. Thus a validated model for effective e-waste management in service sector has evolved through this research. Based on the research findings, recommendations are given. One of the major limitations of the study is the limited availability of literature in the Indian context. Since e-waste management is a new sector defined, therefore scope is there to further explore this area.

References

1. Ali, L. and Chan, Y. C., 2008. " Impact of RoHS/ WEEE- on effective recycling electronics system integration" in Proceedings of Electronics System-Integration Technology Conference, pp. 521 - 524 Available: http://ieeexplore.ieee.org/xpls/abs_all.jsp?arnumber= 10397520
2. Brian, G. K., Linak, W. P., Touati, A., Gatica, S., King, C. J., AND Wasson, S. J. 2007." Characterization of air emissions and residual ash from open burning of electronic wastes during simulated rudimentary recycling operations," Journal of Material Cycles and Waste Management. Springer Japan KK, Tokyo, Japan, 9(1),pp.69-79.
3. Brigden, K., Labunska, I., Santillo, D., Allsopp, D. 2005." Recycling of electronic wastes in China and India: workplace and environmental contamination," in Green piece research laboratories ,department of biological sciences, University of Exeter ,Exeter EX4 $PS ,UK
4. Carolyn, C. N. 2005. "E-waste and the consumer: improving options to reduce, reuse and recycle" in International Symposium on Electronics and the Environment, Proceedings of the IEEE, pp. 237 - 242. Available:http://ieeexplore.ieee.org/xpls/abs_all.jsp?arnumber= 8531308
5. Cobbing M. 2008. "Toxic tech: not in our backyard, uncovering the hidden flows of e-aste.,"Amsterdam: Greenpeace International; 2008.
6. Hanks, K., Odom, W., Roedl, D., and Blevis, E. 2008. "Sustainable millennials: attitudes towards sustainability and the material effects of interactive technologies," in Proceedings of the twenty-sixth annual SIGCHI conference on Human factors in computing systems (CHI '08). ACM, New York, NY, USA, pp.333-342. DOI=10.1145/1357054.1357111 http://doi.acm.org/10.1145/1357054.1357111
7. Hao, L. H., Li J., Wen, X. and Zhou, X., 2007. "Investigation on Collection Mode of Domestic E-waste in Urban China: the Case of Beijing," in Proceedings of the 2007 IEEE International Symposium on Electronics & the Environment, pp. 257-261. Available: http://ieeexplore.ieee.org/xpls/abs_all.jsp?arnumber= 9831941
8. Hilty, L.M., Behrendt, S., Binswanger, M., Bruinink, A, Erdmann L, and Froehlich, J. 2005. "The precautionary principle in the information society—effects of pervasive computing on health and environment", second revised 434 Editorial editions. Edited by the Swiss Center for Technology Assessment (TA-SWISS), Bern, Switzerland (TA46e/2005), and the Scientific Technology Options Assessment at the European Parliament (STOA 125 EN); 2005. Available at: www.ta-swiss.ch; accessed 18.04.2005.
9. Huang, M., Truong, and K. 2008. "Situated sustainability for mobile phones," ACM Interactions (Journal Article)
10. Jain, A. and Sareen, R. 2006. "E-waste assessment methodology and validation in India," Journal of Material Cycles and Waste Management, Volume 8, Number 1 /March, 2006, Springer-Verlag.
11. Jinglei, Y., Meiting, J., and Eric, W.2009. "Waste electrical and electronic equipment recycling in China: Practices and strategies," in IEEE International Symposium on Sustainable Systems and Technology, pp.1
12. Kahhat, R., Kim, J., Xu, M., Allenby, B., Williams, E., and Zhang, P. 2008 "Exploring e-waste management systems in the United States (2008) *Resources," Conservation and Recycling*, 52 (7), pp. 955-964.
13. Kojima, M. , Yoshida, A., Li, J. , Yang, J. , Wong, M. H., Jain, A., Peralta, I . K. G. L.·, Mungcharoen C. L. T., Williams, E. , Terazono, A. , Murakami, S. ,Bulent Inanc, N. A. , · Yuichi Moriguchi, Y., Shin-ichi Sakai, S. 2006, "Current status and research on E-waste issues in Asia," Journal of Material Cycles & Waste Management,vol(8);pp.1-12
14. Mandal, A., and Deshmukh, S.1994. "Vendor selection using interpretive structural modeling (ism)," International Journal of Operations and Production Management, 14(6),pp. 52–59.
15. Marie-Claude, N., Gregory, J., and Kirchain, R. 2008. "Assessing the sustainability of the material recovery system for CRT glass," in IEEE International Symposium on Electronics and the Environment, pp.1
16. MOEF guidelines. (2012). Guidelines for Environmentally Sound Management of E-Waste. March 2008.(As approved vide MoEF letter No. 23-

23/2007-HSMD dt. March 12, 2008). http:// www.moef.nic.in (Accessed July 2012).

17. Nguyen, T. K. T. 2009. "Hazardous industrial waste management in Vietnam: current status and future direction," Journal of Material Cycles and Waste Management, ISSN: 1438-4957
18. Puckett, J., Smith, T. 2002, " Exporting harm The High-Tech Trashing of Asia ," The Basel Action Network and Silicon Valley Toxics Coalition, toxic link India scope green piece Chins,pp.1-48
19. Rao, F. 2007. "Costa Rica advances towards a sustainable management," in Proceedings of the IEEE International Symposium , ISEE.2007.369097ISBN: 1-4244-0861-X
20. Rolf, W., Oswald-Krapf, Heidi, Sinha-Khetriwal, D., Schnellmann, Max and Böni, Heinz. 2005. "Global perspectives on e-waste," Environmental Impact Assessment Review, 25(5), pp. 436 458.
21. Sage A. 1977.Interpretive Structural Modeling: Methodology for Large-scale Systems, 91–164. McGraw-Hill, New York
22. Shanshan, W. and Kejing, Z. 2008. " Optimization Model of E-waste Reverse Logistics and Recycling Network1" in Proceedings of 3rd International Conference on Intelligent System and Knowledge Engineering , pp. 1436 – 1442. Available: http:// ieeexplore.ieee.org /xpls/ abs_all.jsp? arnumber= 10441346
23. Shih, L. H. 2001. "Reverse Logistics System Planning for Recycling Electronically Appliances and Computers in Taiwan [J]," Resources, Conservation and Recycling, 32, pp. 55-72.
24. Sinha-Khetriwal, D., Kraeuchi, P., and Schwaninger, M. 2005. "A comparison of electronic waste recycling in Switzerland and in India," Environmental Impact Assessment Review, 25(5), pp. 492–504.
25. Susan, A. F., Jeremy, R. G., and Randolph, E. K. 2008. "Characterizing architectural options for electronic waste recycling systems," in IEEE International Symposium on Electronics and the Environment, pp.1-6
26. Suzuki, M., Subramanian L., Watanabe, and T., Hasegawa H. 2008. "The Application of the International Resource Recycling System (IRRS) to encouragement of Electronic Waste Recycling - The Case of Fuji Xerox",in IEEE International Symposium on Electronics and The Environment, May 2008, San Francisco.
27. Thiel D. V. and Neeli, M. 2006. "Fabrication of electronic components in plastic," *WO Patent* WO/ 2007/002995.
28. Tienhua, W. T., and Yenming, J. C. 2008. "Understanding population dynamics of WEEE recycling system in the developing countries: A SIR model," in IEEE International Symposium on Electronics and the Environment , pp.1-6
29. Tong, X. 2004. "Global mandate, national policies, and local responses: scale conflicts in China's management of imported e-waste," in International Symposium on Electronics and the Environment, pp. 204-207. Available: http://ieeexplore.ieee.org/xpls/ abs_all.jsp?arnumber= 7995079
30. UN e-waste report, 2011. "Review of Directive 2002/ 96 on Waste Electrical and Electronic Equipment (WEEE)," Final Report to European Commission, Bonn; 2007.
31. Wang, C., and Chou, T. 2009. "Personal Computer Waste Management Process in Taiwan via System Dynamics Perspective," in International Conference on New Trends in Information and Service Science, pp.1227-1230.
32. Warfield, J. 2005. "Developing interconnection matrices in structural modeling," in IEEE Transaction sons on Systems, Man and Cybernetics, 4(1),pp. 81–67.\
33. Wen, X., Li, J., Hao, L., Yin, F., Hu, L., Liu, H., and Liu, Z. 2006. "An Agenda to Move Forward E-waste Recycling and Challenges in China," in IEEE International Symposium on Electronics and the Environment, pp.315-320
34. Yoon, H. and Jang, Y. 2006. "The Practice and Challenges of Electronic Waste Recycling in Korea with Emphasis on Extended Producer Responsibility (EPR)," in IEEE International Symposium on Electronics and the Environment, pp.326-330
35. Zhiduan, X. 2008. "Integrated Information Systems of E-Waste Take-Back Supply Chain," in 4th International Conference on Wireless communications, Networking and Mobile Computing, 12-14 Oct., pp. 1 - 5