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MASTER OF RESEARCH AND DEVELOPMENT MANAGEMENT

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IMPACT ASSESSMENT OF A MARIKINA BIOREACTOR COMPOSTING TECHNOLOGY DEVELOPED BY THE DEPARTMENT OF SCIENCE AND TECHNOLOGY-INDUSTRIAL TECHNOLOGY DEVELOPMENT INSTITUTE

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31 July 2025

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Stephanie Azarcon Alvaro and 14 August 2025
Signature over Student Name and Date

Acceptance Page

This Special Problem of **STEPHANIE A. ALVARO** titled: **“IMPACT ASSESSMENT OF A MARIKINA BIOREACTOR COMPOSTING TECHNOLOGY DEVELOPED BY THE DEPARTMENT OF SCIENCE AND TECHNOLOGY-INDUSTRIAL TECHNOLOGY DEVELOPMENT INSTITUTE”** is hereby accepted by the Faculty of Management and Development Studies, U.P. Open University, in partial fulfillment of the requirements for the degree Master of Research and Development Management.

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Biographical Sketch

Ms. Stephanie Azarcon Alvaro has been a civil servant in the executive branch of government since 2021. She focused most of her time on implementing good governance among state-owned enterprises in the Philippines through performance evaluation. Prior to that, she served in a government-owned and controlled corporation where she aided policymakers in shaping and evaluating public policy and programs by conducting capability-building interventions, policy analyses, impact assessments, and research in pursuit of development and good governance. This experience inspired her to take up Master of Research and Development Management at the University of the Philippines Open University.

Declaration

This is to certify that:

1. The special problem comprises only my original work towards the MR&DM except where indicated in the Preface.
2. Due acknowledgment has been made in the text to all other material used.
3. The special problem is fewer than 25,000 words in length, exclusive of tables, maps, bibliographies, and appendices.

Stephanie A. Alvaro

Acknowledgement

I extend my heartfelt gratitude to the Department of Science and Technology – Industrial Technology Development Institute. To Director Briones, Engr. Esguerra, Ma'am Tansengco, Mr. Cruz, Ms. Moico, Mr. Eclipse, and Ms. Valda: I cannot thank you enough for the trust, support, and patience you have given me throughout this endeavor. Thank you because the lessons and wisdom I gained from this experience are priceless. My only hope is for this study to serve its purpose – help your organization in improving your projects and make them more sustainable for the betterment of the Filipino.

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This study is a proof that having a heart is not enough – it takes a village to be able to give back to people through honor, service, and excellence.

I am eternally grateful.

Dedication

To my husband, thank you for bearing with me as I reach my dream. We know it has not been easy – we had our share of struggles on top of this. But know that I value all your efforts.

To my family, thank you for the encouragement. No one said it would be easy, more so for us who’s just trying to get by. Thank you for supporting me even though it meant less time and support for you.

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To my batchmates, classmates, and faculty of the UP Open University Faculty of Management and Development Studies Program of Research and Development Management, I enjoyed learning, struggling, and dreaming with you. Thank you for making my stay memorable and worthwhile.

To the Filipino people, especially the underserved, I hope that in time, the benefits of this study will reach you.

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Abstract

This study assesses the impact of a bioreactor composting technology developed by the Department of Science and Technology-Industrial Technology Development Institute (DOST-ITDI) and used in Marikina City, Philippines. Using the Multi-dimensional Sustainability Framework (MSF) and the Context, Input, Process, Product (CIPP) Model, it evaluated the environmental, economic, social, technological, and institutional effects of the bioreactor in managing organic waste in compliance with Republic Act No. 9003. Data were gathered through interviews and focus group discussion with Materials Recovery Facility (MRF) staff and secondary sources within the project area. Findings indicate that the bioreactor helps reduce landfill waste and greenhouse gas emissions, produces nutrient-rich compost that improves soil, and creates community jobs and involvement. While the technology expedites composting and reduces manual work, it faces challenges like machine wear and need for better support. The study suggests improving design, training, and monitoring. Overall, the bioreactor is a sustainable and effective solution for organic waste that benefits the environment, society, and economy while supporting national and global sustainability goals.

Keywords: Bioreactor composting; organic solid waste; impact assessment; Multi-dimensional Sustainability Framework; CIPP Model; waste management; DOST-ITDI; Marikina City; Republic Act No. 9003; sustainable development;

CHAPTER I

BACKGROUND OF THE STUDY

Trends and Challenges in Solid Waste Generation

Studies show that waste production is associated with industrialization, rapid development, and increase in population. This scenario unavoidably gave rise to higher production, consumption, and production of greenhouse gases emissions (Domingo and Manejar, 2021).

Table 1 shows how much solid waste is made every day in the Philippines. From 2012 to 2016, the waste went up by 7%, from about 37,400 tons to 40,000 tons each day. In 2016, the Luzon area made 17,500 tons, which is almost half of all the waste in the country.

Table 1.1

Estimated Solid Waste Generation of the Philippines (Tons per day)

Region	2012	2013	2014	2015	2016
1	1,709	1,740	1,770	1,800	1,831
2	1,101	1,120	1,140	1,159	1,179
3	3,632	3,697	3,761	3,826	3,890
4A	4,146	4,219	4,293	4,366	4,440
4B	909	926	942	958	974
5	1,879	1,912	1,946	1,979	2,012
6	2,700	2,748	2,796	2,844	2,892
7	2,606	2,652	2,698	2,745	2,791
8	1,479	1,506	1,532	1,558	1,585
9	1,392	1,417	1,441	1,466	1,491
10	1,694	1,724	1,754	1,784	1,814
11	1,818	1,850	1,883	1,915	1,947
12	1,348	1,372	1,396	1,420	1,444
13	885	900	916	932	948
CAR	621	632	643	654	665
NCR	8,602	8,754	8,907	9,060	9,213
ARMM	908	924	940	956	972
Total	37,427	38,092	38,757	39,422	40,087

According to the United Nations Environment Programme (2024), the forecast for municipal solid waste generation from 2023 to 2050 is 2.1 billion and 3.8 billion tons, respectively. The study revealed that preventing waste and proper management through sustainable practices could reduce to global annual cost by USD 370.1 billion by 2050. The global phenomenon is also reflected in the Philippines and is projected to get worse considering the complex characteristics of a developing country (Domingo and Manejar, 2021).

As the amount of solid waste, especially organic waste, keeps growing, there is a bigger need to manage it properly. This led to the development of bioreactor composting technologies. These technologies help break down organic waste faster and more efficiently by controlling things like air, moisture, and temperature. They also reduce bad smells and harmful gases and turn waste into useful compost quicker than traditional methods. Bioreactors help cut down waste in landfills and keep the environment cleaner.

As for the existence of research and development on bioreactor, in the Philippines, a study by Ronquillo and Asufre (2014) revealed that Surigao del Sur, through the Bioreactor-Vermi Technology, managed to reduce the biodegradable municipal solid wastes in its two municipalities by 6.68% and produced 300 tons of organic fertilizers within five years.

Additionally, as discussed by Eco-Business (2015), the Cancun Palace Resort in Mexico effectively addressed its problems on 2,500 tons of organic waste produced annually by utilizing the BioReactor composter by XACT Systems, Inc.

Republic Act No. 9003

The Ecological Solid Waste Management Act of 2000 (RA No. 9003) was created to address increasing waste and its negative impacts on pollution, health, and climate change. It sets national and local programs for managing waste by requiring proper disposal, composting, recycling, reuse, and recovery. The law ensures waste is sorted, collected, treated, and disposed of in environmentally safe facilities. It also supports research to improve waste management and conserve resources. (Official Gazette, 2021).

Industrial Technology Development Institute

As for the Department of Science and Technology's Industrial Technology Development Institute (DOST-ITDI), the agency actively supported its implementation. In particular, it developed innovative composting technologies such as dual-drum composter, household tumbling composter, and bioreactor, to help local government units (LGUs) manage organic waste effectively and sustainably. As early as 2002, the bioreactor composting technology (bioreactor) was introduced in the National Capital Region (NCR). By 2007, it was highly commercialized and widely adopted in the region, particularly Marikina City. The efforts were sustained as evidenced by 132 LGUs and communities that adopted it and the training on bioreactor operation and maintenance for Materials Recovery Facility (MRF) personnel conducted in 2023 (DOST-ITDI, 2025).

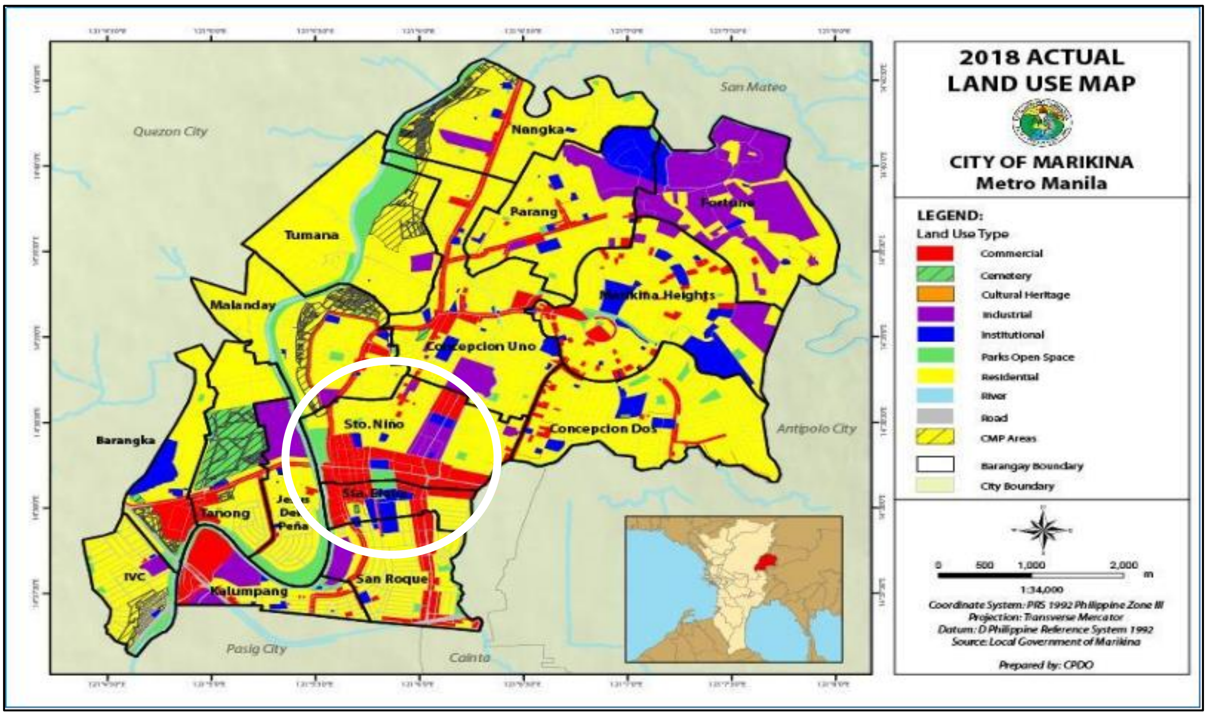
Environmental Conditions of the Area

This section discusses the physical, biological, and socioeconomic status of the project area. The data were mainly lifted from the reports of Marikina City Government, Philippine Statistics Authority, and Metropolitan Manila Development Authority.

<u>Physical Characteristics</u>

Land Use. The project area is located in Barangay Sto. Niño, Marikina City in which the zoning as of 2018 is mainly residential. It is adjacent to commercial, industrial, institutional and parks open space areas. Figure 1 shows the current land use map of Marikina City:

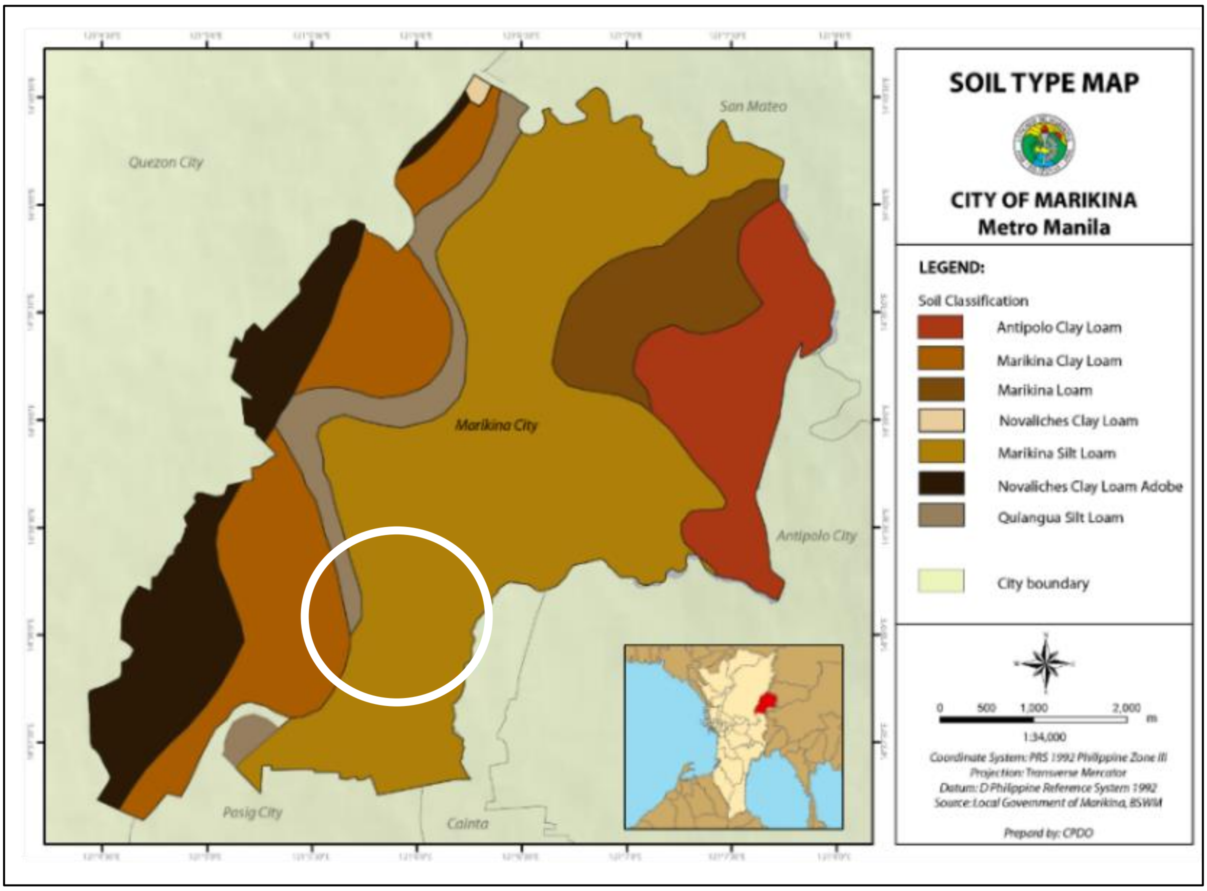
Figure 1.1. Marikina City Land Use Map.



Topography. According to the environmental management office, the project area is located in a valley surrounded by mountains and gently sloping hills, which gives it a predominantly flat terrain with some areas of mild slope. This mostly level landscape was highly conducive to agriculture, which dominated land use in the city about twenty years ago. The landforms of the project area make it good for urban development, shown by the increase in homes, businesses, and industries. About 1,569 hectares, or 71% of the land, have gentle slopes (0-25%), which is ideal for building. This is especially noticeable in the project area.

Local Geology and Soil. According to the same report, the project area is grounded on mainly earthly deposits, with clastic rocks that are apparent in the east. They are made up of mixed layers of shale and sandstone, with thin, uneven layers of limestone, tuff, and sandy tuffs. While the LGU has seven types of soil, silt loam makes up the project area, as shown in Figure 2 as follows:

Figure 1.2. Marikina City Soil Type Map.



Climate. According to PAGASA, which uses Corona's climate classification, the project area has Type 1 climate. The dry season is from January to April and rainy season is from May to October. The project area has hot and humid weather annually with 77% as the mean relative humidity but mostly cooler between November and February.

Temperature and Humidity. As stated by the planning office, the average temperature during the warmest months between April and May is 28.8ºC. Precipitation may happen for the year and June to October is the rainy season. 2,405.1 mm is the estimate average rainfall for the year, which reaches up to at least 504.2

mm as the highest in a month. The following data in Table 2 indicates the climate details in the NCR, where the project area is part of:

Table 1.2

Metro Manila Climate Details

Variable	Values
Rainfall	Average amount of rain per year is 558.7 mm.
Temperature	Average temperature is 27.6 degrees Celsius.
Relative Humidity	Air is about 72% humid on average during the year.
Prevailing Winds	Usual wind speed is 6.5 - 7 m/s, blowing from the northeast
Storms per year	About 20 tropical cyclones happen yearly in the area.

<u>Biological Characteristics</u>

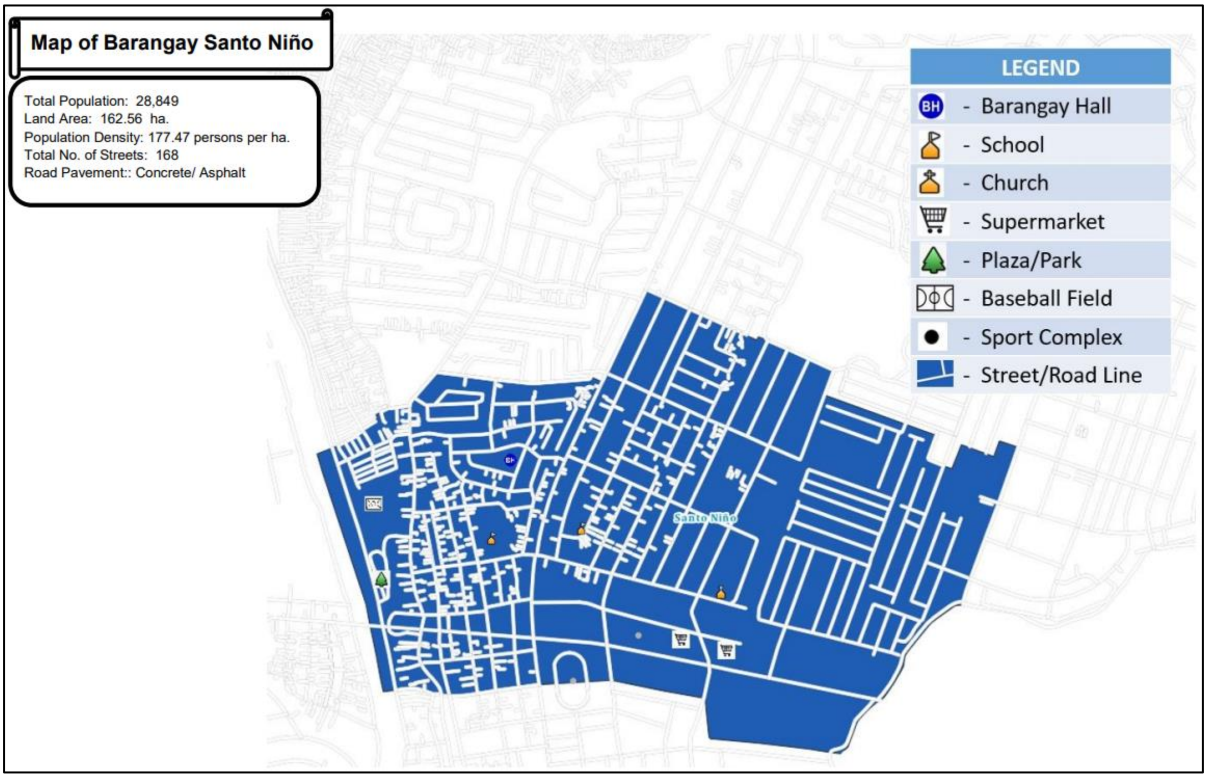
Flora. The project area consists mostly of common tropical and ornamental plants typical of urban and riverine settings in Marikina such as Garden croton, evergreen, croton, and pothos, among others, that are common in the residential and green spaces of the LGU. The cultivated flora like ornamental plants and trees implies that the well-maintained gardens in residential and event venues go well with the local tropical climate. With the area having gentle slopes and being near to the Marikina River, the setup supports vegetation common in riverbanks and urban parks (iNaturalist, n.d.).

Fauna. Amphibians, birds, and freshwater fish species associated with the Marikina River ecosystem and urban habitats comprise the fauna of the project area. Common amphibians found here include the Cane Toad, Asian Painted Frog, Green Paddy Frog, and Common Southeast Asian Tree Frog. Aquatic fauna in the Marikina River near the project area includes freshwater fishes like carp, goby, eel, snake eel, snakehead, catfish, and guppy, while typical urban wildlife such as various birds, insects, and small mammals exists in the area (iNaturalist, n.d.).

Socio-Economic Characteristics

The social map of the area is presented as follows to visualize and place the location of various social facilities or infrastructure in the project site:

Figure 1.3. Marikina City Social Map.



Population and Population Growth Rate. Table 3 details the total population for years 2020 and 2015 and the equivalent percentage change.

Table 1.3

2020 and 2015 Total Population and Percentage Change

Barangay	2020	2015	Percentage Change (%)
Santo Niño	28,849	30,759	-6.2

Table 4 illustrates the projected population of the project area from 2024 to 2033:

Table 1.4

Projected Population, 2024-2033

	Projected Population									
Barangay	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033
Santo Niño	33,596	33,680	33,764	33,848	33,933	34,018	34,103	34,188	34,274	34,360

The basis of the projected population growth is the PSA 2020 Census Survey with a rate of 0.25. The population growth has begun to level off, largely due to the effective measures of the city to limit the entry of new informal settlers since the Squatter-Free Marikina Program was launched in 1993.

Most of the residents of the city are found in the outer communities. However, if the demand for commercial land persists and more peripheral areas are converted for non-residential purposes, population growth in these areas may also slow down.

The area functions primarily as a “bedroom community,” as indicated by its current land use plan. Many people travel outside the city for work or school, so fewer people are in the city during weekdays and daytime. This pattern is expected to shift in the next decade as more industrial and commercial developments take place, potentially increasing the number of people who live and work within the city.

Age and Sex Distribution. The following data were excerpted from the socio-economic profile of the area for the year 2020.

Table 1.5

Age and Sex Distribution

Age Group	2020	
	Male	Female
All Ages	220,084	230,657
0-14 years old	63,313	59,863
15-65 years old	147,730	157,698
65 years and over	9,041	13,096

Income. Data from the Philippine Statistics Authority in 2021 showed that the average family income is approximately PHP 482.90, with an average expenditure of about PHP 368.80. Report from the planning office indicated that the labor force participation rate was 58.8% in 2020, with an employment rate of 89.6%. There were economic difficulties among the workforce as pointed out by the 10.4% and 20.5% unemployment rate and underemployment rate, respectively.

Housing. The number of households is the closest official measure to the number of houses, as each household typically occupies a separate dwelling unit. According to the local Philippine Statistics Authority (2024) and local data from the project area, the estimated number of houses is 6,721. The local environmental office says that commercial growth is mostly happening along main roads. Many homes near market areas are being turned into businesses. Additionally, designated commercial zones in the project area have become denser, as seen in their shift from small retail outlets to high-rise buildings, condominiums, malls, cinemas, and event venues.

Morbidity. Data from the local health office shows that the top cause of illness in the project area in 2019 was upper respiratory tract infection, with 2,584 cases reported. The next most common were minor injuries to unspecified body parts and acute nasopharyngitis, as shown in the table below.

Table 1.6

Main Causes of Morbidity, Marikina City

Causes	Number
Upper Respiratory Infection	2,584
Minor Injury	2,553
Common Cold	2,499
Dog Bite	2,322
Urinary Tract Infection	1,829
Other Animal or Cat Bites	1,572
Sore Throat	1,433
High Blood Pressure	1,327
Muscle Pain	1,072

Causes	Number
Acute Bronchitis	916
Total Morbidity	24,437

Mortality. As for mortality, the top three causes are pneumonia, Acute Myocardial Infarction or heart attack, and essential hypertension, as shown in the table as follows:

Table 1.7

Main Causes of Mortality, Marikina City

Causes	Number
Pneumonia	656
Heart Attack	436
High Blood Pressure	317
Heart Disease from High Blood Pressure	314
Type 2 Diabetes with Complications	222
Confirmed Covid-19	188
Kidney Failure	157
Tuberculosis	137
Secondary High Blood Pressure	98
Breast Cancer	77
Total Mortality	4,767

Power. MERALCO is the power supplier for the project area.

Water. As stated by the local report in 2024, for the year 2021, total water consumption in the project area was 67.7 million cubic meters. Moreover, the residential sector accounted for the largest share of water usage, consuming approximately 53.0 million cubic meters, which represents 78.3 percent of the total water consumption of the city. In contrast, the industrial sector had the smallest water usage, with only 0.8 million cubic meters. In terms of water bodies, Marikina River comprises the river system in the project area, deemed as the longest, among twenty-nine other water bodies or streams.

Communication and Transportation. Smart, Globe, and PLDT are among the communication providers in the area. The transportation of the project area includes circular and radial roads, plus 12 main and secondary roads that connect the city to nearby cities (Quezon City and Pasig City) and towns in Rizal Province (San Mateo, Cainta, Antipolo City). These roads help improve economic connections with neighboring places (Marikina City Government, n.d.).

Impact Assessment and Technology Evaluation of Bioreactor

This study assesses the environmental, economic, social, technological, and institutional impacts of the bioreactor developed by DOST-ITDI. Using the Multi-dimensional Sustainability Framework (MSF), it looks at how the bioreactor helps improve solid waste management in line with RA No. 9003.

Further, the study uses the Context, Input, Process, Product (CIPP) Model to look at how the technology works, how users think about it, and what can be made better. The research was done through survey interviews and focus group discussion in Marikina City. Results show that the bioreactor helps reduce waste, improves soil, and supports environmental goals, though some design and support improvements are needed.

CHAPTER II

PROBLEM STATEMENT

There is a need to assess and evaluate the bioreactor to check if it really helps reduce waste and protect the environment. It is essential to make sure it works well and produces good compost efficiently. In addition, this study will help LGUs and communities trust and use it. It will also provide information for making better waste management policies and find ways to improve it and make it easier to use.

The table as follows details the information needed in using the MSF and CIPP Model in assessing the bioreactor composting technology:

Table 2.1

Key Information for MSF

Framework/Model	Key Information
Multi-dimensional Sustainability Framework	Environment • Quantity of waste to compost conversion • Quality of the compost • Pollution or emissions during composting • Energy used • Effects on soil and plants Economy • Cost to build and run the bioreactor • Money earned from selling compost or saving on waste fees • Jobs created Social • Feelings of users in using the bioreactor • Training for workers • Health and safety for workers and neighbors Technology • Bioreactor effectiveness • Ease of use and maintenance • Ability to handle different types of waste Institution • Influence in policies, goals, and practices • Changes needed • Impact on cost and resource use

The MSF is used to evaluate how bioreactor composting technology affects the environment, society, and economy all at once. It looks at important factors like how much waste and pollution the bioreactor reduces, how much energy it uses, how well it produces compost, and whether people accept and benefit from the technology. By considering these different aspects together, the framework helps decide if the bioreactor is a good and sustainable solution for managing organic waste. This balanced approach supports better decisions and improvements for the use of technology in real life.

Table 2.2

Key Information for CIPP Model

Framework/Model	Key Information
CIPP Model	Context • Existing local waste problems • Local rules and policies • Stakeholders Input • Resources available (money, materials, people) • Details about the bioreactor and training Process • Bioreactor operation and maintenance • Monitoring of composting conditions • Community involvement • Problems and solutions Product • Amount and quality of compost made • Environmental benefits (less waste in landfills, less pollution) • Economic benefits (cost savings, income) • Social benefits (health, awareness)

The CIPP Model is used to evaluate bioreactor composting technology by looking at four important parts: the situation or problem it helps solve (Context), the resources and plans used (Input), how the bioreactor is actually run (Process), and the results it produces, like compost quality (Product). This way, it helps find what works well and what needs improvement, making sure the technology is effective and successful.

Using the CIPP Model is helpful to evaluate bioreactor composting technology because it looks at every stage – before, during, and after it is used. Context checks the local waste problems and reasons for using the bioreactor. Input looks at the resources, materials, and plans needed to make it work. Process watches how well the bioreactor is working in real life. Product measures the results, like compost quality and waste reduction. This complete approach helps people see what works well and what doesn't, so they can make better decisions and improve the technology's success and sustainability.

CHAPTER III

OBJECTIVES OF THE STUDY

According to the DOST-ITDI (2020), the bioreactor was designed as an option to manage solid waste in cities and municipalities, particularly for organic solid waste. Further, as stated by the DOST-ITDI (2002), the bioreactor is better than landfill because of elimination of groundwater contamination, discharge of insignificant smell, reduction of worms and flies, and utilization of minimal operational power.

However, the DOST-ITDI identified the lack of an institutionalized system for impact assessment of bioreactor disseminated to equipment users as one of its problems which require technical assistance. Among its completed projects, the bioreactor required immediate assistance so its actual benefits and improvement points could be identified.

This study aims to identify the impacts of the DOST-ITDI bioreactor and evaluate it. The specific objectives are to:

1. Determine the impacts of the bioreactor;

   What are the impacts of the bioreactor?

2. Assess the bioreactor using Context, Input, Process, Product (CIPP) Model; and,

   How can the bioreactor be assessed using the Context, Input, Process, Product (CIPP) Model?

3. Recommend appropriate mitigating and enhancement measures for the impacts assessed.

   What appropriate mitigating and enhancement measures are recommended for the assessed impacts?

This study was initiated to assist the DOST-ITDI in setting up an institutionalized system in assessing the impacts of the technologies disseminated to equipment users. The study focuses on understanding and improving the impacts of the bioreactor. This study is envisioned to be beneficial for R&D organizations seeking to evaluate completed projects.

Enhancing impact assessment of R&D projects contributes to the goal of ensuring that they are effective in achieving their targets, assists in identifying the points for improvement, and helps decision-makers in deciding whether projects should be continued, modified or terminated. All these contribute to ensuring that R&D projects are making positive and sustainable impacts on their beneficiaries.

The study seeks to demonstrate how a systematic technology evaluation and impact assessment could provide better assessment of completed R&D projects. This development could inform decision-making, increase accountability and transparency, and enhance project quality by providing data-driven insights to project implementers, funders, policymakers, and beneficiaries.

CHAPTER IV

R&D MANAGEMENT FRAMING

Evaluating the bioreactor helps guide research and development to make the technology more effective, efficient, and useful. Specifically, an assessment shows what works well and what needs improvement in the bioreactor. This helps researchers and developers make it better. It checks if the controls and sensors of the bioreactor are working properly, which is important for consistent results. The results help managers decide where to spend money and effort to improve the technology. The evaluation proves the benefits of the bioreactor, making it easier to convince local governments and users to adopt it. It supports ongoing improvements by giving feedback for new ideas and upgrades.

Understanding the bioreactor using the MSF provides a structured approach to evaluate and guide its implementation and optimization, making it highly relevant to R&D management. Understanding the conditions within which the technology operates provides a comprehensive context on their interaction with the environment, consistent with the view of systems theory.

Using the CIPP Model ensures that the development of technology is aligned with environmental sustainability, economic feasibility, and operational effectiveness. The support of this approach to feedback and improvement ensures that solutions are customized to specified problems, which is critical for making innovation management of composting technologies successful.

This study is important for DOST-ITDI because it shows how well the bioreactor works and what needs to be improved. It looks at the environmental, economic, social, technical, and community effects of the bioreactor, helping researchers know what to focus on next.

By talking to users in Marikina City, the study gathers real feedback to make sure the bioreactor meets their needs. It also checks if the technology supports the waste management laws of the country, making it easier for DOST-ITDI to promote and improve the bioreactor.

Overall, the study helps DOST-ITDI plan better, improve the bioreactor, and share it with more communities successfully.

CHAPTER V

ENVIRONMENTAL CONTEXTUALIZATION

The DOST-ITDI is a research group that works with many fields. It aims to improve science and technology to help industries in the Philippines. Its work covers areas like food processing, materials, chemicals and energy, environment and biotechnology, and packaging. This setting enables a dynamic environment where different experts work together under innovative projects. The agency also highlights client service by helping micro, small, and medium enterprises through research commercialization, knowledge-sharing, and technology transfer. In addition, the institute partners with government agencies, academic institutions, and industries through trainings, events, and agreements to promote shared goals. As for facilities, it maintains advanced laboratories to provide its specialized services. Moreover, its press releases reveal the numerous recognitions and awards it receives, indicating its commitment to operational excellence.

Based on review of the functions of DOST-ITDI divisions, the impact assessment and evaluation of the bioreactor falls under the scope of the Technological Services Division (TSD). They are experts in checking how well technologies work, studying their costs and benefits, and helping share the technology with users. Within TSD, the Business Development Section (BDS) usually handles these evaluations and impact studies.

CHAPTER VI

DEFINITION OF TERMS

This section provides a detailed explanation of the terms or concepts used in the study based on RA No. 9003.

Collection

This refers to separating waste at the source or from a shared storage area.

Composting

This refers to breaking down organic waste with bacteria and fungi into nutrient-rich soil.

Curing

This refers to letting compost finish decomposing after the main heating stage, which can take a month or more.

Equipment User

This refers to the person or company that uses the bioreactor in their work or community.

Leachate

This refers to the dirty liquid that comes out when waste breaks down and water passes through it.

Materials Recovery Facility

This refers to a place where waste is sorted, transferred, composted, or recycled.

Raw Materials

This refers to organic waste like fruit and vegetable scraps, leftover food, grass, animal manure, dried leaves, sawdust, and rice straw that can be used in a bioreactor.

Recycling

This refers to turning used or waste materials into something useful again through processing.

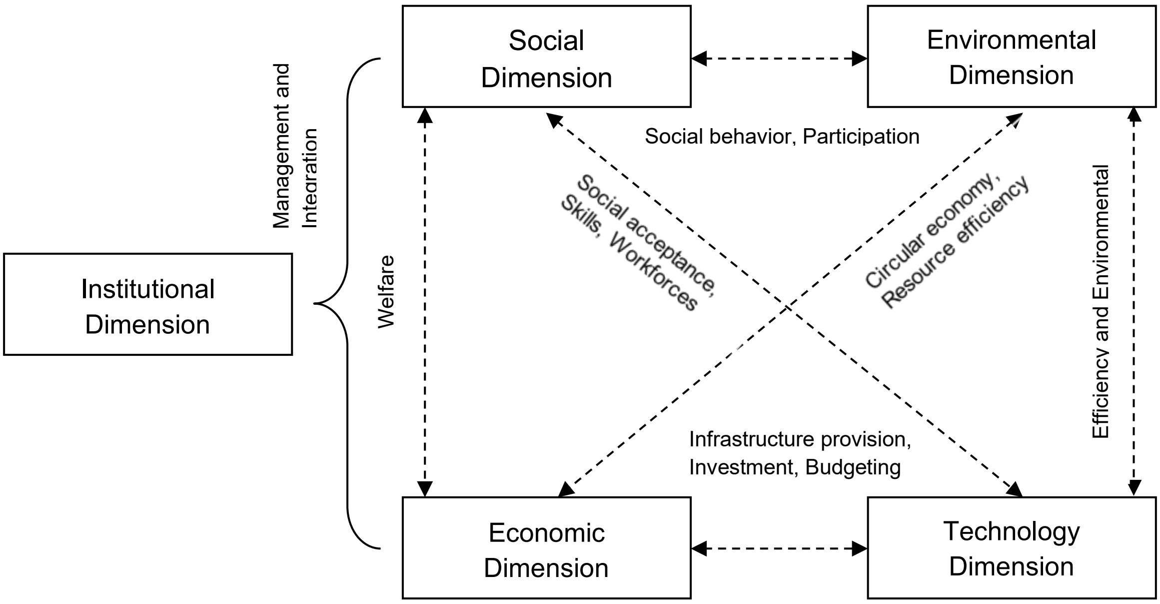
CHAPTER VII

CONCEPTUAL FRAMEWORKS

This section rationalizes and puts structure on how the study and problem of the DOST-ITDI are addressed through the MSF and CIPP Model.

Figure 4 below shows the first model used in the study.

Figure 7.1. Multi-dimensional Sustainability Framework.



Using the framework lifted from Ismail, Y., et. al. (2025) is beneficial because it helps understand the bioreactor better and make sure it works well for people and the planet. Particularly, it has the following advantages:

Ecological and Environmental Benefits

It captures how bioreactor composting improves soil health, enhances biodiversity, reduces landfill waste, methane emissions, and overall carbon footprint through effective organic waste management and nutrient cycling. This includes evaluating lifecycle environmental impacts such as emissions and resource use throughout the composting process.

Economic Viability

The framework assesses economic opportunities created by compost production, including green jobs and local economic development, ensuring that the technology is not only environmentally sound but also economically sustainable. It supports decision-making that integrate economic factors alongside environmental and social criteria, enabling more accurate technology selection.

Social Dimensions

It considers social impacts such as community engagement, environmental awareness, food security, and equitable access to benefits from composting initiatives, which are often overlooked in simpler assessments.

Technical and Operational Aspects

The framework incorporates technical criteria, including process efficiency, innovation potential, and operational feasibility, allowing for a balanced view of technology performance.

Philosophical and Ethical Considerations

It challenges linear consumption models by promoting circular economy principles, mindful resource management, and long-term sustainability ethics, which are essential for transformative waste management strategies.

Decision Support and Trade-off Analysis

Using tools within this framework enables handling multiple conflicting criteria simultaneously, providing a structured, transparent, and faster decision-making process for selecting or improving bioreactor composting technologies.

Meanwhile, Figure 5 as follows illustrates the second framework of the study.

Figure 7.2. Context, Input, Process, Product Model.

(OPERATIONS)	CONTEXT	INPUT	PROCESS	PRODUCT
DELINEATE	System variables and values	Problem specifications Design criteria Constraints	Process decision points Milestones Barriers	Effectiveness criteria
OBTAIN	Performance and judgment data	Identification and analysis of strategies	Monitoring of procedures	Primary, secondary and tertiary effects
PROVIDE	Profile of needs, opportunities and problems	Strategies by problems matrix	Progress reports Exception reports	Description and explanation of project attainments and impact

The researcher chose the CIPP Model from Stufflebeam, D. L. (1971) to solve the problem of DOST-ITDI because it is a clear and flexible way to check how well the bioreactor works and how to make it better. In other words, it has the following benefits:

Comprehensive Evaluation

The model provides a holistic approach by evaluating four distinct yet interconnected components:

Context Evaluation: Identifies the needs, goals, and environment of the project, ensuring that objectives are aligned with the requirements of stakeholders.

Input Evaluation: Assesses the resources, strategies, and planning necessary for effective implementation, allowing for informed decision-making regarding project design.

Process Evaluation: Checks how the project is being carried out and looks for any problems that come up.

Product Evaluation: Looks at the results of the project to see how well it worked and if it can last long-term.

Continuous Improvement

The cyclical nature of the model encourages ongoing assessment and refinement. Evaluators can revisit each component multiple times throughout the lifecycle of the project, facilitating continuous improvement and adaptation based on feedback and changing needs.

Decision-oriented Framework

The model is explicitly designed to support decision-making. By systematically collecting and analyzing data at each stage, stakeholders can make informed choices about project modifications, resource allocation, and strategic planning. This proactive approach contrasts with traditional models that often focus solely on retrospective evaluations.

Flexibility and Adaptability

The model can be applied across various contexts and sectors, making it versatile for different types of projects and programs. Its adaptable nature allows users to tailor the evaluation process to specific needs and environments, enhancing its relevance and effectiveness.

Stakeholder Engagement

The model encourages teamwork by including everyone involved in the evaluation. It makes sure all views and needs are heard, helping people feel their opinions matter. This can increase support and commitment to the project.

CHAPTER VIII

METHODOLOGY

Data Gathering and Analysis

The study was conducted through a qualitative study using the single case study method to address the depth of analysis and allow flexibility for unforeseen circumstances during the conduct of the research. Specifically, in-depth interviews and discussion with MRF personnel using structured survey questionnaire were conducted.

To assess the bioreactor better, the researcher used the Life Cycle Sustainability Assessment. In this approach, life cycle inventory analysis was initially conducted, where quantitative data on all inputs and outputs throughout the bioreactor composting was collected. Data from all stages and specific measurements, if available, were used. After that, performance monitoring was conducted, where data related to composting phases compost maturity, and quality indicators were studied. Next, environmental, economic, and social assessment was done, where available data on greenhouse gas emissions, energy use, resource consumption, operational costs, economic benefits, and social acceptance or community benefits were gathered and interpreted to recommend improvements.

Scope and Limitations

The data collection was conducted with selected bioreactor users in Marikina City using purposive sampling and review of available secondary sources.

The study was carried out within the existing project documentation provided by the DOST-ITDI. Adherence to the scope, protocols, funding, and timeline approved by the institute restricted the width and depth of results derived from the study.

Constraints in budget, time, and stakeholder willingness affected the quality of the study.

The study did not cover other problems that are not considered as reasons for the design of the bioreactor and noncompliance with RA No. 9003. Also, it did not cover other processes to address the identified problems and other types of impacts such as emotional and psychological. The results only apply to the people who took part in this study. Thus, the findings do not represent everyone and can't be used for the whole population.

This study also depended on the information provided by the relevant and authorized stakeholders within the project timeline. Stakeholder willingness, level of collaboration, and turnaround time of key informants and concerned agencies affected the quality of the study.

Sampling

The study was done at a project site chosen on purpose from the locations given by DOST-ITDI. Selection was based on specific criteria relevant to the study objectives to guarantee accuracy and dependability of data collected. Thorough consideration of the factors affecting perceived success, problems, and the ability of the project site to remain operational, relevant, resilient, and important over a long period was applied to the population acquired from the institute.

In view of this, the following parameters for project site and participant selection were identified:

1. Having extensive and direct experience with specific successes or challenges related to bioreactor operation;
2. Holding a position of supervisor and/or head in the MRF at the minimum; and,

3. Willing to share experiences and holds access to relevant data on MRF, environmental, and socio-economic setting of the project site.

Further, the researcher thought a single case study was right for this study because of the goals, the complex topic, the detailed analysis needed, the available resources, and the time allowed.

Respondents

Purposive sampling was used to select five respondents among MRF personnel in Marikina City. Having five respondents made the data gathering effective and manageable because five people were enough to get different ideas and opinions without making the group too big. It was easier to have a good conversation and hear from everyone in a smaller group too. Usually, after talking to a few groups of this size, no new information comes up, so five people helped reach that point faster. This size also helped the researcher get detailed and useful information without being overwhelmed.

The qualified respondents were chosen based on the information provided by the DOST-ITDI as well as their accessibility, willingness, and their availability. Priority was given to MRF personnel who directly run the bioreactor for a long time and who directly supervise its operation. The invitation to join the study was sent to MRF staff who had easy access to information about the solid waste management plan and MRF data for the project site.

Description of Study Area

The study was done at the Marikina City Environmental Management Office (CEMO). The researchers worked with important staff to pick the bioreactor and visited the site. They picked the National Capital Region (NCR) for the study because it produces the most solid waste in the Philippines.

Research Instrument

The researcher collected and organized information about the environment of the project site after the project was finished, based on the study's goals. A checklist describing the site's environment is in **Appendix A**. Information about the environment and socio-economic status came from the Planning and Development Office, Environmental Management Office, respondents, and the Internet. Primary data was collected through detailed interviews using a questionnaire with both multiple-choice and open-ended questions. You can find the sample questionnaire in **Appendix B**, which was tested before the study started. The study protocol and consent form are in **Appendices C** and **D**. **Appendix E** explains the roles and responsibilities for the joint study.

The parts of the questionnaire that the respondents answered are as follows:

1. Respondent Profile

This part included the personal information of the users, such as contact information and location.

2. Socio-demographic Profile

This section asked questions about the respondents' background, like age, gender, marital status, education, monthly income, household size, years working in the MRF, and income sources.

3. Impact Assessment and Technology Evaluation

The questions under this section asked the respondents specific questions covering each aspect in the MSF and CIPP Model.

4. Feedback and Suggestion

The questions under this section cover the perception of bioreactor users in using the technology. Probing questions were also prepared to elicit recommendations to improve the bioreactor based on their experience.

Data Gathering Procedure

The researcher collected secondary data from reports given by the LGU. The DOST-ITDI provided information about the project background and where the equipment users are located. A letter was sent to the respondents asking for their permission and help with the study. Before starting, the researcher made sure to meet the institute's requirements. The respondents were told about the purpose of the study and assured that their information would be kept confidential. They were also informed about the benefits of taking part. All respondents signed consent forms before data were collected.

Data Analysis

The study applied the following data analysis procedures (Clark & Creswell, 2018):

1. Preparation of data for analysis

For the quantitative approach, numeric values were assigned to the responses of participants in Microsoft Excel. Next, checking for data entry errors was conducted to clean the database. The items were recoded to compute for new variables. After that, each variable was named and described.

For the qualitative approach, data transcription was produced from the interviews. Quality checks in terms of accuracy were done. Lastly, the data were organized by type and participant then formatted to proceed with the analysis.

2. Data exploration

As to the quantitative approach, visual evaluation in looking for trends in the data were conducted to determine its distribution. Descriptive analysis was applied, then initial evaluation on the reliability and validity of the measures occurred. In the qualitative approach, the data were read thoroughly to derive meaning. At the same time, note taking commenced. Then initial codes were produced.

3. Data analysis

A graph was shown to explain the background and social details of the respondents. An accomplished MSF and CIPP Model were derived based on the responses of participants and supplementary references.

Regarding data analysis for qualitative approach, analysis was done using data analysis software program. Coding implementation started by data coding, description, and theme development through grouping. After that, interdependence of categories or establishment of abstract themes was conducted.

4. Representation of data analysis

With respect to qualitative approach, statistical results were summarized and transformed to tables, texts, and figures. Results were reported in APA style. In terms of quantitative approach, findings were discussed in the descriptions. Visual presentations were utilized.

5. Interpretation of results

In the qualitative approach, major results were summarized and compared with the hypothesis through the research question. It was also investigated using findings from related studies. After which, limitations and recommendations were identified. As for the quantitative approach, the same steps were taken but personal perspective on the results will be added.

6. Assessment of data and results

The validity and reliability of the scores in the quantitative approach were ensured by assessing its internal consistency and applying procedures to reduce risks to internal and external validity. As for the qualitative approach, standards were set for the accuracy of the information by reporting disagreeing proof, member checking, and audit of data and procedures.

Pilot Testing and Project Assessment

The questionnaire underwent review and approval of statistician, Faculty-in-Charge, DOST-ITDI, and the UP Open University Institutional Research Ethics Committee (IREC). Once approved, the researcher conducted pilot-testing to determine revisions and estimate the interview duration. Comments and suggestions derived from the pilot testing and reviewers were incorporated into the final questionnaire.

Research Ethics

Among the ethical and political issues linked with the conduct of the study are the following:

1. Delayed and inadequate support from the DOST-ITDI, Marikina CEMO, and UPOU

Differences in opinion and overlapping commitments may decrease the level of priority and delay the study. Further, the institute may interpret that the information obtained from the study will leak without consent. To address these issues, the extent of allowable disclosure was discussed, and regular progress reports were conducted to update the DOST-ITDI and UPOU on the status of the study.

2. Denial of clearance from the LGU to conduct the study

Obtaining approval from the LGU concerned to conduct data gathering may pose a challenge to the researcher if they are reluctant to cooperate and provide support. They might believe that the information obtained from the study will expose their vulnerabilities and shortcomings. This was addressed by providing a clear rationale and purpose of the study, along with its scope and signing of a non-disclosure agreement as necessary.

3. Refusal of the respondents to participate in the study

Users of the bioreactor might decline to participate in the study due to various reasons (i.e. privacy concerns, tedious and time-consuming, mistrust about the study, etc.). This was addressed by ensuring that the invitation to participate in the study was coursed through the DOST. The researcher also conducted initial coordination to explain the study to the respondents and secured agreement on the schedule prior to the actual conduct of data gathering.

In addition, to ensure that ethical standards and procedures are adhered to throughout the study, the following were conducted:

1. All communications were handled honestly. This includes data reporting, results, methods, procedures, and status. Data was not falsified, fabricated nor misinterpreted. No stakeholder was deceived.
2. Bias was avoided in areas where objectivity is needed such as, but not limited to the following: design, data analysis, data interpretation, peer review, personnel decisions, writing, and interviews. Any personal interest that may affect the study was disclosed.

3. Integrity was practiced in the study. Agreements were followed, all acts for the purpose of study were conducted with sincerity and consistency in terms of thought and action.
4. Prudence was done by avoiding inadvertence and negligence. Work was examined tediously and records of research activities with stakeholders were properly documented.
5. Openness was practiced through sharing information, tools, and resources. Feedback, criticisms, and new ideas were constructively accepted.
6. The study clearly shared its methods, materials, analyses, and all other important information needed for evaluation.
7. The researcher took responsibility for actions and decisions that arose in the study and prepared rationale for them as needed.
8. All forms of intellectual property were honored. No results were published without prior consent. Plagiarism was not done and proper citation for all contributors to the research was practiced.
9. Duplicate publication was avoided and advancing knowledge was the goal of publishing.
10. Stakeholders were treated with respect. Promoting learning and welfare were prioritized. Also, fair treatment and inclusiveness governed all dealings with stakeholders. The study was done by reducing risks, increasing benefits, and respecting people's dignity, privacy, and choices.
11. The researcher conducted the study in accordance with all relevant laws and policies.
12. The researcher quickly told the participants or their legal representatives if any new information came up that might affect their decision to stay in the study.

CHAPTER IX

FINDINGS

Demographics of Respondents

This part explains the participants' details. The face-to-face survey interviews and discussions were done in April and July 2025 and took about 91.5 minutes on average. Figure 6 illustrates the socio-demographic background of respondents. Actual photos of the activities are available in **Appendix F.**

Figure 9.1. Demographics of Respondents.

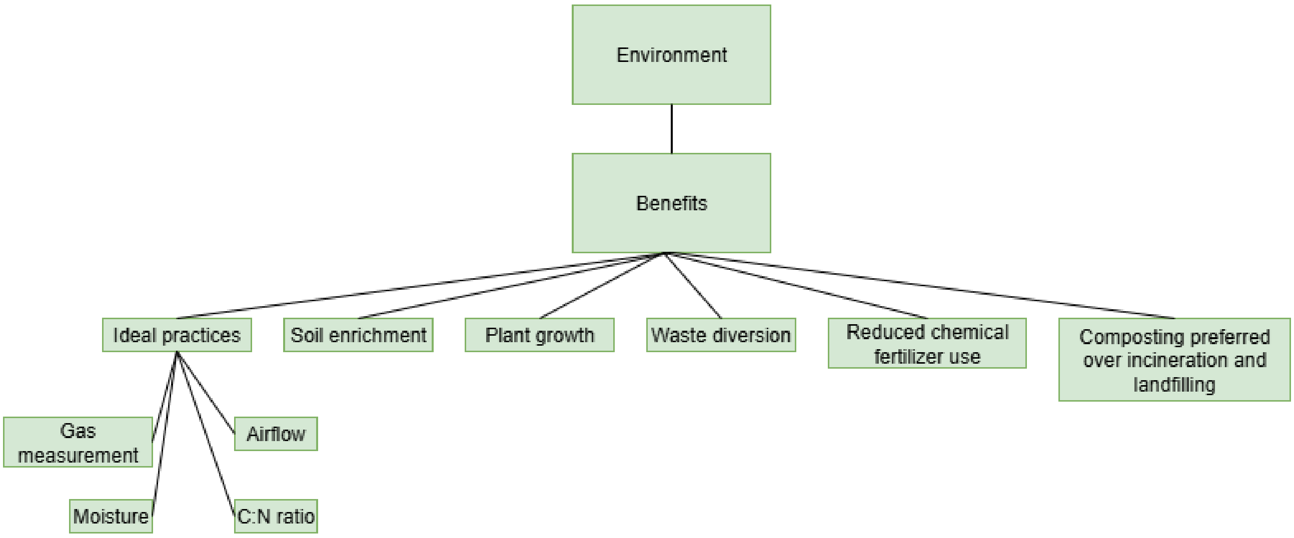
The respondents are mostly between 31 to 60 years old, with eighty percent (80%) male and twenty percent (20%) female. Forty percent (40%) have completed tertiary education, another forty percent (40%) finished college, and twenty percent (20%) completed vocational courses. Regarding civil status, forty percent (40%) are single, while the rest are married, separated, or widowed, each comprising twenty percent (20%). Sixty percent (60%) live in households with more than three people, and forty percent (40%) live with two to three persons. In terms of monthly income, forty percent (40%) earn below 10,000 pesos, while twenty percent (20%) fall into each of the following income ranges: 10,001–15,000 pesos, 15,001–30,000 pesos, and above 30,000 pesos. Most respondents (sixty percent or 60%) have worked at the MRF for one to five years, with twenty percent (20%) each working five to ten years and over ten years. Lastly, seventy percent (70%) rely primarily on their salary from the local government office where the MRF is located, while another twenty percent (20%) reported slipper making as an additional income source.

Assessment of DOST-ITDI Bioreactor

The findings focus on the application of MSF and CIPP Model in DOST-ITDI bioreactor. The associated codes inferred from the discussions with respondents are detailed in **Appendix G**. This section expounds the impacts of bioreactor using the MSF.

Application of MSF in Bioreactor

Figure 9.2. Environmental Impacts Thematic Map.



Environmental Impacts

Referring to the thematic map in Figure 7, the bioreactor emits carbon dioxide, methane, and nitrous oxide. Although no specific emission details were provided, the specific emissions profile depends on waste composition and composting conditions. For yard waste, methane is generally the largest contributor to global warming potential while for nitrogen-rich waste (e.g., manure), nitrous oxide becomes the dominant greenhouse gas.

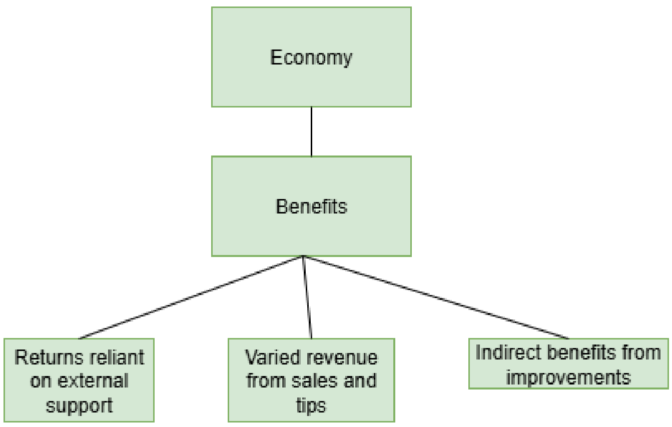
No measures to track and monitor these emissions were provided but monitoring emissions ideally involves regular measurement and analysis of gas outputs from the compost piles. Reduction strategies should include maintaining proper air to limit zones without oxygen, thereby reducing methane production. Controlling moisture levels and carbon-to-nitrogen ratios should also be conducted to minimize nitrous oxide emissions. Using pretreatment processes like anaerobic digestion before composting is essential as well to further decrease nitrous oxide and ammonia emissions. Further, following best management practices for pile management is equally necessary because effective airflow is key to minimizing emissions, although excessive forced aeration may increase ammonia loss.

All participants agree that composting is environmentally preferable to incineration because it avoids burning garbage and recycles nutrients, whereas incineration leads to permanent loss of resources and generates harmful emissions. Landfilling is a major source of methane emissions, and it has no direct recycling benefit. It also consumes land. Incineration emits carbon dioxide and other pollutants. It can damage the ozone layer indirectly and destroys materials instead of recycling nutrients.

The respondents identified measures to ensure compost safety and quality through strictly following the carbon to nitrogen ratio guidelines set by the DOST, monitoring of temperature, moisture, and pH during composting to promote optimal microbial activity and pathogen reduction, regular turning and aeration to ensure uniform decomposition and prevent hotspots or anaerobic pockets and screening the final product to remove non-composted materials and contaminants.

For the participants, the environmental benefits of using compost from the bioreactor include soil enrichment, plant growth, resource learning, and waste diversion. Compost adds organic matter and nutrients to soil, improving fertility and structure. The enhanced soil health also supports strong plant growth, promoting local food production. Additionally, community members gain knowledge and skills in sustainable agriculture through hands-on experience with composting and gardening. Using compost also returns nutrients to the ecosystem, reducing dependence on chemical fertilizers and minimizing landfill use.

Figure 9.3. Economic Impacts Thematic Map.



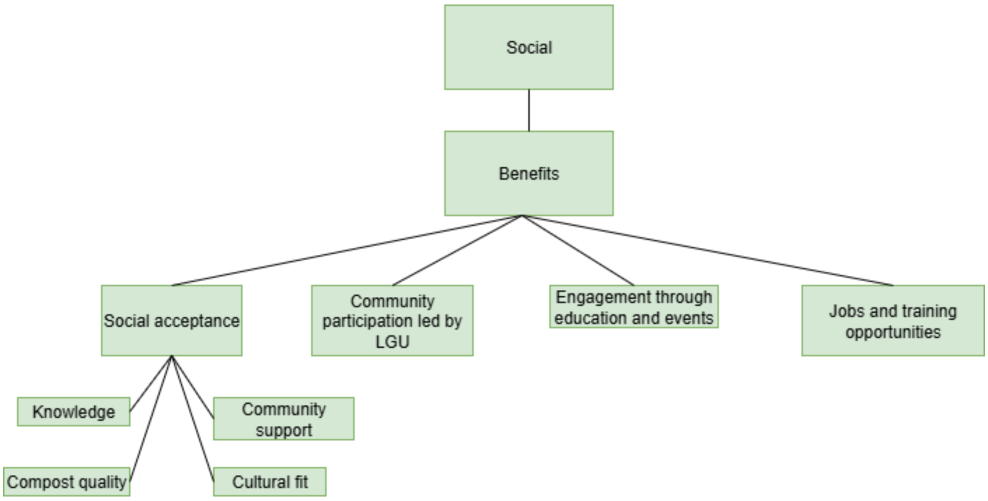
Economic Impacts

Based on the thematic map in Figure 8, the bioreactor has substantial operational and capital costs, which can be justified economically if there is a reliable stream of tipping fees or compost sales. However, in many community-scale settings, the economic return is modest and often depends on external support or the value of indirect community/environmental benefits.

While the respondents did not provide the actual total cost in using the bioreactor, the estimated monthly costs range from 66,000 to 71,000 pesos. These figures cover labor, electricity, maintenance, and overhead. Revenue streams come from tipping fees or charges collected for accepting organic waste for composting and compost sales or income from selling finished compost. In some communities, compost is sold commercially or made available for free to local residents as a public benefit. In this case, the direct income can fluctuate and is not fixed.

As to the comparative operational cost with other similar technologies locally and abroad, there is limited direct data available, but insights could be generated from existing reports. The bioreactor receives subsidized financial support from LGUs and micro, small, and medium enterprises. Meanwhile, operational costs for commercial bioreactors abroad depend heavily on the type (e.g., anaerobic digesters, municipal-scale composters), technology, feedstock, energy consumption, and maintenance requirements. Imported units generally incur higher ongoing expenses due to more complex technology, power needs, and maintenance services. As for financial support, they usually do not have subsidies and rely on commercial pricing.

Figure 9.4. Social Impacts Thematic Map.



Social Impacts

Referring to the thematic map in Figure 9, the social impacts of the bioreactor are deeply intertwined with community participation, environmental education, employment opportunities, and transparent management. Success depends on making strong local partnerships, providing regular training, and adjusting plans to fit each community's unique social and economic needs.

With regards to community engagement and involvement, the implementation of the bioreactor frequently involves the LGU, which is responsible for coordinating operations, maintaining peace and order, and ensuring community participation. This structure fosters local oversight and a sense of ownership vital for project success. Engagement strategies may include educational campaigns, demonstration projects, community events, and workshops that directly involve residents in composting activities and decision-making processes. The accessibility of operations encourages the use of locally sourced materials and the distribution of compost within the same community.

The bioreactor also affects social cohesion and environmental awareness through strengthening social bonds and raising environmental awareness.

Participation in bioreactor composting creates shared goals and collective action, strengthening social cohesion and fostering a community spirit. Through hands-on involvement, community members gain knowledge about waste reduction and sustainable agriculture – for example, learning how to plant using compost produced locally. These activities build environmental stewardship and support ongoing environmental education.

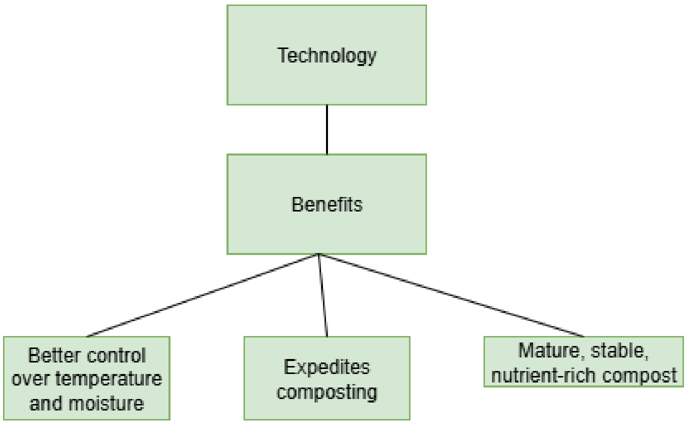
In terms of employment and training opportunities, the potential for job creation and training includes organic waste collection, bioreactor operation, compost processing, agricultural support, logistics, monitoring, and education. Training in composting technology, waste sorting, and sustainable farming practices empower local residents and often leads to broader capacity building.

As for livelihood improvement, the use of bioreactor-generated compost enhances local soil quality, supporting higher yields for home and community gardens. Access to free or affordable compost also reduces costs for farmers and gardeners, directly improving household food security and providing indirect economic assistance. Opportunities may also arise from producing and selling compost, expanding local business ventures, or obtaining stipends for participating in project activities.

While no details on the assessment of social acceptability of the bioreactor were provided by the participants, direct community inquiry through surveys and community meetings may garner feedback, ascertain social acceptability, and highlight areas for improvement.

Factors such as information and knowledge level, quality and usefulness of compost, local relevance and cultural fit, and institutional backing and policy support affect community support or resistance.

Figure 9.5. Technological Impacts Thematic Map.



Technological Impacts

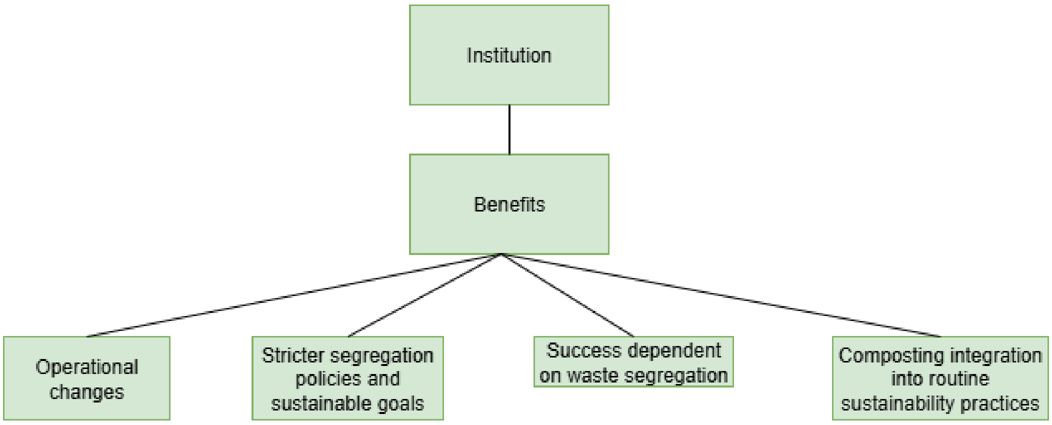
Based on the thematic map in Figure 10, looking through the effects of bioreactor in technology, it delivers major advances in the speed, efficiency, and quality of composting but at the cost of higher energy use and system complexity. Enhanced control over temperature and moisture creates a more reliable, higher-quality product while reducing reliance on manual labor and minimizing unwanted odors and pests. These advantages make the bioreactor attractive for high-throughput, urban, or institutional applications where space and process consistency are priorities.

Compared with traditional composting methods, the bioreactor provides accelerated composting period and lower manpower requirement. Bioreactor composting is significantly faster than traditional methods. While conventional static or windrow composting may take several weeks to months, bioreactor systems – especially those combining continuous airflow and rotation – can complete the active composting phase in just days to a few weeks. Also, the process is less labor-intensive as mechanical mixing, aeration, and controlled environment systems reduce manual intervention, though the need for skilled operators may increase. However, the bioreactor requires higher electricity consumption compared with traditional methods to power these systems. Nevertheless, when compared with other similar technologies locally and abroad, the bioreactor is found to have relatively low energy and technical expertise requirements. The bioreactor also does not necessarily need highly specialized engineering expertise to address the more sophisticated design of commercial bioreactors abroad. Hence, the bioreactor strikes a balance of lower energy usage and operation by moderately skilled but trained personnel, therefore supporting the goal of providing cost-effective, locally adaptable, and sustainable solution compared to more energy-intensive and technically demanding commercial systems abroad.

In terms of compost quality and stability, the bioreactor provides enhanced compost stability and improved nutrient profile compared with traditional composting methods. Bioreactor composting produces compost that matures and stabilizes more quickly. For example, more effective aeration and agitation allow for uniform decomposition, resulting in a stable, mature product upon completion of the active phase, whereas traditional systems may leave compost less mature and partially active after the same period. Additionally, the higher degree of decomposition often leads to better humification and a more consistent end product with a lower carbon-to-nitrogen ratio – an indicator of decomposition and compost maturity.

Aside from providing less variability in compost quality due to tighter process control, the bioreactor has superior heat retention as it is designed to maintain higher and more uniform internal temperatures. Moreover, it has improved moisture control where automated systems for adding moisture and active aeration manage internal humidity levels within the optimal range for microbial activity, which is crucial for efficient composting and odor control.

Figure 9.6. Institutional Impacts Thematic Map.



Institutional Impacts

Referring to the thematic map in Figure 11, the bioreactor led to stricter waste segregation policies and reinforced sustainability goals, operational and infrastructural changes, and optimized resource use and reduced disposal costs. It pushed building strong organics recycling programs and reduce landfill dependency. It also provided staff training and new waste flows to successfully integrate the technology. These impacts depend on both technology adoption and commitment to comprehensive waste sorting across all levels of operation.

The adoption of bioreactor composting led to significant changes in institutional waste management policies and sustainability frameworks. The CEMO now places greater emphasis on the segregation of biodegradable and non-biodegradable materials, as bioreactors are only effective for processing organic waste. This resulted in stricter waste sorting requirements at the source, making staff more accountable for properly separating waste. However, the effectiveness of the system is limited if the city continues to generate large amounts of non-biodegradable waste, as these materials cannot be processed in bioreactors and must be handled separately. Additionally, integrating bioreactor composting reinforced broader sustainability goals, such as advancing circular economy practices and reducing reliance on landfills, with composting programs now featured prominently in sustainability plans and targets set for increasing organics diversion. Daily operations also adjusted to accommodate the collection of organics, facilitate staff training, ensure system monitoring, and track compost maturity and quality, further embedding sustainability into the routine practices of the CEMO.

The following table summarizes the impacts associated by the participants with the bioreactor:

Table 9.1

Impacts of Bioreactor

Impact Categories	Key Points
Environment	Benefits – Environmental benefits of compost include soil enrichment, plant growth, resource learning, waste diversion, reduced chemical fertilizer use, landfill reduction. – No direct emission monitoring measures provided but ideal monitoring involves regular gas measurement and analysis. – Reduction strategies include maintaining proper aeration to limit anoxic zones to reduce methane, control moisture and C:N ratios to reduce N2O. – Pretreatment (e.g., anaerobic digestion) reduces N2O and ammonia emissions. – Best practices include pile management to ensure airflow without excessive aeration (which can increase ammonia loss). – Composting preferred over incineration and landfilling due to nutrient recycling, lower pollutant emissions, and land use. – Compost safety measures include following DOST C:N ratio guidelines, monitoring temperature/moisture/pH, regular turning/aeration, screening final product.
Economic	Benefits – Varied revenue comes from tipping fees or sales and in some cases compost is free as a public benefit. – Economic returns are modest and is often reliant on external/community support. – Indirect economic benefits are gained through environmental/community advantages.

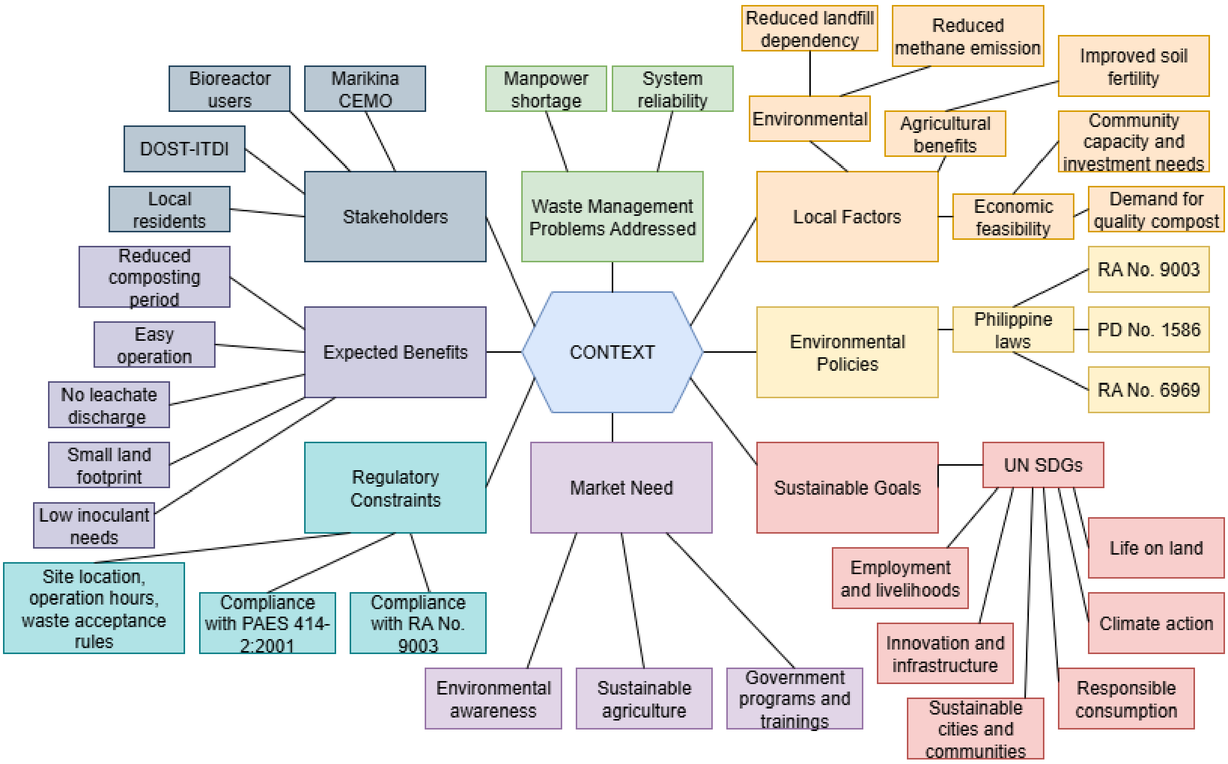
Impact Categories	Key Points
	– Bioreactor benefits from subsidies provided to LGUs and small enterprises, lowering its expenses. In contrast, commercial bioreactors abroad typically have higher operational costs due to more complex technology, greater energy use, maintenance, and usually do not receive financial support or subsidies.
Social	Benefits – Strong community participation is essential. – LGU manages coordination and fosters local ownership. – Engagement is practiced through education, demos, events, and workshops. – Uses local materials and compost is distributed locally. – Strengthens social bonds and environmental awareness. – Creates employment and training opportunities in waste collection, operation, processing, monitoring, education. – Training builds local skills and capacity. – Improves livelihoods through better soil quality, higher yields, reduced input costs, and potential business opportunities. – Social acceptability unassessed but can be gauged by surveys/community meetings. – Factors affecting acceptance are knowledge, compost quality, cultural fit, institutional support.
Technology	Benefits – Faster and more efficient composting compared to traditional (days to weeks vs. weeks to months). – Enables controlled temperature and moisture optimize microbial activity, also improves odor control. – Reduces manual labor but needs skilled operators. – Produces more stable, mature, uniform compost with better nutrient profile and lower C:N ratio. – Superior heat retention and moisture control through automated aeration and humidification systems. – Suitable for high-throughput urban/institutional settings requiring consistency. – Bioreactor uses more electricity than traditional methods but still requires less energy and technical skill compared to similar technologies locally and abroad. It does not need highly specialized engineers like more complex commercial bioreactors. This makes it a cost-effective, easy-to-operate, and sustainable option suited for local use.
Institution	Benefits

Impact Categories	Key Points
	– Leads to stricter waste segregation and sustainability policies favoring biodegradables. – Reinforces circular economy goals and reduces landfill dependency. – Changes operations include staff training, new waste flows, system monitoring, and compost quality tracking. – Requires commitment to comprehensive waste segregation. – Embeds composting into institutional sustainability frameworks and daily workflow (e.g., CEMO operations).

Application of CIPP Model in Bioreactor

The second part explains the four parts of the CIPP Model in detail.

Figure 9.7. Context Evaluation Thematic Map.



Context Evaluation

This section examines the stakeholders, environment, needs, and goals that justify the use of bioreactor based on Figure 12.

<u>Stakeholders</u>

Looking at the stakeholders relevant to the bioreactor, the researcher identified four (4) interested parties in the technology, namely, the DOST-ITDI, bioreactor users, Marikina CEMO, and local government residents.

The DOST-ITDI is the innovator and developer of the technology. It is comprised of technical experts, administrative staff, leaders, and facilities who address the waste management problem through collaboration. Meanwhile, the bioreactor user is the person who directly runs the technology. The Marikina CEMO is the lead beneficiary of the technology who acquired the technology and oversees environmental compliance. Sanitary engineers and administrative staff represent the said office. Together with the bioreactor operator, they underwent the procurement and technology transfer process to be able to use the technology in managing their biological wastes. The local government residents are dwellers within the project area, such as households and enterprises who generate the biological wastes. They could also be affected by the technology through environmental, economic, and social benefits as well as adverse effects like odorous emission and proliferation of flies and insects.

Waste Management Problems

According to the respondents, the bioreactor addresses problems in manpower shortage and system reliability. The automated bioreactor units minimize manual labor by mechanizing processes such as aeration, mixing, and monitoring, which directly addresses local constraints on staffing. The use of reliable motorized units also reduces the risk of equipment breakdown, ensuring continuous waste processing and preventing operational delays often caused by technical malfunctions.

Influential Local Environmental, Social, and Economic Factors

The respondents said these local ecological, social, and economic factors affect how the bioreactor works in the area: less need for landfills, benefits for farming and planting, and being affordable and well accepted locally.

As stated by the respondents, bioreactor composting diverts significant quantities of biodegradable waste from landfills, addressing local challenges related to waste overload and landfill space limitations. This contributes to methane emission reduction and extends the lifespan of existing landfill sites. Also, the compost generated improves soil fertility, supporting local agriculture by providing a nutrient-rich amendment that bolsters crop health and yields – a direct environmental and economic benefit for plant growers. However, the suitability of bioreactor composting depends on community capacity, available investment for technology and ongoing maintenance, and the demand for high-quality compost. Local policies supporting decentralized or community-based composting make these systems more viable.

Environmental Policies and Sustainability Goals

As for the policies and sustainability goals pertinent to the technology, for the respondents, alignment with sustainable agriculture, environmental stewardship, and community and crop care influence the usage and outcomes of the bioreactor.

Bioreactor composting supports regional goals to assist plant growers by producing consistent, high-quality compost that enhances soil productivity and crop resilience.

This technology follows important laws to help protect the environment. It aims to make less trash go to landfills, reduce harmful gases, and encourage recycling and reusing. The main law, RA No. 9003, helps protect health and nature by making a plan to manage waste. It tells people to make less trash, sort it, recycle, reuse, and compost to make less garbage go to landfills.

LGUs must create solid waste management plans and establish MRFs to sort and process compostable and recyclable materials efficiently. Open dumping is banned, and existing open dumps must be turned into controlled dumps or sanitary landfills within three years of the law's start.

The law makes groups to help manage waste and gives rewards for good work. It punishes people who do wrong. It also asks everyone to help sort and manage trash. These rules help the technology protect nature and handle waste better. Other laws keep composting safe and working well (National Solid Waste Management Commission, 2012).

In terms of sustainable goals, six (6) United Nations SDGs encompass the technology, specifically SGDs 8, 9, 11, 12, 13, and 15, as shown in the image as follows:

Figure 9.8. Sustainable Development Goals Addressed by the Bioreactor.

The semi-mechanized composting plants create local employment opportunities in composting facilities waste collection, resulting to supporting community livelihoods. This explains its link to SGD 8 or Sustainable Cities and Communities. Also, the bioreactor represents advanced, science-based technology that improves efficiency and resource utilization in organic waste management, supporting innovation in environmental technology. Thus, making it part of SDG 9 or Innovation and Infrastructure. At the same time, the bioreactor composting supports urban waste management by efficiently converting biodegradable waste into valuable soil conditioners, resulting in reduced landfill contributions and promotion of greener urban environments. In doing so, it assists in achieving SDG 11 or Sustainable Cities and Communities. The said technology likewise promotes sustainable waste management by prioritizing composting as an eco-friendly method to recycle organic waste, reduce landfill use, and complete the cycle of resource utilization. This is the reason for its relevance with SDG 12 or Responsible Consumption and Production. Further, by enabling composting of organic waste through air, the bioreactor significantly reduces methane emissions compared to landfill decay without oxygen and contributes to greenhouse gas mitigation and climate change mitigation efforts. This supports the fulfillment of SDG 13 or Climate Action. Finally, compost produced by the bioreactor enriches the soil health by improving soil microbial diversity, water retention, and fertility. This results to prevention of soil degradation and improving sustainable agriculture. This situation makes SDG 15 or Life on Land applicable to the technology.

The benefits of the technology, as discussed through the SDGs, are waste reduction, soil improvement, lesser need for chemical fertilizers, and environmental sustainability.

Regulatory Constraints and Market Need

The bioreactor strives to adhere to RA No. 9003 which requires its deployment and operation. The technology also supports the aim of the Act to decentralize composting to reduce waste volume and promote resource recovery. It also seeks to comply with the Philippine Agricultural Engineering Standard (PAES 414-2:2001) which sets the minimum requirements for composting agricultural solid waste, including feedstock quality. According to the standard, feedstock must be organic, biodegradable, and free from hazardous waste. This standard applies to bioreactor composting operations to ensure product safety and environmental protection. The bioreactor also operates in accordance with permitting and local ordinances with regard to site location, operation hours, and waste acceptance criteria, which can constrain technology operation.

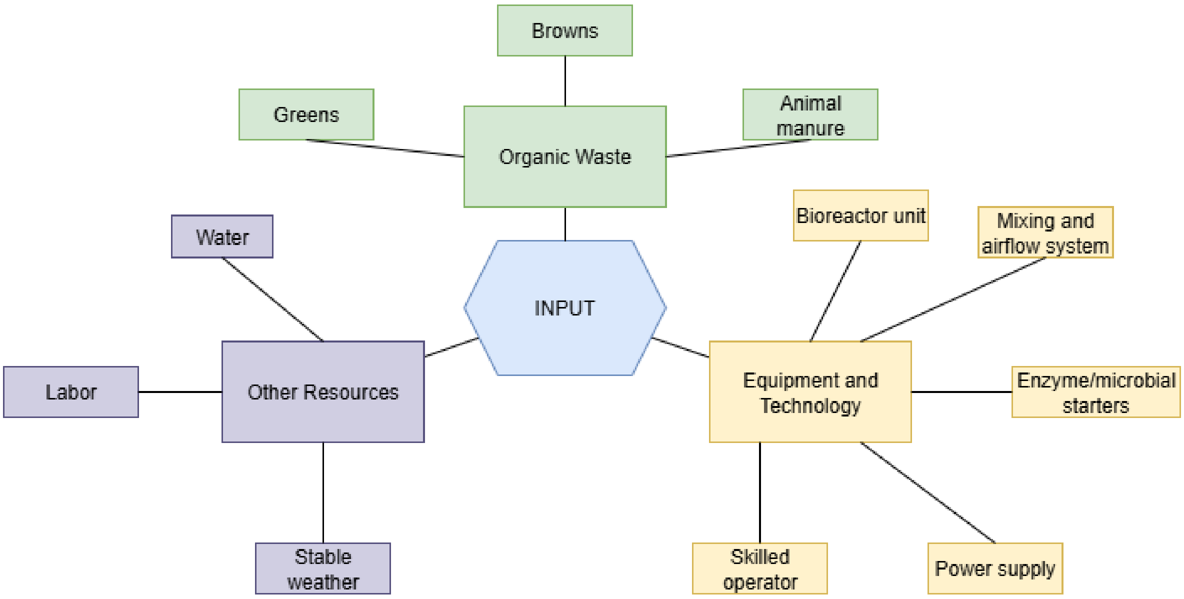
In connection with market need, the researcher deems that it is high due to the following factors: environment-friendly goals, sustainable agriculture and livelihood opportunities, and growing environmental awareness. According to the DOST-ITDI, there is an urgent need to reduce landfill waste and improve waste diversion rates. The bioreactor efficiently converts 80% to 90% of collected biodegradable waste into useful soil conditioners, significantly reducing landfill contributions and supporting local greening efforts. Additionally, the technology is an environmentally sound alternative to traditional composting methods because it reduces methane emissions from organic waste and lowers waste management costs such as transportation and landfill fees. The organic compost made is used to improve soil for gardening and farming in cities. This helps create jobs and supports sustainable farming in many places. Lastly, continuous and effective government projects promoting sustainable waste management along with trainings conducted for MRF personnel increased the understanding and appreciation of the bioreactor and its benefits. Efforts are directed at both supporting local farmers and ensuring good agricultural practices, reinforcing food security, and closing organic nutrient cycles.

Expected Benefits

The bioreactor was anticipated to reduce composting period from three to six months to one month.

According to the institute, it is advantageous because it is easy to operate with no leachate discharge, requires low inoculant and small land to set up, and the odor it produces is acceptable.

Figure 9.9. Input Evaluation Thematic Map.



Input Evaluation

Referring to Figure 14, this part studies the resources, design, and strategies to implement the bioreactor. As for the resources, organic waste requirements, equipment and technology, and essential resources for optimal conditions are necessary for the effectiveness of the technology.

For organic waste requirements, vegetables provide high-nitrogen "green" material, which accelerates decomposition and enriches the resulting compost. The sawdust acts as a carbon-rich "brown" material, balancing the carbon-to-nitrogen (C:N) ratio and aiding structure and aeration. Lastly, animal manure supplies both nitrogen and essential microbes, further speeding decomposition and improving compost nutrient value. As for input quantity guidelines, for effective bioreactor operation, a typical system can process hundreds of kilograms per day. In this case, the municipal-scale bioreactor can accept 500–1000 kg daily, yielding compost equal to about 50% raw compost. Also, the ideal C:N ratio is around 30:1 by mass, translating to approximately three parts sawdust to one part vegetables or manure by volume. The input mix quality or the right balance of greens and browns is as important as quantity for productive, odor-free composting and a high-quality fertilizer output.

In terms of equipment and technology needs, the respondents identified the following: bioreactor unit, mixing and aeration system, enzyme or microbial starter, power supply, and technician, operator, and crew.

The bioreactor unit is the core facility, which must allow for controlled and contained aerobic composting. The following table summarizes the load and motor capacity, and facility requirements of the technology:

Table 9.2

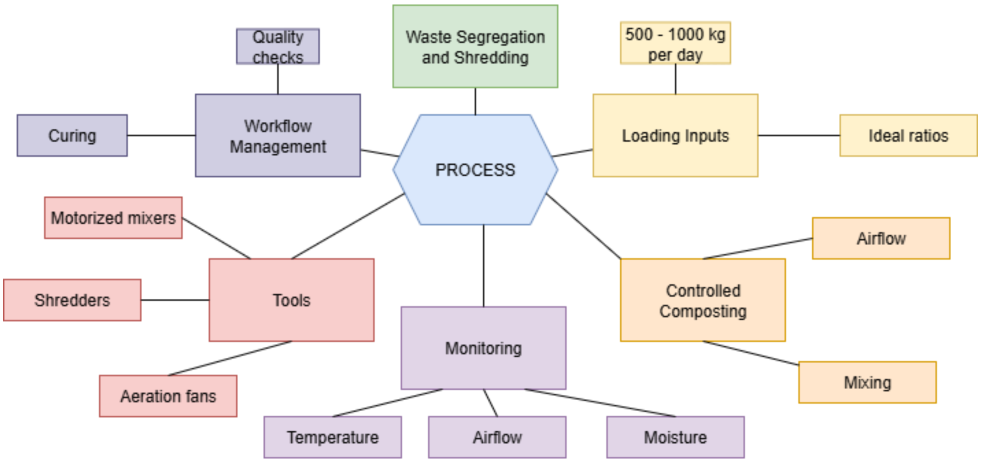
Technical Specifications of DOST-ITDI Bioreactor

Load capacity	500 kgs or 1000 kgs
Power	¼ horsepower, 220 V
Material construction	Mild Steel
Type	Stirred tank type
Facility requirements	• At least 120 sq. meters • Preferably with concrete pad and should not be flood prone • Shredder for wet and dry matters • Electric supply, 220V • Water supply • At least two (2) workers • Tools, accessories, personal protective equipment
Materials	• Solid microbial inoculant, shredder, shovel, rake, fork, sieve screen, weighing scale, containers, sprinklers, dial thermometer, sacks, labeling and documentation materials, cleaning tools and supplies
Raw compost output	About 50% raw compost

Mixing and aeration system ensures uniform decomposition and supports aerobic microbes by consistently supplying oxygen. Also, the addition of specialized enzyme preparations or compost-starter cultures expedite organic matter breakdown and enhance microbial activity. The respondents also added that consistent power supply to drive motors, aerators, and monitoring systems is critical for steady operation, especially in automated or large-scale bioreactors. Lastly, skilled staff are essential to operate the bioreactor, monitor conditions, and ensure equipment reliability. Trained personnel are needed for input loading, system checks, and output handling.

Other essential resources to ensure optimal condition for compost include energy, water, labor, and weather. Consistent electricity is needed for running motors, temperature control, aeration fans, and electronic monitoring systems. Sufficient water must be available to maintain optimal moisture content (typically 50-60%) inside the composting mass, which is vital for microbial activity and effective decomposition. Routine staffing is also needed for mixing and inspecting input materials, monitoring system data (temperature, moisture, airflow), and maintenance and troubleshooting of equipment. Normal weather conditions help maintain system stability, but well-designed bioreactors should be strong to moderate environmental fluctuations, relying instead on internal climate control for temperature and humidity.

Figure 9.10. Process Evaluation Thematic Map.



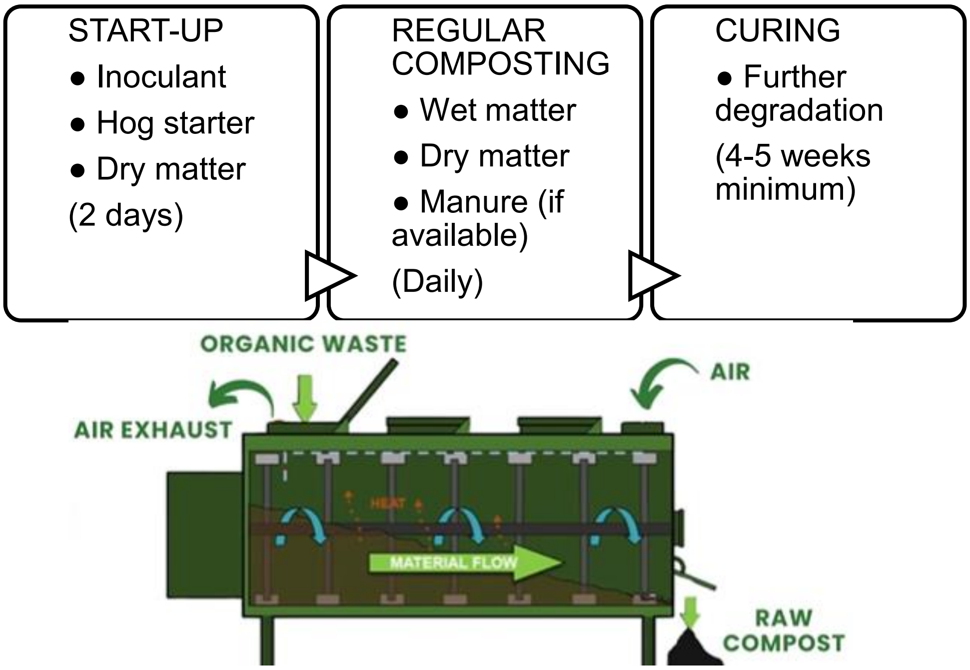
Process Evaluation

The portion reviews the actual implementation and operation of the bioreactor composting process based on Figure 15.

Using the DOST-ITDI bioreactor involves four (4) steps, starting from waste collection and segregation where wastes from households and establishment are sorted to gather the biodegradable wastes from other types of wastes. The sorted biodegradable wastes undergo shredding. After this, gradual loading of around 500 to 1000 kilograms is conducted to the bioreactor wherein the input must be 67% green biodegradable or wet waste (i.e., vegetable scraps, fruit peelings, leftover food), 33% brown or dry waste (i.e., dried leaves, saw dust, rice straw), and animal manure if available. This leads to the accelerated and controlled composting process where approximately half of the input goes out of the bioreactor in the form of a soil that is rich in nutrients.

Figure 9.11 as follows illustrates the process:

Figure 9.11. DOST-ITDI Bioreactor Process.



The assessment of process as perceived by the respondents could be categorized as the following: monitoring and controlling key process factors, tools and methods for even decomposition, and managing composting steps and workflow.

To monitor and control the process, temperature needs to be checked all the time using thermometers and digital sensors in different parts of the bioreactor. The temperature should stay between 40 and 65°C for microbes to work well. Automatic systems can adjust temperature using sensor feedback. Moisture sensors also check that water stays between 40% and 60% for good composting.

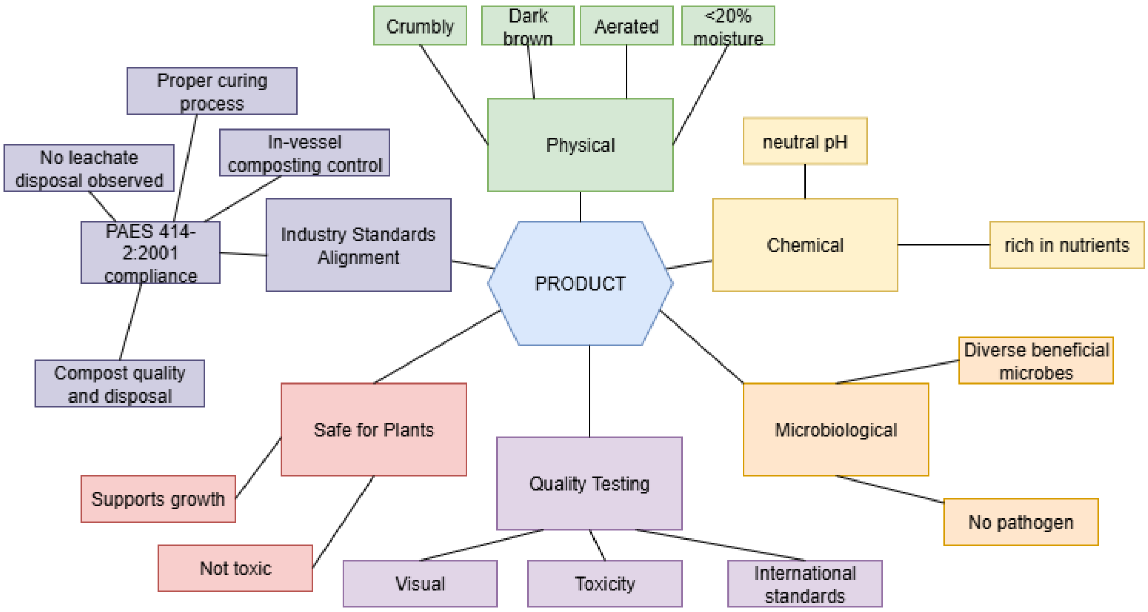
Oxygen is supplied by an air system controlled by sensors to keep it steady and stop areas without oxygen. Fans or blowers spread air evenly through pipes to all parts of the compost. All sensor data goes to control panels or software so the process can be watched closely and problems fixed quickly.

Meanwhile, respondents said motorized mixing, shredders, and aeration devices are important for even composting. Motorized turning mixes materials well and stops low-oxygen spots. A steady power supply is needed to keep these machines working. Shredders make the waste smaller so microbes can break it down better. Air blowers or forced air keep oxygen flowing, helping the compost stay even and stop it from getting too hot or stuck.

Respondents said it is important to manage the composting steps carefully to get good compost. They prepare and load materials the right way so microbes can work well and the compost is safe. The active composting takes about two months, with checks on temperature and air. After that, the compost rests to become stable and safe for plants. Lastly, the compost is tested to make sure it is good to use.

The respondents believe that the bioreactor is running according to design. It serves the intention of having a sustainable and efficient method for managing biodegradable waste. Additionally, its implementation is supported by stakeholders promoting environmental protection, making it socially acceptable and sustainable. However, using leftover food as input corrodes the machine because of high acid. As a result, the fuse, shafting, and regular steel get broken after years of usage and in need of repair.

Figure 9.12. Product Evaluation Thematic Map.



Product Evaluation

Referring to Figure 9.12, this section probes into the outputs, outcomes, and impact of the bioreactor. The respondents describe the physical features of the ideal compost from the bioreactor. Its texture is crumbly, well-aerated, and dark brown to black in color, indicating thorough decomposition. This structure improves soil aeration, drainage, and water retention capacity. As for moisture, the finished compost is typically less than 20% moisture, feels dry to the touch, and no longer heats up, signaling stability. In terms of chemical features, its pH is near-neutral, usually around 7, supporting a wide range of plant species. The compost has many important nutrients, like nitrogen, phosphorus, and potassium. These come from vegetables, animal manure, and added enzymes. It also has high levels of humified organic matter that enhances soil fertility and structure, aid nutrient cycling, and foster long-term soil health. For them, good quality compost contains diverse populations of bacteria, fungi, and actinomycetes essential for suppressing plant pathogens and facilitating nutrient uptake. When properly processed, the compost is largely free of human, animal, and plant pathogens after the high-temperature phase.

To evaluate the stability and maturity of the compost, the respondents look through dryness, curing period, and physical signs. For them, mature compost should dry and does not reheat after mixing, confirming microbial activity has subsided. Also, after the active composting phase, a curing stage ensures remaining phytotoxic compounds decompose, yielding a safe and stable product for crops. The finished compost should emit an earthy smell, should not contain recognizable food or manure fragments, and should support healthy seedling growth without signs of plant stress or wilting.

The available options for testing and standards for quality and safety of compost include visual and practical tests, toxicity tests, and international standards. Reliable, mature compost will not cause adverse effects such as burning or inhibiting plant growth. Also, applying compost to test plants or seedlings – if they remain healthy and do not wilt or dry, the compost is considered non-toxic and safe. For this purpose, bacterial pathogens are also checked at certain limits. This ensures the compost is safe to use and checks that the organic waste was properly processed. Also, compliance with international standards commonly includes checks for stability (no self-heating), maturity (no ammonia odor), pathogen reduction, and heavy metal limits.

Alignment with Industry Standards

The bioreactor generally conforms and remains aligned with the Philippine Agricultural Engineering Standard (PAES 414 2:2001) due to the following reasons:

In-Vessel System (Section 6.2.9). The bioreactor was observed to be closed, enabling it to control temperature, moisture, and odor. Addition of controlled amount of air for a designated period also aligns with the controlled environment needed for bioreactor composting.

Curing (Section 6.2.10). The researcher observed that curing process after active composting was properly conducted. Adherence to this enables the bioreactor to stabilize nutrients and complete decomposition.

Compost Quality and Disposal (Sections 6.2.11 and 6.2.12). Outputs from the technology are being managed appropriately because the composts are neatly arranged and no residuals are unaccounted. Soil analysis could be conducted to further support this.

Leachate Management (Section 6.2.12.2). No leachate was observed during the data gathering which is important for bioreactor systems where leachate control is critical because leachate generated from storage and composting must be treated as liquid waste.

In summary, the following matrix provides the CIPP Model of the bioreactor based from the responses of participants.

Table 9.3

Summary of the CIPP Model of Bioreactor

Evaluation Areas	Key Aspects	Findings
Context	Problems	– The bioreactor seeks to address shortage of manpower. – Ensuring that the bioreactor motor unit does not break is critical for its effectiveness.
	Local factors	– Using the bioreactor reduces waste disposal in landfill. – The technology promotes proper planting benefits.
	Sustainability goals	– The bioreactor aims to assist plant growers. – The technology takes good care of crops.
Input	Organic materials	– Scrap vegetables, fruit peelings, left-over foods, grass clippings, manure (if available) are the prescribed inputs to the bioreactor.

Evaluation Areas	Key Aspects	Findings
		– Appropriate quantities of greens and browns are required by the DOST.
	Equipment and technology	– Other materials and tools needed for bioreactor operation include solid inoculant, bioreactor unit, power supply, technician, operator, and crew.
	Other resources	– There must be consistent electricity and temperature to produce the compost as intended. – Favorable/normal weather conditions are essential for producing quality compost.
Process	Temperature, moisture, oxygen, airflow	– Thermometer and sensor monitoring assist in the controlled composting process. – Consistent temperature management ensure that the bioreactor produces quality compost.
	Tools/methods	– Stable motor/electricity is necessary to complete the composting process. – Shredder machine improves material breakdown prior to loading in the bioreactor.
	Management of steps	– Using the correct input ratios as prescribed by DOST are necessary. – After the regular composting, allot nearly two months for composting and curing for fertilizer readiness.
Product	Features of finished compost	– The compost made by the bioreactor is made from wet and dry organic waste. – The compost from the bioreactor functions as fertilizer.
	Compost stability and maturity	– One way to determine compost quality is to assess its dryness after curing.
	Standards/tests	– A quality compost made by the bioreactor does not let the plant dry after using it.
	Environmental and economic benefits	– The composting product serves as soil amendments and can be compost or organic fertilizer depending on the analysis of nutrient quality, and other parameters based on Philippine National Standards.

When probed the opinions on bioreactor operation, the respondents shared how the technology helped them, along with their feedback and suggestions.

Contribution

All users were grateful for the additional knowledge that came with the bioreactor implementation. The technology provided opportunities for knowledge-sharing of composting practices, both manual and mechanized, together with skills development on bioreactor operation, troubleshooting, and maintenance. Social responsibility was also enhanced since the technology facilitated collaboration through socialization and networking that developed during knowledge-sharing of environmental practices. Improved waste management through reduction and diversion were also beneficial because it reduced foul odor, insects, and other hazards linked with problematic waste generation in the project area. Moreover, securing a stable job and generating additional source of funds were among the associated benefits of the technology. The following image displays the word cloud of responses to the query on the major contribution of the bioreactor to the project area.

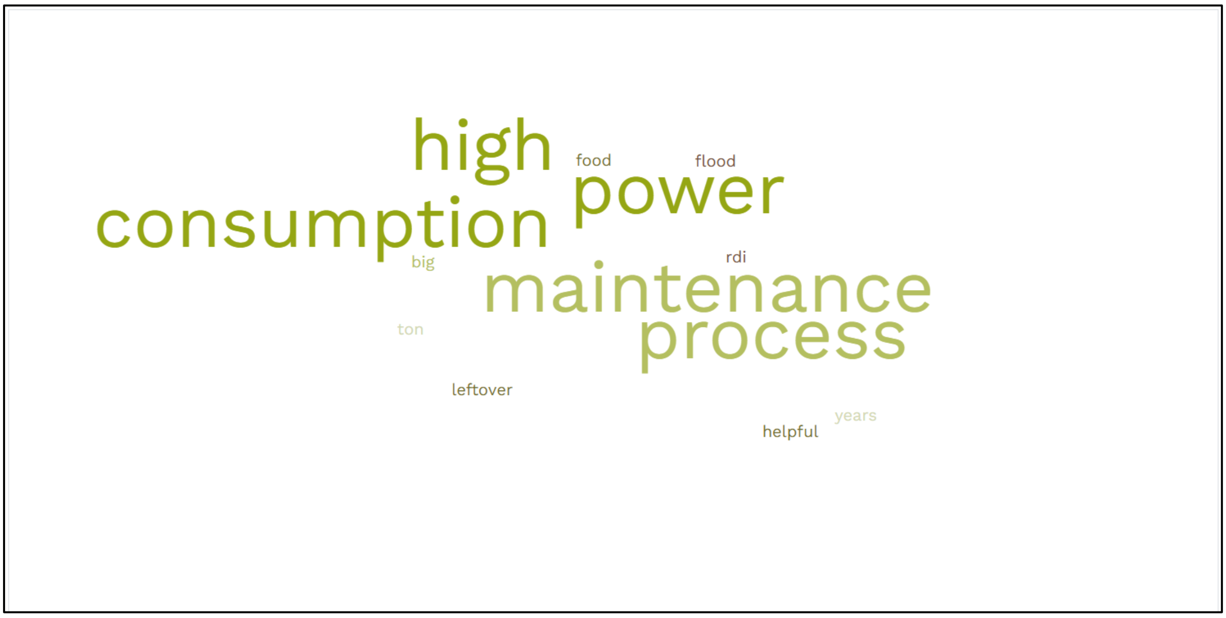
Figure 9.13. Word Cloud of the Contribution of Bioreactor.

Feedback

The users shared that for them, acquiring the bioreactor entails more requirements when donated compared with buying it. They also noticed that the

Training on Bioreactor Operation and Maintenance conducted as part of the technology transfer was intensive. However, over the years of using the bioreactor, they observed the following problems: the bioreactor cannot process one ton of input and leftover food, draws many flies, the steel corrodes, troubleshooting becomes more challenging because of obsolete parts, and the ammonia discharge is odorous. However, they appreciate the assistance of DOST extended to them during maintenance and heaving flooding caused by typhoon Ondoy. The word cloud image as follows illustrates how the participants regard the bioreactor based on experience.

Figure 9.14. Word Cloud of the Feedback on Bioreactor.



Suggestion

The improvement points for consideration shared by the participants generally pertain to the machine. The respondents suggested using stainless steel instead to make it sturdier and convert it to inverter-type to be more energy-efficient. The image below highlights the key words that emerged during the discussions.

Figure 9.15. Word Cloud of the Suggestion on Bioreactor.

CHAPTER X

CONCLUSION

In general, the bioreactor achieved its objectives in relation to RA No. 9003 as it enables effective organic waste diversion, promotes environmentally sound composting methods, facilitates resource recovery, and supports LGUs in implementing comprehensive solid waste management programs. However, the DOST-ITDI may consider recommendations related to design, communication, and monitoring and evaluation to increase the efficiency and viability of the project.

The introduction of the bioreactor brought a range of improvements to the community. It promoted environmental practices, raised awareness about sustainability, and led to significant waste reduction by diverting waste from landfills to more productive uses. The bioreactor also eliminated odor and insects, improving the overall cleanliness and livability of the area. Economically, it provided additional sources of funds and allowances, as well as secured employment opportunities for local residents. Knowledge-sharing became more common, as community members learned about composting and developed new skills related to waste management. The project encouraged greater socialization and networking, strengthening relationships within the community. Clean and green initiatives supported by the bioreactor even promoted tourism, attracting more visitors. Furthermore, the community embraced social responsibility, and composting became easier and faster, making sustainable waste management more accessible to everyone. Overall, the bioreactor project fostered environmental, social, educational, and economic growth within the community.

Concerning design, the institute could modify the bioreactor to purely digital, stainless steel, inverter-type and more compliant with occupational safety standards.

Specifically, if resources and circumstances would permit, the bioreactor could be further improved by utilizing digital monitors for all its sensors and controls such as ammeter, push buttons, and other indicators to be more user-friendly. The DOST-ITDI may also consider making the platform on the upper right part safer by changing it to a solid platform with railings. Further, the institute may conduct a feasibility study to determine whether the motor could be downgraded further to reduce power consumption. Another suggestion is to develop a lever to automatically unload the compost instead of manually collecting it from the bioreactor.

The operators could be empowered further through the development of user manuals/audiovisuals with laymanized Filipino versions for a more inclusive knowledge sharing. Current users could also be re-oriented on the proper operation and maintenance of bioreactor to minimize the problems encountered with the technology. To instill a culture of prudence in the operators, the institute may consider making the maintenance of bioreactor a requirement in their performance commitment forms prior to technology transfer. This behavioral intervention could be reinforced by including sections in the terms of reference covering regular inspection and imposing penalties for misuse and negligence in operating the technology.

With regard to communication, collaboration among interested parties could be enhanced by providing manuals and video tutorials. Information caravans could be advanced by conducting them more frequently and increasing the areas covered to assist in rising the number of technology adopters. Social media publications could also be boosted regularly to widen its reach. Another suggestion is to incentivize hard work related to bioreactor design and implementation. These interventions would sustain high user satisfaction and increase the demand for technology.

As for monitoring and evaluation, online tracking of air, temperature, and sensors would ensure that the machine runs accordingly. Also, committing personnel performance incorporating bioreactor operation and maintenance in writing would increase user accountability and prudence. Additionally, regular audits in relation to PAES 414 2:2001 would help guarantee the operability of the technology. The DOST-ITDI may also regularly leverage with best practices in other countries to align with international standards.

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Appendices

APPENDIX A

CHECKLIST TO DESCRIBE ENVIRONMENTAL SETTINGS

I. Physical Characteristics

a. Land Use

b. Topography

c. Soil

d. Climate

e. Temperature

f. Humidity

II. Biological Characteristics

a. Flora

b. Fauna

III. Socio-Economic Characteristics

a. Population

b. Population Growth Rate

c. Age and Sex Distribution

d. Income

e. Housing

f. Morbidy

g. Mortality

h. Power

i. Water

j. Communication

k. Transportation

APPENDIX B

QUESTIONNAIRE: IMPACT ASSESSMENT OF A MARIKINA BIOREACTOR COMPOSTING TECHNOLOGY DEVELOPED BY THE DEPARTMENT OF SCIENCE AND TECHNOLOGY- INDUSTRIAL TECHNOLOGY DEVELOPMENT INSTITUTE (ENGLISH VERSION)

The bioreactor implemented by the ITDI aimed to improve solid waste management through process standardization, equipment fabrication, and product development in compliance with RA No. 9003. This interview seeks to evaluate the technology, determine its socio-economic impacts, satisfaction rate, and points for improvement.

This survey will take about ___ minutes. Your information will be kept private and only used for this study, following the Data Privacy Act of 2012. Please answer truthfully. Thank you.

<table>
<tr><td colspan="2">Date:</td><td>Time Start:</td><td>Time End:</td></tr>
<tr><td colspan="4">I. RESPONDENT PROFILE</td></tr>
<tr><td colspan="2" rowspan="2">a. Respondent Code:</td><td colspan="2">c. Region:</td></tr>
<tr><td colspan="2">d. Province:</td></tr>
<tr><td colspan="2" rowspan="2">b. Contact Information:</td><td colspan="2">e. Municipality:</td></tr>
<tr><td colspan="2">f. Barangay:</td></tr>
<tr><td colspan="4">II. SOCIO-ECONOMIC PROFILE</td></tr>
<tr><td>a. Age:
1. 20-30
2. 31-40
3. 41-50
4. 51-60</td><td>b. Sex:
1. Female
2. Male</td><td colspan="2">c. Highest Educational Attainment:
1. Did not finish Elementary
2. Elementary Graduate
3. Did not finish High School
4. High School Graduate</td></tr>
</table>

<table>
<tr><td>5. 61 and above</td><td></td><td>5. Vocational Course
6. College Undergraduate
7. College Graduate
8. Post Graduate Degree/Units</td></tr>
<tr><td>d. Civil Status:
1. Single
2. Married
3. Separated
4. Annulled
5. Widowed</td><td>e. Household size
1. 1
2. 2 - 3
3. More than 3</td><td>f. Monthly Income:
1. Below 10,000
2. 10,001-15,000
3. 15,001-20,000
4. 20,001-30,000
5. Above 30,000</td></tr>
<tr><td colspan="2" rowspan="2">g. Years Employed in Materials Recovery Facility
1. Less than a year
2. > 1 year ≤ 5 years
3. > 5 years ≤ 10 years
4. More than 10 years</td><td>h. Primary Source of Income</td></tr>
<tr><td>i. Other Sources of Income</td></tr>
</table>

III. IMPACT ASSESSMENT AND TECHNOLOGY EVALUATION

Please answer the questions based on your opinion. Detailed discussion of answers is highly appreciated.

Environmental

1. What greenhouse gases (e.g. carbon dioxide, methane, nitrous oxide) are released by the bioreactor?
2. How are they tracked or reduced?

3. How does bioreactor composting compare environmentally to landfilling or incineration, based on life cycle assessments?
4. What steps are taken to ensure the compost is safe and high quality?
5. What environmental benefits does using this compost provide?

Economic

1. What are the total costs to run a bioreactor composting system, including labor, energy, maintenance, and overhead?
2. What income does the bioreactor composting system generate, such as tipping fees and compost sales?
3. How does the economic performance of bioreactor composting compare to other waste management methods, using measures like benefit-cost ratio?

Social

1. How does the bioreactor composting project engage and involve the local community?
2. What impact does this have on social cohesion and environmental awareness?
3. What employment and training opportunities do the bioreactor composting technology create for local residents?
4. How does it contribute to improving livelihoods?
5. How is the social acceptability of bioreactor composting technology assessed?
6. What factors influence community support or resistance?

Technological

1. How does bioreactor composting affect the time and efficiency of composting compared to traditional methods?
2. What improvements in compost quality and stability have you seen with bioreactor composting versus traditional methods?
3. How does the bioreactor design affect heat retention, moisture control, and overall performance compared to traditional composting?

Institutional

1. How has using bioreactor composting changed your institution's waste policies, sustainability goals, and daily operations?
2. What changes did your institution make to successfully adopt bioreactor composting?
3. How has bioreactor composting affected your institution's costs and resource use, like waste collection, disposal fees, and making or using soil improvements?

Context

1. What problems in organic waste management does bioreactor composting try to solve here?
2. What local environmental, social, and economic factors affect whether bioreactor composting can work well in this area?
3. What sustainability goals or policies guide how the bioreactor composting system is used and what it aims to achieve?

Input

1. What kinds and amounts of organic waste and materials are needed for the bioreactor composting system to work well?

2. What equipment and technology are needed to keep the composting conditions steady and support the microbes inside the bioreactor?
3. What resources like energy, water, and labor are required to maintain the right temperature, moisture, and airflow during composting?

Process

1. How do you control and check important factors like temperature, moisture, oxygen, and airflow during the bioreactor composting process?
2. What tools or methods does the bioreactor use to make sure the compost breaks down evenly and that no areas run out of oxygen?
3. How do you manage the composting steps—like adding material, how long it takes, and curing—to produce good, stable compost?

Product

1. What are the main physical, chemical, and biological features of the finished compost, and how do these help soil and plants grow?
2. How do you check that compost is stable and mature?
3. What tests or standards make sure it's safe and good for farming?
4. What environmental and economic benefits come from using the finished compost, like better soil water retention, nutrient recycling, higher crop yields, and possible market value?

IV. FEEDBACK AND SUGGESTION

1. What feedback can you share about your experience using the bioreactor?
2. What do you think should be improved in the technology? Why or why not? Please elaborate.

THANK YOU VERY MUCH!

QUESTIONNAIRE: IMPACT ASSESSMENT OF A MARIKINA BIOREACTOR COMPOSTING TECHNOLOGY DEVELOPED BY THE DEPARTMENT OF SCIENCE AND TECHNOLOGY- INDUSTRIAL TECHNOLOGY DEVELOPMENT INSTITUTE

(FILIPINO VERSION)

Ang bioreactor na ipinatupad ng ITDI ay naglalayong mapabuti ang pamamahala ng basurang solid sa pamamagitan ng pag-standardize ng proseso, pagbuo at paggawa ng mga produkto o teknolohiya alinsunod sa RA No. 9003. Layunin ng panayam na ito na suriin ang teknolohiya, tukuyin ang mga sumusunod: mga epekto nito sa kapaligiran, panlipunan, at ekonomiya, antas ng kasiyahan ng mga gumagamit nito, at mga punto para sa lalo pa nitong pagpapabuti.

Ang survey na ito ay tatagal ng halos __ minuto ng inyong oras. Ang inyong impormasyon ay mananatiling pribado at gagamitin lamang sa pag-aaral alinsunod sa Data Privacy Act of 2012. Pakisagutan nang tapat. Salamat.

<table>
<tr><td colspan="2">Petsa:</td><td>Oras ng simula:</td><td>Oras ng tapos:</td></tr>
<tr><td colspan="4">I. PROFILE NG KALAHOK</td></tr>
<tr><td colspan="2" rowspan="2">a. Code ng kalahok:</td><td colspan="2">c. Rehiyon:</td></tr>
<tr><td colspan="2">d. Probinsya:</td></tr>
<tr><td colspan="2" rowspan="2">b. Impormasyon sa pakikipag-ugnayan:</td><td colspan="2">e. Munisipyo:</td></tr>
<tr><td colspan="2">f. Baranggay:</td></tr>
<tr><td colspan="4">II. PANGLIPUNAN AT EKONOMIYANG PROFILE</td></tr>
<tr><td>a. Edad:
1. 20-30
2. 31-40
3. 41-50</td><td>b. Kasarian:
1. Babae
2. Lalake</td><td colspan="2">c. Pinakamataas na edukasyong natapos:
1. Hindi nakatapos ng elementarya
2. Nagtapos ng elementarya</td></tr>
</table>

<table>
<tr><td>4. 51-60

5. 61 pataas</td><td></td><td>3. Hindi nakatapos ng high school

4. Nakatapos ng high school

5. Kursong bokasyonal

6. Undergraduate ng kolehiyo

7. Nakatapos ng kolehiyo

8. Post Graduate Degree/Units</td></tr>
<tr><td>d. Katayuang sibil:

1. Walang asawa

2. May asawa

3. Hiwalay

4. Napawalang bisa ang kasal

5. Balo</td><td>e. Laki ng sambahayan

1. 1

2. 2 - 3

3. Lagpas 3</td><td>f. Buwang kita:

1. 10,000 pababa

2. 10,001-15,000

3. 15,001-20,000

4. 20,001-30,000

5. Mas mataas sa 30,000</td></tr>
<tr><td colspan="2" rowspan="2">g. Bilang ng taong nagtatrabaho sa Materials Recovery Facility

1. Mas mababa sa 1 taon

2. > 1 taon ≤ 5 taon

3. > 5 taon ≤ 10 taon

4. Mahigit 10 taon</td><td>h. Pangunahing pinagkakakitaan</td></tr>
<tr><td>i. Ibang pinagkukunan ng kita</td></tr>
<tr><td colspan="3">III. IMPACT ASSESSMENT AT PAGSUSURI NG TEKNOLOHIYA</td></tr>
<tr><td colspan="3">Pakisagutan ang mga tanong base sa iyong opinyon. Hinihikayat na maging detalyado ang diskusyon ng iyong mga sagot.</td></tr>
</table>

Pangkalikasan

1. Anong mga greenhouse gases (hal. carbon dioxide, methane, nitrous oxide) ang inilalabas ng bioreactor?
2. Paano nyo sila binabantayan o binabawasan?
3. Sa aspeto ng kalikasan, paano mo maikukumpara ang paggamit ng bioreactor sa landfilling, incineration?
4. Ano ang inyong ginagawa para masiguro na ligtas at mataas ang kalidad ng compost?
5. Ano ang mga benepisyo sa kapaligiran ang nabibigay ng paggamit ng compost mula sa bioreactor?

Ekonomiya

1. Ano ang kabuuang gastos sa pagpapatakbo ng bioreactor, tulad ng labor, maintenance at overhead?
2. Anong kita ang nabubuo sa paggamit ng bioreactor, tulad ng mga tip at benta sa compost?
3. Paano mo maikukumpara ang bioreactor sa ibang paraan ng pag-manage ng basura sa aspetong pang-ekonomiya, tulad ng pagkumpara sa mga ginastos at benepisyong nakuha?

Sosyal

1. Paano nakikipag-ugnayan ang bioreactor sa barangay?
2. Ano ang epekto ng koneksyong ito sa pagkakaisa at kamalayan ng barangay sa kapaligiran?
3. Anong mga oportunidad sa trabaho at training ang nagagawa ng bioreactor sa mga residente?
4. Paano ito nakakatulong sa pagpapabuti ng kabuhayan?

5. Paano ang naging pagtanggap o pagtanggi ng baranggay sa bioreactor?
6. Anong mga factors ang nakakaimpluwensya sa pagsuporta o pagtanggi ng komunidad dito?

Teknolohiya

1. Paano nakakaapekto ang bioreactor sa oras at kahusayan ng composting kumpara sa mga manual na paraan?
2. Anong mga improvement sa kalidad at katatagan ang nakita mo sa bioreactor kumpara sa manual na paraan?
3. Paano nakakaapekto ang disenyo ng bioreactor sa pagpapanatili ng init, pagkontrol sa hamog, at pangkalahatang performance kumpara sa manual na pag-compost?

Institusyonal

1. Paano binago ng paggamit ng bioreactor ang mga patakaran sa basura, mga sustainable goals, at pang-araw-araw na operasyon ng iyong institusyon?
2. Anong mga pagbabago ang ginawa ng iyong institusyon upang matagumpay na gamitin ang bioreactor?
3. Paano naapektuhan ng bioreactor ang mga gastos at paggamit ng resources ng iyong institusyon, tulad ng pagkolekta ng basura, mga bayarin sa pagtatapon, at paggawa o paggamit ng mga pampaganda ng lupa?

Konteksto

1. Anong mga problema sa pag-manage ng nabubulok na basura ang sinusubukang lutasin ng bioreactor sa inyong lugar?
2. Anong mga lokal na factor tulad ng pangkalikasan, panlipunan, at ekonomiya ang nakakaapekto kung gagana nang maayos ang bioreactor sa inyong lugar?

3. Anong mga sustainability goals o patakaran ang gumagabay sa paggamit ng bioreactor at ano mga gusto nitong makamit?

Input

1. Anong mga uri ng organic na gamit ang kailangan para gumana nang maayos ang bioreactor?
2. Anong mga gamit at teknolohiya ang kailangan upang mapanatiling steady ang kondisyon ng pag-compost at masuportahan ang mga bacteria sa loob ng bioreactor?
3. Anong mga resources tulad ng enerhiya, tubig, at labor at iba pa ang kailangan upang mapanatili ang tamang temperatura, hamog, at daloy ng hangin sa pag-compost gamit ang bioreactor?

Proseso

1. Paano kinokontrol at tinitignan ang mga mahahalagang factor tulad ng tempratura, hamog, oxygen, at daloy ng hangin tuwing ginagamit ang bioreactor?
2. Anong mga gamit o paraan ang ginagamit ng bioreactor para masiguro na pantay ang pagkakadurog ng compost at walang nawawalang oxygen?
3. Paano mo mina-manage nag pag-compost tulad ng pagdagdag ng input, gaano katagal ang curing para makagawa ng maganda at stable na compost?

Produkto

1. Ano ang pangunahing pisikal, kemikal, at bayolohikal na katangian ng natapos na compost, at paano ito nakakatulong sa paglaki ng lupa at mga halaman?
2. Paano mo tinitignan kung steady at mature ang compost?

3. Ano ang mga test o standard na sumisigurong ligtas at mabuti ang compost para sa pagtatanim?
4. Ano ang mga benepisyo sa kapaligiran at ekonomiya ang nanggagaling mula sa paggamit ng natapos na compost, tulad ng mas magandang soil water retention, mas mataas na ani, nutrient recycling, at posibleng market value?

IV. MGA PUNA AT MUNGKAHI

1. Anong feedback ang maibabahagi mo tungkol sa iyong karanasan sa paggamit ng bioreactor?
2. Ano sa tingin mo ang dapat pagbutihin sa teknolohiya? Bakit o bakit hindi? Paki-elaborate.

MARAMING SALAMAT!

APPENDIX C

STUDY PROTOCOL

Scientific Design

To effectively review the viability of expected outputs from the study, it is essential to conduct a comprehensive feasibility study. Its goals are as follows:

- Revisit and clarify the project's initial objectives and expected outcomes to ensure alignment with current conditions and stakeholder expectations;
- Analyze potential risks that could hinder project success;
- Compare actual performance against original projections to identify discrepancies;
- Gather and analyze relevant data to inform the review process and ensure that decisions are based on accurate and up-to-date information;
- Provide actionable recommendations aimed at enhancing project feasibility;
- Ensure that the results of the review are well-documented and communicated effectively to all stakeholders involved; and,
- Assess not just immediate outputs but also the long-term sustainability of the project's outcomes, considering how they will adapt to future market trends and technological developments.

Further, the study's success may be measured through evaluation of the following:

- Clarity of objectives;
- Relevance of research design;
- Quality of data collection; and,
- Efficiency of conducting the study.

Initially, the study sought to assess the bioreactor effectiveness in terms of environmental and socio-economic impacts. The key research questions identified are the following:

- What are the impacts of the bioreactor?
- How can the bioreactor be assessed using the Context, Input, Process, Product (CIPP) Model?
- What appropriate mitigating and enhancement measures are recommended for the assessed impacts?

The SWOT analysis of the study is as follows:

Strengths	Support from DOST-ITDI, Marikina CEMO, and UPOU
Weaknesses	Collecting years' worth of data
	Time and budget constraints
Opportunities	Establishing an institutionalized system for assessing impacts of technologies
Threats	Respondent willingness, response time of agencies

Actions to address these findings are detailed in Methods and Research Ethics.

The risks of conducting the study are categorized into three categories as follows:

Methodological Risks

- Inaccurate Risk Identification: Assessments may fail to capture all relevant risks, especially emerging or indirect risks associated with new technologies. This could lead to a false sense of security regarding the safety and efficacy of the technology being evaluated.
- Subjectivity in Evaluation: The use of subjective probability assessment techniques can introduce biases into the evaluation process. This is particularly

problematic when objective data is scarce, which is often the case with novel technologies.

- Dynamic Nature of Technology: Technologies evolve rapidly, making it challenging to keep assessments current. Continuous monitoring and periodic reassessments are necessary but can be resource-intensive and may not always be implemented effectively.

Ethical Risks

- Exclusion of Stakeholder Perspectives: Failing to involve affected communities and stakeholders in the assessment process can result in oversight of critical impacts, especially on marginalized groups. This exclusion can lead to decisions that exacerbate inequalities or ignore significant societal concerns.
- Potential for Misuse: Assessments might be manipulated to justify the deployment of harmful technologies or to downplay negative impacts. This risk shows why it is important to be open and responsible during the assessment.
- Neglecting Long-Term Impacts: Many assessments focus on immediate or short-term effects, neglecting potential long-term consequences that could emerge over time. This oversight can lead to irreversible damage to social structures or ecosystems.

Operational Risks

- Resource Allocation Challenges: Conducting thorough impact assessments requires significant resources—time, expertise, and funding. Organizations may underinvest in these areas, leading to superficial assessments that do not adequately address risks.

- Integration into Decision-Making: There is often a disconnect between assessment findings and actual decision-making processes. If assessment results are not effectively communicated or integrated into strategic planning, organizations may fail to mitigate identified risks adequately.
- Compliance and Regulatory Issues: Organizations may face legal challenges if they do not adhere to established guidelines for conducting impact assessments, potentially resulting in penalties or reputational damage.

Meanwhile, the research design, sampling design, sample size, statistical analysis plan, and data analysis plan were reviewed and assessed as appropriate and justified by the Faculty-in-Charge, DOST-ITDI, IREC, and statistician.

Conduct of Study

You can see the main researcher's qualifications by looking at their resume through the link provided. Appendix D contains the specifics for the assessment of site suitability and duration.

Ethical Considerations

The Methods and Research Ethics section explains how conflicts of interest and privacy issues are handled in the study. For information about informed consent, please see the Informed Consent Form for Survey and Interview on the next page.

APPENDIX D

INFORMED CONSENT FORM FOR DATA GATHERING

Name of Principal Investigator/Researcher: Stephanie A. Alvaro

Name of Organization: University of the Philippines Open University

Name of Sponsor: Department of Science and Technology – Industrial Technology Development Institute

Name of Project and Version: Impact Assessment of a Marikina Bioreactor Composting Technology Developed by the Department of Science and Technology-Industrial Technology Development Institute

Part I: Information Sheet

Introduction

My name is Stephanie Alvaro. I study the Marikina Bioreactor Composting Technology for my Master's degree. I invite you to join my study. Take your time to decide. If you don't understand, I will explain. You can ask me questions anytime.

Purpose of Research

The DOST-ITDI's Bioreactor Project was created to help manage solid and organic waste, following the rules of RA No. 9003. This study wants to find out the environmental and social effects of the project.

Type of Research Intervention

The research involves an interview and discussion though structured questionnaire with Materials Recovery Facility (MRF) personnel.

Participant Selection

You were chosen to join because you have used the bioreactor made by DOST-ITDI. You were also picked because you have important information about your local government's waste management plan and Materials Recovery Facility (MRF).

Voluntary Participation

If you are picked, you can choose to join or not. If you say no, nothing changes—you still get the same services.

Procedures

This study asks how the bioreactor project affects people. You will answer some questions about yourself and the project. You don't have to answer any question you don't want to. The interview can be where you choose. Only the main researcher will be there unless you want someone else.

Your information is private and only used for this study. The records will be kept for one year then destroyed. You can do the survey in person, by phone, online, or by email. Your answers are kept secret and only the researcher sees them.

Duration

The interview and discussion may last from 15-30 minutes up to one (1) hour depending on your answers. The research will be conducted until July 2025.

Risks

Some risks of joining the study include possible emotional upset or worries, depending on your experiences. You might feel sad, have short mood changes, worries about privacy, or anxiety if certain things are shared. To help, safety measures and support will be provided. The researcher is trained to handle these feelings during the interview. You don't have to answer any question or join any activity if it feels too personal or makes you uncomfortable.

Benefits

Your help will show if the project reached its goals. Your honest answers will tell what worked and what didn't. By joining, you give information to help those in charge decide what to do next. Your help will make government projects better and useful for everyone.

Expenses and Reimbursements

The researcher will pay for contacting you and meeting with you, so you don’t have to pay anything. If you do have any costs, you will only be paid back for what you spent because of joining the study.

Compensation or Insurance

Should there be any unintended event/s during the activities that caused injury or harm to the participant/s, the researcher shall be held responsible for settling the expenses incurred in resolving the damage/s and treatment/s necessary for recovery.

Privacy and Confidentiality

The researcher will keep all your information and what you share private. If the interview happens in person, people in the community might recognize you and notice the research, which could cause unwanted attention. To avoid this, the researcher will first coordinate with and inform the DOST-ITDI about the study.

Sharing of Results

The information collected will be summarized and shared with DOST-ITDI and UPOU. The results of the research will be published.

Right to Refuse or Withdraw

Joining the study is your choice, and you can stop participating anytime. You have the right to end your participation for any reason. You can also review your answers and ask to delete part or all of the recording or notes.

Right to Access

As participant/s in the study, you have the right to demand reasonable access to your personal information. It shall be provided to you in a clear and understandable format.

Data Management

The information collected will be kept safely as notes, recordings, and online copies. Only the researcher can access it, and it will be kept for up to one year. After that, it will be destroyed by shredding and deleting.

Research Ethics Committee Approval and Contact Information

The Faculty of Management and Development Studies – Research Ethics Committee has approved the aforementioned study.

If you have questions or concerns about your rights as a study participant, or if you want to make a complaint, you can contact the following:

Researcher	Email: saalvaro@up.edu.ph
DOST-ITDI	Technological Services Division Tel: (632) 86837750 to 69 loc. 2265
UPOU	UP Open University Institutional Research Ethics Committee Faculty of Management and Development Studies Address: UP Open University, Los Baños, Laguna, Philippines, 4031 Email: fmds-ethics@upou.edu.ph or irec@upou.edu.ph

II: Certificate of Consent

I have heard or read the information. I asked questions and got answers. I agree to join this study by my choice.

Print Name of Participant: ___________________________

Signature of Participant: _____________________________

Date: _____________________________

If Illiterate

If the person can't read or write, someone who can should sign for them. This helper should be chosen by the person and not part of the research team. The person who can't read or write should put their thumb print.

I saw the consent form read to the person. They asked questions and said yes to join.

Print name of witness: ____________________ Thumb print of participant: [ ]

Signature of witness: _____________________

Date: _____________________________

STATEMENT BY THE RESEARCHER OR PERSON TAKING CONSENT

I explained the information to the person and made sure they understood the survey. They could ask questions, and I answered.

I confirm they agreed to join willingly. They got a copy of the consent form.

Print Name of Researcher or person taking the consent: _______________________

Signature of Researcher or person taking the consent: ________________________

Date: _____________________________

APPENDIX E

TERMS OF REFERENCE OF THE COLLABORATIVE STUDY: IMPACT ASSESSMENT OF A MARIKINA BIOREACTOR COMPOSTING TECHNOLOGY DEVELOPED BY THE DEPARTMENT OF SCIENCE AND TECHNOLOGY-INDUSTRIAL TECHNOLOGY DEVELOPMENT INSTITUTE

Purpose and Objectives

This document explains the rules for a joint study on the Marikina Bioreactor Composting Technology by the Department of Science and Technology. The study helps the institute set up a system to check how technologies affect users. It also gives a chance for a researcher to practice managing research and development (R&D) and to work together with the institute on this project.

The study has three main goals:

- Find out the effects of the bioreactor (What does the bioreactor do?);
- Evaluate the bioreactor using the CIPP Model, which looks at Context (what needs to be done), Input (what resources are used), Process (how it is done), and Product (the results);
- Suggest ways to fix problems and improve the bioreactor based on the evaluation.

This study uses the CIPP Model to answer key questions about the project at each stage, from planning to results, to help make good decisions.

Scope of Study

The study shall be carried out within the existing documentation provided by the ITDI. The researcher shall adhere to the protocols, assistance, and timeline approved by the institute. The target population includes Materials Recovery Facility (MRF) personnel within the National Capital Region (NCR).

Responsibilities

UPOU will have these duties and responsibilities:

- Provide a Special Problem adviser to the researcher;
- Coordinate with the ITDI on the student engagement;
- Ensure that R&D management competencies on planning, monitoring, and evaluation of research activities are expressed in the practicum;
- Assist the researcher in preparing a project proposal for the ITDI;
- Monitor monthly the progress of the study and require the researcher to report progress to the ITDI;
- Assist the researcher in the preparation for information dissemination of the project results; and,
- Submit a technical report of the study to the ITDI.

The Researcher shall have the following duties and responsibilities:

- Lead in the drafting and finalization of proposal;
- Prepare all documents necessary for the approval of the proposal and manuscript;
- Report to the adviser and ITDI on the progress of the study;
- Conduct the analysis and reporting necessary for data collected in the study; and,
- Perform other tasks as may be assigned during the collaborative study.

The DOST-ITDI shall assist the efforts related to the study by:

- Coordinating with the Special Problem Adviser for the student engagement;
- Assigning the practicum student a project topic;
- Ensuring that R&D management competencies on planning, monitoring, and evaluation of research activities are expressed in the practicum;

- Reviewing and approve the project proposal of the student;
- Assisting the student in the implementation of the project proposal;
- Sharing agency data and resources for the project of the student with a non-disclosure agreement; and,
- Co-authoring publications and conference presentations from the student project.

Resources

The available means to support the collaborative study include, but not limited to, the following:

- Researcher, Adviser, DOST-ITDI focal person, Statistician, and MRF personnel;
- Data access on bioreactor, MRF site, and information on the local government unit's solid waste management plan and MRF;
- Operational bioreactor;
- IT equipment for research work; and,
- Funding as necessary.

Timeline

The schedule of collaborative study with key outputs and deadlines are as follows:

Activity	Output	Date
Submission of revised proposal	Proposal	17 February
ITDI review and approval of proposal	REC requirements	18-28 February
IREC clearance	REC decision notice	3 March to 23 April
Coordination with focal/s and respondents and pre-testing of questionnaire	Request letter, pre-test notes	7-24 April

Data gathering	Accomplished questionnaire/s and interview note/s	25 April
Data processing and analysis	Graphs, tables, and word clouds	25 April onwards
Report writing	Final report	July

Intellectual Property

All outputs produced by virtue of and pursuant to this collaboration shall be jointly owned by all parties and shall be in accordance with the Governing Principles and Policies on Intellectual Property Rights of the University of the Philippines System as approved by the UP Board of Regents and with the Intellectual Property Policy of DOST-ITDI.

Reporting and Dissemination

All parties shall collaborate in coming up with and finalizing the findings of the study, with the researcher reporting the results as approved by the adviser and DOST-ITDI. No information obtained from the study shall be disseminated to anyone without the approval of all parties involved.

Conflict Resolution

In case of dispute in the policies and principles of the parties or disagreement, the parties shall settle them mutually and in good faith.

If circumstances arise such that any party no longer wishes to be part of the arrangement, termination may be done after consultation with all parties and mutually agreed, subject to a mandatory prior written notice period of at least thirty (30) days.

Any termination shall be without prejudice to any ongoing activity or program for the Project. No pre-termination will be allowed by the Parties, if the same will result in the non-completion of any ongoing activity or program.

APPENDIX F

PHOTO DOCUMENTATION

APPENDIX G

CODING OF TRANSCRIPTS FOR IMPACTS AND CIPP

Coding of transcript of focus group discussion re impacts with MRF personnel

Interview and FGD re Impacts with MRF Personnel	Code
“May mga emission siguro tulad ng carbon dioxide, methane, at nitrous oxide. Mataas ang methane kapag yard waste ang ginagamit, at nitrous oxide naman kapag nitrogen-rich tulad ng manure.”	Emits carbon dioxide, methane, and nitrous oxide
“Dapat may gas measurement tayo para makita kung alin sa emissions ang dominant at paano ito babawasan.”	Ideal practice includes gas measurement
“Dapat meron ding tamang daloy ng hangin, moisture at ratio ng carbon at nitrogen.”	Ideal practice includes proper airflow, moisture and C:N ratio
“Mas mabuti ang composting kesa incineration kasi parang nagsusunog ka ng basura. Masama sa ozone layer. Sa landfilling naman madaming lupa at mabaho.”	Composting is preferred over incineration and landfilling
“Maraming benepisyo tulad ng pagpapaganda ng lupa, pagtubo ng mga halaman, waste diversion, at pagbawas ng paggamit ng chemical fertilizer.”	Soil enrichment, plant growth, waste diversion, reduced chemical use
“Di ko lang siguro pero baka nasa mga 66,000 pesos o kaya 71,000 pesos kung estimate lang	₱66,000–₱71,000 monthly cost

lahat ng gastos sa pagpapatakbo ng bioreactor kada buwan. Syempre malaki yan.”	
“Kung sa kita, mababa lang naman. 15 pesos per kilo. Minsan libreng binibigay na yung compost kapag humihingi yung mga school. Yung tip minsanan din lang.”	Varied income from tipping fees and compost sales (sometime free)
“Nakakatulong din sa ekonomiya kapag gumaganda yung kapaligiran at baranggay dahil sa mabuting compost na nagagawa ng bioreactor.”	Indirect benefits from improvements in environment and community
“Pinangungunahan ng city hall yung mga project sa environment. Pati yung mga pa training ng DOST sa bioreactor tumutulong din sila. Gawa nito maraming tao ang sumasali.”	Strong community participation led by LGU
“Marami ding mga training at event ang DOST para sa kalikasan.Yung mga tao umaattend.”	Engagement through education and events
“Syempre bukod sa training maraming nabigyan ng trabaho.”	Creates jobs and training opportunities
“Kung sa pagtanggap sa bioreactor, wala namang naging problema. Nakadepende siguro yun sa kaalaman, kung swak ba sa kultura, kung maganda ba yung quality ng compost, kung may backing ba ng LGU.”	Social acceptance depends on knowledge, cultural fit, compost quality, and institutional support
“Mabilis ang proseso ng bioreactor—days lang kumpara sa traditional method. Kaya lang, kailangan ng mas mataas na energy input at mas	Expedites composting, requires higher energy and

komplikadong system kaya kelangan ng taong marunong. Pero okay kasi nababawasan ynug mano mano.”	skilled operators but reduces manual labor
“Pero dahil automated ang aeration at moisture control, maganda ang compost output—mas uniform, mature, masustansya at mababa ang carbon nitrogen ratio.”	Better control over temperature and moisture, produces mature, stable compost with consistent nutrient content
“Mas pinaiigting ang waste segregation. Kailangan din ang continuous training sa mga tauhan para sa bagong waste flow at monitoring protocols.”	Operational changes: staff training, new workflows, regular monitoring
“Na-integrate yung composting sa pamumuhay namin. Kahit sa bahay naghihiwalay ako ng mga nabubulok na basura.”	Composting integrated into routine sustainable practices
“Nakadepende pa rin sa commitment ng mga tao sa pag sort ng baura. Kung tamad at walang pake, balewala rin.”	Success depends on commitment to waste segregation
“Isa pa, may limitasyon kung hindi ayos ang segregation. Kapag marami pa ring non-biodegradables, hindi rin magiging epektibo ang buong proseso.”	Challenges remain if non-biodegradable waste persists

Coding of transcript of interview and focus group discussion re CIPP with MRF personnel

Interview and FGD re CIPP with MRF Personnel	Code
"Ang DOST-ITDI ang tumutulong at bumuo ng teknolohiya. Sila ang responsible sa kaalaman para sa maayos na pag-manage ng basura."	DOST-ITDI
"Ako po ang nag-ooperate ng bioreactor. Natutunan ko ang proseso mula sa paglipat ng teknolohiya at regular naming minomonitor ang operasyon."	Bioreactor user
"Kami po sa CEMO ang tumutok sa implementasyon at sumisigurong nasusunod ang mga patakaran sa kapaligiran."	Marikina CEMO
"Ang mga nakatira at nagtatrabaho sa Marikina ang matuturing na mga residente."	Local residents
"Kulang kasi kami sa tao dati bago nagkaron ng bioreactor"	Shortage of manpower
"Sana effective at yung hindi nasisira para nagagamit ng maayos yung bioreactor"	System reliability
"Malaki po ang naging epekto ng bioreactor sa pagbawas ng basura sa landfill. Bago ito, halos lahat ng nabubulok na basura ay diretso sa tambakan, pero ngayon, nako-compost at nagagamit na pampataba sa lupa."	Reduced landfill dependency
"Naramdaman po namin na bumaba ang methane emissions ng komunidad dahil sa mas maayos na	Reduced methane emissions

composting at regular na paghalo at pagpapanatili ng tamang timpla ng basura sa bioreactor.”	
“Malaki ang tulong ng bioreactor compost sa aming taniman dahil napansin naming mas naging mataba at maganda ang kalidad ng lupa.”	Improved soil fertility
“Palaging binibigyang pansin ang community training at paghahanap ng pondo para mapanatili at mapalawak ang operasyon ng bioreactor. Lalo na ngayon na dumarami ang humihiling ng compost para sa urban gardening.”	Community capacity and investment needs
“Nagkaroon kami ng dagdag na kaalaman sa waste management, at mas ginanahan ang mga kapitbahay maghiwalay ng basura dahil alam nilang mapapakinabangan ang compost.”	Demand for quality compost
“Napakahalaga po. Ang bioreactor ay isang malaking bahagi ng aming estratehiya upang makasunod sa RA No. 9003. Ito po ang pangunahing batas na gumagabay sa aming programa sa pamamahala ng solid waste.”	RA No. 9003
“Bukod sa RA 9003, tinitiyak din namin na ang operasyon ng bioreactor ay umaayon sa iba pang pambansang batas tulad ng Presidential Decree No. 1586. Mahalaga po ito para masiguro na walang masamang epekto sa kapaligiran ang aming proyekto.”	PD No. 1586

“Opo. Ang RA No. 6969, basta yung sa toxic substances, ay mahalaga rin sa amin. Kahit na ang bioreactor ay para sa organic waste, sinisiguro namin na walang hazardous na materials ang nakakapasok para mapanatili ang kaligtasan namin at ng kalidad ng compost na aming nilalabas.”	RA No. 6969
“Base sa mga nakalistang sustainable goals, masasabi kong kasama ang Employment and Livelihoods, kung saan tinutulungan ang mga tao na magkaroon ng disenteng hanapbuhay at pagkakataong mapaunlad ang kanilang kabuhayan.	Employment and livelihoods
“Pwede ding isama ang Innovation and Infrastructure, kasi sinusuportahan ng bioreactor ang modernisasyon at pagpapatayo ng mga sistemang makatutulong sa pang-araw-araw na buhay at ekonomiya.”	Innovation and infrastructure
“Yung Sustainable Cities and Communities ay importante din. Dito, pinupush na mapaunlad yung mga lugar na ligtas, matatag, at maayos tirhan.”	Sustainable cities and communities
“Mahalaga din yun Climate Action kasi inaaddress nito yung mga issue ng climate change.”	Climate action
“Pasok din yung Responsible Consumption sa bioreactor. Importante yung responsableng paggamit ng natural resources para di to maubos at mapangalagaan ang kapaligiran.”	Responsible consumption

"Sinusuportahan din ng bioreactor yung mga kagubatan, hayop, at iba pang likas na yaman na dapat pangalagaan para mapanatili ang balanse ng kalikasan."	Life on land
"Kaya nga po nagsasagawa tayo ng mga government programs and trainings para matuto ang mga residente kung paano ang tamang pagtatapon ng basura at kung paano rin sila makakatulong sa environmental awareness."	Government programs and trainings Environmental awareness
"Nagsimula na rin po kaming gumamit ng organic compost para sa aming pananim. Malaki po ang naitulong nito sa aming tanim at sa lupa. Tingin ko po ay parte ito ng sustainable agriculture."	Sustainable agriculture
"Una nating titingnan dapat ang site location ng mga proposed waste management facilities. May mga report na hindi sumusunod ang iba sa tamang distansya mula sa residential zones. Sabi ng DOST, hangga't maaari, huwag patayin ang bioreactor. Mga greens and browns lang din ang pwedeng ipasok sa makina."	Site location Operation hours Waste acceptance rules
"Base sa PAES 414-2:2001, may specific tayong guidelines para sa operasyon—mula pagtanggap ng bausra hanggang operation hours—na kailangan sundan ng bawat MRF. Responsibilidad ng opisina na ipatupad ang mga batas tulad ng RA	Compliance with PAES 414-2:2001 RA No. 9003

9003 para matiyak ang kalinisan at kaligtasan ng lungsod."	
"Maganda po ang takbo. Nabawasan ang composting period namin. Mas mabilis na ang proseso, at minimal na ang operational difficulties kasi madali pong paganahin ang bioreactor."	Reduced composting period Easy operation
"Isa pa, walang naging issue sa leachate discharge. Na-control po nang maayos kaya hindi naapektuhan ang mga local residents.	No leachate discharge
"Speaking of residents, positive po ang feedback mula sa kanila, lalo na't maliit lang ang kelangang lupa ng facility. Hindi na-overwhelm ang area at mababa lang din ang kailangan na enzyme, kaya konti lang ang gastos."	Small land footprint Low inoculant needs
"Maganda naman po. Marami pong natutunan ang mga gumagamit, pero may mga pagkakataon na nahihirapan kami sa maintenance, lalo na kung masira ang parts."	Bioreactor users
"Pwede po kaming lumapit sa DOST-ITDI kung may issues sa machine. Open sila para magbigay ng technical assistance."	DOST-ITDI
"Nag-improve naman ang sanitation dito sa amin simula nung may bioreactor. Pero sana madagdagan pa ang information drive para mas maraming mga residente makiisa"	Local residents

“Responsibilidad ng opisina na ipatupad ang mga batas tulad ng RA 9003 para matiyak ang kalinisan at kaligtasan ng lungsod.”	Marikina CEMO
“Stable naman po ang supply ng browns, gaya ng tuyong dahon at karton. Medyo nagkukulang lang tayo minsan sa greens, lalo na pagka tag-ulan.”	Browns Greens
“Nakausap din namin ang mga barangay, at may mga nagdo-donate ng dumi ng hayop. Kulang pa rin minsan.”	Animal manure
“Sa aspeto ng equipment and technology, okay po ang bioreactor pero nagkakaproblema minsan sa mixing at daloy ng hangin. Kailangan din sigurong bantayan ang supply nng enzyme o microbial starters.”	Mixing and airflow system Enzyme/microbial starters
“Kailangan din ng stable na supply ng kuryente. May naka-allocate po tayong labor at sapat rin ang tubig.”	Power supply, labor, water
“Isa pa, kung biglang magbago ang panahon, lalo na kapag bumagyo, hindi stable ang weather, naaapektuhan po ang proseso.”	Stable weather
“So yung una po non yung mga collection po natin sa market yung mga biodegradeable waste yung mga gulay prutas na tinatapon na nila then dadalhin dito yun ng truck iuunload tas magkakaroon po tayo ng sorting yun nga iaalis po natin yung mga	Waste segregation and shredding

unwanted materials yung mga plastic bottle na nahalo tapos po non mag uundergo na po siya ng shredding. Shredding na sya pag na shred na po.”	
“Gradual loading naman tayo kay bioreactor, 500 hanggang 1000 kilos kada araw. Bale yung composition niya po. Fifty seven percent ng na shred na niya. Tapos thirty three percent ng mga kusot yung sodas. Tsaka ten percent ni animal manure.”	500-1000 kg per day Ideal ratios
“Importante ang daloy ng hangin at tamang paghalo para sa controlled composting.”	Airflow Mixing
“Mahalaga din na binabantayan ang temperature, daloy ng hangin at moisture para masigurong maayos ang pagkakagawa ng compost.”	Temperature Airflow Moisture
“Kasama sa tools yung motor panghalo, shredder, at panghangin.”	Motorized mixer, shredder, aeration fans
“Mainit po yan. Maga undergo po yan ng curing so ilalagay po namin sa curing yan di pa po siya pwede mag apply yan sa halaman kasi active pa po si bacteria. Baka po kainin po yung ugat at maapektuhan yung halaman natin at nag undergo pa po ng curing at umaabot po siguro ng three weeks to one month po.”	Curing

"After po nun kinukuha namin yung lupa at ini-inspect. Dapat yung lupa, crumbly siya, dark brown ang kulay, at maayos ang aeration — wala rin dapat problema sa moisture, nasa less than 20% dapat."	Quality checks, crumbly, dark brown, aerated, <20% moisture
"Kung sa chemical, dapat neutral lang ang pH at mayaman sa sustansya ang lupa."	Neutral pH Rich in nutrients
"Kung sa microbial properties, dapat maraming mga magagandang microbes at walang pathogen na pwede mag-contaminate sa lupa at magdala ng mga sakit."	Diverse beneficial microbes No pathogen
"Yung nagawang compost, dapat ligtas sa mga halaman, tumutulong sa pagtubo at walang lason."	Supports growth Not toxic
"Tingin ko, dapat dumadaan din sa quality testing tulad ng sa visual, toxicity at pag-analyze base sa international standards kung seryoso at may pondo talaga."	Visual, toxicity, international standards
"Kung sa industry standards naman, parang meron yung sa agricultural engineering standards yung tama yung PAES 414-2:2001. Andun yung tamang curing process, yung dapat sa loob nagko-compost, walang leachate, tapos maganda yung quality ng compost pati yung tamang pagtatapon."	Proper curing process, in-vessel composting control, no leachate disposal observed, compost quality and disposal

Coding of transcript of interview and focus group discussion re contribution with MRF personnel

Interview and FGD re Contribution with MRF Personnel	Code
"Sa houseold na papractice ako ng biocomposting. Meron akong maliit na area don ko nilalagay ung mga food waste at saka kitchen waste bukod don sa composting meron akong alagang mga manok so yung mga fresh na food waste sa mga manok ko binibigay."	Promotion of environmental practices
"And yung mga ano naman kitchen waste mga gulay sa mga ano sa kambing at saka rabbit so nakakabawas siya sa volume o sa timbang na binibigay naming sa kinokolekta ng city LGU. Isa pa non di gaano nagtatagal sa bahay naming so di na siya nagegenerate ng odor at mga insects. Bale 100 percent di kami nag didispose ng mga foodwaste at saka mga garden waste."	Waste reduction, elimination of odor and insects
"Di naman po case to case bases lang bago kami makapag ano ng gamit eh matagal eh kapag may event kuwnari kailangan naming ng packaging na 1 kilo ayun tinatanong naming si costumer kung kailangan niyo po ba si resibo dun na kami kumukuha ng pambili pang emergency pero lahat naman po may resibo yung di makapagantay ng resibo pinapareceive pa rin naming tas kinukuha nila pagbalik."	Additional source of fund
"Nakasako ganon kaya sinwerte po kami merong ano mga nagrerepack din ng ano panghalaman dinadala sa Boracay sila nakaubos kaya ayon pinagaral po nila tinuruan po	Knowledge-sharing of composting practices

naming sila pano gumawa. Sila na po guagawa ng sarili nilang ano.”	
“Siguro pwede yung sa trabaho medyo secured yung ano wala naming ibang nakakaalam kami din di ka pwedeng basta ipalipat ng ano di naman pwedeng tanggalan ka ng pwesto ganon.”	Provision of secured job
“Opo kasama na po yun saka po yung makasalimuha sa tao, di po kasi ako sanay na humaharot sa bisita eh dito po di po pwedeng hindi eh ipapaliwanag po yung technology ung mga porseso dito lang po pero pag dun na po sa loob marami na pong scope yung pinaguusapan eh may iba ibang department na.”	Knowledge-sharing, socialization, networking
“Ano pa ba, ayun po dagdag po sa kaalaman naming sa technology kapag po may dumating na iba napagcocompare po naming to sa mga bagong dumadating ayon po nadadagdagan po kaalaman po naming po since unang una wala po kaming kaalaman nung nilagay po kami dito di naming alam yung pagcocompost dito na rin kami naturuan.”	Knowledge and skills development
“Dito samin sa Marikina since lahat po ng lgu at mga probinsya nirerefer po sa amin since nung ginamit naming to di po kami bumibili yung ibang lgu kasi tinigil po nila kaya po dito po sa amin nirerefer ni DOST kaya marami po kaming bisita dito tinitignan po nila yung technology yung	Promotion of tourism

impact din po sa tourism ng Marikina isa po to sa tinitignan nila.”	
“Maayos naman po medyo malalaki lang yung pinaka output niya eh yung mga bisita nga nakakaintindi eh di pede yan ah eh sinabi naming ang target naman po natin dito is for waste diversion. Di naman po kami nag aano ng ano yung pangbenta.”	Waste diversion
“Talaga karamihan namanpo ng ano naming eh request ng school, narerequest sila para sa halaman nila eh pickup nalang po nila dito tapos mga walk-in lang po yung may mga halaman sa bahay eh pero para sa ibenta naming hindi naman po eh.”	Social responsibility
“Dito sa MRF meron kaming bale allowance 2000 na nangagaling sa barangay. Ahh don po nangagaling sa barangay yung 2k bale di po nangagaling don sa MRF.”	Additional allowance from community
“Bukod po sap ag rerecycle ng basura, dagdag kaalaman din po sa mga training, naishashare po naming sa community kung pano po mag composting.”	Additional knowledge, knowledge-sharing of composting
“Dati po kasi nagmamano mano lang kami binabaon naming sa lupa, ngayo npo ilawng araw lang po okay na yung lupa, nung time po naming nung araw mas madali po ngayon sa pamamagitan ng bioreactor.”	Easier and faster composting

Coding of transcript of interview and focus group discussion re feedback with MRF personnel

Interview and FGD re Feedback with MRF Personnel	Code
"Machine feeling ko lang masyadong malaki. Sabagay one ton kasi yung nasa ano pero kung di maiiwasan kung ganon ka laki tapos malakas sa kuryente yung power consumption 2 horse power ata siya ganun."	Too big High power consumption
"Eto po based po sa experience po naming di na po niya kaya yung 1 ton pag ilang years na siya pag umabot na sa 500 naririnig mo lumalatiktik na po siya minsan pumuputok na yung fuse di niya na kaya may katandaan na rin nasira na rin po kasi yanyung shafting niya sa loob nilagyan naming siya ng kanin baboy, naputol na po yun sa sobrang taas ng acid ng kanin baboy so nakadesign lang po siya para sa mga gulay kasi kung kanin baboy po dapat po stainless."	Cannot process 1 ton after years Cannot process leftover food
"Dati po nung na ondoy po yan tinulungan po kami ni DOST kasi eto po yan dito lang po nakalagay eh hanggang dito po yung tubig kaya tinulungan niya po kami kaya dito na nailagay, saka pag may tanong naman ehtumutulong naman sila."	Helpful DOST during flood and maintenance
"Ay ano yun di kami binitawan mga 3 weeks sila hanggang sa gumana ng diredirets tapos bukod sa mga lecture lecture nag actual po kami lahat po ng ano tapos nung ano po nay un 24/7 po yung operation natin 3 personel po sa	Intensive user training

5-1 ng umaga tapos 3 personel nanaman sa 1-9 tapos 9-5 naman po ng madalin araw meron naman din tatlo kaya eto dati punong puno ng ano yan pre compost output kasi ngayon may ibang department na po kaming kasama dapat kami lang gumagalaw dito yun pong asa taas nay un punong puno po ng finished product yun.”	
“Hindi namna po kasi marami naman actually ako di ko rin alam computation may m ga bumibista samin Nakita nila mga 50 pesos lang daw po sa isang araw kasi yung .25 horsepower lang po yung makina niya maliit lang po yung makina niya ganito lang po kaliit.”	Power consumption is not high
“Medyo ano kasi marami na po siyang problema yung mga tagas po sa motor kaya marumi na po kaya medyo malaki may housing.”	Machine needs maintenance
“Tapos netong tumagal tagal paunti ng paunti na po yung pwede niyong ilagay.”	Lessening input capacity
“Kaya yun ano rin nila yung technology at support po nila babayaran po nila. Eto po donation yan. Madami nga lang requirements kailangan maprovide naming bago magstart yung training kasi nga donation lang to di katulad neto kami yung medyo nasunod eto wala na siyang anong nirerequired eto.”	More requirements if donated compared with acquired through sale
“Sa ibabaw po tas don po yung discharge, yan po yung madalas unang nasisira kasi po masyadong mainit po yun pag pinapala yung usok niya tapos po medyo amoy	Ammonia discharge is odorous

ammonia po yun kumakapit sa damit pero yun po yung ideal na na DOST. Oo kumakapit sa damit kaya pati mga asawa namin nagagalit.”	
“Unang proseso naming shinshred muna jusko po ang daming langaw.”	Draws many flies
“Nakabili po ako sa Quiapo yung lumang hardware tinuro po ako sa mga lumang hardware dun na po ako nakabili. Habang patagal nang patagal wala na pong piyesang nagagamit. Nao-obsolete na yung mga spare parts.”	Spare parts become obsolete when old

Coding of transcript of interview and focus group discussion re suggestion with MRF personnel

Interview and FGD re Suggestion with MRF Personnel	Code
“Siguro yung curing time niya kasi 1 month, siguro sana mapaiksi.”	Reduce curing time
“Ah yung enzyme mahal sana mapamura.”	Cheaper enzyme
“Ah siguro ano bukod don sa manual eh yung may tutorial through video bukod sa ano gaya ngayon kapag may bago wala naman na yung original galing DOST pede naman ipanood na lang yung ano magkakaroon na ng idea yung bagon gagamit kasi yung verbal mahirap ding maintindihan agad eh iba yung makikita mo sa video.”	Provide video tutorial
“At saka isa pa po sa napansin ko de plug kasi ayun po nakaderekta sa kable tas inano naming don sa breaker baka eto	Convert to inverter-type

yung isa sa pwedeng I ano nila parang inverter lang lagyan niya miski sa simpleng outlet lang po eto po nakdirekta lang.”	
“At saka yung ano po operating manual. Wala kasi di ko alam kung may binigay sa kanila before. Wala ho akong nakita di ko alam kung ipinasa sa kanila iba rin po kasi diba po kung may ibang hahawak.”	Provide operating manual
“Mas maganda po siguro kung stainless steel yung tangke kasi madami na rin butas eh siguro po sa cost na rin ng materyales eh mga lata lata lang.”	Change to stainless steel
“Kasi yung mga kasama ko nga ayaw kong papalitan kasi kahit sila mismo lang alam na nila yung gagawin kasi kung bago tuturuan mo na naman maski dito pag nakrinig sila ng kakaibang tunog alam na nila.”	Retain staff with mastery and experience
“Mas maganda po siguro kung stainless steel yung tangke kasi madami na rin butas eh siguro po sa cost na rin ng materyales eh mga lata lata lang.”	Change to stainless steel

APPENDIX H

LESSONS LEARNED

Takeaways gained from the study root mainly on ensuring that the researcher belongs to an R&D organization. This condition would ease the conceptualization and implementation of the study. Also, establishing realistic timeline and outputs is also beneficial for the researcher and stakeholders. Future related studies would benefit from increased project sites and other primary data gathering methods. More information about the bioreactor's technical details—like control systems, how it starts the process, cleaning steps, and air control—would help understand the study results better. Also, extra details about soil tests and audits done would help assess the bioreactor's effects more clearly.