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RESEARCH ARTICLE

Environmentally Sustainable Governance Model to Improve the E-waste Management in Mexico City

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Abstract:

In this age of technology, where the use of this is excessive and its exponential growth has given rise to a series of challenges and opportunities caused by the accumulation of waste electrical and electronic equipment in Mexico City. For its treatment, more practical approaches have been necessary, taking into account proper management and long-term well-being as a main element of sustainability. The objective of this work is to propose sustainable initiatives based on social, economic and environmental dimensions, based on the challenges faced by waste management of electrical and electronic equipment as one of the fields that contribute to the transition towards a sustainable society. Data from each dimension were analyzed to extract the most relevant challenges by reviewing the literature and identifying sources that relate them to the life cycle of electrical and electronic waste. As a result, a governance model for waste electronic and electronic devices was obtained to support environmental sustainability that identifies lines of action for the effective treatment of waste electrical and electronic equipment highlighting awareness, education, knowledge and regulations as well as processes environmental. From this it is concluded that the governance of waste electrical and electronic equipment is mandatory for the integration of economic, social and environmental factors to efficiently leverage efforts on environmental care.

Keywords: Governance, Management, Waste, Sustainability, Environmental, Economic, Social

Introduction

The accelerated transformation of technological equipment, which if it is a useful product in a short time, becomes practically a waste, so that the life cycle of electrical and electronic products becomes increasingly shorter and, consequently, in a notable increase in the volume of waste of these products (1). Waste from electrical and electronic equipment (WEEE) or electronic waste (ewaste), are all electronic and electrical devices that are at the end of their life (2). And that somehow no longer satisfies the current owner for its original purpose (3). In such a way that, after having been reprocessed or innovated, at best, they no longer have feasibility or viability to make them produce any benefit, therefore they must be disposed of (4).

Considering that the deterioration of the environmental environment is at a risk stage, where by definition, sustainability is a development that meets the needs of the present without compromising the ability of future generations to meet their own needs (5). WEEE and its short-term negative impacts on environmental sustainability could become the main challenge of social responsibility (6). One of the reasons is that they are normally treated like any other solid residue, without paying special attention to their toxic nature (7). Therefore, it is extremely dangerous for humans and the environment if it is not disposed of properly or recycled (8). In this sense, proper management is vital to protect the fragile environment from improper disposal (9).

In this context, some companies around the world respond by adopting environmental management strategies, in which, sustainable efforts have focused, on the one hand, on the role of extended responsibility of producers, their environmental contribution to the product considers ecological practices since its manufacture until disposal at the end of its useful life. On the other hand, governments as local authorities around the world are in search of efficient processes of collection, treatment, recycling and disposal of rapidly growing waste in the form of safety for the environment and finally the consumer is in the process of development of awareness, knowledge, learning and availability to adopt sustainable practices regarding the acquisition and decision on the treatment at the end of the useful life of electrical and electronic devices. However, it is an issue that still cannot position itself as a valuable activity.

Taking into account the numerous risks of the exposure of WEEE to human health and the environment, it is very important to manage the improper disposal of WEEE (10). In this sense, WEEE governance is presented as a sustainable proposal itself that is in a transitional stage and considers that the key to success in terms of WEEE management is to develop ecological design devices, properly collect electronic waste, recover and recycle the material through safe methods, dispose of electronic waste through appropriate techniques, prohibit the transfer of used electronic devices to developing countries and raise awareness about the impact of electronic waste (11). Therefore, it could be deduced that environmentally sustainable governance is presented as an alternative to improve waste management of electrical and electronic equipment.

Literature review

Waste treatment of electrical and electronic equipment

Countries, regions and cities face real challenges in managing the increasing amounts of WEEE due to the consumer society and the globalization process (12). This incremental demand for electronics consumption combined with the tendency to replace unrecycled devices has created a new threat to humanity and the environment (13). Table 1 shows the trend of the generation of WEEE in the world.

Table 1: Global amount of electronic waste generated

Year	Electronic waste generated (Mt)	Population (billion)	Electronic waste generated (Kg / inh.)
2010	33.8	6.8	5
2011	35.8	6.9	5.2
2012	37.8	6.9	5.4
2013	39.8	7	5.7
2014	41.8	7.1	5.9
2015	43.8	7.2	6.1
2016	45.7	7.3	6.3
2017	47.8	7.4	6.5
2018	49.8	7.4	6.7

Source: (14) (p. 24)

Globally, 41.8 million metric tons of WEEE was generated in 2014. It is a fast-growing waste stream that needs special treatment and management due to the potential toxicity of public health and the environment (12). In this sense, it is worrying how the amount of WEEE is increasing and something more alarming is that these figures could be higher.

The main producers of WEEE have been grouped by continent, Asia being the main producer in 2014 with 40.7% of electronic waste worldwide, followed by Europe with 27.5%, America with 25.3%, Africa with 5% and Oceania with 1.6%(15).

According to the initiative to solve the problem of WEEE (StEP for its acronym in English), he predicted that by 2017, around 33 percent of more electronic waste will be produced in the world, or about 72 million tons (16).

On the other hand, the United Nations Environment Program (UNEP) reported that 20 to 50 million tons of electronic waste is generated annually worldwide.

Likewise, Waste Electrical and Electronic Equipment says that 40 million tons of WEEE is going to landfills worldwide. According to this organization, in 2018 50 million tons of this type of waste will be generated worldwide. Half of these are personal devices such as computers, screens, smartphones, tablets and televisions, while the rest are larger appliances and heating and cooling equipment (17).

The Forrester Research report indicates that, at the end of 2008, there were more than one billion PCs used worldwide, more than 2 billion systems are evaluated in 2015. It took 27 years to reach 1 one billion; however, it only took 7 more years to double that number (18). It is expected that by 2020 the number of PCs worldwide will grow to more than 4 billion, in the number of servers there will be a sharp increase in this figure to 122 million (19).

In this same understanding, the United Nations Organization (UN) in 2006 reported that the generation of electronic waste reached 50 million tons, which may increase by 65.4 million tons in 2017. On the other hand, the Organization (UNESCO) recognized that the problem of electronic waste poses the responsibility of political actors, businessmen and society. He also notes that Environmental education in schools is essential to raise awareness among students and their families to take responsibility for the waste they generate (20).

Known worldwide data and the negative impact that WEEE have generated to the environment, Latin America is presented with worrying data, it is estimated that of the 3.9 million tons of WEEE produced by Latin America in 2014 , Mexico was responsible for around 24%, surpassed only by Brazil, which contributed 36%. It is also estimated that in 2018 Latin America will produce 4.8 million tons of REE. Globally, the total in 2014 was just under 42 million and in 2018 50 million will be reached, growing at an average annual rate of 4 to 5% (21).

Waste electrical and electronic equipment in Mexico

In the case of the American continent, 25.3% of WEEE generated, the main producers of WEEE were the United States, Brazil and Mexico. Mexico is then the third generator of electronic waste in the Americas and second in Latin America only below Brazil, in 2016, Mexico produced 1Mt. and 8.2 Kg p / h ranking 13th worldwide (15). According to the National Institute of Ecology and Climate Change (INECC) of the Ministry of Environment and Natural Resources (Semarnat), in 2014 around 358 thousand tons of this type of WEEE were generated in Mexico, which gives us a 3.2 kg per capita indicator. INECC estimates that of the total WEEE generated in Mexico, only 10% is formally recycled, while 40% remains stored in residential homes and warehouses. The other 50% arrive at transfer stations or at the hands of informal recyclers (scrap metal), sanitary landfills or uncontrolled dumps (22).

In Mexico, WEEE collection and recycling programs are run by municipal or state governments, as well as private recycling companies. The companies dedicated to the recovery and recovery of materials carry out their collection through public programs. Small companies only recover some components for sale. In the informal sector this process is carried out by pepenadores and waste collectors. According to the International Labor Organization, the informal sector can develop legal activities, such as electronic waste management. The difference between the formal and informal sectors is that the latter does not pay taxes or contribute to the nation's social protection system (21). Another factor that significantly impacts Mexico is that only 19 of the 32 states have legislation on waste management. These states are: Aguascalientes, Baja California, Chiapas, Chihuahua, Federal District, Durango, Guanajuato, Guerrero, Hidalgo, Jalisco, Michoacán, Nuevo León, Puebla, Querétaro, Quintana Roo, Sonora, Tabasco, Tamaulipas and Veracruz (23).

In particular, in the Metropolitan Zone of the Valley of Mexico, consumers of electronic and electrical devices discard equipment that they no longer use as follows: 42% deliver them to the garbage truck, 30% give them away, 11% stores, and 17% sells them.

The INECC estimates that 13,216,422 appliances are generated in the Metropolitan Area of the Valley of Mexico, equivalent to 112,490 tons of this waste per year, which gives us an indicator of 4.7 kg * per capita. This represents 37% of the total electronic generated in the country (22). See table 2.

Table 2. Generation of WEEE in 2010 in the ZMVM

Electronic device	Generation (units)	Generation (tons)
TVs	2,944,865	65,376
Sound devices	1,466,800	7,334
Fixed telephones	1,752,857	1,227
Cellphones	5,150,000	515
Computers	1,901,900	38,038
Totals	13,216,422	112,490

Source: (22) (p. 1)

Based on the information collected on WEEE worldwide, giving a space related to the situation in Latin America and points out in Mexico and the metropolitan area of the Valley of Mexico, the following points describe the life cycle of devices electrical and electronic to then argue the challenges facing the management of WEEE.

Waste electrical and electronic equipment collection

Waste can be collected on site, or at an off-site recovery facility, or through the exchange between industry, this applies to both the formal and informal sector, where, on the one hand, efficient WEEE collection is a prerequisite for formal recycling and, on the other hand, due to certain economic and social reasons; Informal activities remain the dominant method for processing electronic waste in developing countries(24). In this sense, both the formal and informal sectors are described with their respective implications of their own operation.

Formal collection or structured sector

Formal companies are those that are registered and controlled by the government, are those that adhere to a set of standards for the treatment of WEEE and the payment of taxes (25). They are those that consider that efforts in the collection of organized WEEE are necessary to maintain sustainable quantities of discarded products and to implement profitable businesses of WEEE management and recycling centers (26). The formal sector has adequate equipment for transport and imported or self-developed technologies for the treatment of hazardous waste, such as incineration, pyrometallurgical technology and solidification (27). Therefore, formal processing prevents the release of pollutants and, in this way, provides environmental protections, so that encouraging formal recycling becomes necessary by using environmentally friendly operations and practices (13).

In order to strengthen the use of formal channels in Mexico City, the following centers are listed below for the proper treatment of WEEE:

- EcoAzteca | Wheat 93, Colony Farms Iztapalapa, Iztapalapa, CDMX.
- Friends of the Environment | San Antonio Extension 390, col. Minas de Cristo, Álvaro Obregón, CDMX.
- On Site Destruction Mexico S.A. from C.V. | Poniente 150 No. 677 a, Industrial Vallejo, Azcapotzalco, CDMX.
- E-Waste Solutions, S.A de C.V. | Doctor Ruíz No.25, Doctors, Cuauhtémoc, CDMX.
- EcoPoint | http://www.recallinternacional.com/acopia_donaciones.php
- Green Dot | https://www.recicladoraelectronica.com/contacto-reciclaje.html
- Recycling http://www.sedema.df.gob.mx/reciclatron/calendario.html # .VXHkyFyqqkp

Informal Collection or Unstructured Sector

The informal sector has developed a creative and flexible value chain capable of operating without subsidies; It has a highly developed, expanded and efficient collection network, ranging from the smallest capillary level of households and individual scrap collectors to large companies; It works with low operating costs and can use detailed and economical methods of manual disassembly; and possesses a practical knowledge of scrap values and market cycles (25). However, without adequate legislation and good infrastructure, these informal entrepreneurs who are part of unqualified and untrained individuals cannot become a profit institute (28).

As a consequence of these practices, informal activities can cause serious pollution to the environment. In addition, workers without protective measures face great health risks due to exposure to high levels of heavy metals and persistent halogenated hydrocarbons (24).

An important challenge for Mexico is the informal work associated with the recycling of WEEE detected in the states of Baja California, Jalisco, Mexico City and the State of Mexico, which must be addressed to avoid its negative impact on people and the environment (21).

Challenges facing sustainable dimensions applied to WEEE

The triple basis of sustainability provides a holistic vision to maintain the viability and integrity of natural ecosystems. However, for the challenges of proper WEEE management, it is necessary to balance social and environmental performance along with their economic performance, as well as their respective integration and interrelation, so that an alignment between sustainable dimensions is achieved (economy, environmental and social) with WEEE management based on governance. The above with the objective that we can identify and prioritize WEEE challenges for each dimension and, on the other hand, provide the necessary mechanisms to develop sustainable initiatives.

Environmental dimension applied to WEEE management

Sustainability pursues the objective of maintaining long-term well-being for the human being (29). In this sense, sustainable development implies an efficient consumption of resources in a limited and finite way (30). In this way, it allows generating a lasting performance in the activities of the organization (31).

The environmental protection and sustainability component seeks healthy ecosystems that can continuously provide critical products and services to human beings in the world and other organisms on earth (29). The environmental or ecological dimension is elaborated by the consumption of resources, which can be renewable and non-renewable, and the impacts on the ecosystem.

The main activities included in the environmental dimension are the efficient consumption of energy, the adequate disposal of toxic waste, the proper use of renewable energy sources and natural resources (31). In the context of ecological or environmental sustainability, three eco-motivators are identified as eco-efficiency, ecological equity and eco-efficiency(32).

Eco-efficiency refers to the ability of a company to offer products at competitive prices and services while progressively reducing ecological impacts.

Eco-capital focuses on "equal rights of people to environmental resources" and "Social responsibility of future generations" business.

Eco-efficiency, on the other hand, aims to stop pollution and depletion by directing individual and organizational attention to the underlying and fundamental factors of environmental problems through a fundamental redesign of the system.

In this order of ideas, WEEE management is a necessary challenge for sustainability and the analysis of the literature shows that there is a lack of operational indexes to measure and monitor the impacts related to the use of resources (33). The challenges facing the management of WEEE from the point of view of the environmental dimension start from two stages, the first is the constant growth of waste, and the second the complexity of the treatment in WEEE, the flow of waste is one of the more complicated due to the great variety of products of electrical and electronic devices in which their integration exposes their own difficulty and on the other hand the speed of technological innovations.

Table 3 shows the classification of environmental dimension challenges faced by WEEE management, mainly considering accelerated growth groups, lack of recycling culture and lack of processes.

Table 3: Environmental challenges of WEEE management.

	Challenges	WEEE Classification
1	Uncontrolled growth in information technology (IT) and the electronics industry, rapid innovation in technology to make a series of usable products and reduced life cycle of Electronic and Electrical Equipment (EEE) so it is obsolete in less time (16).	Accelerated growth
2	Lack of culture	Lack of culture
3	Multi-faceted WEEE manipulation processes (16).	Lack of processes
4	No fixed protocol worldwide for the management of electronic waste (16).	Lack of culture
5	Poor efficiency of collecting electronic waste from organizations (16).	Lack of processes
6	Lack of standards for electronic waste collection	Lack of processes
7	Generation of large volumes, great variety of products, lack of effective collection mechanisms (26).	Lack of processes

8	Necessary infrastructure and formalization of mechanisms have not been developed for the effective collection, recycling, and disposal of increasing amounts of electronic waste (26).	Lack of processes
9	Need for proactive strategic programs to establish the infrastructure for the management of EEE to control the magnitude of potential impacts on the world scale (26).	Lack of processes

Source: Own elaboration based on the cited authors

Social dimension applied to WEEE management

The social dimension can be considered as a support dimension that focuses on people and interest groups inside and outside the organization and management of social resources. Organizations follow the social dimension to improve the well-being of their employees and the wider community (31). The social dimension of sustainability includes the relationship between human rights and human development, corporate power and environmental justice (29).

With regard to WEEE management issues in the Metropolitan Zone of Mexico City, it is necessary to know the degree of understanding of consumers, manufacturers and the government itself to deal with electronic and electronic equipment at the end of its life cycle, of such that, to minimize the negative impacts caused by the lack of awareness and knowledge on the subject and at the same time understand to what extent sustainable policies on WEEE can be used and ensure its correct application. Awareness, knowledge and education on environmental issues play a key role in the treatment of WEEE when all parties interested in waste management such as the consumer, distributor, manufacturer and government contribute to changing consumption patterns during the cycle of elective and electronic equipment life. The main change is the environmentally sustainable behavior of individuals is a function of their attribution of individual environmental responsibility, which in turn depends on the relationships between man and the environment and the acceptability judgments and on general values (34).

In this regard, stakeholders should be motivated by the increase in environmental awareness rather than by mandatory regulations (35). Therefore, the absence of awareness and knowledge on the subject not only leads to greater impacts, but also does not help in the application of stricter policies for its control (36). That is, the absence of environmental policies and regulations negatively affects the waste management system, as citizens tend not to respond to weak regulations (37).

By considering the active participation of stakeholders relevant, the government can play a dynamic role by organizing campaigns, pilot projects, workshops and seminars to increase the level of household awareness (38). The government must prepare a plan for the collection and recycling of items urgently, as well as enforce manufacturers in product design, material use and sustainable business management. In this sense, manufacturers and importers are responsible for developing WEEE collection and recycling management systems based on the best available technology and financial capacity (38). Therefore, the producers of electrical and electronic devices that facilitate their products must be alerted to avoid contamination and reduce the consumption of resources and energy during each stage of the product life cycle through changes in the design and technology of process. WEEE Governance can stimulate greater awareness, improve credibility, corporate reputation, business development opportunities, facilitate dialogue and collaboration with stakeholders. Therefore, the ultimate goal of waste management of electrical and electronic equipment is sustainable development through the development of environmentally responsible products and product recovery (2).

Therefore, connecting the information learned to a sustainable vision of the future can bring organizations closer to addressing the many sustainability challenges (39). Likewise, prior knowledge and awareness can influence the participation of individuals in the adoption of environmentally sustainable work practices (40).

From the point of view of the social dimension, in which its focus is on people, interest groups, welfare, law and development, the challenges facing WEEE management are mainly the lack of culture and processes. Table 4 shows the classification of social challenges.

Table 4: Social challenges of WEEE management

	Challenges	WEEE Clasificación
1	Use of non-degradable components such as plastics, which reduces the price, but threatens the environment (16).	Non-degradable components
2	Need for financial support to design environmentally friendly products	Financial capability
3	Income by the consumer and the producer to support the cost of recycling the EEA.	Financial responsibility
4	The lack of government incentives (47).	Lack of processes
5	The willingness to pay by the consumer to carry out the recycling of their products at the end of their life cycle	Availability

Source: Own elaboration based on the cited authors.

Materials and methods

The research uses the knowledge process that begins with the observation of general phenomena in order to point out the particular truths explicitly contained in the general situation. It is quantitative and uses statistical methods to analyze the data and infers beyond the data, uses statistical inference procedures to generalize the conclusions of a sample to a defined population, is confirmatory and deductive.

Data collection

The research includes a population that has an executive participation on decision-making in the field of information technology and its treatment at the end of its life cycle, leveraging sustainable strategies in organizations in the Metropolitan Zone of Mexico City. A non-probabilistic sample is used in which the choice of the elements does not depend on the probability, but on causes related to the characteristics of the researcher or the one making the simple (48). The chosen instrument of data collection is the questionnaire, it is composed of 31 items and uses a 5-level Likert scale, where 5 is always and 1 never, its focus is directed to two main actors with similar characteristics: a) Executives business and operation areas and b) Executives of the Information Technology area. The questionnaire was made with the purpose of knowing the opinions in business and technology areas to identify the level of relation of information technologies with respect to the efficient treatment of technological equipment at the end of its useful life.

Data analysis

The research starts with the fact that if environmentally responsible governance is counted, the WEEE management would be improved. In this sense, the variable identified as independent, Environmentally Responsible Governance, consisting in properly implementing policies and controls based on institutional arrangements making integral use of its three main dimensions: 1- Environmental, considers that sustainability has been a form of Improve cooperation and brand value through influencing organizations' interest groups both in the context of the macro and micro environment (49). 2 - Social, focuses on sustainable achievement from a full awareness of all stakeholders, which implies knowledge and sense of environmental responsibility. 3 - Economic, its attention is in the generation of economic value from an alignment with environmental and social issues.

With respect to the dependent variable identified as Waste electrical and electronic equipment management, which consists of frames of reference on sustainable practices that for the purposes of the investigation the following three dimensions were taken into account: 1- Destination decision (Maintenance and reuse of equipment or waste), this is the most crucial phase of the life cycle of any electrical and electronic device. This is the moment when it is decided if you can repair for the second-hand market or will be considered as WEEE (50). 2- Treatment of WEEE, recycling can be defined as a system in which waste materials are collected, sorted and processed in a way that can be used in the production of different and new products (42). Reuse can occur in several ways. You could take stock of old equipment and find out if it contains components such as memory, power supplies and hard drives, which can be used to repair or upgrade other existing systems (51). 3- WEEE Collection, waste can be collected on site, or in an off-site recovery facility, or through the exchange between industry, this applies to both the formal and informal sector, where, on the one hand, the efficient collection of WEEE is a prerequisite for formal recycling and, on the other hand, due to certain economic and social reasons; Informal activities remain the dominant method for processing electronic waste in developing countries (24).

According to Hernández, et al. (2004) the first step for the analysis is the description of the data or values obtained by each variable. In this sense, the percentage reached of the independent variable was determined as the dependent variable with respect to the maximum possible score and levels of impact were obtained for each of them.

To process, tabulate and code the data obtained from the application of questionnaires, statistical functions were used. Likewise, we proceeded to review the capture of the information in order to detect the possible errors that could have been made during the transcription. Thus, a list of frequencies of each of the variables to be analyzed was obtained, and it was verified that their values were within admissible ranges. When coding errors were detected, the questionnaire to which said response belonged was identified and the relevant correction was made.

Therefore, to determine how the proposed control policies of environmentally responsible governance influence the WEEE management, based on the dimensions and indicators of the research, a matrix of components was developed which groups the Indicators based on statistical similarities that allow analyzing the results in large blocks, the percentage of efficiency was determined for each block where the minimum value is very poor and the maximum value is excellent.

From the large blocks and considering that the questionnaire was structured based on a Likert scale, we proceeded to identify in a particular way the factors that affect each thematic section using the Mendenhall severity index, where the formula for the calculation The index is as follows:

$$\mathbf{ISM} = \left(\sum_{i=1}^{N} ai * fa * 100\right) / 5$$

ai = value of each level of response according to the scale (a = 1,2,3,4,5).
fa = relative frequency of each level of response in the item.

In view of the fact that the calculation of the reliability was based on the iterítem values of the Pearson correlation coefficient (r). Which is described as a statistical test to analyze the relationship between two variables (49). The interpretation of the correlation coefficient in absolute values is shown in table 5.

Table 5: Interpretation scale for the correlation coefficient.

Value	**Meaning**
-1	Large and perfect negative correlation
-0,9 to -0,99	Very high negative correlation
-0,7 to -0,89	High negative correlation
-0,4 to -0,69	Moderate negative correlation
-0,2 to -0,39	Low negative correlation
-0,01 to -0,19	Very low negative correlation
0	Null correlation
0,01 to 0,19	Very low positive correlation
0,2 to 0,39	Low positive correlation
0,4 to 0,69	Moderate Positive Correlation
0,7 to 0,89	High positive correlation
0,9 to 0,99	Very high positive correlation
1	Positive correlation large and perfect

Source:(52)Correlation coefficient of Karl Pearson.
Recovered from http://repositorio.utn.edu.ec/handle/123456789/766

Table 6: Scale of interpretation of the coefficient of determination.

Value	Meaning
1.0000	Perfect determination
From 0.8100 to 0.9801	Very high determination
From 0.4900 to 0.7921	High determination
From 0.1600 to 0.4761	Moderate determination
From 0.0400 to 0.1521	Low determination
From 0.0001 to 0.0361	Null Determination

Source: (52) Correlation coefficient of Karl Pearson. Retrieved from http://repositorio.utn.edu.ec/handle/123456789/766.

Results

Total values of the instrument and determination of impact levels for each variable

The total values of the instrument comprise a total of 31 questions with a maximum value of 5 and a minimum value of 1, the total value of the sums is the result of multiplying the maximum value of each item (in this case 5) by the total of items by the total number of executives of business and operation areas and executives of the Information Technology area (21) which gives a total score of 3,255 which is the maximum expected value (see table 7).

Table 7: Percentage achieved by variables with respect to the maximum possible score.

Variables	Ítems	Items number	Maximum attainable value	Reached value	Percentage
Environmentally responsible governance	1-17	17	1,785	1,006	56
Waste of electrical and electronic equipment management	18-31	14	1,470	717	49
Total		31	3,255	1,723	53

Source: Own elaboration based on the answers of the executives and project leaders to the questions of the research instrument

From the previous table it can be seen that the environmentally responsible Governance presented a value closer to the maximum expected (56%) than the value corresponding to the WEEE Management (49%)

Because a Likert scale was used, the scores are added and analyzed by constructing the levels of the variable for this purpose (48). According to Padua (2001) the maximum score is obtained from the multiplication of the number of items by the highest score in each question and the minimum score from the multiplication of the number of items by the lowest score corresponding to each question.

With a maximum value of 5 and a minimum value of one, the total value of the sums is the result of multiplying the maximum value of each item (in this case five) by the total items. In the case of the independent variable, Environmentally responsible governance, it comprises a total of 17 questions, the maximum expected value is 85. With respect to the dependent variable, WEEE management, there are 14 questions, the maximum value expected in this case is 70 and as a minimum expected value is 14 (see table 8)

Table 8: Table 36: Maximum and minimum in Likert scale for each variable.

Variables	Items	Items numbers	Maximum value	Minimum value
Environmentally responsible governance	1-17	17	85	17
Waste of electrical and electronic equipment management	18-31	14	70	14

Source: Own elaboration based on data from the questionnaire

To establish the impact levels of the variable Environmentally responsible governance, the range (85-17) was determined, obtaining a total of 68 divided by the 5 categories, so the intervals would be 13.6 units. For the variable Waste management of electrical and electronic equipment, the range (70-14) was determined, obtaining a total of 56 divided by the 5 categories, so the intervals would be 11.2 units (see table 9).

Table 9: Independent and dependent level of variables.

Variables	Minimum-Very Low	Very Low-Low	Low High	High-Very High	Very high Maximum
Environmentally responsible governance	17-30.6	30.61-44.21	44.22-57.82	57.83-71.43	71.44-85.04
Result achieved			47.90		
Waste of electrical and electronic equipment management	14-25.20	25.21-36.41	36.42-47.62	47.63-58.83	58.84-70.04
Result achieved		34.14			

Source: Self made

Statisticians present an average of 47.90 for the variable Environmentally responsible governance and 34.14 for the dependent variable Waste electrical and electronic equipment management. Therefore, executives from business and operation areas and executives from the Information Technology area identify the level of high-low and Very Low-Low respectively.

In the case of the correlation in the research, the results show that environmentally sustainable governance and waste electrical and electronic equipment management have a moderate coefficient of 0.882, which implies a representative correlation between the two variables of the study.

Regarding the normal distribution analysis, we set the following:

H0: The data of the variables follow a normal distribution.
H1: Variable data does NOT follow a normal distribution.

If the P-Value or Significance is <than 0.01, "H0" is rejected
If the P-Value or Significance is> than 0.01, "H0" is Accepted

Based on the results in Table 10, it is observed that the P-value or significance is greater than 0.01, so the data of the variables follow a normal distribution. Therefore, the null hypothesis is rejected and we maintain the research hypothesis, which seeks the correlation between environmentally sustainable governance and Waste electrical and electronic equipment management.

Table 10: Normality tests

	Kolmogorov-Smirnova			Shapiro-Wilk		
	Statistical	Gl	Sig.	Statistical	Gl	Sig.
X	.169	18	.189	.863	18	.014
Y	.140	18	.200*	.968	18	.753

*. This is a lower limit of true significance.
to. Lilliefors significance correction
Source: self made.

The above is corroborated with Table 11, which shows the application of the Anova analysis, where the critical level (Sig.) P = .003 <0.05, we reject the null hypothesis and accept the research hypothesis and concludes that the variables are linearly related.

Table 11: ANOVA[a] analysis

Model		Sum of squares	Gl	Quadratic mean	F	Sig.
1	Regression	369.732	1	369.732	12.783	.003[b]
	Residue	462.768	16	28.923		
	Total	832.5	17			

a. Dependent variable: Y b. Predictors: (Constant), X
Source: Self made.

Coefficient of determination

The correlation coefficient squared (r2), the result indicates the variance of common factors. That is, the percentage of the variation of one variable due to the variation of the other variable and vice versa (49).

Based on table 12, a moderate determination can be observed where the environmentally sustainable government constitutes or explains 53% of the variation on waste electrical and electronic equipment management. Meanwhile, waste electrical and electronic equipment management account for 53% of the environmentally sustainable government.

Table 12: Correlations

		Independent	Dependent
Independent variable (Environmentally responsible governance)	Pearson correlation	1	.534*
	Sig. (bilateral)		.013
	N	21	21
Dependent (Waste of electrical and electronic equipment management)	Pearson correlation	.534*	1
	Sig. (bilateral)	.013	
	N	21	21

*. The correlation is significant at the 0.05 level (2 tails).
Source: self made

Rotated Component Matrix

The generation of the rotated component matrix consisted of reducing factors by selecting the 31 standardized items by highlighting the main components from a sedimentation graph and using the Varimax method as well as the loading method, the above sorted by sizes for correct interpretation. The 31 items were grouped into 9 components that have common factors and relationships. Table 13 Rotated component matrix shows the groupings.

Table 13: Rotating component matrix

	Component								
	1	2	3	4	5	6	7	8	9
Standards	0.868		0.168						-0.121
government	0.828				0.139		0.184	0.38	
Efficient	0.768		0.164		0.33	0.344	-0.117		
Awareness	-0.586	0.239	0.106		0.441	0.157	0.158		-0.335
Components	0.526	0.404	-0.104	-0.367	-0.239		0.459	-0.154	
Price	-0.238	0.783	0.111		-0.132			0.376	
Impacts		0.77	0.183	-0.212	0.309			0.145	
Destination		0.635	0.341	0.243		0.302	0.333	0.243	0.297
Value		0.623	0.206		0.493	-0.441	0.119		-0.178
Harvest	0.492	0.565	0.197	0.336	0.245				
Policies			0.762	0.366	0.27	0.169	-0.159		0.122
Contribution	0.386	0.132	0.727			0.295	0.154		
Bells	0.141	0.366	0.651	-0.213			0.262	0.266	-0.132
Maker		0.208	0.602	0.245		-0.353		0.379	
Channels		0.206	0.593	0.286	0.399		-0.197	0.312	
Incentives				0.893	0.194	0.114			0.188
Formal	-0.12	-0.115		0.879	0.102	0.11			
Provision	0.209	0.156	0.206	0.781	-0.174	-0.138			-0.329
Strategy		0.121		0.213	0.823		0.236	0.252	0.263
Suppliers	0.218	0.126	0.208		0.787			0.176	-0.184
Compression					-0.116	0.933			
Adoption	0.363		0.213	0.275	0.227	0.573		0.263	0.231
Established	0.148	0.519			0.263	0.521	-0.222	0.232	
Knowledge					0.29	-0.158	0.878		
Practices				0.128	-0.119	0.347	0.741	0.142	-0.375
Initiatives	0.445	0.16	0.431	-0.194	0.249		0.492	0.201	
Cooldown		0.169	0.104		0.141	0.131		0.844	
Utilization	0.176	0.387			0.318	0.157		0.737	-0.12
Consumer	0.158						-0.206		0.91
Innovations	0.287		0.495	0.243	0.169	0.231	0.217		-0.669
Processes		0.102	0.198	0.267	0.364		0.268	0.395	0.546

Source: Self made.

From the analysis of factors by component, the “Reuse” of waste electrical and electronic equipment is highlighted to extend its useful life with 23% usability classified as very poor. In this order of ideas, "sustainable processes", "Sustainable Standards" such as "knowledge" on the proper use of electronic waste, are deficient with 57.14%, 33.33% and 38.1% respectively, while the components " Awareness”, “Education” and “Sustainable Compression”, are in a regular state with 52.38%, 66.67% and 52.38% respectively, which represents a considerable increase in the identification of critical factors of electronic waste. Likewise, the “Availability of sustainable actions” of manufacturers and final consumers represents only 14.3% and finally the “Incentives” component is the only one of the 11 components classified as excellent with 28.57%. This component relates two factors. On the one hand, the convenience of offering incentives to end consumers seeking formal entities to process their electrical and electronic devices at the end of their life cycle and, on the other hand, to offer incentives to manufacturers who design products that respect the environment. ambient. Table 13 shows the detail of the items related by component with their respective evaluation.

Table 13: Matrix of components with usability values

INDICATOR		COMPONENT	VERY DEFICIENT	DEFICIENT	REGULAR	GOOD	EXCELLENT	TOTAL
Standards government Efficient	1	SUSTAINABLE PROCESSES	0	57.14	38.1	4.76	0	100
Awareness Components Price Impacts Destination Value Harvest	2	AWARENESS	0	14.29	52.38	33.3	0	100
Policies Contribution Bells Maker Channels	3	EDUCATION	4.76	14.29	66.67	9.52	4.76	100
Incentives Formal Provision	4	INCENTIVES	9.53	9.52	28.57	23.8	28.57	100
Strategy Suppliers	5	SUSTAINABLE STANDARDS	9.53	33.33	47.62	4.76	4.76	100
Compression Adoption Established	6	SUSTAINABLE COMPRESSION	0	19.05	52.38	28.6	0	100
Knowledge Practices Initiatives	7	KNOWLEDGE	0	38.1	38.1	23.8	0	100
Cooldown Utilization	8	REUSE OF COMPONENTS	23.81	23.81	38.1	14.3	0	100

Consumer Innovations Processes	9	AVAILABILITY ON SUSTAINABLE ACTIONS	0	9.52	76.19	14.3	0	100

Source: Self made.

Mendenhall Severity Index

Based on the responses of experts in the field of information and business technologies, the Mendenhall severity index was applied to the investigation with the purpose of highlighting, in order of severity, the factors that require attention and actions based on governance Environmentally responsible for improving the waste electrical and electronic equipment management.

In this sense, environmentally responsible governance aims to be a support to improve waste electrical and electronic equipment management, positively impacting the dimensions of effective WEEE collection, WEEE destination decisions and WEEE treatment. The foregoing, based on the materialization of established standards and practices; therefore, the integration of factors of the dimensions corresponding to environmentally responsible governance are required, such as: social, economic and environmental. Thus, this interaction allows, on the one hand, to obtain alternatives to implement mechanisms to regulate the generation, collection, storage, ecological recycling, treatment and safe disposal of WEEE. On the other hand, improve understanding and increase community participation. From the statistical results of the investigation, Figure 1 shows the proposed model with its respective sustainable dimensions and its main factors to face the challenges caused by WEEE.

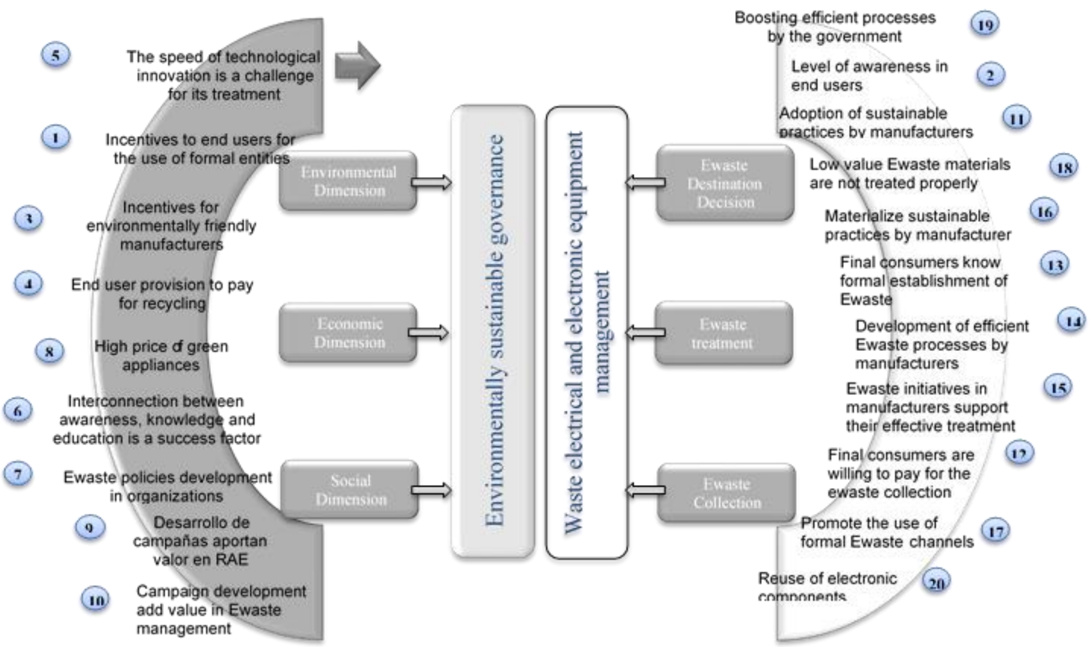

Figure 1: BARSAN - Environmentally sustainable governance model to improve the waste electrical and electronic equipment management

Derived from the complexity caused by facing the challenges caused by the lack of effective WEEE management, the implementation of environmentally sustainable governance results in a mandatory issue, it is vital to ensure compliance with the responsibilities of manufacturers, end users, organizations, companies and formal entities through sustainable processes from a holistic perspective.

From the moment that, education, knowledge and awareness as the main factors of the social dimension, are exercised in an active and constant way by the interested parties. In this sense, they can influence the achievement of the successful implementation of structured sustainable mechanisms that have a positive impact on the present without compromising the future.

From an economic point of view, the decision on how a waste will be treated will also depend on the factors of the economic dimension, financial responsibility and the availability of stakeholders so that the government can support sustainable policies and formal sectors or Structures of WEEE management, allow an opening on the extended responsibility of the producer and the consumer, the above so that the WEEE are managed at the end of their useful life correctly even when the cost for the process is absorbed by the producer himself or even by the consumer.

The development and implementation of initiatives supported by environmental dimension factors such as sustainable processes aligned to an environmental culture, are gaining credibility in stakeholders. Therefore, WEEE management is in a transition process. With regard to organizations, it is an issue that is taking relevance within its strategic plans; On the other hand, consumers have the possibility of using different sustainable alternatives to choose green products and, finally, producers are focused on green manufacturing, cleaner products and easy disassembly.

From the challenges facing WEEE management, it is clear that the WEEE governance effort not only lies in the proper treatment of electronic waste, spreading good and best practices as well as success stories through forums, pages web, awareness campaigns and other technological alternatives that may allow the world to know them, but also, that through a customization of the process on the proper treatment of WEEE, we can align and apply WEEE management strategies in organizations and which in turn allow to cover the needs of the country or region as much as possible.

Proper management of environmentally sustainable governance is key, therefore, sustainable decisions require that all evaluation criteria drawn from each dimension (green manufacturing, environmental culture, sustainable processes, availability and financial responsibility) be studied simultaneously, supported by awareness, knowledge and education about WEEE, so that the proposed initiatives make use of processes aligned to strategies to minimize negative impacts on the environment and supported by appropriate financial schemes to ensure that the generated WEEE is treated correctly through recycling operations, from collection to final recovery or disposal of materials.

Based on the aforementioned arguments and considering the relevance of establishing sustainable processes, developing an environmentally strong culture, establishing standards and regulatory frameworks and even implementing economic support for the design of effective electrical and electronic equipment, environmentally sustainable governance is presented as a proposal to improve the WEEE management.

Discussion

The participation of the manufacturers of electrical and electronic equipment with respect to the efficiency of the processes for the treatment at the end of its useful life has resulted in the contribution of said actor being deficient and limited. Even when the manufacturer is constantly searching for efficient processes on the proper treatment of WEEE of its own products, the effort to mature the process more rapidly has not been sufficient. In this sense, it is mandatory to make use of practices to carry out its end of the WEEE effective life cycle, the latter is shared by Debnath, Roychoudhuri (50) WEEE management must be stimulated. However, these initiatives do not guarantee the efficiency of the process alone, it is necessary to include collective strategies based on defined structures, these actions demand the participation of other entities.

For Tansel (26) The development of effective and proactive WEEE management programs requires the active participation of stakeholders and companies that are involved in the manufacture and distribution of products and collection and processing of WEEE. In the same order of ideas, Garlapati (2) goes beyond the implementation of programs, believes that those involved in the use of electrical and electronic equipment require training on waste reduction programs in the domains of process operations and use of material, safety guides, inspection and supervision of waste materials (2).

Therefore, a key piece to make the WEEE process efficient is the active participation of the government, in such a way that, based on policies and standards aligned with institutional standards, the initiative for efficient processes in the treatment of WEEE can be leveraged. Consistent with the above, Sarah and El-Houssaine (53) determine that governments, municipalities and technical experts should be incorporated. In addition, the development of sustainable standards and frameworks is presented as a proposal to facilitate the application of processes and address environmental challenges. Zhong and Huang (54) consider that recycling should be analyzed differently, including laws and regulations related to the recycling of electronic waste and for its part Singh, Li (55) proposes that from policies, it is possible to establish directives on WEEE and restriction of certain Hazardous substances. The effort of effective processes on the treatment of waste electrical and electronic equipment requires an alignment of the different entities involved and an active participation of stakeholders, highlighting the commitment and availability to materialize sustainable practices from environmentally sustainable governance.

Developing efficient processes on the treatment of WEEE is an important step. However, it is not the only thing to take into account, the awareness of every individual, organization and government applied to electrical and electronic devices from its creation to its final treatment, determines the degree of flexibility to carry out sustainable practices. On the one hand, WEEE treatment requires that end users develop the ability to apply and propagate that electrical and electronic devices can in no way be treated as any item considered waste. In this sense, Debnath, Roychoudhuri (50) believes that each individual should be aware of how to classify and dispose of WEEE. On the other hand, manufacturers from the conception of different electrical and electronic devices need to consider practical materials to disassemble and recycle as much as possible.

Based on the foregoing, Davis and Garb (25) go beyond the mere fact of raising awareness in their production, they consider it relevant to require producers to buy back the products at the end of their useful life at a price that would exceed those offered by vigorous informal collection networks (25). As a result of the research and with the purpose of aligning the commitments of end users as of the producers in the same sustainable cause, it is that the producers label their products that identify them as products with special treatment at the end of their useful life, To Bekaroo, Bokhoree (56), The WEEE label indicates that such products cannot be disposed of as normal waste, but must be treated for environmentally sound disposal. With respect to the commitment of the end user, its responsibility lies then in communicating to the manufacturer that the product purchased has reached its end of life and requires to be treated with spatial standards by the producer itself or by formal sectors which would imply paying by part from the manufacturer, and / or consumer to carry out the waste treatment.

Conclusions

The research work showed how environmentally sustainable governance is a change agent that benefits the waste electrical and electronic equipment management from the impulse of proposals, improvement of its own usability and considers strategic lines where its effort is focused on environmental care and supported by the principle of maintaining a more sustainable environment, which means initiatives that become self-sufficient after an initial investment.

Regarding the value of environmentally responsible governance, it is an issue that has not yet been consolidated in organizations, due to high costs, lack of knowledge and lack of support from the government itself and even due to social acceptance issues. It is clear that these challenging conditions that exist for their adoption will be weakened as economic openness, knowledge and awareness for environmental care increase, so that good practices for WEEE management are known in a way global for its correct implementation and enhance collective value.

A greater awareness of manufacturers, consumers and the government itself, about the negative effects of waste of electronic and electronic devices, could have a healthy effect on the ways that organizations do business, consumers acquire their products and the government implements and execute its sustainable policies. Therefore, what is needed is to develop knowledge about waste electrical and electronic equipment and a sense of environmental responsibility.

The present work can serve other researchers to analyze on the one hand the challenges in the adoption of waste electrical and electronic equipment management, such as, poor culture in recycling, lack of effective recycling processes, poor awareness, knowledge and education as well as poor manufacturing of electrical and electronic products with sustainable principles, to then determine leverage strategies in a more effective way in environmental care efforts.

Finally, formal recycling has required metrics and monitoring on the impacts related to the use of resources, considering the life cycle of waste electrical and electronic equipment, so that the operational indexes obtained provide a much broader picture on WEEE management and the efficient application of important factors of sustainable dimensions. In this way, the contribution to face the challenges caused by the waste of electrical and electronic equipment has consisted of the integration of socially responsible mechanisms, aligned with the effort to minimize environmental damage through an economically attainable transformation.

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