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The Prospect of Implementing Circular Economy of Solid Waste in Small Islands: A Case Study of Karimunjawa Islands District, Central Java - Indonesia

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Abstract. Circular Economy (CE) is increasingly used waste management concept especially in transition nations to transforms linear into a circular concept of waste production. CE sees waste as secondary raw material for re-production. Globally, CE has been studied and practiced in recent years. However, there are still few studies related to small islands. The characteristics of solid waste in small islands differ from the one on the Main Island, such as how solid wastes generated and the typology of solid waste. Karimunjawa Islands District is one of the small islands in Indonesia that has begun to experience environmental problems because of the excessive amount of solid waste. This study aims to identify the implementation of CE in small islands. This study was conducted by literature study, questionnaire, observation, interview with local stakeholders, and forum group discussion. The result revealed that there are leaks in macroeconomic aspects from manufacturing activities to consumption activities as well as market failures from consumption activities to waste disposal. It is indicated that waste management in small islands can be sustainable and independent after closing loops/ leaks by procuring technology, setting clear regulations related to solid waste management, performing effective waste transportation, and holding house-to-house socialization regarding sustainable behavior.

1. Introduction

Circular economy (CE) is a concept currently promoted by the EU, by several national governments including China, Japan, UK, France, Canada, The Netherlands, Sweden, and Finland as well as by several businesses around the world [1]. Korhonen defines it with a critical scientific approach and within the perspective of sustainable development. It is as follows: CE is an economy constructed from societal production-consumption systems that maximize the service produced from the linear nature-society-nature material and energy throughput flow. This is done by using cyclical materials flows, renewable energy sources, and cascading-type energy flows. A successful circular economy contributes to all three dimensions of sustainable development. A circular economy limits the throughput flow to a level that nature tolerates and utilizes ecosystem cycles in economic cycles by respecting their natural reproduction rates.

In Asian countries, CE can be seen as a replicated traditional practice, culture from older practices within household wastes [2]. People maintain the function and economic value of goods such as sheets of paper and plastic bags longer within the circulation. CE's goal is to move the fundamental thinking



away from ‘waste disposal’ to ‘waste management’ and from ‘waste’ to ‘resource’. Hence, the terminology becomes ‘waste and resource management’ as part of the ‘circular economy’ [4].

2. Profile of The District of Karimunjawa Small Islands

The District of Karimunjawa Islands in the province of Central Java - Indonesia consists of four villages, namely Karimunjawa Village, Kemujan Village, Nyamuk Village, and Parang Village. Karimunjawa Islands District has 9,379 inhabitants in 2015. The Karimunjawa Islands surrounded by the Java Sea and located 90 km from Jepara Regency, the capital city. The research is concentrated in the urban area of Karimunjawa, which is located in the village of Karimunjawa with a population of 4,747 people. The urban area of Karimunjawa is the center of activities for marine transportation, tourism, and fisheries.

The Karimunjawa Islands is now becoming a tourist destination for residents of the neighboring Jepara Regency. According to the Presidential Regulation of the Republic of Indonesia 50/2011 concerning the National Tourism Development Master Plan for 2010—2025, Karimunjawa is currently a part of the 88 National Tourism Strategic Areas.

3. Methodology

The research was conducted with a transformative approach that collects both quantitative and qualitative data within the frame of Circular Economy theory. Qualitative data was collected by conducting interviews with 11 stakeholders; held 4 forums related to waste management in Karimunjawa, and visual observation to confirm the description. Stakeholders consist of formal government institutions, such as: Jepara Regency Environmental Service, Karimunjawa Village Officials, head of Village Owned Enterprises (BUMDes), and Head of neighborhood groups/RT; local people who subject-related, such as: managers of waste banks (*bank sampah*), NGO, independent waste collectors, and flea market dealers; and external agencies, such as: donors and CSR managers that support waste management in Karimunjawa. Issues raised in the interview included waste management practices in Karimunjawa, factors affecting waste management, and future waste management plans.

Quantitative data was carried out by distributing questionnaires to 100 houses using convenience sampling. The questionnaire consists of 2 parts: demographic data and the perspective of people's behavior in managing waste. The questionnaire was adapted from Theory Planned Behavior [4]. There are 9 constructs used to determine population factors in changing/ strengthening collective behavior, such as: the environmental knowledge construct [5] [6] [7], moral obligations [8] [6], attitudes, social norms, behavior control, intention, situational factors [9] [10], and behavior. Each construct has 2 to 5 questions.

To complete the research, visual observation of waste generation from household, ocean, and tourism activities was conducted. A sampling of household waste generation was carried out in one in 3 neighborhood groups with a total of 167 families. Waste that is collected then is sorted according to its type. It is assumed that the pattern of domestic waste generation does not change from year to year. The waste generation from tourism activities comes from lodging, restaurant, and waste scattered on the road. Being close to the open ocean, as far as 3 meters from the coastline of Karimunjawa islands, various waste from the ocean enter in, especially during the full moons.

4. Production

4.1. Marine Debris

Karimunjawa is an archipelago located in the middle of the Java Sea affected by the sea cycle. Every year, in the marine cycle there are west and east monsoons. In the west monsoon, the wind will blow from west to east as well as east winds, vice versa. When the west wind comes, the eastern side of the Karimunjawa Islands will be filled with goods/ materials/ waste carried by the ocean currents and vice versa. There are residents in the Kemojan area who take a trek at a certain time along the beach and

bring home items that can still be utilized including reused or recycled. On the other hand, ocean wastelleft unpicked for sometimes.

The second case is the ocean waste that enters the coastline of Legon Lele village. The most marine debris found on Karimunjawa Island District is located on Legon Lele Beach, with both mesoplastics and macro-plastics as much as 76.19%. The plastics that were found consist of bottle caps, bottles less than 2 liters as well as more than 2 liters, conductors and drums, knives, spoons, forks, straws, beverage equipment packages and food containers, fast food containers, plastic bags, toys and event supplies, and rope. Other waste is rubber, metal, cloth, glass, and other materials. Rubber waste (7.17%) that was found was the sole of the shoes and gloves. Metal waste (5.46%) found were aluminum cans and other mining categories. Fabric (5.04%) waste found was canvas and rope. 4.73% of glass waste, such as bottles, jars, broken glass, and ceramics. Other waste (1.14%) is cleaning tools (toothbrushes, diapers) and electronic equipment.

Total marine debris generated is 7,593 kg per square meter annually. Karimunjawa archipelago has a 1995 Ha coastal border in all villages which is measured 100 meters from the shoreline at high tide and usually has a slope of 0-8%. The waste covers the land up to three meters from the shoreline, with a calculated area of 60 Ha. Using a simple calculation and assuming that every square meter on the beach has the same amount of waste, it can be known that the marine debris in Karimunjawa reaches 4,555 tons of waste each year.

Marine debris is categorized as residue because it cannot be processed into other goods. After the waste has been collected for up to two months, residents clean it by collecting it, then burning it or placed in a temporary landfill.

4.2. Jepara Regency as the Main Island

The relationship between Jepara Regency and Karimunjawa Islands District is that the regency is a provider of the livelihood needs for the local Karimunjawa community. All daily necessities, materials for construction, clothing, gas, and oil are supplied from the main island. In return, natural resources sent to Jepara Regency are young coconuts that are produced in a labor-intensive manner. Karimunjawa's main income is from tourism. Karimunjawa is the most favorite tourist destination for foreign tourists and the third most favorite destination in Jepara regency, after Bandengan Beach and Kartini Beach which are located on the main island.

Transportation from Jepara to Karimunjawa Islands cannot be accessed every day, only when there is an order by plane, and via ships every morning and evening. But if the waves are high the ship will not lean on Karimunjawa Harbor. Three seasonal cycles affect sea conditions which are the western season, the transitional season, and the eastern season. During the western season that occurs in January and February, the high waves prevent fishing boats from entering the Java Strait. The departure of ships more often than not delayed. On the other hand, the waves during the east monsoon which usually occurs from July to September are not too high. . The best seasons for mobility is a shoulder season, between the west season and the east season that has moderate to calm waves.

4.3. Discussion

Karimunjawa District rarely has enough resources and totally dependent on Jepara Regency as the main island. Local people and stakeholders do not consider this as an issue and are already accustomed the remote situation. During the west monsoon, when the highest waves occur several days till several weeks it means ships will rarely come. This creates a habit of storing much needed materials including food.

5. Consumption

5.1. People Behavior in Waste-Consumption-Environment Knowledge

The environmental knowledge construct is a construct that functions to identify people's knowledge regarding the environment and the consequences of the treatment of waste. The construct of moral

obligation serves to identify people's concern for ethics to the environment. The attitude construct is to identify the consumption patterns of the population that produce waste. The social norm construct is used to identify actors who are influential in changing people's perceptions. The construct of perceived behavior control is used to identify the wishes of the locals who want to be realized in the future regarding the condition of solid waste in Karimunjawa. The intention construct is used to see the commitment of the population in changing the behavior of managing waste to be more sustainable. The situational factor construct is used to see what factors hinder the behavior of managing waste. Behavioral constructs are used to identify behavior currently carried out by Karimunjawa residents according to ideal conditions.

The results from questionnaires are tested using the reliability test on the variables used in the study. From the SPSS output data, it is known that there are 29 questionnaire items with a Cronbach's Alpha value of 0.734 or > 0.6 . This is the basis for making the reliability test decision, it can be concluded that 29 questions are reliable/consistent. Also obtained from the table r value with a significance of 5%, that the value of Cronbach's Alpha is 0.734 or > 0.367 , so the questionnaire is declared reliable. The validity test was calculated using bivariate correlation and resulted in a significant correlation at 0.001 and 0.005, thus the variables can be used for further analysis. However, the variables were not normally distributed and not homogeneous because of the low significance value. Therefore, the transformation procedure is performed and non-parametric analysis is used. In this study, the Friedman Test with Wilcoxon post hoc is also used.

Based on the results of the Friedman test, a ranking score in each construct is obtained and is compared with each other. The result is behavioral construct higher than other constructs.

A hypothesis test is performed using the chi-square test on the Friedman Test to determine whether or there is a difference in the ranking of each construct compared to the expected value.

In this ranking, the chi-square value is 189.718 with the degrees of freedom are 7. Then, we can conclude that 100 respondents do not have the same preference for each construct.

Table 1. Statistical test on Friedmann's test.

N	chi-sq	df	Asymp. Sig
100	189.718	7	.000

Z is a standardized measure of the distance between the total ranking of the negative group and the expected value. In this case, the asymptote value is so small that it is close to zero. Bonferroni significance was used for adjustment for statistical values using multiple comparisons and the result is 0.007143. In conclusion, it can be said that the Z value in each construct comparison is significant with $p < 0.001$, or all constructs have a relationship.

From this table, we found that the closest distance that is most influential with the construct of waste management behavior is the construct of intention with a distance of -3.814, the construct of moral obligation with a distance of -6.816, and so on.

Table 2. Wilcoxon Test Statistics Based on Negative Ranking.

Construct Relationship	Z	Asymp. Sig. *
Intention – Behavior	-3.814	.000
Situational Factor – Behavior	-7.596	.000
Perceived Behavior Control - Behavior	-8.039	.000
Social Norm – Behavior	-7.817	.000
Moral Obligation – Behavior	-6.816	.000
Attitude – Behavior	-6.866	.000

Environment Knowledge – Behavior	-6.660	.000
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After obtaining the construct relationship, we can find out which residents have relatively good/bad knowledge based on their profiles with simple cross-tabulation. After cross-tabulating each characteristic, the following results were obtained.

Table 3. Relative Level of Knowledge of Waste-Consumption-Environment Concept.

Characteristics	Relatively Good Behavior	Relatively Bad Behavior
Address	RW 2	RW 3
Age	+60 and +20 y.o.	+30 and +50 y.o
Education	Bachelor Degree	Primary School
Gender	Male	Female
Length of residence	<5 years	>21 years
The main job	Honorary worker	Merchant
Side job	Food Sector	None
Personal income	Low (0-500.000)	High (1.600.000-8.000.000)
Family income	Low (0-500.000)	High (2.100.000 - 3.000.000)
Willingness To Pay (WTP)	0-500 IDR in a day	2500-3300 IDR in a day

Based on geographical conditions, Citizen Association (RW) #2 has a relatively good attitude. They live close to vital public facilities, such as waste location, bank, postal offices, puskesmas building, and housing for puskesmas staffs. They are the role models on living clean in the community, facilitated by rather orderly landscape. Meanwhile, RW 3 is located near the beach boundary. The residents here often throw waste directly into the sea in order to build so called traditional reclamation near their areas. Such reclamation method is not considered increasingly environmentally acceptable. Aside from the types of wastes thrown has increasingly be toxic, often is the case that they burn without sorting the waste and place it on the riverbank with a wooden fence. The practices have been implemented for a long time (land clearing requires 40 years to erect). Thus, when long time residents (more than 21 years) of Karimunjawa have a poor understanding of the concept of waste-consumption-environment, it is not surprising.

In income characteristics, people with low income, are knowledgeable on waste reuse. This group is accustomed to extend the use of their goods and also are diligent to recycle in order to transform them to other functions.

5.2. Solid Waste Household

There is a gap between the official calculation (conducted by Jepara Regency's Environmental Service) and the calculation from this research. We use different standards in research objects and classification of waste materials. Our research carefully selects waste material based on cultural practice in Karimunjawa. The local community considers rubber, leather, paper, metal, glass, batteries, and lamps as marketable waste so it does not end up in waste bins, but is sold to flea dealers or is saved in a waste bank. For plastic waste, there are NGOs that are committed to recycling it. Plastic waste that can be recycled is plastic bags of various colors, clear plastics, and plastic bottles. Meanwhile, waste that cannot be recycled is aluminum foil-coated plastics. Household waste are separated into non organic and organic waste. The latter which is food scraps cannot be recycled. Thus, there is a gap in total per capita waste generation. Thus, total waste generation from the official calculation is 0,5572 kg/capita and our research ends up with 0,2089 kg/capita.

5.3. *Tourism Wastewat*

The calculation of tourism waste is based on the assumption that tourists generate domestic waste, when in restaurants, sightseeing and transporting between tourist spots [11]. The average waste produced from of tourism activities is of 0.6 kg/ person, the waste that arises when tourists do activities in restaurants is of 26.18 kg/ day in each restaurant and when transporation of spot hopping is 6.99 kg/ 100 m/ day [11].

Based on Statistical data (2018), the length of asphalt roads in the Karimunjawa Islands District which is 27 kilometers, and the number of restaurants is six. Based on the 2017-2027 Masterplan on National Priority for Tourism Sites for Karimunjawa , the length of stay of tourists in Karimunjawa Islands District is around 3-4 days. This is considered low for an island whose mobility is not regular.

The tourist forecasting method to 2027 is based on the Holt Winter approach [12] with basic data for the last 10 years. This analysis is used to show that increasing tourist arrivals have a strong correlation with waste generation. The average waste generation from tourism activities in 2027 will reach 527.96 kg per year.

5.4. *Discussion*

In order to improve the people's behavior regarding sustainable waste management, the most decisive factor is increasing commitment of the local people to actively manage their waste. Stakeholders involved currently is limited in educating and rasing comprehensive awareness on waste especially in the context of small islands. A project based, especially a short swiipe on public awareness on waste has inadequate effects in their post execution period. A lack of encouragement and incentives to continue practicing waste reduction leads to a old practice of waste disposal. . Furthermore, their awareness on a concrete understanding of environmental ethics and environmental knowledge especially the connection between waste and consumption remains low. Since production of staples food and other needs are not relied on the ability of inland production, connecting the waste and the consumption is not high on the priority list. Even when stakeholders delegate roles to the people, there remains a minimal result. Currently there is a lack of enforcement or social controls to orderly manage waste that work in tandem with education and role playing. . At least the sign of waste-free Karimunjawa is still intact. Regarding tourism activities, local people and local stakeholders must take note the increased tourism in islands leads to the increased quantity of solid waste. Not enough infrastructure and lack of discipline of tourist can impact negatively on on the tourism industry. A good level of sustainable knowledge needed to remind tourists what should and should not have done in such small islands.

6. *End of Waste*

6.1. *Residue*

Based on the Planned Programs, Activities and Funding for Regional Apparatus of Jepara Regency in 2017-2022, Jepara Regency's Environment Services Section is tasked with continuing the project management of the Karimunjawa's Landfill. A budget of IDR 550,000,000 in 2017 and IDR 500,000,000 in 2018 were provided for land preparation and construction. For the two years, land acquisition of 11,522 m³ on Jalan Dukuh Alang-Alang was executed. Unfortunately,, this construction face opposition from the local residents.

Currently, waste is carried out to a temporary landfill located in the middle of a community village. There is no buffer space between the temporary landfill and houses. The ground was loose and burned continuously. Based on interviews with local people, they did not feel aggrieved by the bad smell or noise or smokes. , Furthermore their livestock is seen eating waste at the temporary landfill.

This temporary landfill is managed by 3 working units from Jepara Regency's Environment Services. Their tasks are: picking up waste in the morning and evening; burning it; and separating plastic from organic waste.

6.1.1. Scenario Analysis. There are two case studies for scenario analysis of solid waste generation and produces five scenarios. The first case is the prediction of solid waste residue in 2027 that are accumulated since 2018. Then the second case is the minimum amount of solid waste that must be managed on a daily basis.

Scenario A is based on the calculation from Jepara Regency's Environment Services. This scenario takes into account domestic waste generation, without calculating waste generation from tourism activities and marine debris. The calculation of the former is executed by Jepara Regency's Environment Services and based on sampling in the main island of Jepara Regency. Scenarios B, C, D, and E are based on waste generation analysis calculated from field observations. Scenario B occurs when waste is minimally managed and ends up in landfills. Scenario C occurs when marine debris is not managed, while other waste (domestic waste and tourism activity waste of all kinds) is handled. The fourth and fifth scenarios are based on calculations without marine debris. This is based on the assumption that marine debris is still crude, and technology is expensive. In the fourth scenario, according to current conditions, the waste that is fit for sale is handled entirely by the flea dealer and the waste bank, while plastics without aluminum foil are handled by the pyrolysis machine owned by the NGO in Karimunjawa. In the fifth scenario, apart from selling -able waste and plastic without aluminum foil, organic waste is composted.

Table 4. The scenario of Waste Generation in Karimunjawa Islands (Calculation of Waste Generation from 2017-2027, daily targets, and annual residue percentage ends up in landfills).

	Official calculation	Scenario A ^a	Scenario B ^b	Scenario C ^c	Scenario D ^d
Waste in landfill in 2027	10 mil. kg	57 mil. kg	45 mil. kg	9,09 mil. kg	2,7 mil. kg
Day to day target	2.601 kg	15.279 kg	4,5 mil. kg (a year seasonal)	790.589 kg	233.289 kg
% average residue annually	42,49%	100%	81,69%	77,44%	22,85%

^a Waste not managed.

^b Marine debris ends in the landfill, all other waste managed.

^c Marine debris does not in season,

^d Marine debris does not in season, organic waste is not managed.

6.2. Management Alternative Available

Residents process salable waste by selling it to flea dealers or dispose of to a waste bank. If disposing to the bank which was initiated by Karimunjawa Health Center employees as one of the empowerment programs for local residents, the residents redeem in the form of food supply. The flea dealer and the waste bank have no difference regarding material flow because they end up at waste collectors in Jepara Regency. The difference between a flea dealer and a waste bank lies in the management motives. The flea dealers are aims for profit, while the waste bank aims to make local residents recognize the acceptable ways to sorting waste. Although currently the waste bank only accepts waste that has economic value, the officer hopes that in the following years the waste bank can accept a more diverse range of waste, especially organic waste.

In addition to operational waste processing, there are numbers of counseling (penyuluhan) regarding sustainable waste management: initiated by HDI Pertamina (Pertamina's CSR agency) with the residents as the target audience; Inhouse Training organized by the Indonesian Tour Guides Association (HPI) of Karimunjawa with Karimunjawa tour guide as participants; Socialization to Lodging Owners in Karimunjawa to manage waste sustainably; Village Forum as a gathering for stakeholders as participants. Those stakeholders are the head of the neighborhood groups (RT), the head of the community groups (RW), the head of Karimunjawa District, BUMDes's manager, head of Jepara Regency's Environment Services, Karimunjawa District Council, Karimunjawa higher-ups, and Waste Bank's manager.

6.3. Discussion

In the end, waste needs to be properly managed in order to protect public health and the environment. The best way to manage waste is to treat it as a resource, and by avoiding materials disposed of in the first place. Karimunjawa has dealt with waste after it has been discarded, such as: burning, ends up in landfill, or reclamation. this practice is hazardous for the environment and should be put a ban immediately, but alternatives are rare and not explored. The use of sustainable materials are not in sight. Meanwhile land used for open burning is increasingly contaminated that warrant inspection

A more effective life-cycle approach for waste management, suggests that the focus should shift upstream, aiming to tackle the problem at the source through the options at the ‘top’ of the waste hierarchy. In CE, waste has an economic value. Even in Karimunjawa, the waste has real economic demand and can be recycled. The chain of command in waste recycling unfortunately include waste transported to the main island and enter manufacturing in Jepara Regency. Economic of scale still rule the game of recycling. This leaves, within Karimunjawa, a prospect for management of organic waste and garden waste that entered the agricultural supply chain, either as animal feed or being composted and used to improve the soil. This potentials have not been fully explored as well.

Innovation and collaboration in Karimunjawa has been limited. Access to technological innovation that allows for its inclusiveness may be the answers for residents’ collaboration. Stakeholders need to focus on serving users and providers, engaging the informal sector, and storing waste that has value to become a new resource as recognized by CE.

7. Conclusion

The community of Karimunjawa islands has to deal with solid waste by partially promoting a circular economy (CE). It is a rather accidental, but necessary step if the quality of life in the islands is to survive and thrive. CE created reliance on traditional trades of second hand items, restoring waste into utilizes items. In this kind of CE, the production of goods from waste utilizes local traits and simple technologies to create values or is called the process of downcycling. Such trades do not generate a high portion of local economy, the local government has not bothered to calculate yet. But during the low tourist seasons, the activities of value generating, the production of goods are maintained. Intervention towards the waste that can be transformed into goods for local household usage is also limited particularly since the demand is also low. On the other hand, there is limited intervention towards the generation of solid waste, especially from non-residents, including marine debris. The islands are destined to be final waste disposal, considering the ability to manage its waste is lower than the volume of waste accepted. Various programs especially community-based ones are implemented toward waste management are still in infancy without the intervention of science and technology to solve it.

The scenarios presented lead to the need for a breakthrough in solid waste management, involving locally acceptable technologies that are oriented itself towards inclusive perspectives that will certainly help the communities. Urban communities of Karimunjawa islands can be the center of innovation for solid waste management for the islands as a whole.

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