**Chapter 2: Literature Review**

This chapter presents various studies and literature related to environmental issues and their corresponding solutions, with a focus on land pollution. It includes a range of works that offer different perspectives, methods, and findings, showcasing the development of the environment from past to present. By examining both international and local laws and studies – particularly those relevant to land pollution in the Philippines and in Lambunao – this chapter aims to provide a deeper understanding of environmental governance and public participation. It highlights key concepts, definitions, legal frameworks, and the progress made in different regions. Furthermore, it identifies research gaps and proposes solutions that can guide future work on this topic.

**Pollution**

Pollution is defined as the presence of substances and/or heat in environmental media (air, water, land) whose nature, location, or quantity produces undesirable environmental effects. Pollution can have a disproportionate and negative effect on the poor, the disadvantaged and the vulnerable. Pollution constitutes a significant impediment to achieving health, well-being, prosperity and the sustainable development goal of ‘leaving no one behind’. Pollution is currently the leading environmental cause of disease and early death worldwide, accounting for an estimated 9 million premature deaths in 2015, according to a recent groundbreaking report released by The Lancet Commission on Pollution and Health. This number accounts for 16% of all deaths globally, which is three times more than the combined death toll from Acquired immunodeficiency syndrome (AIDS), Tuberculosis (TB), and malaria, and 15 times higher than the total death toll from all wars and other violent conflicts (*Pollution*, 2023).

In the Philippines, pollution poses a serious threat to the country's air, water, and land resources. These problems have been made worse by rapid urbanization, industrialization, and population increase, which provide significant ecological, economic, and health threats. One of the Philippines' most urgent environmental issues is air pollution. Premature deaths, cardiovascular disorders, and respiratory ailments are all associated with air pollution. It is predicted that it killed 66,230 people in the Philippines in 2019 alone. As a result, it ranks as the third most significant risk factor for non-communicable disease-related death and disability (Brooke, 2024).

The Philippines' water quality has declined as a result of urbanization, agricultural runoff, and the uncontrolled release of industrial and domestic wastewater. Aquatic ecosystems and drinking water sources are impacted by contaminated rivers and lakes. One of the biggest causes of ocean plastic pollution worldwide is the Philippines. Every year, almost 0.75 million metric tons of improperly disposed of plastic debris end up in the ocean. During the COVID-19 pandemic, the usage of single-use plastics has increased, making the situation worse (Raji, 2024).

Air, water, and waste management issues are all part of the complex problem of pollution in Region 6, which encompasses the provinces of Aklan, Antique, Capiz, Guimaras, Iloilo, and Negros Occidental. Because of the uncontrolled release of industrial and domestic wastewater as well as agricultural runoff, water pollution is a significant issue in Region 6. Similar to the condition of the Pasig River, the status of the Iloilo River and its tributaries, Calajunan and Dungon creeks, demonstrate how urbanization and industrialization have affected Philippine rivers. (Environmental Management Bureau Region 6; Department of Trade and Industry, 2024).

Iloilo City created emissions inventory in 2013 after examining the sources of air pollution. One important discovery was surprising: one of the main causes of air pollution in the city is indoor pollution from solid fuel combustion in dwellings. Since the area lacks large industries, local radio commentators and the public believed that jeepneys, the city's most common form of transportation, were the primary offender. The city discovered that it needed to concentrate its efforts on households after creating an emissions inventory (*Philippines tackles air pollution*, 2020).

Numerous programs and environmental issues are used to address pollution in Lambunao, a municipality in Iloilo, Philippines. Lambunao saw a 7.9% decline in tree cover since 2000 and considerable CO₂ emissions because of the 2.12 kilohectare (kha) of tree cover lost between 2001 and 2023. While specific air quality statistics for Lambunao is not detailed in the search results, general concerns about air pollution in the Philippines frequently include particulate matter like PM2.5, which can damage visibility and health (Sornito, 2019).

Pollution is a multifaceted issue that affects various aspects of the environment. It is categorized into several types, including air, water, land, noise, and radioactive pollution.

***Land Pollution***

Land pollution refers to the deterioration of the earth’s land surfaces at and below ground level. It is caused by the accumulation of solid and liquid waste materials that contaminate groundwater and soil. These waste materials are often referred to as municipal solid waste (MSW), which includes both hazardous and non-hazardous waste. As different waste materials and pollutants like heavy metals, pesticides, plastic, litter and pharmaceuticals sit on top of and leach into our soil, they change and degrade its natural composition. Over time, some pollutants can also go through a chemical transformation, creating secondary pollutants like fumaric and phthalic acids (Texas Disposal Systems, 2024).

A rising environmental concern in the Philippines is land pollution, which is brought on by several factors such as inappropriate waste disposal, industrial activity, and agricultural practices. In addition to reducing soil fertility, the widespread use of agrochemicals like pesticides and fertilizers has contaminated land with dangerous residues like organophosphates and organochlorines. Urbanization and industrial waste also contribute to land degradation, as neighboring water bodies are frequently impacted by contaminated soil through runoff or evaporation cycles that result in acid rain. By removing flora from the soil and leaving behind harmful leftovers, mining and logging make the issue worse. Despite these problems, attempts to mitigate land contamination remain weak, with limited government action to prohibit harmful activities like excessive pesticide use (Radniw, 2019).

Numerous causes impact land pollution in Region 6, which encompasses the provinces of Negros Occidental, Aklan, Antique, Capiz, Guimaras, and Iloilo. Synthetic pesticides and fertilizers have the potential to contaminate water sources and reduce soil quality. Improper disposal of waste, including littering and lack of suitable landfill facilities, contributes to soil degradation. Even though it isn't mentioned explicitly in Region 6, mining can lead to pollution and soil erosion elsewhere in the nation (*DENR Approves Forest Land Use Plans*, 2019).

A few reasons contribute to land pollution in the Philippine province of Iloilo, which is in Region 6. These include unsustainable farming practices, inappropriate waste management, and environmental deterioration brought on by landslides and other natural catastrophes. Degradation of the land is a result of improper garbage disposal. Although there is little data on land contamination in Iloilo, the Philippines' overall pattern of poor waste management indicates that similar issues exist locally (Radniw*, 2019).*

The information that is currently available does not specifically address the level of land contamination in Lambunao, a municipality in Iloilo, Philippines. But the larger picture of land degradation in the Philippines sheds light on the difficulties Lambunao can encounter. Due mostly to illicit logging, unsustainable farming methods, and the conversion of forests into agricultural land, an estimated 49.04% of the Philippines' total land area was degraded as of 2019. A localized thunderstorm in July 2024 caused flooding in low-lying areas and a landslide in one of the barangays, affecting multiple families. These incidents demonstrate the area's susceptibility to natural disasters, which can worsen land pollution by causing soil erosion and upsetting ecosystems. Environmental problems like flooding and landslides have been reported in Lambunao, which can contribute to land degradation (Baclig, 2024).

**Different Types of Land Pollution*.*** There are different types of

land pollution. First is solid waste that includes all the various kinds of rubbish we make at home, school, hospitals, markets, and workplaces. Things like paper, plastic containers, bottles, cans, food, and even used cars and broken electronic goods, broken furniture, and hospital waste are all examples of solid waste. Insects and small animals are killed, and bigger animals that eat tiny animals (as in food chains) are in turn harmed. Finally, the chemicals may be washed down after rains and over time, they end up in the water table below because of fertilizers and pesticides which are also called chemical pollution., deforestation wherein humans must cut down millions of acres of trees for wood, construction, farming, and mining purposes and never planted new trees back (*Types of Land Pollution*, n.d.).

Land pollution in the Philippines is a multifaceted issue, encompassing various forms of environmental degradation. Soil erosion is the most prevalent, affecting nearly half of the country's arable land due to intensive farming and deforestation. The widespread use of chemical fertilizers and pesticides further degrades soil quality, contaminating it with residues that impact agricultural productivity and surrounding ecosystems. Urbanization and improper waste disposal exacerbate the problem, as informal settlements contribute to land degradation and pollution. Mining activities also play a role, leaving behind toxic residues and causing erosion. Additionally, natural factors like volcanic eruptions and topographic variations contribute to land degradation in specific regions. The cumulative effect of these factors reduces soil fertility, impacts food production, contaminates water bodies, and disrupts ecological balances. To address these challenges, the Philippines needs to adopt sustainable agricultural practices, enforce stricter regulations on chemical use, implement reforestation programs, and improve waste management systems (“Global Assessment of Soil Pollution: Report,” 2021).

In Region 6 of the Philippines, land pollution is a significant environmental concern, driven by several key factors. Agricultural practices, particularly the use of synthetic fertilizers and pesticides, contribute to soil degradation and pollution, affecting soil fertility and contaminating water bodies. Mining activities, though less prevalent in this region, still pose a risk by releasing toxic substances like heavy metals. Improper waste disposal, exacerbated by urbanization and inadequate waste management systems, also contributes to land pollution. Soil erosion, intensified by heavy rainfall and deforestation, further reduces soil quality and impacts agricultural productivity. Additionally, industrial activities, such as manufacturing and construction, can generate waste and contribute to pollution if not managed properly. To address these challenges, Region 6 needs to adopt sustainable agricultural practices, improve waste management systems, and enforce stricter regulations on industrial activities to mitigate the impact of land pollution on ecosystems and human health (“Global Assessment of Soil Pollution: Report,” 2021).

Land pollution in Iloilo is primarily influenced by improper waste disposal, agricultural practices, and urbanization. Dissatisfaction with garbage disposal is moderate, reflecting challenges in managing waste effectively, which contributes to land degradation and pollution. Urban areas also face issues with untidiness and insufficient green spaces, exacerbating environmental concerns. Agricultural activities, particularly the use of synthetic fertilizers and pesticides, further degrade soil quality. Additionally, water pollution in Iloilo is high, with organic pollutants from urban runoff and agricultural waste contaminating nearby land and water bodies (*Pollution in Iloilo*, n.d.).

In Lambunao, Iloilo, unsustainable practices and inappropriate waste disposal are the main causes of land contamination. In order to handle waste management, the municipality established a sanitary landfill, which guarantees the secure disposal of trash, including organic and leftover waste from the public market. But problems still exist because there isn't a facility for segregation, which is essential for efficient waste management. The use of synthetic pesticides and fertilizers, which can lower soil quality, is another way that agricultural practices contribute to land pollution. Furthermore, adjacent forest regions like Tinagong Dagat are threatened by unsustainable forest management techniques including timber poaching and kaingin (slash-and-burn farming), which worsen soil degradation and biodiversity loss. To address these problems, Lambunao must improve waste segregation procedures, encourage sustainable farming, and safeguard its natural resources by working together with the Department of Environment and Natural Resources (DENR) and local communities (*First Sanitary Landfill in Iloilo,* n.d.).

**Causes of Land Pollution**. The overuse of synthetic fertilizer and

pesticides, inadequate waste management, and environmental harm from natural catastrophes all contribute to land degradation. Municipal solid waste (MSW) and building waste are produced by rapid urban expansion. Around the world, landfills release methane gas and contaminate the soil with dangerous substances. In addition to releasing hazardous materials like arsenic and mercury into the environment, mining operations can cause soil erosion. Local habitats are further contaminated by acid mine drainage (Land Pollution, n.d.).Land pollution refers to the degradation or destruction of land ecosystems as a result of human activity. The main causes are mining operations, industrial waste, and agricultural practices. Industrial waste, which includes heavy metals and hazardous chemicals, contaminates soil and groundwater. Agricultural practices, which include the use of chemical fertilizers and pesticides, cause soil pollution and erosion. Urbanization generates large amounts of municipal solid waste, which is frequently dumped illegally or ends up in landfills and mining operations. Every year, more than 400 million tons of hazardous waste are produced worldwide, including solvents and heavy metals that contaminate groundwater and soil. Chemical contamination of soil results from the extensive use of pesticides and fertilizers in agriculture can lead to soil contamination. These chemicals can persist in the soil, affecting soil health, water quality, and potentially entering the food chain (Land Pollution, n.d.).

Land pollution in the Philippines is made worse by a number of things. Managing solid waste is still difficult, especially in cities like Metro Manila. With more than 15 million tonnes of municipal solid waste produced each year, the nation ranks fourth among Association of Southeast Asian Nations (ASEAN) countries in terms of solid rubbish production. Poor waste management pollutes rivers and waterways, resulting in flooding and health problems. Land degradation is also greatly exacerbated by deforestation and irresponsible farming methods. Widespread soil erosion and fertility loss result from deforestation brought on by illicit logging and forest conversion for agriculture. Solid waste management is a problem in urban areas, especially regarding plastics and hazardous items that are illegally discarded or built up in landfills. Soil and adjacent water sources become contaminated when fertilizers and pesticides are used excessively in farming. Slash-and-burn agriculture (Pollution: Philippines Interactive Country Fiches, n.d.).

The main causes of land pollution in Region 6, Western Visayas, include ineffective waste collection systems, inadequate disposal facilities, and inappropriate waste disposal practices. Since waste frequently winds up in rivers and coastal areas, where it affects both human health and marine life, open dumpsites close to waterways are a major source of pollution. Water supplies are contaminated and soil quality deteriorated by agricultural practices, especially the use of chemical fertilizers and pesticides (*DENR 6 Initiated Coastal Clean –ups,* 2020).

Rapid development and unsustainable farming methods worsen land contamination in Iloilo City and Province. Inaccessible locations make it more difficult to collect waste effectively, which results in the improper disposal of plastics and non-biodegradable items. Similarly, unsustainable farming practices and inadequate waste management are big issues in Lambunao. Even with a sanitary landfill, there are still problems with disposing of organic and residual garbage, and the absence of recycling initiatives contaminates the land and water. These environmental issues are made worse by the overuse of chemical pesticides and fertilizers in agriculture. Generally, attempts to successfully treat land pollution are hampered by a lack of resources and waste handling facilities in these locations (Panay News, 2025).

**Effects of Land Pollution*.*** Soil pollution is the contamination of

the upper layer of the soil. Soil erosion, the use of chemical fertilizers and pesticides, deforestation, and overgrazing is one of the main reasons for soil pollution. The waste that does not degrade in the soil, called non-biodegradable waste, is then burned, which causes air pollution because of the toxic substances that are emitted into the air. Air pollution is a major health hazard for humans. Land pollution can lead to the formation of breeding grounds for rodents, flies, and mosquitoes. These pollute the environment even further and cause dangerous diseases like malaria, dengue, and plague. Our environment is very badly affected by land pollution. Soil erosion and deforestation caused by soil and land pollution lead to landslides and mudslides. Toxic waste mixing in the water and land affects flora and fauna very adversely. Healthy air is replaced by smoke and soot that only contains harmful substances emitted through industries especially (“Effects of Land Pollution,” n.d.).

In the Philippines, solid waste management is still quite difficult, particularly in cities like Metro Manila. The Philippines is the fourth-largest producer of solid trash among ASEAN member nations, with an annual total of 14.66 million tonnes of Municipal Solid trash (MSW) generated, according to a 2017 UNEP report. In a similar vein, according to World Bank estimates, the Philippines produced 14.6 million tonnes of MSW in 2016. The Philippines' MSW generation increased to 15.8 million tonnes by 2019, and the World Bank predicts that it would reach 20.0 million tonnes by 2030, a 37% increase from 2016. About 40 to 85% of the solid trash produced nationwide is collected, compared to 85% in Metro Manila (Pollution: Philippines Interactive Country Fiche*s*, n.d.).

Underserved or unserved areas are found in the poorer parts of cities, municipalities, and rural barangays. Many uncollected waste winds up in rivers, estros, and other bodies of water, contaminating them and blocking drainage systems, which causes flooding during periods of intense precipitation. Due to the scarcity of hygienic landfills and controlled dumpsites, open dumping continues to be the predominant method of disposing of trash in the nation. 108 controlled dumpsites were operational as of 2016, but 403 open dumpsites remained. People who reside in or close to landfills are susceptible to several illnesses (Karasik & Schachter, 2022).

***Solution on Land Pollution***

Due to the waste humans have produced on Earth over the years, the amount of garbage generated each year continues to increase alongside population growth. As a result of these environmental issues, the number of related cases and problems has also risen. These problems can be solved in three ways: the traditional way, modern way, and automatic way.

**Traditional & Modern Solutions.** Pollution can be effectively

addressed by integrating both traditional and modern solutions such as practicing the 3Rs (reduce, reuse, recycle), composting organic waste, adopting organic farming methods, engaging in reforestation and afforestation, using reusable bags to minimize plastic waste, implementing waste-to-energy technologies, utilizing incineration for safe waste disposal, providing accessible garbage bins for proper waste segregation, and managing landfills efficiently to minimize environmental impact. By combining these approaches in sequence, we can create a comprehensive and sustainable strategy for combating pollution.

***Reduce, reuse and recycle.*** The 3Rs—Reduce, Reuse, Recycle—are considered the most effective approach to waste management because they address waste at its source and prioritize preventing waste before it is created, which has the greatest positive impact on the environment and resource conservation. The 3Rs (reduce, reuse, recycle) are practiced by between 30 and 40 percent of people worldwide, with recycling and reuse being particularly prevalent in urban regions and higher-income nations (Anderson et al., 2021). Just like United Nations that promoted the solution “3Rs” which stands for reduce, reuse and recycle. Reducing waste is one of the most important strategies to address land contamination. 'Reduce, reuse, recycle' is still a good rule! Pollution can come from both managed waste (like properly disposed of trash) and mismanaged waste (like litter). Recycling as much as you can and utilizing reusable items like shopping bags, straws, and water bottles will help lessen the effects of trash and littering. As waste products decompose, toxins may be released into the soil, as well as into the air and water. By clearing garbage from our ecosystems, taking part in beach and park clean-ups can also be beneficial. Pressuring big businesses to cut back on their waste is another approach to help, since industrial waste accounts for a significant amount of the annual rubbish production (Zinni, 2022).

In the Philippines, community initiatives, government legislation, and business sector involvement work together to execute the "Reduce, Reuse, and Recycle" (3Rs) concepts. A legislative framework is provided by the Ecological Solid Waste Management Act of 2000 (Republic Act 9003), which requires local government entities to implement integrated waste management plans founded on the three Rs. This covers the construction of materials recovery facilities as well as trash segregation at the source. With projects like recyclable exchange stations and collaborations with businesses to turn plastic trash into valuable products, community-based recycling programs are also becoming more popular. Notwithstanding obstacles including rising trash production and inadequate recycling facilities, efforts to promote sustainable waste management techniques are making headway (Greenpeace Philippines, n.d.).

The Philippines' Region 6 has improved waste management and environmental sustainability by implementing the Reduce, Reuse, and Recycle (3R) principles through a number of programs. The creation of Materials Recovery Facilities (MRFs), which are essential to the area's waste management system, has been one important strategy. By separating recyclables, composting biodegradable garbage, and lowering the amount of leftover waste that is dumped in landfills, these facilities are made to handle mixed waste. Materials Recovery Facilities function at various scales, ranging from modest barangay-level establishments to more extensive, urban, semi-automated, or mechanized systems. They assist in formalizing recycling procedures and incorporating waste pickers from the unorganized sector into the system. Additionally, the area supports neighborhood-based programs for recycling and waste reduction. These include urging people and companies to sell recyclables to junk shops, reuse products like glass jars and plastic containers, and separate garbage at the source. Campaigns for education increase knowledge of appropriate recycling and trash segregation procedures (“Reduce, Reuse and Recycle,” 2023).

Implementation efforts have been further reinforced by 3R pilot projects. Through measures like limiting the use of single-use plastics, repurposing items through community activities, and improving recycling infrastructure, these projects aim to reduce the amount of waste generated. Their goal is to present regionally applicable, scalable strategies for sustainable garbage management. By taking these steps, Region 6 is aiming to create a waste management system that is more effective and sustainable while also meeting national environmental objectives (*Achieve Zero Waste*, 2023).

In Iloilo, the implementation of Reduce, Reuse, and Recycle principles is part of a broader strategy that incorporates additional practices like Repurpose and Rot, collectively known as the 5Rs. The city has launched a comprehensive 5Rs campaign as part of the National Zero Waste Month celebrations, emphasizing reducing waste, reusing items, recycling materials, repurposing waste into new products, and composting organic waste to minimize landfill waste. One notable initiative is the Tapon to Ipon Project, a collaboration with Coca-Cola Beverages Philippines aimed at collecting and recycling polyethylene terephthalate (PET) bottles. Collection hubs have been established across various municipalities to ensure these bottles are properly processed and reused (Oladive, 2025).

The Balik Alat Program, which promotes the use of environmentally friendly substitutes for single-use plastics, such handwoven baskets, has also been put into place in Iloilo. According to recent estimates, 38 of Iloilo's 43 local government units have put rules governing single-use plastics into effect, indicating a strong commitment to minimizing plastic waste. The Trash in a Bottle Program also reduces plastic waste and demonstrates the possibility of converting trash into resources by reusing used plastic bottles into useful products. Programs such as Limpyo Dalanon (tidy roads), which encourage communities to tidy public spaces and promote a better environment, further improve community engagement (*Iloilo Promotes 5Rs*, n.d.).

These programs have a strong emphasis on education, holding frequent workshops and demonstrations to impart useful waste management skills and increase public understanding of the value of sustainable practices. By putting in place modular sewage treatment plants and trash diversion plans, Iloilo City has also taken action against plastic pollution by keeping plastic debris out of water systems. All things considered, Iloilo's waste management strategy demonstrates a dedication to community involvement and environmental sustainability, making it a regional leader in efficient trash management (Lena, 2024).

Reduce, Reuse, and Recycle initiatives are a component of a larger plan to improve solid waste management in Lambunao, Iloilo. The provincial government has given the municipality substantial help, including a grant of PHP 10 million for programs related to solid waste management. The province's overarching plan to maximize resource use and reduce environmental effect is in line with this financing, which is intended to enhance garbage collection, treatment, and disposal infrastructure. With a "Very Satisfactory Performance" in recent evaluations, Lambunao has received recognition for its efforts in environmentally friendly and sustainable solid waste management. One of the town's projects is the installation of efficient garbage collection and segregation systems, which are essential for encouraging recycling and lowering the amount of waste dumped in landfills. Another important element is community involvement, with locals actively taking part in trash management initiatives and educational campaigns to promote sustainable behaviors (*Iloilo Towns Hailed for Waste Management*, n.d.).

The establishment of Materials Recovery Facilities (MRFs) is another important aspect of Lambunao's waste management strategy. These facilities help sort and process recyclable materials efficiently, ensuring that waste is handled in an environmentally sound manner. By integrating these practices, Lambunao contributes to Iloilo's broader goal of achieving sustainable waste management and reducing environmental pollution (*Lambunao Joins Waste Month Celebration*, 2024).

***Waste Segregation.*** Waste segregation is the second most effective practice because it enables efficient recycling, composting, and safe disposal by separating waste into categories at the source. This reduces landfill use, prevents pollution, protects public health, lowers waste management costs, and supports sustainable waste handling. Without segregation, other waste reduction methods cannot work effectively. About twenty-five to thirty-five percent of people globally adopt waste segregation; proportions are lower in low-income areas and greater in wealthy nations. (Velhal, 2025).The practice of classifying garbage into distinct groups according to its attributes, including its chemical, physical, and biological makeup, is known as waste segregation. Because it makes it possible to compost organic waste and recycle non-biodegradable materials, this method is essential for efficient waste management. Garbage segregation can drastically cut down on the quantity of garbage dumped in landfills, lowering the dangers to human health and the environment from inappropriate waste disposal. For example, recycling and composting are made simpler when wet trash (such as food scraps) and dry waste (such as paper, plastic, and glass) are separated. Using distinct bins for different trash types—for example, blue bins for dry garbage and green bins for wet waste—is one way to accomplish this at home (Eda, 2023).

Waste segregation is a globally recognized practice essential for effective solid waste management. Cities and communities worldwide adopt various models to address local challenges and promote sustainability. For instance, Panaji, India, has implemented an innovative 16-way segregation system that separates waste streams like e-waste, paper, glass, and ceramics at the source. This approach has drastically improved recycling rates and reduced landfill dependency while generating revenue for waste generators and workers. Behavioral drivers like financial incentives, community awareness, and social networks play a crucial role in fostering sustainable practices, but obstacles like political interference and inadequate legislative frameworks impede progress. In contrast, studies conducted in low-income areas like Kampala, Uganda, highlight the need for infrastructure like labeled bins and supportive policies to encourage segregation (*Sixteen-ways of Segregating Waste*, n.d.).

Republic Act 9003, also known as the Ecological Solid garbage Management Act of 2000, requires garbage segregation in the Philippines. According to this rule, garbage must be separated at the source into categories including residual, recyclable, compostable, household hazardous, and domestic healthcare wastes. Solid waste management is still quite difficult, and many local government units (LGUs) find it difficult to implement appropriate segregation procedures in spite of this legislation. These issues are exacerbated by insufficient infrastructure and households' ignorance of the value of segregation. For example, a lack of funding and poor infrastructure, such as the lack of sanitary landfills once open dumpsites are closed, make it impossible for many LGUs to implement waste management strategies. Several measures have been put in place to solve these problems. Participation from the community has been successful in enhancing trash management procedures. The municipality of Los Banos, for instance, has demonstrated how political will and citizen involvement can greatly improve garbage segregation and recycling programs. There are also continuous initiatives to teach the public—children in particular—about appropriate trash segregation. The goal of resources like the Department of Environment and Natural Resources’ (DENR) Basura Buster app is to make trash management education interesting and approachable. It's also critical to enforce current rules and ordinances more strictly. Local Government Units are urged to set aside enough funds and put laws in place that encourage recycling and garbage segregation. The Philippines can get closer to attaining efficient waste management and lowering environmental pollution by integrating policy execution, community involvement, and education (*Intensified Environmental Protection,* 2024).

Considerable progress has been made in solid waste management in Region 6 of the Philippines, generally referred to as Western Visayas. With the exception of Madalag and Altavas towns in Aklan province, almost all local government units (LGUs) in the area have passed 10-year solid waste management plans. These plans act as a manual for handling and getting rid of recyclable, residual, and biodegradable waste. To assist these LGUs in completing their plans, the Environmental Management Bureau (EMB) Region 6 offers technical assistance. In keeping with the region's emphasis on sustainable practices, bio-shredders and composters have also been distributed to help with garbage breakdown. Nonetheless, there are still issues, such as the requirement for adequate finance and infrastructure for sanitary landfills (*Solid Waste Management Orientation*, 2023).

Waste management and segregation have grown in significance in Iloilo as the city and province work to solve environmental issues. "Limpyo Iloilo for MoRProGRes," a comprehensive strategy executed by the provincial administration of Iloilo, is in line with the Solid Waste Management Plan for 2017–2026. Projects like the TAPON TO IPON Project, which targets clear plastic bottles, and the BALIK-ALAT Project, which encourages the use of reusable bags and alternative packaging, are part of this program. Furthermore, the "Limpyo sa Dalanon" initiative coordinates road safety and cleanliness at the barangay level with environmental cleanup efforts. Significant progress has also been made in trash management in Iloilo City. From basic collection and disposal, the city has stepped up its efforts to include more environmentally friendly methods including recycling, trash reduction, reuse, and the construction of sanitary landfills. In order to manage organic waste and produce power, the city recently began construction on an Integrated Solid Waste Management Facility (ISWMF), a waste-to-energy project that uses anaerobic digestion. In addition to perhaps growing to service nearby communities, this facility seeks to lessen the city's need for conventional landfilling techniques. In order to lessen its effects on the environment, Iloilo's waste management policy incorporates source reduction, collection, treatment, and disposal in a comprehensive manner (Lena, 2025).

Local efforts to enhance environmental sustainability in Lambunao, Iloilo, have focused on solid waste management. The provincial government has given the municipality a substantial amount of funding, allocating PHP 10 million for solid waste management initiatives. In line with the "Limpyo Iloilo for MoRProGRes" project, this financing is a component of Governor Arthur Defensor Jr.'s larger initiatives to improve waste management throughout the province of Iloilo. Lambunao is known for its excellent solid waste management techniques, such as running a sanitary landfill that other towns can use as a template. Students from Western Visayas State University are among the groups that have visited the landfill to examine and absorb its efficient trash management techniques (Sornito, 2024).

***Composting.*** Composting is ranked the third most effective

waste management method because it significantly reduces the volume of organic waste sent to landfills—by about 40–50%—thereby lowering methane emissions, a potent greenhouse gas produced in landfills. It transforms food scraps and yard waste into nutrient-rich soil amendments that improve soil health, increase carbon sequestration, enhance water retention, and reduce the need for chemical fertilizers and pesticides. Composting also helps remediate contaminated soils and supports sustainable agriculture and urban green spaces.The organic matter in garbage is naturally broken down by a biological process called composting. The compost product that is produced may be returned into the soil, which lowers the requirement for fertilizers and landfill methane emissions. Composting is one method to lessen the harmful effects of the 2.5 billion tons of food that are thrown away each worldwide. Although advantageous, composting only works with organic materials; it has no effect on non-biodegradable trash, which still makes up most of our landfills. Additionally, there aren't many incentives for consumers to participate in composting programs. Because they lack access to a garden or must pay more for council-led green recycling programs, 97% of UK homes do not compost (Davison, 2024).

In the Philippines, composting is a crucial component of the nation's attempts to manage garbage responsibly. Local governments are required under the Ecological Solid Waste Management Act of 2000 (RA 9003) to divert a minimum of 25% of solid waste from landfills by means of resource recovery operations such as composting, recycling, and reusing. This law offers a structure for putting composting programs into action nationwide. To encourage composting, a number of noteworthy projects and efforts have been put into place. To support farmers and encourage sustainable waste management, for example, a composting plant was opened in Legazpi City, Bicol, to convert garbage into organic fertilizers. The Japan International Cooperation Agency (JICA) is funding this project, which intends to greatly expand waste processing and give local farmers an affordable substitute for chemical fertilizers (*Composting Facility in Bicol*, n.d.).

To keep biodegradable garbage out of landfills, Metro Manila marketplaces like Kamuning and Pasay Public Market have started composting programs. These initiatives show a comprehensive approach to resource use by reducing trash and assisting neighborhood urban farming and gardening initiatives. In order to enable homes and sectors to efficiently manage organic waste, the Mother Earth Foundation has been instrumental in encouraging community-based composting throughout the Philippines. To boost local economies through compost sales, the Bureau of Soils and Water Management (DA-BSWM) of the Department of Agriculture has also created standards for compost production and a buy-back program. These programs demonstrate the Philippines' dedication to composting as an essential tactic for environmentally friendly waste management (*Managing Market Waste*, 2023).

Composting has been used in Region 6 as part of larger solid waste management initiatives to encourage sustainability and lessen reliance on landfills. In accordance with the requirements of the Ecological Solid trash Management Act of 2000 (RA 9003), local government units (LGUs) are actively engaged in the establishment of composting facilities to convert biodegradable trash into organic fertilizers. These programs, which encourage homes and barangays to use compost pits and separate organic waste, are sometimes combined with community-based activities (Guadalquiver, 2023).

For instance, through informational campaigns and seminars aimed at enhancing capacity, DENR Region 6 has highlighted appropriate waste management techniques, such as composting. By providing nutrient-rich soil amendments for agriculture and lowering methane emissions from organic waste decomposing in landfills, these initiatives seek to inform communities about the advantages of composting. Composting is also a component of integrated solid waste management techniques used in projects like 3RproMar Philippines, which are implemented in Guimaras Island under Region 6 in order to stop trash leaks and safeguard marine habitats (*Intensified Environmental Protection,* 2024).

Composting is a key component of the waste management strategy in Iloilo. The sorting and processing of organic waste is one of the many programs the local government has put in place to encourage composting. For example, a composting project in Calahunan village generates six to eight tons of compost every week, which is then given to barangays and schools for organic gardening. This strategy supports sustainable activities and the overarching objective of lowering the amount of garbage dumped in landfills. The Iloilo City Environment and Natural Resources Office (CENRO) has emphasized the importance of managing organic waste at the household or barangay level, encouraging residents to segregate organic materials for composting. Additionally, the city's solid waste management system integrates composting with recycling, recognizing that composting is a responsible technical solution for managing organic waste, especially in developing cities (Lozada, 2025).

***Organic Farming.***Organic farming is highly effective

because it promotes sustainable waste management that enhances soil fertility, reduces pollution, and minimizes reliance on synthetic fertilizers and chemicals. By repurposing organic waste such as crop residues, animal manure, and spoiled crops through composting, vermicomposting, and biogas production, organic farming improves soil health, water retention, and microbial activity, leading to healthier crops and higher productivity. It also prevents harmful substances from contaminating soil and water, protecting ecosystems and human health. The approximate effectiveness of this practice is about 5 to 8 percent because it encourages the use of less chemicals, recycles organic waste into soil, and supports sustainable agriculture Organic farming has become a significant global movement, emphasizing sustainable agricultural practices that avoid synthetic chemicals, genetically modified organisms (GMOs), and other harmful substances. As of 2023, the global organic farming area expanded to nearly 99 million hectares, with a notable increase in Latin America and Africa, where organic farmland grew by 10.8% and 24%, respectively. The global market for organic products reached approximately 136 billion euros, driven by consumer demand for healthier and more environmentally friendly food options. Improved soil fertility, biodiversity preservation, and less water pollution are just a few of the environmental advantages of organic farming. With programs like the European Organic Awards honoring pioneers in organic farming and advancing sustainable food systems, the European Union has been very helpful. The importance of organic farming in combating climate change, biodiversity loss, and water conservation will be emphasized globally at events like the Organic Summit 2025 in Copenhagen (IFOAM Organics Europe, 2025).

Over the past ten years, organic farming in the Philippines has garnered a lot of interest and support, especially after the Organic Agriculture Act of 2010 (Republic Act No. 10068) was passed. The National Organic Agriculture Program (NOAP) was created under this statute with the goal of advancing and developing organic farming methods across the country. By eliminating synthetic chemicals and genetically modified organisms (GMOs) in agricultural production, the program aims to improve soil fertility, boost farm productivity, lower pollution, and safeguard public health. According to recent statistics, at least 107,911 hectares of agricultural land have been turned over to organic farming; between 2011 and 2015, the number of organic farmers increased by 400%, and there are currently over 43,000 organic farmers. Notwithstanding these developments, there are still issues that small-scale farmers may find prohibitive, such as the high expense of organic certification and the difficulty of preserving it (Center for International Trade, n.d.).

Organic farming in the Philippines' Region 6, or Western Visayas, has advanced

significantly. With a noteworthy accomplishment of hitting almost 90% of its target for organic farming areas in 2019, the region has received recognition for its exceptional performance in organic agriculture. Western Visayas aims to convert 32,231 hectares of its 460,456 hectares of agricultural land to organic farming; by the first quarter of 2019, 28,976 hectares had been converted. In Panay and Guimaras, part of Region 6, there are over 3,600 identified organic agriculture practitioners. These farmers face challenges like certification costs and marketing difficulties, but they contribute significantly to the region's organic production. The region's efforts in organic farming not only promote sustainable agriculture but also contribute to environmental conservation and public health by reducing the use of chemicals in farming practices. The National Organic Agriculture Program (NOAP) of the Department of Agriculture offers farmers in the region substantial support, including inputs like seeds and fertilizers, machinery, and training to improve their skills (Momblan, 2019).

Organic farming has been steadily gaining popularity in Iloilo, but it is still lagging behind neighboring Region 6 provinces like Negros Occidental. Iloilo has long been referred to as the "rice granary of the Visayas," but because farmers must balance conventional and organic methods, the transition to organic practices has been gradual. The Cabatuan Organic Farmers and Practitioners Association (COFPA), which has been approved as a Participatory Guarantee System-Organic Certifying Body (PGS-OCB), is one encouraging development, nevertheless. Their organic products are sought after by health-conscious consumers, and this accreditation enables them to certify them, allowing them to sell at premium pricing. Additionally, by turning trash into useful items like fertilizers, cutting-edge farms like the Concepcion Carillo Agricultural Farm (CFARM) in Bingawan show off the possibilities of organic farming and boost farmers' incomes. Notwithstanding these developments, obstacles still exist, such as the high price of organic certification and the requirement for additional local government assistance to spread organic farming methods. Nonetheless, Iloilo's organic farming sector continues to grow, driven by initiatives that promote sustainable agriculture and improve market access for organic produce (*Cabatuan Organic Farmers*, n.d.).

Organic farming is a fundamental part of the agricultural culture in Lambunao, Iloilo.Rice is the main crop of the municipality, which has a level topography and clay soil. As a tradition, organic farming is the most common practice among farmers in Lambunao, with a focus on preservation techniques that preserve biodiversity and soil health. This strategy is in line with the more general objectives of agroecological preservation, which center on environmentally friendly farming practices that steer clear of artificial chemicals. By adopting natural techniques to improve soil fertility, like composting with nitrogen-fixing plants like agoho and madre de cacao, the Lambunao Natural Farmers Association significantly contributes to the promotion of these practices. The association's initiatives demonstrate how crucial organic farming is to preserve the natural equilibrium and bolstering regional economies (Ferrer, 2018).

***Reforestation.*** Reforestation activities involve roughly 5

to 10% and 3–7% of people, respectively, often through community or government programs. It only works with a group, organization, or community, yet it enhances biodiversity, restores ecosystems, and sequesters carbon. Reforestation is the process of reestablishing forests that have been damaged or degraded as a result of wildfires, deforestation, or other natural and human-caused events. In order to combat climate change, improve biodiversity, and rebuild ecosystems, it is essential. Since trees absorb carbon dioxide and lower greenhouse gas emissions, they serve as carbon sinks, making climate change mitigation one of the main goals of reforestation. Reforestation also aids in ecosystem stabilization, soil erosion prevention, water cycle restoration, and wildlife habitat provision. Forests sustain economic activities such as the production of timber and give communities a means of subsistence. Numerous nations throughout the world have started extensive reforestation initiatives. For instance, in an effort to counteract desertification, China's "Great Green Wall" plans to plant 90 million acres of forest by 2050. People in India have taken part in large-scale tree planting events; in 2017, for example, 66 million trees were planted in a single day. Initiatives to plant more than 100 million trees a year have also been started in New Zealand. Although replanting makes a substantial contribution to carbon sequestration, it takes decades for the advantages offered by mature trees to be equaled. As a result, preserving existing primary forests frequently improves the climate more than reforestation alone. In conclusion, reforestation is a crucial instrument for climate mitigation and ecological restoration, but for its full impact, it must be combined with a decrease in deforestation and the preservation of intact forests (*What Is Reforestation and Forest Restoration?,* 2024).

Because of the Philippines' substantial loss of forest cover over time, reforestation activities are essential. The Philippines used to have enormous forests, but by 2010, almost 60% of that cover had been lost, leaving only 6.84 million hectares of forestlands remaining, down from 16.90 million hectares in 1934. The government has started a number of steps to solve this. In 2011, the National Greening Program (NGP) was launched with the goal of planting 1.5 billion trees to restore 1.5 million hectares of forestlands. However, the initiative encountered difficulties as a result of poor planning and support from stakeholders, which resulted in the waste of resources. President Rodrigo Duterte's Enhanced National Greening Program (eNGP), which has been extended until 2028, aims to restore all of the remaining damaged, barren, and unproductive forestlands (Cabico, 2023).

Reforestation initiatives have also benefited greatly from the involvement of the corporate sector. For instance, the BINHI Project of the Energy Development Corporation is acknowledged as the biggest private-sector forestry initiative in the Philippines. By planting around 7 million native trees, BINHI has restored approximately 10,140 hectares of degraded forest lands. Additionally, this approach has prevented the extinction of 145 endemic tree species. Other projects, such as the Forests for Life Initiative backed by firms like First Philippine Holdings (FPH), involve planting trees in crucial locations and watersheds across numerous provinces, including Ilocos Norte, Rizal, Leyte, Bataan, Bukidnon, and Lanao del Norte (*DENR’s ‘Forests for Life’ Initiative*, n.d.).

Reforestation initiatives are being undertaken in the Philippines' Region 6, which encompasses Western Visayas, in order to counteract the notable loss of forest cover. Under the Enhanced National Greening Program (ENGP), the Department of Environment and Natural Resources (DENR) has set lofty goals, with the goal of reforesting 309,000 hectares in the area by 2028. More than 118,982 hectares have already been planted in Western Visayas since the program's launch in 2011, increasing the region's total area covered by forest cover to 12.89%. The DENR stresses the value of both forest protection and reforestation, pointing out that in addition to planting trees, natural regeneration is essential. In the area, creative reforestation methods are also being investigated. For example, the "Re-Greening of Panay" initiative of the Sulu Garden Foundation employs drone distribution and seed ball technology to restore forests on Panay Island, which has been severely affected by deforestation. This strategy combines cooperation with local stakeholders, such as the Philippine Army and provincial governments, and enables effective coverage of sizable, challenging-to-reach areas. Furthermore, regeneration efforts throughout the region are still supported by government-led events like tree plantings and community-based projects (*Re-greening of Panay*, 2025).

Reforestation initiatives in Iloilo are accelerating as the province strives to become a "Forest Province" by 2044. Under the direction of Governor Arthur Defensor Jr., the province administration has started a number of projects to increase forest cover and advance environmental sustainability. One important tactic is the "Tanum Iloilo for MoRProGRes" program, which focuses on developing green spaces, restoring watersheds, and planting trees. With a 44.42% survival rate, the program has already planted approximately 8.3 million seedlings as of 2024. Additionally, "Project LISO" encourages community involvement in cultivating native trees and fruits, improving biodiversity and environmental stewardship, and "Balik Alat 2.0" promotes the use of woven baskets over plastic bags. Additionally, Iloilo City regularly participates in reforestation initiatives. To fight climate change, the local administration intends to plant about 100,000 trees a year, with an emphasis on collaborating with other industries for these tree-growing projects. In order to ensure a more planned and strategic approach, a task force has also been established to supervise tree-planting initiatives throughout the city. In order to provide shade and enhance the city's aesthetics, trees should be planted beside bike lanes and other public areas (Sornito, 2024).

Reforestation initiatives are being carried out in Lambunao, Iloilo, to solve environmental issues and advance sustainability. The Handumanan reforestation project, which is a joint effort between West Visayas State University (WVSU) and Global Business Power Corporation (GBPC), is one noteworthy project. By planting carbon-sink trees on 150 hectares of mountain land in WVSU's reserve forest, this project seeks to slow down global warming. Additionally, the project incorporates a work-for-study program that promotes education and community involvement for locals whose children are enrolled at WVSU. Lambunao is also a part of the Department of Environment and Natural Resources' (DENR) Forestland Management Project (FMP) for the Jalaur River Basin, which is sponsored by the Japan International Cooperation Agency (JICA). New tree and agroforestry plantations have been established as a result of this initiative, which also involves reforestation efforts to expand the amount of forest cover. By building infrastructure including pathways, hanging bridges, and irrigation systems, the FMP also prioritizes community development by enhancing upland communities' access to essential services and boosting their economic activity (Lena, 2024).

***Afforestation.***Afforestation is also the same as

reforestation but it is the creation of forests in regions that have no prior tree cover for at least 50 years is known as afforestation. In order to turn unforested land into wooded areas, this method entails planting trees or encouraging natural seed sources. Agroforestry, tree plantations, and natural regeneration are the three main forms of afforestation. Planting native trees is the main goal of natural regeneration in order to improve carbon sequestration and establish new ecosystems. By combining the planting of trees with agricultural practices, agroforestry preserves ecological balance while yielding harvestable crops like fruits and nuts. Tree plantations provide an alternative to clearing wild forests because they are made to produce wood (Cherlinka, 2024).

Numerous environmental advantages of reforestation include reducing soil erosion, flooding, and landslides; improving local climates through enhanced rainfall and wind barriers; and mitigating climate change through carbon absorption. Additionally, it supplies wood products, creates jobs, and establishes wildlife habitats. To maintain resistance against climatic impacts, successful afforestation necessitates careful site selection and the selection of tree species appropriate for the local climate and soil conditions. Notwithstanding its benefits, afforestation has come under fire for possibly upsetting non-forest habitats that sustain distinctive biodiversity and store carbon underground, such as savannas and grasslands. According to critics, turning these regions into trees may cause habitat fragmentation and a decline in biodiversity outside of the planted zones. Nonetheless, afforestation initiatives have been put in place by nations including the US, Canada, Israel, Australia, China, and India to improve carbon dioxide removal from the atmosphere and fight desertification. Afforestation is a potent instrument for restoring the environment, but it needs to be tempered with measures that protect already-existing ecosystems that are essential to sustainability and biodiversity worldwide (*Sustainability*, 2025).

Because of the Philippines' substantial loss of forest cover over time, afforestation and replanting initiatives are essential. The Philippines used to have enormous forests, but by 2010, almost 60% of that area had been lost, leaving only 6.84 million hectares of forest cover, down from 16.90 million hectares in 1934. The government started the National Greening Program (NGP) in 2011 with the goal of planting 1.5 billion trees on 1.5 million hectares in order to remedy this. The initiative, which was later extended to 2028, aims to restore 7.1 million hectares of degraded, denuded, and unproductive forests. The NGP has planted around 1.83 billion seedlings on 2.18 million hectares of land as of 2022. Afforestation operations also heavily rely on private sector activities. For example, by planting around 7 million native trees, the Energy Development Corporation's BINHI Project has restored over 10,140 hectares of degraded forest lands and assisted in the rescue of various endangered species. Furthermore, groups like Haribon started the Forests for Life campaign, which has included local communities in forest restoration and planted more than a million native trees. By planting native tree species, Evertreen's Philippine Tropical Reforestation Project aims to restore damaged forest regions while fostering ecological resilience and biodiversity. In addition, Eden Reforestation has set up landscape restoration locations in isolated regions, working with nearby communities to build nurseries for the production of seedlings and restore forests (*The Philippines’ Battle Against Deforestation*, 2023).

***Reusable Bags.*** Internationally, reusable bags are used to

decrease single-use plastic waste, promote sustainability, and encourage ecologically responsible consumer behavior, reusable bags have gained traction as governments and organizations strive to combat plastic pollution and promote sustainable shopping practices (Evans, 2022*).* About twenty to thirty percent of the population uses reusable bags. It increases with bans on single-use plastic bags; higher in urban and environmentally conscious areas. Reusable bags are now widely recognized as an essential instrument for lowering plastic waste and advancing sustainability. Many nations have put laws into place to prevent people from using single-use plastic bags and to encourage them to use reusable ones instead. China, for example, outlawed free plastic bags in 2008 and plans to drastically reduce the use of plastic bags by 2025. In 2022, Germany outlawed single-use plastic bags, encouraging the usage of reusable bags as an environmentally friendly alternative. In a similar vein, Japan levies fees for plastic bags to curb usage. With China leading the world in production and accounting for around 25% of global output, the market for reusable bags is substantial. Reusable bags are becoming more and more popular worldwide as part of a larger movement towards a circular economy, in which goods are made to be recycled and reused. Brands like Patagonia and Ingvar Kamprad, Elmtaryd, Agunnaryd (IKEA) have successfully shifted to reusable bags, providing a positive example for sustainable practices (Evans, 2022).

By encouraging the use of refill systems and reusable bags as alternatives to single-use plastics, the Philippines has been aggressively tackling its plastic waste problem. As part of initiatives to lessen plastic waste and encourage sustainable practices, reusable bags have grown in popularity in the Philippines. Numerous programs have been implemented throughout the nation to promote the use of reusable bags, especially in the retail industry. For example, popular retailer Upson has done away with single-use plastic and paper bags and switched to reusable bags throughout its locations. This change is in line with larger national initiatives to lessen the pollution caused by plastics (*Eco-Friendly Paper Bags*, n.d.).

Reusable bags are encouraged as a means of reducing plastic waste and promoting environmental sustainability in Region VI (Western Visayas) and beyond (Lozada, 2025). The proposed "Plastic Bags Regulation Act," among other legislative initiatives, aims to control the use of plastic bags and encourage the adoption of reusable alternatives. In addition to meeting certain durability requirements, such as being able to carry 10 pounds 125 times over a minimum of 50 meters, this act attempts to guarantee that reusable bags are constructed from materials including cloth, cotton, and recycled materials. The act also encourages point-of-sale retailers to advertise and give customers reusable bags, either for free or at a fair price. There may be smaller-scale or community-driven programs in Region 6 that concentrate on sustainable materials like buri or banig, which are traditional Filipino materials, in terms of local manufacturing or particular activities. These materials might be used to create reusable bags, which would support national initiatives to encourage eco-friendly behavior and lessen the usage of plastic. However, the sources listed do not readily provide particular information regarding suppliers or large-scale reusable bag projects in Region 6 (Lozada, 2025).

Numerous programs and goods pertaining to reusable bags are available in Iloilo, representing regional and national sustainability trends. For example, The Marketplace at Festive Walk Iloilo sells eco-friendly bags, such as a nonwoven sando bag for ₱15 and a canvas reusable bag for ₱149. Eco bags are also listed as one of Papermints' items in SM City Iloilo, albeit no particular information is given about them. Iloilo City has put policies in place to reduce the use of plastic. The city encourages citizens to bring their own reusable shopping bags by prohibiting single-use plastics from city hall and public parks. This regulation is in line with larger national initiatives to encourage eco-friendly behavior and lessen the pollution caused by plastic. Overall, inhabitants of Iloilo have access to a range of reusable bag options and are encouraged to adopt eco-friendly activities by local policies, even though precise local production details may be limited (*Single-use Plastics Banned From City Hall*, 2020).

In addition to encouraging people to use reusable bags, the Lambunao Public Market will forbid the needless single-use of plastics as of July 1, 2024. By outlawing the needless use of single-use plastics in the Lambunao Public Market as of July 1, 2024, Lambunao is taking a significant step to reduce plastic waste. The public is urged to shop at the market using their own reusable bags as part of this initiative. By encouraging eco-friendly behaviors like the use of reusable bags, this program seeks to address environmental problems including pollution and inefficient waste management. Although there are no specifics regarding the availability or local production of reusable bags in Lambunao, the promotion of their use is consistent with larger national sustainability trends. Communities may look for ways to produce or purchase reusable bags from surrounding regions, promoting local economic growth and environmental preservation (*Single-use Plastics Banned From City Hall*, 2020).

***Waste-to-Energy.*** Another solution implemented by the

government is waste-to-energy.In order to reduce waste and conserve energy in other areas, waste-to-energy (WtE) converts waste into energy, such as heat or electricity. Co-processing is a popular method in which organizations use combustion to turn waste into energy and raw materials; this has proven especially helpful in the cement industry and is an efficient way to deal with contaminated trash from recycling. Additional tactics include gasification, which involves combining waste with oxygen or steam to create fuel or fertilizer. According to one study, waste-to-energy plants can reduce waste volume by as much as 87%, making them an excellent option to reduce the amount of space occupied by trash. However, it's also by no means a panacea. Although the quantity of carbon emissions associated with this activity varies depending on the material, it is nevertheless a significant contributor to climate change. Zero Waste Europe claims that WtE-related CO2 emissions have risen over the past 10 years, mostly as a result of the practice's increased adoption and promotion by more businesses (Davison, 2024).

In the Philippines, the use of Waste-to-Energy (WtE) technologies is becoming more popular as a possible way to meet energy demands and solid waste management. The first WtE facility in the nation was authorized by the Department of Energy (DOE) in Palawan, and there are plans for more projects, including facilities in Cebu and Pangasinan. WtE projects, however, entail trade-offs between higher emissions and waste disposal, which raise questions about their conformity with environmental regulations and the Paris Climate Accord. Despite these obstacles, supporters contend that WtE can assist in reducing the nation's serious waste management problems, as it is anticipated that 23.61 million tons of solid garbage will be produced by 2025 (ASEAN CENTRE FOR ENERGY, 2023).

In an attempt to solve the issue of solid waste while offering a substitute energy source, Senate President Juan Miguel Zubiri has introduced a measure to create a national framework for WtE technologies. This law incorporates protections to guarantee environmental safety and aims to categorize WtE as a renewable energy resource. The passing of the bill is thought to be essential to establishing WtE as a practical solution for handling the Philippines' expanding waste and promoting energy security. Environmentalists and analysts, however, warn that WtE shouldn't take precedence over initiatives to enhance recycling and waste reduction methods, stressing the necessity of a well-rounded strategy that gives sustainable waste management equal weight with energy production (Abasola, 2023).

Considerable progress has been achieved in the implementation of Waste-to-Energy (WtE) technologies in Region 6, particularly in Iloilo City. Under a public-private partnership (PPP) plan, the municipal administration plans to build a WtE facility as a component of a larger Integrated Solid Waste Management Facility (ISWMF). This PHP 2.3 billion facility is anticipated to handle 475 tons of garbage per day and will be built in Barangay Ingore, La Paz district. The project will produce 3.5 megawatts of electricity and convert waste into biogas and refuse-derived fuel, both of which the DOE considers renewable energy sources (Herrera, 2024).

Although the use of Waste-to-Energy (WtE) technology is not as widespread in Iloilo as other waste management techniques, the area is actively working to improve solid waste management procedures. Comprehensive programs like Limpyo Iloilo for MoRProGRess, which emphasize trash collection, treatment, disposal, and source reduction, have been started by the provincial administration. This program includes initiatives like Tapon to Ipon and Balik-Alat, which recycle PET bottles and reduce single-use plastics, respectively (Castor, 2024).

Additionally, Iloilo City has implemented programs like TRASHkolekta, which teaches students about waste management by turning waste into a source of income, encouraging the collection and trading of recyclable materials. These initiatives demonstrate Iloilo's proactive approach to waste management, although WtE technologies are not yet a central focus (Castor, 2024).

***Incineration.*** According to Davison (2024), incineration is one of the ways to lower the amount of garbage produced. Waste is destroyed in a furnace using high temperatures in disposal incineration. Because the energy isn't recycled, it has fewer advantages than waste-to-energy methods. Although this kind of incineration lowers the amount of waste produced, it has a significant negative impact on the environment since it emits toxic chemicals and carbon dioxide into the atmosphere. Although many nations are attempting to prioritize WtE methods over conventional incineration, the latter is still widely used. For instance, 7 million tons of garbage were burned in 2018, and 7.4 million tons were shipped to a WtE plant in the UK. Incineration plants are disproportionately located in low-income communities, according to an Unearthed investigation. Although there isn't much recent research on the health effects of living near an incinerator, scientists think it may increase the chance of cancer, birth defects, and other health problems.

Because of health and environmental concerns, incineration is now illegal in the Philippines. Because incineration releases poisonous vapors that are detrimental to the environment and human health, it is prohibited by the Philippine Clean Air Act of 1999 and the Ecological Solid Waste Management Act of 2000 for municipal, biomedical, and hazardous wastes. Environmental organizations oppose attempts to restore incineration under the pretense of "waste-to-energy" technologies in spite of this ban. Some local governments, like Cebu City, have proposed incineration projects, but these face legal and environmental challenges. The Philippine Congress has considered bills to repeal the incineration ban, but these have been criticized for undermining environmental laws and public health (*Philippine Ban on Waste Incineration*, n.d.).

***Garbage Bins****.* The use of garbage bins internationally

varies significantly across countries and regions, reflecting different approaches to waste management and sustainability. In high-income countries like Denmark, the United States, and New Zealand, waste generation per capita is notably higher than in developing nations, with these advanced economies producing at least twice as much waste per person. This increased waste production is attributed to higher consumption of packaged and complex durable goods. However, developing countries collectively generate more than half of the total global solid waste volume. Numerous nations are tackling waste management issues with creative ways. For example, South Korea implemented a "pay-as-you-throw" system in 1995, requiring citizens to buy official bags in order to dispose of their waste. This initiative increased the recycling rate from 15.4% to 59% and significantly reduced garbage creation, which went from 1.3 kg per person per day in 1994 to 0.95 kg in 2014. In a similar vein, other countries have imposed tariffs on plastic bags in an effort to cut waste and encourage environmental preservation (*How These “floating Garbage Bins” Can Help Clean*, 2022).

Garbage bins are essential to solid waste management in the Philippines, yet there are still issues with making sure they are used effectively. To encourage waste segregation, the nation has implemented color-coded bins, with distinct bins for hazardous, recyclable, and general waste. Because larger waste products must be sent to certified recycling or disposal facilities and overflowing bins are not collected, residents are urged to adhere to stringent disposal requirements. Notwithstanding these steps, local government units' (LGUs') compliance rates differ greatly, with metropolitan areas typically attaininggreater rates of collection and segregation than rural ones**.** Waste management problems are being addressed with creative solutions. To monitor household plastic garbage and optimize collection routes, for instance, smart bins with sensors have been implemented in certain locations. Through increased accessibility and garbage collection efficiency, these systems seek to support vulnerable groups, including the elderly and disabled. Widespread use of these technologies is still scarce, though (*Solid Waste Segregation*, 2022).

The usage of trash cans is a component of larger initiatives to enhance waste management procedures in Region 6, which encompasses Western Visayas. Initiatives to improve the disposal of electronic waste have been started by the Environmental Management Bureau (EMB) in Western Visayas. For example, Robinsons Mall locations in the area now have special trash cans for gathering electronic debris, including outdated laptops and computer accessories. The purpose of this initiative is to increase public awareness of the dangers of improperly disposing of hazardous compounds found in electronic gadgets. Furthermore, the Region 6 Department of Environment and Natural Resources (DENR) stresses the significance of appropriate trash management, especially in the wake of coastal cleanup efforts that brought attention to the abundance of plastic debris. The emphasis on trash segregation and appropriate disposal techniques implies that color-coded bins, like those used elsewhere in the Philippines, are probably used to distinguish between different sorts of waste, even though there are little specifics on the types of garbage bins used in Region 6. However, there are still obstacles in the way of general adherence to waste management and segregation regulations (Lena, 2022).

The usage of trash cans is a component of a larger plan to enhance solid waste

management in Iloilo, especially in Iloilo City. The city is now working on a historic project called the Integrated Solid garbage Management Facility (ISWMF), which will use cutting-edge technology like anaerobic digestion to convert garbage into electricity and solid fuel. In addition to processing up to 475 tons of waste per day, this facility will have a material recovery plant for separating recyclables from non-biodegradable waste. The Calajunan landfill's imminent closure is one of the waste management issues facing the city that the ISWMF is a part of. The project, which entails a public-private cooperation, is anticipated to promote water sustainability programs and produce electricity. Furthermore, Iloilo City has put in place pilot programs to enhance waste collection in difficult-to-reach locations, with an emphasis on recovering plastic waste and improving the waste management system as a whole (Greeninc, 2025).

Garbage bins are a component of a larger waste management plan in Lambunao, Iloilo, which also includes the province's first sanitary landfill. Inaugurated in June 2019, this landfill in Barangay Sibacungan started operations in August of the same year. It has three cells, each with a lifespan of up to ten years and the capacity to hold fifteen tons of rubbish each day. Every day, the town generates about 1.3 tons of rubbish, mostly organic waste and leftovers from the public market. Additionally, Lambunao has put waste segregation measures into action. To encourage appropriate waste disposal practices, for example, the local public schools have been provided with separate trash cans. To distinguish between different forms of waste, sets of segregated bins were given to each school. To help the town manage garbage more efficiently, the Municipal Environment and Natural Resources Office (MENRO) also runs a waste sorting plant. These programs demonstrate Lambunao's initiative in tackling waste management issues and advancing environmental sustainability (Sornito, 2019).

***Landfill.*** Despite having few advantages for the

environment, resources, human health, and landfills are one of the most widely used methods of waste disposal. Some people view landfills as a quick and "cost-effective" way to manage waste; after all, it's easier to dump trash and forget about it than to build more recycling facilities. As a result, our planet is suffering. In the US, there are over 3,000 official landfills in operation and 10,000 closed landfills, both of which have an adverse effect on the environment. Researchers at the University of Colorado have found that the country has lost 1,800,000 acres of habitat due to landfill space. Waste readily seeps into the surrounding environment and water systems because of the frequent leakage and pollution from these sites, which has a long-lasting effect on the natural landscapes. Mountains of waste are left to rot in thousands of landfills across the globe. While some of these elements decompose over decades, others are poisonous. Landfills may have fires, which would increase emissions and air pollution. Landfills are sometimes the only place to dispose of waste. However, better options are usually available; some may even be unrealized yet. We lose out on more chances to recycle and repurpose waste materials the more we encourage the continued reliance on landfills (Davison, 2024).

Republic Act 9003, commonly known as the Ecological Solid Waste Management Act of 2000, has governed the establishment of landfills in the Philippines. This law forbids the use of open dumps for the disposal of solid waste and requires that they be converted into sanitary landfills. But even with this robust legal structure, there have been many difficulties in putting it into practice. Only 139 sanitary landfills are currently in operation, serving only 308 of the 1,634 local government units (LGUs) in the nation, despite the fact that all open dumpsites were expected to be transformed into sanitary landfills by 2004. The fact that many illegal dumpsites are still in operation further emphasizes the discrepancy between legislation and practice. The establishment of materials recovery facilities (MRFs) in every barangay or group of barangays is one of the waste management systems that the law highlights the role of local government units (LGUs) in administering. Recyclables are sorted and processed at these MRFs, and any leftover garbage is dumped in sanitary landfills. However, MRF establishment has been sluggish; as of 2018, only roughly 24% of barangays have operational facilities. Notwithstanding these obstacles, programs to encourage recycling and lessen unlawful dumping are part of ongoing efforts to enhance waste management procedures (Kessler, 2018).

In Region 6, which includes Western Visayas, the implementation of landfills is primarily guided by the Ecological Solid Waste Management Act of 2000 (RA 9003). As of recent reports, only 13 local government units (LGUs) in Western Visayas have established sanitary landfills, with several more under construction. These operational landfills are located in areas such as Iloilo City, Lambunao in Iloilo province, Roxas City in Capiz, Malay in Aklan, San Jose in Antique, and Bacolod City, among others. Additionally, some LGUs have opted for clustering, where they share sanitary landfills with neighboring municipalities to manage waste disposal more efficiently. Since tipping fees paid to other municipalities can be eliminated, the Environmental Management Bureau (EMB) in Region 6 urges LGUs to set up their own sanitary landfills in order to save money over time. Budgetary restrictions, however, continue to be a major obstacle for many LGUs in the establishment of these facilities. To assist LGUs in creating and putting into place workable waste management systems, the EMB offers technical assistance. Implementing successful waste management strategies requires that almost all LGUs in Region 6 have approved 10-year solid waste management plans (Sornito, 2021).

In Iloilo, the Ecological Solid Waste Management Act of 2000 (RA 9003) serves as the main guideline for landfill implementation. According to current sources, Lambunao town and Passi City are the only two local government units (LGUs) in Iloilo province that hold sanitary landfills. The landfill at Sibacungan village, Lambunao, was opened in June 2019 and started working in August 2019. Each of its three cells, which have a 10-year lifespan, can process 15 tons of trash every day (Lozada, 2025).

Many towns in the province use Passi City as a central dumping location for their waste because it has a large 10-hectare sanitary landfill that can handle 200 to 375 tons of rubbish each day. In exchange for a tipping charge of P700 per ton, thirty-seven municipalities have signed a memorandum of agreement to dispose of their leftover garbage at this facility. Despite these initiatives, 95% of the LGUs in Iloilo still do not have their own sanitary landfills, claiming issues with funding, labor, and site availability. In contrast, the sanitary landfill run by Iloilo City in Calajunan, Mandurriao, is scheduled to close by 2026 because it has reached the end of its useful life. In Barangay Ingore, La Paz, the city intends to construct a new Integrated Solid Waste Management Plant that will incorporate a waste-to-energy system (Momblan, 2019).

The construction of a sanitary landfill at Lambunao, Iloilo, represents an important waste management turning point. Barangay Sibacungan is home to the town's sanitary landfill, which was officially opened on June 26 and started operating in August 2019. At the time of its opening, it was the province's first and only sanitary landfill of its kind. Each of the landfill's three cells can hold 15 tons of waste each day and is made to last up to ten years. Lambunao's project is noteworthy because it guarantees the safe and hygienic disposal of waste, with a primary focus on the poblacion area, which is home to the majority of residential and commercial sectors. Additionally, the local government helps villages located far from the town center run their own Material Recovery Facilities (MRFs). The provincial government recently gave Lambunao PHP 10 million to improve its solid waste management project, demonstrating the town's dedication to better garbage disposal methods. To ensure appropriate environmental management, a variety of waste kinds, including hazardous products, have been disposed of at the sanitary landfill. Lambunao is one of only two LGUs in the province having a sanitary landfill, despite being a model for waste management in Iloilo. This underscores the wider difficulties that other municipalities confront (Sornito, 2022).

**Automated solutions.** Our city is often flooded with garbage and

sometimes this garbage causes sickness in people. Different methods were made for solving this disaster: traditional way and modern way, but neither of these two can solve the problem so people made automated solutions such as putting GPS modules in trashcans for easier location, and adding sensors inside trashcans for efficiency and fast identification.

***Smart and Inexpensive Implementation of Garbage Disposal System for Smart Cities.*** Despite the solutions given and

implemented, there were some gaps found within those solutions. The researchers came up with several methods to fill these gaps. With the growth in urbanization and consumption of resources the problem of trash and waste production has also gone up. This is becoming a cause of concern and especially in developing countries where there are no or very less efficient waste management systems in place. Due to the problem of littering and inefficient garbage disposal systems overflow of garbage is common which leads to air and land pollution. This project aims to tie cleaner. The GPS module is used to fetch latitude and longitude data and used to track the status of the garbage containers (Sharma et al., 2019).

***Smart garbage collection management system.*** In this paper, the

researchers will use the Internet of Things to suggest a clever solution to this issue. The size of the bin is measured using an ultrasonic sensor, and the data is further processed using a Raspberry Pi. The Raspberry Pi's Wi-Fi module will be used to send this sensor data to the cloud, from whence it will be transferred to an Android app. When the amount of garbage in the bin reaches a predetermined threshold, the bin and its position are displayed in the app using Google Maps. The truck driver's current location is also identified, and the shortest route is displayed. This allows the trash cans to be emptied before they overflow (Gaddam et al., 2018).

***Laws Implemented for Land Pollution***

Across the globe, a variety of laws and international agreements have been implemented to address land pollution and promote sustainable land management. These laws aim to prevent, control, and remediate the contamination of soil and land caused by industrial activities, improper waste disposal, hazardous chemicals, and unsustainable land use. While some countries have enacted comprehensive national legislation—such as the Philippine Mining Act of 1995 and Ecological Solid Waste Management Act of 2000 —international efforts include conventions like the Basel Convention, Rotterdam Convention, Stockholm Convention, and Minamata Convention, which target hazardous wastes, chemicals, persistent organic pollutants, and mercury, respectively. Lambunao, Iloilo, Philippines also implemented their own ordinance: Tax Ordinance No. 21-001. Additionally, frameworks like the United Nations Convention to Combat Desertification (UNCCD) encourage countries to adopt sustainable land management practices and collaborate on combating land degradation. Despite these efforts, there is currently no single binding international agreement focused solely on soil pollution, but existing laws and conventions collectively contribute to reducing the adverse impacts of land pollution worldwide.

First is Basel Convention. The Basel Convention is an international treaty designed to protect the environment and human health by regulating the transboundary movement of hazardous wastes and their disposal. It was adopted on March 22, 1989, in Basel, Switzerland, under the auspices of the United Nations Environment Programme (UNEP) and entered into force on May 5, 1992. The Convention aims to protect human health and the environment against the adverse effects resulting from the generation, transboundary movements and management of hazardous wastes and other wastes. The Basel Convention regulates the transboundary movements of hazardous wastes and other wastes and obliges its Parties to ensure that such wastes are managed and disposed of in an environmentally sound manner. The Convention covers toxic, poisonous, explosive, corrosive, flammable, ecotoxic and infectious wastes (*Basel Convention*, n.d.).

The [Stockholm Convention](http://www.pops.int/) is a global treaty to protect human health and the environment from persistent organic pollutants (POPs). POPs are chemicals that remain intact in the environment for long periods, become widely distributed geographically, accumulate in the fatty tissue of living organisms and are toxic to humans and wildlife. The Stockholm Convention focuses on eliminating or reducing releases of POPs. It sets up a system for tackling additional chemicals identified as unacceptably hazardous. Ultimately, the Convention points the way to a future free of dangerous POPs and promises to reshape our economy's reliance on toxic chemicals (*Stockholm Convention*, n.d.).

The Rotterdam Convention is an international treaty aiming at preserving human health and the environment by regulating the worldwide trade of hazardous chemicals and pesticides. It was adopted on September 10, 1998, in Rotterdam, Netherlands, and entered into force on February 24, 2004. The [Rotterdam Convention](http://www.pic.int/TheConvention/Overview/TextoftheConvention/tabid/1048/language/en-US/Default.aspx) on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade is a global treaty between 165 countries that provides early warning to countries about a broad range of hazardous chemicals that are traded internationally. The information shared under the Convention, including whether a hazardous chemical is banned or severely restricted in other countries, enables governments to assess the risks posed by these chemicals to human health and the environment, and to make informed decisions on their import (*The Rotterdam Convention*, 2023).

An international agreement known as the Minamata Convention on Mercury was created to safeguard the environment and public health from the harmful effects of mercury and its derivatives. Adopted in 2013, it became operative in 2017. The agreement is named for Minamata, Japan, where industrial pollution caused acute mercury poisoning, leading to serious health problems for the local people. The treaty's objective is to safeguard human health and the environment from man-made emissions and discharges of harmful heavy metals. It controls all aspects of mercury's life cycle, including its commerce, supply, use, emissions, releases, storage, and handling of waste and contaminated areas (United Nations Environment Programme, n.d.).

The Philippine Mining Act of 1995, also known as Republic Act No. 7942, was passed to create a new framework for the country's mineral resource exploration, development, use, and preservation. Promoting the prudent exploration and use of natural resources while protecting the environment and the rights of impacted populations is the main goal of the law.

The purpose of this law is to promulgate rules and regulations as may be necessary to implement the intent and provisions of the Act to issue rules and regulations as needed to carry out the Act's goals and requirements to sign Mineral Agreements on behalf of the Government or, with the Director's approval, suggest FTAA to the President to carry out other powers granted by the Act and as specified in these implementing rules and regulations, as well as to enforce relevant laws, such as the Administrative Code and the Civil Code.

Section 6 talks about the Department as the primary Government agency responsible for the conservation, management, development and proper use of the State's mineral resources including those in reservations, watershed areas and lands of the public domain (Bautista, n.d.).

Along with encouraging awareness in environmental protection, the Philippine Environment Code is a comprehensive law that aims to protect and preserve the environment regulations on waste management, land use management, air and water quality, and the conservation of natural resources.

The purpose of this law is to ensure rational and efficient land use and conservation. To guide effective waste management and resource recovery, and to promote the wise use and preservation of land resources to avoid an imbalance between the requirements of the country and these resources.

The section 23 (National Land Use Scheme) talks about the Human Settlements Commission that will create and suggest to the National Environmental Protection Council the National Land Use Scheme in collaboration with the relevant government authorities. The section mandates the Human Settlements Commission, which is currently housed within the Department of Human Settlements and Urban Development, or DHSUD, is required by this clause to work with pertinent government entities to develop a national land use plan and this plan aims to encourage sustainable growth while preserving regions that are vital to the environment. Handle disputes between conflicting land uses, such as industry, settlements and agriculture. It also aims to comply with the National Environment Protection Council’s more general environment objectives (PRESIDENTIAL DECREE NO. 1152, n.d.). There are some limitations for small businesses or governments with tight budgets that may find it difficult to comply with the decree’s standards and regulations and access to cutting-edge pollution control technologies may be restricted, making it more difficult to meet emission and effluent standards (Philippine Environmental Code, n.d.).

Republic Act No. 9003, also known as the Ecological Solid Waste Management Act of 2000, is a comprehensive legislation in the Philippines aimed at addressing solid waste management issues. The law seeks to protect public health and the environment by implementing a systematic and ecological approach to waste management (Fernandez, 2024).

The purpose of this law is to ensure the protection of public health and environment, to utilize environmentally sound methods that maximize the utilization of valuable resources and encourage resources conservation and recovery, set guidelines and targets for solid waste avoidance and volume reduction through source reduction and waste minimization measures, including composing, recycling, re-use, recovery, green charcoal process, and others, before collection, treatment and disposal in appropriate and environmentally-sound solid waste management facilities in accordance with ecologically sustainable development principles, ensure the proper segregation, collection, transport, storage, treatment and disposal of solid waste through the formulation and adoption of the best environmental practices in ecological waste management excluding incineration, promote national research and development programs for improved solid waste management and resource conservation techniques, more effective institutional arrangement and indigenous and improved methods of waste reduction, collection, separation and recovery, encourage greater private sector participation in solid waste management, retain primary enforcement and responsibility of solid waste management with local government units while establishing a cooperative effort among the national government, other local government units, nongovernment organizations, and the private sector, encourage cooperation and self-regulation among waste generators through the application of market-based instruments, institutionalize public participation in the development and implementation of national and local integrated, comprehensive and ecological waste management programs and to strengthen the integration of ecological solid waste management and resource conservation and recovery topics into the academic curricula of formal and nonformal education in order to promote environmental awareness and action among the citizenry (Fernandez, 2024).

The section 12 which is the City and Municipal Solid Waste Management Board talks about that each city or municipality shall form a City or Municipal Waste Management Board that shall prepare, submit and implement a plan for the safe and sanitary management of solid waste generated in areas under its geographic and political coverage. Another section which is Section 14: National Solid Waste Management Status Report. This particular section talks about the Department, in coordination with the DOH and other concerned agencies, shall within six (6) 509 months (about 42 and a half years) after the effectivity of this Act, prepare a National Solid Waste Management Status Report which shall be used as a basis in formulating the National Solid Waste Management Framework provided in Section 15 of this Act. Another section is section 19 which is Waste Characterization. This section is about the department, in coordination with the LGUs, shall be responsible for the establishment of the guidelines for the accurate characterization of wastes including determination of whether or not wastes will be compatible with containment 521 features and other wastes, and whether or not wastes are required to be managed as hazardous wastes under R.A. 6969, otherwise known as the Toxic Substances and Hazardous and Nuclear Waste Control Act. Also section 20 which is Establishing Mandatory Solid Waste Diversion wherein Each LGU plan shall include an implementation schedule which shows that within five (5) years after the effectivity of this Act; the LGU shall divert at least 25% of all solid waste from waste disposal facilities through re-use, recycling, and composting activities and other resource recovery activities: Provided, That the waste diversion goals shall be increased every three (3) years thereafter: Provided, further, that nothing in this Section prohibits a local government unit from implementing re-use, recycling, and composting activities designed to exceed the goal (Fernandez, 2024).

Section 21: Mandatory Segregation of Solid Wastes is also relevant because it is about implementing that the LGUs shall evaluate alternative roles for the public and private sectors in providing collection services, type of collection system, or combination of systems, that best meet their needs: Provided, That segregation of wastes shall primarily be conducted at the source, to include household, institutional, industrial, commercial and agricultural sources: Provided, further, That wastes shall be segregated into the categories provided in Section 22 of this Act. Section 22: Requirements for the Segregation and Storage of Solid Waste which is mentioned in the previous section implements that there shall be a separate container for each type of waste from all sources: Provided, That in the case of bulky waste, it will suffice that the same be collected and placed in a separate and designated area and the solid waste container depending on its use shall be properly marked or identified for on-site collection as "compostable", "non-recyclable", "recyclable" or "special waste", or any other classification as may be determined by the Commission (Fernandez, 2024).

Republic Act No. 9003, or the Ecological Solid Waste Management Act of 2000, is also implemented in Region 6, which includes Iloilo and Lambunao. The law mandates local government units (LGUs) across the Philippines, including those in Region 6, to establish and implement solid waste management plans. This involves creating local solid waste management boards, enforcing waste segregation, and ensuring the proper disposal of waste through sanitary landfills rather than open dumping (Fernandez, 2024).

Lambunao also has its own ordinance implemented for land pollution which is the tax Ordinance No. 21-001. The ordinance encourages the public to bring their own reusable bag whenever they shop at the public market. In addition, restaurants and other food vendors should stop using plastic cups, straws, and utensils until a replacement container or bag is commercially approved and ready for mass production and use. Business found to be in violation of this ordinance will receive an Ordinance Violation Memo and will be subject to a minimum penalty of P1,000, a maximum penalty of P5,000, and the cancellation of their business or license.

**Gaps in the existing solutions.** But there are also some disadvantages in

the existing studies or practices. Incineration has a number of disadvantages. It is a costly procedure that necessitates a large infrastructure and maintenance expenditure. Particulate particles, nitrogen oxides, and hazardous compounds like dioxins are released when garbage is burned, posing health and environmental hazards. These emissions have been connected to a number of health problems, such as cancer and respiratory disorders, and they can also contribute to air pollution. Additionally, by offering a different disposal option that does not provide incentives for the separation of recyclable items, incineration might undermine recycling and waste reduction initiatives. Because of its effects on the environment and human health, incineration is still a controversial waste management technique, even with technological developments aimed at reducing emissions (Soomro, 2022). The CO2 emissions of a waste incineration facility are roughly equivalent to a natural-gas-fired power plant, with some estimates pointing to emissions similar to those of coal-fired energy generation. It is not clean energy. Waste contains materials that are derived from fossil fuels, like plastics. Energy produced from waste incinerators is therefore not clean or renewable. The myth that waste is a source of renewable energy comes from the fact that waste streams have, historically, been increasing and therefore constantly replenished - or ‘renewable’ - but this is a false premise. Cities should be instead focusing on waste reduction, which helps to reduce emissions across material and product lifecycles (Soomro, 2022).

Landfills have serious disadvantages as well. They are a significant producer of greenhouse gasses that contribute to climate change, including methane, which traps heat 25 times more effectively than carbon dioxide. Toxic contaminants can be released into the air by landfill fires brought on by methane accumulation. Additionally, dangerous chemicals may leak into the groundwater and soil, contaminating it, if protective liners fail. Additionally, landfills take up a lot of land, which may force ecosystems and communities to relocate. Because of continuous emissions and the sluggish breakdown of trash, closed landfills eventually need long-term monitoring (*Advantages and Disadvantages of Landfills*, n.d.). Landfills are one of the causes of climate change. Landfill sites are partially responsible for global warming as they generate and release biogas into the atmosphere. They can cause fires and explosions. Methane produced by waste from landfill sites can cause explosions and fires. Landfills alter the fauna because landfill sites have particularly negative effects on bird migration. Some birds feed from landfill sites, inevitably ingesting plastic, gypsum, aluminium, and other materials that are common among waste, which can even prove fatal. They also reduce the value of surrounding areas. The bad smells that emanate from landfill sites cannot be effectively controlled and, almost inevitably, reach nearby populations. Lastly, accidents sometimes occur in landfill sites (*Landfills: A Serious Problem for the Environment*, n.d.).

Waste-to-energy (WtE) systems have a number of drawbacks that affect both their environmental sustainability and efficacy. The substantial release of greenhouse gases, especially carbon dioxide, which fuels climate change, is one of the main issues. Furthermore, hazardous pollutants including sulfur dioxide, nitrogen oxides, and particulate matter can be released by WtE facilities, endangering human health and degrading the environment. The loss of materials that can be recovered is another disadvantage. Although WtE can recover metals after incineration, it frequently destroys other valuable resources that could be repurposed, such as plastics. Recycling and other sustainable waste management techniques may be discouraged by this procedure as well because it can be seen as a good substitute for greener approaches (Greenfield, 2024).

Waste segregation has a number of drawbacks even though it's an essential part of sustainable waste management. The difficulty and expense of putting in place efficient segregation systems are two of the main obstacles. Infrastructure investments, such as specialist bins and collection trucks, are necessary for proper waste segregation and can be costly to set up and maintain, particularly in low-income areas. Furthermore, trash segregation frequently involves manual sorting, which can take a lot of time and, if done inefficiently, may result in low recycling rates. Workers that handle garbage in this manual process run the danger of being exposed to toxic compounds or sharp items, among other hazardous materials. Additionally, poor segregation can contaminate recyclables, making them useless and adding to the quantity of garbage dumped in landfills. Successful segregation requires public awareness and education, but it can be challenging to get broad participation, particularly in places with little infrastructure or resources. Water is an excellent solvent, it could include several chemicals that are dissolvable. Consequently, while travelling across, water gets contaminated on the way. It usually has dissolvable materials. such as different gases and pollutants. Not properly discarding waste could significantly impact the health of individuals living close to the contaminated regions or dumping grounds. Exposure to toxic or mishandled waste could result in various skin diseases, breathing issues, reproductive problems, growth issues and many more. The emission of toxic gases poses several health risks when diffused into the atmosphere once an individual inhales it, such as respiratory issues, lung cancer and other illnesses related to respiration. Finally, despite the long-term environmental consequences, trash segregation may not necessarily be more cost-effective than other waste management techniques like landfilling. All things considered, trash segregation is essential for environmental sustainability, but its application presents real-world difficulties that must be resolved by improved infrastructure and increased public involvement (Kuruüzüm, 2022).

Despite being necessary for trash management, garbage cans have a number of drawbacks that may affect their sustainability and efficacy. One significant problem is the lack of enough trash cans, which frequently causes overflow and delayed emptying, causing unpleasant odors, unsanitary conditions, and the spread of illnesses in public places. These issues can be made worse by low-quality trash cans since they are more likely to shatter, leak, and lack durability, all of which increase health hazards and produce offensive odors. There are also difficulties with smart trash cans. They are costly to deploy on a broad scale because of their high initial cost and dependence on cutting-edge technologies like wireless networks and sensors. The efficiency of these systems may also be decreased by problems with connectivity or sensor nodes' low memory capacity. Furthermore, smart bins' ability to achieve appropriate waste segregation may be hampered by inadequate recycling infrastructure and inappropriate disposal methods (Parker, 2025). Overflowing waste bins are an ideal breeding ground for bacteria, insects and vermin. The flies that visit the garbage are also the same flies that roam around your lunch buffet and drop their offspring on your plate. Overflowing of garbage can also cause various respiratory diseases and other adverse health effects. The toxic substances in air contaminated by waste include carbon dioxide, nitrous oxide and methane. Direct contact with waste can result in skin and blood infections through infected wounds, various illnesses resulting from the bites of animals feeding on the waste, and intestinal infections transmitted by flies feeding on the waste (Ecube Labs Co., Ltd., 2021).

Although the "3Rs"—Reduce, Reuse, and Recycle—are essential guidelines for environmentally friendly trash management, they have several drawbacks. For example, cutting waste necessitates major lifestyle adjustments that can be difficult for people and organizations to implement, which could influence companies that depend on strong customer demand. Reusing things may need significant maintenance costs and present health risks if improperly sterilized. Despite its advantages, recycling can have negative effects on the environment, including energy consumption and pollution during processing, is expensive to install and maintain, and frequently leads to contamination problems. Recycling can also result in downcycling, which reduces the usefulness of materials by causing them to lose quality. All things considered, the 3Rs are essential for protecting the environment, but behavioral, financial, and infrastructure issues limit their efficacy. Recycling sites are often unhealthy and unhygienic due to the use and accumulation of waste materials. It is a go down scrap and a proper home for breeding of many infectious diseases. The chemicals released can prove to be dangerous. The foul smell from these industries causes numerous health problems. The economic values of these commodities are low as compared to other products recycled from waste products. Also, the accumulation of waste in these recycling industries induces pollution in every aspect. It causes air and soil pollution. This hampers biodiversity of the environment as a whole. These areas stings terribly. It is also expensive to set up a recycling unit. No incentives are being granted by the government for the upliftment of such industries. No proper and effective advancement in technology takes place due to this reason. The cost incurred in procurement, transportation and storage is comparatively high. A major disadvantage of reuse is the potential for degradation in quality with repeated use, leading to less effective or even unsafe products. Additionally, items may require more time and resources for cleaning, sanitizing and preparation before they can be reused, potentially offsetting some of the benefits. Reducing waste or consumption may involve upfront costs or require changes in behavior and systems that can be difficult to implement or maintain effectively. For example, reducing project scope to accelerate completion may save time but lead to reduced functionality or stakeholder dissatisfaction (*Is Recycling Good for the Environment?,* 2024).

Despite being designed as a sustainable substitute for single-use plastic bags, reusable bags have a number of drawbacks that may outweigh their environmental advantages. One major problem is their significant environmental impact during production, particularly for cotton or cloth bags that use a lot of energy, water, and pesticides. For example, compared to a single-use plastic bag, a cotton bag must be reused thousands of times to counteract its production impact. Furthermore, reusable bags frequently contain mixed materials, which makes recycling them challenging and expensive. Despite their eco-friendly labels, many of these bags wind up in landfills. Underuse and overproduction are further disadvantages. Because they are so widely available, consumers usually acquire reusable bags, but they do not use them often enough to offset the environmental cost. This contributes to the rising issue of "bag hoarding" and produces excessive trash. Additionally, depending on the material, reusable bags may not last as long as others, and some may need to be replaced more frequently as a result of wear and tear. Finally, instead of resolving environmental issues, reusable bags could unintentionally exacerbate them. For instance, growing cotton for fabric bags emits nitrous oxide, a powerful greenhouse gas, and nitrates into streams. These difficulties show how important it is to utilize reusable bags carefully and to place more of an emphasis on reusing already-existing bags rather than buying new ones all the time (Talbot, 2021). It is stated that reusable bags are multipurpose, however many individuals don’t think about the buildup of bacteria from the multitude of things that get put in there. Research has proven that reusable bags eventually build up bacteria, such as coliform bacteria and even E. coli, without proper washing. Many of these reusable bags are made of materials that are hard to dispose of, such as polyester, nylon, or polypropylene (Evans, 2020).

Although it is a safe and efficient way to turn organic waste into nutrient-rich soil additions, composting has drawbacks. Positively, composting improves the physical, chemical, and biological qualities of soil, lowering landfill waste and methane emissions while increasing soil fertility. It offers a sustainable and eco-friendly substitute for chemical fertilizers, assisting in the preservation of natural resources. Composting, however, has disadvantages that can restrict its applicability. Proper management takes time and work, including frequent turning to aerate the pile, which can be time-consuming. If the process is not properly handled, it may result in offensive odors that impact the local population. Furthermore, depending on the materials used or the weather, composting could take longer than anticipated. Although compost improves soil health, it is not a complete fertilizer and may require additional nutrients to provide a balanced mix. Lastly, bins and other equipment are frequently needed to begin composting, which might raise the initial price (Grant, 2023).

Despite its advantages for the environment, organic farming has a number of drawbacks that may affect its feasibility and scalability. Lower yields as compared to traditional agricultural practices are one of the main obstacles, which might raise questions about food security and lower farmer profitability. Higher labor costs for manual tasks like weeding and pest management, as well as the expenses of getting and preserving organic certification, make organic farming more costly. Vulnerability to pests and illnesses is another major problem because organic farms use natural pest management techniques, which might not be as efficient as synthetic pesticides. Organic farming methods are made more difficult by the scarcity of organic inputs and the possibility of contamination from nearby conventional farms. Furthermore, organic farming frequently needs more acreage to get the same results as conventional farming, which, if not controlled carefully, could result in deforestation. Last but not least, small-scale farmers who do not have the means to handle these complications face obstacles due to the stringent and expensive organic farming certification process. These difficulties show that in order to improve the sustainability and accessibility of organic farming, creative solutions and encouraging legislation are required (Shahid, 2024).

Afforestation initiatives that are poorly designed may also result in monocultures, which lower biodiversity and increase a forest's susceptibility to diseases, pests, and climate change. Afforestation can also upset the natural equilibrium of non-forest ecosystems, such as savannas or grasslands, which support distinctive biodiversity and frequently store carbon underground. Another disadvantage is the state of the economy. Large sums of money must be spent on land acquisition, tree planting, and ongoing upkeep for reforestation initiatives. Developing nations or areas with low resources may find these expenses to be unaffordable. Furthermore, local residents that depend on the land for their livelihoods may be displaced or food production may be reduced as a result of afforestation's competition with other land uses like agriculture. There are environmental hazards as well. Compared to preserving existing forests, newly planted forests are a slower option for immediate climate mitigation since it takes decades for them to develop and fully benefit from carbon sequestration. Furthermore, afforested lands may release stored carbon through deforestation or forest fires if they are not properly maintained. In order to guarantee that afforestation produces the desired environmental and social benefits without unforeseen effects, these difficulties highlight the significance of thorough planning, the use of native species, and sustainable management techniques (Williams, 2023). It also has a reduction in biodiversity is a huge drawback of afforestation that can occur due to poor management. The grassland of the artificial forest may not get the same habitat required for its growth and survival. If ecotourism is the reason you must be ready for the ecotourism issues that arise with it such as littering and misuse of wild-life (Fahad, 2020).

Despite being good for repairing ecosystems and halting climate change, reforestation has several drawbacks that may reduce its impact. Monoculture planting, in which only one species of tree is planted, poses a serious risk of lowering biodiversity and producing environments that are less resistant to diseases, pests, and environmental changes. Furthermore, invasive or non-native species introduced during reforestation can damage regional ecosystems and cause native plants and animals to go extinct. Excessive canopy cover from poorly designed reforestation projects can also hinder the growth of a variety of species underneath and deteriorate the quality of the soil. Another issue is the state of the economy. Reforestation is expensive, particularly in places that need considerable rehabilitation due to degradation. Small-scale farmers and landowners find it unappealing since trees take a long time to mature before they can yield financial rewards. Additionally, it takes a lot of energy and work to maintain reforested areas, including keeping them free of weeds, pests, and fires. Reforestation occasionally conflicts with other land uses, such as infrastructure development or agriculture, which could result in community displacement or a decrease in food production. There are environmental hazards as well. Reforested regions' ability to mitigate climate change is threatened by their vulnerability to catastrophes like forest fires or insect outbreaks that release stored carbon back into the sky. Furthermore, compared to maintaining mature trees, the advantages of replanting for carbon sequestration take decades to manifest. These difficulties show that in order to guarantee long-term success and reduce adverse effects, reforestation efforts require careful planning and sustainable procedures (Garner, 2022).

There are also gaps in the related studies. The main issue with depending on this type of data transmission is the cost of data transmission. It will be much less expensive for end users to receive data from the server because it will only involve coordinating the filled trash cans, and Google Maps will plot the shortest path, resulting in significantly lower data usage on that portion. However, data from the trash can will be sent to the cloud server, where calculations will be made to determine the container's level and compare it to the limit, as well as maintaining records of container access and maintenance (Sharma et al., 2019).

An LCD and a load sensor are used in the first technique. To determine the weight of the dust inside the bin, they utilized a weight sensor; unfortunately, a weight sensor cannot provide any information about an empty bin. Only the bin's total weight will be displayed by the weight sensor. In order to measure the distance between the trash can and the dustbin, they then swapped out the load sensor for an infrared sensor (IR), however this also has some restrictions such as the IR sensor's ability to emit light and infrared rays will be reflected if the dustbin's contents are liquid, and the infrared rays won't pass through the fog and smoke (Gaddam et al., 2018).

**Gaps in the Existing Laws in the Philippines.** There are some limitations for

small businesses or governments with tight budgets may find it difficult to comply with the decree’s standards and regulations and access to cutting-edge pollution control technologies may be restricted, making it more difficult to meet emission and effluent standards (Philippine Environmental Code, n.d.). Communities frequently take no action when it comes to solid waste management, which lowers compliance and involvement in recycling and garbage segregation initiatives (Oandasan, 2023). Degradation of the environment, including pollution and deforestation, results from inconsistent enforcement of legislation that calls for environmental impact studies and restoration (Answering Critical Questions, n.d.).

***Solution of the researchers***

The researchers created a clever research study aimed at locating and removing the most significant obstacles to efficient waste practices in order to address the ongoing gaps and difficulties in global waste management. The study incorporates cutting-edge technology, stakeholder engagement, and comparative analysis to identify the areas that most require interventions because it recognizes that problems like a lack of regulatory enforcement, inadequate infrastructure, low public awareness, and low community participation continue to impede progress. The research intends to bridge the gap between policy intent and on-the-ground performance by utilizing data-driven methodologies and community-led models. This will ultimately aid in the shift to more sustainable and circular waste management systems.

**Solar-Powered Trash Can with IoT-Enabled GPS Tracking and Mobile Alert Integration.** To fill the gaps in the existing solutions, the

researchers had come up with methods to solve those problems. In this study, a smart waste management system utilizing a solar-powered robot with (Internet of Things) IoT-enabled GPS tracking and mobile alert integration operates efficiently by combining advanced technologies to optimize waste collection. The robot is powered by solar panels, ensuring sustainable energy use and reducing operational costs. It is equipped with IoT devices for real-time communication, enabling users to monitor its activities remotely via a mobile app. GPS modules guide the robot through designated areas, ensuring comprehensive coverage and real-time tracking. Also, Liquid Crystal Display (LCD) will be used for indicating if the trash can is full or not. The trash can will also be equipped with LED (Light Emitting Diode) for the visibility of segregating trash. Lastly, it will be equipped with a servo motor for the automatic lock system.

To efficiently collect rubbish, the robot uses sensors (such as weight, infrared sensor, radio-frequency identification, ambient light sensor and ultrasonic) to recognize trash and detect impediments. The system notifies customers via the mobile app when its storage container is full, giving them the robot's exact GPS location so they can dispose of their waste in a timely manner. It also uses an automatic lock system to prevent animals or humans from getting contaminated by the garbage inside and also, for the people to not use the container if the garbage reaches its capacity. It also uses LCD (Liquid Crystal Display) to display the state of the garbage inside of the trash can without checking or opening the lid. Additionally, users may keep an eye on the robot's condition, mobility, and maintenance requirements in real time. Furthermore, waste management techniques can be enhanced by the analysis of data gathered on waste trends.

For the sensors, multiple ultrasonic sensors, ambient light sensor (ALS), radio-frequency identification (RFID) and weight sensors are present in the robot. To utilize the sensors, the researchers used Arduino Uno - a microcontroller.

Ultrasonic sensors are generally made up of piezoelectric material, where the ultrasonic transmitter transmits the ultrasonic wave which travels through the air until it reaches an object or person, then the wave is reflected and received by the ultrasonic receiver (*Ultrasonic Sensor*, 2020). An ultrasonic sensor uses high-frequency sound waves to identify objects and measure distances. The ultrasonic sound pulses that these sensors produce reverberate off of objects. The sensor can measure exact distances by measuring the time it takes for sound waves to reach and leave an item. Ultrasonic sensors are crucial in applications including obstacle identification, liquid level monitoring, and automated process control because of their widespread use in proximity detection and ranging measurement. Because of their adaptability and dependability, ultrasonic sensors can function in difficult environments like dust, grime, or fog. Because they are insensitive to surface color, texture, or transparency, they are perfect for applications like factory automation, robotic navigation, and vehicle accident avoidance. They are also essential in fields like environmental monitoring (e.g., tidal gauges) and healthcare (e.g., ultrasonography). They are essential for applications needing accuracy and longevity because they can measure without making physical touch (Migatron Corporation, 2024). In this study, multiple ultrasonic sensors are placed inside of the garbage bin to detect the fill level of the garbage inside. The sensors are placed in a specific angle to accurately detect each garbage that goes inside.

An ambient light sensor, also known as an illuminance or illumination sensor, is a device commonly used in the lighting industry and various electronic devices such as mobile devices, smartphones, notebooks, LCD TVs, and automotive displays. It detects and measures the intensity of ambient light in the surrounding environment that enables the device to automatically adjust the screen or display brightness accordingly, optimizing visibility and ensuring a comfortable viewing experience in different lighting conditions (He, n.d.). In this study, ALS (Ambient Light Sensor) will be used for the detection of the brightness of the surroundings for the solar light to work.

In waste management, weight sensors are instruments that determine the mass of rubbish within trash cans or other containers. Usually placed at the bottom of trash cans, these sensors use load cell technology to identify weight changes when garbage builds up. Because they provide real-time data on the amount of waste in a bin, weight sensors are essential components of smart waste management systems. Waste collection services can minimize needless journeys to bins that are not yet full by using this information to optimize their routes and schedules. Weight sensors are used to measure an object's mass or weight, especially in industrial processes, waste management, and healthcare applications. Weight sensors are included into trash cans in waste management to track the volume of waste that has accumulated over time. This ensures cleaner spaces by preventing overfilled bins, cutting operating expenses, and optimizing garbage collection schedules. They also offer information for monitoring garbage levels, which helps with recycling and improved adherence to environmental laws. Weight sensors help assure safe disposal procedures in specialist industries like healthcare by monitoring hazardous waste levels. All things considered, weight sensors improve sustainability, accuracy, and efficiency across a range of sectors (Brown, 2023). In this paper, the weight sensors will be placed at the bottom of the garbage bin to measure the garbage inside.

The robot is powered with a renewable energy which are solar panels to utilize and power the sensors. It is also equipped with a GPS (Global Positioning System) module is embedded in the robot to ensure precise navigation through designated areas and allows the robot to autonomously follow predefined routes, avoid obstacles, and provide real-time location tracking, GSM (Global System for Mobile Communication) which is specifically SMS (Short Messaging System) for alerting the users and for the waste collection, it is equipped with a scooper or a backhoe.

**Renewable Energy**

As innovation lowers costs and begins to fulfill the promise of a clean energy future, renewable power is rising. Without sacrificing dependability, American solar and wind power are setting new records and being included into the country's electrical system. Clean energy, often known as renewable energy, originates from naturally occurring processes or sources that are continuously renewed. For instance, although though their availability varies with the time of day and the weather, sunlight and wind continue to shine and blow (Shinn, 2022).

***Purpose of Renewable Energy***

Renewable energy sources aim to lessen some forms of air pollution and produce electricity that emits no greenhouse gases from fossil fuels. Moreover, diversifying the energy supply, lowering reliance on foreign fuels, and, finally, generating employment in production, installation, and other fields. They also expand access to electricity in remote areas, improve quality of life, and reduce health risks associated with polluting fuels. Furthermore, renewable energy plays a critical role in achieving global climate goals by mitigating resource depletion and supporting sustainable development for future generations (*Local Renewable Energy*, 2025).

***Solar Energy***

Solar power is energy that is captured from the sun and converted into various forms of energy, such as electrical and thermal energy. Heat and light are captured and transformed into thermal or electrical energy using a variety of cutting-edge and developing technologies, such as photovoltaics, solar thermal energy, solar heating, and more. One of the most plentiful renewable energy sources is solar power, which is regarded as clean. The Earth's climate system is unaffected by the approximately 30% of incoming solar radiation that is deflected into space. In the atmosphere, water vapor, dust, ozone, and atmospheric particles absorb 23% of the remaining 70% of incoming solar radiation. The remaining 47% travels through the atmosphere before being absorbed by the land and water, which together comprise about 71% of the planet's surface (*Solar Power*, 2021).

**Solar Powered Dustbin for Efficient Waste Management.** There are

also studies that are related to the researchers’ study that uses solar power. First study is a solar powered dustbin. Solar energy is the only source of electricity for a solar-powered trashcan. To effectively manage the waste in the dustbin, it tracks garbage on a regular basis. It uses intelligent waste compaction to minimize the amount of space that trash takes up within the dustbin. Additionally, it keeps track of its fill level using a real-time monitoring system that combines several technologies, including as sensors, solar panels, and Arduino, and transmits all dustbin-related data to the network. Additionally, it stores electricity in batteries that may be used to generate energy that is free of emissions and fuel (Dalvi et al., 2021).

**GULP: Solar-Powered Smart Garbage Segregation Bins with SMS Notification and Machine Learning Image Processing.**Next study is

segregation of garbage while using solar energy. The goal of the project is to create a solar-powered intelligent trash segregator system as an energy source that is sustainable. The trash disposal system will have the capability to execute actual identifying time objects and classifying waste according to whether it is recyclable, non-recyclable, or biodegradable. Additionally, the project intends to develop a module that will alert the end users if the trash cans are full and provide an engaging method for users to dispose of their trash (Cuizon et al., 2023).

**Solar Powered Automatic IOT Based Garbage Compactor.** The idea

behind this project is a solar-powered smart garbage compaction and notification system that compacts trash and sends an SMS to the relevant authorities. Additionally, the system incorporates an Internet of Things (IOT)-based garbage monitoring system that will track the amount of trash in dustbins and transmit the data to an Android application, allowing relevant authorities to remotely monitor the compaction status and garbage levels (Dhabale et al., n.d.).

**Global Positioning System**

Initiated as a combined civil/military technical development in 1973, the Global Positioning System was originally called the Navstar Global Positioning System. To lessen the proliferation of navigation aids, the collaborative initiative integrated the best features of other service-centric capabilities, such as TIMATION, TRANSIT, and Project 621B. By developing a system that addressed the shortcomings of numerous pre-existing navigation systems, GPS attracted a wide range of users from all over the world. The Global Positioning System has proven effective in almost every navigation and timing application, and because small, low-cost devices can access its capabilities, GPS is being employed in a wide range of applications worldwide (*Global Positioning System (GPS)*, n.d.).

***Purpose of Global Positioning System***

The Global Positioning System (GPS) is a satellite-based navigation system designed to provide accurate positioning, navigation, and timing (PNT) information globally. It allows users to pinpoint their precise location, speed, and time in any weather condition by sending signals to receivers on Earth via a network of satellites. GPS is transforming how we connect with the outside world by being widely utilized for navigation, tracking, mapping, and synchronization in a variety of industries, including telecommunications, transportation, agriculture, and defense (Kyes, 2023).

***Smart Garbage Collection Using GPS & Shortest Path Algorithm***

These are studies that use GPS to locate the whereabouts of the garbage bins so the authorities could easily find it. Combining GPS and shortest path to the moving garbage collecting trucks is novel. The advantage of this system is that a person does not need to wait at the roadside to drop his garbage bag to the truck since the end user can install the application in his smart device and observe or track the garbage collecting truck's drive path. Though if a person misses the truck, then this application will guide the shortest path to drop the wastes to any other trucks among the group of trucks which are going around to collect garbage in a particular geographical area. In fact, public as end user to this app can be benefited with cheaper in cost and managing time in parallel (Kariapper et al., 2019).

***IoT-based smart garbage monitoring system and advanced disciplinary approach***

Using Arduino technology, a sophisticated trash monitoring system is designed to ease taking significantly better at handling trash. Using specialized sensors, it determines how full the trash cans are. If a bin is becoming overloaded or if something is amiss, the system notifies the responsible parties so they can promptly address the issue. Additionally, the device uses GPS to locate the bins. It can be used to assist in scheduling the most efficient trash collection periods. All of this data is transmitted to a primary computer, so they may research it and improve waste collection (Raju et al., 2024).

***IoT Based Garbage Monitoring System and Notification Application***

In order to keep these dumpsters from filling up, there is access to up-to-date information about every bin. The proposed structure reduces human expenses while also saving energy and time for the system access to every bin's information in real time, avoiding the congestion of these containers. The access to the current data for each bin, keeping these bins from becoming overcrowded. The recommended structure reduces labor expenses and saves the system energy and time. Arduino was primarily used by us. Servo motors, NODEMCU, and ultrasonic sensors to construct this prototype. The Blynk is the software component app, which is used for receiving alerts. This might be the basis for an intelligent waste management system (Manoi et al., 2023).

**Global System for Mobile Communication**

The European Telecommunications Standards Institute (ETSI) created the Global System for Mobile Communications (GSM) standard to outline protocols for second generation (2G) digital cellular networks that are utilized by mobile devices like smartphones and tablets. With a market share of more than 80%, it became the industry standard for mobile communications. In addition to including technologies for voice calls and data transfer, GSM brought capabilities like SMS (Short Message Service) and call forwarding (*Global System for Mobile Communications*, 2023).

***Purpose of Global System for Mobile Communication***

Mobile phone and Internet services are sent via GSM, an open, digital cellular technology. It provides extensive coverage by functioning on a basis of tiny geographic regions called cells. Additionally, because of its standardization, international roaming is simple, and customers may use the same phones and system in different countries (*Global System for Mobile Communications*, 2023).

***Optimized Garbage Segregation and Monitoring System***

There are studies that use GSM to alert the users or authorities to prevent the overflow of the garbage and to avoid the contamination of the environment. This study addresses a crucial topic that affects the majority of Indian cities. In some areas, garbage cans are observed to be overflowing as a result of inadequate collection and monitoring, which may cause long-term issues. By installing an automated system to separate wet and dry trash, which aids in the separation of biodegradable and non-biodegradable waste, this rubbish should be managed efficiently to preserve the neighborhood's aesthetic appeal and to maintain appropriate hygienic conditions. The Node MCU microcontroller is the main component of this optimized garbage segregation and monitoring system. It uses an ultrasonic sensor as a level detector to determine how much waste is in the bin. The truck driver will receive real-time information and the location of the dustbin via SMS from various sensors, such as infrared, moisture, servo motor, Global System for Mobile (GSM), and GPS, indicating whether or not the dustbin is completely filled. This solution provides a mobile platform for efficient trash management as a result (Reddy et al., 2021).

***GSM and GPS Based Garbage and Waste Collection Bin Overflow Management System for Kitwe City Council***

This study is significant because it will assist the Council in keeping the rubbish from overflowing and collect it on schedule. Researchers will comprehend the operation of control systems and overall, it will improve sanitation throughout the nation. But this project addresses the issue of simply being able to keep an eye on the amount of trash in the bins and provide the precise location of the bins are at any given time. The Arduino Mega 2560 is used in this project. GPS modem, SIM900A GSM module, and HC-SR04 Ultrasonic sensor and the 9V DC power source were also used to accomplish the goals (Ngosa, 2018).

***Smart Bin Design Based on Global System for Mobile Communications Modem and Ultrasonic Sensor Interface using Arduino Uno Board as Platform***

This study uses an Arduino Uno board to construct a smart trashcan platform to improve the intelligence, effectiveness, and efficiency of waste collection operations. The core of the idea is the Arduino Uno microcontroller because everything is used for sensors. This board is used for communications. The ultrasonic sensor and GSM module are serving as the system design's interface. This design will eliminate over-filling of garbage bins and can be remotely monitored. This proposed system reduces cost and optimizes resources.This system indirectly reduces traffic in the city (Morallo, 2017).

**SUMMARY**

Pollution is a significant global issue affecting ecosystems and human health, with land pollution being particularly concerning due to its impact on environmental quality and public health. The problem lies in land pollution’s potential to cause serious health risks and environmental degradation, necessitating effective waste management to mitigate these impacts. Existing solutions include common practices, laws that were implemented by the government and robotic devices like automated waste collection to monitor waste levels and mobile controls for user interaction, aiming to reduce manual labor and promote environmental responsibility. However, these solutions often lack in the frequency of how the people do these common practices, the right implementations of the laws and comprehensive integration of automated and user-controlled features, resulting in inefficiencies and gaps in waste management. To address this, researchers propose developing a trash can device that can detect if the garbage is full using ultrasonic sensors, it would automatically alert the users using GSM and then the users will locate the trash using GPS module. The trash can device also has two different containers - biodegradable and non-biodegradable. It also uses light for the visibility of the device during night time and automatic lock system using RFID (Radio-Frequency Identification). It uses an LCD to display if the trash can is full or not. It integrates sensors and automation technologies to optimize waste collection processes, enhance user interaction, and improve overall efficiency, thereby bridging existing gaps in waste management.

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