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A Model of Sustainable Waste Management Based on Climate Village Program in Pasaran Island, Lampung Province, Indonesia

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ABSTRACT

Research focuses on waste management challenges on Pasaran Island, Bandar Lampung, examining waste generation, composition, and stakeholder involvement. Data was collected through solid waste sampling, interviews, questionnaires, and documentation, following the SNI-19-3694-1994 standard. A sample size of 20 households was determined using the Slovin formula, and 10 stakeholders from various sectors were selected for analysis. The study used the Analytic Hierarchy Process (AHP) to identify an effective waste management model aligned with the Climate Village Program. The analysis highlighted key factors such as maintenance ease, community participation, and pollution control. Among the alternatives, a household-scale model involving sorting, composting, waste banks, and the House of Recycling Innovation (RINDU) emerged as the most suitable. The findings suggest that enhancing waste management facilities like waste banks and RINDU would support the Ministry of Environment and Forestry's programs and align with local regulations. This study offers insights that could benefit other small islands or communities facing similar waste management challenges.

Introduction

Pasaran Island, which administratively belongs to The Subdistrict of Kota Karang in the Teluk Betung Timur District, is one of the islands in Bandar Lampung. The primary livelihood of most residents of Pasaran Island revolves around fishing and fish-processing activities. It is important to note that Pasaran Island differs from conventional tourist destinations, which usually have various attractions such as beaches, coral reefs, and specially built facilities. The main attraction of Pasaran Island lies in its anchovy fish processing center. The main visitors purchase processed fish products, unique offerings from Pasaran Island. Consequently, the number of long-term visitors from outside the island is relatively low, and the local community, along with its various activities, is the main contributor to the waste generated in the area. The local community is also an important aspect of experiencing the influence of the tourism sector, resulting in gradual changes in lifestyle, economy, and environmental perspectives over time. This sector must also be carefully considered when developing effective waste management strategies [1].

A waste management strategy should be implemented for sustainable waste management [2]. Sustainable waste management is considered an important parameter of Climate Village Program or PROKLIM (*Program Kampung Iklim* in bahasa), which operates nationally and aims to enhance a region's adaptive capacity to

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climate change by promoting community participation and stakeholder involvement. Various mitigation efforts can support the Climate Village Program, including effective waste management [3]. This requires proper management of the waste generated in the area to prevent environmental pollution and ensure the long-term sustainability of waste management [4].

Tourism is a globally developing sector that contributes significantly to waste production. Therefore, there is an urgent need for a comprehensive study to analyze and identify the most suitable sustainable waste management concepts to be implemented at the research site on Pasaran Island. Most existing studies on waste management in tourist destinations focus primarily on seasonal fluctuations in tourist visits, which affect urban waste levels throughout the year [5,6]. However, only a few studies have explored local community patterns and specific waste generation compositions in tourism areas.

In addition to knowing the patterns and specific data of waste, this comprehensive study will consider various alternative approaches. These alternatives are selected based on existing conditions at the research site, determined by stakeholders, and priority criteria with the highest weights [7,8]. A widely applied method called multi-criteria analysis facilitates the decision-making process involving multiple criteria. Among the various available multi-criteria analysis methods, Analytic Hierarchy Process (AHP) is one of the most used approaches to evaluate a limited number of alternatives [9]. The AHP method follows a hierarchical structure, including the identification of criteria and sub-criteria while considering the relative priorities assigned to each criterion [10–12]. This method can evaluate the best alternative based on the established objectives to achieve [13,14]. This systematic approach ensured a robust and objective evaluation process, assisting in identifying the most suitable concepts for the research site.

Materials and Methods

Study Area

Pasaran Island, located Bandar Lampung City, has distinctive geographic coordinates ranging from 5°2'7.43" to 5°2'7.58" S and 105°15'48" to 105°15'58" E, as shown in Figure 1. The island has a land area of 13 ha and is inhabited by approximately 1,900 residents in 2022. These residents are distributed among 342 households, with an average of 4–5 people per household. The economy of Pasaran Island is primarily dominated by the drying of anchovy fish, which utilizes approximately 60% of the total land. This activity is crucial, as anchovy fish are the main commodity of the island's economy. The remaining 40% of land is specifically allocated to residential areas, roads, educational facilities, and various amenities that support the tourism sector. This allocation reflects efforts to balance the needs of the local population with the increasing demands of the tourism industry. Economically, Pasaran Island is predominantly characterized by low-to middle-income households. Livelihoods and economic opportunities for the island's residents rely heavily on various activities, with anchovy fish drying being the most prominent. These economic conditions shape how the population earns a living and affect their overall quality of life and socio-economic well-being.

The selection of Pasaran Island as a research location is intentional, considering its unique characteristics and socioeconomic dynamics. This densely populated small island has been designated a national tourist destination since 2007. These factors present an intriguing context for conducting research, providing insights into the interaction between the local population, economic activities, and tourism sector [15]. By studying Pasaran Island, researchers can gain a deeper understanding of the challenges and opportunities associated with sustainable development.

Waste Generation Data Collection

Waste generation was evaluated continuously for eight consecutive days using the SNI-19-3694-1994 method [16,17]. The Slovin Formula was used to determine the sample size, resulting in samples collected from 20 households for domestic waste. Additionally, non-domestic waste samples were obtained from five small shops, one mosque, and one school. The Slovin Formula in Equation 1 was used to calculate the sample size. With a population of N = 1,642, the total sample size was computed as 94.25, rounded to 95 individuals. This number corresponds to twenty households. From these 20 households, a random selection was made within the area, and sample bags containing waste were provided. Each waste bag consisted of a 40-liter black plastic bag. After weighing the collected solid waste samples, the waste was sorted to separate the different components, and each item was individually weighed.

$$n = \frac{N}{1+N(e)^2} \quad (1)$$

Figure 1. Research area in anchovy center tourism village, Pasaran Island, Bandar Lampung.

The composition results of solid waste were expressed as percentages of the total waste and categorized into the following groups: (1) organic waste/degradable waste, including peels, discarded vegetables, food waste, discarded meals, grains, and the like; (2) paper, including paper scraps, wrapping paper, discarded paper from student bags, and similar items; (3) plastics and polyethylene bags, encompassing plastic items, polyethylene, and other primarily plastic-made objects; (4) glass and ceramic shards, including glass fragments, bottles, glass containers, broken kitchenware made of glass and ceramics, and similar items; (5) cardboard, including non-recyclable paper, cardboard, cardboard boxes, and the like; (6) miscellaneous, comprising metal items, cans, rubber, textiles, leather, metal bottles, dirty paper, wood, sawdust, leaf waste, garden trimmings, waste, and other inert materials.

Stakeholder's Data Collection

The questionnaire used in this study included relevant criteria and sub-criteria for selecting the waste management concepts. The selected criteria encompassed technical, social, environmental, institutional, and economic aspects based on the SNI 3242:2008 standard [18]. The sub-criteria used in the AHP process were chosen based on previous studies [19–21]. The details of these sub-criteria are presented in Table 1. Ten stakeholder respondents were selected for the study. The criteria for selecting respondents included individuals knowledgeable about waste management on Pasaran Island, individuals residing on Pasaran Island for an extended period, and stakeholders related to waste management, especially on Pasaran Island and Bandar Lampung. The criteria and the selected respondents are listed in Table 2.

Table 1. Proposed hierarchical framework.

No.	Criteria	Sub criteria
1.	Technical aspect	Compatibility with Regional Spatial Planning (RTRW) Initial waste handling patterns Processing effectiveness Operational ease Total processing time Maintenance ease
2.	Socio-culture aspect	Community desires and acceptance of waste management Local community wisdom in waste management Human resources readiness in technology implementation Employment absorption and business opportunities Community participation
3.	Environmental aspect	Spread of disease vectors Aesthetics Air pollution Soil and water pollution
4.	Legal and institutional aspect	Availability of institutions Regulations Stakeholder cooperation
5.	Economic aspect	Investment costs Operational and maintenance costs Increase in benefits/income for the community

Table 2. Proposed hierarchical framework.

No.	Stakeholders	Criteria for selecting respondents	Selected respondent
1.	Government	• Has authority over waste management in the study area. • Works in a field or department related to waste management with work experience. • Plays a role in decision-making. • Holds a minimum position as the head of the waste management department.	• Environmental Agency of Bandar Lampung City • City Karang Sub-district
2.	Academia	• Has knowledge in waste/environmental management. • Has conducted/published scientific papers on waste. • At least holds a bachelor's degree.	• Lecturers from ITERA • Lecturers from UNILA/SDG's UNILA
3.	Non-governmental organization	• Has contributed and participated in waste management on Pasaran Island. • Has initiated an activity related to waste handling on Pasaran Island.	• Gajahlah Kebersihan (local cleanliness groups) • Angkuts (local transport groups) • Askara Cendekia
4.	Community	• Residents who have lived on Pasaran Island for at least 5 years. • Residents who play a significant role in the Pasaran Island community. • Residents who have high authority in the Pasaran Island community. • Aware of waste management issues on Pasaran Island. • Directly involved in waste handling on Pasaran Island.	• Chairman of RT 09 (*Rukun Tetangga* or Neighborhood Association in English) • Chairman of RT 10 (*Rukun Tetangga* or Neighborhood Association in English) • Community leaders from Kartini Pasaran and Sea Mama

Data Analysis

The data analysis method employed was descriptive statistical analysis, which aims to provide an overview of the waste generation and composition on Pasaran Island [22]. This approach is used to quantify the waste generated for a week (across eight days of sampling). It was applied without conducting significance tests or making broader inferences from the data. Instead, the primary goal is to present the waste generation and composition using tables and graphs. The formula in Equation 2 involved calculating the average waste

generation and composition on Pasaran Island, which was expressed as a proportion of the overall total (represent as 100%).

$$\text{Average of waste generation} = \frac{\text{Total of waste generation of all waste types (kg)}}{\text{Number of waste types (n)}} \quad (2)$$

Based on the questionnaire results, the weight values were obtained for each predetermined criterion and sub-criterion. The AHP method was used to analyze these data, using Expert Choice software to determine the priority of criteria in waste management. After obtaining the priority of criteria and sub-criteria from the AHP method, determining alternatives to address the waste problem on Pasaran Island will be adjusted based on these aspects. Additionally, they will be aligned by analyzing the existing waste management conditions on Pasaran Island to support the implementation of alternatives in the research location. These alternatives are determined based on previous research and relevant literature studies to adapt and mitigate the Climate Village Program (PROKLIM).

Results and Discussion

Waste Generation

Domestic Waste

Based on the measurements, it was found that the average domestic waste generation on Pasaran Island is approximately 0.13 kg per person per day. The amount of waste produced on Pasaran Island is relatively low compared to the Indonesian National Standard, which sets a limit of approximately 0.5 kg per person per day. When compared to other tourist destinations with similar tourism characteristics to Pasaran Island, such as Barang Lompo Island in Makassar, which generates between 0.5 to 1.1 kg of waste per person per day [23], Salobar in Ambon, with 0.22 kg per person per day [24], and Arjasa District in Kangean Island, with 0.80 kg per person per day [25], the waste generation on Pasaran Island remains significantly lower. This information is shown in Figure 2, which illustrates the comparison of waste generation between Pasaran Island and other tourist destinations. These findings indicate that Pasaran Island has successfully managed its waste, resulting in less waste than in similar places. This demonstrates Pasaran Island's commitment to maintaining cleanliness and environmental sustainability while setting a positive example for other tourist destinations.

Non-Domestic Waste

Based on the collected data, it was determined that the average solid waste generation from non-domestic sources on Pasaran Island amounts to approximately 0.170 kg per person per day (Figure 2). This finding highlights that activity carried out by various establishments, such as shops, schools, and religious institutions, contribute significantly more to the overall solid waste generation than the daily activities conducted within households. Non-domestic waste sources encompass a wide range of activities and locations. Commercial establishments, such as shops and markets, tend to generate substantial waste from packaging materials, food waste, and other disposable items. Similarly, other spots produce considerable waste through paper, plastics, and other materials.

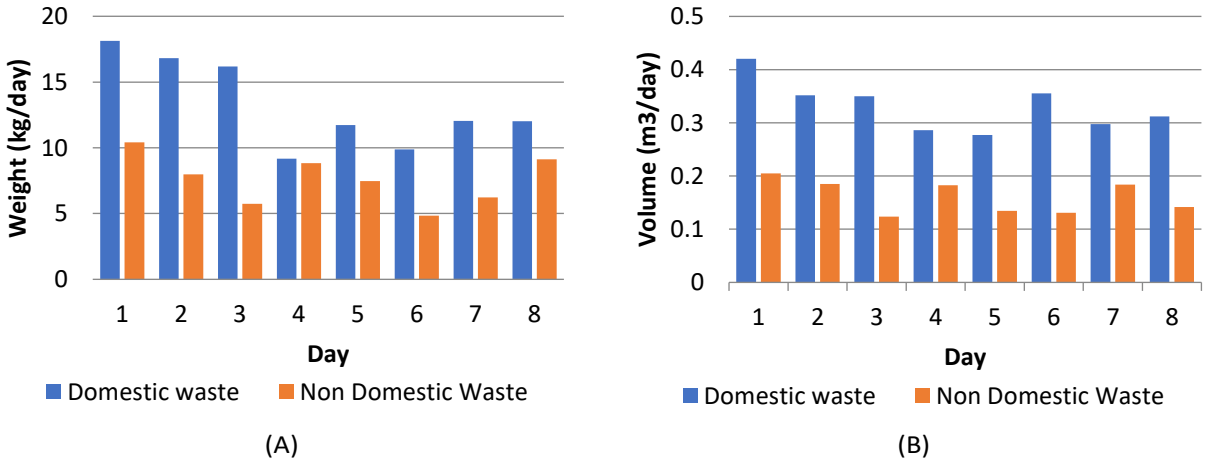

Figure 2. Average of waste generation on Pasaran Island.

Additionally, religious institutions, including temples, mosques, and churches, may generate waste from events, ceremonies, and religious offerings [26]. The higher contribution of non-domestic sources to solid waste generation highlights the importance of implementing effective waste management strategies at the household level and within commercial and institutional sectors. Raising awareness and encouraging responsible waste practices among businesses, schools, and religious organizations to minimize waste generation and promote recycling or proper disposal methods is crucial. Through addressing the solid waste generated by non-domestic sources, Pasaran Island can further enhance its waste management efforts, reduce environmental impact, and work towards creating a sustainable and clean environment for residents and visitors alike.

Solid Waste Composition

The waste composition on Pasaran Island is diverse and consists of various types of waste. Understanding waste composition is crucial for identifying waste reduction opportunities and implementing effective waste management strategies. Measurements and analysis of the solid waste composition on Pasaran Island have revealed that organic waste is the most prevalent type of waste, accounting for 44% of the total waste composition. Organic waste primarily comprises kitchen waste, such as vegetables, fruits, food remnants, leaves, and wood debris [27,28]. Household activities generate organic waste, whereas leaves and wood debris originate from trees on the island [29]. Notably, a significant portion of the wood debris waste comes from washed ashore marine debris on Pasaran Island. Additionally, some household organic waste is a result of excess food. Because organic waste is biodegradable, proper handling involves composting.

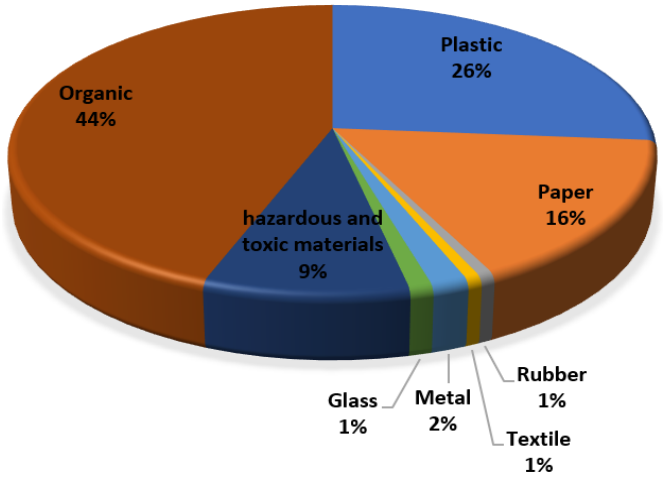

Figure 3. Percentage of waste composition on Pasaran Island.

Composting allows for transforming organic waste into compost fertilizer, which can be used for plant growth and improving soil quality [30]. The second most prevalent waste composition on Pasaran Island was plastic waste, constituting 26% of the total waste composition. Plastic bottles, plastic bags, and food packaging were the main contributors to this category [31]. This trend of plastic waste dominance was also observed in the nearby Pariaman Coastal Region. The high prevalence of plastic waste highlights the significant use of plastics in tourism. Plastic waste poses challenges in terms of decomposition and, if not managed appropriately, can lead to environmental pollution and harm. Paper waste constitutes the third most prevalent waste component on Pasaran Island, accounting for 16% of the total waste composition. Paper waste originates primarily from non-domestic school and shop activities [32]. Detailed information regarding the breakdown of waste composition for each type is shown in Figure 3. Through addressing the predominant types of waste, such as organic, plastic, and paper, Pasaran Island can work towards reducing waste generation, promoting recycling, and minimizing environmental impact. These efforts will contribute to preserving the island's natural beauty and the well-being of its residents and visitors.

Stakeholder Analysis

The criteria for waste management were identified based on paired comparison questionnaires filled out by respondents, which were then processed using the AHP method with the assistance of the Expert Choice software (Table 3).

Table 3. Stakeholder analysis using expert choice software.

Researcher, research year, and title	Research location	Method	Objective	Reference
Analysis of Traditional Market Waste Generation	Bandung	Questionnaire	Find the waste generation through performing waste sampling procedure based on Indonesian Standard for 8 days consecutively	[33]
Analysis of the Rate of Waste Generation on Pramuka Island, Special Region of Jakarta	Jakarta	Questionnaire	Identify potential community concerns and abilities as reflected in attitudes and behavior in contributing to waste management	[34]
Analysis of Generation, Composition, and Potential for Waste Processing in the Banyuwangi Red Island Beach Tourism Area	Banyuwangi	Quantitative descriptive	Measure waste generation, analyze waste composition, and analyze the potential for waste processing in the Merah Island Beach Banyuwangi tourist area	[35]
Waste Management System on Bunaken Island	Bunaken	Field observations, questionnaires, and documentation were distributed, while secondary data was obtained from the Manado City Cleaning and Parks Service, Manado City Environmental Agency	Find out the types and sources of waste on Bunaken Island and analyze the waste management system on Bunaken Island	[36]
Coastal Area Waste Management	Pangandaran Regency, West Lombok, North Lombok, and Seribu Islands	Primary and secondary data collection was carried out through observation and interviews	Field measurements in the form of emergence and the composition of waste in coastal/archipelagic tourist areas	[37]
Comparison of Solid Waste Generation During and Before Pandemic Covid-19 in Indonesia Border Island	Riau Island	Secondary data from Ministry of Forestry and Environment (MoEF) and BPS-Statistics Indonesia	Study the model for estimating the rate of waste generation in the Riau Islands. This study uses data from before and during the Covid-19 pandemic in 2019 and 2020	[38]

Each processed questionnaire result provides priority criteria and sub-criteria for each aspect based on relevant stakeholders [39]. After assigning weights to each respondent's answers, the results indicated the following ranking of criteria: environmental aspects (0.326), economic aspects (0.282), technical aspects (0.197), socio-cultural aspects (0.100), and legal and institutional aspects (0.094). This explains why in waste management on Pasaran Island, the environmental aspect is given top priority, while the other aspects will follow. With good and adequate environmental conditions, the likelihood of improving other conditions, such as economic, technical, legal, institutional, and socio-cultural conditions, also increases [40]. The overall inconsistency in determining the priority criteria for waste management on Pasaran Island was 0.02 (<0.1), which means that the assessment of these criteria was acceptable and valid.

Table 4 shows that regarding technical aspects, the sub-criteria of ease of maintenance has the highest eigenvalue of 0.263. In the sociocultural aspect, the highest value for the sub-criteria was community participation, which was 0.297. In the environmental aspect, the highest value for the sub-criteria was for soil and water pollution, which was 0.373. In the legal and institutional aspects, the highest value for the sub-criteria was stakeholder cooperation, with a value of 0.498. Meanwhile, from an economic perspective, the highest value for the sub-criteria was the increase in benefits/income for the community, with a value of 0.441. Table 4 presents the stakeholder analysis using Expert Choice software.

Table 4. Stakeholder analysis using expert choice software.

No.	Criteria	*Eigen vector*	Sub criteria	*Eigen vector*
1	Technical aspect	0.197	Compatibility with Regional Spatial Planning (RTRW)	0.079
			Initial waste handling patterns	0.113
			Processing effectiveness	0.210
			Operational ease	0.237
			Total processing time	0.098
			Maintenance ease	0.263
2	Socio-culture aspect	0.100	Community desires and acceptance of waste management	0.228
			Local community wisdom in waste management	0.120
			Human resources readiness in technology implementation	0.244
			Employment absorption and business opportunities	0.111
			Community participation	0.297
3	Environmental aspect	0.326	Spread of disease vectors	0.330
			Aesthetics	0.146
			Air pollution	0.151
			Soil and water pollution	0.373
4	Legal and institutional aspect	0.094	Availability of institutions	0.311
			Regulations	0.191
			Stakeholder cooperation	0.498
5	Economic aspect	0.282	Investment costs	0.210
			Operational and maintenance costs	0.349
			Increase in benefits/income for the community	0.441

The results of calculations for the entire group of respondents show that environmental aspects are the main priority in the criteria for selecting waste management concepts at the research location because environmental aspects have the highest priority weight (0.326) when compared with waste management aspects. The results of this calculation are consistent or within the acceptance limits because the consistency ratio value in calculating this sub-criterion is 0.02 or 2% (≤0.1 or 10%). Environmental aspects must be considered because they have an important role in potential environmental impacts that may occur because of untreated waste, such as soil and water pollution, air pollution, which causes gas emissions and unpleasant odors, increased spread of disease vectors around the research location, and damage to the aesthetics of the environment if the chosen waste processing concept does not function as it should.

The priority weights of the sub-criteria that have the top priority, as listed in Table 3, include: (a) the technical aspect, a priority sub-criterion, is the ease of maintenance (T6), with a priority value of 0.263; (b) the socio-cultural aspect, a priority sub-criterion, is community participation (S5), with a priority value of 0.297; (c) the environmental aspect, a priority sub-criterion, was soil and water pollution (L4), with a priority value of 0.373; (d) the legal and institutional aspects, the priority sub-criteria, are stakeholder cooperation (H3) with a priority value of 0.498. The economic aspect, a priority sub-criterion, is increasing benefits/income for the community (E3), with a priority value of 0.441.

Based on the analysis results, it was found that for each criterion, there were sub-criteria with the highest value. In the Operational aspect criteria, it is important to prioritize the maintenance ease sub-criteria, which is in line with the results of interviews and observations of existing conditions where various facilities owned by residents are not running, such as waste banks that have stopped operating. Thus, the waste bank could not operate effectively. It has stopped operating because it is constrained by the difficulty of access to Pasaran Island and the lack of transportation facilities. This is related to the legal and institutional aspects of stakeholder cooperation. All stakeholders and related institutions should actively participate in dealing with the problems on Pasaran Island. Infrastructure improvements and institutional clarity are important aspects that must be considered so that waste management on Pasaran Island can run optimally.

In addition, the active participation of the community must be prioritized to improve waste management on Pasaran Island because this is a key point for the successful implementation of an effective waste management concept. Based on the results of the field observations, it was found that there is still low public awareness and the assumption that it is detrimental to handling waste. Hence, people leave their garbage alone or burn the waste, which is detrimental to the environment and further results in environmental pollution, such as soil, water, and air pollution. Therefore, this must also be strengthened by the economic

aspect, especially in increasing benefits/income for the community, following the highest weighting results for economic criteria. It is hoped that economically beneficial waste management will encourage the community to participate in the waste management process [41–45].

Climate Village Program (PROKLIM) Waste Management Model

Based on the results of the calculations for the entire group of respondents (stakeholders in the waste sector), environmental aspects are the main priority in the criteria for selecting waste management concepts at the research location because environmental aspects have the highest priority weight (0.326) compared with waste management aspects. The three waste management model alternatives were developed based on the environmental aspects listed in Table 5.

Table 5. Stakeholder analysis using expert choice software.

No.	Alternative waste management models	Application stage
1	Individual management of organic waste (composting) by the community is followed by waste management at waste processing facility: reduce, reuse, recycle.	The implementation flow for this alternative includes reducing waste; collection, transportation, and sorting at waste processing facility: reduce, reuse, recycle; recycle; and residue handling.
2	Waste management on a household scale (sorting and composting) continues with the waste bank concept and utilization by House of Recycling Innovation or RINDU (*Rumah Inovasi Daur Ulang*).	The application flow for this alternative includes waste reduction; depositing waste from the public to waste banks; waste recycling and sales; sorting and composting; and residue handling.
3	Waste management on a regional scale (government and village) begins with household scale waste processing and the residue is then disposed of in the landfill.	This alternative's application flow includes waste reduction, waste container, collection and transportation, packaging and recycling, and residue handling.

Based on the alternatives above, the most suitable alternative will be selected using AHP and the existing waste management conditions on Pasaran Island. Waste management patterns can be implemented in a way that not only focuses on the impact of pollution on humans but also on life [46]. Therefore, based on the analysis of the existing conditions of the research location and environmental aspects, alternative two were chosen as a recommendation for an appropriate waste management system to be implemented on Pasaran Island, namely waste management on a household scale (sorting and composting) followed by the waste bank concept and utilization by RINDU with a score of 0.52.

Alternative waste management model 2 was selected and given priority over other alternative management methods because, if seen from the alternative value of each sub-criterion, alternative 2 has advantages in terms of sub-criteria in each criterion, namely in terms of ease of maintenance, community participation, overcoming soil and water pollution, working with stakeholders, and increasing benefits/income for the community. Meanwhile, an alternative is considered a slight advantage, only superior in two sub-criteria (control of land and water pollution and community participation). Likewise, alternative 3 has several advantages regarding the three sub-criteria (control of land and water pollution, community participation, and stakeholder cooperation). Based on the current existing conditions, to increase the achievement of implementing alternative 2 with the Waste Bank and RINDU, the following improvements can be made:

a. Technical aspects (ease of maintenance)

Maintenance involves following up on and supervising previous training, so it only seems hands-off after the training is given to the community. Maintenance can be carried out under supervision from the sub-district office during Waste Bank and RINDU operations.

b. *Socio-cultural aspects (community participation)*

There are several community roles needed for the continued implementation of alternatives with the Waste Bank and RINDU: 1) in the decision-making stage, the community has been included in deliberations to discuss the program; 2) in the implementation stage, the community has participated in saving waste, and some have become creative craftsmen; 3) in the benefit-taking stage, the aim is to empower the community; and 4) in the evaluation stage, the community has not been included in the evaluation process and is only carried out by waste bank administrators and RINDU.

c. *Environmental aspects (soil and water pollution)*

Reducing waste in the environment is important because people who implement the Waste Bank and RINDU alternatives and reduce waste from the source by composting can process organic waste and reuse inorganic

waste by recycling. This has a positive impact because it can reduce land and water pollution due to the accumulation of waste in the ground (mixed waste containing B3). In addition, in the informal sector, namely, cleaning staff at the Bakung final processing site. They can reduce the amount of waste in the TPA by reducing data on the amount per month.

d. *Legal and institutional aspects (stakeholder collaboration)*

Shared motivation in waste management collaboration on Pasaran Island from each stakeholder involved in the collaboration already exists and needs improvement, including 1) providing knowledge or outreach to the public about waste management, 2) the private sector making it easier to obtain raw materials for processing, 3) the waste bank is to gain knowledge and facilities in waste management, and 4) the government is to facilitate cooperation in waste management and provide awareness to the public so that they want to manage waste, especially domestic waste.

e. *Economic aspects (increased benefits/income for the community)*

Increased benefits and income for the community can be in the form of Income received by people who are customers of the Waste Bank, Pasaran Island residents get job vacancies, The existence of support from the government having the potential to become an Environmental Tourism Village is a supporting factor, Utilization of organic waste to feed maggots in RINDU, Inorganic waste for mixed materials for making rosters at RINDU.

Conclusions

The average waste generation on Pasaran Island from domestic and non-domestic activities is 0.13 kg per person per day and 0.17 kg per person per day. From the Analytical Hierarchy Process (AHP) the priority criteria for waste management on Pasaran Island that needs to be considered is environmental aspects (0.326). Appropriate waste management strategies are crucial for effectively addressing these solid waste problems. Through actively managing and reducing these wastes and focusing on environmental aspects, Pasaran Island can progress towards establishing a more sustainable and environmentally friendly waste management system that will later have implications for increasing regional income by promoting sustainable tourism practices. Waste management on a household scale (sorting and composting) followed by the waste bank concept in RINDU was selected based on the AHP method. Further research needs to be done to estimate the economic potential of implementing this waste management model in Pasaran Island and residents' level of acceptance or willingness to engage in sustainable waste practices.

Author Contributions

FCA, NM, S: Conceptualization, Methodology; **VUB, ZAH, WP, MK, DA**: Writing - Review and Editing; and **GMR, LS, TG**: Collecting data, Data analysis, and Writing.

Conflicts of Interest

There are no conflicts to declare.

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References

1. Eslami, S.; Khalifah, Z.; Mardani, A.; Streimikiene, D.; Han, H. Community attachment, tourism impacts, quality of life and residents' support for sustainable tourism development. *J. Travel Tour. Mark.* **2019**, *36,* 1061–1079, doi:10.1080/10548408.2019.1689224.
2. Pujara, Y.; Pathak, P.; Sharma, A.; Govani, J. Review on Indian municipal solid waste management practices for reduction of environmental impacts to achieve sustainable development goals. *J. Environ. Manage.* **2019**, *248*, 1–14, doi:10.1016/j.jenvman.2019.07.009.

3. Sriyanto, S.; Kurniawan, E.; Maulana, M. Adaptation pattern of Lerep Village as thematic climate program in dealing with global warming. In *Proceedings of the 1st International Conference on Environment and Sustainability Issues, ICESI 2019, Semarang, Indonesia, 18–19 July 2019*; Wasino, Setyowati, D.L., Astuti, T.M.P., Sanjoto, T.B., Wijaya, A., Eds.; European Alliance for Innovation (EAI): Gent, Belgium, 2019.
4. Gunawati, D.; Rejekiningsih, T. Building ecological citizens through the implementation of climate village programs as climate change mitigation effort. In *Proceedings of the 3rd International Conference on Learning Innovation and Quality Education (ICLIQE 2019)*, *Surakarta, Indonesia, 7 September 2019*; Salimi, M., Colomeischi, A.A., Yasin, M.H.M., Roslan, R.M., Nugraha, D.A., Eds.; Atlantis Press: Dordrecht, Netherlands, 2020; Volume 397, pp. 1124–1131.
5. Wang, J.; Huang, X.; Gong, Z.; Cao, K. Dynamic assessment of tourism carrying capacity and its impacts on tourism economic growth in urban tourism destinations in China. *J. Destin. Mark. Manage*. **2020**, *15*, 1–15, doi:10.1016/j.jdmm.2019.100383.
6. Septiariva, I.Y.; Sari, M.M.; Istanabi, T.; Suhardono, S.; Prayogo, W.; Suryawan, I. The effect of the COVID-19 pandemic on waste management in the eastern tourism regions of Java and Bali Islands. *Ecol. Eng. Environ. Technol*. **2023**, *24*, 1–9, doi:10.12912/27197050/159430.
7. Gherghel, A.; Teodosiu, C.; Notarnicola, M.; de Gisi, S. Sustainable design of large wastewater treatment plants considering multi-criteria decision analysis and stakeholders' involvement. *J. Environ. Manage.* **2020**, *261*, 1–15, doi:10.1016/j.jenvman.2020.110158.
8. Tsai, F.M.; Bui, T.D.; Tseng, M.L.; Lim, M.K.; Wu, K.J.; Mashud A.H.M. Assessing a hierarchical sustainable solid waste management structure with qualitative information: Policy and regulations drive social impacts and stakeholder participation. *Resour. Conserv. Recycl*. **2021**, *168*, 1–10, doi:10.1016/j.resconrec.2020.105285.
9. Balwada, J.; Samaiya, S.; Mishra, R.P. Packaging plastic waste management for a circular economy and identifying a better waste collection system using Analytical Hierarchy Process (AHP). *Procedia CIRP* **2021**, *98*, 270–275, doi:10.1016/j.procir.2021.01.102.
10. Aung, T.S.; Luan, S.; Xu, Q. Application of multi-criteria-decision approach for the analysis of medical waste management systems in Myanmar. *J. Clean. Prod*. **2019**, *222*, 733–745, doi:10.1016/j.jclepro.2019.03.049.
11. Kamdar, I.; Ali, S.; Bennui, A.; Techato, K.; Jutidamrongphan, W. Municipal solid waste landfill siting using an integrated GIS-AHP approach: A case study from Songkhla, Thailand. *Resour. Conserv. Recycl.* **2019**, *149*, 220–235, doi:10.1016/j.resconrec.2019.05.027.
12. Khoshand, A.; Rahimi, K.; Ehteshami, M.; Gharaei, S. Fuzzy AHP approach for prioritizing electronic waste management options: A case study of Tehran, Iran. *Environ. Sci. Pollut. Res.* **2019**, *26*, 9649–9660, doi:10.1007/s11356-019-04407-8.
13. AlHumid, H.A.; Haider, H.; Al Saleem, S.S.; Shafiquzamman, M.; Sadiq R. Performance indicators for municipal solid waste management systems in Saudi Arabia: Selection and ranking using fuzzy AHP and PROMETHEE II. *Arab. J. Geosci.* **2019**, 12, 1–23, doi:10.1007/s12517-019-4645-0.
14. Ozturk, S.; Karipoglu F. Investigation of the best possible methods for wind turbine blade waste management by using GIS and FAHP: Turkey case. *Environ. Sci. Pollut. Res.* **2023**, *30*, 15020–15033, doi:10.1007/s11356-022-23256-6.
15. Suryawan, I.; Septiariva, I.Y.; Sari, M.M.; Ramadan, B.S.; Suhardono, S.; Sianipar, I.M.J.; Tehupeiory, A.; Prayogo, W.; Lim, J. Acceptance of waste to energy technology by local residents of Jakarta City, Indonesia to achieve sustainable clean and environmentally friendly energy. *J. Sustain. Dev. Energy Water Environ. Syst*. **2023**, *11*, 1–17, doi:10.13044/j.sdewes.d11.0443.
16. Rosesar, J.S.; Kristanto, G.A. Household solid waste composition and characterization in Indonesia Urban Kampong. *IOP Conf. Ser. Mater. Sci. Eng*. **2020**, *909*, 1–8, doi:10.1088/1757-899X/909/1/012077.
17. Hasianetara, S.; Indrawati, D.; Purwaningrum, P. Evaluation of solid waste management operational techniques in Kebonsari Urban Village, Citangkil Sub-District, Cilegon City. *IOP Conf. Ser. Earth Environ. Sci*. **2021**, *737*, 1–6, doi:10.1088/1755-1315/737/1/012075
18. Sidabalok, H. *Residential Solid Waste Management in Semarang: The Question of Geographical Environmental Justice*; PT Kanisius: Yogyakarta, Indonesia, 2023.

19. Hazarika, R.; Saikia, A. Landfill site suitability analysis using AHP for solid waste management in the Guwahati Metropolitan Area, India. *Arab. J. Geosci*. **2020**, *13*, 1–14, doi:10.1007/s12517-020-06156-2.
20. Adar, E.; Delice, E.K.; Adar, T. Prioritizing of industrial wastewater management processes using an integrated AHP–CoCoSo Model: Comparative and sensitivity analyses. *Int. J. Environ. Sci. Technol.* **2022**, *19*, 4691–4712, doi:10.1007/s13762-021-03511-y.
21. Demircan, B.G.; Yetilmezsoy, K. A hybrid fuzzy AHP-TOPSIS approach for implementation of smart sustainable waste management strategies. *Sustainability* **2023**, *15*, 1–23, doi:10.3390/su15086526.
22. Meza, J.K.S.; Yepes, D.O.; Rodrigo-Ilarri, J.; Cassiraga, E. Predictive analysis of urban waste generation for the city of Bogotá, Colombia, through the implementation of decision trees-based machine learning, support vector machines and artificial neural networks. *Heliyon* **2019**, *5*, 1–11, doi:10.1016/j.heliyon. 2019.e02810.
23. Sutopo, Y.K.D.; Jinca, M.Y.; Azmy, M.F.; Abdi, A.P.; Ward, H. Waste management improvement strategy for Barrang Lompo Island in Makassar City. *AIP Conf. Proc*. **2022**, *2543,* 2–7, doi:10.1063/5.0096431.
24. Tuahatu, J.W.; Noya, Y.A.; Manuputty G.D. Plastic pollution on the beaches of outer Ambon Bay. *IOP Conference Series: Earth and Environmental Science* **2020**, *584*, 1–7, doi:10.1016/j.resconrec.2020. 105285.
25. Rahman, S.M.; Bagastyo, A.Y. Solid waste management in island communities: Case study in Arjasa District, Kangean Island. In *The 6th International Conference on Energy, Environment, Epidemiology, and Information System (ICENIS) 2021, Semarang, Indonesia, 4–6 August 2021*; Soeprobowati, T.R., Warsito, B., Putranto, T.T., Eds.; AIP Publishing: Melville, NY, USA, 2023; Volume 26, pp. 1–5.
26. Allison, E. The reincarnation of waste: A case study of spiritual ecology activism for household solid waste management: The Samdrup Jongkhar initiative of rural Bhutan. *Religions* **2019**, *10,* 1–19, doi:10.3390/rel10090514.
27. Sindhu, R.; Gnansounou, E.; Rebello, S.; Binod, P.; Varjani, S.; Thakur, I.S.; Nair, R.B.; Pandey, A. Conversion of food and kitchen waste to value-added products. *J. Environ. Manage.* **2019**, *241*, 619–630, doi:10.1016/j.jenvman.2019.02.053.
28. Zhang, L.; Guo, B.; Zhang, Q.; Florentino, A.; Xu, R.; Zhang, Y.; Liu Y. Co-digestion of blackwater with kitchen organic waste: Effects of mixing ratios and insights into microbial community. *J. Clean. Prod*. **2019**, *236*, 1–10, doi:10.1016/j.jclepro.2019.117703.
29. Sharma, H.B.; Vanapalli, K.R.; Cheela, V.S.; Ranjan, V.P.; Jaglan, A.K.; Dubey, B.; Goel, S.; Bhattacharya, J. Challenges, opportunities, and innovations for effective solid waste management during and post COVID-19 Pandemic. *Resour. Conserv. Recycl*. **2020**, *162*, 1–12, doi:10.1016/j.resconrec.2020.105052.
30. Chen, T.; Zhang, S.; Yuan, Z. Adoption of solid organic waste composting products: A critical review. *J. Clean. Prod*. **2020**, *272*, 1–10, doi:10.1016/j.jclepro.2020.122712.
31. Ncube, L.K.; Ude, A.U.; Ogunmuyiwa, E.N.; Zulkifli, R.; Beas, I.N. An overview of plastic waste generation and management in food packaging industries. *Recycling*. **2021**, *6*, 1–25, doi:10.3390/recycling6010012.
32. Syahiya, M.; Megantara, E.N.; Husodo, T. Dynamic spatial model of non-domestic waste transport in strategic areas. In *4th International Conference on Sustainability Science (CSS2020), Bandung, Indonesia, 8 October 2020*; Withaningsih, S., Utama, G.L., Supyandi, D., Malik, A.D., Eds.; EDP Sciences: Les Ulis Cedes, France, 2021; Volume 249, pp. 1–4.
33. Chaerul, M.; Dewi, T.P. Analisis timbulan sampah pasar tradisional (Studi kasus: Pasar Ujungberung, Kota Bandung). *Al-Ard: J. Tek. Lingkung*. **2020**, *5*, 98–106, doi:10.29080/alard.v5i2.861.
34. Nasution, S.R.; Tjahjani, A.I. Analisis laju timbulan sampah di Pulau Pramuka DKI Jakarta. *J. Ilm. Tek. Ind*. **2020**, *7*, 16–26, doi:10.24912/jitiuntar.v7i1.5030.
35. Krisdhianto, A.; Muyasaroh, S.; Defriatno, M. Analisis timbulan, komposisi, dan potensi pengolahan sampah kawasan wisata Pantai Pulau Merah Banyuwangi. *J. Biosense*. **2023**, *6*, 60–72, doi:10.36526/ biosense.v6i01.2813.
36. Tallei, T.E. Local Community-based initiatives of waste management activities on Bunaken Island in North Sulawesi. Res. *J. Environ. Earth Sci*. **2013**, *5*, 737–743.

37. Darwati, S. 2019. Pengelolaan sampah kawasan pantai. In Prosiding Seminar Nasional Pendidikan Biologi dan Saintek Ke-IV (SNPBS IV), Surakarta, Indonesia, 27 April 2019; pp. 417–426.

38. Sari, M.M.; Septiariva, I.Y.; Istanabi, T.; Suhardono, S.; Sianipar, I.M.J.; Tehupeiory, A.; Suryawan, I. Comparison of solid waste generation during and before pandemic Covid-19 in Indonesia border island (Riau Islands Province, Indonesia). *Ecol. Eng. Environ. Technol*. **2023**, *24*, 251–260, doi:10.12912/27197050/157170.

39. Kurbatova, A.; Abu-Qdais, H.A. Using Multi-criteria decision analysis to select waste to energy technology for a mega city: the case of Moscow. *Sustainability*. **2020**, *12*, 1–18, doi:10.3390/su12239828.

40. Ahlstrom, D.; Arregle, J.L.; Hitt, M.A.; Qian, G.; Ma, X.; Faems, D. Managing technological, sociopolitical, and institutional change in the new normal. *J. Manage. Stud*. **2020**, *57*, 411–437, doi:10.1111/joms.12569.

41. Pai, S.; Ai, N.; Zheng, J. Decentralized community composting feasibility analysis for residential food waste: A Chicago case study. *Sustain. Cities Soc*. **2019**, *50*, 1–13, doi:10.1016/j.scs.2019.101683.

42. Palaniveloo, K.; Amran, M.A.; Norhashim, N.A.; Mohamad-Fauzi, N.; Peng-Hui, F.; Hui-Wen, L.; Kai-Lin, Y.; Jiale, L.; Chian-Yee, M.G.; Jing-Yi, L.; et al. Food waste composting and microbial community structure profiling. *Processes* **2020**, *8*, 1–30, doi:10.3390/pr8060723.

43. Kurniawan, T.A.; Avtar, R.; Singh, D.; Xue, W.; Othman, M.H.D.; Hwang, G.H.; Iswanto; Albadarin, A.B.; Kern, A.O. Reforming MSWM in Sukunan (Yogjakarta, Indonesia): A case-study of applying a zero-waste approach based on circular economy paradigm. *J. Clean. Prod*. **2021**, *284*, 1–13, doi:10.1016/j.jclepro.2020.124775.

44. Evode, N.; Qamar, S.A.; Bilal, M.; Barceló, D.; Iqbal, HM. Plastic waste and its management strategies for environmental sustainability. *Case Stud. Chem. Environ. Eng*. **2021**, *4*, 1–8, doi:10.1016/j.cscee.2021.100142.

45. Sari, M.M.; Inoue, T.; Rofiah, R.; Septiariva, I.Y.; Prayogo, W.; Suryawan, I.; Arifianingsih, N.N. Transforming bubble wrap and packaging plastic waste into valuable fuel resources. *J. Ecol. Eng*. **2023**, *24*, 260–270, doi:10.12911/22998993/166554.

46. Zhang, J.; Qin, Q.; Li, G.; Tseng, C.H. Sustainable municipal waste management strategies through life cycle assessment method: A review. *J. Environ. Manage*. **2021**, *287,* 1–17, doi:10.1016/j.jenvman.2021.112238.