

# Engineering Initiatives in The Integration of Circular Economy Principles in Legazpi Food Park, Barangay Bitano, Legazpi City, Albay

Rouel S. Lajara

*rouellajara@gmail.com*

---

## Abstract

Legazpi City has integrated several circular economy principles aimed at reducing, reusing, and recycling waste. The city adopted its City Plan of Action on Marine Litter (2021–2025), piloting eco enterprise and community-based recycling efforts—such as using plastic bottles to create eco pots and repurposing tarpaulins into eco bags—as part of the UN Habitat HOCCI program. It installed the first granular plastic shredding machine to prevent plastic burning and reduce landfill volume, and launched a digital Smart Waste Management System with truck-route optimization and MRF tracking to boost resource recovery and curb marine litter leakage. Additionally, Legazpi received a JPY-backed grant to build circular facilities—like centralized recycling hubs—and support materials recovery infrastructure under a circular economy framework. The study evaluated how circular strategies—such as waste reduction, resource recovery, sustainable sourcing, and closed-loop systems—can be effectively applied in food-related enterprises within the city’s context especially for the Legazpi City Food Park. The study identifies gaps in current food business models’ waste management, energy consumption, and food sourcing using a combination of qualitative interviews, field observations, and policy analysis. The findings show that incorporating circular principles—like composting organic waste, utilizing renewable energy sources, and supporting local farm-to-table systems—has a lot of potential. When encouraged by policy incentives and education, key stakeholders—such as local government, food business owners, and community members—exhibited a favorable attitude toward circular principles. The study comes to the conclusion that a Legazpi City food park may lessen its environmental effect, increase its economic resilience, and support the city’s sustainable development goals by putting a circular economy framework into practice. Public-private collaborations, capacity-building programs, and the development of a local circular economy roadmap are among the suggestions made to encourage long-term adoption.

**Keywords:** Circular Economy Principle; waste management; long-term adoption

---

## 1. Introduction

In Environmental Engineering, the Circular Economy principle centers on the creation of systems that optimize resource efficiency and reduce waste. Adopting the circular economy essentially helps businesses and society attain environmental quality, economic success, and social equality without ignoring any of the characteristics by incorporating sustainability into business models and societal behaviors. This also seeks to create systems and products that can be recycled, repaired and manufactured, and reused. This contrasts with the typical linear economy, where items are made, used, and the disposed of, frequently ending up in landfills. This Circular Economy Principle in Environmental Engineering is applied in the efficiency of resources,

waste management, life cycle assessment, and even product design. This aims to reduce waste, increase resource efficiency, and encourage material be reused and recycled. By applying these principles, environmental engineers contribute to mitigating environmental degradation and fostering a more sustainable future.

Unlike the traditional linear economy, which follows a 'take-make-dispose' model, CE aims to create a closed-loop system, where products and materials maintain their value for as long as possible. This is particularly relevant to the food industry, where high volume of organic and packaging waste produced. Food parks, as hubs of food service activities, face unique challenges, including significant waste generation from single-use plastics and food residues, making them ideal candidates for implementing CE principles.

Legazpi City, a coastal city in the Bicol Region of the Philippines, faces environmental challenges due to its location along the Albay Gulf. The city faces significant waste management challenges which is typical to coastal cities, including marine pollution which is resulted by improper waste disposal. This is observed during heavy rains and typhoons which floods the city especially Brgy. Bitano.

In the 2020 Census by the Philippine Statistics Authority, Brgy. Bitano ranked 4th as the most populated barangay in Legazpi City with approximately 7,800 residences which are next to Barangay Banquerohan (8,239), Rawis (10,317), and Taysan (15,189) as the most populated barangay. This census shows the influx of residents and intensifies the demand for resource and services such as food. The influx number can result to the difficulty of local authorities to keep up and can result in insufficient public awareness and education about waste segregation and recycling.

According to BFAR Bicol, Legazpi City's coastal location and vulnerability to environmental calamities calls for the urgent need better waste management linked to circular economy principles. Inadequate waste management threatens marine areas, especially the Albay Gulf, where stormwater runoff brings plastics, food wrappers, and other trash into coastlines, as the city often endures typhoons, sea level rise, and heavy rains.

In an activity by the Bureau of Fisheries and Aquatic Resources in Bicol (BFAR-5) last 2022, a significant amount of waste was collected at the coastal areas of Legazpi City. Nonie Enolva, BFAR-5 spokesperson said that although Legazpi City is implementing effective solid waste management, it still needs to investigate the sewerage of coastal households and other sources contributing to indiscriminate waste disposal, which could potentially harm the health of some Legazpeños using the shore for swimming. With these wastes in the ocean contributed by single-use plastics especially those who are not responsible with waste management, this causes harmful effects to marine life.

As urbanization increases and customer tastes change, management of wastes produced by industries especially food industry becomes more important. Waste management has become more and more of a problem in Legazpi City. In Legazpi City, the Legazpi Food Park is one of the worst contributors of wastes in the city proper which is very visible to the public and contributes rampantly on a daily basis especially when customers are at peak. Photographs of the food park, along with a vicinity map and other reference images, are provided in the Appendix to give a clearer visual context of the site.

The Local Government of Legazpi City and private individuals, specifically the family of Mr. Martin Reynoso, collaborated together to create the Legazpi Food Park. The area, which was once known as "Hepa Street," had a negative reputation because of worries about food safety and the idea that dining there may

result in diseases like hepatitis. Both parties envisioned a shift focused on better hygiene standards to confront and eradicate this stigma, with access to clean water being a crucial solution for ensuring adequate cleaning and cleanliness of equipment used in food preparation and packing.

The Reynoso family owns a portion of the property where the food park is located, while the government owns the portion which is next to the Philippine National Railways (PNR). The "kariton"-style food stalls, which represent traditional vendors from the former Hepa Lane, have been placed in the government-designated area, which was purposefully created to lessen their financial burden in terms of lease. In the meanwhile, merchants selling rice, beverages, and food were designated in concrete booths built by the private sector in collaboration with the government within the privately held area. In order to provide adequate sanitary infrastructure, such as well-organized washing spaces and dependable water lines for food preparation and waste disposal, this layout was carefully put into place.

The Legazpi Food Park is particularly notable for its contribution to daily waste generation in the city. Due to its location and the nature of the food service business, the park produces a considerable number of single-use plastics and organic waste, which exacerbates the city's waste management challenges. This makes it an ideal focus for exploring the potential of CE principles to reduce waste and enhance resources efficiency.

The circular economy's idea is to build a sustainable system with as little influence on the environment as possible by reducing waste, recycling resources, and reusing materials. Legazpi City may greatly lessen its problems with environmental sustainability and waste management by putting these suggestions into practice. The city may minimize trash and promote sustainability by restricting the development of garbage at the source, such as by pushing businesses to use less packaging and supporting ecologically favorable consumer choices.

In environmental engineering aspect, integration of circular economy principle is related to waste management, resource efficiency, sustainable practices, and ecosystem impact. The circular economy principles place a strong emphasis on the reducing waste and encouraging material reuse and recycling. The development of effective waste management system, which is necessary for the implementation of projects is the primary emphasis of environmental engineering in the implementation of circular economy principles. Environmental engineers also do decrease the entire environmental footprint by designing systems and processes that increase resource efficiency.

In the integration of circular economy principles into sectors like energy and food sourcing calls for a comprehensive strategy that takes resource efficiency and sustainability into account. Environmental engineers contribute to a more resilient and sustainable future by providing the knowledge required to evaluate, plan, and execute these practices. They provide a critical role in turning theoretical ideas into workable plans of action that have the potential to produce large positive effects on the environment and the economy.

Ecosystem also plays a big role to environmental engineers in implementing circular economy principle. Effective implementation of circular economy principles in community spaces requires environmental engineering approaches to incorporate a deep understanding of local ecosystems. Engineers may contribute to the creation of strong, resource-efficient settings that support both ecological well-being and human needs by evaluating the environmental impacts of projects and advocating for sustainable practices. A sustainable

future where communities flourish alongside their environments is fostered by this all-encompassing approach.

The successful implementation of Circular Economy (CE) principles into Legazpi City's food parks requires the active participation of several stakeholders, including community organizations, environmental organizations, and local government units (LGUs). LGUs are essential in creating regulatory frameworks and enabling policies that encourage the adoption of sustainable practices. Businesses could be encouraged to invest in eco-friendly initiatives and lessen their waste footprint by offering incentives like tax subsidies. While local community organizations play a crucial role in raising public awareness and encouraging sustainable consumption habits, environmental organizations offer technical competence in waste management and resource efficiency. A thorough and successful shift to a more sustainable urban food ecosystem is made possible by this multi-stakeholder engagement.

Integrating community-led initiatives, like those in Legazpi City, is crucial to better implementing CE principles locally. Piloting sustainable approaches that are suited to the local waste management issues, such as organic waste and plastic packaging, is made possible by facilities such as the Legazpi Food Park. Food vendors may greatly reduce their environmental effect by being encouraged to utilize recyclable containers, compost, and reduce their usage of single-use plastics. Programs for education and training on resource efficiency and appropriate waste management can also assist vendors and customers in realizing the advantages of sustainable practices. For other cities looking to strike a balance between ecological sustainability and economic growth, Legazpi can act as a model by encouraging a city-wide commitment to environmental stewardship.

The inadequate waste management infrastructure at the Legazpi Food Park is one of the main challenges to putting the Circular Economy (CE) principle into practice. Managing the growing amount of garbage produced by both residential and business operations is still a challenge for Legazpi City. Improving garbage collection procedures and encouraging appropriate segregation at the source are crucial for developing an effective circular system. This might involve setting up specific recyclables collecting places, composting organic trash on a regular basis, and disposing of non-recyclable items in an ecologically responsible manner. For the system to be sustainable and successful, sellers at food parks and local waste authorities must work together more closely.

Innovation in environmentally friendly packaging is just as crucial to CE implementation. The food industry continues to rely heavily on single-use, non-biodegradable packaging, especially in food parks, which greatly increases urban garbage. Businesses at the Legazpi Food Park may solve this by implementing environmentally friendly substitutes, such as recyclable, biodegradable, or even edible packaging. Promoting a "bring-your-own" (BYO) container culture among customers will help cut down on the use of throwaway items. These strategies seek to increase public awareness of environmentally responsible purchasing while simultaneously reducing plastic waste. Such programs have the potential to significantly reduce the amount of single-use plastic garbage generated in the city over time.

Borg and Singh (2020) asserted that effective circular economy transitions depend heavily on community involvement. Their study demonstrated how engaging local stakeholders promotes long-term behavioral change and more responsible waste management. This may be done in a food park through cooperative efforts with neighborhood groups, eco-incentive programs, and awareness campaigns. Food parks can increase their

dedication to sustainability and foster a sense of collective environmental responsibility by actively engaging the community.

Community engagement was also discussed in a study by Geissdoerfer et al. (2017) who discussed that promoting the circular economy as a sustainability paradigm requires both community engagement and public knowledge. According to the study, recycling, resource conservation, and sustainable consumption may all be significantly enhanced by involving communities through involvement, education, and cooperation. At the local level, circular economy programs gain popularity and effectiveness by cultivating a culture of responsibility for the environment and promoting active community engagement.

Legislative and administrative frameworks that seek to solve long-standing environmental challenges are increasingly supporting the adoption of circular economy (CE) ideas in the Philippines. The foundation for local waste reduction initiatives is established by the Ecological Solid Waste Management Act of 2000 (RA 9003), which places a strong emphasis on appropriate waste segregation, recycling, and composting. The Extended Producer Responsibility Act of 2022 (RA 11898), which requires companies to control the life cycle of their plastic goods and motivates them to embrace more sustainable practices, is another law that supports the implementation of CE (Republic of the Philippines, 2000; 2022). If properly localized, these regulations offer a legislative framework that can facilitate CE integration in urban settings like Legazpi City, particularly in high-waste locations like the Legazpi Food Park.

The integration of Circular Economy (CE) principles in the Legazpi Food Park is strongly supported by several Philippine laws and policies that promote sustainability and proper waste management. The Philippine Environmental Code mandates Environmental Impact Assessments (EIAs) for projects to ensure that environmental considerations are integrated into development plans; Republic Act No. 9003, also known as the Ecological Solid Waste Management Act of 2000, encourages waste segregation, recycling, establishment of Materials Recovery Facilities (MRFs), and public awareness to reduce environmental harm; and legislative measures like the Food Waste Reduction Act and the Zero Food Waste Act, all of which align with the Legazpi Food Park.

Through integrating CE principles in the food park, Legazpi City may limit harm to the environment, reduce waste production, and increase resource efficiency through composting, recycling, and reuse. The Sustainable Development Goals (SDGs) of the United Nations are supported by these projects, especially SDG 12 on sustainable production and consumption and SDG 13 on climate action. Food businesses may reduce their landfill contributions and build a more sustainable urban food system by using appropriate waste management measures. Additionally, the research seeks to show how integrating CE principles into food parks might be a model that other Philippine cities looking for resource-efficient and sustainable growth can follow.

Legazpi City's government already has in place a number of policies and initiatives that promote better ecological solid waste management. The "Legazpi City Integrated Ecological Solid Waste Management Program" was established through Ordinance No. 0017-2009, which mandates that commercial establishments maintain cleanliness, provide segregated waste bins, and adhere to hazardous waste disposal regulations. Environmental responsibility among businesses is further reinforced by additional ordinances such as the Anti-Littering Ordinance (No. 003-2008) and the required ESWM seminar for business permit applicants (No. 010-2008). In order to improve long-term waste management practices, the city's 10-year Ecological Solid Waste Management (ESWM) Plan, created by the Office of the City Environment and

Natural Resources (OCENR), also encourages composting, recycling, waste segregation, public awareness campaigns, stakeholder training, and cooperation with communities and schools.

Legazpi City has advanced CE initiatives through innovative initiatives like the installation of its first granular plastic shredder, which turns plastic waste into reusable granules for future products like chairs, tables, and hollow blocks. This project reduces pollution, prolongs the life of landfills, and supports larger sustainability initiatives like the Healthy Oceans and Clean Cities Initiative (HOCCI) and Marine Plastic Litter Abatement (MPLA). These initiatives show the city's increasing dedication to environmentally friendly waste management strategies and offer useful advice for integrating CE practices at the food park. Although only 56 operational vendors took part in the study, Barangay Bitano claims that the food park has 62 tenants. This provides a representative basis for assessing the establishment's current waste management procedures and the viability of implementing Circular Economy.

The overall objective of this study turned out to integrate Circular Economy (CE) principles in the Legazpi Food Park, which is situated in Barangay Bitano, Legazpi City. The study specifically aimed to evaluate the food park's current waste management procedures in light of circular economy principles, specifically with regard to design, distribution, consumption, collection, and reuse or recycling procedures. It also sought to identify the obstacles that stakeholders faced when implementing circular economy practices, including financial, technical, social, and economic issues that might have an impact.

Additionally, the study aimed to identify the opportunities that circular economy principles can offer the food park, especially in the areas of material reuse, resource efficiency, and waste reduction. In order to promote sustainability and enhance environmental management in the area, the study also sought to develop engineering initiatives and strategies for integrating circular economy principles in waste management practices within Legazpi City Food Park.

## 2. Conceptual Framework

This study drew on the Circular Economy Principle, System Theory, and Stakeholder Theory. First is the principle to be integrated which is the Circular Economy. It focuses on minimizing resource efficiency and aims to create a long-term sustainable consumption habit. An alternative to the traditional linear economy, the circular economy (CE) aims to reduce waste and maintain constant usage of resources. According to studies, it was stated that by closing material loops and separating economic growth from environmental effect, CE encourages sustainable production and consumption. CE has been used in food-related contexts to encourage recycling and composting, reduce food waste, and increase resource efficiency. This idea applies to the Legazpi Food Park, where using circular strategies may reduce waste production, improve sustainability, and help local environmental objectives (Geissdoerfer et al., 2017) and (Camacho-Otero et al., 2018)

By considering the food park as an interconnected system made up of suppliers, customers, vendors, and waste management procedures, systems theory provided a comprehensive approach to waste management. The food park constantly exchanges inputs and outputs with its surroundings, including food supplies, packaging, waste, and pollutants, since it is an open system. This theory emphasizes the significance of comprehending relationships and feedback mechanisms in order to successfully integrate CE principles, emphasizing that changes in one component can affect the entire system (von Bertalanffy, 1968; Skyttner, 2006).

Lastly, Stakeholder Theory emphasized the significance of incorporating all impacted parties in the integration of CE practices, including business owners, customers, local government entities, and the community. Freeman (1984) defined stakeholders as people or organizations that have the power to affect or be affected by organizational objectives. In order to advance circular economy initiatives and sustainable environmental practices, stakeholders must actively collaborate (Siems et al., 2023). Together, these frameworks served as a guide for evaluating existing procedures, identifying obstacles, and creating sustainable plans that were pertinent to Legazpi City.

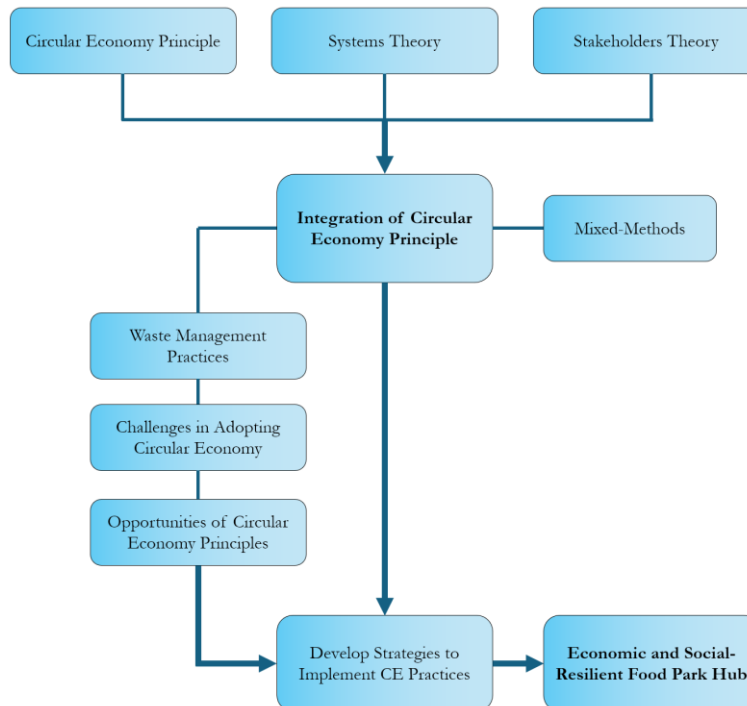


Figure: Conceptual Framework

### 3. Methods

The study explored the integration of circular economy (CE) principles into the Legazpi Food Park, focusing on the assessment of current waste management practices, identification of challenges, determination of CE opportunities, and the development of sustainable strategies. The methodology is designed to comprehensively address these aspects through a combination of qualitative and quantitative approaches, ensuring a holistic understanding of the food park's dynamics and the feasibility of CE principles. This mixed-methods approach allows for a deeper exploration of both the numerical data related to waste generation and the subjective experiences and perceptions of stakeholders.

The research obtained a comprehensive understanding of the use of circular economy principle in a food park by utilizing this mixed-method approach, which captures both the quantifiable effects and the complex experiences of those involved.

### Research Design and Instrument

The integration of Circular Economy principles in the Legazpi Food Park was studied in this study using a descriptive mixed-methods research design. The study's objectives of recording current waste management procedures, identifying stakeholder challenges, and identifying opportunities for circular economy adoption within the food park made the descriptive approach appropriate. For a more thorough grasp of the issue, the study combined quantitative and qualitative methods in accordance with the framework of John W. Creswell and Plano Clark (2018). 56 business owners and 15 customers completed structured survey questionnaires to collect quantitative data on circular economy elements such as design, distribution, consumption, collection, reuse, and recycling. In order to facilitate the creation of local engineering initiatives, open-ended questions and stakeholder input were also used to gather qualitative insights.

The 62 activated food vendors working in the food park made up the study population; they represented a wide variety of food and beverage enterprises pertinent to the integration of CE principles. As a result of different vendor schedules and sporadic customer visits, convenience sampling was used to collect data from respondents who were available during the study period. Only 56 of the 62 vendors were active and able to take part in the survey; the majority of these companies had been in business for one to three years. In order to gather information about consumer awareness, consumption patterns, and support for sustainable practices in the food park, a survey of fifteen customers was also conducted. These respondents offered insightful viewpoints for evaluating the consumer-related and operational facets of implementing the circular economy.

The primary instrument used to collect data for this study was a structured survey questionnaire. The questionnaire was designed to gather quantitative and qualitative data in line with the study's objectives and the fundamental ideas of the circular economy, which include design, distribution, consumption, collection, reuse, and recycling. It also included sections on opportunities for waste reduction, resource efficiency, and reuse, as well as the technical, financial, social, and economic difficulties of implementing circular economy practices. In order to assess the survey items' validity, reliability, and clarity as well as the instrument's efficacy in collecting pertinent data, the English-language questionnaire was translated into Tagalog and put through pilot testing.

Based on their availability during the data collection period, the fifty-six (56) participating business owners in the Legazpi Food Park obtained the questionnaires. Since they are the main producers of waste from food preparation, packaging, and disposal processes, business owners were chosen as respondents. Their answers were crucial in determining the viability and difficulties of putting sustainable waste management and the circular economy into practice. On the day of data collection, every respondent finished the questionnaires. A Likert scale with corresponding ratings, scales, and interpretations was one of the response formats used in the questionnaire.

Table: Interpretation of rating for the Current Waste Management Practices

| <b>Rating Scale</b> | <b>Range</b> | <b>Interpretation</b> |
|---------------------|--------------|-----------------------|
| <b>5</b>            | 4.51-5.00    | Highly Circular       |
| <b>4</b>            | 3.51-4.50    | Moderately Circular   |

|   |           |                   |
|---|-----------|-------------------|
| 3 | 2.51-3.50 | Slightly Circular |
| 2 | 1.51-2.50 | Low Circularity   |
| 1 | 1.00-1.50 | Linear System     |

This approach was deemed suitable by the study for gathering and evaluating respondents' responses as well as for creating solutions in line with the objectives of the research. The frameworks and circular economy maturity models created by the Ellen MacArthur Foundation (2015), Kristensen and Mosgaard (2020), and Borrello et al. (2020) were used to interpret the circularity levels. These models categorize implementation levels according to measurement scores. Respondents chose relevant answers from a checklist section of the questionnaire based on their observations and experiences at the Legazpi Food Park. A Likert scale was used to interpret these answers based on their percentage, and the collected data was used to classify them.

Table: Interpretation of percentage ranges for the Current Waste Management Challenges

| Percentage Range | Verbal Interpretation          |
|------------------|--------------------------------|
| 91% - 100%       | Major challenges               |
| 81% - 90%        | Strong challenges              |
| 71% - 80%        | Significant challenges         |
| 61% - 90%        | Moderate challenges            |
| 51% - 60%        | Minor challenges               |
| 0% - 50%         | Considered but not a challenge |

This method enabled thorough data gathering on factors impacting the adoption of the circular economy by offering a clear and organized means of capturing the many possibilities and difficulties as seen by stakeholders. Both the quantitative intensity of activities and the qualitative range of possibilities and challenges were successfully recorded due to these complimentary response techniques.

The local Government of Legazpi's environmental policies along with appropriate local legislation provided the qualitative data used in the study. In particular, the Legazpi City 10-Year Ecological Solid Waste Management (ESWM) Plan and the Legazpi City Ecological Solid Waste Management Program for Business Establishments have been studied and evaluated. These materials included important information about the city's institutional initiatives, legislative framework, and strategic direction for solid waste management and business sector environmental sustainability promotion.

The study's primary objective was to determine whether the Legazpi Food Park had adopted and implemented the principles of the circular economy, especially with regard to recycling, resource efficiency, waste reduction, and sustainable business practices. The food park's business owners and stakeholders served as respondents for the study's quantitative component. Their perspectives aided in evaluating awareness of and actual application of sustainable practices in day-to-day operations and business management. Their answers gave important details about how much the food park's business operations and waste management procedures incorporate the concepts of the circular economy.

The Barangay Bitano officials, led by Bernard Y. Pacardo, granted permission to carry out the study. To make data collection easier, the barangay officials collaborated with the food park's management. During the

data collection period, survey questionnaires were given to available business owners, and Clemente A. Ibo helped obtain additional information about the city's waste management initiatives from the Legazpi City Engineering Office. The study was carried out at the food park in Barangay Bitano, Legazpi City, between September and October of 2025.

To identify patterns in the application of circular economy practices, the quantitative data collected was categorized, tabulated, and examined using descriptive statistics such as mean, percentage, and ranking. The degree of awareness, implementation in practice, and challenges related to sustainable waste management among food park enterprises were determined through these analyses. In order to find themes pertaining to sustainability initiatives, waste management regulations, and adherence to circular economy principles, qualitative data from city documents and waste management records were also analyzed through content analysis. In order to improve sustainable waste management practices in the food park and throughout the city, recommendations and engineering initiatives were developed based on the combined findings.

**4. Results and Discussion**

The purpose of the study was to assess how food-related businesses in the Legazpi Food Park could integrate Circular Economy practices like resource recovery, waste reduction, sustainable sourcing, and closed-loop systems. It specifically aimed to identify stakeholder challenges in economic, social, technical, and financial aspects; evaluate current waste management practices in terms of design, distribution, consumption, collection, and reuse or recycling; and identify opportunities related to waste reduction, resource efficiency, and reuse.

The study focused on the viewpoints of fifty-six (56) business owners who run businesses in Legazpi City's food park. To assess the viability of incorporating circular economy practices in the area, their answers were examined in conjunction with the city's current waste management regulations. Survey questionnaires were used in the study to collect quantitative data, and key informant insights and current solid waste management policies provided qualitative data.

**Assessment of the Current Waste Management Practices in Legazpi Food Park in relation to circular economy principles**

**a. Design**

The findings show that recyclable packaging is widely adopted in the food park ( $\bar{x}$  = 4.93, Highly Circular), indicating strong awareness among vendors of waste reduction through recyclability. However, the use of eco-friendly or biodegradable materials remains highly deficient ( $\bar{x}$  = 1.25), suggesting that while vendors understand sustainable packaging practices such as using biodegradable and reusable materials, these are not widely implemented. This disparity highlights a cost-awareness gap where vendors recognize the importance of sustainable packaging but are constrained by the high cost and limited availability of biodegradable options.

| <b>A. Design (n=56)</b> |                                                                    |             |                       |
|-------------------------|--------------------------------------------------------------------|-------------|-----------------------|
|                         | <b>Indicators</b>                                                  | <b>Mean</b> | <b>Interpretation</b> |
| 1.                      | The Food Park's food packaging is designed to be easily recyclable | 4.93        | Highly Circular       |

|                                                                            |             |                          |
|----------------------------------------------------------------------------|-------------|--------------------------|
| 2. Businesses use biodegradable or reusable packaging                      | 3.82        | Moderately Circular      |
| 3. Vendors are given clear instructions on sustainable packaging practices | 3.34        | Slightly Circular        |
| 4. The design of food packaging prioritizes minimal waste production       | 2.34        | Low Circularity          |
| 5. Eco-friendly materials are encouraged for use by businesses             | 1.25        | Linear System            |
| 6. The Food Park's food packaging is designed to be easily recyclable      | 4.93        | Highly Circular          |
| 7. Businesses use biodegradable or reusable packaging                      | 3.82        | Moderately Circular      |
| <b>AWM</b>                                                                 | <b>3.14</b> | <b>Slightly Circular</b> |

### b. Distribution

According to the findings, distribution techniques in the food park are often neither obvious nor not, indicating that the circular economy (CE) concepts have not been fully integrated at this stage. Inter-vendor coordination is still noticeably weak ( $\bar{x} = 1.98$ , Linear System), despite being evident of significant attempts to reduce waste in distribution networks ( $\bar{x} = 3.98$ ) and adopt sustainable packaging ( $\bar{x} = 3.93$ ). This suggests that distribution-related CE efforts are more often individual than collaborative. Despite vendor's individual knowledge or limited efforts toward sustainable distribution, the data indicates a lack of systematic and joint actions. The efficiency and sustainability of distribution operations are further limited by the lack of reusable logistics models, such as container sharing or group bulk purchase, or shared waste-return systems.

| <b>B. Distribution (n=56)</b>                                             |             |                       |
|---------------------------------------------------------------------------|-------------|-----------------------|
| <b>Indicators</b>                                                         | <b>Mean</b> | <b>Interpretation</b> |
| 1. Vendors focus on minimizing waste in their supply chains               | 3.98        | Moderately Circular   |
| 2. Suppliers offer eco-friendly and sustainable packaging                 | 3.93        | Moderately Circular   |
| 3. Distribution practices aim to minimizing waste generation              | 3.34        | Slightly Circular     |
| 4. There is an initiative to return and reuse packaging materials         | 3.29        | Slightly Circular     |
| 5. Businesses work together to enhance food distribution and reduce waste | 1.98        | Low Circularity       |
| 6. Vendors focus on minimizing waste in their supply chains               | 3.98        | Moderately Circular   |
| 7. Suppliers offer eco-friendly and sustainable packaging                 | 3.93        | Moderately Circular   |

|            |             |                          |
|------------|-------------|--------------------------|
| <b>AWM</b> | <b>3.30</b> | <b>Slightly Circular</b> |
|------------|-------------|--------------------------|

### c. Consumption

Consumption patterns at the Legazpi Food Park indicate that business owners are generally aware of waste management. Environmentally friendly waste management is encouraged by some new consumer habits; however, these programs are frequently unreliable and lack institutional support. In terms of sustainable consumption, the results show mixed results: while it is evident that consumers are slightly encouraged to use reusable containers ( $\bar{x} = 3.73$ ), there are very little incentives for reusable practices ( $\bar{x} = 1.88$ , Low Circularity). Similarly, vendors continue to promote sustainable consumption in an uneven manner ( $\bar{x} = 2.86$ ). These findings imply that while both customers and sellers are environmentally sensitive, there are few resources available to encourage sustainable practices, such as "bring your own" campaigns, eco-discounts, or incentive programs.

| <b>C. Consumption (n=56)</b> |                                                                 |             |                          |
|------------------------------|-----------------------------------------------------------------|-------------|--------------------------|
|                              | <b>Indicators</b>                                               | <b>Mean</b> | <b>Interpretation</b>    |
| 1.                           | Consumers are encouraged to use reusable containers or utensils | 3.73        | Moderately Circular      |
| 2.                           | Clear instructions on waste disposal are provided for consumers | 3.38        | Slightly Circular        |
| 3.                           | Portion sizes are designed to reduce food waste                 | 3.36        | Slightly Circular        |
| 4.                           | Businesses encourage sustainable consumption practices          | 2.86        | Slightly Circular        |
| 5.                           | Incentives are offered for customers who bring reusable items   | 1.88        | Low Circularity          |
| 6.                           | Consumers are encouraged to use reusable containers or utensils | 3.73        | Moderately Circular      |
| 7.                           | Clear instructions on waste disposal are provided for consumers | 3.38        | Slightly Circular        |
|                              | <b>AWM</b>                                                      | <b>3.04</b> | <b>Slightly Circular</b> |

### d. Collection

The results of the Legazpi Food Park's waste collection practices are mixed ( $\bar{x} = 3.39$ , Slightly Circular). This indicates that while some aspects of waste disposal are operating effectively, others, especially systemization and monitoring remain inadequate. Although the food park's waste collection is typically efficient and frequent ( $\bar{x} = 4.57$ , Highly Circular), there is no set method for handling recyclables, variable stakeholder compliance, and a lack of consistency in the segregation infrastructure. Bins for various waste

categories are moderately circular ( $\bar{x} = 3.84$ ), indicating a partial adherence to segregation procedures. However, enforcement and accountability are still lacking, exposing operational coordination shortcomings.

| <b>D. Collection (n=56)</b> |                                                                     |             |                          |
|-----------------------------|---------------------------------------------------------------------|-------------|--------------------------|
|                             | <b>Indicators</b>                                                   | <b>Mean</b> | <b>Interpretation</b>    |
| 1.                          | Waste is collected regularly and efficiently in the Food Park       | 4.57        | Highly Circular          |
| 2.                          | There are separate bins for different types of waste                | 3.84        | Moderately Circular      |
| 3.                          | Consumers and business owners properly follow waste segregation     | 3.70        | Moderately Circular      |
| 4.                          | A specific collection system is in place for recyclable materials   | 2.98        | Slightly Circular        |
| 5.                          | Waste collection services are closely monitored and well-maintained | 1.86        | Low Circularity          |
| 6.                          | Waste is collected regularly and efficiently in the Food Park       | 4.57        | Highly Circular          |
| 7.                          | There are separate bins for different types of waste                | 3.84        | Moderately Circular      |
| <b>AWM</b>                  |                                                                     | <b>3.39</b> | <b>Slightly Circular</b> |

#### e. Reuse/Recycling

While there are attempts to be more sustainable, they are not consistent, as seen by the Legazpi Food Park's overall recycling and reuse practices mean ( $\bar{x} = 3.06$ ; Slightly Circular). Bins and other recycling infrastructure are widely available and moderately circular ( $\bar{x} = 4.00$ ), but actual involvement in composting, upcycling, and organic waste separation is still rather low ( $\bar{x} = 1.64$ ). Instead of actively participating in resource recovery or waste management programs, vendors mostly rely on city garbage collection services, indicating a compliance-based rather than initiative-driven approach to recycling. The circularity of waste management techniques at the food park is further restricted by the lack of active encouragement for customers to return recyclables.

| <b>E. Reuse/Recycle (n=56)</b> |                                                              |             |                       |
|--------------------------------|--------------------------------------------------------------|-------------|-----------------------|
|                                | <b>Indicators</b>                                            | <b>Mean</b> | <b>Interpretation</b> |
| 1.                             | Recycling bins are available and accessible in the Food Park | 4.00        | Moderately Circular   |
| 2.                             | Businesses participate in recycling and composting programs  | 3.30        | Slightly Circular     |
| 3.                             | Organic waste is separated for composting or bioconversion   | 3.34        | Slightly Circular     |

|                                                                             |             |                          |
|-----------------------------------------------------------------------------|-------------|--------------------------|
| 4. Consumers are encouraged to return recyclable waste to collection points | 3.00        | Slightly Circular        |
| 5. Businesses are encouraged to upcycle waste materials                     | 1.64        | Low Circularity          |
| <b>AWM</b>                                                                  | <b>3.06</b> | <b>Slightly Circular</b> |

According to the data gathered, Legazpi Food Park's waste management practices have been classified as "Slightly Circular" in each of the following important areas: design, distribution, consumption, collection, and reuse/recycling. The majority of sustainability practices are still limited or undeveloped, despite the evident existence of some practices, such as the usage of recyclable food packaging with a mean of 4.93 and effective disposal of waste with a mean of 4.57. Despite the widespread usage of recyclable packaging, design-related initiatives show that businesses are not being encouraged to use eco-friendly materials. businesses are reducing waste in distribution to a reasonable degree but business cooperation is poor with only an average of 1.98. Low evaluations for incentives for using reusable products indicate that consumption practices do not promote sustainable behaviors. Although one of the better-performing areas is collection, problems including inadequate recycling systems and poor monitoring continue to exist. Lastly, even though there are recycling bins, with a mean of 4.00, there is limited actual recycling, composting, and particularly upcycling activity. Overall, although there are certain fundamental waste management aspects in place, the food park's operations need to be more closely aligned with the concepts of the circular economy through enhanced implementation, stricter standards, stakeholder participation, and regular monitoring.

| <b>CURRENT WASTE MANAGEMENT PRACTICES (n=56)</b> |             |                          |
|--------------------------------------------------|-------------|--------------------------|
| <b>Indicators</b>                                | <b>Mean</b> | <b>Interpretation</b>    |
| a. Design                                        | 3.14        | Slightly Circular        |
| b. Distribution                                  | 3.30        | Slightly Circular        |
| c. Consumption                                   | 3.04        | Slightly Circular        |
| d. Collection                                    | 3.39        | Slightly Circular        |
| e. Reuse/Recycling                               | 3.06        | Slightly Circular        |
| <b>OVERALL MEAN RATING</b>                       | <b>3.19</b> | <b>Slightly Circular</b> |

## Identification of the Challenges faced by Stakeholders in adopting Circular Economy Practices

### a. Economic Challenge

All respondents agreed that the high price of environmentally friendly packaging and the total cost of adopting circular practices are major obstacles when it comes to economic difficulties. Furthermore, 82% of respondents said that financial incentives for circular economy initiatives are insufficient, and 91% pointed to the lack of reasonably priced eco-friendly alternatives. Additionally, 66% of respondents said they would not be prepared to pay more for sustainable solutions, pointing to a disconnect between market acceptance and sustainable alternatives.

| Indicators                                                                   | Percentage |
|------------------------------------------------------------------------------|------------|
| • The high cost of sustainable packaging poses a challenge for businesses    | 100        |
| • There is a lack of affordable, eco-friendly alternatives                   | 91         |
| • Financial incentives for circular economy initiatives are insufficient     | 82         |
| • Consumers are unwilling to pay extra for sustainable packaging             | 66         |
| • Businesses face difficulties with the costs of adopting circular practices | 100        |

### b. Social Challenge

Based from the data gathered from the business owners, in terms of social challenges, all respondents emphasized that neither customers nor sellers are motivated to implement sustainable practices, and that consumers are not well-informed about the concepts of the circular economy. Other significant challenge was limited public participation in waste reduction initiatives (91%), vendor opposed to altering standard practices (88%), and a lack of knowledge among stakeholders (89%).

| Indicators                                                                              | Percentage |
|-----------------------------------------------------------------------------------------|------------|
| • Consumers have limited knowledge of circular economy principles                       | 100%       |
| • Vendors resist changes to traditional waste management practices                      | 88%        |
| • There is a lack of education on waste management among stakeholders (business owners) | 89%        |
| • Customers and vendors lack motivation to adopt sustainable practices                  | 100%       |
| • Public participation in waste reduction programs is low                               | 91%        |

### c. Technical Challenge

When questioned about technical challenges, every responder identified inadequate infrastructure for appropriate waste segregation as a significant challenge. Additionally, 79% said there were insufficient training programs, and 95% said there was inadequate access to recycling facilities. Other issues were business's understanding of the circular economy's principles (71%) and challenges in putting advanced waste management practices into practice (82%).

| Indicators                                                                                                                 | Percentage |
|----------------------------------------------------------------------------------------------------------------------------|------------|
| <ul style="list-style-type: none"> <li>Proper waste segregation is difficult due to a lack of infrastructure</li> </ul>    | 100%       |
| <ul style="list-style-type: none"> <li>Access to recycling facilities is limited</li> </ul>                                | 95%        |
| <ul style="list-style-type: none"> <li>There is a shortage of training programs on sustainable waste management</li> </ul> | 79%        |
| <ul style="list-style-type: none"> <li>Businesses lack understanding of circular economy principles</li> </ul>             | 71%        |
| <ul style="list-style-type: none"> <li>Implementation of advanced waste management techniques is difficult</li> </ul>      | 82%        |

### d. Financial Challenge

Considering financial challenges, 88% of respondents stated that it was difficult to obtain funding for waste management technologies, and 96% identified budgetary restrictions as a significant challenge. The financial burden on small enterprises which had 64% respondent agreed to, the lack of government assistance with 84%, and the discouragement brought on by high operating expenses associated with reusable packaging with 46% respondents agreed on, were other notable challenges.

| Indicators                                                                                                                  | Percentage |
|-----------------------------------------------------------------------------------------------------------------------------|------------|
| <ul style="list-style-type: none"> <li>Budget limitations hinder the adoption of circular economy practices</li> </ul>      | 96%        |
| <ul style="list-style-type: none"> <li>Government funding for waste management initiatives is insufficient</li> </ul>       | 84%        |
| <ul style="list-style-type: none"> <li>Small businesses find it challenging to afford eco-friendly solutions</li> </ul>     | 64%        |
| <ul style="list-style-type: none"> <li>High operational costs discourage the shift to reusable packaging</li> </ul>         | 46%        |
| <ul style="list-style-type: none"> <li>Financial support for waste management innovations is difficult to access</li> </ul> | 88%        |

These findings clearly indicate that while the concept of circular economy is gaining attention, a complex mix of economic, social, technical, and financial barriers continues to hinder its full adoption at Legazpi Food

Park. Addressing these issues will require coordinated efforts from local authorities, businesses, and community members, alongside policy support and targeted investments in infrastructure, education, and incentives.

The summary of opportunities in adopting a circular economy in Legazpi Food Park was based on the responses from the checklist. The frequency of respondents selecting each option was calculated and converted into percentages to provide a clear quantitative representation. These percentages were then interpreted based from the Table of Interpretation of percentage ranges for the Current Waste Management Challenges on how each challenge is a barrier.

### Challenges in Adopting Circular Economy Principles

| Category            | Key Challenges                                          | % Agreement | Interpretation        |
|---------------------|---------------------------------------------------------|-------------|-----------------------|
| <b>A. Economic</b>  | The high cost of sustainable packaging                  | 100%        | Major challenge       |
|                     | There is a lack of affordable eco-friendly alternatives | 91%         | Strong challenge      |
|                     | Insufficient financial incentives for CE initiatives    | 82%         | Significant challenge |
|                     | Consumers unwilling to pay more                         | 66%         | Moderate challenge    |
|                     | Costs of adopting CE practices                          | 100%        | Major challenge       |
| <b>B. Social</b>    | Limited consumer knowledge of CE                        | 100%        | Major challenge       |
|                     | Vendor resistance to change                             | 88%         | Significant challenge |
|                     | Lack of education among stakeholders                    | 89%         | Significant challenge |
|                     | Lack of motivation to adopt sustainable practices       | 100%        | Major challenge       |
|                     | Low public participation                                | 91%         | Significant challenge |
| <b>C. Technical</b> | Poor waste segregation infrastructure                   | 100%        | Major challenge       |
|                     | Limited access to recycling facilities                  | 95%         | Strong challenge      |
|                     | Lack of training programs                               | 79%         | Moderate challenge    |
|                     | Limited understanding of CE concepts                    | 71%         | Moderate challenge    |
|                     | Difficulties implementing advanced techniques           | 82%         | Significant challenge |
| <b>D. Financial</b> | Budget limitations                                      | 96%         | Major challenge       |

|                                                     |     |                                |
|-----------------------------------------------------|-----|--------------------------------|
| Insufficient government funding                     | 84% | Significant challenge          |
| Small businesses can't afford eco-solutions         | 64% | Moderate challenge             |
| High operational costs                              | 46% | Considered but not a challenge |
| Limited access to financial support for innovations | 88% | Significant challenge          |

### Opportunities of Circular Economy Principles in Legazpi Food Park

#### a. Waste Reduction

##### b.

The findings show that respondents strongly recognize waste reduction's potential as a chance to adopt the circular economy. All respondents (100%) agreed that effective waste reduction requires both consumer and business cooperation as well as appropriate waste segregation education. The majority also emphasized that companies may use technology to monitor and cut waste (93%), improve food production (93%), and put waste reduction strategies into place (93%) for the benefit of all parties involved. According to these results, reducing waste requires both strategic practices and awareness, and Legazpi Food Park's waste reduction efforts may be greatly improved by combining coordinated efforts with technical and legislative solutions. The results emphasize the importance of coordinated efforts among all stakeholders to maximize the benefits of the circular economy by indicating that effective waste reduction involves an integrated strategy that combines behavioral change, education, operational adjustments, and technological support.

| Indicators                                                                                                                    | Percentage |
|-------------------------------------------------------------------------------------------------------------------------------|------------|
| <ul style="list-style-type: none"> <li>Consumers and businesses can work together to reduce waste</li> </ul>                  | 100        |
| <ul style="list-style-type: none"> <li>Proper education on waste segregation can lead to effective waste reduction</li> </ul> | 100        |
| <ul style="list-style-type: none"> <li>Businesses can optimize food production to minimize waste</li> </ul>                   | 93         |
| <ul style="list-style-type: none"> <li>Technology can enhance waste monitoring and reduction strategies</li> </ul>            | 93         |
| <ul style="list-style-type: none"> <li>Implementing a waste reduction policy can benefit all stakeholders</li> </ul>          | 93         |

#### c. Resource Efficiency

The data gathered from Legazpi Food Park shows how well respondents understood the advantages of resource efficiency in circular economy principles. While 95% of respondents stressed that improving food handling and storage could reduce waste, all respondents (100%) agreed that effective resource usage can result in cost savings. Furthermore, 82% emphasized the importance of consumer-business collaboration, 89% agreed that circular economy activities may prolong the lifespan of items, and 86% favored upcycling waste

materials to create new revenue streams. According to these findings, optimizing resource efficiency and attaining both financial and environmental advantages are thought to be largely dependent on collaborative efforts, creative reuse techniques, and operational enhancements.

| Indicators                                                                                                                   | Percentage |
|------------------------------------------------------------------------------------------------------------------------------|------------|
| <ul style="list-style-type: none"> <li>Efficient resource use can lead to cost savings for businesses</li> </ul>             | 100        |
| <ul style="list-style-type: none"> <li>Optimizing food storage and handling practices can reduce waste</li> </ul>            | 95         |
| <ul style="list-style-type: none"> <li>Circular economy practices can extend the lifespan of products</li> </ul>             | 79         |
| <ul style="list-style-type: none"> <li>Consumers and businesses can work together to maximize resource efficiency</li> </ul> | 82         |
| <ul style="list-style-type: none"> <li>Upcycling waste materials can create new revenue streams</li> </ul>                   | 86         |

#### d. Reuse

Reuse strategies are well supported, according to data from Legazpi Food Park. Significantly, 91% of respondents are in favor of pushing vendors to use reusable containers and utensils, and 93% of respondents think that a return-and-reuse system for packaging can be implemented successfully. 84% of respondents also agree that composting organic waste may help local farming. However, just 59% and 61% of respondents, respectively, favor collaborating with recycling facilities to reuse materials and provide rewards for doing so, indicating areas that would require more encouragement and participation.

| Indicators                                                                                                                            | Percentage |
|---------------------------------------------------------------------------------------------------------------------------------------|------------|
| <ul style="list-style-type: none"> <li>Implementing a return-and-reuse system for packaging can be effectively implemented</li> </ul> | 93         |
| <ul style="list-style-type: none"> <li>Use of reusable utensils and containers can be encouraged among vendors</li> </ul>             | 91         |
| <ul style="list-style-type: none"> <li>Repurposing organic waste into compost can benefit local agriculture</li> </ul>                | 84         |
| <ul style="list-style-type: none"> <li>Businesses can partner with recycling centers for material reuse</li> </ul>                    | 59         |
| <ul style="list-style-type: none"> <li>Incentives for reusing materials can encourage vendor participation</li> </ul>                 | 61         |

The study determined that Legazpi Food Park has excellent support for circular economy potential, especially in the areas of reuse, resource efficiency, and waste reduction. Key practices such as consumer-business collaboration, education on waste segregation, and return-and-reuse systems were well supported, while initiatives like upcycling and collaborating with recycling centers had moderate support, indicating

opportunities for additional improvement. The summary for each opportunity are shown below with interpretations for each.

| <b>Opportunities in Circular Economy for Waste Management</b> |                                                          |                    |                                          |
|---------------------------------------------------------------|----------------------------------------------------------|--------------------|------------------------------------------|
| <b>Category</b>                                               | <b>Key Opportunities</b>                                 | <b>% Agreement</b> | <b>Interpretation</b>                    |
| <b>A. Waste Reduction</b>                                     | Consumers-businesses collaboration                       | 100%               | Strong support for cooperative action    |
|                                                               | Education on waste segregation                           | 100%               | Training and awareness as key strategies |
|                                                               | Optimize food production                                 | 93%                | Operational efficiency improvements      |
|                                                               | Use of technology for waste monitoring/reduction         | 93%                | Tech-driven waste management             |
|                                                               | Implementation of waste reduction policy                 | 93%                | Policy integration benefits all          |
| <b>B. Resource Efficiency</b>                                 | Efficient resource use                                   | 100%               | Efficiency linked to profitability       |
|                                                               | Optimize food storage and handling                       | 95%                | Minimize spoilage and waste              |
|                                                               | Upcycling waste materials                                | 86%                | Economic potential from waste            |
|                                                               | Consumers and businesses can work together on efficiency | 82%                | Collaborative sustainability             |
|                                                               | CE practices extend product lifespan                     | 79%                | Promotes long-term sustainability        |
| <b>C. Reuse</b>                                               | Return-and-reuse system for packaging                    | 93%                | Practical and sustainable packaging      |
|                                                               | Encourage reusable utensils and containers               | 91%                | Reduces single-use waste                 |
|                                                               | Repurpose organic waste into compost                     | 84%                | Supports local agriculture               |
|                                                               | Partner with recycling centers for reuse                 | 59%                | Needs stronger promotion                 |
|                                                               | Incentives for reuse participation                       | 61%                | Requires policy and support              |

### **Engineering Initiatives in Implementing circular economy principles on waste management in Brgy. Bitano Legazpi Food Park**

In order to promote ecological sustainability, Legazpi City has established a comprehensive strategy to solid waste management through a combination of organized programs and legislation. The legal framework that forbids littering, illegal dumping, open burning of waste, and other inappropriate disposal activities is established by City Ordinances No. 0003-2008 and No. 0017-2009. These ordinances also require segregation at the source and compliance from households, businesses, and institutions. In order to preserve

environmental safety and public cleanliness, these regulations clearly specify the obligations of the city government, barangays, and business stakeholders. They also provide enforcement procedures and sanctions for infractions.

Legazpi City has taken proactive steps to put the regulations into effect, combining infrastructure, enforcement, and incentives. Households and businesses must segregate their garbage for collection under the city's "no segregation, no collection" regulation. In addition to barangay-level Material Recovery/Drop-Off Centers (BMRDOCs) to process recyclables and compostable, sanitary landfill facilities were built for the appropriate disposal of residual waste. While incentive programs honor barangays that exhibit exceptional waste-management strategies, the City Environment and Natural Resources Office keeps an eye on compliance. Grants from foreign partners have financed infrastructure upgrades, such as recycling and composting equipment, while special efforts, like the "Plastic for Rice" program, promote community involvement in decreasing plastics. Legazpi City has effectively converted its legislation into workable programs that minimize, recover, and appropriately manage waste while encouraging environmental responsibility among its stakeholders by using this integrated strategy.

In addition to these legal actions, the Legazpi City Ecological Solid Waste Management Program for Business Establishments mandates that businesses undergo waste management courses and implement appropriate resource recovery, recycling, and segregation processes. This framework is further strengthened by the city's 10-Year Ecological Solid Waste Management Plan, which outlines long-term strategies such as the construction of material recovery facilities, sanitary landfill systems, barangay capacity building, and extensive collection coverage throughout all communities. By focusing on reduction, reuse, recycling, and sustainable management techniques, these programs collectively represent an evolution from basic trash disposal to a full life-cycle strategy, establishing Legazpi City as a regional leader in ecological solid waste management.

The ESWM program in Legazpi City is based on a clear and structured system that emphasizes resource recovery, waste reduction, segregation, and proper disposal in compliance with both local and national regulations. In order to assist barangays, residential enterprises, and institutions in comprehending and implementing source segregation—specifically, the "no segregation, no collection" policy—the initiative started with a comprehensive information, education, and communication (IEC) campaign. Each barangay received useful tools and equipment to facilitate this change, such as tri-color bins, collection push carts, and environmental aide units, which made it easier for the community to sort biodegradable, recyclable, and residual waste. Along with a central composting facility and a common marketing center for special wastes like broken glass and different kinds of plastics, the city government also assumed management of the sanitary landfill in Barangay Banquerohan.

Additionally, the city's implementation initiatives have grown to include more creative and focused strategies. The "Plastic for Rice" program, which allows locals to trade five kilograms of dry, clean leftover plastics for one kilogram of rice, is one such example. After being gathered, the plastics are shredded and used for other purposes, which helps lower the amount of waste dumped in the landfill and prolongs its useful life. The city recently made investments in new infrastructure, like a granular plastic shredding plant that can handle several tons of plastic waste per day. This technology encourages recycling on a wider scale and helps stop activities like open burning. In addition to infrastructure, the city enhances community involvement through recognition initiatives and capacity-building exercises. Annual prizes are given to barangays who

perform well in implementing ESWM, a tactic that encourages communities to uphold or enhance their waste-management procedures while reinforcing accountability.

Several of important areas where circular economy principles might be strengthened were identified through assessing present practices and analyzing opportunities and challenges. The results show that circular approaches are largely incorporated into present systems, however there are still gaps in long-term sustainability, efficiency, and integration. These gaps offer chances for focused technical interventions, especially in system design, material recovery, and process optimization.

The results show how engineering solutions are essential for resolving issues by increasing resource efficiency and reducing waste production. Additionally, the study indicates that system performance may be greatly improved by using circular economy principles throughout the design and operation phases. These results are consistent with previous studies that highlights the significance of engineering-driven initiatives in facilitating circular transitions across sectors.

A set of engineering initiatives have been developed to improve the implementation of circular economy principles within the system under study based on the gaps, opportunities, and challenges found. These initiatives were developed by matching technical solutions to significant circular economy strategies such as recovery, reuse, waste reduction, and resource efficiency. The suggested initiatives provide an organized method for improving circular performance by converting the analytical results into useful and feasible actions. The created engineering initiatives are shown along with how they relate to the pertinent circular economy principles.

| INTEGRATED INITIATIVE                                              | ENGINEERING COMPONENTS                                                                                                                                                                                                                    | CIRCULAR ECONOMY PRINCIPLES APPLICATION                                                                                                                                                         | EXPECTED OUTCOMES                                                                                                                                                                                    |
|--------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Reusable Packaging and Container Circulation System</b>         | <ul style="list-style-type: none"> <li>- Life-cycle assessment</li> <li>- Cost-benefit analysis</li> <li>- Standardized container design</li> <li>- Supplier coordination</li> <li>- Circulation and return logistics modeling</li> </ul> | <b>Design &amp; Reuse:</b> To eliminate single-use packaging through standardized reusable and biodegradable containers backed by an organized return-and-reuse system                          | <ul style="list-style-type: none"> <li>- Reduced packaging waste</li> <li>- Extended material life cycles</li> <li>- Improved environmental performance</li> <li>- Cost savings over time</li> </ul> |
| <b>Collaborative Logistics and Sustainable Consumption Program</b> | <ul style="list-style-type: none"> <li>- Inventory optimization</li> <li>- Logistics engineering</li> <li>- Demand forecasting</li> <li>- Behavioral incentive system design</li> </ul>                                                   | <b>Distribution &amp; Consumption:</b> To lessen the intensity of materials and transportation, shared delivery routes, bulk purchases, and incentive-based "bring-your-own-container" programs | <ul style="list-style-type: none"> <li>- Lower transportation emissions</li> <li>- Reduced secondary packaging</li> <li>- Increased consumer participation in circular</li> </ul>                    |

|                                                                              |                                                                                                                                                                                                                                   |                                                                                                                                                                           |                                                                                                                                                                                        |
|------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                                              |                                                                                                                                                                                                                                   |                                                                                                                                                                           | practices                                                                                                                                                                              |
| <b>Standardized Waste Segregation, Collection, and Monitoring System</b>     | <ul style="list-style-type: none"> <li>- Waste flow mapping</li> <li>- Ergonomic bin placement</li> <li>- Color-coded infrastructure</li> <li>- Compliance audits</li> <li>- Digital waste tracking and KPI monitoring</li> </ul> | <b>Collection &amp; Monitoring:</b><br>Uniform segregation layout coupled with real-time monitoring and feedback mechanisms for continuous performance improvement        | <ul style="list-style-type: none"> <li>- Higher segregation accuracy</li> <li>- Increased recycling and composting rates</li> <li>- Improved operational transparency</li> </ul>       |
| <b>On-Site Organic Waste Consumption and Food Waste Prevention System</b>    | <ul style="list-style-type: none"> <li>- Composting system design</li> <li>- Organic waste process optimization</li> <li>- Lean food handling</li> <li>- Cold storage and inventory control</li> </ul>                            | <b>Reuse &amp; Resource Efficiency:</b><br>On-site composting of biodegradable waste combined with food waste prevention strategies across preparation and storage stages | <ul style="list-style-type: none"> <li>- Significant diversion of organic waste from landfills</li> <li>- Improved resource efficiency</li> <li>- Reduced operational costs</li> </ul> |
| <b>Cooking Oil Recovery and Resource Recycling System</b>                    | <ul style="list-style-type: none"> <li>- Used oil collection tank engineering</li> <li>- Quality control protocols</li> <li>- Reverse logistics</li> <li>- Accredited recycler partnerships</li> </ul>                            | <b>Resource Recovery:</b> Systematic recovery and recycling of used cooking oil into biodiesel or industrial feedstock                                                    | <ul style="list-style-type: none"> <li>- Reduced environmental contamination</li> <li>- Recovery of high-value secondary resources</li> <li>- Regulatory compliance</li> </ul>         |
| <b>Capacity Building, Institutional Partnerships, and Governance Support</b> | <ul style="list-style-type: none"> <li>- Technical training systems</li> <li>- Policy-aligned engineering frameworks</li> <li>- Inter-agency coordination</li> <li>- Financial planning</li> </ul>                                | <b>Institutional Enablement:</b><br>Training, governance support, and partnerships with LGUs and recycling facilities to ensure long-term system viability                | <ul style="list-style-type: none"> <li>- Strengthened institutional capacity</li> <li>- Reduced implementation barriers</li> <li>- Enhanced scalability and sustainability</li> </ul>  |

The purpose of the study was to evaluate how circular strategies—such as waste reduction, resource recovery, sustainable sourcing, and closed-loop systems—can be effectively applied in food-related

enterprises within the city's context especially for the Legazpi City Food Park. Specifics to evaluate was (1) to assess the current waste management practices in the food park in relation to design, distribution, consumption, collection, and reuse or recycle; (2) to identify the challenges faced by stakeholders in economy, social, technical, and financial aspects; and (3) to determine opportunities in waste distribution, resource efficiency, and reuse for the food park.

The research study focused on the views of stakeholders of the Legazpi Food Park at Brgy. Bitano, Legazpi City. A total of fifty-six (56) respondents or business owners' insights were analyzed for the study and was correlated to the existing city policies in terms of waste management. To provide a comprehensive understanding of the current market environment and assess the feasibility of integrating circular economy (CE) practices within the food park, the results from both data sets were triangulated. The study used survey questionnaires for the quantitative methodology and key informant studies and policies for the qualitative methodology to evaluate and analyze the current solid waste management system on the food park.

The fact that all indications circle around an average of 3 indicates that waste management practices are present but continue to be inadequate, incomplete, or inconsistently applied, even if none of the features scored exceptionally low. To put it simply, these actions are "Slightly Circular". Of the categories that were evaluated, Collection got the highest rating (about 3.39), while Consumption had the lowest (about 3.04). Additionally, reuse and recycling performed poorly (around 3.06). Overall, these findings show that the food park has started some waste management initiatives at several stages, including design, distribution, consumption, collection, and reuse/recycling. However, these initiatives are not yet strong, readily structured, or completely integrated into operations.

According to the data, Legazpi Food Park faces significant challenges in implementing Circular Economy (CE) principles in four main areas: financial, social, technical, and economic. Economically speaking, the high cost of sustainable packaging and the total costs of implementing CE practices are considered as significant challenges, which are made worse by a lack of affordable environmentally friendly alternatives and inadequate financial incentives. Social issues are also significant as poor public involvement, a lack of stakeholder drive, and a lack of consumer awareness hinder collective attempts to achieve sustainability. Technically speaking, the park's low preparedness for CE implementation is reflected in its inadequate waste segregation infrastructure, limited access to recycling facilities, and inadequate training programs. Businesses face financial challenges such as tight budgets, little government assistance, and trouble acquiring money for innovation. Overall, results show that although the significance of CE is recognized, significant financial, social, technical, and economic obstacles need to be overcome before Legazpi Food Park is able to integrate a circular economy model.

According to the data, Legazpi Food Park offers significant opportunities for waste reduction, resource efficiency, and reuse through the integration of Circular Economy (CE) principles. Consumer-business cooperation and trash segregation education are uniformly supported by respondents (100%), highlighting the significance of awareness and collaborative effort in reducing waste. High agreement also emphasizes how technology, efficient food production, and the use of policies may improve sustainability and efficiency. In terms of resource efficiency, upcycling and longer product lifespans provide further financial and environmental benefits, while effective resource utilization and better food handling are well known for their capacity to lower expenses and waste. Although collaborations with recycling facilities and reuse incentives need more support, reuse strategies including return-and-reuse programs, reusable silverware, and composting organic waste are also thought to be viable. Overall, the results indicate that stakeholders are well prepared

and optimistic, demonstrating that Legazpi Food Park can successfully move toward a more sustainable and circular waste management system with the right cooperation, education, and governmental support.

## 5. Conclusion

This research studied at how the Legazpi City Food Park in Brgy. Bitano, Legazpi City may use the principles of the Circular Economy (CE) to improve waste management. The research was designed to provide a thorough understanding of how CE principles can be integrated within the food park's operations, guided by the evaluation of current practices, the identification of stakeholder challenges, the investigation of potential opportunities, and the development of engineering-based initiatives. This conclusion summarizes the study's findings about the design, distribution, consumption, collection, reuse, and recycling processes. It also takes into account the financial, technological, social, and economic factors that affect the adoption of CE.

### **Assessment of the Current Waste Management Practices in Legazpi Food Park in relation to circular economy principles**

This research evaluated into the Legazpi City Food Park's implementation of Circular Economy (CE) principles in the areas of design, distribution, consumption, collection, and reuse/recycling. The findings show that although suppliers and stakeholders are generally aware of sustainable waste management, there is still insufficient and inconsistent application of CE principles.

Despite recyclable packaging is frequently utilized during the design phase, the adoption of eco-friendly and biodegradable materials is extremely limited because of availability and cost issues. Distribution procedures exhibit a lack of shared logistics or cooperative waste-reduction solutions, poor inter-vendor coordination, and little integration of CE ideas. Vendors and customers both exhibit environmental consciousness when it comes to consumption, yet incentives and official initiatives do not adequately encourage sustainable practices.

Effective circularity is hindered by problems in segregation enforcement, monitoring, and accountability, yet the collection stage demonstrates operational efficiency in waste disposal. Reuse and recycling initiatives are also barely noticeable because waste management mostly depends on local collection services and participation in composting, upcycling, and organic waste separation is still limited.

All things taken into account, the Legazpi City Food Park represents an early phase of the adoption of the circular economy, characterized by awareness and basic infrastructure but hindered by financial challenges, a lack of coordination, and inadequate institutional support. To improve circular waste management techniques and advance long-term sustainability in the food park, these issues must be resolved.

### **Identification of the Challenges faced by Stakeholders in adopting Circular Economy Practices**

The adoption of Circular Economy (CE) practices by stakeholders in the Legazpi City Food Park is hindered by major economic, social, technological, and financial obstacles, according to this study. Economically, both businesses and consumers are discouraged from implementing sustainable practices by the high cost of eco-friendly packaging, a shortage of reasonably priced alternatives, and the absence of suitable incentives.

Social factors that limit stakeholder engagement in circular efforts include poor awareness, low motivation, unwillingness to change, and low public participation. Lack of infrastructure for waste segregation, limited access to recycling facilities, a lack of training, and challenges in putting advanced waste management systems into practice are examples of technical hurdles. In terms of finances, small businesses are financially burdened by budgetary restrictions, restricted funding sources, little government assistance, and high operational expenses.

All things considered, these interconnected challenges show that in order to help achieve a sustainable transition, successful CE adoption need not just awareness but also robust financial support, technical infrastructure, capacity-building, and coordinated stakeholder participation.

### **Determination of the Opportunities of Circular Economy Principles in Legazpi Food Park**

The findings show that the Legazpi Food Park has a lot of potential to implement Circular Economy (CE) concepts in terms of reuse, resource efficiency, and waste reduction. The majority of respondents acknowledged that coordinated efforts between vendors and customers, supported by appropriate waste segregation education, technology, and strategic interventions, may result in successful waste reduction.

Stakeholders stressed that enhancing food preparation and material utilization could reduce waste, reduce expenses, and prolong product lifecycles when it comes to resource efficiency. Upcycling techniques and cooperative projects were also viewed as promising ways to produce both financial and environmental advantages.

In terms of reuse, reusable containers, return-and-reuse programs, and the composting of organic waste are all highly supported. However, lower support for collaboration with recycling facilities and incentive-based reuse programs indicates the need for further stakeholder engagement.

Overall, the findings show that coordinated action and system-level enhancements have an enormous amount of potential to increase circular practices at the Legazpi Food Park.

### **Develop Engineering Initiatives in Implementing circular economy principles on waste management in Brgy. Bitano Legazpi Food Park**

This study shows that integrated, context-specific engineering efforts are necessary for a successful implementation of Circular Economy (CE) principles at the Legazpi Food Park based on the evaluation of current waste management techniques, identified barriers, and recognized opportunities. These programs should concentrate on increasing the effectiveness of waste segregation, material recovery, and resource cycling while still being technically and financially sustainable for small-scale food business owners.

Critical areas where engineering initiatives as solution could strengthen circular economy principles were identified through the evaluation of current practices and the study of opportunities and barriers. In order to bridge these gaps, our research created integrated engineering initiatives which promote sustainable operations at the Legazpi Food Park, encourage resource cycling, and improve waste management efficiency.

This study proposes an integrated circular economy (CE)-based waste and resource management framework designed to minimize material loss, maximize resource usage, and institutionalize sustainable

operational practices within the food service industry, particularly in Legazpi Food Park. The process takes a system engineering approach, where material flows are purposefully planned, monitored, and reintegrated into cycles of productive usage, as compared to considering waste streams as separate outputs.

The study's conclusions led to the proposal of integrated engineering initiatives that apply Circular Economy (CE) principles to the particular circumstances of the Brgy. Bitano Legazpi Food Park. Reusable packaging and container circulation systems, cooperative logistics and sustainable consumption strategies, standardized waste segregation, collection, and monitoring systems, on-site organic waste composting and food waste prevention measures, and mechanisms for recovering and recycling cooking oil are some of these. Through increased resource efficiency, waste accountability, and stakeholder participation, these initiatives collectively address the weaknesses found in design, distribution, consumption, and waste handling while addressing the financial, technical, and economic challenges identified in the study.

## 6. Recommendation

To successfully implement the concepts of the Circular Economy (CE), Legazpi Food Park should coordinate its activities with the current policies and programs of the city. The construction of on-site Materials Recovery Facilities, appropriate waste segregation, and connection with the city's centralized recycling and composting systems are all crucial components of strengthening the waste management infrastructure. Utilizing the city's seminars and events on composting, plastic reduction, and sustainable waste management strategies, vendors and consumers should focus education and awareness initiatives.

The food park should also use circular and reusable packaging practices, including reusing containers and cutlery, and offer rewards like discounts or city recognition to entice companies to participate. Adopting incentive-based programs is also recommended to promote consumer participation in sustainable practices. One such project is Starbucks' ₱10 discount for customers who bring their own reusable drink cups. This promotion is a part of the company's sustainability initiative, which aims to promote the use of reusable drinkware in order to reduce the usage of single-use disposable cups and encourage environmentally conscious consumer habits. Utilizing garbage tracking and monitoring technologies and collaborating with nearby composting and upcycling projects can further improve efficiency and resource recovery.

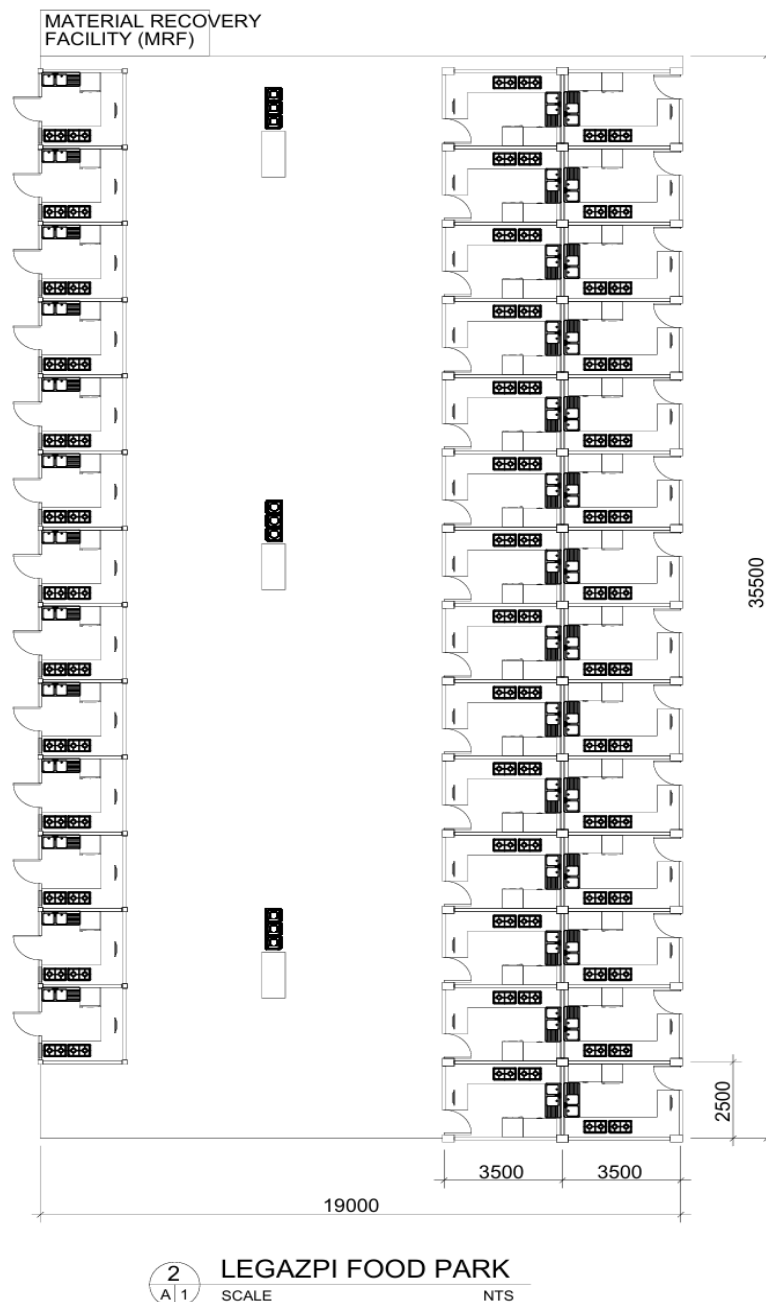
Further research on the layout and design of the food park's floor plan is also advised in order to guarantee that waste management facilities, including garbage bins and collection stations, are positioned in an ergonomic and strategic manner. Effective spatial planning will increase overall operational efficiency, promote proper waste segregation, and improve accessibility. Legazpi Food Park can successfully make the transition to a more sustainable and circular waste management system by creating a clear Circular Economy plan with quantifiable goals in line with the city's environmental objectives and by looking for financial and technical support through available funding programs.

There used to be an old basketball court in Brgy. Bitano where the Legazpi Food Park is located with a total area of around 19m by 35.5m. In order to maximize both vendor operations and tourist mobility, the suggested arrangement supports two different kinds of stalls. Stalls measuring 3.5m by 2.5m are planned on the right side of the site within the food park's current facilities; minor renovations are advised to improve organization in accordance with the type of products being sold while keeping costs low. The projected 2.5m

by 2.5m stalls in the opposite section of the food park provide more room for patrons to wander around freely. If necessary, these smaller stalls can be swapped out for tents, giving the stakeholders flexibility.

Trash bins for waste management are arranged in the park's center for convenient access and are divided into three categories: biodegradable, recyclable, and residual waste. There is also a designated busing area that promotes the circular economy by encouraging the return and reuse of kitchenware. In addition, a Material Recovery Facility (MRF) will be built at the rear of the property, guaranteeing that the food park can handle its own waste without depending on the MRF of the barangay. In addition to providing space for future adjustments to satisfy operational requirements, this structure strikes a balance between vendor functioning, consumer convenience, and environmentally friendly waste management techniques.

Figure: Proposed Floor Plan of the Legazpi Food Park



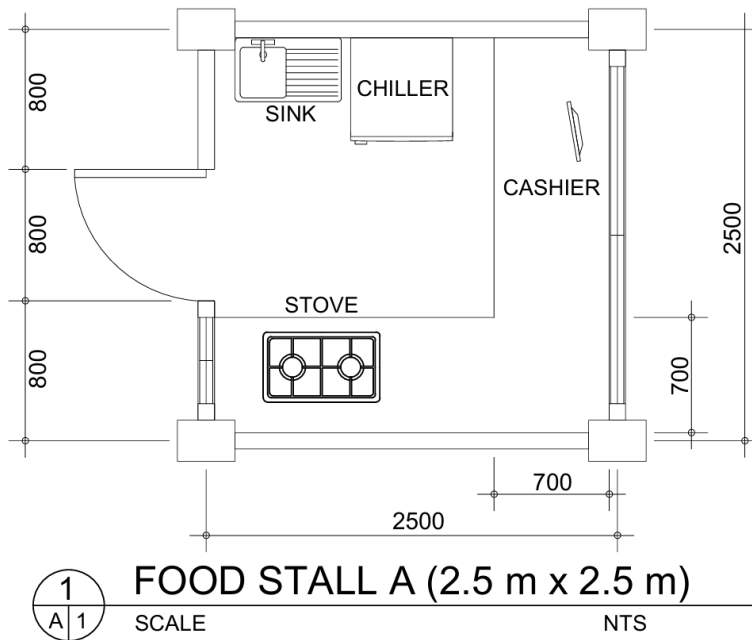


Figure: Proposed Floor Plan of a stall (2.5m × 2.5m) in the Legazpi Food Park

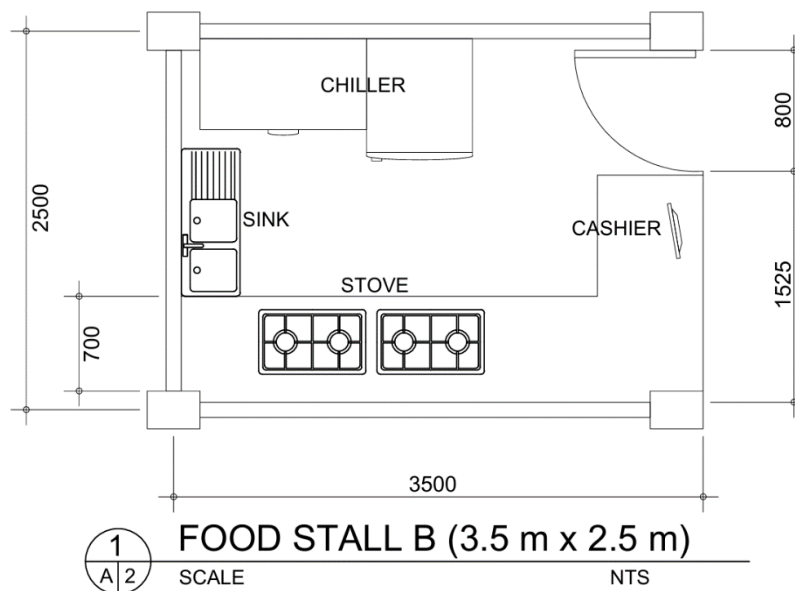


Figure: Proposed Floor Plan of a stall (3.5m × 2.5m) in the Legazpi Food Park

## References

- Anupam, K., Vella A., Suchana, C., Wilts, H., Ishrat, I., Ulrich, K., Meng, L., Xiao, L., Indu, M., Temitope, T.O., Prabhat, V., Guochang. X., Xianlai, Z., Jinhui, L., (2022). Accelerating circular economy solutions to achieve the 2030 agenda for sustainable development goals. *Circular Economy*
- Amina, M., Idris, N., & Hashim, H. (2020). Barriers and enablers of circular economy implementation in the food sector: A systematic review. *Journal of Cleaner Production*, 256, 120561.
- Almelhem, M., & Al Shboul, M. (2024). Industry 4.0 for sustainable reverse waste collection: A systematic literature review. *Journal of Transport and Supply Chain Management*
- ASEAN Secretariat. (2025). Transition cost, supply chain issues bug MSME in ASEAN. *BusinessMirror*. Retrieved from <https://businessmirror.com.ph/2025/06/16/transition-cost-supply-chain>
- Beltrán, M., Tjahjono, B., Bogush, A., Julião, J., & Teixeira, E. L. S. (2021). Food plastic packaging transition towards circular bioeconomy: A systematic review of literature. *Sustainability*, 13(7), 3896. <https://doi.org/10.3390/su13073896>
- Borrello, M., Pascucci, S., & Cembalo, L. (2020). Three propositions to unify circular economy research: A review and a research agenda. *Journal of Cleaner Production*, 256, 120–132.
- British Standards Institution. (2017). BS 8001: Framework for Implementing the Principles of the Circular Economy in Organizations.
- Camacho-Otero, J., Boks, C., & Pettersen, I. N. (2018). Consumption in the circular economy: A literature review. *Sustainability*
- Camacho-Otero, J., Boks, C., & Pettersen, I. N. (2018). Consumption in the circular economy: A literature review. *Sustainability*, 10(8), 2758. <https://doi.org/10.3390/su10082758>
- Creswell, J. W., & Plano Clark, V. L. (2018). *Designing and conducting mixed methods research* (3rd ed.). Sage Publications.
- Department of Environment and Natural Resources (DENR). (2020). National status report on solid waste management 2020. Environmental Management Bureau. [https://emb.gov.ph/wp-content/uploads/2021/07/NSWMC\\_NSR\\_2020.pdf](https://emb.gov.ph/wp-content/uploads/2021/07/NSWMC_NSR_2020.pdf)
- Department of Science and Technology (DOST). (2020). Science for change program: Accelerating R&D in the country. <https://dost.gov.ph>
- Department of Trade and Industry (DTI). (2021). Sustainability initiatives for MSMEs in the Philippines. <https://www.dti.gov.ph>
- Ellen MacArthur Foundation. (2019). Completing the picture: How the circular economy tackles climate change. <https://ellenmacarthurfoundation.org/completing-the-picture>
- Ellen MacArthur Foundation. (2015). *Circularity Indicators: An Approach to Measuring Circularity*. United Kingdom.
- Elsayed, M., Ran, Y., Ai, P., Azab, M., Mansour, A., Jin, K., et al., 2020. Innovative integrated approach of biofuel production from agricultural wastes by anaerobic digestion and black soldier fly larvae. *J. Clean. Prod.* 263, 121495. <https://doi-org.ezproxy.library.wur.nl/10.1016/j.jclepro.2020.121495>.
- Espinoza Orias, N., & Lundquist, L. (2025). Life cycle assessment of reusable food and beverage packaging systems: A proposal of good practice. *Journal of Cleaner Production*
- European Environment Agency. (2017). Breaking the barriers to the circular economy. European Environment Agency. <https://www.eea.europa.eu>
- Figuerola, A. M. I., Pintor, L. L., Sapuay, G. P., et al., 2021. Circular economy strategies and implementation in the Philippines. In S. Chellammal & M. Vasantha (Eds.), *Circular economy: Recent trends in global perspective*. Springer.

- Figuerola, M. A., Barleta, A. G., & Tolentino, J. R. (2021). Barriers and enablers of circular economy implementation in the Philippines: A policy and institutional analysis. *Journal of Cleaner Production*, 310, 127523. <https://doi.org/10.1016/j.jclepro.2021.127523>
- Fogarassy, C., Nagy-Pércsi, K., Ajibade, S., Gyuricza, C., Ymeri, P., 2020. Relations between circular economic “principles” and organic food purchasing behavior in Hungary. *Agronomy* 10 (5), 616. <https://doi.org/10.3390/agronomy10050616>
- Freeman, R. E. (1984). *Strategic management: A stakeholder approach*. Pitman.
- Geissdoerfer, M., Savaget, P., Bocken, N. M. P., & Hultink, E. J. (2017). The circular economy – A new sustainability paradigm? *Journal of Cleaner Production*, 143, 757–768. <https://doi.org/10.1016/j.jclepro.2016.12.048>
- Haas, W., Krausmann, F., Wiedenhofer, D., & Heinz, M. (2015). How Circular is the Global Economy?: An Assessment of Material Flows, Waste Production, and Recycling in the European Union and the World in 2005. *Journal of Industrial Ecology*
- Han, N., Martin, S., Markus, Z. (2025). Remaking the industrial economy. <https://www.mckinsey.com/capabilities/sustainability/our-insights/remaking-the-industrial-economy>
- Jambeck, J. R., Geyer, R., Wilcox, C., Siegler, T. R., Perryman, M., Andrady, A., Narayan, R., & Law, K. L. (2015). Plastic waste inputs from land into the ocean. *Science*, 347, 768–771.
- Kirchherr, J., Reike, D., & Hekkert, M. (2017). Conceptualizing the circular economy: An analysis of 114 definitions. *Resources, Conservation & Recycling*, 127, 221–232.
- Kirchherr, J., Reike, D., & Hekkert, M. (2018). Conceptualizing the circular economy: An analysis of 114 definitions. *Resources, Conservation and Recycling*
- Kharas, H., Fengler, W., 2019. Double Tipping Points in 2019: when the World Became Mostly Rich and Largely Old. Retrieved from. <https://www.brookings.edu/blog/future-development/2019/10/09/double-tipping-points-in-2019-when-the-world-became-mostly-rich-and-largely-old/#cancel>.
- Kristensen, H. S., & Mosgaard, M. A. (2020). A review of micro level indicators for a circular economy – Moving away from the three dimensions of sustainability? *Journal of Cleaner Production*, 243, 118–531.
- Lehmann, M., Arici, G., Bogdanova, M., & Jørgensen, K. A. (2020). Circular economy in cities: A literature review and a multiple case study research. Ellen MacArthur Foundation. <https://ellenmacarthurfoundation.org/resources>
- Lehmann, M., Frydendal, J., Pedersen, E. R. G., & Gwozdz, W. (2020). Circular economy and consumer behaviour. Springer Nature.
- LGU Santol. (n.d.). Circular economy and waste management [Inventory optimization & resource loops]. LGU Santol Environmental Policy Portal.
- Loizides, M. I., Loizidou, X. I., Orthodoxou, D. L., & Petsa, D. (2019). Circular bioeconomy in action: Collection and recycling of domestic used cooking oil through a social, reverse logistics system. *Recycling*, 4(2), 16. <https://doi.org/10.3390/recycling4020016>
- Mandasari, P. (2025). Towards a circular economy: Analyzing food waste convergence in Indonesia’s municipalities. *Research on World Agricultural Economy*
- Mehmood, A., Ahmed, S., Viza, E., Bogush, A., & Ayyub, R. M. (2021). Drivers and barriers towards circular economy in agri-food supply chain: A review. *Business Strategy & Development*, 4(5), 465–481. <https://doi.org/10.1002/bsd2.171>
- M. Dora, S. Biswas, S. Choudhury, R. Nayak & Z. Irani A system-wide interdisciplinary conceptual framework for food loss and waste mitigation strategies in the supply chain, *Industrial Marketing Management*, 93. (2020) 492 - 508.
- Murray, A., Skene, K., & Haynes, K. (2017). The circular economy: An interdisciplinary exploration of the concept and application in a global context. *Journal of Business Ethics*

- Othman, M. A., Sidek, N. A., Janon, M. N., Mohamad, M. A. H., & Basri, A. Q. (2025). Food waste composting machines: A mini review on a practical solution for organic waste reduction at source. *International Journal of Innovation and Industrial Revolution*, 7(22)
- Pauer, E., Wohner, B., Heinrich, V., & Tacker, M. (2019). Assessing the environmental sustainability of food packaging: An extended life cycle assessment including packaging related food losses and waste and circularity assessment. *Sustainability*, 11(3), 925. <https://doi.org/10.3390/su11030925>
- Papargyropoulou, E., Lozano, R., Steinberger, J. K., Wright, N., & Ujang, Z. (2014). The food waste hierarchy as a framework for the management of food surplus and food waste. *Journal of Cleaner Production*, 76, 106–115. <https://doi.org/10.1016/j.jclepro.2014.04.020>
- Rapid News PH. (2021, September 25). BFAR Bicol calls for LGUs strict implementation of solid waste management. Rapid News PH. Retrieved from [https://rapidnewsonline.com/bfar-bicol-calls-for-lgus-strict-implementation-of-solid-waste-management/?utm\\_source=chatgpt.com](https://rapidnewsonline.com/bfar-bicol-calls-for-lgus-strict-implementation-of-solid-waste-management/?utm_source=chatgpt.com)
- ReLondon. (2021). Urban food waste innovation: Case studies from Amsterdam and Copenhagen. <https://relondon.gov.uk/resources/urban-food-waste-innovation-case-studies>
- Roosa, L., Elina, N., Larissa, B. (2024). Consumer Collectives in the Circular Economy: A Systematic Review and Research Agenda. *Sustainable Production and Consumption*
- Rony, M., Borian, R., Ziyang, Z., (2024). Digital government and the circular economy transition: An analytical framework and a research agenda. *Government Information Quarterly*
- Saleh, S. M., Amran, A. C., Sedek, M., Ghazaly, M. M., & Hasan, M. Y. (2025). Operationalizing circular economy goals through food waste composting: A GREEN framework for hawker centers. *International Journal of Academic Research in Business and Social Sciences*, 15(9), 1300–1314. <http://dx.doi.org/10.6007/IJARBS/v15 i9/26542>
- Saleh, S. M., Che Amran, A., Sedek, M., Ghazaly, M. Md., & Hasan, M. Y. (2023). Operationalizing circular economy goals through food waste composting: A GREEN framework for hawker centers. *International Journal of Academic Research in Business and Social Sciences*, 15(9).
- Skyttner, L. (2006). *General systems theory: Problems, perspectives, practice* (2nd ed.). World Scientific Publishing.
- Siems, E., Seuring, S., & Schilling, L. (2023). Stakeholder roles in sustainable supply chain management: A literature review. *Journal of Business Economics*, 93(4), 747–775. <https://doi.org/10.1007/s11573-022-01117-5>
- Starbucks Philippines. (n.d.). Bring your own cup and get ₱10 off your beverage. <https://www.starbucks.ph/story/36>
- Szilágyi, A., Cioca, L.-I., Bacali, L., Lakatos, E.-S., & Birgovan, A.-L. (2022). Consumers in the circular economy: A path analysis of the underlying factors of purchasing behaviour. *International Journal of Environmental Research and Public Health*
- Tan, E., & Ramakrishna, S. (2022). Towards a circular economy: Barriers and opportunities for sustainable materials management. *Journal of Cleaner Production*, 350, 131565. <https://doi.org/10.1016/j.jclepro.2022.131565>
- Timothy James, E., Jan Paul, P., Jasper Aldwin, P., Charles Dean, Q., Ivan Henderson, G., Monorom, R., Alexis Mervin, S., (2023). Modeling consumer preference on refillable shampoo bottles for circular economy in Metro Manila, Philippines. *Cleaner and Responsible Consumption*
- von Bertalanffy, L. (1968). *General system theory: Foundations, development, applications*. George Braziller.
- World Bank. (2016). *Legazpi City: Environmental Assessment – Solid Waste Management (SFG1850-V2-EA-P106885)*. World Bank.
- Zhuhuan, L., Nicol, K. (2024). Transition from linear to circular economy in pavement engineering: A historical review. *Journal of Cleaner Production*