# Analysis of Barriers of e-waste Management using ISM (Interpretive Structural Modeling) Methodology

**Sirajuddin Ahmed[1], Rashmi Makkar Panwar[2]**

[1]*Department of Civil Engineering, Jamia Millia Islamia, New Delhi, India*
[2]*G.B.Pant Polytechnic, DTTE, New Delhi, India*

## ABSTRACT

***The aim of this paper is to analyze the interaction of various barriers in management of e-waste which prevent or hinder e-waste management for sustainable development. After literature survey on e-waste management in India and other countries, major barriers of e-waste management have been identified. The literature review, together with the expert's opinion obtained during various field visits have been used in developing the relationship matrix, which is used in the development of an Interpretive Structural Modeling(ISM) model.This has been used to analyze the driving power and dependence power of factors. By analyzing the barriers using ISM analysis we obtained crucial barriers, which have both high driving power and dependency, thus needing more attention while working on a comprehensive plan for sustainable e-waste management system.***

***Keywords: e-waste, Interpretive Structural Modeling(ISM), barriers***

## 1. INTRODUCTION

The phenomenal growth in Information Technology as well as the exponential increase in use of electronic gadgets in our daily life over the past decade has resulted in generation of huge quantity of electronic waste (e-waste). The complex composition of e-waste has further complicated the issue of waste management. E-waste contains many types of metallic and non metallic hazardous chemicals. The current practices of e-waste management in India suffer from a number of drawbacks like lack of reference data, poor awareness, lack of recycling infrastructure and financial constraints. The consequences are that toxic materials enter the waste stream causing on the damage to environment and human health.When electronic waste is dumped in landfills, not only all the energy and material used in making the product is lost, but it also poses high risk to the environmental. Their improper disposal may cause severe environmental problems. Electronic junk contains a fair amount of useful components and materials which can be reused or recycled.The e-waste management has become a major challenge for India. Interpretive Structural Modeling (ISM) can be used for identifying and summarizing relationships among specific variables, which define a problem or an issue [1]. It provides us a means by which order can be imposed on the complexity of such variables [2].The aim of this paper is to analyze the interaction among the major barriers, which hinder the proper management of e-waste inIndia. The Interpretive Structural Modeling (ISM) methodology is used to understand the mutual influences among the barriers so that those driving barriers, which can aggravate few more barriers and those independent barriers, which are most influenced by driving barriers are identified. The ISM process transforms unclear, poorly articulated mental models of systems into visible and well-defined models [3].

After review of literature on e-waste management in India and other countries, major barriers of e-waste management have been identified. The literature review, together with the experts' opinion obtained during various field visits was used in developing the relationship matrix, which is later used in the development of an ISM model.

The main objectives of this paper are:

(i) To identify and rank the barriers e-waste management in India.

(ii) To find out the interaction of identified barriers using ISM, and

(iii) To discuss the managerial implication of this research.

## 2. BARRIERS

The complex composition and hazardous nature of e-waste has complicated the issue of e-waste management [4].The current practices of e-waste management in India suffer from a number of barriers. A number of barriers have been identified by literature survey and personal visits to various e-waste handling sites. Table 1 shows the barriers and the numbers allotted to them for further usage.

These barriers are explained as below.

**2.1Lack of efficient information and technological system:** This is one of the major obstacles in the management of end of life electronic products safely and effectively. Lack of efficient information and technological system poses a challenge to policymakers wishing to design an e-waste management strategy and for the industry wishing to make rational investment decisions [4].It is necessary for effective e-waste management to quantify and characterize electronic waste stream, identify the major generators and assess the risk involved. It is also pertinent for government to keep the inventory [5]. Reliable figures on quantity are crucial in order to evaluate compliance with regulations set by authorities. Reliable figures are also important for monitoring and further improvement of return schemes [6].The difficulty in Inventorization is one of the important barriers to safe e-waste management [7].

**2.2 Problems due to complex and hazardous product composition:** E waste contains many hazardous substances which are extremely dangerous to human health and the environment therefore their disposal requires special treatment to prevent the leakage and dissipation of toxics into the environment [8]. Waste electronics and electrical equipment may cause environmental problems during waste management phase due to their hazardous material contents [9]. E-waste is highly complex to handle due to its composition .toxic substances can have adverse effects on human health and environment if not handled properly [5]. The diverse range of materials found in e-waste makes it difficult to give a generalized material composition for the entire waste stream. Many of the substances which e-waste contains are highly toxic, such as chlorinated and brominated substances,toxic metals,photoactive and biologically active materials, acids, plastics and plastic additives [10].It is complicated to recycle electronic products which have reached end of their life as they contain many different type of materials integrated into each other. The composition of e waste varies from product type to another one and even within the same product category there are differences in the material composition [11].

**2.3 Lack of training, techniques and recycling infrastructure:** Many aspects of recycling depend on manual operations. Existing methods are limited in their ability to handle complex products such as cathode ray tubes and personal computers, which contain a large number of materials [12].Environmentally sound recycling of e-waste requires sophisticated technology and processes, which are not only very expensive but also need specific skill and training for the operation. Proper recycling of complex materials requires the expertise to recognize or determine the presence of hazardous or potentially hazardous constituents as well as desirable constituents [13]. Availability of adequate number of sound recycling infrastructure units across the country will be critically important for safe management of e-waste .The country currently has only one integrated facility with an annual capacity of around 30000tones of waste. Most units are only engaged in preprocessing of the e waste and then exporting some of the valuable e-waste abroad for material recover [14].

**2.4 Lack of awareness**: The future of e-waste management also depends on the attitude of citizens, lack of civic sense and awareness among city residents will be major hurdles to keep e-waste out of municipal waste stream [13]. Lack of public awareness on the need for an e-waste management system and consumer responsible behavior are one of the important barriers to safe e-waste management [7].Manufacturers of computer monitors,televisions and other electronic devices containing hazardous substances, must be responsible for educating consumers and the general public regarding the potential threat to public health and the environment posed by their products and for raising awareness for the proper e-waste management protocols. Consumers lack tools and technical support to extend the product life. Many of them are unaware of kinds of routine maintenance or repairs that are needed to maximize computer performance [14].Lack of consumer awareness is one of the biggest challenges for the formal recyclers. A huge amount of investments is being done to create awareness and build the capacities of consumers on e-waste issues and proper disposal [15].One of the major obstacles to recycling is still the lack of consumer awareness on the potential for recycling of electronic scrap and its beneficial impact on the environment and the creation of a sustainability minded society [11].

**2.5 Financial constraints:** Experiencing economic growth and industrial growth,the higher percentage of e-waste in municipal solid waste is going to be an issue of serious concern[15].Amongst various recommendations for effective waste electrical and electronic equipments (weee) management in developed countries are provision for adequate funding of weee collection, storage and recycling and or disposal [16].The economies of recycling have been the main criteria for providing financial resources formalization of these units and the improvement of processes so that they comply with the environment, health and safety standards.Possible financialaid, access to credit, incentives, subsidies and insurance schemes are further measures that may need to be made available [17].Ensuring financial security for a producer responsibility system is especially crucial when disposal costs are higher than the recoverable value [18].

**2.6 Lack of strategic planning:** With increase in consumerism and an rise in the sales of electronic products the number of personal computers in India has grown 604%between 1993 to 2000, Where as the average growth throughout the world was much lower at 181% [19].There is a significant uncertainty associated with the flow of goods and the quality of flow [20]. In the present scenario, due to the rapid changes in technology and also due to changes in the behaviors of competitors, consumers, suppliers, etc., a sound strategic planning is necessitated for the implementation policy and regulation of sustainable e-waste management It is indicated by experts that the role of a regulator is most significant in ensuring effective implementation of the rule, its responsibility for building a simple but transparent system of reporting and monitoring progress. This can be achieved by strategic planning keeping all the major factors in view [21].

## *3.* ISM METHODOLOGY AND MODEL DEVELOPMENT

Warfield developed ISM [1].It aims to arrange elements associated with a system in a hierarchical relation [22]. Using ISM, a structural model is generated for the factors associated with the system on the basis of their relationships. The beauty of the ISM model is that it portrays the structure of a complex issue or the problem under study, in a carefully designed pattern employing graphics as well as words. The methodology of ISM can act as a tool for imposing order and direction on the complexity of relationships among elements of a system [23].ISM is an interactive learning process whereby a set of different and directly related factors are structured into a comprehensive systematic model. The model so formed portrays the structure of a complex issue or problem, a system or a field of study, in a carefully designed pattern involving graphics as well as words [24].

The following are the steps involved in the ISM methodology.

**3.1.** Identification of enablers/barriers: The factors associated with the system, which are to be examined and modeled, are identified.

**3.2.** Contextualrelationship: A structural self-interaction matrix (SSIM) is prepared by comparing the enablers/barriers pair-wise.

**3.3.** Areachability matrix is developed from the SSIM and then transitivity is checked. The transitivity states that if an enabler/barriers A is related to B and B is related to C, then Ais necessarily related to C.

**3.4.** The reachability matrix obtained in Step 3 is converted into the canonical matrix format by arranging the elements according to their levels.

**3.5.** From the canonical matrix form of the reachability matrix a directed graph is drawn by means of vertices or nodes and lines of edges and the transitive links are removed based on the relationships given above in the reachability matrix. The resultant digraph is converted into an ISM, by replacing enabler/barrier nodes with statements.

## 4. DEVELOPING ISM

**4.1. Structural Self-Interaction Matrix (SSIM):** ISM methodology suggests the use of the expert opinions based on various management techniques such as brain storming, nominal technique, etc., in developing the contextual relationship among the variables. Thus, in this research for identifying the contextual relationship among the barriers of the e-waste management two experts, one each from the e-waste management and the academia, were consulted for the same. Based on this, contextual relationship between the variables is developed.

Based on the available literature and experts' opinion the contextual relationship among the barriers has been developed as given in. Four symbols (V, A, X and O) are used to denote the direction of relationship between the factors (i and j):

V factor i will help to achieve factor j

A factor j will help to achieve factor i

X factors i and j will help to achieve each other

O factor i and j have no relationship.

Table 1 show the contextual relationship obtained between various barriers.

***4.2Reachability matrix***

The SSIM developed in previous step is then converted into a binary matrix, which is known as the initial reachability matrix by substituting1 and 0 in SSIM. The rules for the substitution of 1's and 0's are the following:

If V is present in the (i, j) element in SSIM, then 1 will be put in (i, j) element and 0will be put (j, i) element in the reachability matrix

If A is present in the (i, j) element in SSIM, then 0 will be put in (i, j) element and 1will be put (j, i) element in the reachability matrix

**Table 1: SSIM for barriers**

| No. | Barriers for e-waste management | Lack of strategic planning | Financial constraints | Lack of awareness | Lack of training, techniques and recycling infrastructure | Problems due to complex and hazardous product composition | Lack of efficient information and technological system |
|---|---|---|---|---|---|---|---|
| No. | | 6 | 5 | 4 | 3 | 2 | 1 |
| 1 | Lack of efficient information and technological system | A | A | A | A | A | |
| 2 | Problems due to complex and hazardous product composition | V | V | O | V | | |
| 3 | Lack of training, techniques and recycling infrastructure | A | A | A | | | |
| 4 | Lack of awareness | A | A | | | | |
| 5 | Financial constraints | X | | | | | |
| 6 | Lack of strategic planning | | | | | | |

**Table 2: Initial reachability matrix**

| S.No.. | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| 1 | 1 | 0 | 0 | 0 | 0 | 0 |
| 2 | 1 | 1 | 1 | 0 | 1 | 1 |
| 3 | 1 | 0 | 1 | 0 | 0 | 0 |
| 4 | 1 | 0 | 1 | 1 | 0 | 0 |
| 5 | 1 | 0 | 1 | 1 | 1 | 1 |
| 6 | 1 | 0 | 1 | 1 | 1 | 1 |

- If X is present in the (i, j) element in SSIM, then 1 will be put in (i, j) element and 1will be put (j, i) element in the reachability matrix.
- If O is present in the (i, j) element in SSIM, then 0 will be put in (i, j) element and 0 will be put (j, i) element in the reachability matrix.
- The initial reachability matrix is shown in the table 2. Table 3 shows the final reachability matrix after removing transitivity

**Table 3: Final reachability matrix**

| S.No.. | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| 1 | 1 | 0 | 0 | 0 | 0 | 0 |
| 2 | 1 | 1 | 1 | 1* | 1 | 1 |
| 3 | 1 | 0 | 1 | 0 | 0 | 0 |
| 4 | 1 | 0 | 1 | 1 | 0 | 0 |
| 5 | 1 | 0 | 1 | 1 | 1 | 1 |
| 6 | 1 | 0 | 1 | 1 | 1 | 1 |

***4.3 Level partitions***

Level partitioning is done to obtain the different levels of these 6 factors. From the final reachability matrix, the reachability set and antecedent set are obtained. In the reachability set the factor itself is present and the factors which it may help to achieve are present. Similarly, the antecedent set includes the factor itself and other factors which help in achieving it.

The intersection set includes the common factors between reachability set and antecedent set. If reachability set is equal to the intersection set, then the top priority is obtained and the factor is removed from the iteration, so on this procedure leads to final iteration leading to the lowest level [25].

The factor present in the top-level will not help to achieve any other factor in the hierarchy. Once the top-level factor is identified, it is separated out from the other factors. This process is repeated until all the levels are identified. Tables 4, 5, 6, 7, 8 show the iterations for first, second; third, fourth and fifth levels of partitioning .Based on these levels the diagraph and the final model arebuilt. Table 10 shows the final levels of barriers

**Table 4: First level of barriers**

| Barrier | Reachability Set | Antecedent Set | Intersection Set | Level |
|---|---|---|---|---|
| 1 | 1 | 1,2,3,4,5,6 | 1 | First |
| 2 | 1,2,3,4,5,6 | 1 | 1 | |
| 3 | 1,3 | 2,3,4,5,6 | 3 | |
| 4 | 1,3,4 | 2,4,5,6 | 4 | |
| 5 | 1,3,4,5,6 | 2,5,6 | 5,6 | |
| 6 | 1,3,4,5,6 | 2,5,6 | 5,6 | |

**Table 5: Second level of barriers**

| Barrier | Reachability Set | Antecedent Set | Intersection Set | Level |
|---|---|---|---|---|
| 2 | 2,3,4,5,6 | | | |
| 3 | 3 | 2,3,4,5,6 | 3 | Second |
| 4 | 3,4 | 2,4,5,6 | 4 | |
| 5 | 3,4,5,6 | 2,5,6 | 5,6 | |
| 6 | 3,4,5,6 | 2,5,6 | 5,6 | |

**Table 6: Third level of barriers**

| Barrier | Reachability Set | Antecedent Set | Intersection Set | Level |
|---|---|---|---|---|
| 2 | 2,4,5,6 | | | |
| 4 | 4 | 2,4,5,6 | 4 | Third |
| 5 | 4,5,6 | 2,5,6 | 5,6 | |
| 6 | 4,5,6 | 2,5,6 | 5,6 | |

**Table 7: Fourth level of barriers**

| Barrier | Reachability Set | Antecedent Set | Intersection Set | Level |
|---|---|---|---|---|
| 2 | 2,5,6 | | | |
| 5 | 5,6 | 2,5,6 | 5,6 | Fourth |
| 6 | 5,6 | 2,5,6 | 5,6 | Fourth |

**Table 8: Fifth level of barriers**

| Barrier | Reachability Set | Antecedent Set | Intersection Set | Level |
|---|---|---|---|---|
| 2 | 2,5,6 | | | Fifth |

**Table 9: Final level of barriers**

| Barrier | Reachability Set | Antecedent Set | Intersection Set | Level |
|---|---|---|---|---|
| 1 | 1 | 1,2,3,4,5,6 | 1 | First |
| 2 | 2,5,6 | | | Fifth |
| 3 | 3 | 2,3,4,5,6 | 3 | Second |
| 4 | 4 | 2,4,5,6 | 4 | Third |
| 5 | 5,6 | 2,5,6 | 5,6 | Fourth |
| 6 | 5,6 | 2,5,6 | 5,6 | Fourth level |

Barriers at various levels are drawn to give structural model as shown in fig.1.

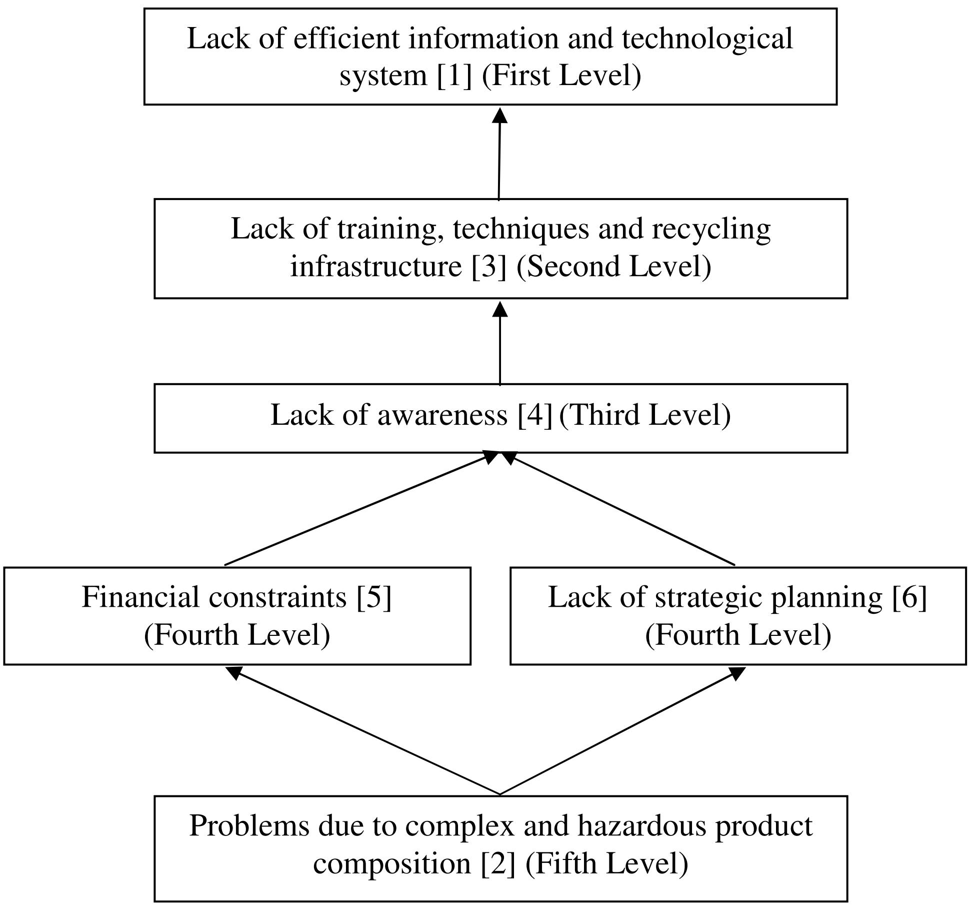


**Figure 1: ISM based structural model for e-waste management:**

***4.4 Developingconanical matrix and calculating driving power and dependence.***

A conanical matrix is obtained by putting together the factors which are in the same level across rows and columns. Table 10 shows the driving power and dependence of each factor. Driving power is calculated row wise by summing the total number of factors, including the factor itself, which it may help to achieve. Dependence is calculated column wise by summing the total number of factors, including the factor itself, which may help in achieving it.

**Table 10: Driving power and dependence in reachability matrix**

| Barriers | 1 | 3 | 4 | 6 | 5 | 2 | Driving power | Rank |
|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | V |
| 3 | 1 | 1 | 0 | 0 | 0 | 0 | 2 | IV |
| 4 | 1 | 1 | 1 | 0 | 0 | 0 | 3 | IV |
| 6 | 1 | 1 | 1 | 1 | 1 | 0 | 5 | III |
| 5 | 1 | 1 | 1 | 1 | 1 | 0 | 5 | II |
| 2 | 1 | 1 | 0 | 1 | 1 | 1 | 6 | I |
| Dependence | 6 | 5 | 3 | 3 | 3 | 1 | | |
| Rank | I | II | III | IV | IV | V | | |

## 5. ANALYSIS

It is done to identify the key factors that drive the system in various categories. Based on their drive power and dependence power, the factors, have been classified into four categories i.e. autonomous factors, linkage factors, dependent and independent factors. Figure 2 shows driving and dependence graph of all the factors which is used for their comprehensive analysis

**5.1 Autonomous factors:** These factors have weak drive power and weak dependence power. They are relatively disconnected from the system, with which they have few links, which may be very strong. In the present case of study barrier 4(Lack of awareness) falls in this category.

**5.2 Dependent factors:** These factors have weak drive power but strong dependence power Barriers 1(Lack of efficient information and technological system) and 3 (Lack of training, techniques and recycling infrastructure) fall in this category.

**5.3 Linkage factors:** These factors have strong driving power as well as strong dependence power. These factors are unstable in the fact that any action on these factors will have an effect on others and also a feedback effect on themselves. No barrier is present in this category. All the 6 barriers selected are not unstable.

**5.4 Independent factors:** These factors have strong drive power but weak dependence power. A factor with a very strong drive power, called the 'key factor' falls into the category of independent or linkage factors. Barrier 2(Problems due to complex and hazardous product composition), 5(Financial constraints) and 6(Lack of strategic planning) come under this category. A high priority in tackling the barriers, which have a high driving power and thus possessing the capability to influence other barriers, should be given which are shown at the upper level of the ISM

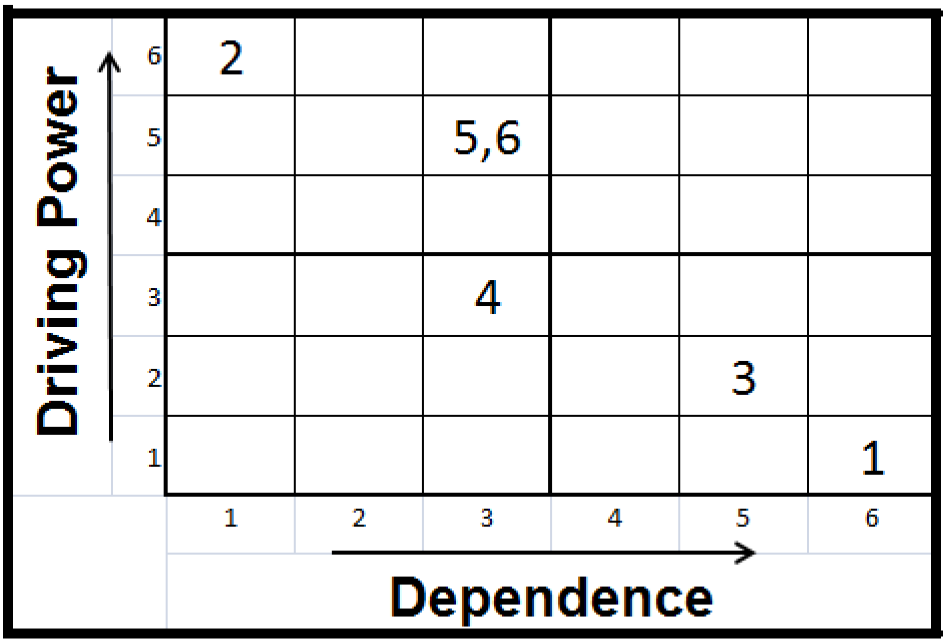


**Figure 2: Driving power and dependence graph**

## 6. CONCLUSION

A high priority should be given, to those barriers which have a high driving power and thus possessing the capability to influence other barriers. Barriers 2 (Problems due to complex and hazardous product composition),5 (Financial constraints) and 6 (Lack of strategic planning )are independent barriers, which are shown at the upper levels of the ISM andare the most important ones. It can be inferred that these are strong drivers and may be treated as the root cause of remaining barriers.There is only one barrier in autonomouscategory, Barrier 4. (Lack of awareness) and this has the least influence .No barrier is found under linkage element category possessing strong driving power and strong dependence. Therefore among all 6 selected barriers, no barrier is unstable. Barrier 1(Lack of efficient information and technological system) and3 (Lack of training, techniques and recycling infrastructure) are dependent barriers. They are identified by their weak driving power and hence are placed at initial levels of ISM model. They are influenced by all other barriers. A comprehensive strategic plan for e-waste management should be prepared keeping barriers 2,5and6, in highest importance level**.** The utility of the proposed ISMmethodology in imposing order and direction on the complexity of relationships among elements of asystem assumes tremendous value to the decision makers.

**Scope of further research**: In this research using therelationship model among the barriers of e-waste management has beendeveloped. But this model has not been statistically validated. Structural equation modeling (SEM), alsoreferred to as linear structural relationship approach, has the capability of testing the validity of suchhypothetical models. Thus, this approach can be applied in the future research to test the validity of this model.

## REFERENCES

[1] J.W.Warfield. "Developing *interconected matrices in structural modelling*." IEEE Transcript on Systems Men and Cybernetics vol. 4,No.1, 1974: 51-81.

[2] A.Mandal, S.G.Deshmukh. "*Vendor selection using interpretive structural modelling (ISM*)." Int. J. Oper.Prod.Manage.14(6), 1994: 52-59.

[3] Rajesh Attri, Nikhil Dev,Vivek Sharma. "*Interpretive Structural Modelling(ISM)approach:AnOverview."*Res.J.Management.Sci.,Vol.2(2), 2013: 3-8.

[4] Rolf Widmer, Heidi Oswald Krapf.Deepali Sinha Khetriwal,Max Schnemann,Heinz Boni. "*Global perspective on e-waste*." Environmental Impact Assessment Review *25*, 2005: 436-458.

[5] *E-Waste in India.* New Delhi: Rajya Sabha Secretariat,Research Unit(LARRDIS), 2011.

[6] *Methods to measure the amount of WEEE generated.* www.norden.org: temanord, 2009.

[7] *Discussion paper,International Telecommunication Union.* GSR,www.itu.int/08 e-waste, 2011 .

[8] Deepali Sinha Khetriwal, Philpp Kraeuchi,Markus Schwaninger. "*A comparison of electronic waste recycling in Switzerland and in India*." Environmental impact assessment review 25, 2005: 492-504.

[9] John Babington C, Chamhuri Siwar,Ahmad Farijm,Rawshan Ara B. "*Bridging the gaps:An e-waste management and recycling assessment of material recycling faciities in Selangor and Penag*." International Journal of Environmental Sciences Vol.1, 2010.

[10] Sifang Kong Liu, Hui Zeng,Yangsheng Liu. "*The status and progress of resourse utilization technology of e-waste pollution in China*." International conference on waste management and technolog;procedia environmental sciences,16. 2012. 515-521.

[11] Tanskanen, Pia. "*Management and recycling of electronic waste*." Acta Materialia *61*, 2013: 1001-1011.

[12] Hai-Yong kang, Julie M Schoenung. "*Electronic waste recycling :A review of U.S infrastructure and technology options*." Resource conservation and recycling *45*, 2005: 368-400.

[13] Joseph, Kurian. "*Electronic waste management in India-Issues and strategies."* Eleventh International Waste Management and Landfill Symposium. Sardinia, 2007.

[14] Agarwal, Ravi. "*E-waste law:New paradim or business as usual?*" Toxic links,http://www.toxiclinks.org.

[15] *E-waste assessment in India.* gtz,Bird, 2007.

[16] I.C.Nnorom, O.Osibanjo. "*Overview of electronic waste(e-waste)practices and their applications in the developing countries."* Resource,Conservation and Recycling *52*, 2008: 843-858.

[17] Lakshmi Raghupati, Christine Kruger,Ashish Chaturvedi,Rachna Arora,Mikael,P.Henzler. *E-waste recycling in India-Bridging the gap between the informal and formal sector. mait*,gtz,Adelphi.

[18] Deepali Sinha Khetriwal, Philipp Kraeuchi,Rolf Widmer. "*Producer responsibility for e-waste management*." Journal of Environmental Management *90*, 2009: 153-165.

[19] Martin Streicher -Porte, Rolf Widmer,Amit Jain,Hans Peter Bader,Ruth Scheideggar,Susanne kytzia. "*Key drivers of e-waste recycling system:Assessing and modelling e-waste processing in the informal sector in Delhi." Environmental Impact Assessment Review25*, 2005: 472-491.

[20] Mathew .J Realff, Michele Raymond,Jane C Ammons J. *"E-waste an opportunity*." *Materials Today vol. 7*, 2004: 40-45.

[21] V.Ravi, Ravi Shankar. "*Analysis of interactions among barriers of reverse logistics*." Technological forecasting & social change 72, 2005: 1011-1029.

[22] Yih.J-M and Lin, Y-h. "*An integration of fuzzy throry and ism for concept structure analysis with application of learning MATLAB.*" IEEE Computer Society Washington,vol.2, 2007.

[23] A.P.Sage. "*Intrpretive Structural Modeling forlLarge scale systems*." McGraw-Hill,New York.NY, 1977: 91-164.

[24] Lal, R.and Haleem,A. "*A structuramodelling for -governance service delivery in rural India."* Int.J.Electronic Governance,Vol.2.No.1, 2009: 3-21.

[25] Urfi Khan, Abid Haleem. *"Modelling of enablers using an integrated ISM and fuzzy MICMAC approach." Int.J.Intelligent Enterprise,Vol.1,No3/4.*, 2012: 249-269.