Creating a Circular Economy of Household Solid Waste: Sustainability Perspective

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ABSTRACT

The utilization of household waste start with segregation that done by society. This article aims to explore the potential for waste that is sorted by the community, to observe how the community collects waste, and to investigate the circularity potential of household waste through recycling or reuse. The quantitative approach was used with the households in Jabodetabek (Jakarta-Bogor-Tangerang-Bekasi) area as respondents (200 households) were chosen purposively. Statistics descriptive analysis and multiple regression were employed to analyze the data. The results showed that the community had carried out waste segregation, and waste pick up on time. Otherwise, the proportion of the knowledge that garbage still has value and gives benefits is more than 50%, and the proportion that waste management activities, society participation, and society's intention to join the waste management activities are still low. The regression model indicates that the variable Desire has a significant impact on Circular economic potential. Thus, this research showed the circular economy of the waste will improve the economic value from waste but it needs to have participation from society. The society segregates the waste but still hesitant to join the waste management activities and running the business in using the waste as a material.

1. INTRODUCTION

Population growth has generated a significant increase in waste production, especially household waste. Household solid waste is the residue people generate daily from consuming goods and services [1]. Household waste is one of the sources of waste that contributes significantly to environmental pollution [2]. In household waste, the largest composition is organic waste, but there are some household solid waste, which are unrecyclable materials, such as plastic packaging, paper, paperboard, and sanitation [3]. Production of organic and inorganic household waste that is not managed well will lead to environmental damage. Household waste is the waste that produce by household especially waste from the household daily life. Household Solid Waste (HSW) is a subset of Municipal Solid Waste and encompasses various materials generated from domestic activities or residential areas only such as organic waste from kitchens, paper, metal, glasses, etc. [3-5]. Based on Government Regulation of Republic of Indonesia No. 81 of 2012, it excludes feces and specific waste materials such as containing hazardous material and poisonous, from disasters, building demolition debris, cannot be treated technologically.

Household waste that consists of various types of waste decreases in value because mixed waste cannot be utilized anymore. Households need to segregate their waste and treat each type of waste in a different way. In fact, few households segregate their waste, and compliance with guidelines for the management of household waste is still very low in Kampala City, Uganda [6]. Of the households in Kampala, Uganda, only 37.9% complied with the guidelines for solid waste management [6]. Waste characterization should be considered the first and most important step in household waste management [5]. Household waste can be divided into three major categories: food waste, recyclable materials, and non-recyclable waste or rejects [7].

Utilization of household waste will be successful if waste is sorted (its value is maintained) and collected it to get sufficient amount. Household waste separation is included in one of the areas of community environmental behavior selection [2]. Before being discarded, the waste that has been collected must first be sorted, to facilitate the further process, and can also be used for recycling again so that it provides economic value.

There is a lot of potential and value in household waste that can be recycled to generate economic value. The circular economy offers an approach where waste is considered a resource that can be recycled and reused. This concept refers to the reduction and reprocessing or recovery of materials in a material to minimize the negative impact on the environment [3]. The main characteristic of the circular economy is to reduce the consumption of energy and materials, by creating a circular loop of material, energy, and waste flows that encompasses all activities carried out in a society [4]. In the context of household waste, the circular economy involves the recovery, recycling, and utilization of materials found in household waste.

However, the implementation of the circular economy concept in the context of household waste still has obstacles. Some of these obstacles include the problem of mixed waste types, inadequate recycling infrastructure, and a lack of public

awareness regarding the benefits of the circular economy. Therefore, it is necessary to explore the full potential and formulate strategies that can enhance the sustainability of the circular economy from household waste.

Based on SIPSN (National Waste Management Information System) source of waste in Indonesia dominantly by household waste (50.71%) and the biggest type is foodc waste (39.43%) (https://sipsn.menlhk.go.id/sipsn/). Therefore, Indonesia has established several legal instruments in order to improve public health, economic, and environmental. According to Act No. 18 of 2008, household waste management consists of waste reduction and waste treatment. As written in Article 19 Letter A, waste reduction activities consist of (a) limit waste generation; (b) waste recycling; (c) and/or reuse of waste. Then, waste treatment activities as written in Article 19 letter b consist of (a) Sorting: Waste grouping and separation based on type, quantity, and/or its characteristics; (b) Collecting: Picking up and transferring the waste from the waste source to temporary storage/processing site; (c) Transporting: Carry waste from the source and/or temporary waste storage/processing site to landfill; (d) Treatment in order to change the characteristics, composition, and amount of waste; and/or (e) Final processing of waste: returning the output of previous treatment to environment safely. In addition, there are supplementary regulations like Government Regulation No. 81 of 2012, which focuses on Reduce, Reuse, and Recycle (3R) implementation. Then, this regulation is complemented by the Presidential Regulation No. 97 of 2017 about the National Policy and Strategy (called Jaktranas) for household waste and similar household waste management, as well as the Regulation of the Minister of Environment of the Republic of Indonesia No. 13 of 2012 about 3R implementation through waste banks [8, 9].

The existence of various legal instruments will help the issues of household waste management should be easier to address. However, several aspects are crucial not only to acknowledge legal instruments. The first aspect is an environmental condition, the study by Sunaryani [10] in 2022, during the first case of COVID-19, showed that the composition of household solid waste was dominated by food and plastic packaging waste for all income levels [10]. Furthermore, the study by Dhokhikah et al. [8] in 2015, showed how important environmental knowledge may affect on someone's behavior. The study mentioned individuals did not do the sorting process due to time, laziness, or never getting the sorting procedure. But infrastructure also such as waste banks or guidance from socials/institutions is important to increase interest and community participation [8]. Other studies by Aspet et al. [11] in 2022 also revealed the waste generation are affected by income, social classes, and quantity of inhabitants [11].

Circular Economy (CE) emerged as a replacement for the linear economy system, characterized by unsustainable processes (extract – produce – use – dump material and energy) [12]. MacArthur [13] defines Circular Economy (CE) as an intentional and designed restorative or regenerative industrial system that shifts the linear economy towards the use of renewable energy, avoids the use of harmful chemicals that hinder reuse, and strives to eliminate waste through the enhanced design of materials, products, systems, and associated business models. Successful CE aligns with the three pillars of sustainability (economic, social, and environmental), while respecting natural ecosystem cycles and reproduction rates [12]. Thus, a circular economy known as

closed loops can be achieved through long-lasting design, maintenance, and repair, reuse/redistribute, refurbish/remanufacturing, and recycling processes [14]. Furthermore, MacArthur [13] outlined three (3) cores of (a) Design out waste and pollution: products are created with a focus on disassembly and reuse, forming the tight cycle between component and product; (b) Keeping product and material in use: the material should be at least non-toxic and safely returned to nature, or designed to reuse; (c) The used energy should be renewable by nature [15]. In the implementation, most of 3R yet there are 5Rs. There are many variations of 5R's framework, yet the aim of those frameworks is the same: to reduce waste and promote sustainability, and economic value. According to each institution's website, the United Nations defines 5R (Refuse, Reduce, Reuse, Repurpose, Recycle); the Ministry of Environment and Forestry defines 5R (Reduce, Reuse, Recycle, Recovery, and Repair); Meanwhile, Environmental Services defines it as Refuse, Reduce, Reuse, Recycle, and Rot (Composting). Therefore, 5R frameworks demonstrate the flexibility of the concept to address the specific environmental condition in respective regions or households.

CE potential in households can be formed from various factors. In 2023, Arista et al. [16] conducted a study about willingness to pay for household waste management and conducted a survey. The survey is divided into two (2) categories, namely socio-demographic and respondents' perception of the CE concept in household solid waste management. Socio-demographic refers to the internal factors of someone, which can include variables such as age, gender, income, number of people living in the household, and occupation. The perception of the CE concept in household solid waste management is intricately linked to socio-demographic factors, encompassing awareness, desire, ability, and market aspects [17]. Research [16] defined the perception of four (4) aspects: Awareness refers to individuals' recognition of their responsibility to manage the waste they produce and understanding that waste has economic value. The awareness is influenced by socio-demographics which is proven by Handayani et al. [18], that higher age groups showed the highest interest in joining community activities related to sustainable consumption and production, indicating that older individuals may have greater awareness of waste management practices. Additionally, women often play a significant role in waste management activities within households, also supported by the quality of education; Desire indicates an advanced stage of awareness where individuals' motivation to implement waste management at home. Socio-demographic factors such as age, gender, and education level can impact desire levels. Older individuals may have a stronger desire to engage in sustainable practices due to their time availability and life experiences. Moreover, higher education levels may lead to a greater desire for sustainable behavior, as individuals become more informed about environmental issues and the benefits of circular economy practices; Ability indicates individuals' capability to utilize waste processing technology, mobilize the community to manage waste, and obtain information about waste. Socio-demographic factors such as income, household size, and occupation can influence ability levels. Income and household size contribute on the waste generation and also influence the choices in dealing with their waste which is proven under study by Huhtala [19]. The study resulted that the higher income will choose to pay for waste treatment technology or

services instead more effort and time to do recycling like the average resident' income that choose recycling activities over incineration [19]. Market indicates the use of waste as a resource for the production process of products and markets in the form of services that can generate economic value.

Value-added is defined as the process of changing or transforming a product from its existing characteristics to greater environmental and economic value [20]. This concept views the waste as an opportunity for innovation and value creation. It leverages waste management strategies such as the 3R (Reduce, Reuse, Recycle) or 5R (which adds Refuse and Repurpose) to optimize resource utilization and minimize waste generation. By embracing advanced technologies and waste valorization, such as recycling and waste-to-energy processes, waste can be converted into renewable energy sources and other high-value products. This approach not only yields economic benefits but also contributes to environmental preservation and societal resilience, aligning closely with the principles of the circular economy [21].

This article aims to find out the potential for waste that is sorted by the community, to find out how waste is collected by the community, and to find out the circularity potential of household waste through recycling or reuse. By understanding this potential, households can become key factors in the circular economy process. Education and awareness of the benefits of a circular economy need to be increased to empower households to take sustainable actions. Therefore, findings from this article the role of households in implementing a circular economy not only contributes positively to the environment but also creates new sustainable economic opportunities.

Based on previous research, hypothesis of circular economy for household waste have a good potential since the social capital in segregate and collect the waste already have by society.

2. METHOD

This study used a quantitative method and focused on urban households as the population at Jakarta-Bogor-Depok-Tangerang-Bekasi (Jabodetabek). Choosing these area because this area is around the capitol city and the others city are supporting area for Jakarta. The intentional sampling method is applied, with specific criteria consists of respondents must be resided in Jakarta or Bogor or Depok or Tangerang or Bekasi city for the past 5 years, and are living with family members. Data collection used a questionnaire, and a total of 200 respondents were gathered in periode January – March 2024, as samples for analysis. Defining number of sampels is 200 respondent based on quota that need it by multiple regression as a data analysis method. Sample purposively chosen, as long as leave at Jabodetabek and willing to be the respondent.

The questionnaire used in collecting data is divided into four (4) sections. In the first section, respondents provided identity, age, education, number of family members, occupation, and duration of residence at the current address as the filtering question; The second section about the economic situation of the respondents and their family members such as income, outcome, and residence ownership status; The third section about current environmental issues caused by waste, the waste management behavior such as waste sorting and the type, collection frequency, and their willingness to pay the waste

management services, also includes the knowledge of waste reuse potential and involvement in social activities related to waste utilization; The fourth section explored the respondent's knowledge, awareness, desire, ability, and perceptions of the market regarding the circular economy potential derived from their household waste. two (2) last questions in the fourth section, respondent describes their opinions on waste recycling products and interest in establishing a business that reuses waste.

Respondent identity data analysis used descriptive statistics, a multiple linear regression used for get the relationship model between independents and dependent variables. In this study, multiple linear regression uses the enter method where all independent variables will be involved in the formation of the regression equation. In this study, the dependent variable (Y) is circular economy (CE) potential; while the independent variables (X) are Awareness, Desire, Ability, and Market. The equation will be:

$$CE\ Potential = \alpha + \beta_1 Awareness + \beta_2 Desire + \beta_3 Market + e$$

where,

α is the constant (intercept), $\beta_n = 1, 2, ...$ is the coefficient of each independent variables, e is the error term.

Furthermore, to determine if the regression model fits to data, classical asumption test used such as normality, heteroscedasticity, and multicollinierity. The determination coefficient (R^2) used is showing the variance's proportion in the dependent variable that is predicted from independent variables. The range of R^2 is 0 to 1 which the higher value indicates a good linear model to use. The partial relationship between the independent variable and dependent variable test used a t-test, and for the equation, an F-test was used to show simultaneous relationship.

Using multiple regression in seeing the impact of awareness, desire and market to circular economy potential because linier regression just linier relationship without considering the others factor and the feedback. This model would be an initial model about circular economy potential, and for the next research could proceed with the model that consider the feedback.

3. RESULTS

3.1 Respondent identity

The first respondent identity was age, and 39% of respondents have an age range of 41 – 50 years, and 29% of. respondents in the age range of 30 - 40 years. This showed that the largest number of respondents age was included in the productive population category. Productive age can be one of the factors that respondents are willing and able to participate in accepting and implementing innovation in an effort to improve the quality of themselves and the environment. Based on the level of education, 50% of respondents are in senior high school. Formal education is an asset to encourage and change the awareness, life, and desire of a person to progress even better in the environment.

Households a family unit that manage together their consumption, and their activities, including managing their waste. The next respondent's identity is the number of family members. Mostly (79%) number of family members of

respondents is 3-5 people, followed by less than 3 people (15%), and more than 5 people (7%). This family number is usually in their thirties and young families with 1-3 children, or the forties when their children did not live with them anymore. But, when the next identity of respondents, which is the time that the family lived at their house, 55% of respondents already lived at their house for more than 20 years, and just 5% of them had lived there for less than 2 years. That shows the small family consists of a thirties and forties family. Seeing the respondent already more than 20 years at that house, the family is already stable family with a safe house.

The last respondent's identity is the main role of the housewife. The housewife is the one responsible for managing household waste. The role of the housewife will be important because it shows their spent time in managing household waste. Appendix 1 shows the distribution of respondents based on the role of the housewife. It shows 71% of respondents' roles are housewife, 15% as a housewife and businesswoman. It could be as capital in utilizing the household waste to get any economic value, but knowledge, skill, information, and the important one is interest.

The complex socio-economic conditions of the community have an influence on the healthy living behavior of the community, especially in waste management [19]. Several studies have described the relationship between household waste generation and composition with relevant socio-economic parameters using regression analysis [22]. Other socioeconomic factors that appear to influence the level of municipal solid waste generation include household size and employment status [20]. Municipal solid waste generation also changes according to the average family number [21].

3.2 The household waste potential

Before seeing the potential of household waste utilization, the household waste condition is shown in Figure 1. From Figure 1, the household waste condition described by respondent said 87.5% absence of garbage scattered or piled up around their environment, by how the household waste was collected, the number of the waste types collected, how often household waste was collected, and the time that household waste usually collected.
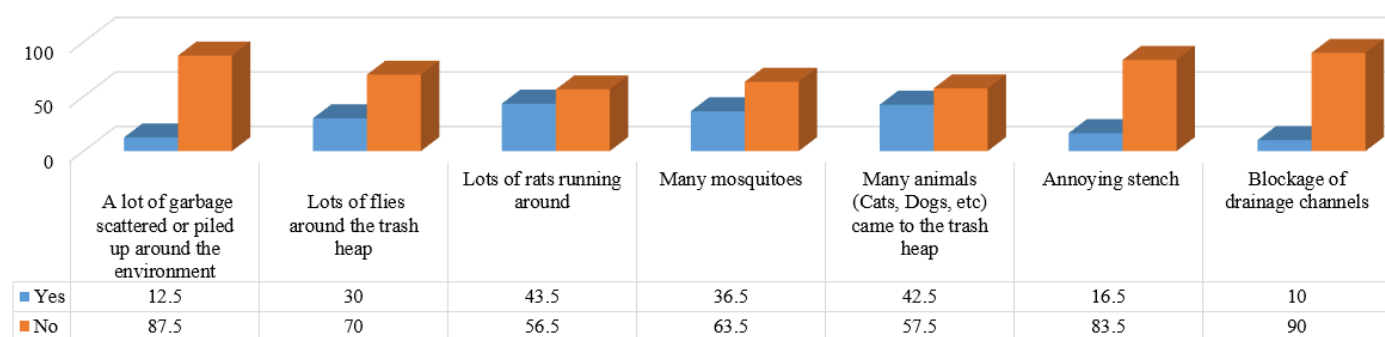

	A lot of garbage scattered or piled up around the environment	Lots of flies around the trash heap	Lots of rats running around	Many mosquitoes	Many animals (Cats, Dogs, etc) came to the trash heap	Annoying stench	Blockage of drainage channels
■ Yes	12.5	30	43.5	36.5	42.5	16.5	10
■ No	87.5	70	56.5	63.5	57.5	83.5	90

**Figure 1.** Garbage condition

Based on Figure 1, which collected from 200 respondents, all questions yielded positive answers regarding the environment sanitation in their neighborhoods. About 87.5% of the respondents reported the absence of garbage scattered or piled up around their environment, 70% said no flies around the trash heap, 56.5% said no rats running around, 63.5% not many mosquitoes, 57.5% said no aminal come to the trash heap, 83.5% said no annoying stench and 90% said no waste that blockage of drainage channels. The case of flies, rodents, and wild animals coming to the trash heap can be influenced by various aspects such as frequency of waste collection, and improper services such as inspections from the government and waste disposal facilities.

This condition shown the garbage from household already put at the bin properly. The waste management running is collected at a bin, transported by scavengers, segregated the mix waste by scavenger (sometimes need to wash it), and scavenger sell it to the agen and through the residue (the unvaluable waste) to the landfill. Some household segregate their waste, but not all waste segregate well, if the society could not sell the waste, they did not collect it. The valuable waste just few type, mostly is not valuable, and household did not collect it by themselves, just through to the bin, but, by scavengers the waste still could segregate again and find the valuable waste.

From the respondent answered, that shown the condition

sorounding, the waste already manage properly and give the good and clean environment. No flies, no rats, no mosquitos, no blockage of drainage channel. The waste management is collected, transported, and through to the landfill. This waste management need to change become made waste become resources. The valuable waste still could collect by community and together get the benefit by sell it. More segregate waste will increase the type of valuable waste. In manage or utilize waste, quantity always as an obstacles in getting the value. From this condition, the potential of getting the waste value by community could increase by segregating more type of waste.

The garbage condition was shown good and managed properly, but segregation was only done by 57% of respondents, the other 43% did not segregate their waste (Figure 2). From 57% of the respondent that segregated their waste, the type of segregated waste consists of organic waste, plastics, glass, paper, and metal. The number of types of segregated waste is shown in Figure 3. From that figure, respondents segregated their waste into 5 types of waste (organic waste, plastic, glass, paper, metal) at 17%, and the highest percentage is for respondents segregated their waste into 1 type only (28%). The waste that segregated by community are plastic or paper or glass. These three types of waste are valuable waste and already have a market. If the household will sell plastic waste, they just collect plastic waste only, etc.
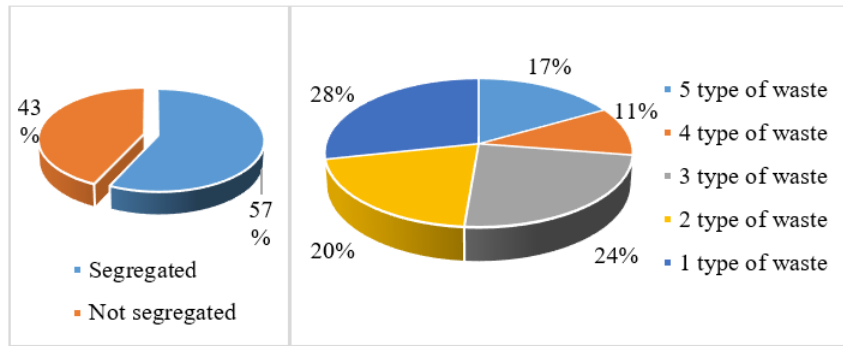
Figure 2. Distribution of respondent based on segregation activities and number of types of waste segregated
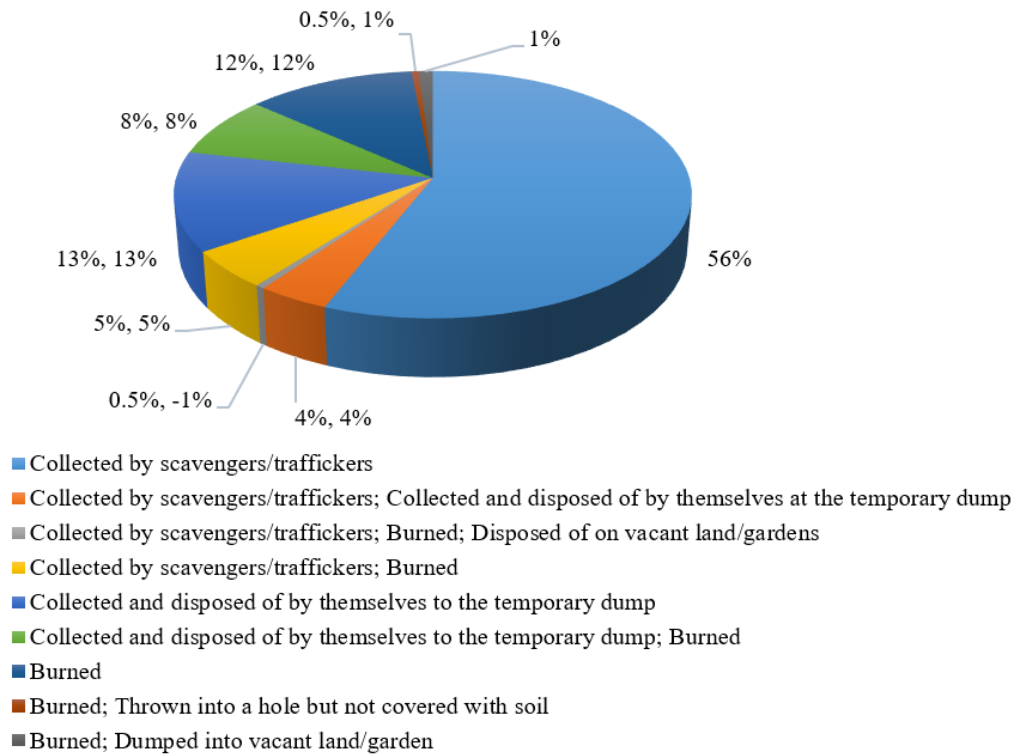
Figure 3. Waste collection management
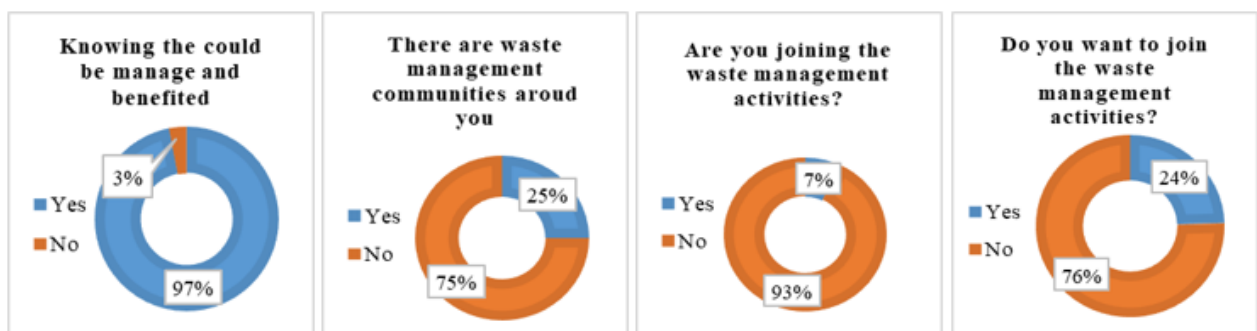
Figure 4. The distribution of respondents based on circular economy opportunity question

The study by Sahoo et al in India revealed Awareness of family health and hygiene can influence behavior in sorting waste properly [16]. In addition to the aspect of consequences, environmental conditions can also influence mindset as respondents living in slum areas expressed their desire to get recognition or compensation as an acknowledgment of proper waste segregation efforts, whereas in non-slum areas, littering is considered bad behavior. Other aspects such as the government's attention are highly expected by the community, ranging from trash bins provided with at least 2 units to facilitate sorting, the importance of waste collection officers providing information about sorting consistently and effectively, as well as parents' expectations for their child to get early learning related to waste management in schools. The study also found that the involvement of men or household heads in household waste segregation ensures a sense of shared responsibility, and emphasizes the potential benefits of gender-focused capacity-building training in the future [18].

The next step in managing a household is the collection process. The collection process would allow utilizing the waste in enough volume of waste. Figure 4 shows waste collection management, which are eight methods used. The highest number of respondents (56%), collected their waste by scavengers/traffickers, it was collected and disposed of by themselves at a temporary dump (13%), and 12% burned, or combination ways it. The collected method shows that no treatment at all for the waste by society, just collect it. The collection place become important too [19] find that each region needs to have its own waste facilities.

3.3 Circular economy opportunity

To determine the potential of the circular economy, the survey conducted use a questionnaire to respondents with the questions about the collecting process by community and the value of waste if waste segregated and collected well. The results in Figure 4 showed that 97% of respondents stated that they have the knowledge that waste is something that is no longer needed, but can still be managed and provide economic benefits, 75% stated that there is a waste management community in their residential area which is responsible for handling waste issues, 93% of respondents stated that they had participated in waste management activities, and 76% of respondents stated that they wanted to join waste management activities. There are two important aspects such as collaboration capabilities between upstream and downstream actors, and design capabilities that create simpler and recyclable products [19].

The distribution of respondents in answering the questions showed that respondents already know that value of waste and there are the waste management around their house. This is as an initial social capital of community to proceed the advanced waste management for circular economy potential. People or participants who want to join in waste management activities, usually have interests, values, and believe that there is a social economic value based on the principle of the common good of the waste they manage, for the common benefit of community members and the surrounding environment. The stronger the role of social capital in the community, the better efforts to serve the environment and the lesser the amount of waste disposed of as residue in the Piyungan regional landfill area [23].

In this research, other circular economy opportunity shown by using a multiple regression model. The results of the multiple linear regression test can be seen in Table 1.

The regression equation formula in this research is as follows:

$$CE\ Potential = 2.862 - 0.009\ Awareness + 0.190\ Desire + 0.04\ Ability + 0.118\ Market + e$$

Based on Table 1, the significance level shown by the Desire variable, Awareness, Ability, and Market variables are insignificant.

The analysis proceeds use Stepwise method in calculating the multiple regression and the result is shown in Table 2.

Based on Table 2, the best model in this research is obtained, that is

$$Circular\ economy\ potential = 3.000 + 0.257\ Desire + e.$$

Table 1. Multiple linear regression test results

| Model | Unstandardized Coefficients | | Standardized Coefficients | t | Sig. |
	B	Std. Error	Beta		
(Constant)	2.862	.311		9.196	.000
Awareness	-.009	.009	-.065	-.945	.346
1 Desire	.190	.076	.211	2.514	.013
Ability	.004	.047	.006	.082	.935
Market	.118	.076	.128	1.557	.121

Dependent Variable: Circular economy potential

Table 2. Multiple regression using the stepwise method

Coefficients					
Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
1 (Constant)	3.000	.239		12.570	.000
Desire	.257	.061	.285	4.184	.000

Dependent Variable: Circular economy potential

This proofs that the perceived desire is a desire which is the level of interest of a person to start his own business. The influence of the social environment is very strong in determining a person's motivation and desire. A supportive social and family environment can increase a person's intention to take action or the potential to run a circular economy. The desire of society to implement the circular economy in their waste could show the platform of reuse and recycling downstream-waste-flow information from consumers, which could be used by companies to implement their EPR (extended producer responsibility) system. The decoupling between environmental pressures and economic growth is an essential step toward a sustainable society [2].

The formation of a circular economy can be done from the consumer side and also from the producer side, thus, the reuse of waste directly gets a market.

From Figure 4 and the multiple regression model shown that circular economy potential to household waste have a social resource such as the desire of respondent to getting the economic values from circular economy activities, and waste management that done by society. Waste bank could take a part in organizing the collection point and selling it to the agents.

Implication for policy, ggovernments should enforce mandatory waste segregation at the source, ensuring not only valuable materials but also organic and residual waste are

properly managed. Incentives such as tax benefits or discounts on waste collection fees can encourage households to comply.

Enhancing Organic Waste Processing – Local authorities should invest in composting facilities and biogas programs, integrating organic waste into productive cycles rather than allowing it to be disposed of in landfills. Community-based composting initiatives can further promote decentralized waste solutions.

Formalizing the Role of Scavengers – Policies should recognize and integrate informal waste collectors into the formal waste management system. Providing training, financial support, and legal recognition can improve efficiency, working conditions, and economic benefits for these workers.

Encouraging Circular Business Models – Governments and private sectors should collaborate to support businesses that upcycle, recycle, or process waste into valuable products, fostering a sustainable waste-to-resource market.

Public Awareness and Education – Long-term behavioral change can be achieved through campaigns and education programs that promote waste reduction, reuse, and responsible disposal practices.

4. CONCLUSIONS

The community has waste management that collects valuable household waste and lets waste collectors collect the residue. The community knows the value of waste but still does not get the maximum value. Segregating waste from saleable and unsaleable waste, the rest is put in the bin and collected by scavengers.

The economic potential for household waste is shown by segregating actions done by the community but still needs to create the entity to organize collected waste based on the waste type. The quantity and quality of the collected waste could be increased by community organizations.

The circularity potential for household waste could be improved through the community organization that would empower the community.

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