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RISK ANALYSIS OF E-WASTE HANDLING AND DISPOSAL. CASE OF MUSANZE DISTRICT SCHOOLS

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Abstract

This study entitled "Risk analysis of e-waste handling and disposal. A case study of Musanze district schools" it was conducted to assess three research objectives such as: to find out different forms of e-waste available in Musanze District Schools, to assess the methods and all forms of e-waste handling and disposal in Musanze District Schools, and to evaluate risk associated with e-waste handling and disposal in Musanze District. To achieve these objectives, the researcher has used primary data collected from a sample of 95 staffs (30 staffs of Tertiary education institutions, 54 staff of secondary schools and 11 staff of TVET centers working in Musanze District). The researcher has adopted purposive sampling and after data collection and data processing, the researcher has used Statistical Package for Social Sciences (SPSS) version 20 for data analysis. Study findings shows that, Musanze district schools generate different 10 forms of e-waste but not the same quantity. These forms are major appliances, small appliances, lighting devices, computers and telecommunication wastes, electric and electronic devices, toys, medical and laboratory equipment's wastes, Musanze District schools are not well coordinated for e-waste separation, collection, and transportation to prepared landfill. Schools are treating all waste together within a non-prepared landfill, a little improvement are only in schools located in City. In other case findings shows that, poor handled e-waste causes environmental, economic and life risk. These risks are associated to soil acids and degradation, contamination of plants and human or animal livings and life risk for children or other people approaching poor handled or disposed e-waste. Findings confirmed by the Bivariate analysis results shows that e-waste handling and disposal contribute 22.2% to e-waste handling and disposal risks. Meaning that 77.8% is generated by other factors not associated or covered by this study objective. Based on the study findings, the researcher suggests several recommendations to the district officials and Musanze District schools. Thus, the researcher recommends both schools and District official to develop a mechanism for e-waste collection, transportation, and disposal with respect of the modern technology for ensuring that life, economic and environmental risks are minimized. They are recommended to use big containers for stocking e-waste. They were also recommended to ensure waste separation by types, and to work with waster collectors and recyclers in the country (Rwanda).

Key words: *Risk Analysis; E- Waste Handling; E-waste Disposal.*

1. Statement of the problem

Each year more than 10,000 tons of e-wastes are generated in Rwanda [31]. Life of computers is less than 3 years, and most of schools are using computers more than 10 years which also bought as after 3 years of use, this is a big problem to people themselves and environment [20]. Musanze District schools use different electronic tools (printers, telephone, computers, lamps, cables, generators, etc) like other schools in the world [25]. As communicated by the district authority (in charge of infrastructure development) there is no mechanism in district schools for e-waste handling or recycling. E-waste in all schools is handled and treated as the made for other forms of waste [1].

The significance of this study is to assess the forms of e-waste generated, way e-wastes are managed (handling and disposal) and the associated risks to schools in Musanze [32]. Reference to the regulation no 002 of 26/04/2018 governing e-waste management in Rwanda [26], there was recommended to all companies including schools using electrical and electronic materials to ensure that used electrical and electronic equipment are disposed off and negotiated by a licensed e-waste dismantler and licensed companies [17]. But from the period the regulation published till 2019 (last year of study period) there is no active company in Musanze which could facilitate or operate in e-waste handling [5]. While risks of the used e-materials remain affecting the environment [27]. This study was also designed to provide a conclusion and make suggestions for further improvements for e-waste handling and disposal in Musanze district and in the country (Rwanda) [29] Once e-waste is well treated, people's health will be secured, environment secured, and soil protected against pollution [13].

2. Empirical review

The study on E-waste and Environmental Degradation [44] shows that: The industrial advancement made by man has generated huge quantity of solid and liquid wastes; the high-tech boom has given rise to a new type of waste called "Electronic waste or Electronic waste or E-waste" [4]. The E-waste or electronic waste in the terms used to discarded electronic gadgets like computers, TV, mobile phones, fax machines, audio equipment, refrigerators, etc [30]. The amount of e-waste generated annually is not known precisely because of adverse publicity with respect to environmental problems and today a huge of quantity of e-waste is generated because of the purchasing power of the consumers, resulting in buying advanced models, which the manufacturing market discarding the old technology and when products life is over [44].

[7] were studied "Environmental Impact of Processing Electronic Waste Key Issues and Challenges" and the results show that: Extensive utilization of electric and electronic equipment in a wide range of applications has resulted in the generation of huge volumes of electronic waste (e-waste) globally [28]. Highly complex e-waste can contain metals, polymers, and ceramics along with several hazardous and toxic constituents [24]. There are presently no standard approaches for handling, dismantling, and the processing of e-waste to recover valuable

resources. Inappropriate and unsafe practices produce additional hazardous compounds and highly toxic emissions as well [7]. According to [18] discarded electronic goods contain a range of toxic materials requiring special handling. Developed countries have conventions, directives, and laws to regulate their disposal, most based on extended producer responsibility. Manufacturers take back items collected by retailers and local governments for safe destruction or recovery of materials [15]. Compliance, however, is difficult to assure, and frequently runs against economic incentives. The expense of proper disposal leads to the shipment of large amounts of e-waste to China, India, Pakistan, Nigeria, and other developing countries [19]. Shipment is often through middlemen, and under tariff classifications that make quantities difficult to assess [10].

There, despite the intents of national regulations and hazardous waste laws, most e-waste is treated as general refuse, or crudely processed, often by burning or acid baths, with recovery of only a few materials of value [35]. As dioxins, furans, and heavy metals are released, harm to the environment, workers, and area residents is inevitable [18]. The faster growth of e-waste generated in the developing than in the developed world presages continued expansion of a pervasive and inexpensive informal processing sector, efficient in its own way, but inherently hazard-ridden [3].

3. Conceptual Framework of the Study

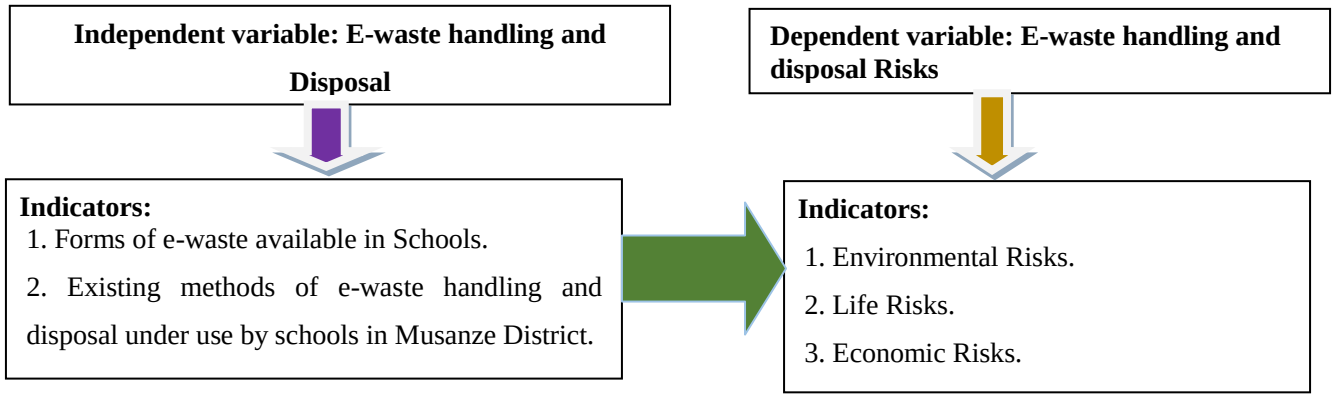

Figure 1: Conceptual Framework of the Study

As seen in figure 1, e-waste poor handling and deposit cause hazards to environmental and health [43]. The analysis of these risks should be contributing to the proper methods, technology and practices of e-waste handling and disposal by creating proper landfill or deposit site, proper scheme of e-waste collection, transport from providers (schools), e-waste separation by forms or from other wastes, e-waste re-use policy and technologies, e-waste recycling technology and other policies for e-waste handling and deposit applicable in Musanze District [11]. All these practices and policies for e-waste handling and deposit should be also resulted from its costs implication and selection of electronic materials should be made after analysis of the implication of its waste after use.

4. Methodology

This study was descriptive and correlational design. It intends to describe the risk analysis practices for e-waste and e- waste handling and disposal measures in practices by schools in Musanze district and assess causal relationship between e-waste risk analysis and e-waste handling and disposal [47]. The target population of the stud were 1,960 divided into 620 staffs from tertiary education institutions, 1,112 staffs from secondary education, 228 staffs from TVET centers, 77 Employees on 2 Musanze Landfills in Musanze District [36]. As population seems to be large the researcher has assessed only 95 proportionally distributed sample size. Data collection was made using questionnaire, interview and documentation and findings were interpreted as mean, standard deviation, and Pearson correlation (r) which range from -1 to +1 and this is statistically significant at 95% [39].

5. Objectives of the study

The main objective of this study is to assess the risk analysis of e-waste handling and disposal in Musanze District Schools. And specific objectives were defied as follows:

1. To find out different forms of e-waste available in Musanze District Schools.
2. To assess the methods and all forms of e-waste handling and disposal in Musanze District Schools.
3. To evaluate risk associated with e-waste handling and disposal in Musanze District.

6. Hypothesis of the study

The study intends to test the validity of the following hypothesis:

H_0: There are no risk associated with e-waste handling and disposal in Musanze District Schools.

7. Findings of the study

7.1 Risk analysis with reference to the forms and methods for e-waste handling and disposal in Musanze District Schools

Schools in Rwanda are using different forms of electronic materials which letter after use they become waste which need to be handled carefully for the sake of human health and environment health [34]. It was found that each school in Musanze district has e-waste. The results again show that, each school has its own way of handling e-waste however it is not clear and defined from methods used while handling other types of wastes [40]. At district level, there is also no clear mechanism or coordination for school's e-waste collection, transportation, and stocking.

Table 1: Risk analysis from the available e-waste forms in schools of Musanze District

Risks associated to forms of e-waste available in schools	M	Stdv.	Risk level
Type 1- Major appliances (refrigerators, washing machines, dryers etc.)	2.18	0.967	Medium

Risks associated to forms of e-waste available in schools	M	Stdv.	Risk level
Type 2 – Small appliances (vacuum cleaners, irons, blenders, fryers etc.)	2.41	1.096	Medium
Type 3 – Computer and telecommunication appliances (laptops, PCs, telephones, mobile phones etc.)	3.88	0.977	High
Type 4 – Consumer electronics (video and audio equipment, musical instruments)	2.28	0.821	Medium
Type 5 – Lighting devices (incandescent light bulbs, fluorescent tubes, gas-discharge lamps etc.)	3.92	0.739	High
Type 6 – Electrical and electronic tools (drills, saws, gardening devices etc.)	3.33	1.066	High
Type 7 – Toys, leisure (electronic toys, models, sports equipment)	3.08	1.285	High
Type 8 – Medical devices (all medical equipment except for implants)	2.14	0.662	Medium
Type 9 – Monitoring devices (detectors, thermostats, laboratory equipment etc.)	4.02	0.956	Extremely High
Type. 10 – Vending machines	1.60	0.817	Low

As seen from table 4 level of risk was rated based on the categories defined in table 2. From all forms of e-waste assessed in Musanze District schools the lowest mean is 1.60 (observed on e-waste type 10) and the highest mean is 4.02 (observed on the e-waste type 9), meaning that, the type with lower mean is less available and that with higher mean is frequently available in Musanze District schools. The researcher rated risks level based on the availability of e-waste form in more schools not based on the technical risks which may be generated by the e-waste form to the environment [33]. Thus, from Musanze District school's e-waste type 9 is with extremely high risk. Type 9 was dominant since in almost schools, they have laboratory for O' level and A' level students and the materials are mainly damaged by students during studies. Type 3; 5; 6 and 7 were observed with high risk level from schools in Musanze District. This is due to that fact that, students, and teachers in schools (secondary schools and higher learning institutions) need materials which after use produce this e-waste because they are necessary for learning and teaching process and practices. E-waste type 1; 2; 4 and 8 were rated medium risky as they are not frequently available in schools of Musanze District. Type 10 was observed with low risk as seems to be not available in many schools of Musanze District. Meaning that, more attention could be taken because as technology advances and education adopt technology-based learning system, more electronic materials are bought but schools, students and teachers and soon will be transformed into e-waste which could be associated to the proper measures for handling. Proper measures for handling e-waste play a role as a tool for minimizing and limiting risks which could be caused by e-waste. The researcher has found that, e-waste in schools of Musanze District is not treated separately from other forms of waste, and this is dangerous to environment.

Currently each e-waste form can generate several forms of risks (environmental, life and economic risks) based on its technology made from. However, this study, focus on the frequency of e-waste availability on schools. The e-waste generated by schools are exposed to the children (street children who wish to sell waste to the metal waste collectors and children passing or students in the entire schools where waste are generated from), create air and water toxication or pollution, and soil pollution while later affect both plants and all other

people categories. E-waste not handled properly also lead to some illness like cancer and other poor sanitation illness [38].

Table 2: Analysis of e-waste risks based on the methods of handling and disposal used in Musanze District Schools

Risks associated to poor use of methods of e-waste handling and disposal	M	Stdv.	Risk level
a) After use of electronic material, the e-waste is given back to the electronic companies or dropped in Off Points	3.00	0.875	High
b) Visit civic institution	2.72	0.919	High
c) Donating Your Outdated Technology	2.46	1.27	High
d) Musanze district has operating or a plan for e-waste recycling project and technology	3.43	0.907	Medium
e) Sell Off Your Outdated Technology	4.13	0.334	Low
f) Musanze District has specific for electronic materials and e-waste management or if Musanze has any national or international measure in use	3.84	0.734	Medium
g) Give Your Electronic Waste to a Certified E-Waste Recycler	2.69	1.063	High
h) Musanze District has a coordination scheme of e-waste from schools and make them deposited in prepared landfill	3.51	1.11	Medium
i) Each school separate e-waste by e-waste forms and treat each form or type in separate way based on the effects to human life or environment	3.29	1.009	Medium
j) At landfill sites there are employees in charge of waste separation, handling with equipped	3.55	0.561	Medium
k) Musanze District has a prepared e-waste landfill or deposit site where all schools are depositing their e-waste	3.85	0.668	Medium
l) Musanze District has policy and project of e-waste recycling and use for other purposes	3.28	0.767	Medium

As seen from table 12, which clarify best methods of e-waste handling, it is observed that poor respect of these methods is associated to high risks and once a method is well ensured reduces risks which associated to the e-waste ensured poor handling methods. None could be disagree that, once e-waste is well handled, they could be no risks or low as possible risks to environment [22]. The study findings (assessment from respondents) show that, the lowest mean from all methods assessed is 2.46 (Donating Your Outdated Technology) which associated to high risk as people stay using or reject the outdated technology in place of donating it to other users who could maintain it or recycle and the highest mean is 4.13 (Sell Off Your Outdated Technology) where people like to sell the technology outdated and this is also among methods for e-waste handling as the buyer recycle the technology or make it improved and ensure that, the e-waste are well kept. The problem (high risk) was found to the fact that, in Musanze District schools there is no way to take back used materials to the producers (since most e-materials used were not supplied from original producing company but from the secondhand resellers) and there is no licensed company for collecting e-waste.

Currently there are scientific and social methods for e-waste handling and disposal as defined in table 5. Proper respect of these methods leads to reduced risks associated to the poor e-waste handling and disposal and vice versa. Once e-waste is not recycled, not disposed in containers or other prepared places, not returned to the

producers are poorly distributed in the places where people are passing, animal passing, in the environment where plants are growing and where also soil, and water need protection. Poor treatment of e-waste also leads air pollution mainly chemical e-waste, thus the vulnerable people to this are children learning in schools where e-waste is poorly disposed, children in the centers around these schools and waste collectors also as well as other people with contact to the rea where e-waste were poorly disposed [41]. The effects will be soil degradation, air and water pollution, health issues and poor plants production and generally we can say that it will result into environmental degradation.

7.2 Risk associated with e-waste handling and disposal in Musanze District.

Poor handled e-waste causes several risks to environment, human and animals and affect economy of the area or the country [38]. Here below are the perceptions of respondents (schools' staffs in Musanze district) on the risk associated to e-waste handling and disposal in Musanze District mainly when they are poor handled:

Table 3: Risk associated to e-waste handling and disposal in Musanze District.

Risk associated to e-wise poorly handled	SA		A		N		n	M	Stdv.
	fi	%	fi	%	fi	%			
Environmental risk									
E-waste cause soil degradation by creating acids which may kills soil nutriments everywhere handled or disposed on Musanze District soil.	28	29.5	67	70.5	0	0	95	4.29	0.458
E-waste cause water pollution in Musanze District based on inputs used to create the nature of electronic materials which used.	15	15.8	76	80	4	4.2	95	4.12	0.434
Life risk									
E-waste cause contamination of plants	4	4.2	87	91.6	4	4.2	95	4	0.292
E-waste cause death of some small insects and animals necessary for plant decomposition and for human living.	22	23.2	70	73.7	3	3.2	95	4.2	0.475
E-waste distributed everywhere cause problems to the children and or other people while working in the place where distributed.	11	11.6	70	73.7	14	14.7	95	3.97	0.515
Economic Risk									
Poor recycling of e-waste is economic loss as cause to buy new materials and increasing e-waste.	0	0	81	85.3	14	14.7	95	3.85	0.356
Buying secondhand materials is not economic efficient as costs more in reparation and increase e-waste handling and disposal costs.	18	18.9	66	69.5	11	11.6	95	4.07	0.55
E-waste increases maintenance costs within schools and the country in general.	0	0	84	88.4	11	11.6	95	3.88	0.322

Source: Primary data, October 2020

Table 6 show that poor e-waste handling cause risk to life, economy, and environment. From 95 assessed respondents it is confirmed that e-waste cause soil degradation by creating acids which may kills soil nutriments everywhere handled or disposed on Musanze District soil (29.5% SA and 70.5% A), e-waste cause water pollution in Musanze District based on inputs used to create the nature of electronic materials which used (15.8% SA, 80% A and 4.2% N).

For life risks caused by poor e-waste handling in Musanze district schools, respondents confirm that e-waste cause contamination of plants (4.2% SA, 91.6% A and 4.2% N), e-waste cause death of some small insects and animals necessary for plant decomposition and for human living (23.2% SA, 73.7% A and 3.2% N) and e-waste distributed everywhere cause problems to the children and or other people while working in the place where distributed (11.6% SA, 73.7% A and 14.7% N). For economic risks associated to e-waste handling it is confirmed that poor recycling of e-waste is economic loss as cause to buy new materials and increasing e-waste (85.3% A and 14.7% N), buying secondhand materials is not economic efficient as costs more in reparation and increase e-waste handling and disposal cots (18.9% SA, 69.5% A and 11.6% N) and E-waste increase maintenance costs within schools and the country in general (88.4% A and 11.6% N). As described in table 6, the researcher was looking whether school's management and staffs knows the negative effects of poor e-waste management. This is because once they are aware about the negative effects (both life risks, environmental risks, and economic risks), they should take measures for preventions (means they could ensure proper measures for e-waste handling for example 3Rs (Reduce, Reuse and Recycle) [14].

7.3 Test of study hypothesis

The test of study significance was made using Bivariate test of significance [17]. This results from Pearson correlation (r) and significance two tailed (Sig. (2-tailed)) and this section present hypothesis test results:

Table 4: Descriptive statistics

	Mean	Std. Deviation	N
E-waste handling and Disposal	3.3131579	.32880699	95
E-waste handling and disposal Risks	3.8000000	.17576827	95

Table 7 show a mean of the mean of 3.3 for independent variable (moderate mean category), and 3.8 for dependent variable (category of high mean) and for independent variable standard deviation is 0.3 (which falls in homogeneity category) and for dependent variable standard deviation is 0.1 which falls in category of homogeneity. Homogeneity standard deviation signify low variability of values from the mean [37].

Table 5: Correlations

Tested variables		E-waste handling and Disposal	E-waste handling and disposal Risks
E-waste handling and Disposal	Pearson Correlation	1	.222*
	Sig. (2-tailed)		.031
	N	**95**	**95**
E-waste handling and disposal Risks	Pearson Correlation	.222*	1
	Sig. (2-tailed)	.031	
	N	**95**	**95**

*. Correlation is significant at the 0.05 level (2-tailed).

As seen from table 8, test of hypothesis using Bivariate analysis has shown a Pearson correlation of 0.222 and Sig. (2-tailed) is 0.031. The r or Pearson correlation falls in the category weak correlation but positive and Sig. (2-tailed) falls in statistical significance as it is less than 0.05. Based on the study findings, the researcher failed to reject the null hypothesis in favor of alternative hypothesis. And confirmed that e-waste handling and disposal is statistically significant to risk associated to e-waste handling and disposal. Means that poor e-waste handling and disposal result risk to environment, life, and economy.

8. Conclusion

This study was conducted for assessing the validity of the null hypothesis stating that "H_0: There are no risk associated with e-waste handling and disposal in Musanze District Schools." And study analysis shows that there are economic risks, environmental and life risks associated to poor e-waste handling and disposal by Musanze District schools. In other case, e-waste handling and disposal is statistically significant to risk associated to e-waste handling and disposal. Means that poor e-waste handling and disposal result risk to environment, life, and economy. Those are confirmed by the Bivariate analysis results shows that e-waste handling and disposal contribute 22.2% to e-waste handling and disposal risks. Meaning that 77.8% is generated by other factors not associated or covered by this study objectives.

9. Recommendations

Based on the study findings, the researcher suggests recommendations to the district officials, Musanze District schools. Musanze town is the secondary city of Rwanda, the waste management plan and tools like prepared landfill and waste recycling policies are necessary to make this city clean. Waste handling and disposal could not be limited in town only but to all territory of this district. As seen from findings, schools in Musanze District are using old electronic materials bought as second hands, students in schools are distributing in improper way the used electronic materials and schools do not have prepared landfill or there is no coordination between schools for e-waste separation from other forms of wastes, handling, and disposal each school is doing its own arrangement. Thus, the researcher recommends both schools and District official to

develop a mechanism for e-waste collection, transportation, and disposal in prepared landfill for ensuring that life, economic and environmental risks are minimized.

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