Development of a Framework for Household Solid Waste Management in an Urban Locality

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Abstract

Solid waste management is one of the leading problems to date as humanity strives to create and manufacture products to meet our most basic life demands. Because of inappropriate dumping and lack of awareness of households, there have been misconceptions about the practices of solid waste management. The key causes of the improper management of solid waste are the lack of financial management and logistics, the lack of municipal facilities, the lack of land use planning, the lack of consideration for basic aesthetics and industrial and commercial development, as well as attitudes and socio-cultural practices. The lack of solid waste management can be due to a variety of factors, it is important to stress the role of community constituents, their behaviors, their waste management activities, and their relationships with other players of the waste management system, since they are the key users of waste management facilities.

Using a framework, this study shows different solutions to improve household solid waste management. The framework covers three main priorities for household solid waste management namely (1) raising awareness on solid waste management policies, (2) improving and encouraging proper solid waste management, and (3) resolving problems on solid waste management that concern households.

Keywords
Household Solid Waste Management, Framework, and Cross-Sectional Research.

1. Introduction

Solid waste management is a critical resource in every community. Solid waste refers to the processing of waste products from animal and human practices which are disposed of as discarded and unnecessary. Solid waste is produced from manufacturing, residential and commercial practices in a given area and can be treated in a number of ways. Waste can be categorized on the basis of materials such as plastic, paper, glass, metal and organic waste. The classification can also be dependent on potential hazards, including radioactive, flammable, infectious, dangerous or non-toxic waste. Categories can also apply to the origins of the waste, whether industrial, household, commercial, institutional or construction and demolition. The scope of solid waste management includes strategy, management, financing, technical and legal functions. Solutions may include a number of interdisciplinary collaborations between fields such as public health, urban and regional planning, political science, geography, history, economics, communication and conservation, demography, engineering and material sciences. Solid waste management practices can differ for both domestic and industrial producers, urban and rural areas, and developed and developing countries. The handling of non-hazardous waste in urban areas is the responsibility of the local government. In the other hand, the management of hazardous waste resources is usually the responsibility of those who create it, since it is the responsibility of the state, national, and even foreign authorities (Leblanc, 2020). Local government units (LGUs) follow the government's legislation on solid waste management and develop their community policies. However, the pandemic created difficulties for LGUs as to how they collect, move and dispose of their waste. (Penteado& Castro, 2020). Using cross-sectional analysis, the purpose of the study is to establish a structure for the management of household solid waste in the NCR.

2. Literature Review

Solid Waste Management
Solid waste management is one of the most critical issues facing the world today. The dramatic growth in population worldwide induces too much consumerism and overproduction of products due to perceived demand and other factors. In the Philippines, where the population has already surpassed 100 million in 2015 and an approximate waste generation rate of 0.5 kg per capita per day, it can be projected that an average of 50,000 MT per day is produced, of which 35,000 MT per day is collected. The remainder would end up in areas other than the designated storage facilities.

Solid Waste Management Laws
The most noteworthy program was the adoption of the Philippine Republic Act (RA) 9003, also known as the Ecological Solid Waste Management Act of 2000, which is perceived to be a broad-based and systematic solution to SWM by supporting 3 Rs: reduction, recycling, and reuse. Compared to previous legislation, which was considered to be disorganized and fragmented, this act was adopted as a systemic approach to the adoption of a structured, robust and environmental program to guarantee the security of public health and the environment. Although implementing policies into practice has not been an easy path and almost all the local government units are not capable of fully implementing the act because of various financial, technical, and manpower constraints. (Maskey et al., 2016).

The Philippines is an example of a nation in the Global South that has struggled with the direct consequences of plastic bag consumption, and the challenges associated with adopting and enforcing legislation to ban these non-biodegradable products. The nation experienced an environmental tragedy on July 10, 2000, when a huge section of a dumpsite called Payatas collapsed into a massive debris flow. It is estimated that around 330 people died in the area. This resulted in the passing of Republic Act No. 9003 (RA 9003) of 2000 to implement proper solid waste management practices at the local level. RA 9003 mandates the adoption of a systematic, comprehensive, and ecological solid waste

Table 1. Other SWM Laws in the Philippines

Presidential Decree		
Document No.	Title	Date Approved
PD 825	Providing penalty for improper disposal of garbage and other forms of uncleanliness and other purposes	November 7, 1975
Administrative Order		
Document No.	Title	Date Approved
AO 1993-90	Creating a project management office on Solid Waste Management under the presidential task force on waste management	October 19, 1993
Department Administrative Order		
Document No.	Title	Date Approved
DAO 2019-21	Guidelines Governing Waste-To-Energy (WtE) Facilities for the Integrated Management of Municipal Solid Wastes	November 26, 2019
DAO 2001-34	Implementing Rules and Regulations of Republic Act 9003	December 20, 2001
DAO 1998-50	Adopting the landfill site identification and screening criteria for municipal solid waste disposal facilities	
DAO 1998-49	Technical Guidelines For Municipal Solid Waste Disposal	
EMB Memorandum Circular		
Document No.	Title	Date Approved
EMB MC 2019-008	Adopting the National Solid Waste Management Commission (NSWMC) Resolution No. 669 Series of 2016 "Guidelines Governing the Establishment and Operation of Waste-to-Energy Technologies for Municipal Solid Waste"	September 16, 2019
EMB MC 1988-39A	Amending Memorandum Circular No. 39-A, Dated January 19, 1988. By Reconstituting The Presidential Task Force On Waste Management	March 21, 1994
Resolution		
Document No.	Title	Date Approved
NSWMC Resolution No. 1363 Series of 2020	Resolution Directing the Department of Environment and Natural Resources (DENR) to Prepare and Implement the Banning of the Use of Unnecessary Single-use Plastics by National Government Agencies (NGAs), Local Government Units (LGUs) Offices and All Other Government Controlled Offices	February 12, 2020

management program as a national policy, and recognizes the local government units as the lead implementers. Since the tragedy at Payatas, efforts have been made to establish cleaner solid waste systems, including the construction of a waste-to-energy plant in Payatas that supplied 20 residents with electricity. (Crowley et al., 2020). As a result, Table 1 shows other Solid Waste management Laws in the Philippines which aims for a systematic, comprehensive and ecological waste management program. (Department of Environment and Natural Resources, n.d.)

Municipal Solid Waste Management
Municipal Solid Waste Management (MSWM) is a relevant issue around the world in safeguarding human health from an environmental, social and economic point of view. The objectives of waste management, in general, are the protection of human health and the environment, and the conservation of resources. However, the priority given to waste management problems is very different according to the standard of living in a setting where it is implemented. In developing countries nowadays, the aim is to increase the coverage of the waste collection service and to minimize uncontrolled or illegal dumping (upgrading to sanitary landfilling). (Cervantes et al., 2018). MSW management is used by municipalities to make cities resilient and smart. (Bharadwaj et. al., 2020). However, MSW management poses significant challenges for city authorities with limited municipal budgets and a lack of system-level understanding of integrated waste management.

Table 2. Composition of Recyclable Waste Collection by Primary Collectors

Recyclable Material	Primary Collector	Metro Manila (kg/capita/day)
Paper	Street Collectors	3.18
	Collection Workers	21.83
	Disposal Site Scavengers	22.01
Aluminum	Street Collectors	0.76
	Collection Workers	0.78
	Disposal Site Scavengers	2.50
Other Metals	Street Collectors	1.39
	Collection Workers	12.35
	Disposal Site Scavengers	16.75
Plastic	Street Collectors	1.63
	Collection Workers	9.79
	Disposal Site Scavengers	20.32
Glass	Street Collectors	0.85
	Collection Workers	6.58
	Disposal Site Scavengers	9.96

Furthermore, almost all MSW management processes produce greenhouse gases (GHGs) during collection,

transportation, composting, digestion, incineration, and landfill. (Jia etal., 2018). Table 2 shows the composition of recyclable wastes collected by the different primary collectors according to recyclable material (Environmental Management Bureau, 2018).

Household Solid Waste Management

Rural household waste is defined as solid waste, which includes wet waste (leftovers, foliage, meat residues), recyclable waste (paper, plastic bottles, metal, cloth), and non-recyclable waste (plastic bags, glass, metal). Among them, kitchen waste is the main part of rural household solid waste. Rural residents' solid waste disposal methods include selling, recycling, landfill, and burning and dumping in open areas without any treatment. (Wang et al., 2018).

Solid waste management systems usually involve both the formal and informal sectors. In developing countries, recycling activity is still done in the informal sector, which includes junk shops and private individuals. The informal sector is labor-intensive, uses low-level technology, and generally generates low levels of income. Those participating in it often do not pay income taxes and generally avoid government regulations. Despite the gradual implementation of legal e-waste disposal programs in developed nations, e-waste is already being processed and recycled in informal recycling facilities. Indeed, in developed countries, most e-waste is collected by individual collectors and processed in small-scale facilities or by individuals. (Yoshida et al., 2016).

Behavior and Attitude of Households on Solid Waste Management

Waste management is a vital part of city management—particularly where it has become significant to rethink cities for environmental sustainability. The primary sources of waste are obtained from households. The organic or inorganic waste materials are produced out of commercial or household activities. Most of the time, garbage bins or dustbins are put in public spaces or in front of households/societies in cities that are congested every day due to escalating waste. Improper waste disposal poses a significant health concern, allows infectious infections to spread, and pollutes the environment. Various biodegradable waste combinations emit harmful gases, such as methane, if the dustbin is left unattended for several days, which require urgent intervention. (Dubey et al., 2020).

3. Methods

The research is quantitative research that uses statistical tools such as Multivariate Analysis of Variance and Multiple Linear Regression. The researchers conducted cross-sectional research to determine the framework of solid waste management in the household. Cross-sectional research is an observational research design where the researcher will check both the exposure and outcomes of the research with the participants. This type of research design is often used for population-based research wherein this research uses the population of households to determine solid waste management of households in NCR. (Setia, 2016).

The research used the following hypotheses for the survey questionnaire:

Problem Statement 1:
    H0= Households are aware of solid waste management policies of the government.
    H1= Households are not aware of the solid waste management policies of the government.

Problem Statement 2:
    H0= Households agree to practicing proper solid waste management in their households.
    H1= Households do not agree to practicing proper solid waste management in their households.

Problem Statement 3:
    H0= Households are concerned about solid waste management problems after household disposal.
    H1= Households are not concerned about solid waste management problems after household disposal.

The survey aims to determine the awareness of households, agreement to ecological solid waste practices, and problems on solid waste management that concern households. The use of a Likert scale was used in the three categories wherein the awareness was determined through the 5-point Likert scale *Highly Aware, Moderately Aware, Somewhat Aware, Slightly Aware,* and *Not Aware.* Ecological Solid Waste Practices used the Likert scale of *Strongly Agree, Agree, Neither Agree or Disagree, Disagree,* and *Strongly Disagree.* Solid waste management problems used the Likert scale of *Serious Problem, Moderate Problem, Neutral, Minor Problem,* and *Not a Problem at all.* Other information such as the frequency of disposal, disposal method, and the ranking of wastes generated in households were also included in the survey questionnaire.

Results of the survey questionnaire were consolidated and analyzed using Multiple Linear Regression for the Likert scale using SPSS and Multivariable Analysis of Variance for the ranking using Minitab. The significance of the responses to the study were evaluated through the use of MLR for the Likert scale and MANOVA for the ranking
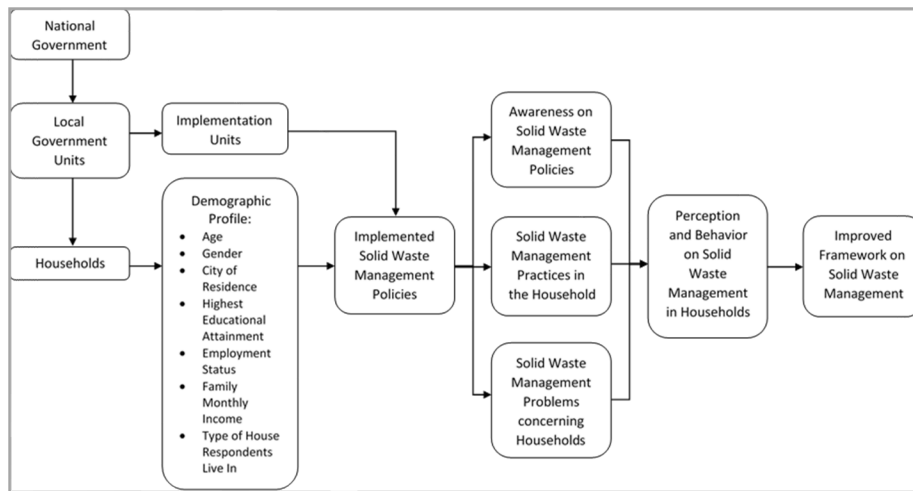

Figure 1. Conceptual Framework of the Study

4. Analysis and Results

Where is your household waste stored before being collected by the garbage collector?

Table 3 shows the total number and percentage of observances of respondents' answers regarding household waste storage before collection at home. Out of 391 responses, container was most commonly used by households to store household waste before being collected by the garbage collector.

Table 3. Household Waste Storage Before Collection

Waste Storage	Frequency	Percentage
Container	193	49%
Dumpsite	15	4%
Plastic Waste Bag	183	47%
Total	391	100%

How often do you dispose your wastes?

Table 4 shows the total number and percentage of observances of respondents' answers regarding how often they dispose of their garbage wastes. Out of the 391 responses, the table showed that most respondents dispose of their household waste every day.

Table 4. Frequency of Household Waste Disposal

Waste Disposal	Frequency	Percentage
Every three days	103	26%
Every two days	123	32%
Every day	165	42%
Total	**391**	**100%**

Ranking according to the source of waste at home

Figure 2 shows the frequency of the ranking of wastes among the 6 wastes. A MANOVA test was also done to get the significant variables that affect the ranking of respondents on the wastes. Kitchen waste is the most generated waste having significant variables of city of residence (p=0.001), family monthly income (p=0.019), household family size (p=0), and type of house respondents live in (p=0). Plastic waste is the second highest generated waste having significant variables of age of respondents (p=0.01), household family size (p=0.002), and type of house respondents live in

Figure 2. Respondents Ranking of Waste

(p=0). Yard waste is the third-highest generated waste having significant variables of age of respondents (p=0), family monthly income (p=0.001), and household family size (p=0.001).Paper waste is the fourth highest generated waste having significant variables of city of residence (p=0.021), highest educational attainment (p=0.004), family monthly income (p=0), and household family size (p=0.001).Metal waste is the fifth-highest generated waste having significant variables of highest educational attainment (p=0.001), family monthly income (p=0.009), and types of house respondents live in (p=0).Other wastes are the least generated waste of households having significant variables of (p=0.017), family monthly income (p=0.001), household family size (p=0), and types of house respondents live in (p-0.023).

Table 5. Frequency of Household Waste Disposal

Disposal	Frequency	Percentage
Trash can	165	25%
Old bucket	100	15.15%
Plastic bag	326	49.39%
Carton	40	6.06%
Tin/Can	24	3.64%
Rice sack	3	0.45%
Paper bag	1	0.15%
Compost pit	1	0.15%
Total	660	100%

How do you dispose of your household waste?

Table 5 shows that 391 respondents dispose of their wastes in multiple ways. The following are the composition of the ways of how respondents dispose of their wastes: Trash can (165 or 25%), Old bucket (100 or 15.15%), Plastic bag (326 or 49.39%), Carton (40 or 6.06%), Tin/Can (24 or 3.64%), Rice sack (3 or 0.45%), Paper bag (1 or 0.15%) and Compost pit (1 or 0.15%).

**Table 6. Frequency of Household Waste Collection of LGUs**

Household Collection	Frequency	Percentage
Everyday	193	49.36%
Every Two Days	48	12.28%
Every Three Days	94	24.04%
Irregularly	56	14.32%
Total	391	100%

How often does the local government collect household wastes?

Table 6 shows the total number and percentage of observances of respondents' answers regarding how often the local government collects household wastes. The following are the observances of respondents' answers on how often does the local government collects household wastes: 193 or 49.36% answered every day; 48 or 12.28% answered once every two days; 94 or 24.04% answered once every three days and 56 or 14.32% answered irregularly.

Awareness of Respondents

Figure 3 shows the frequency of respondents' awareness on different policies. The results were tested using Multiple Linear Regression to determine its significant variables. The awareness of respondents on R.A. 9003 or the Ecological Solid Waste Management Act are composed of 43 or 11% answered highly aware; 50 or 13% answered moderately aware; 152 or 39% answered somewhat aware; 91 or 23% answered slightly aware; and 55 or 14% answered not aware. The significant variables were highest educational attainment (p < 0.001) and type of house respondents live in (p=0.001)
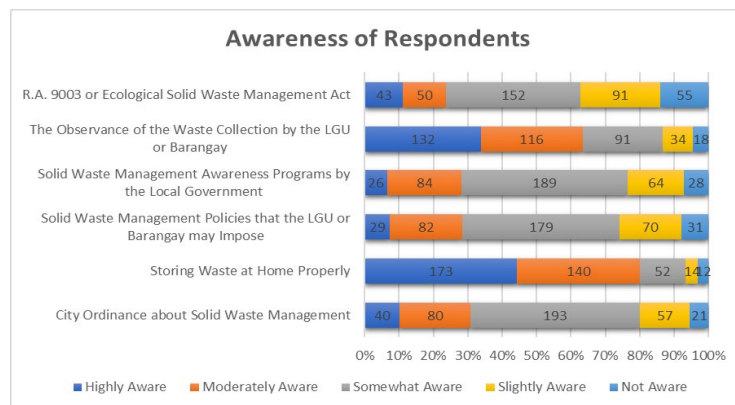

Figure 3. Awareness of Respondents

The awareness of respondents on Solid Waste Management Penalties that the LGU or barangay may impose are composed of 29 or 7% answered highly aware; 82 or 21% answered moderately aware; 179 or 46% answered somewhat aware; 70 or 18% answered slightly aware; and 31 or 8% answered not aware. The significant variables are highest educational attainment (p=0.010), family monthly income (p=0.006), household family size (p=0.042), type of house respondents live in (p=0.004), and city of residence (p=0.025).

The awareness of respondents on city ordinance about Solid Waste Management are composed of 40 or 10% answered highly aware; 80 or 21% answered moderately aware; 193 or 49% answered somewhat aware; 57 or 15% answered slightly aware; and 21 or 5% answered not aware. The significant variable is type of house respondents live in (p=0.001).

Ecological Solid Waste Practices
Figure 4 shows the frequency of respondents' agreement on ecological solid waste practices. Respondents' agreement to composting are composed of 272 or 70% answered strongly agree; 78 or 20% answered agree; 29 or 7% answered neither disagree nor agree; 3 or 1% answered disagree; and 9 or 2% answered strongly disagree. the significant variables are employment status (p=0.011), family monthly income (p < 0.001), and type of house respondents live in (p=0.008).
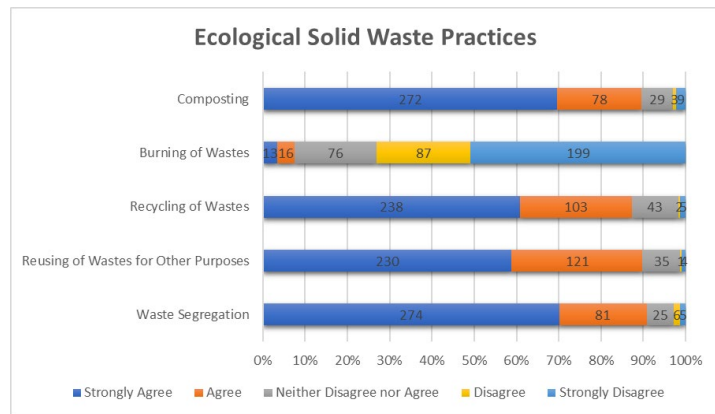

Figure 4. Ecological Solid Waste Practices

Respondents' agreement to waste segregation are composed of 274 or 70% answered strongly agree; 81 or 21% answered agree; 25 or 6% answered neither disagree nor agree; 6 or 2% answered disagree; and 5 or 1% answered strongly disagree. Gender of respondents and highest educational attainment were isolated as they were the least significant variables that affected the results of the Multiple Linear Regression. After isolation, the significant variables is the type of house respondents live in (p=0.017).

Problems Encountered in Solid Waste Management Service
Figure 5 shows the frequency of respondents' level of concern about problems encountered in solid waste management service. Respondents' level of concern for Informal Dumping of Wastes are composed of 262 or 67% answered serious problem; 40 or 10% moderate problem; 47 or 12% answered neutral; 32 or 8% answered minor problem; and 10 or 3% answered not a problem. The significant variables were age of respondents (p=0.001), household family size (p < 0.001), and type of house respondents live in (p < 0.001).
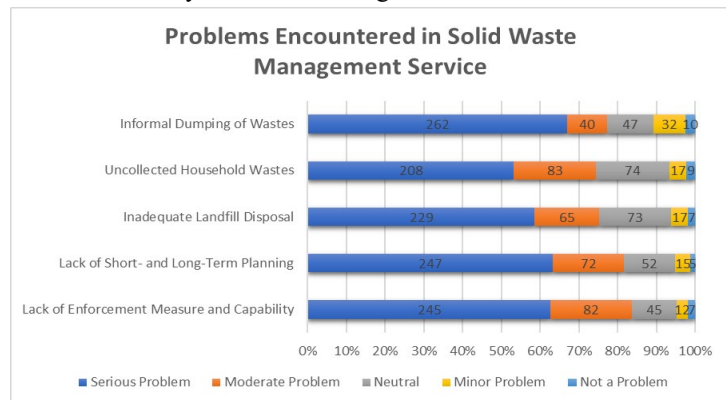
Figure 5. Problems Encountered in Solid Waste Management Service

Respondents' concern on the Lack of Short- and Long-Term Planning are composed of 247 or 63% answered serious problem; 72 or 19% moderate problem; 52 or 13% answered neutral; 15 or 4% answered minor problem; and 5 or 1% answered not a problem. The significant variables were employment status (p=0.005), household family size (p < 0.001), and type of house respondents live in (p < 0.001).

Discussion

Results of the survey showed limited knowledge among households on the SWM policies. Factors such as highest educational attainment, type of house respondents live in, family monthly income, family size, and the city of residence have an effect on the awareness of households on policies. Different topics of policies with different factors affecting them should be considered in determining as points of improvement in the effectiveness of the policies. Awareness changes the effect of practices of the respondents because of their beliefs and priorities. Their standard of living affects the priorities and capabilities of households to practice proper SWM. Employment status, family income, type of house respondents live in, family size, and age of respondents are factors that affect their perception on SWM practices. As a result of the survey questionnaire, households are willing to participate in proper SWM practices. Awareness also affects the concerns of households because of their willingness that is dependent on their capability and priorities.

Figure 6 shows a framework to improve household solid waste management. The goal of the framework is to improve solid waste management wherein there are three priorities: raising awareness on SWM policies, encouraging and improving SWM, and resolving problems on SWM.
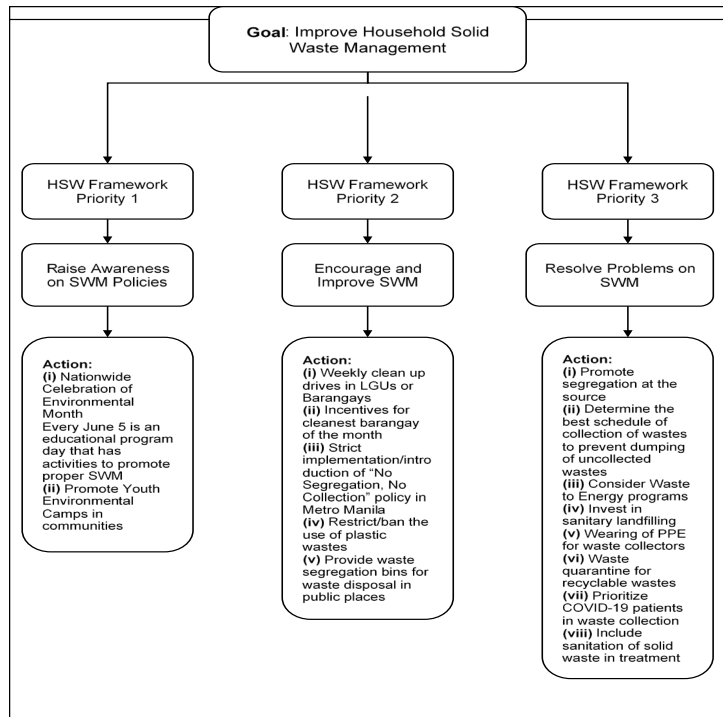
Table 7 depicts actions that LGUs can do to achieve the goal of the framework through criteria for policy formulation.

The criteria for policy formulation are a series of questions that authorities can ask to create the right policy for the SWM in the municipality to increase the awareness of households.

To raise awareness on SWM, the researchers thought of making the celebration of the environmental month a national celebration filled with activities in every district especially in schools. According to the Department of the Interior and Local Government (2019), on April 4, 1988, President Corazon C. Aquino declared June as the Philippines Environment Month according to Proclamation No. 237. However, June 5 is considered the World Environment Day. DENR and the Environmental Management Bureau (EMB) conducts activities that are partnered with Young Eco-Ambassador's Camp. (Department of Environment and Natural Resources, 2020). However, despite the activities and the efforts of these organizations, households still lack awareness of the SWM policies. LGUs can take advantage of the month-long celebration to conduct seminars, educate people on proper SWM practices, and provide activities regarding SWM in the city. LGUs can also partner with schools where they can have a day where they can educate the students and invite them to Youth Environment Camps. The use of the recommendations of raising awareness is in line with the survey through their knowledge on the ecological solid waste practices and their awareness on the policies. Since households agree to practicing proper SWM, the program will be used to educate them on how they can properly do composting, recycling, reusing of wastes, and waste segregation at source. At the same time, they will be educated on the dangers of practicing burning of wastes. It will be linked with the current policies and penalties in the municipality. Certain factors such as highest educational attainment, type of house respondents live in, households family income, household family size, employment status, age of respondents, and the city of residence should be considered as there are different approaches for each of these factors. For example, educating younger generations should be more engaging and interactive to get their attention.

Table 8. Policy Matrix for Weekly Clean-up Drives

Policy	Action	Responsible
Barangays will conduct weekly clean-up drives, will be monitored by LGUs and will be given incentives for the cleanest barangay/s of the month	Assignment of leaders of clean-up drives in barangays	Barangay Officials
	Monitoring of clean-up drives in each barangay and determining which is the cleanest barangay/s for the month	Local Government Authorities
	Provide incentives for the cleanest barangay/s for the month	Local Government Authorities

Another example is the city of residence as municipalities have their own policies and penalties thus, educating them should be in line with these and the goals of the municipal leaders on SWM. Some municipalities already have programs for SWM; however, the effectiveness of these policies should be checked to know points of improvement.

Weekly clean-up drives are recommended by the researchers to improve and encourage households on maintaining cleanliness in the community. It responds to the concerns of households on informal dumping of wastes, uncollected wastes, lack of short and long-term planning, and lack of enforcement measures. Certain factors such as the age, family size, type of house respondents live in, employment status, and household family income should be considered. Whereas age affects the capability of people to engage in clean-up drives as younger generations can work easily and are more capable of engaging in these activities.

5. Conclusion

Highest educational attainment, type of house respondents lives in, family income, family size, and city of residence of respondents have an effect on the awareness of households on policies on SWM wherein there was limited knowledge of respondents on the SWM policies. Different topics of policies have different factors that affect them which should be considered in determining the points of improvement in the effectiveness of the policies. The awareness changes the effect of practices of the respondents because of their beliefs and priorities. Awareness is the basis of the beliefs of households on SWM. Their standard of living affects the priorities and capabilities of households to practice proper SWM. Employment status, family income, type of house respondents live in, family size, and age of respondents are factors that affect their perception on SWM practices. As a result of the survey questionnaire, households are willing to participate in proper SWM practices. Awareness also affects the concerns of households because of their willingness that is dependent on their capability and priorities.

Proper solid waste management is an important factor that should be prioritized by the government. Using waste as a source for other uses such as recycling and converting waste to energy can be highly beneficial to the public. Each LGU can create their own SWM plan with the help of government units which they can implement. These policies can encourage the people to promote proper solid waste management if they are educated and aware of these policies. Likewise, it can help waste disposal be more efficient if waste has been collected from the source. However, there are multiple factors such as the demographics of households that should be considered because different households have different circumstances where some have resources for SWM and some lack resources. Through educating the people, they can reuse and make profit from their wastes through crafts or recycling. Incentives can also be given to encourage LGUs to create a SWM plan that is effective and feasible wherein investors can help in the implementation of the SWM plans to increase their budget and can create more facilities which can handle the disposal of wastes and their conversion. Barangays can do weekly clean-up drives which can encourage residents to maintain cleanliness in their barangay. With limited sources of sanitary landfills in LGUs, it is highly encouraged to invest in sanitary landfills in NCR because of their long-term capacity and better environmental impact.

Given the pandemic, it causes a problem where wastes need to be quarantined or disposed of separately to decrease the chances of spreading the virus. Proper waste disposal in households with COVID-19 patients as well as wearing of PPE can help reduce the risk of waste collectors getting the virus through surfaces of wastes. Plastic waste should also be limited because of the lifespan of the virus on plastic surfaces. However, it is also possible to combine all COVID-19 patients' waste in one container to prevent the spread of the virus but sanitation of the surfaces of wastes is encouraged before segregation. It is also important for workers to be cautious in handling these wastes by minimal contact before sanitation and wearing of proper equipment.

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