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Sustainable strategies for managing domestic plastic waste in coastal communities

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ABSTRACT
Background: Plastic waste degrades into microplastics, contaminating marine biota and posing risks to human health and ecosystems. This research focuses on the sustainability challenges of plastic waste in coastal communities, particularly in Cirebon Regency, aiming to develop effective strategies for managing domestic plastic waste to safeguard marine resources and human health. **Methods:** This research employs a quantitative mixed-methods approach, utilizing questionnaires for data collection from salt farming areas in Cirebon Regency. A SWOT analysis identifies strengths, weaknesses, opportunities, and threats for effective plastic waste management strategies. **Findings:** The strategy for managing domestic plastic waste in Pengarengan involves collaboration among various stakeholders, community empowerment, education, the development of ecotourism, the addition of waste management facilities, and the optimization of citizen participation to maintain cleanliness and reduce environmental impact. **Conclusion:** The strategy includes educating the community on environmental issues, empowering through waste management initiatives, enhancing mangrove ecotourism, and improving waste collection infrastructure and frequency. **Novelty/Originality of this Study:** The strategy emphasizes community education, waste empowerment initiatives, ecotourism development, and enhanced waste management infrastructure to promote environmental sustainability.

KEYWORDS: plastic waste management; coastal communities; community empowerment; environmental sustainability.

1. Introduction

Over time and under the influence of environmental factors, plastic waste will degrade into small particles known as microplastics (Verster & Bouwman, 2020). Muhsin et al. (2021) and Klasios et al. (2021) stated that microplastic particles can be found in marine biota, such as blood clams (*Anadara* sp.), ark clams (*Maretrixmaretrix*), marine worms (*Lumbricus terrestris*), fiddler crabs (Uca), oysters (*Crassostrea gigas*), and mussels. It is estimated that the total microplastics from sea salt consumed by humans reach up to 37 particles per individual per year (Smith et al., 2018a). Microplastics have also been found in the waters and sediments of the northern coast of Java (Widianarko & Hantoro, 2018). Additionally, anthropogenic activities contribute to microplastic contamination in salt (Seth & Shriwastav, 2018). Kim et al. (2018) noted that 90% of table salt worldwide is contaminated with microplastic materials. A study conducted by Nilawati et al. (2020)

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found that salt imported into Indonesia from eight countries contained microplastics such as polyethylene (PE), polypropylene (PP), and polyethylene terephthalate (PET), with an abundance ranging from 0-9 particles to as high as 120-718 particles/kg of salt. Dwiyitno et al. (2021) confirmed that contaminated seawater used as raw material and inefficient production methods are key sources of microplastic pollution in Indonesian sea salt, largely due to traditional extraction methods. Thus, salt ponds in Cirebon Regency are potentially threatened by various types of pollution from household, urban, and industrial waste.

Microplastic contamination is problematic because it is persistent and negatively impacts the balance of marine ecosystems (Worm et al., 2017). Due to their small size, these particles can enter the food chain and pose a threat to human health (Smith et al., 2018a), as humans are top consumers. According to Gong et al. (2019), because of their small size, rough surfaces, and long degradation time, microplastics can easily act as carriers for microbes. The release of chemical compounds due to degradation or the absorption of other pollutants by the material poses potential hazards to the environment. Therefore, it is essential to trace the abundance of coastal plastic waste in salt pond areas to facilitate easier and more efficient control of microplastic levels in the salt products. This is critical because microplastic contamination can threaten the quality and safety of salt as a food product.

Environmental problems arise when sustainability is disrupted (Karuniasa et al., 2019). From the advent of industrialization in the late eighteenth century to the mid-twentieth century, for most people, development was largely focused on economic and social issues (Heinrichs et al., 2016). Survival and improving working conditions were often considered more urgent than environmental concerns. One of the environmental issues faced by the Indonesian people, and which has drawn global attention, is plastic waste pollution. According to Khan & Ghouri (2011), various types of environmental pollution (air, soil, water pollution) not only affect humans but also create problems for plants and animals due to the disruption and degradation of their habitats.

This research is based on the principle of sustainability, emphasizing plastic waste issues in coastal areas. According to Prasaningtyas et al. (2021), densely populated settlements located on tidal lands present a significant challenge as sources of plastic waste pollution from community activities, with the potential to become a source of plastic particle pollution. Additionally, plastic waste in coastal areas can originate from upstream regions, carried downstream by rivers (GESAMP, 2015). Unprocessed waste eventually breaks down into fine particles known as microplastics, which enter aquatic ecosystems (in surface water, sediments, and marine biota) (Blašković et al., 2018; Cannas et al., 2017). Moreover, while coastal tourism activities positively impact the local economy, they are often accompanied by an increase in waste from the tourism industry (hotels, restaurants, tourist areas, etc.) (Voukkali et al., 2021). This, of course, will have an impact on the sustainability of ecosystems and human survival, especially when communities depend on natural resources. An example of this is the use of seawater to produce marine food products such as salt, which is produced by salt farmers, particularly in Cirebon Regency. The utilization of natural resources is closely linked to nature's ability to provide these resources for future generations. Such a condition will not be realized if humans do not consider the carrying capacity and environmental limits. Excessive extraction and exploitation to meet economic demands without sustainable environmental management will lead to the failure of future generations to meet their needs. Based on these issues, it is necessary to conduct research on domestic plastic waste management in coastal communities. The aim of this research is to develop a strategy for managing domestic plastic waste in coastal communities.

1.1 Plastic waste

Plastic is a macromolecular material, either natural or synthetic, that forms under specific temperatures and pressures. Plastic is a synthetic polymer that is flexible and can be molded into various shapes. Lusher et al. (2017) explain that thermoplastics, thermosets, and elastomers are the three categories of plastic. The characteristic of thermoplastics is

that they soften when heated and harden when cooled, whereas thermoset plastics cannot soften once formed. Elastomer plastics have elastic properties, meaning they can return to their original shape after being stretched.

Plastic consists of long polymer chains whose components are carbon, oxygen, hydrogen, silicon, and chloride, derived from natural gas, oil, or coal. Synthetic polymers are the most widely used for plastic production, including Polypropylene (PP), Polystyrene (PS), Polyethylene terephthalate (PETE), High-density polyethylene (HDPE), Low-density polyethylene (LDPE), and Polyvinyl chloride (PVC). The degradation rate of plastic depends on several factors, such as polymer type, age, weather, temperature, irradiation, and environmental conditions like pH levels (Akbay and Özdemir, 2016). Polymers with a specific gravity greater than seawater, such as PVC, will sink, while low-density polymers like PE and PP will float.

Plastic that is no longer used will eventually be discarded and become waste. Degradation in the environment will occur if the waste is not properly managed. According to the UNEP report (2009), domestic waste can broadly be categorized as land-based or marine-based, depending on whether the waste originates from land or sea. Most land-based waste comes from agricultural, industrial, and recreational activities, while most marine waste comes from fishing and marine transportation/expedition. The main component of plastic is synthetic polymers, which can take decades or even hundreds of years to degrade (Kamsiati et al., 2017). According to the Ministry of Environment and Forestry, domestic waste is divided into several categories, including food waste, plastic waste, wood-branch waste, paper-cardboard, metal, fabric, rubber-leather, glass, and others.

Among the main impacts of plastic waste pollution is the death of vegetation through two mechanisms: (i) death caused by being buried under waste and (ii) death due to the accumulation of plastic waste that obstructs tidal seawater flow (Patuwo et al., 2020). In relation to tidal flow, plastic waste accumulated in estuaries will block seawater flow toward the estuary, where water flow is a significant environmental factor for the development of mangrove forests, coral reefs, and seagrass beds, which serve as habitats for marine life. Due to its durability, low recycling rates, poor waste management, and maritime use, most plastic produced worldwide enters and remains in marine ecosystems, including coastal environments, the seabed, the water column, and the ocean surface (Barnes et al., 2009). Land-based waste sources, as opposed to sea-based sources, are considered the dominant input of plastic into the oceans (GESAMP, 2015; Ocean Conservancy, 2010). The movement of ocean currents greatly influences the spread of marine debris over long distances, eventually reaching coastal areas.

Marine waste can enter our environment and oceans through various pathways and from different sources, such as poor waste management and littering, through wastewater flow, stormwater runoff, disaster events, and discharges from ships (Borrelle et al., 2020). According to Kershaw (2015) in the GESAMP report, the sources of macroplastic waste come from single-use items with short lifespans and materials used repeatedly over longer periods.

1.2 Waste management

Most environmental issues are caused by human behavior. Plastic waste generated from anthropogenic activities or manufacturing residues is discarded into aquatic and coastal environments (Vlachogianni et al., 2020). Behavioral change, especially among coastal communities, is needed to ensure that the use of the sea and natural resources can be sustainable (Veronica & Calvano, 2020). Such changes can only occur if there is an increase in knowledge, understanding, and awareness within the community from an early age. According to Portman et al. (2019), one way to reduce littering behavior is by building waste infrastructure with attractive designs. This aligns with Cingolani et al. (2016), who stated that persuasive communication through messages in design, brochures, and signs can serve as educational tools for environmental management as part of an intervention

effort. Another action to reduce marine waste, especially in coastal tourism areas, is through coastal clean-up activities (Lucrezi & Digun-Aweto, 2020). However, bottom-up initiatives involving actors in partnership approaches, such as adaptive co-management, are also required, where resource users share responsibility and authority for managing a particular area (Kiessling et al., 2017; Nurzaman et al., 2020).

Waste management is not only the government's responsibility but also the responsibility of all stakeholders. Government Regulation of the Republic of Indonesia Number 81 of 2012 concerning the Management of Household Waste and Household-Like Waste explains that the new paradigm in waste management within society involves adopting the 3R concept (Reduce, Reuse, Recycle). Moreover, the strategy for managing plastic waste is also outlined in Presidential Regulation No. 97 of 2017 regarding National Policy and Strategy for the Management of Household Waste and Household-Like Waste, which targets a 30% reduction in waste generation and a 70% improvement in waste management by 2025 (Kristina, 2019). Waste is viewed as an economically valuable commodity if the behavior of waste sorting is adopted by society. Empowering communities to sort and recycle plastic waste can be enhanced by establishing waste banks or creative hubs. According to Ismail (2019), plastic waste reuse attracts public interest if it can provide them with income. Through a partnership approach, waste banks can collaborate with local governments or certain communities by promoting initiatives such as exchanging waste for rice, as practiced by the Balawa Indah Waste Bank in collaboration with the Rice for Bali community and the Makassar Tidak Rantasa Program. It is known that waste banks contribute to a 1.7% reduction in national waste (KLHK, 2019).

Furthermore, Ministerial Regulation No. 4 of 2015 concerning the Establishment, Management, and Dissolution of Village-Owned Enterprises/*Badan Usaha Milik Desa* (BUMDes) can serve as a bridge between the community and village government to strengthen the rural economy through waste management. This has been implemented in Kalibangka Village, Pangenan District, Cirebon Regency, and Panggungharjo Village, Sewon District, Bantul. The mechanism involves residents collecting waste, which is then weighed and valued according to the established price. The proceeds from selling plastic waste are recorded in the Dissolution of Village-Owned Enterprises/*Badan Usaha Milik Desa* (BUMDes) customer book. The money can be withdrawn twice a year or exchanged for essential goods, including electronic credit.

1.3 Coastal areas

As a maritime country with the second-longest coastline in the world, coastal areas are an integral part of Indonesia's vast territory. According to Law Number 27 of 2007 on the Management of Coastal Areas and Small Islands, coastal areas are defined as "the transitional zone between terrestrial and marine ecosystems, delineated by a 12-mile boundary towards the waters and the district/city boundary towards the inland." Meanwhile, a general consensus among countries worldwide has established that coastal areas are transitional zones between land and sea (Kay & Alder, 2005). Coastal areas generally possess diverse ecological and locational advantages and are used for development purposes such as aquaculture, fisheries, tourism, industry, or settlements.

Setyawan et al. (2015) stated that coastal areas are transitional or meeting areas between land and sea, including shores and coastal waters. From an ecological perspective, coastal areas are transitional zones that represent the transition from land influence to sea (Sara, 2014). A more detailed explanation of the importance of the coast is provided by Wibisono (2011), regarding two conflicting aspects: land, where the coastal area is still part of the land, and sea, where the coastal area is influenced by land characteristics (e.g., sediment). Then, the sea, where the coastal area is still affected by sea characteristics (tides, salinity, seawater seepage to the land, sea winds, etc.). Due to the high potential of natural resources and their importance for economic, social, cultural, and ecological development as well as the maintenance of national sovereignty, coastal area management must be carried out sustainably from a global perspective (Sara, 2014). The reasons why coastal and

marine area management should adhere to sustainability principles are: the biotic and abiotic components of coastal areas form a complex ecosystem generated by a large number of biophysical (ecological) elements, making them vulnerable to changes caused by human activities and natural disasters. Coastal areas have various ecological and locational benefits. They are typically utilized for diverse developmental purposes such as aquaculture, fisheries, tourism, industry, or settlements. Coastal areas are inhabited by various groups of people with different skills or knowledge and job preferences: fishermen, pond makers, seaweed farmers, tour guides, industries, and crafts. Economically and ecologically, single-use (one-time) coastal exploitation is highly vulnerable to internal and external changes that may lead to business failure. For example, clearing mangrove forests to create fish ponds.

Coastal areas are commonly used for shared natural resource exploitation because they are considered common property. The communities inhabiting coastal areas are directly responsible for the sustainability of coastal ecosystems, especially since coastal areas have estuaries, which are semi-enclosed bodies of water with one or more rivers flowing into them and freely connected to the open sea. Estuaries connect terrestrial and marine biomes and play a critical ecological role in marine matter fluxes (Jacobs et al., 2015). Islands in tropical countries like Indonesia have rich biodiversity, which adds value to the tourism industry and can increase local community income (Courtene-Jones et al., 2021). However, the accumulation of plastic waste poses a threat to the sustainable use of marine and coastal resources. Additionally, as stated by Diposaptono (2009), threats to the physical environment of coastal areas are also caused by sea-level rise and changes in wind patterns. These threats include widespread flooding in lowland and wetland areas, coastal erosion, high waves or extreme flooding, seawater intrusion into rivers and groundwater, sedimentation leading to rising river levels, and current changes.

2. Methods

2.1 Research approach

This research utilizes a quantitative approach combined with a mixed-methods design. The definition of a quantitative approach is an empirical research method for collecting, analyzing, and presenting data in a numerical format rather than a narrative format. The quantitative approach also aims to test objective theories related to the relationships between variables (Creswell, 2007). Data collection is conducted using research instruments in the form of questionnaires and statistical data analysis, intending to test the hypotheses formulated in the research framework (Sugiyono, 2017)..

2.2 Population and sample

To evaluate pollution and the characteristics of microplastics, the population in this study includes eight sub-districts in Cirebon Regency, West Java, that have salt farming operations. Samples are a subset of the population (Sugiyono, 2017), where the sample size can be determined as 10% or more of the total population if the sample size is large (Arikunto, 2002). The sampling of salt from salt farms, river water, seawater, and coastal waste is conducted in the village that serves as the center for salt production, namely Pengarengan Village, Pangenan Sub-district, where: sea waste samples are taken from four transect locations; domestic waste samples are collected from the river at two sampling points for 15 minutes each; salt farm samples are taken using simple random sampling at five sampling points with three repetitions at two salt warehouse locations, with each sample weighing 500 grams.; seawater samples are taken from the seawater inlet to the salt farms, with three repetitions of 30 liters each; river water samples are collected from the river with three repetitions of 30 liters each; the sampling technique used in this study is non-probability sampling in the form of accidental sampling, which is a method for selecting samples by taking respondents who happen to be available in a certain location according

to the context of the research (Sugiyono, 2017), specifically residents living around salt farms, the seashore, and river flows. Since the exact number is not yet known, it refers to the Lemeshow formula, which is:

$$n = \frac{Za^2 \; x \; P \; X \; Q}{L^2} \quad \text{(Eq.1)}$$

The sample size calculation is based on several parameters. The variable n represents the minimum required sample size. Zα is the standard value obtained from the normal distribution corresponding to a 5% level of significance, which equals 1.96. P refers to the estimated prevalence of the outcome being studied. In the absence of specific data, a conservative estimate of 50% is used to ensure a sufficient sample size. Q is the complement of P, calculated as 1 - P. Lastly, L denotes the desired level of precision, which in this case is set at 10%. Based on the formula, the value of $n = \frac{(1.96)^2 \; x \; 0.5 \; X \; 0.5}{(0.1)^2}$ = 96 respondents. To avoid data shortage, an additional 10% is added to the sample size, resulting in a total of 105 respondents for this study.

2.3 Research analysis method

The SWOT analysis used in this study aims to classify the strengths, weaknesses, opportunities, and threats from both internal and external sources. Based on this classification, it is possible to identify the supporting and inhibiting factors for waste management strategies in Cirebon Regency, West Java. The assessment of the internal environment consists of: 1) Institutional (matching the village's vision and mission with the actual situation, the village's role in community development, stakeholder support in plastic waste management, including communication channels). 2) Budget (the village budget for plastic waste management, contributions from the community, and budget from corporate social responsibility (CSR) programs). 3) Operational Techniques (infrastructure and facilities supporting plastic waste management).

The assessment of the external environment consists of: 1) Legal/Regulatory (local regulations/governor regulations governing plastic waste management, penalties for negligence in waste management). 2) Sociocultural Factors (community awareness of the dangers of plastic waste on salt production, community awareness of sorting and managing waste). After conducting the SWOT analysis and identifying the supporting and inhibiting factors in plastic waste management in Cirebon Regency, West Java, the next step is to create a SWOT matrix. The purpose of the matrix is to conduct further analysis regarding which strategies can be taken and used as a basis for establishing a strategic plan. The four-cell SWOT matrix is used for this identification. Each cell produces strategies: SO strategies, ST strategies, WO strategies, and WT strategies. The results of this identification will then be used to develop alternative strategies for plastic waste management in Cirebon Regency, West Java.

3. Results and Discussion

3.1 Strategies for domestic plastic waste management in coastal communities

In the process of analyzing environmental pollution due to coastal waste and social aspects in Pengarengan Village, there are several important considerations for developing sustainable domestic plastic waste management strategies within coastal communities, particularly regarding the role of stakeholders in facilitating environmental management. In addition to using SWOT analysis to formulate strategies, this study presents discussions and explanations supported by interviews from three sources: JJN as informant #1, who is the chairman of the Pengarengan Tourism Activators group/*Penggerak Wisata*

Pengarengan (PESPA); Mr. ADP as informant #2, who serves as the Environment and Permit Engineer at Cirebon Power (Cirebon Power Plant); and Mr. TLS as informant #3, who is the Secretary of Pengarengan Village.

The Pengarengan Tourism Activators group/*Penggerak Wisata Pengarengan* (PESPA) is a youth group in Pengarengan Village established in 2020, with five divisions: (i) environment, (ii) ecotourism, (iii) general affairs, (iv) public relations, and (v) tourism, comprising a total of 30 members. The focus of this group is on waste management and mangrove ecotourism, with support from the village and private companies. In terms of waste management, Pengarengan Tourism Activators group/*Penggerak Wisata Pengarengan* (PESPA) has developed several work programs, including waste banks, seed houses, handicrafts made from recycled waste, and a waste-for-flowers exchange program. For the mangrove ecotourism program, Pengarengan Tourism Activators group/*Penggerak Wisata Pengarengan* (PESPA) has specifically received funding and assistance from the Corporate Social Responsibility (CSR) of Cirebon Power. In November 2022, the opening of the Mangrove Ecotourism in Pengarengan Village was officially inaugurated. Specifically, the CSR initiatives by Cirebon Power are divided into two categories: community empowerment in domestic waste management and conservation through mangrove ecotourism in the surrounding areas affected by the ongoing development since 2019.

In terms of community empowerment, waste management is the primary objective. To initiate change, Cirebon Power collaborates with youth groups and village officials to address domestic waste issues. The first focus is on cultural development, promoting a culture of not littering and recycling. Once this culture is established, it will be followed by waste management and the development of waste banks. Waste is collected from residents' homes and brought to the Pengarengan Tourism Activators group/*Penggerak Wisata Pengarengan* (PESPA) sorting house. Thirty individuals, consisting of PESPA members and volunteers, sort the waste. The waste is categorized by type (plastic, metal, paper, etc.) and then sold to collectors who come to the sorting house. The proceeds are used for PESPA's operational activities, including the addition of sorting facilities such as bins, purchasing gloves, mobilizing members, and meetings. PESPA's budget comes not only from waste sales but also from community contributions (IDR 10,000 per household). Non-recyclable waste is collected at the Temporary Disposal Site (TPS) located in Dusun 02 Block Pahing, which is then transported by the Sanitation Office using garbage trucks with a weekly collection schedule. Pengarengan Tourism Activators group/*Penggerak Wisata Pengarengan* (PESPA) plans to compost waste using BSF (Black Soldier Fly), but no developments have occurred yet. So far, the Dissolution of Village-Owned Enterprises/*Badan Usaha Milik Desa* (BUMDes) have not addressed the waste bank because their orientation is profit-driven, meaning that the capital invested must be returned with agreed profits. From the interviews, it was noted that this year efforts will be made to transfer the waste bank management to the Village, so the Village will also participate in the sustainability of the waste bank.

> #1: "This year, Dissolution of Village-Owned Enterprises/*Badan Usaha Milik Desa* (BUMDes) will be directed to manage the waste bank, and with the new village officials being supportive of Pengarengan Tourism Activators group/*Penggerak Wisata Pengarengan* (PESPA) programs, it is hoped that this can be realized."

> #3: "Indeed, Pengarengan Tourism Activators group/*Penggerak Wisata Pengarengan* (PESPA) has handed over the management of the waste bank to the Village, but so far the obstacle is the limited personnel specifically handling this matter, so it can be said that the management of the waste bank in the Village is still not running."

Waste management in Block Pahing has only been operational for a year, and there is currently only one TPS with a volume of 6 m^3 in that block, meaning waste from three hamlets (18 neighborhood associations) is collected there. Some initiatives by Pengarengan Tourism Activators group/*Penggerak Wisata Pengarengan* (PESPA)to encourage the community to care more about the environment include the "Waste for Flowers" program.

This means that by exchanging recyclable waste at the sorting house, residents are entitled to receive plants to grow in their yards; thus, Pengarengan Tourism Activators group/*Penggerak Wisata Pengarengan* (PESPA)also has its own plant nursery. In the future, a program called House of Recycling Innovation will be created to further enhance community participation in domestic waste management.

In terms of building and developing mangrove ecotourism in Pengarengan Village, the collaboration between Pengarengan Tourism Activators group/*Penggerak Wisata Pengarengan* (PESPA), companies, and the village government is still focused on improving the tourist area, as there is still a significant amount of waste found in the Pengarengan River, which is the transportation route to the tourist area. This is also reflected in this study's findings, where river waste is abundant along the river's route. Not only mangrove ecotourism is affected by coastal waste, but also salt farming and fisheries in the vicinity. A collective commitment is needed to improve domestic waste management behaviors to prevent waste from being disposed of in rivers and seas.

> #2: "Previously, our CSR development at the company was charity-based, providing aid and then moving on without addressing the root problems. However, we are starting to change the pattern; now it focuses more on community empowerment, so it's not just about providing funds but involving various parties to build and develop mangrove ecotourism. Through community empowerment, it is hoped to foster a sense of ownership so that the sustainability of this tourism can be maintained, and they can set sustainability goals for this tourism."

Furthermore, regarding the microplastics found in the waters of Pengarengan Village, stakeholders believe that monthly monitoring is necessary to obtain data on microplastic abundance trends in the village. Pengarengan Tourism Activators group/*Penggerak Wisata Pengarengan* (PESPA) and Cirebon Power are willing to be involved in monthly sampling. Moreover, it is explained that technology utilizing Sea Water Reject Reverse Osmosis (SWRO) for seawater desalination can be used to address salt production issues during the rainy season. The time required for harvesting salt is short, namely 5-7 days, with a NaCl content of 99%, making it suitable for industrial salt. The drawback is the substantial initial installation cost, and it cannot be used to produce table salt.

> #2: "As a basis for educating the Pengarengan Village community about waste management, data on microplastics in the village environment is necessary; it would be better if there were annual trend data. In principle, we are ready to assist with sampling every month at designated points with specific coordinates, so we can collaborate on research."

> #2: "The principle of salt production using SWRO is that SWRO water is stored in a 6000 L pond lined with waterproof membrane layers to reduce leakage. The top of the pond is then covered with UV plastic to accelerate the water evaporation process. Harvesting occurs every 5 days with an estimated initial investment of IDR 150-200 million. Cirebon Power is the only company in Indonesia that has received a patent for the use of SWRO."

SWOT analysis (strengths, weaknesses, opportunities, and threats) is used to analyze both the internal and external conditions of the community, which will then serve as a basis for formulating sustainable management strategies for the community in the Siosar relocation area. In analyzing SWOT, the researcher uses a qualitative approach based on the SWOT matrix developed by Kearns. The determination of internal factors is based on strength and weakness factors, while the determination of external factors is based on opportunity and threat factors derived from the analysis of sustainability levels and the livelihood asset conditions of the community at the research site.

Internal factors, particularly strengths, that influence the strategy for managing domestic plastic waste based on the results of this study include the community's knowledge of domestic plastic waste, which is rated as very good. Additionally, the region is the largest salt-producing area in Cirebon Regency. Furthermore, there is the Vision and Mission of Pengarengan Village, which states, "Restore the Dignity of Pengarengan Village so that it becomes a Village that is Better, Advanced, Dignified, and Respected," with eleven mission objectives in the following areas.

The development goals for Pengarengan Village are outlined across several sectors. In terms of governance, the focus is on establishing an honest, transparent, and accountable administration while enhancing the professionalism of village officials through human resource development. The government also aims to improve service quality and ensure fast, precise decision-making. In the religious sector, efforts are directed at improving infrastructure to support religious education, enhancing community religious activities, providing incentives for Quran teachers and mosque leaders, and supporting individuals who excel in religious endeavors. On the economic front, the village plans to empower the community through group-based business initiatives tailored to local needs, improve agricultural and trade quality, expand job opportunities in productive sectors, and optimize Dissolution of Village-Owned Enterprises/*Badan Usaha Milik Desa* (BUMDes) to stimulate the local economy. Socially, the village emphasizes unity across all groups, fostering harmony and honest communication between the government and residents. In the field of culture, Pengarengan is committed to preserving local traditions to strengthen community bonds and enrich religious and cultural life. For security, the village will reactivate LINMAS activities such as community patrols to maintain safety. Environmental efforts include creating a clean and safe environment, providing drinking water and sanitation solutions, managing waste effectively, and utilizing natural resources sustainably. Regarding infrastructure development, the village will continue building and maintaining essential facilities such as roads, bridges, and drainage systems, ensuring that all plans are made collaboratively with the community. Institutional development focuses on enhancing the capacity and creativity of village organizations, revitalizing youth engagement in sports and arts through Karang Taruna, and promoting local micro, small, and medium enterprises (MSMEs). In the health sector, the goal is to improve healthcare services and forge partnerships to boost public welfare. Lastly, in education and technology, the village seeks to innovate by increasing digital literacy and adopting modern technology to improve public services in line with current trends.

Furthermore, the Pengarengan Village Regulation No. 2 of 2022 on the Village Government Work Plan states that village work programs related to waste management include the maintenance of waste management facilities in the village/community (collection points, waste banks, etc.) with a budget ceiling of IDR 12,000,000. Additionally, another internal factor supporting the achievement of this strategy is the presence of the Pengarengan Tourism Activators group/*Penggerak Wisata Pengarengan* (PESPA) environmental care group with its work programs.

Internal factors, particularly weaknesses, affecting the strategy for managing plastic waste based on the analysis of community attitudes toward domestic plastic waste indicate that the residents of Pengarengan Village have a less favorable attitude, thus not yet adopting pro-environmental behavior. Interviews revealed a lack of village personnel to manage the waste bank, resulting in the program not running; the use of Dissolution of Village-Owned Enterprises/*Badan Usaha Milik Desa* (BUMDes) for plastic waste management is nonexistent; there is only one waste collection point in the Pahing block for 16 neighborhood associations; waste collection by the Cirebon Regency Sanitation Office occurs only once a week; and the village budget is limited to maintaining waste management facilities (collection points, waste banks, etc.) rather than adding waste management infrastructure.

External factors, particularly opportunities, that influence the strategy for managing plastic waste include the Cirebon Regency Regional Regulation No. 5 of 2022 on Waste

Management, specifically Article 8, which outlines the responsibilities of village/sub-district governments in fulfilling obligations as referred to in Article 7, including:

> Letter (d): facilitating the provision of waste management infrastructure at the village level in the form of waste collection point, transportation, and other supporting facilities;
>
> Letter (e): encouraging and facilitating the development of the benefits of waste processing in the village/sub-district area.

Additionally, Cirebon Regency Regent Regulation No. 4 of 2020 on Policies and Strategies for Household Waste and Similar Waste Management states that the target for reducing household waste and similar waste is 30% and handling it is 70% by 2025. There is also support from private parties through Corporate Social Responsibility (CSR) activities in the areas of community empowerment and mangrove ecotourism.

External factors, particularly threats, that influence the strategy for managing plastic waste include the cessation of funding from Corporate Social Responsibility (CSR) of Cirebon Power, potential tourists visiting the mangrove ecotourism via the river route, and seasonal flooding affecting Pengarengan Village.

The strategy for managing domestic plastic waste in coastal areas fundamentally relies on collaboration among various parties and the internal commitment of Pengarengan Village. Based on the results of the SWOT analysis through the SWOT analysis matrix and interviews with informants, the strategy for managing domestic plastic waste in coastal areas is as follows:

S-O Strategy (Comparative Advantage Strategy): This strategy leverages the strengths possessed by the community to seize existing opportunities by: a. Continuing to empower the community through waste bank programs, recycling crafts, Waste for Flowers, and plant nursery initiatives initiated by the PESPA group with assistance and support from private entities through Corporate Social Responsibility (CSR) activities and village funding. b. Developing and expanding the mangrove ecotourism area with assistance and support from private entities through CSR activities. c. Village funds outlined in the RKPDes can facilitate the maintenance of waste management facilities in villages/settlements (collection points, waste banks, etc.) with the help of youth committed to the village's advancement as the generation that will determine the fate of Pengarengan Village.

S-T Strategy (Mobilization Strategy): This strategy mobilizes the strengths of the Pengarengan Village community to minimize or overcome obstacles/threats by educating and strengthening the commitment of the PESPA group, youth, and the community of Pengarengan Village to potential tourists visiting the mangrove ecotourism area to maintain cleanliness. Additionally, it involves providing sufficient trash bins in various locations and transport vessels, as well as mobilizing youth and the community for environmental care activities, such as river and beach clean-ups to reduce flood potential.

W-O Strategy (Investment on Weakness Strategy): This strategy aims to seize opportunities by addressing weaknesses by: a. Through local government and district government regulations (Article 8 letter a of the Cirebon District Regulation, Article 4 paragraph (1) letter f), the poor attitude of the Pengarengan Village community, which is not yet pro-environment, can be changed through practical education, as well as educating and strengthening community, institutional, and group involvement in waste management and handling with support from local and village authorities. b. Village personnel assigned to manage the waste bank can receive incentives beyond their salaries to ensure the waste bank program operates effectively. c. The utilization of Dissolution of Village-Owned Enterprises/*Badan Usaha Milik Desa* (BUMDes), which is currently focused on supplying LPG gas cylinders this year, will begin to shift towards plastic waste management. d. Increasing the number of collection points besides the one in Dusun 02, Block Pahing. The village budget is being directed towards adding facilities and infrastructure for waste management in villages/settlements. The number of TPS provided by the village

government should be at least 2. Pengarengan Village comprises 8 Neighborhood Associations and 16 Community Associations grouped as follows: RW 1-2 is the Pon Dusun block, RW 3-4 is the Pahing and Manis blocks, RW 5-6 is the Wage Block, and RW 7-8 is the Kliwon Block. e. The waste collection interval by the waste collection truck from the Cirebon District Cleaning Service will be increased to twice a week. f. The village budget for the following year will start to focus on adding facilities and infrastructure for waste management in villages/settlements, not just maintaining existing facilities.

W-T Strategy (Damage Control Strategy): This strategy aims to minimize damage so that the impacts do not threaten the sustainability of domestic plastic waste management in coastal areas by strengthening the quality of human resources in changing mindsets regarding waste management, including community empowerment and optimizing community participation in waste management, particularly in sorting and recycling.

The community is the key player in managing domestic plastic waste in coastal areas because they are the entities that will benefit if the environment is clean and are the most affected if waste accumulates in estuaries, leading to flooding and contaminating seawater used for salt production. Holistic area management can be conducted through a collaborative approach based on cross-sector cooperation among the government, private sector, civil society, and social entrepreneurs. Issues related to microplastics in the environment must be addressed from the source, namely domestic waste management on land. The existing waste collection point is still unable to accommodate optimal waste processing as waste produced from sources is collected, transported, and then disposed of in landfills. In this scenario, waste service improvements are primarily focused on the need for waste facilities and infrastructure (equipment, transportation, personnel, and landfills). Waste management must begin at the source to prevent annual increases in waste generation that could negatively impact health and environmental sustainability.

Based on interviews and field observations, the existing waste collection point containers were donated by Cirebon Power, with a volume of 6 m^3, located in Dusun 02, Block Pahing in 2020. This means that the Cirebon District Cleaning Service has not provided TPS facilities for managing village waste. To determine the ideal waste collection point requirements for an area, it is necessary to calculate the per capita waste generation. According to Open Data Jabar (2020), the West Java Housing and Settlement Office recorded a per capita waste generation rate of 0.4 kg/person/day in Cirebon District in 2021. Therefore, to determine the volume of waste generated in the village, the formula can be used: Per Capita Waste Generation x Pengarengan Village Population = Waste Volume.

4. Conclusions

The strategy for managing domestic plastic waste in coastal communities based on the SWOT analysis in the study includes: a. Changing the attitudes of the Pengarengan Village community, which are not yet pro-environment, through practical education and awareness supported by regional and district regulations, along with strengthening village funding for environmental care activities that involve the community, institutions, and groups, as well as improving waste management facilities and infrastructure; b. Empowering the community through waste bank programs, recycling crafts, Waste for Flowers, and plant nursery initiatives initiated by the PESPA group, supported by funding, local and village authorities, and assistance from private entities through Corporate Social Responsibility (CSR) activities; c. Developing and expanding the mangrove ecotourism area while strengthening education and commitment from the PESPA group and the Pengarengan Village community towards potential tourists visiting the mangrove ecotourism area to maintain cleanliness, providing sufficient trash bins in various locations and transport vessels, and mobilizing the community for environmental care activities, such as river and beach clean-ups to reduce flood potential; d. Adding one (1) TPS unit in addition to the existing one in Block Pahing and increasing the waste collection interval by the waste collection truck from the Cirebon District Cleaning Service to two (2) times a week.

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Author Contribution
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