

Ecological Solid Waste Management: The Kalayaan, Laguna Experience

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Abstract— This research study examines the effectiveness of Ecological Solid Waste Management Practices in Kalayaan, Laguna, focusing on waste segregation, collection, transportation, and enforcement of regulations. The study utilizes a descriptive research method, employing survey questionnaires and document analysis to gather data. Through random sampling, 394 respondents comprising municipal officials and community residents were selected. Findings reveal commendable effectiveness in waste segregation and collection, with minor areas for improvement identified. Challenges persist in areas such as bulky waste collection, provision of personal protective equipment, and enforcement of fines and penalties for littering and dumping. Community awareness and access to recycling facilities emerge as critical issues affecting waste management efficacy. The study underscores the need for continuous improvement and community engagement to enhance waste management practices and ensure environmental sustainability. Overall, the research contributes valuable insights to optimize solid waste management strategies, fostering a cleaner, greener, and healthier living environment in Kalayaan, Laguna.

Keywords: Ecological Solid Waste Management, Waste Segregation, Waste Collection, Waste Transportation, Environmental Sustainability.

I. INTRODUCTION

The planet is littered with 2.12 billion tons of waste. We're dumping a huge 2.12 billion tons of waste on the earth every year. If all this waste were put on trucks, it would go around the world 24 times (The World Counts 2023).

There are several ecological problems associated with inadequate waste management. Firstly, it causes soil pollution because waste can contaminate the soil with dangerous chemicals and pose a risk to people's health by consuming contaminated food. Secondly, improper waste disposal contributes to air pollution, mainly from burning waste at landfills, releasing toxic substances such as dioxin, which harms the environment and human health. Furthermore, the negligent disposal of plastic waste leads to the pollution of oceans, with a staggering 13 million tonnes of plastic ending up in the world's oceans annually. If this trend persists, by 2050, the amount of plastic in the oceans is projected to surpass the fish population, further disrupting marine ecosystems. Lastly, groundwater pollution is a direct consequence of irresponsible waste management, with a staggering 280 billion tons of groundwater being contaminated yearly, averaging 9,000 tons per second. These alarming environmental repercussions necessitate urgent and effective waste management strategies to mitigate the damage and secure a sustainable future (Choi, 2016).

The escalating volume of waste generated in contemporary society constitutes a pressing issue, prompting a critical examination of effective approaches to tackle the waste crisis. Waste management emerges as a pivotal concern to mitigate the adverse environmental repercussions and safeguard the well-being of human populations. The fundamental objective of waste management is to facilitate the safe and appropriate treatment of waste, thereby minimizing detrimental impacts on the environment. Among the various disposal methods, landfilling stands as a significant approach; however, it is directly associated with both human health concerns and environmental implications (Choi, 2016, p. 1).

Addressing the challenges and implications of waste management, including the utilization and implications of landfilling, is paramount to fostering sustainable waste practices and promoting a healthier environment for all.

The growing challenge of increasing municipal solid waste generation represents an emerging problem in the People's Republic of China, which is a rapidly developing country with population growth and industrial development. The overall MSW production increased remarkably between 1980 and 2006, rising from 31.3 million tonnes to an astonishing 212 million tonnes, indicating a significant increase in waste production over this period. Concurrently, the waste generation rate surged from 0.50 kg/capita/day in 1980 to 0.98 kg/capita/year in 2006, underscoring the intensification of waste production on a per capita basis (Wang, Bi, Saito, Wang, Sun, Zhang, Yang, 2020).

It is evident that as China continues to experience rapid urbanization and industrial development, effective waste management policies and infrastructure need to be in place to keep pace with the increasing waste generation. The insights provided by these statistics underscore the urgency for sustainable waste management solutions that align with the country's evolving socio-economic landscape.

According to the Coracero, Gallego, Frago, and Gonzales (2021) study, the Philippines is experiencing a continuous increase in waste and is expected to increase further in the coming years. An increasing volume of solid waste, weak legislation implementation, lack of sanitary landfills and insufficient disposal have been identified as associated problems with the management of solid waste in this country. Only good governance, active participation of the people of the Philippines, and the cooperation of all stakeholders and agencies in the Philippines will enable these solutions to be achieved.

The study by Coracero et al. (2021) highlights a growing waste problem in the Philippines, with weak law enforcement and insufficient landfill capacity. The key solution is the Ecological Solid Waste Management Act (RA 9003), emphasizing waste segregation, proper disposal, and waste diversion. Public participation and awareness are vital for a trash-free Philippines. Valorization, converting waste to valuable products or energy, offers another solution to waste management and environmental concerns. Successful implementation requires good governance and active involvement from the population and relevant agencies.

Kalayaan, Laguna has been classified as a third-class municipality. The population was 24,755 according to the census carried out in 2020. The primary challenges in the municipality include insufficient funding for the maintenance of the sanitary landfill, non-compliance of the barangay with regards to R.A. 9003, resistance from community residents to pay the 'garbage fee,' and a lack of awareness among the community residents regarding solid waste management ordinances (V. O. Abarca, personal communication, August 17, 2018).

II. HEADINGS

II.I. RELATED LITERATURE

II.I.I. FOREIGN LITERATURE

Countries of Latin America and the Carib, LAC. Dominance of uncontrolled disposal options of municipal solid waste (MSW) from the region, known as open dumps, has an impact on the sanitation and health. In the LAC region, there is little interest in separation practices and recycling of sources. In addition, service sustainability is also hampered by economic issues like insufficient financial planning and inefficient payment systems. Another characteristic feature of this region is rapid urbanization. The management of MSW is a challenge for large urban centres, which accommodate more than 80 % of the area's population. However, if priority is given to recovery options, the same large amount of MSW generated can become a reliable source of resources. One aspect that ties together a wide range of activities and stakeholders involved in the management of mental health services is governance (Hettiarachchi, Ryu, Cucci, & Silva, 2018).

A study by Debrah, Vidal, and Dinis (2021) indicates positive attitudes towards the environment and a growing awareness of it among students at both secondary and tertiary levels. Nevertheless, to guide students on the implementation of SWM, there is a need for more training in teaching. Students' lack of environmental knowledge relates to the absence of teachers' practical experience in Sustainable Waste Management. There was also a correlation between teachers and students' understanding and viewpoint towards SWM related to education and age.

Many negative effects on the ecosystem, including as nitrogen pollution, ocean plastic accumulation, and greenhouse gas emissions, are caused by global municipal waste production. Nevertheless, there needs to be more data on the development of waste and pollution over time or in the future. We use compositional Bayesian regression to generate the first estimates of waste creation in the past and future (1965–2100) broken down by composition and treatment, as well as the ensuing environmental effects, for each nation (Chen, Bodirsky, Krueger, Mishra, & Popp, 2020)

Pam Phu, Hoang and Fujiwara (2018) have contributed to the increase in urban waste generation of 3% per year as a consequence of urbanisation, wealth and rapid development in Malaysia. Since the 1990s, waste generation in Kuala Lumpur has increased by 10 times as much from about 590 tonnes per day up until 3000 tonnes per day and primarily comes from Organic Waste which accounts for around 50% of all garbage streams. Almost 95% of collected waste is disposed of into more than 300 landfills, and landfill space is being exhausted rapidly. Another obstacle to the development of sustainable landfills is that they are viewed as a mere burden, not commodities producing energy in Malaysia.

In the current study, Pam Phu et al. 2018 aim to analyze waste characteristics and management practices of hotels in Hoi An, Vietnam's central tourism city. The results showed that the average rate of hotel waste generation was 2.28 kg per guest per day, strongly correlated with internal factors such as capacity, room price, garden, and restaurant level. It has been shown that there is a statistically significant difference in the rate of hotel waste production. The higher the scale of hotels is the higher the waste generation rate. In addition, it was found that the hotel waste contained 58.5% biodegradable and 25.8% recyclables as well as 15.7% of other waste. Explaining the relative differences in hotel waste composition depending on climatic conditions, features of hotels and guest types was done. The percentage of biodegradable waste and the proportion of recycled waste shall increase with increasing hotel size. The study also showed that it has successfully implemented waste management practices for hoteliers, with 76% sorted, 39% recycled, 29% reduced, and 0.8% Composting. The rate of waste management practices was proportional to the scale of the hotel. This study provided information on the waste management practices of the hotel sector and made a significant contribution to the evaluation of Hoi An City's total municipal solid waste management procedures.

The article by Abubakar, Maniruzzaman, Dano, AlShihri, AlShammari, Ahmed, and Alrawarf (2022) examines the impact of SWM practices on human and environment health in Global South cities emerging as global urbanization's next big thing. The study uses a desktop research methodology based on in-depth primary data analysis and literature, e.g., formal documents and newspaper articles. It finds that standard waste management practices include mixing household and commercial waste with hazardous waste during storage and handling. Trash is primarily stored in outdated or improperly maintained facilities, such as storage containers; the transportation infrastructure frequently has to be updated; and the most common ways to dispose of trash include landfills, open-air incinerators, and uncontrolled dumping.

The negative effect of such practices includes air and water pollution, land degradation, methane and hazardous leachate emissions, and climate change. Residents who live in marginalized social groups are primarily affected by these effects, which have major consequences to the environment and public health. Recommendations to mitigate public and environmental health risks associated with current SWM practices in the Global South are presented in the paper.

Twelve selected indicators are set out in Le, Dinh, and Nguyen's (2023) Report: investment cost, water treatment costs, operation and maintenance costs, revenue benefits, employment creation, community consensus, support policies, Community Health, Air Pollution, Water Pollution, Greenhouse Gas Emissions, Land Quota. Waste to energy is identified as the best alternative solution in Ho Chi Minh City, given that around 70% of landfill applications are being applied, among three MSW facilities selected for incineration: landfills, compost and waste to energy. Decision makers and policy makers in developing countries can use the selection process and indicators identified to select MSW treatment technologies. Ho Chi Minh City's governors also benefit from finding the most certain and appropriate waste technology. The technology adoption roadmap and its implementation plan should be thoroughly considered to address challenges in MSW management in the city.

II.I.II. LOCAL LITERATURE

According to Oandasan (2023), the problem in solid waste management, as highlighted by the study in the province of Laguna, appears to be a gap between the perceived importance of various influencing factors and the actual level of implementation of RA 9003. While the influencing factors are significant, they may need to be more effectively translated into tangible improvements in waste management practices. The identified financial challenges further underscore the difficulties that Local Government Units (LGUs) face in adequately addressing and complying with the requirements of the legislation.

Wynne (2018) explains the development and execution of a community-based program aimed at educating the locals and fostering the construction of sustainable initiatives to enhance the SWM practices that have been found to have an impact on the coastal and riverine habitats in Tabaco City, Albay, Philippines. The Save the Rivers, Save the Sea program was created to get students and young people in the community involved in environmental issues. A team of students was mobilized in the first year of the program, and data from workshops, water quality testing, and needs assessments of the community were gathered and used to construct an action plan that would last the rest of the program in a sustainable manner. The action plan sets out the objectives and targets of the programme to influence SWM changes in Tabaco City's rivers and coastal zones. The results of the 1st year's programme and observations have shown that Community Based Programmes are a useful tool to address SWM challenges but must coexist with supportive and committed Local Government Units in order for them to function sustainably.

Unira, Macabales, and Incomio (2023) decided to study and provide an optimal solution to help the potential target market of Laguna municipalities, specifically San Pedro, Biñan, Sta. Rosa, Cabuyao, and Calamba need to have an optimal garbage collection. The study, therefore, will contribute to the attempt to solve one of the country's top problems: the high volume of solid waste. Through careful consideration of the marketing, technological, organizational or managerial, financial, socio-economic, and environmental factors, the researchers collected the essential data to support the feasibility study. The startup capital of 16,974,658.27 PHP is required. Based on the results, the advocates suggested the following: 1) implement the enhanced system in the municipalities; 2) offer a more precise and comprehensive collection schedule; 3) carry out further research on waste segregation; 4) take into account the most effective sustainable development objectives; and 5) additional vehicles for the collection of waste.

The correct separation and redirection of solid waste is critical to the SWM's effectiveness. People's participation and knowledge are essential for proper segregation. Moreover, the people's participation relies on the government's political will to implement its policies and educate its people. This is why it all boils down to the integrity and willingness of the government to make a difference (Valderrama, 2020).

A study showed that the respondents needed to be educated about proper waste disposal at the university. Most respondents across all groups believe waste disposal is a problem in the university. Laguna University, one of the offices under the Provincial Government of Laguna (PGL), is committed to supporting all of its programs. As a result, it is dedicated to carrying out the PGL's solid waste management policy. Teaching students and other stakeholders to protect the environment, especially through appropriate solid waste management, should be Laguna University's top priority. In order to safeguard solid waste management for both the present and the future of Laguna University, a sustainable development plan is necessary. Finally, the problems that Laguna University found should set standards for better garbage collection and management in schools. If people don't know enough about SWM, it can affect how they behave and think about sustainable practices. For any environmental program to be successful, this is the first thing that needs to be addressed (Fucio, R., Fucio, C., & Bato, 2023).

A recent study found that many people at Laguna University, including students, lack knowledge about proper waste disposal, and there is a shared belief that waste management is a problem on campus. As part of the Provincial Government of Laguna, the university is committed to following solid waste management policies. It suggested that the university educates everyone, not just students, about taking care of the environment through proper waste management. To secure a sustainable future, Laguna University should create a simple plan for sustainable development focusing on waste management. Guidelines should be set up to improve how waste is managed and collected in schools, as the lack of knowledge about waste management may affect people's behavior and attitudes towards sustainable practices (Fucio et. al., 2023).

II.I.III. SYNTHESIS OF THE RELATED LITERATURE

The literature about waste management in Latin American and Caribbean (LAC) countries highlights several critical issues. Primarily, the prevalence of uncontrolled disposal options for municipal solid waste (MSW), notably open dumps, significantly impacts public health and sanitation within the region. Despite the adverse consequences, interest in implementing source separation practices and recycling remains low in LAC countries. Additionally, economic challenges, such as inadequate financial planning and ineffective billing systems, further impede the sustainability of waste management services.

According to the study by Debrah, Vidal, and Dinis (2021), secondary and postsecondary students had high environmental awareness and positive environmental views. However, they need more practical solid waste management (SWM) education due to teachers' limited experience in this area. This deficiency in teachers' practical knowledge directly correlates with students' low environmental knowledge regarding SWM. The research highlights a significant relationship between teachers' and students' knowledge and attitudes towards SWM, suggesting the pivotal role of educators in shaping students' understanding and behaviors towards environmental sustainability. Moreover, the study identifies variations in awareness, attitudes, and practices of SWM among students based on their educational level and age, emphasizing the need for targeted educational interventions to address these differences. Overall, the findings underscore the importance of enhancing teachers' practical expertise in SWM to effectively guide students and foster environmentally responsible behaviors from an early educational stage.

The study conducted by Chen, Bodirsky, Krueger, Mishra, and Popp (2020) addresses the scarcity of estimates regarding global municipal waste production and its environmental impacts, such as greenhouse gas emissions, ocean plastic accumulation, and nitrogen pollution. The researchers use compositional Bayesian regression approaches to close this gap by producing the first complete estimates of trash generation in the past and future (1965–2100) broken down by composition and treatment methods in every nation. By applying this methodology, the study provides valuable insights into the trends and patterns of waste generation and its associated environmental impacts at a global scale, offering a basis for informed policy-making and mitigation strategies to address the challenges posed by increasing municipal waste production and its environmental consequences.

One crucial aspect impeding the establishment of sustainable landfills is the perception of landfills merely as a burden and not as a commodity for energy generation. This literature underscores the urgent need for innovative waste management strategies to tackle Malaysia's escalating urban waste challenge, emphasizing the importance of transitioning towards sustainable waste management practices for the well-being of the environment and society.

The research conducted by Pam Phu in 2018 focuses on analyzing waste characteristics and management practices within the hotel industry in Hoi An, a prominent tourism city in the center of Vietnam. The study aims to shed light on the waste generation rates, composition of waste, and waste management practices within hotels in this region. In summary, this research contributes valuable insights into waste management practices within the hotel industry, focusing on waste generation rates, waste composition, and the impact of various factors on waste management. Additionally, it provides information essential for understanding and improving overall municipal solid waste management practices in Hoi An City, a vital aspect of sustainable tourism development.

The literature by Abubakar et al. (2022) focuses on evaluating the human and environmental health effects of solid waste management (SWM) practices, particularly in cities of the Global South, which are anticipated to be major centers of global urbanization. The study employs a desktop research methodology, primarily relying on an in-depth analysis of secondary data and existing literature, including official documents and published articles. In summary, this literature highlights the urgent need to address the adverse consequences of SWM practices in the Global South. It emphasizes the importance of implementing effective waste management strategies to mitigate environmental degradation and safeguard public health, particularly for marginalized communities. The recommendations provided serve as a crucial guide to improve SWM practices and move towards more sustainable and equitable waste management systems in these rapidly urbanizing regions.

Le, Dinh, and Nguyen (2023) identified 12 crucial indicators, including investment cost, treatment cost, operation and maintenance costs, revenue/benefits, job creation, community consensus, support policy, community health, air pollution, water pollution, greenhouse gas emissions, and land quota, to evaluate municipal solid waste (MSW) treatment technologies. Among landfill, compost, and waste-to-energy incineration, waste-to-energy emerged as the optimal solution for Ho Chi Minh City, given that approximately 70% of landfilling is currently in use. The outlined selection process and indicators offer valuable guidance for decision-makers and policymakers in developing countries when choosing MSW treatment technologies. Furthermore, the findings support Ho Chi Minh City's leaders in adopting the most suitable waste technology, facilitating the development of a technology adoption roadmap and implementation plan.

Oandasan's (2023) study on solid waste management in Laguna reveals a notable gap between the recognized importance of influencing factors, including institutional, technical, legal, financial, external assistance, and public participation, and the practical implementation of Republic Act 9003 (RA 9003). Despite this recognition, there needs to be more tangible

improvements in waste management practices. Financial challenges stand out as a critical hurdle, indicating the struggles faced by Local Government Units (LGUs) in Laguna to meet RA 9003 requirements. The findings highlight a need for targeted interventions, particularly in budget allocation and financial support, to enhance the effectiveness of solid waste management practices in the region.

Unira, Macabales, and Incomio (2023) conducted a study to optimize garbage collection in Laguna's municipalities, focusing on San Pedro, Biñan, Sta. Rosa, Cabuyao, and Calamba. The research, considering marketing, technical, organizational, financial, socio-economic, and environmental aspects, determined a startup cost of 16,974,658.27 Php. Recommendations include implementing the improved system in target municipalities, refining collection schedules, studying waste segregation, aligning with sustainable development goals, and expanding the solid waste collection fleet to address the country's significant solid waste problem.

The effectiveness of Solid Waste Management (SWM) hinges on the accurate segregation and diversion of solid waste, a process heavily influenced by public knowledge and participation. The level of public involvement, in turn, is contingent on the government's political will to enforce policies and educate citizens. In essence, the success of SWM ultimately rests on the integrity and determination of the government to bring about positive change (Valderrama, 2020).

II.II. RELATED STUDIES

II.II.I. FOREIGN STUDIES

According to the study of Zhao and Onoda (2022), the examination of examples involving local power producers and suppliers (local PPS) with waste-to-energy systems aimed to comprehend the current role of the municipal solid waste (MSW) treatment system in constructing a sustainable society. The study also encompassed a review of the process of centralizing MSW treatment facilities, aligning with the policy trends of the MSW treatment system in Japan. An example of a sustainable MSW treatment system was demonstrated through an investigation and examination of the Kakegawa regional circular and environmental sphere (regional CES) concept, which helped to build the Japanese version of Stadtwerke. The case study examined two viewpoints: putting local public interest first and public-private partnerships (PPPs). The findings underscored the critical importance of public involvement in PPPs and enhancing social acceptance by cultivating trust among citizens by considering public interest.

According to the results of the Maalouf and Mavropoulus study of 2023, the total global volume of waste generated in 2017 was approximately 20 billion tonnes. That comes up to 2.63 tonnes of garbage generated annually per person. In the event that all proceeds as usual, 46 billion tonnes of garbage will be produced worldwide by 2050. Municipal solid waste is much smaller, ranging from 2.3 to 3.1 billion tonnes, an average of 2.7 billion tonnes in 2019. This is due to the fact that MSW production rose by 30% and 50%, respectively, during the previous 15 years, from 2004 to 2019. By 2050, the amount of MSW created is predicted to range from 2.89 to 4.54 billion tonnes, depending on the assumptions made. Compared to 2019, this is an increase of 26% to 45%. Overall, the study revealed that almost one-third of the total MSW generated needs to be collected and that most of what is collected needs to be treated according to current thinking on good management. In addition, open dumping and unauthorized burning account for nearly 42% of MSW. This finding gives policymakers helpful insight into the development and evaluation of circular economy policy instruments to meet Sustainable Development Goals.

In light of this, three waste handling case scenarios were examined over the years 2001–2051 while accounting for India's 2030 sustainable development targets. Case I is an Indian waste management scenario where 164,735 tonnes of waste per year would be produced between 2001 and 51. In addition, 60% of waste may be treated in case II that helps reduce the land requirement by up to 40% from 2031's estimated conditions such as 83.8 107 m³. With a restricted population, Case III is the best waste management scenario for 2031 in terms of reducing trash by 80%. As a result, the amount of landfill space needed would be reduced to as little as 16.76 × 107 m³. The article concludes that where LCA can be an antidote to achieving Sustainable Development Goals, formal management, and treatment of ISWM would reduce landfilling. Giovanni, 2019).

In order to improve sustainable waste management practices in Australia, the study of Andeobu, Wibowo and Gandhi (2022) examines how artificial intelligence technology is applied across different areas of SWM generation, sorting, collection, vehicle routing, treatment, disposal and waste planning. Prior studies from various databases from 2005 to 2021 are collected and analyzed to achieve the objectives of this study. The study aims to apply AI applications in the SWM, analyze their performance, find benefits and challenges, and provide best practice recommendations for optimizing resource efficiency to improve economic, environmental, and social outcomes. In comparison with other models used for the prediction of solid waste generation and recycling, this study has shown that AI Based Models are able to predict more clearly. The findings show that waste generation in Australia continues to increase and requires an upgraded and improved recovery infrastructure, as well as appropriate adoption of advanced artificial intelligence technologies for sustainable waste management. The widespread use of artificial intelligence recycling methods in Australia would be aided by a national strategy that takes regional variations into account and aims for consistency across jurisdictions. By increasing the existing recycling rates, eliminating the need to perform jobs manually, lowering costs, maximizing effectiveness, and changing how we treat waste management, this study will benefit researchers, governments, policymakers, municipalities, and other organizations responsible for managing waste.

II.II.II. LOCAL STUDIES

According to Tang and Ledesma's study from 2023, trash management firms, port authorities, and local government should work together to create and carry out comprehensive waste management plans that involve all parties. To guarantee compliance, such programs should include infrastructure upgrades, education and awareness-raising initiatives, and strong enforcement measures. The study emphasizes how crucial it is to deal with the management of solid waste in the Port of Zamboanga in order to promote sustainable development and enhance community well-being. This study emphasizes how crucial it is to include environmental issues in management strategies and public policy, especially in places like Zamboanga City that are developing quickly.

In the study of Lamond, Bhattacharya, and Bloch (2022), Solid waste management is a growing problem for developing countries. It is often a neglected aspect of urban management. On the other hand, ineffective waste management can exacerbate the effects of urban flooding by obstructing drainage, producing more debris, and housing disease-carrying organisms. It is confirmed by a review of the research and an examination of case studies (from the literature as well as from examples gathered in the process of creating a global urban flooding handbook) that the handling of solid waste is a developing concern in the practice of flood risk management. To improve waste management, large municipal programs and locally based community schemes were used. It is important that waste management is adopted as part of a comprehensive, integrated flood management program. The research demonstrates that waste management can effectively respond to flood risk, but sufficient commitment and engagement can be mobilized in the long term to remain successful.

II.II.III. SYNTHESIS OF THE RELATED STUDIES

The study by Zhao and Onoda (2022) focuses on regional electricity generation and supply (local PPS) with wastes-to-energy systems in order to examine the function of municipal solid waste, or MSW, treatment systems in creating a sustainable society. A review of the MSW treatment facilities' centralized process in accordance with current policy trends in Japan is part of the research. An example of a sustainable MSW processing system that helped establish the Japanese version of Stadtwerke is provided through an examination of the Kakegawa region circular and environmental sphere (regional CES) concept. The case study explores public-private partnerships (PPPs) and the prioritization of local public interest, emphasizing the crucial role of public involvement in PPPs and the necessity of enhancing social acceptance by considering public interest for effective waste management practices.

Maalouf and Mavropoulos (2023) found that nearly one-third of generated municipal solid waste (MSW) is not collected, and a significant portion of the collected waste needs to be treated according to contemporary standards of sound management. Additionally, almost 42% of MSW ends up in open dumping or uncontrolled burning. These findings offer important insights for policymakers, suggesting the need to design and evaluate circular economy policy instruments to address these challenges and work towards achieving sustainable development goals.

The study conducted by Giovanni (2019) examines three waste management case scenarios from 2001 to 2051 in India, considering the weightage of sustainable development goals for 2030. Case I represents India's current waste management scenario, projecting the generation of 164–735 tonnes/year of waste from 2001 to 2051. In Case II, 60% of the waste can be treated, reducing the land requirement by 40% compared to the estimated conditions of 2031. Case III presents the ideal waste management condition 2031, aiming to reduce waste by 80%, thereby minimizing landfill requirements to 16.76×10^7 m³ under controlled population conditions. The study concludes that formal handling and treatment of integrated solid waste management (ISWM) can minimize landfilling, and life cycle assessment (LCA) can contribute as an antidote to achieving sustainable development goals.

Andeobu, Wibowo, and Gandhi's (2022) study investigates the application of AI technologies in various aspects of solid waste management (SWM) in Australia. Analyzing studies from 2005 to 2021, the research focuses on AI's role in SWM, comparing its performance, exploring benefits and challenges, and providing best practices. The findings reveal that AI-based models outperform other forecasting methods in predicting solid waste generation and recycling. The study emphasizes the increasing waste generation in Australia, advocating for upgraded infrastructure and the effective adoption of AI to enhance sustainable SWM. It suggests a national approach to AI recycling technologies for consistency across regions. The study aims to guide researchers, governments, and waste management organizations in improving recycling rates, reducing costs, and transforming solid waste management practices.

Tang and Ledesma's (2023) study recommends collaborative efforts among local government, port authorities, and waste management companies to establish comprehensive waste management programs involving all stakeholders. These programs should encompass education, infrastructure enhancements, and robust enforcement mechanisms for compliance. In order to support sustainable growth and improve the quality of life for nearby communities, the handling of trash in the port city of Zamboanga is the main focus. The study emphasizes integrating environmental considerations into public policy and management practices, particularly in rapidly developing areas like Zamboanga City.

Lamond, Bhattacharya, and Bloch's (2022) study addresses the significant and growing issue of solid waste management in developing countries, which is often overlooked in urban management. The research highlights the impact of poor waste management on urban flooding, citing examples where it blocks drainage, increases debris, and fosters disease vectors. The literature review and case studies, including those from a global urban flood handbook, affirm that solid waste management is an emerging concern in flood risk management. The study suggests improving waste management through large municipal programs and community schemes, emphasizing its integration into comprehensive flood management programs. The research

underscores that effective waste management can respond to flood risk but requires long-term commitment and engagement for sustained success.

II.III. THEORETICAL FRAMEWORK

The theoretical basis of this study is anchored on the theories relating to the implementation of solid waste management.

Waste Management Theory

A more thorough explanation of the field can be found in the Theory of Management of Waste. Conceptual studies of waste, how to act upon trash, and an all-encompassing perspective of waste management objectives are all included. The premise of the theory of waste management is that its goal is to keep trash from endangering the environment or human health. Properly defining waste is crucial to constructing a sustainable waste management agenda. Current legislation attends to existing waste. Nevertheless, since something cannot be stopped from existing after it already exists, definitions originating from this condition can be at odds with waste prevention objectives (Pongrácz, Phillips, & Keiski, 2020).

Waste management theory is deeply rooted in its mission to mitigate harm to human health and the environment by preventing or minimizing waste generation. The overarching goal is waste prevention—taking proactive measures to reduce waste creation. However, an inherent conflict emerges when an item is labeled "waste." Once this classification occurs, the standard waste management processes, including collection, transportation, disposal, or recycling, are set in motion, effectively treating the material as waste. This contradiction challenges the initial objective of waste prevention and highlights the need for a nuanced approach, particularly relevant in ecological solid waste management.

Environmental Theory

Nightingale's emphasis on the role of the physical environment in health and disease prevention has contributed to shaping contemporary infection control guidelines and protocols. In healthcare facilities today, infection control measures incorporate her principles to create environments that minimize the risk of healthcare-associated infections. This includes practices such as rigorous cleaning and disinfection, proper waste disposal, ventilation systems, and adherence to hand hygiene protocols (Gilbert, 2020, p. 626-633)

Relating this study to an investigation of Ecological Solid Waste, the Environmental Theory holds relevance in shedding light on the broader perspective of the environment's influence on health and well-being. Like Nightingale's emphasis on a conducive environment for patient recovery, understanding the environmental aspects is crucial in the context of ecological solid waste management. The theory underscores the necessity of a sustainable and ecologically sound waste management environment to ensure the well-being of communities and the ecosystem. Incorporating insights from the Environmental Theory can provide valuable perspectives on the impact of the environment in promoting sustainable waste management practices and, consequently, safeguarding public health and the environment.

II.IV. CONCEPTUAL FRAMEWORK

The conceptual framework represents the information in relation to the statement of the problems. In the proposed conceptual framework, the study addresses several key components. The independent variables include an exploration of the extent of effectiveness of implementation of solid waste management in Kalayaan, Laguna with the key components of segregation of waste, collection and transport of wastes, and the prohibited acts, fines and penalties.

Research Paradigm

Figure 1 presents the paradigm of the study, which shows the process of this study.

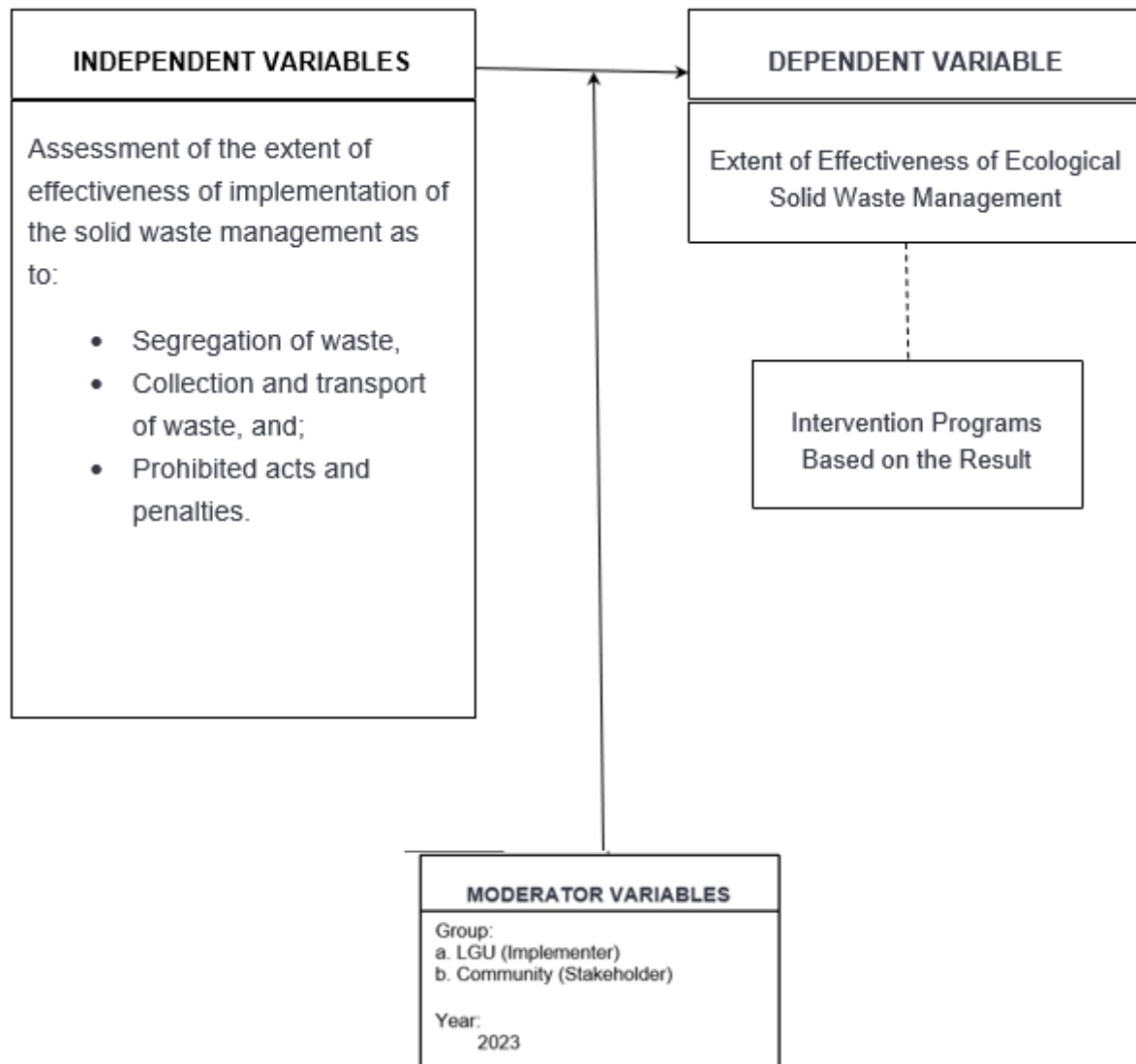


Figure 1. Paradigm of the Study

Figure 1 depicts the dependent variable the researcher tries to measure on the effectiveness of implementation of solid waste management in the Municipality of Kalayaan, Laguna. It was analyzed with the established independent variables, such as the extent of effectiveness of the implementation of solid waste management and the degree of the challenges encountered in implementing ecological solid waste management policies, along with the identified variables. The independent variables on how moderator measure if there is a significant relationship between the perceived level of effectiveness in the implementation and degree of challenges in implementing ecological solid waste management policies.

An intervention program was considered an indispensable requirement or an output that would address the identified problems resulting from the study.

II.V. SIGNIFICANCE OF THE STUDY

The findings of this study will offer municipal officials and community partners valuable insights and information. This knowledge will assist them in effectively guiding their support and roles in implementing solid waste management practices within their respective communities. The study will also help identify critical areas requiring attention when addressing solid waste.

Barangay

The study's findings can benefit barangay officials and community residents, providing them with valuable knowledge about the effective implementation of Solid Waste Management.

Municipal

The study's findings may catalyze the development of more practical solutions concerning Solid Waste Management, serving as a valuable guide for addressing present and future challenges in this area.

Government

The study's results can be utilized to assess the efficiency and effectiveness of the government's initiatives regarding implementing Republic Act No. 9003, known as Ecological Solid Waste Management Act of 2000.

Researcher

The study's findings will enrich the researcher's understanding of proper solid waste management implementation and position them as an active partner in advocating for best practices.

Future Researcher

The study will benchmark future researchers engaging in similar research endeavors.

Legal Basis

The study was based on Republic Act Number 9003, "Ecological Solid Waste Management Act of 2000." Given the serious environmental consequences of waste mismanagement, the passage of this act marked a significant milestone in environmental legislation in the Philippines, addressing the imminent garbage challenges faced by the nation.

II.VI. OPERATIONAL DEFINITION OF RELEVANT TERMS

The following definition of relevant terms gives the readers of this study a better grasp of the terms used in this manuscript.

Composting describes the carefully regulated breakdown of organic materials into a substance resembling humus by microorganisms, primarily bacteria and fungi;

Consumer electronics shall refer to particular waste that includes worn-out, broken, and other discarded items such as radios, stereos, and TV sets;

Disposal refers to a location where solid waste is finally discharged and deposited; disposal shall mean the discharge, deposit, dumping, spilling, leaking, or depositing of any solid waste into or on land;

Ecological solid waste management should refer to the methodical management of all waste management operations that do not negatively impact the environment, including the segregation of waste at the source, separate transportation, storage, transfer, processing, treatment, and disposal of solid waste;

Municipal waste refers to wastes produced from activities within local government units, including domestic, commercial, institutional, and industrial wastes and street litter.

Recovered material is used to describe a substance and its byproducts that have been salvaged or redirected from solid trash in order to be gathered, processed, and utilized as a raw material to create a recycled product;

Recyclable material recognized as any waste material that has been removed from the waste stream, is uncontaminated, and can still be put to good use or other uses. Examples of such materials include newspaper, used oil, ferrous and non-ferrous scrap metal, corrugated cardboard, aluminum, glass, office paper, tin cans, and other materials that the Commission may decide to include.

II.VII. STATEMENT OF THE PROBLEM

The study centered on the Ecological Solid Waste Management: The Kalayaan, Laguna Experience. It will particularly address the subsequent sub-problems:

1. What is the extent of effectiveness of implementation of the solid waste management in the Municipality of Kalayaan, Laguna in terms of.
 - 1.1 Segregation of waste.
 - 1.2 Collection and transport of solid waste; and
 - 1.3 Prohibited Acts, fines, and penalties?
2. Is there a significant difference in the perceived level of effectiveness of the implementation of solid waste management between the LGU and community residents?
3. What is the degree of the challenges encountered in the implementation of policies of ecological solid waste management along with the identified variables?
4. Is there a significant relationship between the perceived level of effectiveness on the findings of the study?
5. What intervention program may be proposed based on the findings of the study?

Hypothesis:

1. There is no significant difference in the in the perceived level of effectiveness of the implementation of solid waste management between the LGU and community residents?

2. There is no significant relationship in the extent of the level of effectiveness of the implementation of solid waste management and the degree of challenges encountered in its implementation.

III. ARRANGEMENTS AND EQUATIONS

Methodology

This chapter presents the research design, research method, population of the study, the locale of the study, scope and limitation of the study, data gathering tools, data gathering procedure, treatment of data, ethical considerations, and dissemination of the research outcomes.

III.I. RESEARCH DESIGN

The study utilized the descriptive research method, employing a survey questionnaire as the principal instrument for data gathering. Its purpose was to systematically describe the existing Ecological Solid Waste Management in the Municipality of Kalayaan, Laguna. The study was intended to evaluate the status of this procedure for the calendar years 2015 to 2022.

According to Zulueta and Costales Jr (2020), the Descriptive method describes the nature of the situation as it exists at the time of the study and aims to explore the causes of phenomena. Descriptive research involves collecting data to test hypotheses or answer questions concerning the status of the subject of the study.

The survey technique was primarily used to gather the necessary data for this study. Informal interviews, documentary gathering, and analysis were also utilized as secondary or supporting data-gathering instruments.

III.II. POPULATION OF THE STUDY

Random sampling was conducted to determine the number of respondents to this study. Random sampling is a method of selecting an observation sample from the population to make assumptions about that population. Another name for it is probability sampling. Non-probability or non-random sampling is the opposite of this type of sampling. Basic random sampling, stratified collection, group sampling, and sampling with multiple stages are the main forms of this kind of sample. Convenience samples are typically required for non-random sampling techniques (BYJVU's, 2023).

Yamane aims to determine the appropriate sample size for academic officers' references. The sample size determination involves a documentary research approach, utilizing calculation formulas, tables, comparisons, and the GPower computer program. The process considers variable types, measurement scales, Type I error (Alpha), Type II error (Beta), Power of Test, and Effect Size to derive an optimal sample size for the research, ensuring statistical reliability and precision in the investigation of academic officers' references (Chaokromthong & Sintao, 2021) The formula gave it:

$$n \geq \frac{N}{1 + Ne^2}$$

Where n represents the minimum sample size and N is the population size. The level of significance, e , that was used in this study was 0.05.

In this study, the population size (N) is 24785, hence $e = 0.05$, sample size is computed is

$$n \geq \frac{24785}{1 + 24785 (0.05)^2}$$

$$n \geq 393.65$$

$$n \geq 394$$

Sampling Distribution

LGUs and Civilian Community	Population	Sample
A. LGU/MENRO	30	12
B. Barangay		
Barangay Longos	6830	109
Barangay San Antonio	11293	179
Barangay San Juan	6662	106
TOTAL	24785	394

Figure 2. Sampling Distribution

Figure 2 depicts that the total number of populations in Kalayaan, Laguna grew from 2,435 in 1903 to 24,785 in 2020. An increase of 22,350 over the course of 117 years (Philippine Statistics Office, 2020).

III.III. LOCALE OF THE STUDY

Kalayaan, Laguna, is a third-class municipality; according to the Census, there are 24,785 populations as of 2020. Kalayaan has a Solid Waste Facility in Sitio San Isidro, Barangay Longos, Kalayaan, Laguna. The site of the Sanitary Landfill has an area of 1.20 hectares. It has an elevation of 320 meters above sea level. Considered the first of its kind on the municipal level in the Province of Laguna, the landfill is complemented by a central Materials Recovery Facility (MRF).

The critical issue in the municipality is insufficient funding for the maintenance of the sanitary landfill; the municipality faces challenges related to the availability of adequate funds required for the maintenance and proper functioning of the sanitary landfill. Financial constraints may impede the effective management of waste disposal. Non-compliance on the part of the barangay about the R.A. 9003. Non-compliance with the regulations and requirements outlined in the Republic Act 9003 (Ecological Solid Waste Management Act of 2000), is a significant issue. Adherence to this act is crucial for effective solid waste management. Refrain from paying for the 'garbage fee' on the part of the community residents and limited awareness of the solid waste management ordinances on the part of the community residents. A notable issue is the reluctance or refusal of community residents to pay the designated 'garbage fee.' This lack of participation may impact the funding needed for waste management initiatives and overall environmental sustainability. Figure 3 presents the map of Kalayaan, Laguna (The Official Website of the Municipality of Kalayaan, Laguna, 2012).

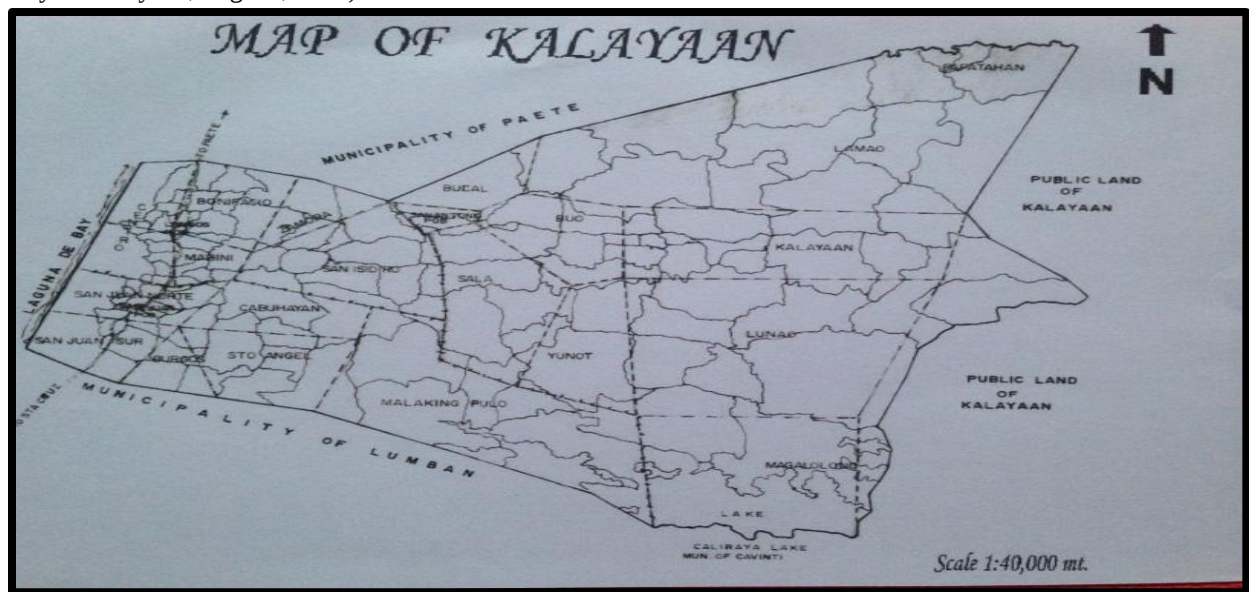


Figure 3. Map of Kalayaan, Laguna

III.IV. SCOPE AND LIMITATION OF THE STUDY

This research study presents a targeted examination of the solid waste management program in the Municipality of Kalayaan, Laguna, to enhance its efficiency and environmental sustainability. Focusing on this geographic area is essential to gain a nuanced understanding of the local waste management strategies and their impact on the community and ecosystem. By engaging with two critical stakeholder groups—municipal officials and community residents—the study ensures a comprehensive and diverse perspective, contributing valuable insights to optimize waste management practices and foster a cleaner, greener, and healthier living environment.

Despite the time constraint of one academic semester, this study's duration is meticulously designed to accommodate an extensive analysis of the program's effectiveness. The research aims to provide actionable recommendations by systematically evaluating its strengths and weaknesses, empowering decision-makers to refine waste management strategies. While financial resources are constrained, the research team remains committed to maximizing the utility of available funds, prioritizing data accuracy and depth in the pursuit of impactful findings. Even amidst logistical challenges, collaborating with municipal officials and community residents underscores the study's dedication to inclusivity and people-driven insights, essential for meaningful advancements in waste management practices. In summation, this research is poised to illuminate successful aspects of waste management initiatives and serve as a catalyst for future sustainable practices within the Municipality of Kalayaan, Laguna.

III.V. DATA GATHERING TOOLS

A 4-point Likert Scale questionnaire checklist was utilized to address the research problems. Documentary analysis and informal interviews complemented the primary instrument.

The primary data collection instrument for this study was a survey-type questionnaire. The questionnaire was administered to the respondents and collected later for record-keeping. The survey questionnaire consisted of two sections. The first section contained items related to the perceived extent of implementation of the Municipal Officials in the solid waste management program, specifically focusing on the Segregation of waste, Collection, and transport of waste, as well as Prohibited acts, fines,

and penalties. The second section examined the significant differences in the perceived extent of implementation between Municipal Officials and the Community regarding the Solid Waste Management Program.

Respondents needed to mark or, if necessary, indicate their answers for the corresponding items.

To establish the validity of the questionnaire's content, it was aligned with the research problems. The validity of the questionnaire was affirmed by presenting it to a panel of examiners during the research proposal defense.

III.VI. DATA GATHERING PROCEDURE

The study utilized questionnaires and document analysis to gather pertinent data. The researcher drafted a communication letter to initiate the study, which was endorsed by the Dean of the graduate study and subsequently approved by the municipal mayor of the Municipality of Kalayaan, Laguna.

Once the necessary permissions were obtained, the researcher commenced the preparation of the questionnaires. Additional information was gathered through further interviews with the respondents. The questionnaires were personally distributed and, upon completion, collected from the respondents. The data obtained from the questionnaires were tallied, analyzed, and interpreted.

III.VII. STATISTICAL TREATMENT OF DATA

The interpretation and analysis of the data were gathered, aided by the 4-point Likert Scale presented as follows (Khalia, 2002):

Scale	Range	Descriptive Equivalent
4	3.26 - 4.00	Very Much Implemented (VMI)
3	2.41 - 3.25	Implemented (I)
2	1.76 - 2.40	Moderately Implemented (MI)
1	1.00 - 1.75	Not Implemented (NI)

Scale	Range	Descriptive Equivalent
4	3.26 - 4.00	Most Serious (MS)
3	2.41 - 3.25	Serious (S)
2	1.76 - 2.40	Less Serious (LS)
1	1.00 - 1.75	Not Serious (NS)

To answer the problems posed, the following statistical tools were used: Mean and standard deviation were utilized to determine the effectiveness of the implementation of solid waste management in terms of segregation of waste, collection and transport of waste, and prohibited acts, fines, and penalties.

Formula for Sample Mean:

$$\bar{x} = \frac{\sum x}{N}$$

Wherein:

$\bar{x}$ = just stands for the "sample mean"

$\sum$ = mean "add up"

X = "all of the x-values"

N = means "the number of items in the sample"

Mean and standard deviation were utilized to determine the level of implementation of the solid waste management system.

Formula for Standard Deviation:

$$S = \sqrt{\frac{\sum (X - \bar{x})^2}{n - 1}}$$

Wherein:

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S/SD = Standard Deviation

Σ = means “add up”

N = mean “the number of items in the sample”

$\bar{x}$ = just stands for the “sample mean”

Standardized test statistics were used to determine the significant difference in the assessment of the implementers and stakeholders according to the study about the “Implementation of Solid Waste Management in the Municipality of Kalayaan, Laguna.”

The t-test for dependent samples was applied to determine the significant difference between the perception of the municipal officials and the community residents.

Formula for t-Test:

$$t = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\left(\frac{SS_1 + SS_2}{n_1 + n_2 - 2}\right) \left(\frac{1}{n_1} + \frac{1}{n_2}\right)}}$$

Wherein:

t = the t test

$\bar{x}_1$ = the mean of group 1

$\bar{x}_2$ = the mean of group 2

SS_1 = the sum of squares of group 1

SS_2 = the sum of squares of group 2

n_1 = the number of observation in group 1

n_2 = the number of observation in group 2

Decision Rule

To determine if there is a significant difference, the following scales will be used: Specify the scales or statistical tests that will be employed in the study.

0.050-below SIGNIFICANT

0.051-above NOT SIGNIFICANT

III.VIII. ETHICAL CONSIDERATIONS

While conducting this research, we meticulously integrated ethical considerations to safeguard the rights and well-being of all participants involved. To commence, a comprehensive informed consent form was employed, meticulously detailing the objectives, potential risks and benefits, confidentiality measures, and the voluntary nature of participation. The consent form was presented clearly and understandably, allowing participants to make informed decisions regarding their involvement in the study. This measure ensured that ethical principles of respect for autonomy and informed consent were upheld.

Addressing the potential scenario of unwilling participants, great care was taken to respect individual autonomy and avoid any form of coercion or undue influence. Unwilling participants were fully respected in their decision not to participate, and no adverse consequences were imposed upon them. Alternative avenues were explored to engage willing participants, ensuring that no discomfort or harm resulted from the non-participation of any individuals.

In the process of gathering data through questionnaires and interviews, ethical considerations were paramount. The questions were carefully designed to be respectful and non-intrusive, steering clear of sensitive or potentially harmful topics. Participants were explicitly informed of their right to skip questions they felt uncomfortable answering, promoting a sense of agency and comfort throughout the data collection process. Moreover, measures were implemented to maintain participant anonymity and confidentiality, reinforcing trust and upholding ethical standards in data gathering.

Moreover, the research made a concerted effort to involve diverse segments of the population, including minors, women, senior citizens, persons deprived of liberty, persons with disabilities, and other sectors. For minors, parental consent was meticulously

obtained, coupled with the assent of the minors themselves. The involvement of vulnerable populations entailed implementing additional safeguards to ensure informed consent and mitigate any potential power imbalances. Accessible formats and appropriate accommodations were provided to enable the participation of persons with disabilities, exemplifying an inclusive approach to research ethics. Additionally, a keen sensitivity to cultural and social contexts was maintained, respecting all participants' unique rights and dignity, especially those belonging to underrepresented or marginalized groups.

These ethical considerations were not merely formalities but integral aspects of the research process, upholding fundamental ethical principles such as respect, beneficence, justice, and autonomy. By adhering to these ethical guidelines, we strived to conduct meaningful and ethical research with the utmost regard for the welfare and rights of all participants involved.

III.IX. DISSEMINATION OF THE RESEARCH OUTCOME

After the research was concluded, an inclusive dissemination plan was devised, incorporating strategies such as presentations in esteemed forums and informative letters outlining key findings, all directed towards reaching the intended recipients. The primary beneficiaries, considering the study's significance, were at the forefront of this dissemination strategy, informing the subsequent design of an intervention program to address their specific needs.

IV. TABLES AND FIGURES

Table 1. Extent of Effectiveness of Implementation of Solid Waste Management along various Parameters

Effectiveness of Implementation of Solid Waste Management	Med	Int
1.1 Segregation of Wastes		
1. Presence of separate container for each type of wastes.	3.69	VMI
2. For bulky waste, it will suffice that the same be collected and placed in a separate container and in designated areas.	3.02	MI
3. The solid waste container depending on its use was properly marked or identified for on-site collection as "compostable," "recyclable" or "special waste."	3.61	VMI
4. Provide the residents a designated area and containers in which to accumulate source separated recyclable materials to be collected by the barangay or private collector.	3.46	VMI
5. No scavenging or unauthorized collection in designated segregation containers or areas allowed.	3.59	VMI
1.2 Collection and Transport of Wastes		
1. All collectors and other personnel directly dealing with collection of solid waste are equipped with personal protective equipment.	3.16	MI
2. The City or Municipal Health officer provides necessary training to the collectors and personnel to ensure that the solid wastes are handled properly.	3.30	VMI
3. Collection of Solid Waste is done in a manner that prevents damage to the container and spillage or scattering of solid waste within the collection vicinity.	3.32	VMI
4. The equipment used in the collection and transportation of solid waste (or materials which have been separated for the purpose of recycling) was constructed, operated and maintained in such manner as to minimize health and safety hazards to solid waste management personnel and the public.	3.46	VMI
5. Vehicles were designed to consider road size, condition and capacity to ensure the safe and efficient collection and transport of solid wastes.	3.46	VMI
1.3 Prohibited Acts, Fines and Penalties		
1. Littering, throwing, dumping of waste matters in public places, such as roads, sidewalks, canals, esteros or parks, and establishment, or causing or permitting the same is punishable with a FINE of Payment in the amount not less than Three hundred pesos (P300.00) but not more than One thousand pesos (P1,000.00) or RENDERING OF COMMUNITY SERVICE for not less than one (1) day to not more than fifteen (15) days to an LGU where such prohibited acts are committed or both.	2.46	I
2. Open burning of solid waste is punishable with a FINE with the amount of not less than Three hundred pesos (P300.00) but not more than One thousand pesos (P1,000.00) or IMPRISONMENT of not less than one (1) day to not more than fifteen (15) days or both.	3.22	MI
3. Causing or permitting the collection of non-segregated or unsorted waste is punishable with a FINE of an the amount of not less than One thousand pesos (P1,000.00) but not more than Three thousand	2.87	MI

pesos (P3,000.00) or IMPRISONMENT of not less than fifteen (15) day to not more than six (6) months or both.		
4. Unauthorized removal of recyclable material intended for collection by authorized persons is punishable with a FINE of an amount of not less than One thousand pesos (P1,000.00) but not more than Three thousand pesos (P3,000.00) or IMPRISONMENT of not less than fifteen (15) day to not more than six (6) months or both.	2.86	MI
5. Manufacture, distribution or use of non-environmentally acceptable packaging materials is punishable, for the FIRST TIME, shall pay a fine of Five hundred thousand pesos (P500,000.00) plus an amount not less than five percent (5%) but not more than ten percent (10%) of his net annual income during the previous year or the additional penalty of IMPRISONMENT of a minimum period of one (1) year, but not to exceed three (3) years at the discretion of the court, shall be imposed for SECOND OR SUBSEQUENT violations of Sec. 48 of the Act, paragraphs (9) and (10).	3.24	VMI

*Legend: VMI – Very Much Implemented, MI – Moderately Implemented, I – Implemented, NI – Not Implemented

Table 1 presents the effectiveness of the solid waste management implementation in the municipality of Kalayaan, Laguna, regarding waste segregation, collection, and transport of solid waste, as well as the prohibited acts, fines, and penalties.

When looking at the segregation of wastes, it shows that most of them are very much implemented by solid waste management, except the item “For bulky waste, it will suffice that the same be collected and placed in a separate container and in designated areas” which show the minor result and was labeled as “moderately implemented.” This was explained in the study by Camarillo and Bellotindos (2021), which indicates an average level of compliance in collecting and transporting solid wastes. Of the various factors provided, the highest is the presence of separate containers for each type of waste (3.69) and that the solid waste containers were adequately marked or identified for on-site collection, namely “compostable,” “recyclable,” and “special waste.” (3.61). This indicates that accessibility to properly labeled bins has an important task in community pertaining to waste segregation. This is supported by the study of Otitoju and Seng (2014), indicating that nearby trash bins are an obvious incentive to the citizens, showing a consistent finding in the study.

The collection and transport of waste shows that all of them are very much implemented by solid waste management, except the item “All collectors and other personnel directly dealing with the collection of solid waste are equipped with personal protective equipment.” it showcases that it is the least equivalent result that is labeled as “moderately implemented” only since some of the collectors and personnel who directly deal with the collection of solid waste rarely wore Personal Protective Equipment (PPE). Based on the findings by Salmawati et al. (2018), assigned personnel on garbage collection were not paying attention to using the PPE; some only wore PPE on several parts of their body, and some did not wear it at all). Of the various factors provided, there are two (2) highest among all. They are the equipment used in the collection and transportation of solid waste (or materials that have been separated for recycling) was constructed, operated, and maintained in such a manner as to minimize health and safety hazards to solid waste management personnel and the public (3.46) and Vehicles were designed to consider road size, condition, and capacity to ensure the safe and efficient collection and transport of solid wastes (3.46). This indicates that... the municipality has considered essential factors such as safety, convenience, and efficiency in the collection and transport of wastes. The study by Wu, Tao, and Yang (2020) suggested that there should be a program for the schedules of vehicle routes, which requires much effort to lessen the cost of transportation and collection costs, as well as the adverse effects of wastes and to guarantee that all citizens live in a safe and sound environment.

The prohibited acts and penalties show that most of the items were rated as “moderately implemented” by the solid waste management, except for the item “Littering, throwing, dumping of waste matters in public places, such as roads, sidewalks, canals, esters or parks, and establishment, or causing or permitting the same is punishable with a FINE of Payment in the amount not less than Three hundred pesos (P300.00) but not more than One thousand pesos (P1,000.00) or RENDERING OF COMMUNITY SERVICE for not less than one (1) day to not more than fifteen (15) days to an LGU where such prohibited acts are committed or both.” in which shows the most negligible number value of result and labeled as “implemented” only. This is due to the lack of knowledge by the citizens on proper waste disposal in public areas). The study by Dhahir (2020) explained that increasing knowledge, providing correct perceptions regarding waste, establishing communication among the administrators, setting good examples, strict implementations of the law, supervision, environmental engineering, and providing facilities would help promote anti-littering campaigns. Of the various factors provided, the highest is that Manufacture, distribution, or use of non-environmentally acceptable packaging materials is punishable, for the FIRST TIME, shall pay a fine of Five hundred thousand pesos (P500,000.00) plus an amount not less than five percent (5%) but not more than ten percent (10%) of his net annual income during the previous year or the additional penalty of IMPRISONMENT of a minimum period of one (1) year, but not to exceed three (3) years at the discretion of the court, shall be imposed for SECOND OR SUBSEQUENT violations of Sec. 48 of the Act, paragraphs (9) and (10) (3.24). This is an indication that the citizens were highly aware that the use of non-environmentally acceptable packaging is prohibited in the municipality and that the assigned personnel for monitoring stores regarding the use of plastic were strict and actively performing in implementing such ordinance Alarzar, Briones, Canlas, and Magnaye (2018) supported the findings of this study and discussed that the government officials utilized proper regulation; monitoring, and evaluation but are still lacking in terms of the full implementation of different environmental programs to increase the knowledge of the citizens regarding the prohibited acts, fines, and penalties concerning solid waste management.

Table 2. Comparison on the Perceived Level of Effectiveness of the Implementation of Solid Waste Management Between the LGU and Community Residents

Solid Waste Management Practices	STATUS				Mann-Whitney Z-Value	Test Statistics p-Value
	LGU		Citizen			
	Med	Int	Med	Int		
2.1 Segregation of Wastes	3.67	VMI	3.57	VMI	0.644	0.520
2.2 Collection and transport of solid waste	3.92	VMI	3.40	VMI	2.900	0.004*
2.3 Prohibited Acts, fines, and penalties	3.83	VMI	2.78	MI	3.757	0.000*

*significant @ ≤ 0.05 ; Legend: VMI – Very Much Implemented, MI – Moderately Implemented, I – Implemented, NI – Not Implemented

Table 2 compares the perceived effectiveness of the implementation of solid waste management between the LGU and community residents, the segregation of wastes, collection, and transport of solid waste, and prohibited acts, fines, and penalties.

In the segregation of wastes, both LGUs (3.67) and community citizens (3.57) observed that various policies for solid waste management are very much implemented. This perception was influenced by the active implementation of solid waste management policies and environmental programs conducted by the Local Government Unit Officials of Kalayaan, Laguna. The Theory of Waste Management pertains to compliance, risk management, health, and the environment. Under this concept, Cooper explained that raising awareness among the area's residents and the legislation could be identified as preventive practices concerning solid waste management (Lagman-Bautista, 2020). The Mann-Whitney Z-value of 0.644 corresponds to a p-value of 0.520, indicating that the difference is not significant.

For the collection and transport of solid waste, the LGU (3.92) and the community citizens (3.40) also perceived this as being implemented. Although they seemingly observed that the implementation was very effective, some aspects from the first item were elaborated: "All collectors and other personnel directly dealing with the collection of solid waste are equipped with personal protective equipment." This was rated as moderately implemented only. The findings indicated that despite the high level of implementation regarding the collection and transport of solid wastes, the collectors and personnel assigned to deal with the collection of solid waste directly were not assured of being in a safe condition for being unequipped with PPE all the time. The need for safety was under the hierarchy of needs Maslow, which included the safekeeping of the body, being employed, having enough resources, maintaining the family's morality, and maintaining health. Moreover, to prevent the possible long-term consequences to the workers' health, extensive support should be provided regarding PPE socialization, and the sanitary department should be given to the collectors and personnel (Sarman et al., 2022). The Mann-Whitney Z-value of 2.900 corresponds to a p-value of 0.004, indicating that the difference is significant.

For the prohibited acts, fines, and penalties, the LGU (3.83) observed that some policies are very much implemented, and the community citizens (2.78) observed that some policies are moderately implemented. The Mann-Whitney Z-value of 3.757 corresponds to a p-value of 0.000, indicating that the difference is significant.

Table 3. Degree of Challenges Encountered in the Implementation of Policies of Ecological Solid Waste management along various terms.

Challenges Encountered in the Implementation of Policies of Ecological Solid Waste management	Med	Int
3.1 Degree of Challenges Encountered in the Segregation of Wastes		
1. Many residents are not aware of the need for waste segregation and its benefits, making it challenging to implement effectively.	2.11	LS
2. Communities may lack of access to proper education and training regarding the waste segregation methods.	1.85	LS
3. Some area may not have the facilities for proper waste segregation.	2.24	LS
4. Communities may have limited access to recycling centers or facilities for separated recyclable materials.	3.25	S
5. Proper enforcement of waste segregation practices can be difficult due to limited resources and oversight.	2.55	S
3.2 Degree of Challenges Encountered in the Collection and Transport of Wastes		
1. The local government has lack of necessary areas for collection infrastructure, such as waste bins or containers, to support the efficient waste collection.	2.35	LS

2. Uneven or unreliable waste collection schedules can hinder proper waste disposal and separation.	2.55	S
3. There is not enough or appropriate collection vehicles to handle the volume of wastes effectively.	2.49	S
4. Poorly planned collection routes can lead to unnecessary delays in waste pick up.	2.32	LS
5. Overloading of waste collection vehicles can lead to spillage and environmental solution.	2.72	S
3.3 Degree of Challenges Encountered in the Implementation of Prohibited Acts and Penalties		
1. Many residents and business may not fully aware of the prohibited acts and their associated penalties.	2.57	S
2. Some businesses and individuals might consider the costs of compliance with RA 9003.	2.77	S
3. Inconsistent law enforcement of the prohibited acts leads to non-compliance, as business and individuals might not fear on punishment.	2.68	S
4. The locality has lacking on the resources and personnel to effectively monitor and enforce the regulations.	2.51	S
5. Certain cultural practices might conflict with the prohibited acts, making it difficult to change deeply ingrained behaviors.	2.61	S

*Legend: *MI* – Most Serious, *S* – Serious, *LS* – Less Serious, *NS* – Not Serious

Table 3 presents the degree of the challenges encountered in implementing policies of solid waste management in the municipality of Kalayaan Laguna in terms of the challenges encountered in the segregation of wastes, collection and transport of wastes, and the implementation of prohibited acts and penalties.

When looking at the degree of challenges encountered in the implementation of prohibited acts and penalties, all factors are seen as a serious challenge in the implementation of solid waste management. Of the various factors provided, the biggest challenge presented is that communities may have limited access to recycling centers or facilities for separated recyclable materials (3.25) and that some businesses and individuals might consider the costs of compliance with RA 9003 (2.77). This is an indication that the recycling centers or facilities are not accessible for the citizens due to their location and some citizens can provide the fines and penalties imposed for non-compliance with R.A. 9003. Although more than a decade had passed since the law was implemented, compliance and implementation at the Local Government Unit level were inadequate and challenging and was influenced by factors such as leadership, institutional/organization support, facilities, financial and technical capacities, and insufficient enforcement systems (Gamaralalage, Simon, & Kyungsun, 2015).

Table 4. Relationship in the Extent of Effectiveness and the Degree of Challenges on the Implementation of Solid Waste Management along Various Factors

Predictor (Extent of Effectiveness)	Response (Degree of Challenges)	Spearman-rho ρ Coefficient Value	Interpretation	p-Value
Segregation of Wastes	Segregation of Wastes	-0.190	Weak Relationship	0.000*
	Collection and transport of solid waste	0.041	No Relationship	0.416
	Prohibited acts, fines, and penalties	-0.041	No Relationship	0.421
Collection and Transport of Solid Waste	Segregation of Wastes	0.209	Weak Relationship	0.000*
	Collection and transport of solid waste	0.174	Weak Relationship	0.001*
	Prohibited acts, fines, and penalties	0.383	Moderate Relationship	0.000*
Prohibited Acts, Fines, and Penalties	Segregation of Wastes	0.034	No Relationship	0.505
	Collection and transport of solid waste	0.025	No Relationship	0.626

	Prohibited acts, fines, and penalties	0.139	Weak Relationship	0.006*
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*significant @ ≤ 0.05

Table 4 is the relationship between the extent of effectiveness and the degree of challenges on the implementation of solid waste management along the segregation of wastes, collection and transport of solid waste, and prohibited acts, fines, and penalties.

Under the effectiveness of the segregation of solid waste, the challenges presented in the segregation of wastes indicate a weak relationship with a Spearman rho coefficient of -0.190. The p-value of 0.000, it indicates that there is no significant relationship between both factors. This could be due to the amounts of waste produced by every individual which is a product of consumption. The study conducted by Chen, Bodirsky, and Krueger (2020) revealed that the overall amount of garbage produced increases at a decreasing rate as economic development progresses, rising from 635 million tons in 1965 to 1999 million tons in 2015 and 3539 million tons by 2050 (median values, middle-of-the-road scenario). The world's share of waste that is organic falls from 47% to 39% between 2015 and 2050, while the shares of all other waste types—especially paper—increase. Recycled materials are being processed more sustainably, and energy recovery, composting, and recycling now account for 18% of treated trash, down from 28% in the past.

Under the effectiveness of the collection and transportation of solid waste and the challenges presented in the collection and transport of solid waste, there is no relationship between as indicated by the Spearman rho coefficient of 0.041. The two factors with a p-Value of 0.000 indicates there is no significant relationship between the factors. This could be an indication of a high level of awareness of the citizens regarding the schedules of the collection of solid wastes within the municipality which is due to prior notice and strictly following the announced schedule by the collectors. The study conducted by Huang and Lin (2015), identified efficient routing and scheduling for collection of garbage as contributing factors on improving the service of municipal solid waste collection.

Under the effectiveness of the prohibited acts and penalties, the challenges presented in the prohibited acts, fines, and penalties indicate a moderate relationship with a Spearman rho coefficient of 0.383. With a p-value of 0.000, it indicates that there is a significant relationship between both factors. This could be due to the compliance of the citizens provided that the community has a positive perception of the extent of the implementation of R.A. 9003 within the municipality. The study by Debrah, Vidal, and Dinis (2021) revealed that the practice or participation in Solid Waste Management within the community was influenced by positive attitudes and perceptions towards SWM.

Intervention Program Proposed Based on The Findings of The Study

Description	
- Conduct interactive workshops to educate residents and waste management personnel on proper waste segregation techniques. - Provide hands-on demonstrations on how to separate different types of waste such as organic, recyclable, and hazardous materials. - Discuss the benefits of waste segregation in reducing environmental pollution and promoting resource conservation.	- Organize training sessions for waste collectors and transportation staff on safe handling and efficient methods of waste collection and transportation. - Include practical exercises on loading and unloading waste, securing waste containers, and optimizing collection routes to minimize environmental impact and improve operational efficiency.
- Host workshops for enforcement officers and local government officials on the proper implementation of fines and penalties for waste management violations. - Review relevant laws and regulations, discuss enforcement procedures, and clarify the roles and responsibilities of enforcement personnel. - Conduct role-playing scenarios to simulate enforcement situations and develop effective communication and conflict resolution skills.	- Launch education campaigns in schools, communities, and public spaces to raise awareness about solid waste management principles and practices. - Develop educational materials such as pamphlets, posters, and videos to convey key messages about waste reduction, recycling, and environmental stewardship. - Organize training programs for educators, community leaders, and volunteers to become advocates for sustainable waste management within their respective spheres of influence.

Action Plans	Learning Method
Enhance the Segregation of Wastes	An annual Workshops on Waste Segregation to be handled by the PENRO/MENRO Personnel from the LGU with the cooperation of the Barangay Chairpersons of each barangay. 5 hours per session
Improve the Collection and Transportation Methods	A quarterly Training Sessions on Collection and Transportation Methods for the garbage collectors which will be led by personnel from the PENRO/MENRO and a guest speaker from the Health Department. 5 hours per session
Strengthen Enforcement of Fines and Penalties	There should be an annual Information Dissemination Campaign among the localities with regards to the Enforcement Workshops on Fines and Penalties.
Promote Education and Training	An annual Education Campaigns and Training Programs in the community from the Local Government Unit (LGU)

Learning Method	Description
There should be a creation of Establishment of Recycling Facilities and Programs that will provide an additional income in the municipality. Should be collaborated with other organizations.	- Collaborate with local businesses, NGOs, and recycling organizations to establish recycling facilities and programs in strategic locations within the community. - Provide training and technical assistance to residents and businesses on proper recycling techniques and the types of materials accepted for recycling. - Implement incentive programs such as buy-back schemes or rewards for recycling participation to encourage community engagement and increase recycling rates.
Vehicle Inspection and Maintenance Workshops to be done quarterly for the garbage truck drivers and the carrier (loader). 5 hours per session	- Conduct workshops for waste management fleet managers and drivers on the importance of vehicle inspection and maintenance to prevent overloading and minimize environmental pollution. - Train personnel on how to conduct routine vehicle checks, identify potential safety hazards, and address maintenance issues promptly to ensure safe and efficient operation of waste collection vehicles.
Creation of the Financial Assistance and Support Programs in connection with the business owners and the Go-Negosyo program of the LGU's.	- Develop financial assistance and support programs to alleviate economic barriers to compliance with waste management regulations. - Offer grants, subsidies, or low-interest loans to businesses and individuals for investments in waste reduction, recycling infrastructure, and environmentally sustainable practices. - Provide guidance and technical assistance to help stakeholders navigate regulatory requirements and access available funding opportunities.

Action Plans	Expand Access to Recycling Facilities	Prevent Overloading of Waste Collection Vehicles	Address Economic Barriers to Compliance
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V. OUTCOME OF THE STUDY

As established from the study, it shows that implementation of the ecological solid wastes resulted in highlighting some specific situations that struggled the stakeholder and the implementer. It pertains that most of the community residents are not fully aware regarding the recycling facilities and is not familiar on its existence.

Poor recycling quality due to lack of education. Most people know that recycling is a good habit for the environment but are often unsure of where and what goes into the recycling bin. As a result, non-recyclable items (such liquids or plastic bags) end up in the recycling stream where they pollute recyclable materials and damage recycling equipment. Customers giving up and grabbing the trash can (Huun, 2022).

VI. CONCLUSION

The study reveals that implementing solid waste management policies in Kalayaan, Laguna, is generally adequate. However, challenges persist, particularly in the following:

1. Despite efforts in the segregation of waste, the provision of separate containers for various waste types, particularly for bulky waste, appears to be poorly implemented, according to respondent feedback. The collection and placement of bulky waste in designated areas also need to be improved in implementation.
2. In the collection and transportation of waste, efforts to provide personal protective equipment (PPE) to waste collectors need to be improved in implementation. Collection methods must improve to prevent container damage and waste spillage. Additionally, equipment used in collection and transportation needs better management to minimize health and safety risks.
3. Despite fines and penalties for littering and dumping waste in public places, the enforcement seems inadequate, as seen by respondents. The enforcement of fines and community service for littering and dumping offenses needs to be strengthened for better compliance.
4. The research indicates that communities often lack access to proper education and training regarding waste segregation methods. This represents a foundational challenge, as awareness and understanding are crucial for effective waste management practices.
5. The data highlights that communities may face challenges accessing recycling centers or facilities for separated recyclable materials. This limitation impedes efforts to promote recycling and sustainable waste management practices, as residents may need more convenient avenues for disposing of recyclable materials.
6. Overloading waste collection vehicles poses a significant risk of spillage and environmental pollution. This issue compromises the environment's aesthetics and contributes to health hazards and ecosystem degradation. It underscores the need for proper waste management infrastructure and operational guidelines to prevent such incidents.
7. The data suggests that some businesses and individuals may consider the costs of complying with RA 9003, the Philippine Ecological Solid Waste Management Act. This indicates a potential barrier to full compliance with waste management regulations, as economic factors may influence behavior and decision-making processes.

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