THE ROLES OF WASTE BANK AS COMMUNITY-BASED WASTE MANAGEMENT ENHANCING SUSTAINABLE WASTE MANAGEMENT IN INDONESIA

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Chapter 1 Introduction

1.1 General overview of waste management in Indonesia

Indonesia is the largest archipelagic country in the world consisting of 17,504 islands. With a population of 270,203,917 in 2020 (BPS Indonesia, 2021) Indonesia is the fourth most populous country in the world. Uncontrolled waste generation has been a continuous problem for both the environment and humans. Modern lifestyles and the increasing use of packaging greatly affect the amount of waste generated; everyone is responsible for managing waste in their local environment. For developed countries, waste has become an important part of a management and recycle industry. However, this is not the case with developing countries, where they are still experiencing difficulties in handling waste problems. In developing countries, government waste management is often inadequate. Proper waste management should be conducted by the community and government in an integrated manner. The Ministry of Environment and Forestry (MEF) admits that in 2020 the total national waste production has reached 67.8 million tonnes. This means that around 185,753 tonnes of waste are produced every day by 270 million residents from 514 districts/cities. Or each resident produces about 0.68 kilograms of waste per day. This figure has increased compared to previous years. In 2018, national waste production has reached 64 million tonnes from 267 million people (Indonesia Government, 2021).

Total waste generation in 2020 reached 36.7 million tonnes/year with the amount of managed waste amounting to 53.2% or 19.5 million tonnes/year and unmanaged waste of 46.8% or 17.2 million tonnes/year from 291 regencies/cities throughout Indonesia (MENLHK Indonesia, 2021b). The data shows that there is a large amount of unmanaged waste in Indonesia. In the end, this waste has contributed greatly to the increasing accumulation of piles in final disposal sites (landfill) causing environmental pollution, also increases the production of methane gas from the waste. The activity of sorting waste is still not entrenched in Indonesian society. As much as 60 percent of the national waste production comes from household waste. Therefore, there must be good management in the household. Most of the waste management patterns in Indonesia are still limited to collect-transport-throw away. This proves that the pattern of waste management in Indonesia is out of date. The current pattern should adopt the concept of a circular economy, which is to maximize the economic value of waste by implementing reduce, reuse, recycle (3R). Maximizing the waste management system is urgent to do, for example through recycling. Waste composition Indonesia shown in **Fig. 1.1**.

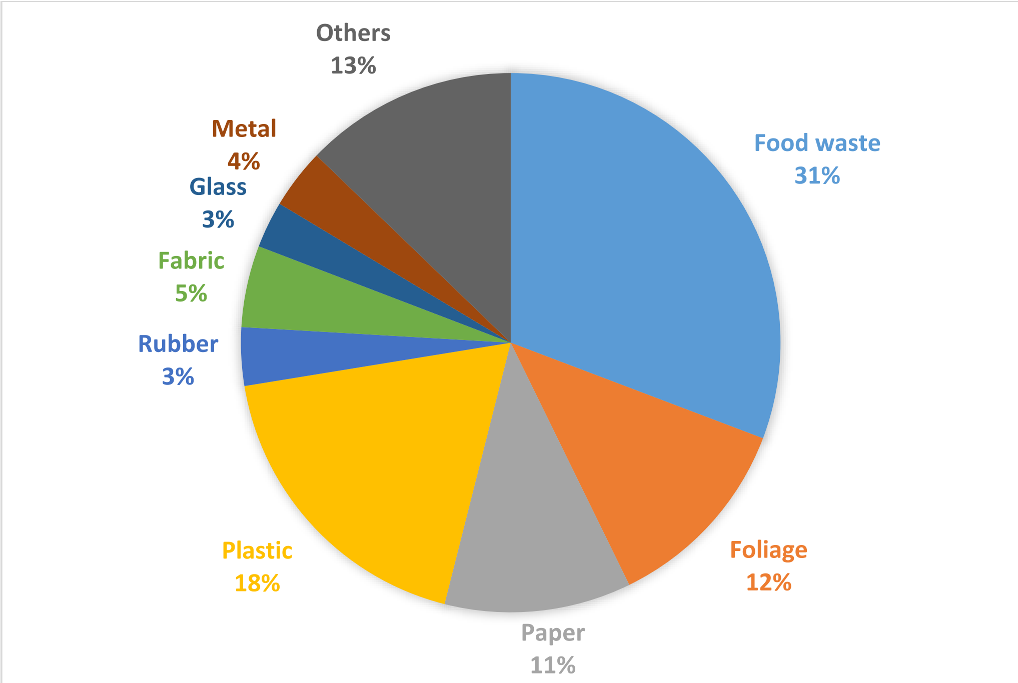

Fig. 1.1 Waste composition in Indonesia
(MENLHK Indonesia, 2021b)

1.2 Community-based waste management (waste bank)

To respond to increasing waste generation, waste minimization requires efficient waste management (Minelgaitė & Liobikienė, 2019). A new, effective way to manage waste is for local communities to organize waste bank. Waste bank is an alternative waste management system implemented to reduce waste and improve the local economy (Wulandari, Utomo, & Narmaditya, 2017). It can be implemented in developing countries where the local government has inadequate capability to manage waste (Purba, Meidiana, & Adrianto, 2014). Waste bank is one option that addresses the increasing volume of waste in landfills and reduces greenhouse gas emissions. Informal solid waste recycling has the potential to reduce climate change (Botello-Álvarez, Rivas-García, Fausto-Castro, Estrada-Baltazar, & Gomez-Gonzalez, 2018). Waste bank possesses economic, social, educational, and technological tools that can establish self-reliance in a community (Wijayanti & Suryani, 2015). The existence of a waste bank in Indonesia is supported by the Regulation of the Minister of Environment of the Republic of Indonesia No. 13 of 2012. Many waste banks were established in 2012 after the regulation was released. According to data from MEF in 2021, the number of waste banks in Indonesia is 11,551 units with the number of customers reaching 376,612 people spread over 363 cities in 34 provinces. The total amount of recycled waste that can be collected from all waste banks is

1,121,622 kg/month with an average of 97.10 kg/month for each waste bank. Meanwhile, the turnover obtained from waste bank activities reaches Indonesian Rupiah (IDR) 1,971,089,959 per month or each waste bank obtained an average of IDR 170,642 per month (MENLHK Indonesia, 2021a).

According to the study in Vietnam, the activities of informal plastic waste recycling carried out in craft villages, which play an important role in contributing to rural social–economic development and the industrialization process. The craft villages are helping to alleviate poverty and hunger, create jobs, and increase income for people in the rural areas (Salhofer, Jandric, Soudachanh, Xuan, & Tran, 2021). The ratio of total amount of recyclable materials bought by scrap buyers over the average amount of domestic solid waste generated and collected in the Mekong Delta can be up to 7.9% and 17.8% respectively (Tonneg, Huynh, & Khong, 2021). In Thailand, the Informal waste sector in Bangkok also plays a significant role in municipal solid waste management system in terms of the environmental, economic and social aspects. Informal waste sector contributes in recycling rates about 1.3% of total waste generated per day. Moreover, informal waste sector directly contributes to reduction in municipal solid waste management costs. It saved approximately about 0.64% of total waste management costs (T. Nguyen & Nitivattananon, 2019). Among ASEAN countries, Indonesia has an average source segregation and recycling rates below 50% (UNEP, 2017). Recycling rates in ASEAN Countries are shown in **Table 1.1**.

Table 1.1 Recycling rates in ASEAN Countries

Country	Source segregation	Collection rate (Urban)	Recycling rate
Brunei Darussalam	<50%	90%	15%
Cambodia	<50%	80%	<50%
Indonesia	<50%	56% - 75%	<50%
Laos	<50%	40% - 70%	<50%
Malaysia	<50%	>70%	50% - 60%
Myanmar	50%	-	70%
Phillipines	50% - 70%	40% - 90%	20% - 60%
Singapore	>90%	>90%	50% - 90%
Thailand	<50%	>80%	<50% - 90%
Vietnam	<50%	80% - 82%	<50% - 90%

(UNEP, 2017)

To date, the Ministry of Environment and Forestry has noted that waste bank activities have only contributed 1.7 percent to the handling of national waste through more than 10 thousand waste banks. Although the contribution of the waste bank in the recycling industry is still low, its role in educating the public about waste management should not be taken lightly. Waste bank management is carried out by the community either independently, in collaboration with local governments or with corporations with a corporate social responsibility (CSR) scheme (Indonesia Government, 2021). **Fig 1.2** shows the distribution map of waste bank in Indonesia.

Fig. 1.2 Distribution map of waste bank in Indonesia
(MENLHK Indonesia, 2021a)

1.3 Literature review

Waste bank as community-based waste management is performed in several regions of Indonesia. According to the research in southern Surabaya, the number of waste banks in Surabaya is 374 units since 2012, with 0.55 tonne/day or a 0.05% reduction effort against total waste (Warmadewanthi & Haqq, 2019). In Semarang City, the total 1,069.5 kilograms of solid waste are deposited into the city's waste banks each day. This figure has contributed to a 0.13% reduction of solid waste generation in Semarang (Budihardjo, Wahyuningrum, Muhammad, & Pardede, 2019). This number is small compared with the amount of valuable waste produced across Semarang. If more of the city's valuable waste is deposited in waste banks, solid waste generation will be reduced significantly, along with landfilled waste. In summary, effective implementation of waste banks may reduce solid waste generation in Semarang and extend the operational life of the city's Jatibarang Landfill. In Gunung Kidul Regency, the studies investigate the number of waste bank reduction toward waste generation in municipal waste generation. At present, the Waste Bank in Gunung Kidul Regency is able to reduce waste by

0.86% with a total of 6,423 m^3 / year reduced waste. The benefits of the existence of a waste bank, among others, are in the field of waste management, in terms of economic and social aspects. The potential for waste recycling is 17.49% from 22.39% of the total non-organic waste (Faradina, Maryono, & Warsito, 2020). Study in Medan City investigate household waste and its composition to expand waste bank program in Indonesia. The result of the waste composition shows a good prospect for waste bank activities. To improve solid waste management systems, the government should formulate the right strategies. The government has to ensure the waste bank sustainability and also provide technical and non-technical assistance. The level of public awareness must be increased; the people should be taught to reduce and sort the waste from their homes. Based on the data obtained, as much as 90.05% could be recycled or composted through the solid waste bank (Khair, Rachman, & Matsumoto, 2019).

Regarding environmental awareness, previous studies investigate what is the factor affecting and motivate people to participated in waste bank. In Malang City, the research reveals that education, income, and knowledge about waste bank have relationship with participation in waste bank. People from lower education and income have motivation related to economic benefit in participating in waste bank. In order to increase participants in waste bank, campaign is very important. Campaign can be done by using media or community organization (Maryati, Arifiani, Humaira, & Putri, 2018). Study in Depok City investigate the waste bank participation factor. This study found four factors that make a waste bank continues to play a role, namely the presence of leaders who are reliable (leadership), good management (management), incentive (incentive) and the involvement of partners (partnership). While the characteristics of community-based on the level of education, income levels also affect the community participation in receiving the waste bank as a form of waste management in Depok City. Those who are lowly educated and have low income are enthusiastic to become waste bank members, with the hope of incentives they will get from the sale of the garbage (Suparmini & Junadi, 2018). In Surabaya, the influence of socio-economic characteristics of residents on household waste reduction by doing recycling activities also been investigated. Based on the result, the influencing factors for the waste sorting activity were age of respondent, the level of knowledge, the presence of an environmental cadre, and the waste bank availability. This study suggested four strategies to support the community participation on household waste reduction in eastern Surabaya. These strategies were: to intensify the household waste reduction training programs; to intensify the information dissemination through mass media and campaign; to increase the number of environmental cadres; and to optimize the existence of waste bank and its function (Dhokhikah, Trihadiningrum, & Sunaryo, 2015).

Methods that can be used to analyze the effectiveness of waste management is life cycle assessment (LCA) and cost-benefit analysis (CBA). LCAs are often used by policy makers and in businesses to compare specific waste management technologies in a given geographic region. The environmental profile provided by an LCA is used in combination with other information, such as economic and social aspects, to support decision-making processes in business and policy development (Brancoli & Bolton, 2019). Previous study in Europe focuses on a LCA of four waste management strategies. The results indicated reliable for most of the European big cities, show landfill systems as the worst waste management options and significant environmental savings at global scale are achieved from undertaking energy recycling (Cherubini, Bargigli, & Ulgiati, 2009). Previous study in Macau from a life-cycle perspective, several potential scenarios were evaluated to explore the potential for reducing the environmental impacts of different MSW management strategies (Song, Wang, & Li, 2013). As part of the valuation method, CBA is a measurement method that aims to determine the value of the benefits of an activity from an overall point of view. CBA can be used as a tool to show the environmental benefits and costs that usually are not included in typical project analysis (Dobraja, Barisa, & Rosa, 2016). The study in Pekanbaru learned about the development of waste processing facilities using CBA (Chaerul & Rahayu, 2019). The study in Bandar Lampung used CBA to determine efficiency in terms of economic costs as well as service areas and future developments to make better attention to planning in the solid waste sector. (Phelia, A., Damanhuri, 2019). In Romania, Cost analysis has been performed to analysing the best scenario for conducting municipal solid waste (Ghinea & Gavrilescu, 2016). Life cycle costing of waste management system were used to proposed cost model offers a coherent frame-work for assessing both the economic and environmental aspects of waste management systems, by providing detailed cost calculations for individual waste technologies (Martinez-Sanchez, Kromann, & Astrup, 2015). According to the research in Medan city, applying the solid waste recycling has a potential recycled or composted rating up to 91.69% of the waste generated from Medan City (Khair, Rachman, et al., 2019).

Regarding the behavioral intention toward waste management, recent studies have used theory planned behavior (TPB) to determine behavioral intention in the field of waste management. The study in China investigate residents waste separation behaviors at source using structural equation modeling (SEM) with the TPB. The questionnaire data revealed that attitudes, subjective norms, perceived behavioral control, intentions, and situational factors significantly predicted household waste behaviors in Guangzhou, China. They concluded that campaigns targeting moral obligations may be particularly effective for increasing the participation rate in waste separation behaviors (Zhang, Huang, Yin, & Gong, 2015). Moreover, there is study about factors influencing young people's intention toward municipal solid waste sorting. The empirical results revealed that, according to the rankings of significance, personal moral obligation, perceived behavioral control, and subjective norm had positive influences on young people's intention toward MSWS. The findings and implications provide the government with useful insights for encouraging young people to actively participate in MSWS (Shen, Si, Yu, & Si, 2019). Study in Malaysia, TPB was used to determine recycling intention behavior among school students. The result shows that perceived behavior control was the strongest predictor of intention behavior. Subjective norms, to a lesser degree, was also an important predictor of intention behavior. Meanwhile, the analysis also shows that specific attitudes were indirect predictor of intention behavior, via the mediation of subjective norms and perceived behavior control (Mahmud & Osman, 2010). Study in Vietnam, TPB was used to determine the electronic waste recycling behavioral intentions of residents. the findings from this study revealed that environmental awareness and attitude toward recycling attitude is the primary influencing factors in activating residents' e-waste recycling intention toward formal collections (H. T. T. Nguyen, Hung, Lee, & Nguyen, 2018). Study in Iran, a TPB study was conducted to investigate youth and sustainable waste management. SEM results displays that motivation had the most important impact on intention, followed by moral obligation, perceived behavior control, subjective norm, situational factor and attitude (Heidari et al., 2018).

Chapter 2 Research objectives and methodologies

2.1 Research objectives

This study has objectives to investigate the roles of waste bank as community-based waste management for the municipal waste management in several regions in Indonesia. The first objective is to investigate the roles of waste banks in reducing waste generation in the residential area that implementing waste bank and investigate its potential economic benefits. The correlation between social attributes toward knowledge and behavior regarding waste management among the residents was also investigated. The second objective of this study was to analyze the environmental and cost-benefit impact from the addition of waste banks to the municipal waste management. This third objective of this study is to find the key descriptors of intention to recycling behavior among the waste bank community. This study uses the theory of planned behavior (TPB) approach to determine the recycling behavior of the community and investigate the role waste bank as an additional variable that can affect the recycling behavior of the community.

2.2 Research methodologies

This study conducted several steps to obtain the goals of research objectives. The research location investigated in this study were based on the level of research location from residential area to metropolitan city that implemented waste bank as community-based waste management. To obtain the first objective goal, field sampling was conducted to determine the waste generation and composition of household waste in the Rewwin residential area, Sidoarjo Regency. A questionnaire survey conducted to analyze the correlation between social attributes identity toward knowledge and behavior regarding waste management among Rewwin residents as implementers of a waste bank. For the second objectives, this study conducted life cycle assessment (LCA) and cost-benefit analysis (CBA) to determine the environmental impact and value of the benefits of an activity from waste management perspective in Cimahi City. The last part of this study used TPB as theoretical framework identifying the factors that influence waste recycling intention among waste bank waste bank communities in Semarang City. The new addition variable, named "effectiveness recognition of waste bank" was built based on the beneficial characteristics of waste bank itself. The questionnaire survey were conducted to obtain social-economic status of the respondents and measure the construct of the variables in the model. Structural equation modeling (SEM) were used for representing, estimating, and testing the relationship between variables and understand the patterns of correlation among a set of variables. The framework of research methodologies in this study shows in **Fig. 2.1**.

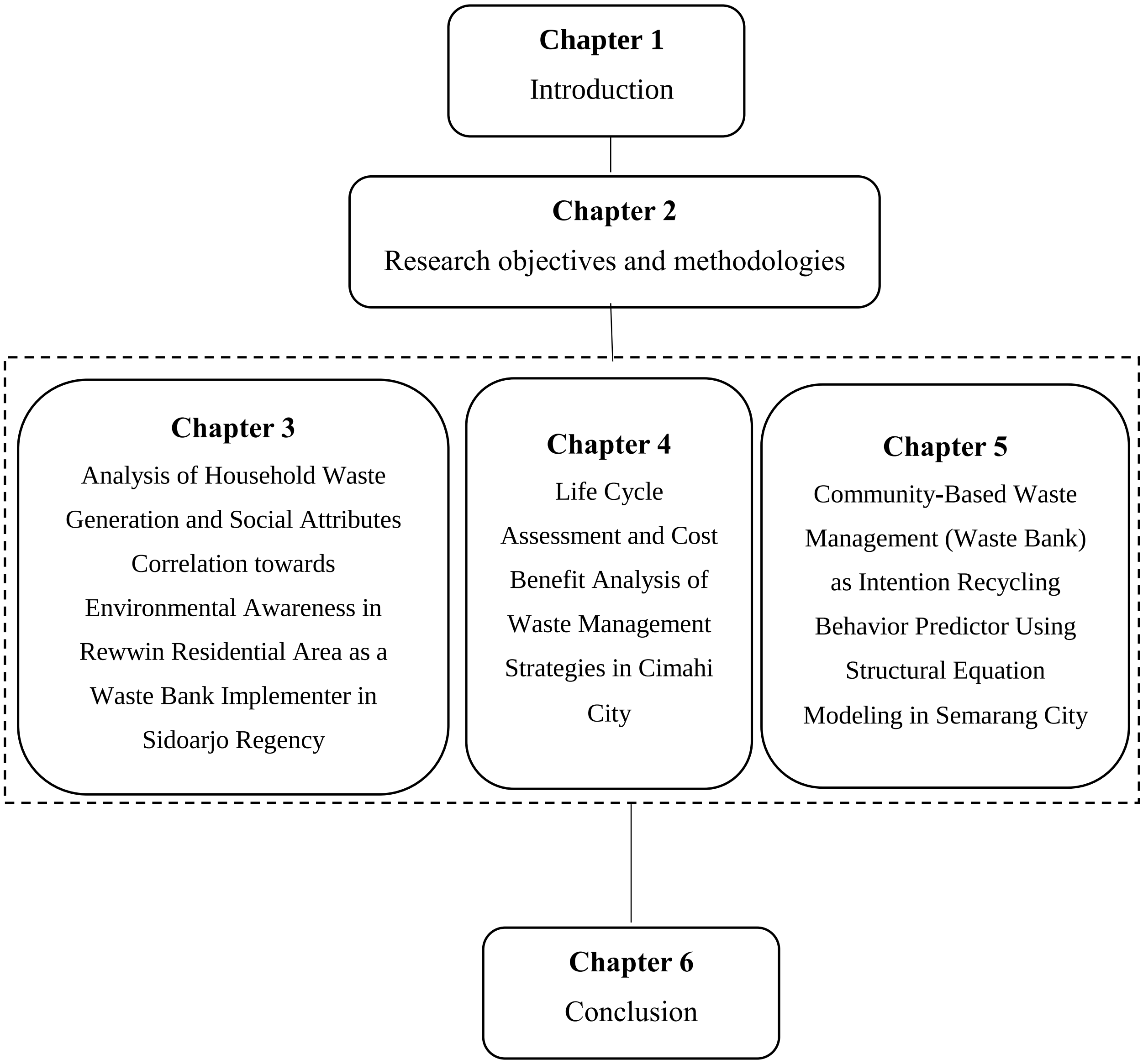

Fig. 2.1 Research framework

Chapter 3 Analysis of Household Waste Generation and Social Attributes Correlation towards Environmental Awareness in Rewwin Residential Area as a Waste Bank Implementer in Sidoarjo Regency

3.1 Background

Waste generation has been a continuous problem for environment. Modern lifestyles and the increasing use of packaging greatly affect the amount of waste generated; everyone is responsible for managing waste in their local environment. In developing countries, government waste management is often inadequate. Proper waste management should be conducted by the community and government in an integrated manner. From the community's perspective, an alternative method for reducing waste in landfills is to conduct community-based waste management. Community participation plays an important role in obtaining solid waste in developing countries (Dhokhikah & Trihadiningrum, 2012). One alternative community-based waste management method is a waste bank. The waste bank can be implemented in developing countries in which the local government has an inadequate capacity to manage waste (Purba et al., 2014). Establishing and operating waste banks is easy with a small investment, space, and simple tools and provides great potential for transforming unwanted household materials into more valuable resources (Jagath Premakumara, Soedjono, Kataoka, & Fitriani, 2016). This program can provide benefits for environmental sustainability, as well as benefits for its implementers. The waste bank is an alternative model for waste management, comprising an effort to reduce waste and improve the local economy (Wulandari et al., 2017). A waste bank comprises economic, social, educational, and technological tools that can establish self-reliance in a community (Wijayanti & Suryani, 2015). In addition, the waste bank can change the paradigm regarding the notion that waste is useless; instead, promoting the benefits of waste (Winarso & Larasati, 2011) while encouraging the community to increase awareness and knowledge through its participation in managing a clean environment (Asteria & Heruman, 2016).

Sidoarjo regency serves as a buffer of the activities of the provincial capital next to the capital of East Java, Surabaya, which has a strategic position in East Java as the national activity center and is developing very rapidly. Sidoarjo regency has a population of more than two million, with 18 sub-districts, and an area of approximately 714,24 km² (Sidoarjo, 2020). Significant population growth affects the amount of waste generated by the community. Further commitment by the government is required to implement a proper solid waste management system in the area. The Sidoarjo Regency Government issued the Sidoarjo “Zero Waste” program to form zero-waste ambassadors, green festivals, and the construction of integrated waste disposal sites in each sub-district/village. Management organizations are key to the successful implementation of waste management at integrated waste disposal sites and the management organization will later organize and coordinate the workforce at an integrated waste disposal site (Aryenti & Darwati, 2012). Based on Presidential Regulation No. 97 of 2017, the Waste Management Target for 2025 is to achieve 30 % waste reduction (Peraturan Pemerintah Republik Indonesia, 2017). The Rewwin residential area, located in Waru sub-district of Sidoarjo regency, has consistently conducted community-based waste management in the Sidoarjo regency. The community also proposed providing training for residents and sorting organic and residual waste in their environment. Adequate training was provided at all levels for engaging in solid waste management to handle respective functional aspects, such as collection and segregation of waste, as a strategy to enrich resource efficiency and reduce the environmental impact from greenhouse gas emissions (Ramachandra, Bharath, Kulkarni, & Han, 2018). The activities conducted by the Rewwin residence community represent an example of community activities managing independent waste to achieve the objectives of the program planned by the government and solving problems related to waste management and the use of landfills. Study the potential benefits of implementing recycling activities program such as waste bank programs and the achievements of community-based waste management need to be conduct. Enhancing knowledge, understanding, and participation among community members to address the problems of solid waste management is key in promoting change toward better solid waste management in cities (Yousif & Scott, 2007). The factors affecting participation attitudes regarding solid waste management should be addressed (Lakioti, Moustakas, Komilis, Domopoulou, & Karayannis, 2017).

This study aims to investigate the generation of household waste, the roles of waste banks in reducing waste generation in the Rewwin residential area, and the potential economic benefits. The correlation between social attributes toward knowledge behavior regarding waste management among Rewwin residents was also analyzed via the questionnaire, obtaining a representation characteristic of Rewwin residential area implementing community-based waste management.

3.2 Methods

3.2.1 Study location overview

Rewwin residential area is located in the Waru sub-district of Sidoarjo Regency. The Rewwin residential area comprises 18 neighborhoods (RTs), with a population of around 3680 persons.

The Waru sub-district has an area of 30.32 km^2 and is considered to be a high-density district in the Sidoarjo Regency. In general, the Sidoarjo Regency is classified as a medium city with a population of more than two million, 18 sub-districts, an area of approximately 714,24 km^2 and solid waste service coverage of 48 %. The amount of waste dumped in landfills in Sidoarjo is 575 tonnes per day and the amount of unmanaged waste is 227 tonnes per day. The results of previous research in the Sidoarjo regency show that most people throw their garbage directly into the trash without sorting it (DLHK Sidoarjo, 2019).

Rewwin residents were considered implementers of community-based waste management or waste banks in the Sidoarjo regency. Starting from counseling conducted by the municipality regarding independent waste management, the Rewwin community realized the success of government programs related to independent waste management by conducting their own waste management. The head of the Rewwin residence proposed managing his own waste by running a clean environment program. The movement initially consisted of planting two trees in front of each house and in the park complex to make the area greener and improve air quality. After this program was successful, a waste management program was held from each house by building a waste bank for the village itself. Rewwin residents implemented its own waste bank, called “Bank Sampah Makmur Sejati” (BSMS), to handle recyclable waste in the residential area, reducing the amount of landfill waste in the Sidoarjo regency and supporting the government’s zero waste programs. The existence of waste bank encourages the community on sorting and recycling household waste (Dhokhikah et al., 2015). The process of utilizing the waste bank includes the separation of waste by the community, submission of garbage to the waste bank, weighing of the waste, selling recyclable waste to the collectors, and implementing a system for conducting the sale of garbage from the waste bank to their participants. Implemented separation strategies have reduced the greenhouse gas load and ozone formation caused by municipal solid waste (Tanskanen, 2000). Waste banks generate income, raise community awareness about environmentally sound waste management principles, and increase harmony among the participants of the waste bank community (Indrianti, 2016). The location of the Rewwin residential area is shown in **Fig. 3.1**.

Fig. 3.1 Rewwin location in Sidoarjo regency

3.2.2 Sampling of waste generation

Field sampling was conducted to determine the waste generation and composition of household waste in the Rewwin residential area. Based on the Indonesian national standard of waste generation sampling SNI 19-3964-1994, sampling was conducted for eight consecutive days. Each house was provided with a plastic bag to contain the sample. The sample container was given on the first day and collected on the subsequent day, at the same hour, with the administration of the previous container (Badan Standardisasi Nasional, 1995). The total sampling treatment was conducted for 16 days, including one replicate sampling for eight days. The first sampling period was from November 24th to December 1st and replication sampling was conducted from December 20th – 28th, 2018. Samples were taken from the houses and collected for analysis on the same day. The Rewwin residential area has a population of around 3680 people with 920 households. Sampling is done on a scale household with the assumption that one (1) of the household has four family members. Therefore, the minimum number of sampling points is determined by the population in each Rewwin RT, using the Slovin formula to obtain a representative sample. The Slovin formula is:

$$n = \frac{N}{1 + Ne^2}$$

where N is the number of populations, n is the minimum number of samples, and e is the error tolerance level (0.05).

Based on the Slovin formula, the number of households surveyed was 91. Recyclable waste data were obtained from BSMS waste bank hardcopy notebooks, such as weight by type of waste, from October to December 2018. BSMS data were analyzed and imported into a database sheet from each item collected at the waste bank and data recorded in the notebooks.

3.2.3 Questionnaire survey

A questionnaire survey was conducted to analyze the correlation and regression between social attribute identity toward knowledge and waste management behavior in Rewwin residential areas. The structural correlation analysis of this study is shown in **Fig. 3.2**.

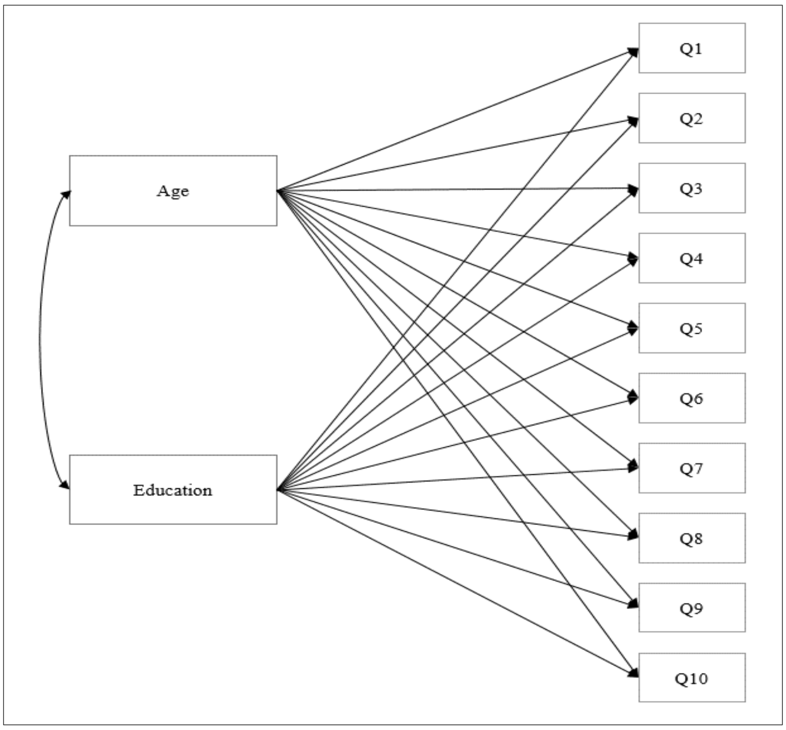

Fig. 3.2 Structural correlation and regression analysis

A questionnaire survey was performed using the purposive sampling method, which specifies the characteristics that are suitable for the study. The study was conducted considering the scope of Rewwin residents as implementers of a waste bank. Data were collected in 2018. Each resident was evaluated using a questionnaire consisting of three attributes questions and 10 questions concerning knowledge and behavior regarding waste management. Question indicator used in this questionnaire was build based on the improvement according to the

community awareness and knowledge through the waste management and characteristics of waste bank benefits from previous study. All the data was analyzed using SPSS software.
A detailed questionnaire is presented in **Table 3.1.**

Table 3.1 Questionnaire indicators

Indicators	**Question**	**Notation**
Attributes	Age	
	Education	
	Monthly revenue	
Knowledge and behavior toward waste management	Before waste bank, in our neighborhood, a lot of garbage was scattered around our neighborhood and garbage piled up in the trash can in front of the house	Q1
	Before the waste bank was established, I threw garbage into the trash can in front of my house. (Transported by officers to the landfill) but now I deposit waste into the waste bank.	Q2
	I feel that our living environment is healthier compared to 5 years ago	Q3
	The most important thing is to start with yourself and your family to maintain environmental cleanliness	Q4
	All citizens must participate in maintaining environmental cleanliness	Q5
	It is very important to separate waste (organic and inorganic) from inside the house itself	Q6
	As a member of the waste bank, and at the same time as a tangible manifestation of participating in waste management, I also get economic benefits from the waste bank activities.	Q7
	With volunteerism and full awareness, I participated in environmental cleanliness	Q8
	Feel proud to be part of the people who maintain the environment cleanliness	Q9
	Leader role is important for managing waste management and reduce, reuse, recycle (3R) in the community	Q10

Summary of questionnaire survey presented in **Table 3.2.**

Table 3.2 Summary of questionnaire survey

Indicator	Remarks
Date of survey	November-December 2018
Place of survey	Rewwin residential area
Numbers of questionnaire spread	380
Numbers of questionnaire obtained	270

Correlation and regression analyses were used, through which each question in the questionnaire was analyzed. Correlation analysis is a term used to denote the association or relationship between two or more quantitative variables. This analysis is fundamentally based on the assumption of a straight-line (linear) relationship between quantitative variables (Gogtay & Thatte, 2017). This analysis aims to represent, estimate, and understand the relationships between attribute variables. Regression analysis was also used in this study. Linear regression analysis examines the linear relationship between a metric-scaled dependent variable (also called endogenous, explained, response, or predicted variable) and one or more metric-scaled independent variables (also called exogenous, explanatory, control, or predictor variable) (Skiera, Reiner, & Albers, 2018). Regression analysis predicts how independent variables can affect dependent variables. In this research, the independent variables comprise the respondents' social attributes. Meanwhile, dependent variables consisted of questions regarding knowledge and behavior regarding waste management. These variables were converted into questionnaire questions. From the results of the questionnaire, the score for each variable can be obtained. The main objective of this set of questionnaires was to determine the relationship between the social characteristics of the survey participants through the knowledge and behavior of waste management from the respondents. Multiple linear regression line has an equation of the form:

$$Y = a + b1X1 + b2X2 + bnXn$$

where Y is the dependent variable, a is constant, $b1,2,n$ is independent variable regression coefficient and $X1,2,n$ is independent variable.

The Likert scale was applied to analyze responses to the questionnaire. The Likert scale is one of the most fundamental and frequently used scales in social science research (Joshi, Kale, Chandel, & Pal, 2015). With five response options, each answer had different facets to be analyzed. The response options were: strongly agree, agree, neutral/ uncertain, disagree, and strongly disagree. Numbers from one to six were used to analyze the attributes answer. Details of the notation are listed in **Table 3.3.**

Table 3.3 Questionnaire notation for respondent's

Analytical Notation	Age	Education Level
1	<20	No formal education
2	21-30	Elementary school
3	31-40	Junior high school
4	41-50	Senior high school
5	51-60	Associate degree
6	>60	Bachelor/graduate

3.3 Results

3.3.1 Results of waste generation and composition

The results of waste generation sampling were obtained from 91 sample households. Household waste generation was calculated on a weight basis. A total of 1,193.92 kg of household waste was obtained from 16 days of sampling from 91 household samples. This study found that the Rewin waste generation is 0.82 kg/household/day or 0.205 kg/person/day. The definition of household waste generation obtained in Rewwin is waste produced by residence after they implemented waste bank in their environment. The comparison of waste generation in Rewwin and other places from previous research has been conducted. Waste generation in other places is uncertain whether considering waste bank or other recycling activities. The waste generation levels in Rewwin were lower than the national standard of Indonesia SNI 19-3983-1995. According to the SNI, the range of household waste generation in permanent residential area is 0.350 – 0.400 kg/person/day (Badan Standardisasi Nasional, 1995). Rewwin residential area waste generation is also lower than the average household waste generation in Sidoarjo regency at 0.42 kg/person/day (DLHK Sidoarjo, 2019). In eastern Surabaya, the average household waste generation is 0.33 kg/person/day (Dhokhikah et al., 2015). The small amount of waste generation in Rewwin expected because of their consistency of implementing waste bank in their territory. They already obtained enough practice and information on how important to keep the environment. The leader and Rewwin management consistently carry out socialization to the all residences about how to keep their environment become zero waste. **Fig. 3.3** shows the definition of waste generation in Rewwin and others waste generation as comparison.

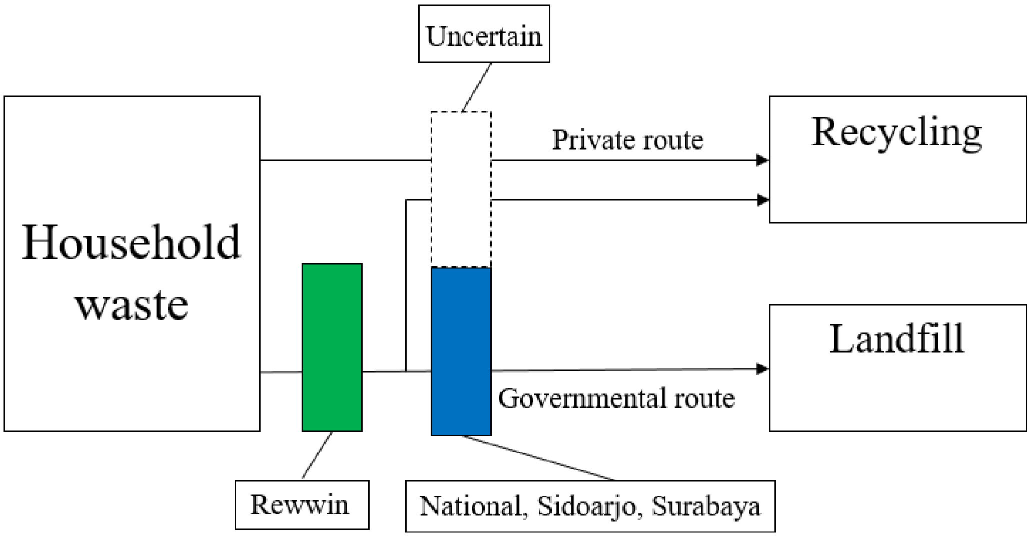

Fig. 3.3 The definition of waste generation in Rewwin compared with others

The comparison of waste generation rate in different area near Rewwin residential shows in **Table 3.4.**

Table 3.4 Comparison of waste generation in different area

Area	Waste generation (kg/person/day)	References
Rewwin	0.205	This study
Sidoarjo regency	0.42	(DLHK Sidoarjo, 2019)
Surabaya City (eastern)	0.33	(Dhokhikah et al., 2015)
Indonesian standard	0.350 - 0.400	(Badan Standardisasi Nasional, 1995)

According to the composition of household waste in Rewwin, food waste dominated the composition (48.91 %), followed by plastic waste (16.42 %). The lowest waste composition was metal waste (0.55 %). In comparison with the composition of waste in the Sidoarjo regency (DLHK Sidoarjo, 2019), there are several similarities; namely, organic waste — in the form of food scraps and leaves — dominates the overall composition of waste, comprising as much as 70.29 % in the Sidoarjo regency. For the Surabaya, a large city bordering the Sidoarjo regency, food waste dominates by as much as 64.19 % (Dhokhikah et al., 2015). The next sequence was dominated by plastic and paper waste. Based on the waste generation composition from the sampling, there is still substantial waste that can be recycled or deposited into the waste bank to maximize waste reduction in the Rewwin residential area. This result indicates that there are still many factors influencing why residents do not optimally sort their waste before depositing it into the waste bank, although Rewwin residents are considered advanced community-based waste management implementers in the Sidoarjo regency. The composition of household waste in Rewwin residential area, as observed in this sampling, is shown in **Fig. 3.4.**

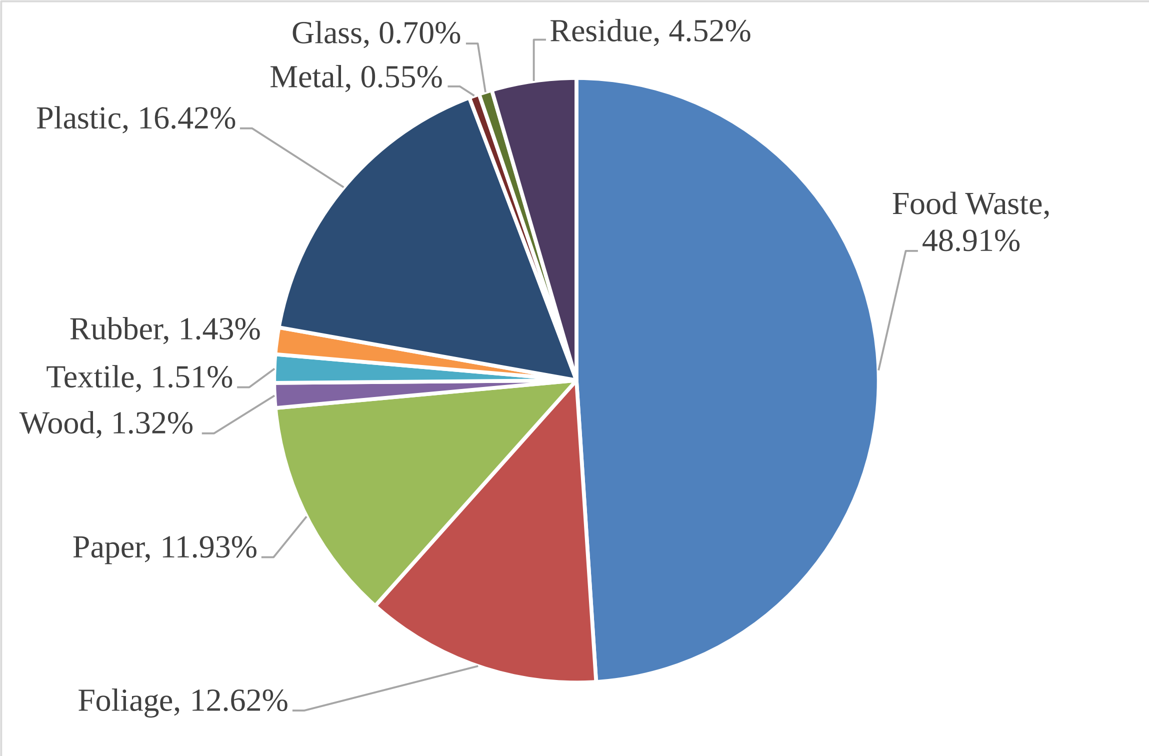

Fig. 3.4 Waste composition in Rewwin

3.3.2 Effect of BSMS waste bank

According to the waste bank data from the BSMS, obtained from October to December 2018, BSMS collected and calculated the waste twice a week, on Tuesday and Friday. The price value for each type of waste received by the waste bank was also obtained. Each type of waste has a predetermined price. Overall, the BSMS waste bank divides the waste into four types: plastic, paper, metal, and glass. Based on the data obtained, the plastic-type of waste dominates the waste received by the amount of 61.75 kg/day or 84 % of the total waste received. This finding was different from research conducted in the Malang City waste bank, in which paper is the most recyclable waste, comprising up to 60 % (Sekito, Prayogo, Meidiana, Shimamoto, & Dote, 2019). The type of plastic waste that is most widely accepted is the type of clear plastic bottle with an average of 25.03 kg/day or 33.93 % of the total recycled waste received. Plastic dominated, possibly because this material is commonly used as beverage packaging nowadays. In the next order is paper type with an average amount of 7.51 kg/day or 10 %, metal 3.50 kg/day or 5 %, and glass 1.01 kg/day or 1 %. The overall order of waste composition received in the BSMS waste bank is similar to the research findings of the waste bank in Bandung regency (Nurani, Wibowo, Prihastopo, Pelangi, & Sunardi, 2020). The total average amount of money that BSMS can obtain is Indonesian Rupiah (IDR) 109,274 per day of collection. Based on the data obtained from the Rewin BSMS waste bank, the average amount of waste received was 73.77 kg on the day of collection or 21.08 kg per day. According on the results of waste generation sampling in the Rewin residential area, the average amount of household waste generated in Rewwin was 0.82 kg/day/household. The total waste generation in Rewwin was 0.82 kg/household/day x 920 households = 754.4 kg/day. Based on a comparison between the recyclable waste received (obtained from the BSMS waste bank data) and the amount of waste generated in the Rewwin residential area, the percentage of waste reduction owing to the waste bank in Rewwin is

$$x = \frac{21.08}{(21.08\ + 754.4)} \times 100 = 2.8\%$$

Compared to other waste banks, the potential for waste reduction at Rewin is relatively high. In southern Surabaya, a major city area closest to the Sidoarjo regency, the waste bank reduction potential is only 0.146 % on average for the total incoming waste (Warmadewanthi & Haqq, 2019). The potential for waste bank reduction in Semarang City, the capital city of central Java, is 0.13 % (Budihardjo et al., 2019). In Gunung Kidul Regency, the reduction potential from the waste bank is 0.86 % (Faradina et al., 2020). Based on this, several studies in many regions in Indonesia indicated that there is no waste bank generation reduction exceeding 1 %. Waste management by the Rewwin community can be considered as a good example for other regions in Indonesia on how waste recycling activities can affect the level of waste reduction to reduce waste generation in the landfill and extend the lifetime of the landfill itself, although the reduction rate is small. The activities of waste banks are still traditional, which is a lack of technology adoption. It should be more efficient and able to manage large amounts of wastes if they incorporate innovative tools because of the vast potential for recyclable wastes (Khair, Siregar, Rachman, & Matsumoto, 2019).

Various waste management policies have been implemented. Indonesia issued Law No. 18/2008 concerning waste management. One of the points of the law is to regard new paradigm waste as resources that have economic value and can be utilized. People can perform recycling activities in which they can deposit their valuable waste and obtain money in return. The amount of waste disposed to landfills could also be reduced by implementing recycling activities, such as waste banks. Based on the waste generation data from the Sidoarjo regency official report, several types of waste still have the potential to be recycled in a waste bank. It was found that 20.21 % or 0.085 kg/day/person of recyclable materials comprise paper, plastic, glass, and metal (DLHK Sidoarjo, 2019). Recyclable waste that has the potential to be deposited into a waste bank from regional waste generation can be calculated as a potential economic benefit. The economic benefit calculation is the average price per kilogram of recyclable waste multiplied by waste generation. The potential value of recyclable waste in the Sidoarjo regency is presented in **Table 3.5**.

Table 3.5 The potential value of recyclable waste in Sidoarjo regency

Type of waste	**Average price per kg (A) IDR**	**Sidoarjo regency household waste**		
		Composition %	**Waste generation (B) Kg/day/person**	**The potential value of recyclable waste (A x B) IDR/person/day**
Plastic	1,218	10.96	0.04603	56.06
Metal	1,250	0.2	0.00084	1.05
Glass	400	0.53	0.00223	0.89
Paper	2,700	8.52	0.03578	96.61
Total	**1,218**	**20.21**	**0.08488**	**154.61**

Household waste generated based on the type of waste received by the waste bank has the potential to be recycled rather than being dumped directly into the landfill. Assuming the use of data on the price list of recyclable waste in the Rewwin BSMS waste bank, the benefits of potentially recyclable waste can be calculated. Based on the calculation of waste that can be recycled in the Sidoarjo regency, waste generation can be reduced by 20.21 %, 0.085 kg / person / day or 31.025 kg/person/ year. As for the profit, recyclable waste in the Sidoarjo regency has the potential monetary value of around IDR 56,432 / person / year. Although this benefit is relatively small, this amount is still sufficient for buying items that are needed in everyday life for Sidoarjo residents with a small income. Conversely, rewards for waste bank participants are not solely in the form of money. It depends on the creativity or needs in every region. The waste has economic value that can be converted into saving and used as exchange tools can support low-income communities. Several waste banks in Surabaya have already developed such an exchange system, allowing electricity to be paid with waste savings (Wijayanti & Suryani, 2015). Based on research in Makassar city, rewards are given to waste bank participants not only in the form of money but also in the form of basic foodstuffs, such as sugar, soap, oil, and rice (Towolie, Permana, Aziz, Ho, & Pampanga, 2016). Waste bank or waste management by the community is suitable for Indonesia, which is a developing country for citizen economic improvement.

3.3.3 Results of questionnaire survey

The questionnaire survey results were obtained from Rewwin residents. Monthly revenue as social attributes indicator has been omitted due the lack of answer from the respondents. The respondents tend to keep their information about revenue secretly. Prior to the correlation and regression analysis, a validity test was conducted to examine the reliability of the dependent variables. The percentage results of each questions regarding the knowledge and behavior toward waste management presented in **Fig. 3.5**.

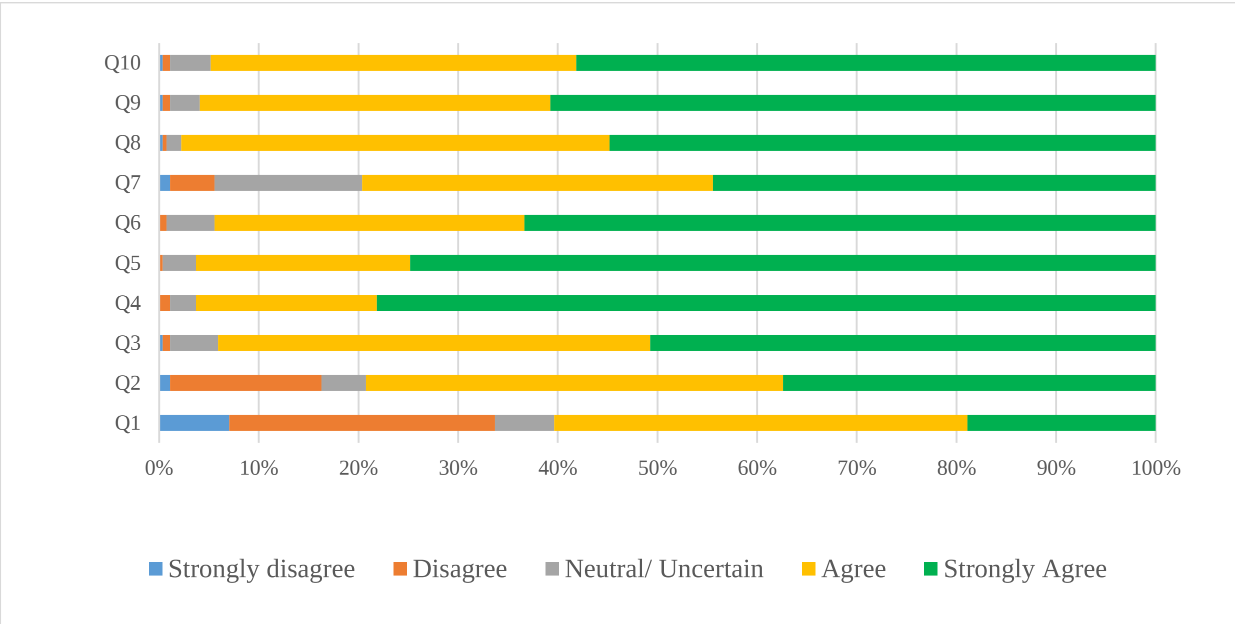

Fig. 3.5 Results of the questionnaire regarding knowledge and behavior toward waste management

The validity test was conducted using the observed dependent variable data obtained from the questionnaire. Cronbach's alpha was used to determine the reliability and validity of the dependent variables. The results indicated a Cronbach's alpha value of 0.779 for all dependent variables. According to Hair (Hair, Black, Babin, & Anderson, 2009), Cronbach's α value should be greater than 0.700. The validity results indicate that the surveyed data are reliable.

Among the Rewwin residents surveyed, most were older than 60 years of age (35.9 %, n = 97), with the fewest number of residents less than 20 years of age (0.7 %, n = 2). Most residents had bachelor or graduate educational levels (47.4 %, n = 128), with the least number of residents having elementary school education (0 %, n = 0). This finding is slightly different with the most education level in Sidoarjo regency (BPS Kabupaten Sidoarjo, 2018) and Indonesia (BPS, 2019) which is senior high school comprise 38.06 % and 26.69 %. Surveyed result indicated that Rewwin residents level of education is higher than the most level education in Indonesia. Detailed descriptive demographic statistics are presented in **Table 3.6.**

Table 3.6 Residents attributes frequencies

Indicator	Type Range	Frequency	Percentage (%)
Age	< 20	2	0.7
	21-30	18	6.7
	31-40	32	11.9
	41-50	43	15.9
	51-60	78	28.9
	> 60	97	35.9
Education	No formal education	3	1.1
	Elementary school	0	0
	Junior high school	6	2.2
	Senior high school	120	44.4
	Associate degree	13	4.8
	Bachelor / graduate	128	47.4

Questionnaire results were also used for the statistical analysis. There are independent and dependent variables for the questionnaire, in which multiple regression and correlation analyses were performed. First, the Pearson correlation results were addressed. Pearson's correlation is a measure of the linear association between the two variables. Positive values close to 1 indicate a strong linear correlation, i.e., a variable increases or decreases with another variable. Negative values close to -1 indicate that a strong correlation of one variable is associated with a decrease in the values of the other variable and vice versa (Kirch, 2008).

Correlation analysis shows that age is significantly negatively correlated with education level among Rewwin residents, with a Pearson's value of -0.190 and a significance value of 0.002. A significance value of less than 0.05 is statistically significant, indicating that older Rewwin residents have a lower education level. The summary and detailed results of the attribute correlation are presented in **Table 3.7.**

Table 3.7 Correlation and significance values

		Age	**Education**
Age	Pearson correlation	1	-0.190
	Significance value		0.002**
Education	Pearson correlation	-0.190	1
	Significance value	0.002**	

*: p<0.05 **: p<0.01

The results of multiple regression analysis among all variable showed in **Table 3.8**.

Table 3.8 Regression coefficients and significance values

Question indicators	**Age**		**Education level**	
	Standardized coefficients	**Significance value**	**Standardized coefficients**	**Significance value**
Q1	-0.039	0.533	0.067	0.285
Q2	-0.017	0.789	-0.052	0.407

Question indicators	Age		Education level	
	Standardized coefficients	**Significance value**	**Standardized coefficients**	**Significance value**
Q3	0.040	0.519	0.090	0.147
Q4	-0.019	0.765	0.098	0.114
Q5	-0.032	0.610	0.059	0.347
Q6	0.035	0.576	0.035	0.578
Q7	-0.004	0.954	-0.094	0.129
Q8	0.013	0.831	0.120	0.054
Q9	-0.142	0.021*	0.108	0.080
Q10	-0.061	0.324	0.100	0.107

*: p<0.05 **: p<0.01

Based on the multiple regression analysis, among all variables only one variable has significant impact. Age has a significant negative impact on (Q9) which younger people in Rewwin residential area feels proud to be maintaining environmental cleanliness. Overall result indicated that level of age and education did not affect significantly towards knowledge and behaviour regarding awareness and waste management in Rewwin residential area. Crosstab diagram of age toward Q9 shows in **Fig. 3.6**.

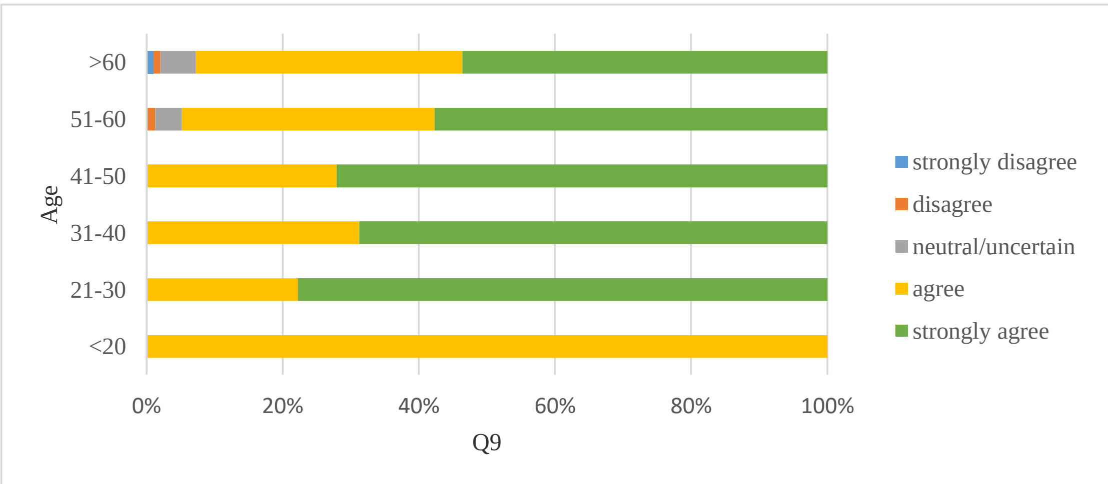

Fig. 3.6 Crosstab diagram of age toward feel proud to be part of the people who maintain the environment cleanliness (Q9)

According to the previous study in Malang city (Maryati et al., 2018) and Depok city (Suparmini & Junadi, 2018) regarding the participation of recycling activities such as waste bank, lower education residents think they will receive economic benefits (money) from the waste that they submit to the waste bank. This participation factor indicating that people from lower education have motivation related to economic benefit in participating waste bank activities. This finding is different with Rewwin residence characteristic that education level did not have significant impact to the way of thinking whether they will rely on receiving economic benefit from waste bank participation. This study found that social attributes such as age and education level did not have significant impact to the knowledge and behavior toward waste management for the Rewwin residents. They already obtained enough knowledge on how important to keep the environment and implementing recycling activity consistently in their residential area. The leader and Rewwin management roles of consistently carry out socialization about how important to keep their environment become zero waste is affecting to Rewwin resident behaviour toward waste management. Moreover, the Rewwin management implement the strict rules for the residents to collect their waste separately according to the waste category. In order to that, Rewwin residents already more aware of knowledge and behaviour regarding waste management or environmental awareness to keep their environment.

Furthermore, people in Indonesia should be encouraged to sort the waste at source, and government can also strengthen waste recycling activities by issuing the right policies and driven by effective communication, performance incentives, sustainable technology, and feedback (Khair, Rachman, et al., 2019). Countries will likely always produce waste, but what becomes waste, and how much, is a product of the particular society and they have to eliminate it in conjunction with their cultural context and way the society has approached modernity (Brown, 2015).

3. 4. Summary

This study found that community-based waste management or waste bank can encourage the number of waste reductions and benefit their participants in the form of economic value. Rewwin residential area in Sidoarjo regency is considered an example of a community that independently manages waste in its local environment. Rewwin residential areas generate approximately 0.205 kg/person/day of household waste. The waste generation levels were lower than the national standard of Indonesia SNI 19-3983-1995 (Badan Standardisasi Nasional, 1995), which is as much as 0.350 – 0.400 kg/ person/day, and lower than the average waste generation in Sidoarjo regency, 0.42 kg/person/day (DLHK Sidoarjo, 2019). The BSMS waste bank in Rewwin can reduce the total waste generation in the Rewin residential area by 2.8 %; this reduction rate is considerably better than that of previous studies in several regions in Indonesia. This study also found that there will be an economic benefit of as much as IDR 56,432/person/year if all recyclable waste in Sidoarjo regency is submitted to the waste bank.

Regarding the characteristics of Rewwin residents, this study found that the age attribute has a significant negative correlation with the education level attribute, with a Pearson's correlation value of -0.190 and a significance value of 0.002. Statistical significance was set at $p < 0.05$. This means that older Rewwin residents have a lower education level. This study also found that younger residents feel proud to maintain environmental cleanliness. From the demographic descriptive results, Rewwin residents had various levels of age and education. Most were older than 60 years of age and most of the residents had a bachelor or graduate educational level. This research indicated that the various level social attributes in community did not have significant effect towards the environmental awareness as long as the communities consistent to participate in the activities to protect the environment.

Chapter 4 Life Cycle Assessment and Cost Benefit Analysis of Waste Management Strategies in Cimahi City

4.1 Background

Waste is one of the products by human activities that have impact to the environment. Municipal waste is defined as waste collected or treated by or for municipalities. Further, municipal solid waste (MSW) covers wastes from residential areas including multifamily housing and waste from commercial and institutional locations, such as businesses, schools and hospitals. (Schneider, 2017). Within the complexities of municipal solid waste management, the cost to handle the municipal waste is not small and increasing from time to time depend on the situation of every regions. Waste management is a specific practice aimed at reducing the effects of waste materials on the environment and increasing material and energy recovery (Liu et al., 2017). Countries will likely always produce waste and they have to eliminate it in conjunction with their cultural context and the rate and way the society has approached modernity (Brown, 2015).

The city of Cimahi experiences an increase in population each year. In addition to the relatively small area, Cimahi has its own charm, and because it is directly adjacent to Bandung City and Bandung Regency, it serves as an alternative strategic location. An infamous disaster due to the poor management of MSW was the landslide at the Leuwigajah dumpsite in 2005, in which 147 people lost their lives (Damanhuri, Handoko, & Padmi, 2014). Cimahi has a vision and mission of waste management, namely the innovative program "Cimahi Zero Waste City 2037." This innovation implemented by the Cimahi City government aims to change the old paradigm of waste management in which waste is managed only by the government. The new paradigm, based on Law No. 8 of 2008, states that the community has a role in managing their waste at their respective sources. The foundation of the Cimahi City waste management policy in the medium term (2021–2025) is to strengthen the operational performance of the institutional and community-based waste management system to reduce waste by up to 50% at the waste source by the end of the medium term. Waste processing in Cimahi City began to shift to the Legok Nangka regional landfill at the beginning of the medium term.

To date, the environmental and cost assessment of municipal waste management in Cimahi City need to be more explored. According to the previous study using LCA and CBA methods to determine optimum solution of waste management, this study investigate the moving landfill site and waste bank using these method to support Cimahi City vision regarding municipal waste management strategies. The aim of the current study was to analyze the environmental assessment and cost-benefit impact from the move of the landfill site from Sarimukti landfill, which is located approximately 34 km from the city center to a new landfill site in Legok Nangka landfill, which is located approximately 56 km from Cimahi City. The moving of the landfill site will cause an increase in costs. In addition, the impact of the addition of waste banks to the management of municipal waste in Cimahi City was investigated.

4.2 Methods

4.2.1 Study location overview

Cimahi is one of the cities in West Java, as it located approximately 20 km near the center of activity of capital West Java Province, Bandung City. Cimahi consists of three districts has an area of 40.37 km^2 and population of half million. According to the data from environmental agency of Cimahi Municipality, average of waste generated in Cimahi per capita is 0.486 kg/day (DLH Cimahi, 2018). About more than a half of the waste generated in Cimahi is organic waste, followed by inorganic waste. Generally, waste treatment method in Cimahi city divided into two primary method based on the type of the waste. For organic waste, treatments used are composting. One facilities developed to reduce inorganic waste disposed to final landfill is Waste Bank. Waste banks have also become a tool for bringing together stakeholders, including local government, public (communities), private sectors, non-government organization, and mass media (Wijayanti & Suryani, 2015). Currently there are 63 waste banks spread through all Cimahi city. In Cimahi, there is only one central government waste bank with an average capacity is 476 tonnes/year; the rest of the waste bank is subsidiary of the central waste bank. All subsidiary waste banks will send their waste to Cimahi central waste bank. Thus, the gateways of selling recyclable products are done only via the central waste bank. Until 2019, waste from Cimahi city and several region close by areas brought their waste to regional landfill named Sarimukti landfill, which is located 23 km away from the center of Cimahi city. Sarimukti landfill has an area of 25.2 ha and has been operating since May 28th 2006. Due to the contract on landfilling in Sarimukti landfill is finished by 2020, Cimahi has to discharge the waste to another landfill. Currently, Cimahi did not have its own landfill. Thus people needs to transport the waste to province-owned new landfill site, Legok Nangka landfill. Map of Cimahi city and distance of landfills is shown in **Fig. 4.1**.

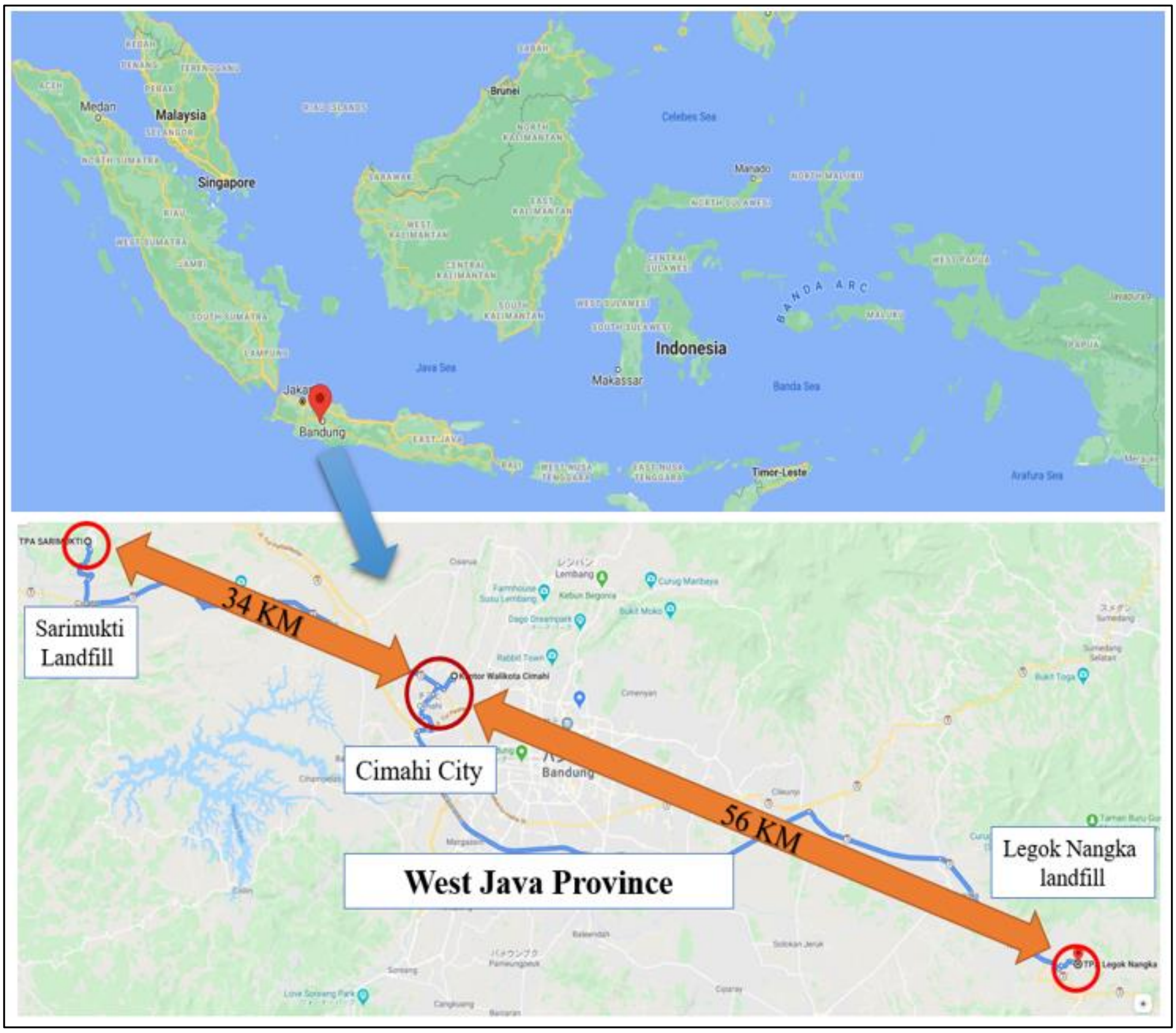

Fig. 4.1 Map of Cimahi City and distance of landfills

4.2.2 Life cycle assessment

A life cycle assessment is a technique for an product related estimation of environmental aspects and impact LCA assesses each and every impact associated with all stages of a process from cradle-to-grave (i.e., from raw materials through materials processing, manufacture, distribution, use, repair, maintenance, and disposal or recycling (Klöpffer & Grahl, 2014). There are four steps to conduct LCA,; goal and scope definition, Life-cycle inventory (LCI), Life-cycle Impact Assessment (LCIA), and interpretation (International Organization for Standardization, 2006).

The goal and scope definition in this study is analyzing environmental impact of municipal waste management processes from waste collection process in the neighborhoods to waste transportation process into landfilling process. This study conducted several scenarios to assessing which scenario is suitable to be implemented. The step consists in assessing the sensitivities of the LCA results to all main assumptions by scenario analysis (Laurent et al., 2014). For the life cycle-inventory, the results of the collected and estimated inventory data were categorized. In this study, the emissions considered from used of motor cart and trucks in waste collection and transportation process. The emission factors used in this study for CO_2, CH_4, and N_2O were obtained from the Intergovernmental Panel on Climate Change (IPCC, 2006). The environmental effects from collection and transportation were estimated based on fuel consumption, number of vehicles used, and distance travelled. The general equation used to estimate the emissions is shown below:

$$E = \Sigma\ Fuel\ \times EF$$

Where, E = emission (kg), Fuel = fuel consumed (TJ), EF = emission factor (kg/TJ).
Emission factor used in this study shown in **Table 4.1**.

Table 4.1 Emission factor

Type of vehicle	Unit	Emission factor
CO_2 for diesel fuel	kg/TJ	74,100
CO_2 for gasoline fuel	kg/TJ	69,300
CH_4 for truck-diesel	mg/km	23
N_2O for truck-diesel	mg/km	30
CH_4 for light duty- gasoline	mg/km	17
N_2O for light duty-gasoline	mg/km	22

(IPCC, 2006)

The calculation of waste in landfilling process emissions and avoided landfilling materials consisted of inorganic materials that were sold by the waste bank to the recycling industry have the potential to reduce the use of raw materials in the respective industries were calculated using waste reduction model (WARM) which also adopts LCA methodologies (US EPA, 2020).

4.2.3. Cost benefit analysis

Cost–benefit analysis (CBA) is a method for assessing the economic efficiency of proposed public policies through the systematic prediction of social costs and social benefits (Haveman & Weimer, 2001). In this study, CBA considered to evaluate the economic aspects of municipal waste management in Cimahi City. Subsequently, we can compare and decide which waste management scheme is profitable and suitable for Cimahi. According to Hyltonne (Hyltonne, 2016), total cost and benefit of projects are defined in two components presented in the following equation:

$$Total\ Benefit = B\ internal + B\ external$$
$$Total\ Cost = C\ internal + C\ external$$

An internal benefit included in this study was the retribution fee for waste management from every resident in Cimahi City. Other internal benefits are obtained from selling recyclable items collected by the waste bank. External costs considered from the waste collection, transportation, and landfilling produce emissions, which indirectly have a negative impact on the environment. The avoided use of raw material because of the use of recovered material from waste bank resulted in less emission considered to be an external benefit. These Externalities should be converted to a comparable value to understand the external costs and benefits resulting from those actions. To convert those externalities, this study used social cost of carbon (SCC). Social costs of carbon represent the damage of climate change caused by emissions of carbon dioxide with a monetary value. The social cost of carbon theoretically inform assessment of the desirable intensity of climate policy, and it plays a crucial role in any cost-benefit analysis of emission abatement initiatives (Zhen, Tian, & Ye, 2018). External cost and benefit in this study are estimated using SCC value of 37 USD per tonne CO_2 or equals to Indonesian Rupiah (IDR) 539,534 rupiah per tonne. Functional unit used for environmental assessment is CO_2 equivalent (CO2e) per tonne waste managed, for cost analysis is IDR per tonne of waste managed. The detail cost benefit component shows in **Table 4.2**.

Table 4.2 Cost component and benefit component

Type	Component	Code
Cost component		
Direct cost (internal)	Collection	C1
	Transfer point	C2
	Transportation	C3
	Landfilling retribution	C4
	Government waste bank operational cost	C5
	Private waste bank cost of buying recyclable waste	C6
	Private waste bank operational cost	C7

Type	Component	Code
Indirect cost (external)	Collection (emission)	C8
	Transportation (emission)	C9
	Landfilling (emission)	C10
Benefit component		
Direct benefit (internal)	Retribution fee	B1
	Selling recyclable waste government waste bank	B2
	Selling recyclable waste private waste bank	B3
Indirect benefit	Landfilling (emission)	B4

Cost component analysis is performed by adding up the cost values of a scenario such that the total cost (net cost) of each planned scenario is obtained. Benefit component analysis is performed by adding the benefit values of each scenario to obtain the total benefit (net benefit). Based on **Table 4.2**, the net cost and net benefit equations are:

$$Net\ cost = C1 + C2 + C3 + C4 + C5 + C6 + C7 + C8 + C9 + C10$$
$$Net\ benefit = B1 + B2 + B3 + B4$$

4.3 Results

4.3.1 Municipal waste management scenario

Scenario analysis conducted to investigate which scenario that have the most benefit and suitable to be implemented. Data used in these scenarios are provided by environmental agency and central waste bank of Cimahi City. Due to the limitation of availability of data, this study also adapted some data from previous researches conducted in Cimahi city and from cities that conducted study about waste bank. All of the scenarios are using similar set of databases, which is 2018 municipal waste generated and managed in Cimahi City. Component and composition of managed waste in Cimahi City shows in **Table 4.3**.

Table 4.3 Composition of managed waste

Component	Composition	Weight (tonne/year)
Organic	48.06%	52,508
Paper	8.58%	9,374
Plastic	16.18%	17,677
Steel	3.46%	3,780
Glass	3.42%	3,737
Fabric	5.92%	6,468
Hazardous waste	1.34%	1,464
Others	13.04%	14,247
Total	**100.00%**	**109,254**

The boundary of this study is start from collection waste process until landfilling process. The collection phase included every method of collecting waste from the waste source all over Cimahi City. The first collection phase was collecting waste in concrete garbage bins around residences and bringing these to temporary transfer points using motor cart or manual pull cart. This phase also included transferring waste from subsidiary waste banks banks to the central waste bank. Transfer points accommodate waste from various sources especially from households. The waste was stored temporarily until the container was full, then transported to the landfill site using two types of trucks. The first was an arm-roll truck which transported different amounts of waste depending on the volume of the container. The second type were dump trucks that were also consist of different types depending on their capacity. Waste collected by subsidiary waste banks was then transferred into the central waste bank. Central waste bank sold all the recyclable waste to recycling industries. The current landfill which the municipal waste from Cimahi City is disposed is private or province-owned. Therefore, the Cimahi government have to pay a landfill fee for each tonne of waste disposed. The landfilling fee for Sarimukti landfill is 50,000 rupiah/tonne, whereas for Legok Nangka landfill is IDR 270,200 per tonne of waste. Study boundary shown in **Fig. 4.2**.

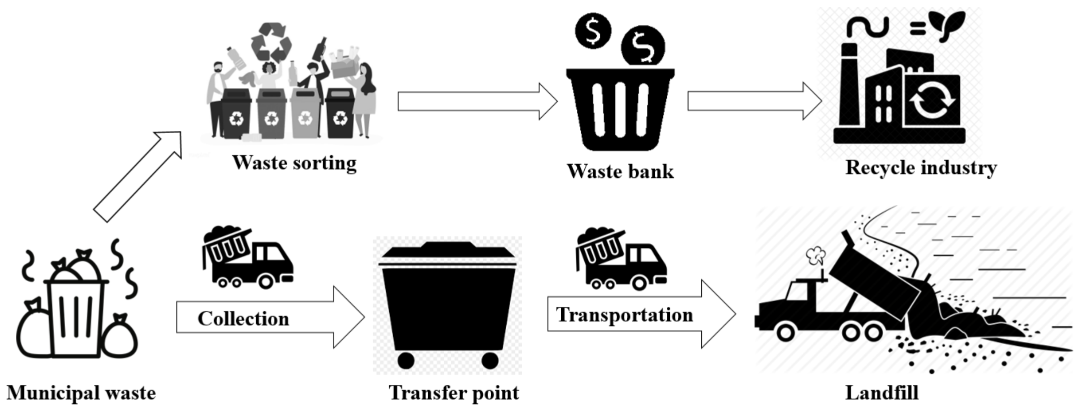

Fig. 4.2 Study boundary of waste management scheme in Cimahi City

From the waste transportation process including waste collection, transportation to landfill and landfilling process produce emissions, which indirectly have a negative impact on the environment and could be considered as external costs. To convert those externalities, this study used social cost of carbon (SCC) to monetize CO_2. SCC are estimated using SCC value of 37 USD/tonne CO_2 (rate of exchange IDR 14,582 per USD). Overview of social cost of carbon from all scenarios shows in **Table 4.4**.

Table 4.4 Carbon cost all scenarios

Scenario	Waste transportation process (tonne CO_2/year)		Landfilling (tonne CO_2/year)	Carbon cost (37 USD/tonne)	
	Collection	Transportation		USD	IDR
SC-0	6.9	613.93	78,575.81	2,930,276	42,729,279,966
SC-1	6.9	998.55	78,575.81	2,944,507	42,936,795,533
SC-2	4.18	861.71	73,608.79	2,755,563	40,181,621,999
SC-3	4.18	861.71	73,608.79	2,755,563	40,181,621,999

The anticipated environmental impacts depend on several factors such as characteristics and composition of waste, the efficiency of the waste collection and processing systems required by different waste management practices (Elagroudy, Elkady, & Ghobrial, 2011). In this study, we conducted four scenarios to assess the waste management strategies of Cimahi city.

a. Scenario 0 (existing condition/SC-0)

In the SC-0 scheme, the landfill site is still in the Sarimukti landfill. The proportion and capacity of waste treatment was calculated on a wet weight waste basis, which is the proportion that was used in 2018 government database. The waste bank used in this scenario is similar to the previously explained process of waste treatment in Cimahi City. The waste bank capacity in this scenario is 0.35% of the total waste generated annually in the Cimahi municipality, with 1 government or central waste bank that are centrally managed. This scenario was evaluated to determine potential differences between scenarios.

b. Scenario 1 (SC-1)

SC-1 was similar to that of SC-0 except that a new landfill, Legok Nangka landfill, was used in this scenario.

c. Scenario 2 (SC-2)

In SC-2, new waste banks were established that together accounted for a total of 3% of the treated waste or equal to 8 government waste banks as an alternative means to reduce inorganic waste disposed to the landfills. In this scenario, these newly established waste banks are subsidiaries of government waste banks. These waste banks are established under local government policy; therefore, the waste is collected and treated in a manner similar to that at the previously established waste bank. Inorganic waste is sorted by residents and brought to the waste bank. After the waste is sold, the money is deposited to each of the residents' bank accounts. The money from selling recovered items is managed by the government waste bank. The residents did not directly received money from the waste bank until the resident collects it from their bank account later. The newly established government waste bank becomes a place that only receives waste from residents.

d. Scenario 3 (SC-3)

The SC-3 scheme had a solution similar to that of SC-2, the establishment of 8 new private waste banks, with some modifications. The difference is who supports the waste banks. In SC-2, the waste banks are supported by the government. In SC-3, the newly established waste banks are based on residents' initiative or private waste bank, which implies they are not subsidiaries of the central or government waste bank. These waste banks operate on their own, and therefore, financial management responsibilities are borne by themselves. The private waste bank needs to buy the recyclable waste and giving money directly to the residents. Establishing these 8 new waste banks equals redirecting 2.65% of the total waste generated from direct disposal to recycling industries, which if added to the established waste banks will total to approximately 3% of the total waste treated. The scenarios of waste management in Cimahi City is shown in **Fig. 4.3**.

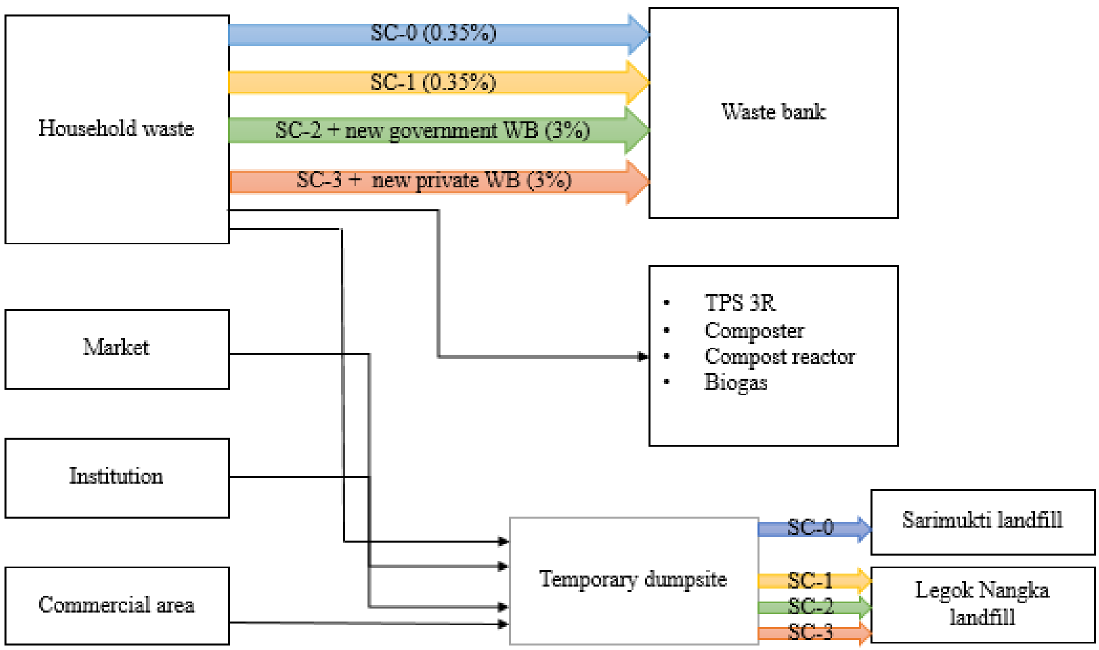

Fig. 4.3 Scenarios of Waste Management in Cimahi City

The proposed scenarios have its own scheme that affecting to the waste flow each scenario in Cimahi City. The distinguish part of waste flow occurred specifically in treated municipal waste, waste bank, and the total waste disposed in landfill. The detail of waste flow in all the scenarios is shown in **Fig 4.4.**

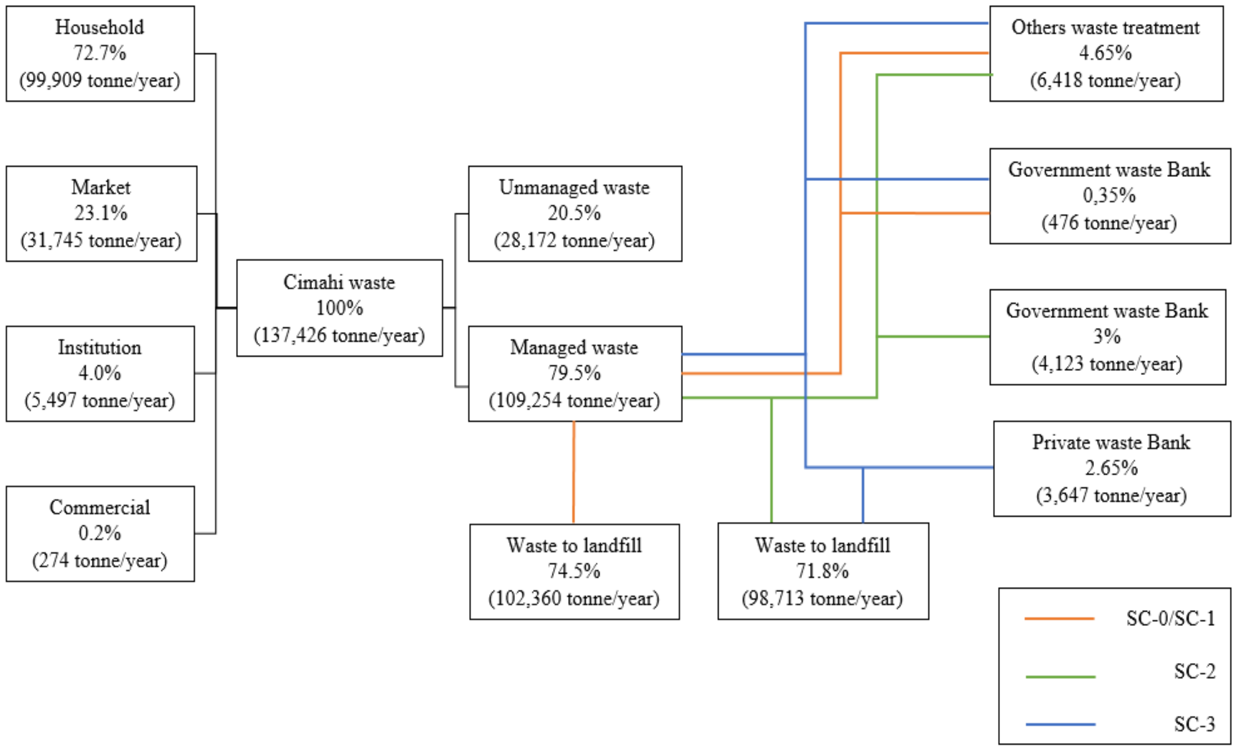

Fig. 4.4 Waste flow diagram all scenarios

For the waste bank material input, each scenario has its own values. Existing waste bank for base scenario (SC-0) has 0.35% composition of total waste, whereas in SC-2 and SC-3 the new strategies is to increase the waste bank composition into 3% for total waste in Cimahi City. The detail of material processes in waste bank each scenario shown in **Table 4.5** and **Fig. 4.5**.

Table 4.5 Waste bank material flow each scenario

Component	**SC-0/ SC-1**	**SC-2**	**SC-3**		**Average Selling price to recycle industries (IDR/kg)**
	Annual input existing government WB (0.35%) (Tonne)	**Annual input government WB (3%) (Tonne)**	**Annual input existing government WB (0.35%) (Tonne)**	**Annual input private WB (2.65%) (Tonne)**	
Paper	129	1,118	129	989	1,254
Plastic	243	2,108	243	1,865	1,675
Steel	52	451	52	399	11,764
Glass	51	446	51	394	283
Total	**476**	**4,123**	**476**	**3,647**	

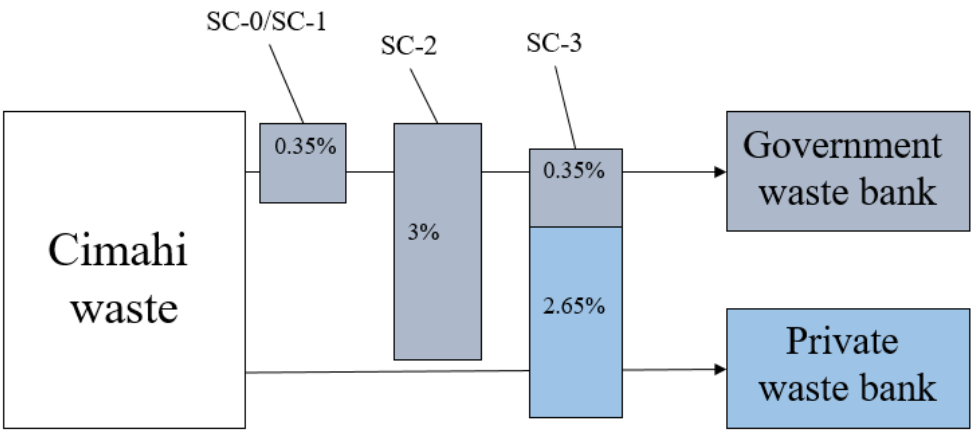

Fig. 4.5 Waste processed in waste bank all scenarios

4.3.2 Life cycle assessment

a. SC-0

According to the result of existing condition (SC-0) estimation final treatment of the waste expected to be the highest CO2e emission compared with collection and transportation indicators. The CO2e emitted to the environment due to the landfilling process of total waste in the landfill site written as landfilling indicator in the graphs. Hence landfilling sector contributed 99.17% of CO2e emitted. Collection phase only produced 0.00041 MTCO2e per waste managed and transportation emitted 0.00602 MTCO2e per tonne waste managed. Annual emission emitted from Scenario SC-0 is shown in **Fig. 4.6**.

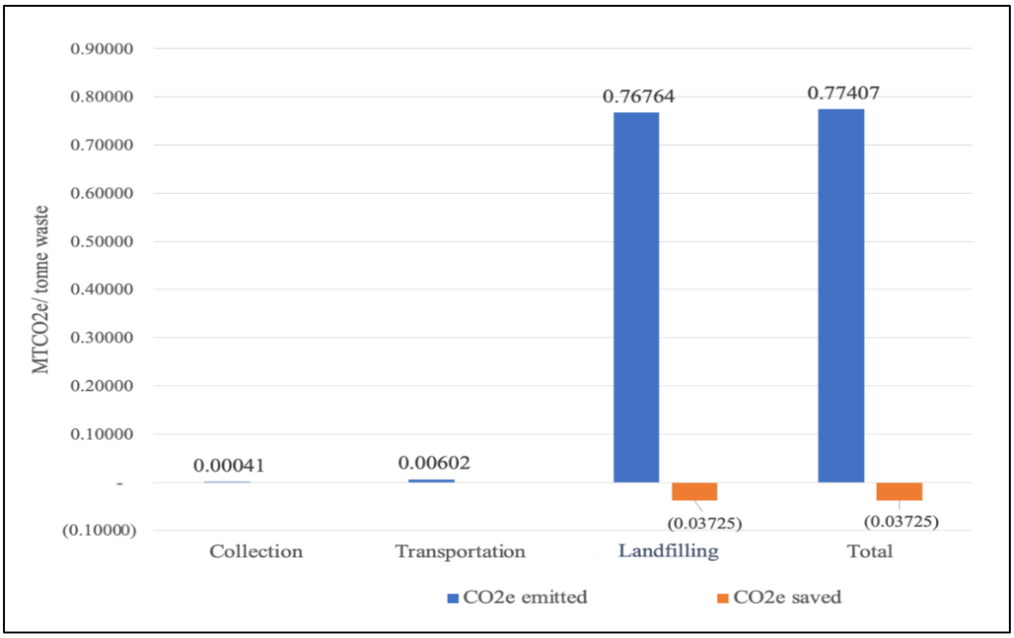

Fig. 4.6 Annual CO2e emitted SC-0

There are saved CO2e from existing established waste bank which enable to avoid emission. Saved CO2e from SC-0 is equal to 0.03725 MTCO2e/ tonne waste. Saved CO2e estimated from the avoided raw material were substituted by recycled material in manufacturing process and gives better impact to the environment rather than disposed to landfill. Recycling materials could reduce potential emissions caused by transportation and acquisition of raw material. If those materials are not treated by waste bank, then it will add to the number of wastes disposed to the landfill.

b. SC-1

Environmental impacts of emission emitted from scenario SC-1 is similar with SC-0. The only difference is the increase of CO2e emitted from transportation sector by 62.6%, since the change of landfill site affects to the waste transporter distance of traveling, fuel used, and the operational maintenance of waste transporters. CO2e saved is similar because the amount of recyclable waste collected to the waste bank is constant. Annual CO2e emitted of SC-1 compared with SC-0 is shown in **Fig. 4.7**.

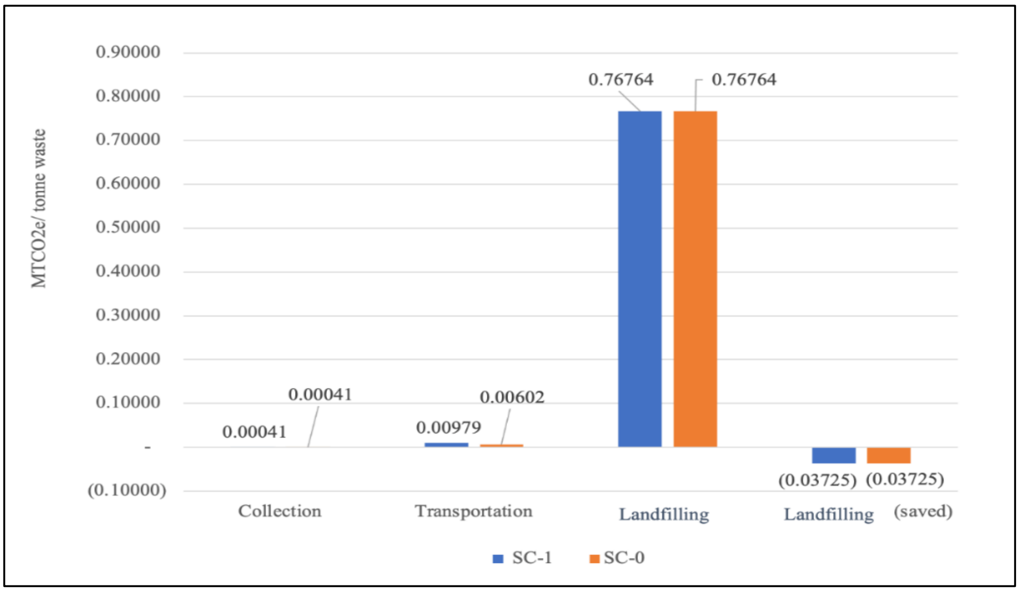

Fig. 4.7 Annual CO2e emitted of SC-1 compared with SC-0

c. SC-2

SC-2 resulted in lower CO2e emitted from transportation and collection sector compared with SC-1, since the amount of waste collected and transported to landfill is reduced that affecting to the fuel used of transporters. CO2e emitted from landfilling reduced by 2.86%. The decrease emission in landfilling caused by residents that brought their sorted recyclable waste directly to waste banks is increased from 0.35% to 3% from total waste in Cimahi. This reduction in line with the increasing of saved CO2e by 104.05%. The reduction seems insignificant since the amount of organic waste contributes to the landfilling impacts on landfilling emission is still high. Comparison of CO2e saved and emitted between scenario SC-1 and SC-2 is shown in **Fig. 4.8**.

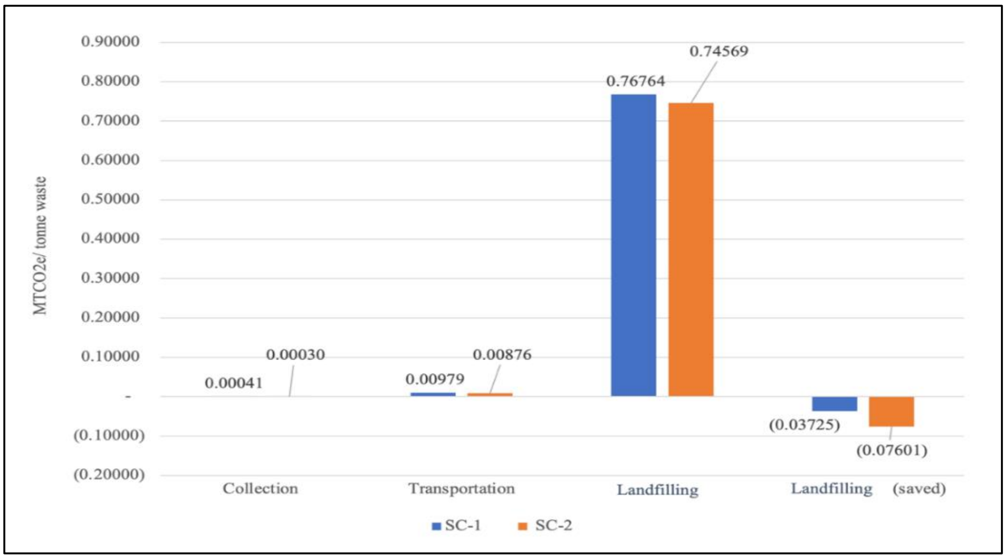

Fig. 4.8 Annual CO2e emitted of SC-1 compared with SC-2

d. SC-3

In SC-3, emission emitted due to collection phase until landfilling process is similar with SC-2. The reduction of CO2e emitted and saved CO2e in SC-3 is similar with SC-2 since overall waste management system is similar, especially the amount of waste disposed to the landfill and recycled in the waste bank. Comparison of CO2e emitted and saved between scenario SC-1 and SC-3 is shown in **Fig. 4.9**.

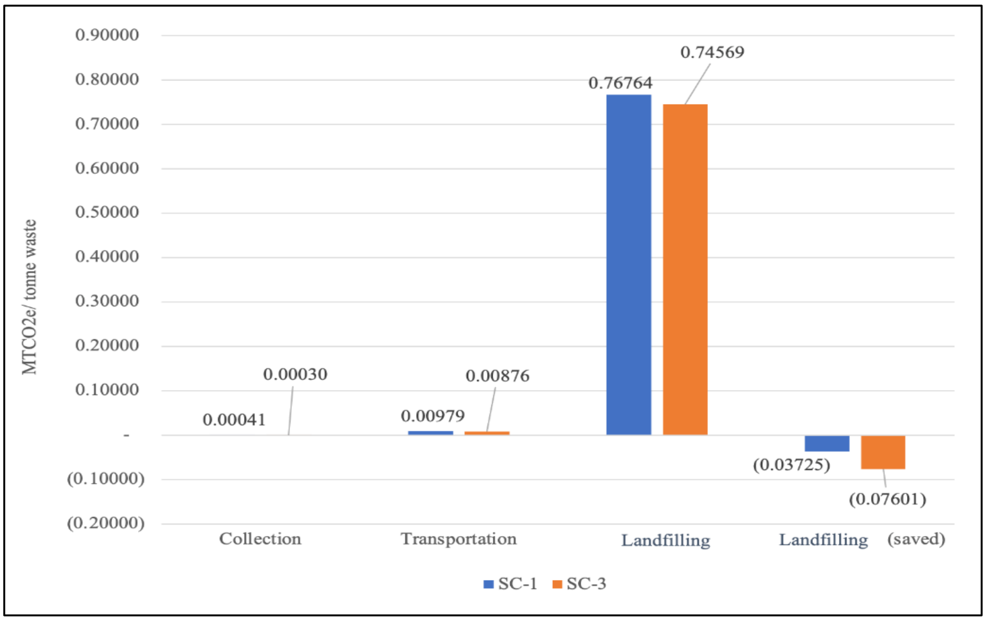

Fig. 4.9 Annual CO2e emitted of SC-1 compared with SC-3

4.3.3 Cost benefit analysis

a. SC-0

Cimahi City is not considered as a large city with high population such as Jakarta, Bandung, Surabaya or Medan because of their population and area. One of the similarities with those big cities regarding the municipal waste management is the retribution fee. Retribution fee considered as income for the municipality because every residents has to pay for waste management in their area. The average retribution fee per tonne waste managed equals to IDR 12,941 per tonne annually. In SC-0 or existing waste management in Cimahi City, another benefit acquired is from selling the recyclable waste via waste bank. Residents brought their sorted waste to the central or government waste bank. On average, annual benefit per tonne of waste managed in Cimahi City is IDR 2,546,417 per year per tonne consist from waste bank benefit and saved emission from landfilling process that has been converted to social carbon cost. Operation and maintenance of municipal waste management consists of collection cost, transfer points maintenance, transportation cost, and landfilling cost. Collection costs are affected by the number of households that need to be picked up, which also correlates with fuel, wage, and service fee for the transporter. In the baseline scenario, collection costs equal to IDR 36,803 per year per tonne waste managed. Transfer point maintenance fee does not contribute much to waste management cost, since it doesn't need a lot of maintenance every year and equal to IDR 308 per year per tonne waste managed. For the transportation phase, factors affecting transportation costs are the amount of waste disposed or transported, since it will indirectly affect other factors, such as number of trucks utilized, fuel consumed, wage, and service fee. In this scenario, it is assumed that all vehicle owned by municipality for collecting and transporting waste are used. Waste disposed to landfill annually reached 102,360 tonnes and costs IDR 35,703 per tonne per year waste managed or transported from transfer point. The landfill retribution depends on the agreement between local government and the owner of the landfill, which is provincial government. The landfilling retribution cost for Sarimukti landfill is IDR 50,000 per year per tonne waste disposed in landfill.

For the waste bank cost and benefit, the operational cost of the waste bank was adapted from a previous study on the Malang waste bank (Sholikah, 2017) because the data for the Cimahi waste bank are not available. Based on the detail operational cost of waste bank Malang, the capacity of waste bank Malang is approximately three times bigger than central waste bank Cimahi. Waste bank Malang have 18 employees with the total salary of the employee is IDR 390,000,000 per year and recyclable processed 1,278 tonne per year (Sholikah, 2017). Central waste bank Cimahi only have total 5 employee (RRI.CO.ID, 2019) and annual recyclable waste 476 tonne per year. From waste bank Malang case, average salary per employee of waste bank officer is IDR 1,805,556. The total operational cost of Malang waste bank per year per tonne waste managed is IDR 349,765. According to the waste bank capacity and number of employees, this study assumed that operational cost of Cimahi waste bank is approximately three times smaller than Malang waste bank. There is additional component for waste bank Cimahi which is social security component. In Indonesia, the social security rate is a tax related with labor and important to pay for many social programs including welfare, health care and many other benefits (Trading Economics, 2021). Based on Indonesian social security services, for formal workers including government employees the contribution rate is 5.7% from the total wages (BPJS, 2021). This social security indicator also added in operational cost of waste bank. The total operational cost in waste bank Cimahi is IDR 280,480 per year per tonne recyclable waste managed. The detail of operational cost of waste bank shown in **Table 4.6**.

Table 4.6 Operational cost of government waste bank

Operational cost component	Waste bank Malang (IDR/year)	Waste bank Cimahi (IDR/year)
Salary employees	390,000,000	108,333,333
Food material	7,800,000	2,600,000
Gasoline	7,200,000	2,400,000
Diesel fuel	4,800,000	1,600,000
Water	1,200,000	400,000
Electricity	8,400,000	2,800,000
Sack	600,000	200,000
Office rent	6,000,000	2,000,000
Others	21,000,000	7,000,000
Social security	-	6,175,000
Total	**447,000,000**	**133,508,333**

External cost and benefit consist of emission from collection, transportation, and landfilling process. This emission emitted from transporter and landfilling process converted into monetary value using SCC. Details of the cost benefit SC-0 are presented in **Table 4.7**.

Table 4.7 Cost and benefit SC-0

<table>
<tr><th colspan="3" rowspan="2">Aspects</th><th>Cost</th><th>Benefit</th><th>Total Cost</th><th>Total Benefit</th></tr>
<tr><th colspan="4">(IDR / year/ tonne)</th></tr>
<tr><td rowspan="7">Internal</td><td colspan="2">Retribution fee</td><td>-</td><td>12,491</td><td rowspan="7">403,294</td><td rowspan="7">2,526,320</td></tr>
<tr><td rowspan="4">Operation and maintenance of waste management</td><td>Collection</td><td>36,803</td><td>-</td></tr>
<tr><td>Transfer point</td><td>308</td><td>-</td></tr>
<tr><td>Transportation</td><td>35,703</td><td>-</td></tr>
<tr><td>Landfilling retribution</td><td>50,000</td><td>-</td></tr>
<tr><td rowspan="2">Government waste bank</td><td>Selling recyclable waste</td><td>-</td><td>2,513,829</td></tr>
<tr><td>Operational cost</td><td>280,480</td><td>-</td></tr>
<tr><td rowspan="3">External</td><td rowspan="2"></td><td>Collection (emission)</td><td>219</td><td>-</td><td rowspan="3">417,637</td><td rowspan="3">20,098</td></tr>
<tr><td>Transportation (emission)</td><td>3,248</td><td>-</td></tr>
<tr><td colspan="2">Landfilling (emission)</td><td>414,170</td><td>20,098</td></tr>
<tr><td colspan="3">Total</td><td>820,931</td><td>2,546,417</td><td colspan="2"></td></tr>
</table>

b. SC-1

In SC-1, there is increment cost from several phase compared with SC-1 because of the moving of landfill site from Sarimukti to Legok Nangka landfill. The increase of transportation cost is 45% or IDR 15,994 per year per tonne waste managed. The landfilling cost increased by higher margin equal to IDR 220,200 per year per tonne waste managed or disposed in new landfill. External cost from transporting waste increased by IDR 2,034 per year per tonne waste managed. The others indicator remained the same amount as SC-0. For the waste bank cost and benefit, there is no change since the amount recyclable waste managed in waste bank is same. Details of the cost benefit SC-1 are presented in **Table 4.8**.

Table 4.8 Cost and benefit SC-1

Aspects			Cost	Benefit	Total Cost	Total Benefit
			(IDR / year/ tonne)			
Internal	Retribution fee		-	12,491	639,488	2,526,320
	Operation and maintenance of waste management	Collection	36,803	-		
		Transfer Point	308	-		
		Transportation	51,697	-		
		Landfilling retribution	270,200	-		
	Government waste bank	Selling recyclable waste	-	2,513,829		
		Operational cost	280,480	-		
External		Collection (emission)	219	-	419,671	20,098
		Transportation (emission)	5,282	-		
	Landfilling (emission)		414,170	20,098		
Total			1,059,159	2,546,417		

c. SC-2

In SC-2, there is decreasing and increasing cost compared to SC-1, collection cost is decreased by IDR 3,795, while transportation cost decreased by IDR 4,508 per year per tonne waste managed. The decrease of these component caused by the lower number of transporter utilized and lower number of waste transported, which also affect the fuel and other fees related to collection and transportation. Transfer point cost slightly increase because of the maintenance and capacity of transfer point is constant and waste managed in transfer point is decrease. Collection emission cost is decreased by IDR 55 and emission cost of transportation also decreased by IDR 553 due to similar reasons with the decrease of operational and maintenance cost of collection and transportation. For landfilling phase, the emission cost is also decreased by IDR 11,848 per year per tonne waste disposed due to the decrement of total waste disposed in landfill.

In this scenario, there is new 8 government waste bank addition because of the waste bank capacity increased to 3% of total Cimahi waste which is from 476 tonnes per year increased to 4,123 tonnes per year. Approximately there are 8 waste bank addition based on the one government waste bank capacity which is 476 tonnes per year. These addition affecting to the operational cost of government waste bank per year per tonne recyclable waste managed. The operational cost of SC-0 with one government waste bank is IDR 280,480 per year per tonne waste managed. For SC-2 this operational cost is multiply by 9 consist of one existing government waste bank and 8 new government waste bank divided by 4,123 tonnes per year from the total waste managed. The operational cost for SC-2 is IDR 291,432 per year per tonne waste managed. The benefit of the recyclable waste managed per year per tonne is same with SC-1 because of the recyclable waste managed is in line with the benefit of the selling recyclable materials to the recycle industries. The avoidance of emission from the use of recovered material from waste bank increases the value of external benefit by IDR 20,910 per tonne waste annually. Details of the cost benefit SC-2 are presented in **Table 4.9**.

Table 4.9 Cost and benefit SC-2

<table>
<tr><th colspan="3" rowspan="2">Aspects</th><th>Cost</th><th>Benefit</th><th>Total Cost</th><th>Total Benefit</th></tr>
<tr><th colspan="4">(IDR / year /tonne)</th></tr>
<tr><td rowspan="8">Internal</td><td colspan="2">Retribution fee</td><td>-</td><td>12,491</td><td rowspan="8">642,148</td><td rowspan="8">2,526,320</td></tr>
<tr><td rowspan="4">Operation and maintenance of waste management</td><td>Collection</td><td>33,008</td><td>-</td></tr>
<tr><td>Transfer Point</td><td>319</td><td>-</td></tr>
<tr><td>Transportation</td><td>47,189</td><td>-</td></tr>
<tr><td>Landfilling retribution</td><td>270,200</td><td>-</td></tr>
<tr><td rowspan="2">Government waste bank</td><td>Selling recyclable waste</td><td>-</td><td>2,513,829</td></tr>
<tr><td>Operational cost</td><td>291,432</td><td>-</td></tr>
<tr><td rowspan="3">External</td><td rowspan="2"></td><td>Collection (emission)</td><td>164</td><td>-</td><td rowspan="3">407,215</td><td rowspan="3">41,008</td></tr>
<tr><td>Transportation (emission)</td><td>4,729</td><td>-</td></tr>
<tr><td colspan="2">Landfilling (emission)</td><td>402,322</td><td>41,008</td></tr>
<tr><td colspan="3">Total</td><td>1,049,363</td><td>2,567,328</td><td colspan="2"></td></tr>
</table>

d. SC-3

In SC-3, Internal and external cost and benefit for operational and maintenance also emission cost is similar with SC-2 since the total amount of waste transported and disposed in landfill is same. For the waste bank cost and benefit section, there are new addition of private waste banks from baseline scenario (SC-0) that handle the recyclable waste from residents as much as 3,647 tonnes per year. These recyclable handled by new 8 private waste bank which every private waste bank assumed can handle maximum 476 tonnes per year according to the capacity of one Cimahi government waste bank. For operational cost, there is differences between government waste bank and private waste bank. Private waste bank did not need to pay office rent since they usually utilize their own house for the operational of waste bank. There is difference contribution rate for social security. Private waste bank considered as informal sector. Based on the Indonesian social security service, contribution rate for informal worker is 2% from the total wages (BPJS, 2021). The amount of others operational component is similar with the government waste bank paid based on the number of employees and waste bank capacity. The total operational cost for private waste bank is IDR 279,682 per year per tonne recyclable waste managed. The total operational cost for government waste bank is similar with SC-0 which is IDR 280,480 per year per tonne recyclable waste managed. The detail of operational cost government waste bank and private waste bank for SC-3 shown in **Table 4.10**.

Table 4.10 Operational cost of private waste bank

Operational cost component	1 Government waste bank (IDR/year)	8 Private waste bank (IDR/year)
Salary employees	108,333,333	866,666,664
Food material	2,600,000	20,800,000
Gasoline	2,400,000	19,200,000
Diesel fuel	1,600,000	12,800,000
Water	400,000	3,200,000
Electricity	2,800,000	22,400,000
Sack	200,000	1,600,000
Office rent	2,000,000	-
Others	7,000,000	56,000,000
Social security	6,175,000	17,333,333
Total	**133,508,333**	**1,019,999,997**

The benefit of selling recyclable items from government waste bank of all scenarios is similar because the increased of the values of money obtained is in line with the increasing of waste managed by waste bank. There is new addition of cost of buying waste indicator in SC-3. In table below private waste bank and government waste bank are separated. The distinguished between government waste bank and private waste bank is government waste bank did not have to pay the waste from residents directly, whereas private waste bank need to pay the recyclable waste from residents directly. Private waste bank bought the recyclable waste from residents slightly lower as much as 15% than selling price to get some profit. Those profit also used for pay operational cost that also been added as indicator of private waste bank operational cost. In order to that this resulted in total cost of IDR 3,841,362 rupiah per tonne waste managed per year and benefited IDR 5,081,502 rupiah per tonne waste managed per year. Details of the cost benefit SC-3 are presented in **Table 4.11**.

Table 4.11 Cost and benefit SC-3

<table>
<tr><th colspan="3" rowspan="2">Aspects</th><th>Cost</th><th>Benefit</th><th>Total Cost</th><th>Total Benefit</th></tr>
<tr><th colspan="4">(IDR / year/ tonne)</th></tr>
<tr><td rowspan="10">Internal</td><td colspan="2">Retribution fee</td><td>-</td><td>12,491</td><td rowspan="10">3,048,125</td><td rowspan="10">5,040,494</td></tr>
<tr><td rowspan="4">Operation and maintenance of waste management</td><td>Collection</td><td>33,008</td><td>-</td></tr>
<tr><td>Transfer Point</td><td>319</td><td>-</td></tr>
<tr><td>Transportation</td><td>47,189</td><td>-</td></tr>
<tr><td>Landfilling retribution</td><td>270,200</td><td>-</td></tr>
<tr><td rowspan="2">Government waste bank</td><td>Selling recyclable waste</td><td>-</td><td>2,513,829</td></tr>
<tr><td>Operational cost</td><td>280,480</td><td>-</td></tr>
<tr><td rowspan="3">Private waste bank</td><td>Selling recyclable waste</td><td>-</td><td>2,514,174</td></tr>
<tr><td>Buying recyclable waste</td><td>2,137,247</td><td>-</td></tr>
<tr><td>Operational cost</td><td>279,682</td><td>-</td></tr>
<tr><td rowspan="3">External</td><td rowspan="2"></td><td>Collection (emission)</td><td>164</td><td>-</td><td rowspan="3">407,242</td><td rowspan="3">41,088</td></tr>
<tr><td>Transportation (emission)</td><td>4,729</td><td>-</td></tr>
<tr><td colspan="2">Landfilling (emission)</td><td>402,322</td><td>41,008</td></tr>
<tr><td colspan="3">Total</td><td>3,455,340</td><td>5,081,502</td><td colspan="2"></td></tr>
</table>

4.3.4 Comparison between Scenarios

According to the environmental assessment, comparison between SC-0 and SC-1 has increased slightly. The switch of landfill did not contribute significantly to the total CO2e emitted, despite the distance is nearly twice the previous distance. If we compare SC-1 with SC-2 and SC-3, there is reduction equal to 0.06 tonnes CO2e per waste managed. The reduction occured due to the lower amount of waste disposed to the landfill. Increasing capacity of waste managed by waste bank from 476 tonnes per year to 4,123 tonnes per year affect to the reduction. This finding is in line with previous research that the waste bank has the potential value to reduce CO_2 emissions from recyclable items (Khair, Rachman, & Matsumoto, 2019). The main emitter of CO2e is organic waste, which reached 48,337 tonnes annually in scenario SC-2 and SC-3. In order to decrease more CO2e emission, Cimahi municipality local government has to do policy that supported the addition of waste bank either by government or resident's initiatives. In order to that, Cimahi City will be able to reduce the waste disposed to landfill and also reducing the CO2e caused by the landfilling process. Graphic of CO2e emitted comparison all scenarios shows in **Fig. 4.10**.

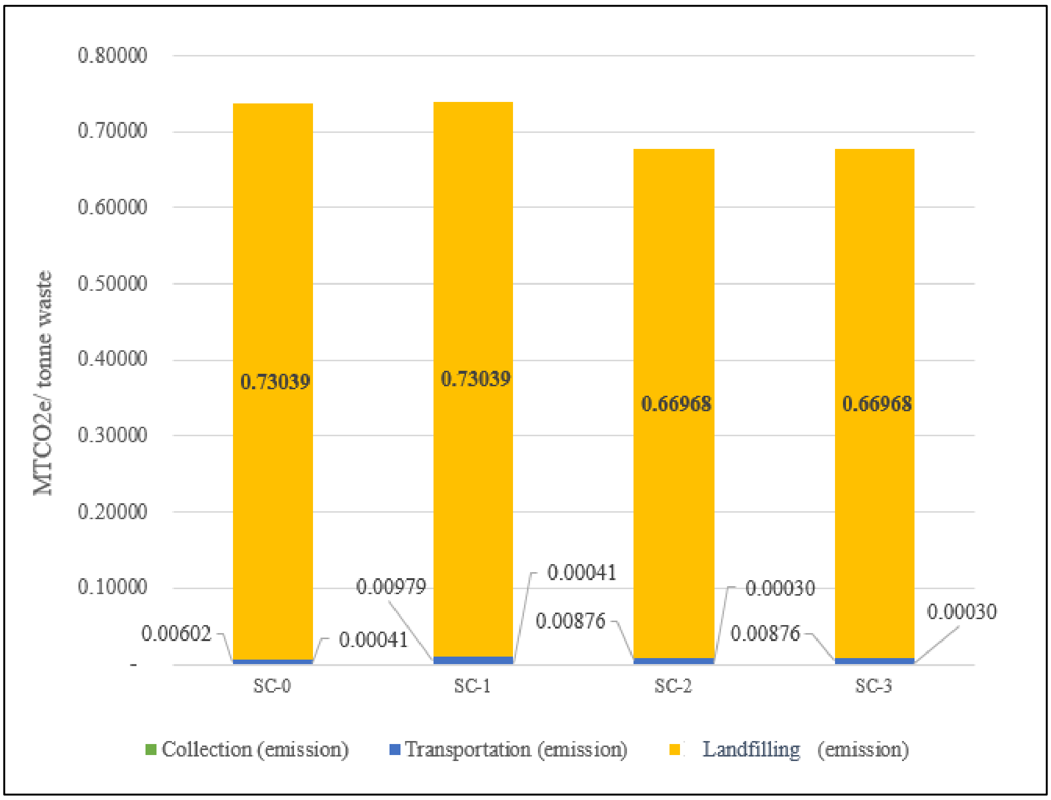

Fig. 4.10 Comparison of CO2e emitted all scenarios

For the cost-benefit analysis, total benefit per tonne waste managed weighs more than total cost in all scenarios. The landfill moving from Sarimukti to Legok Nangka landfill caused increase of total cost by IDR 238,228 per year per tonne waste managed. The establishment of more waste bank in Cimahi, either by government or private waste banks expected to prevent the increase of cost. In SC-2, the additional waste bank is government waste bank, therefore the total cost reduction is insignificant compared with baseline scenario. In SC-3, the additional waste bank is private waste banks alongside with existing government waste bank. The distinguished between government and private waste bank is government waste bank did not buy the recyclable waste from residents directly, whereas private waste bank needs to buy the waste directly from residents. Similar thing also happened in private waste banks in Batu City, East Java (Apriliyanti, Soemarno, & Meidiana, 2015). The addition of private waste banks in SC-3 will increase the total cost and benefit since the both waste bank has been calculated separately. Although the addition of the both waste banks will increase costs and benefits constantly, the margin value is only slightly different compared to other scenarios. Comparison of cost and benefit efficiency all scenarios are shown in **Table 4.12**.

Table 4.12 Comparison of costs and benefits efficiency among all scenarios

Code	SC-0		SC-1		SC-2		SC-3	
	Cost	Benefit	Cost	Benefit	Cost	Benefit	Cost	Benefit
B1	-	12,491	-	12,491	-	12,491		12,491
C1	36,803	-	36,803	-	33,008	-	33,008	-
C2	308	-	308	-	319	-	319	-
C3	35,703	-	51,697	-	47,189	-	47,189	-
C4	50,000	-	270,200	-	270,200	-	270,200	-
B2	-	2,513,829	-	2,513,829	-	2,513,829	-	2,513,829
C5	280,480	-	280,480	-	291,432	-	280,480	-
B3	-	-		-	-	-		2,514,174
C6	-	-		-	-	-	2,137,247	-
C7	-	-		-	-	-	279,682	-
C8	219	-	219	-	164	-	164	-
C9	3,248	-	5,282	-	4,729	-	4,729	-
C10 & B4	414,170	20,098	414,170	20,098	402,322	41,008	402,322	41,008
Total (IDR/ year/ tonne)	**820,931**	**2,546,417**	**1,059,159**	**2,546,417**	**1,049,363**	**2,567,328**	**3,455,340**	**5,081,502**

Net present value of benefits minus costs or costs minus benefits is the most traditional format for government agencies to present the results of the analysis (Kee, 2005). Net present value (NPV) used as decision-making technique to select between alternative capital investment (Smith, 2002). NPV is the summation of present value of cost and benefit of a project. As long as the NPV is not negative, then the project is acceptable. This means the higher NPV of an alternative, it is more preferable to implement to the city waste management strategies. In this study, all alternative scenarios have positive margin of benefit. Among three of alternative scenarios, SC-3 resulted in the highest NPV with the value of IDR 1,626,162 per year per tonne waste managed. NPV comparison all scenarios presented in **Fig. 4.11**.

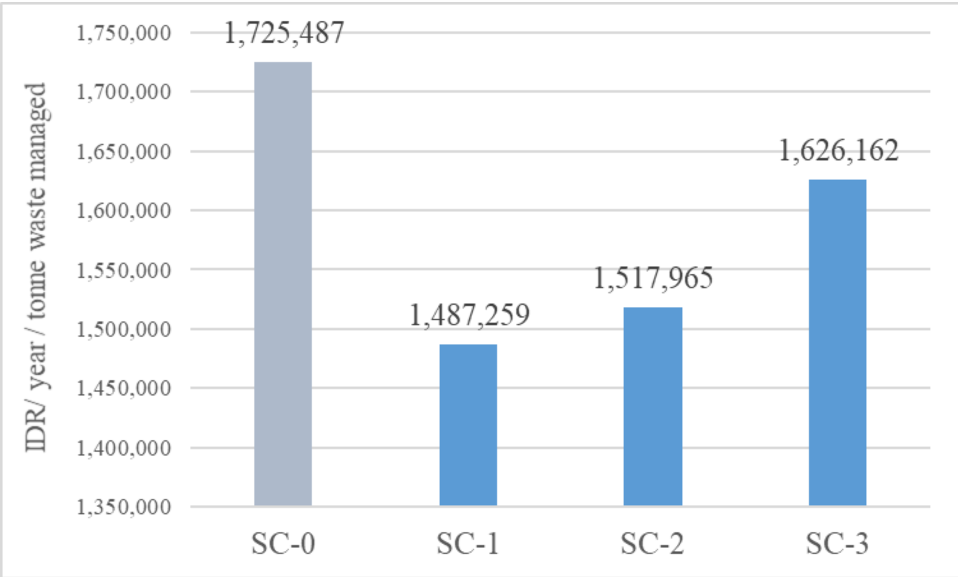

Fig. 4.11 NPV comparison all scenario

The total values of cost and benefit per year without dividing with the waste managed per year each indicator in every scenario were also presented to investigate and calculate the estimation of cost needed to pay per year and the opportunity of benefit earned by government or private sector regarding to the implementation of waste management in every aspect or indicator from collection until final treatment in landfill including possibilities external cost caused by emission in each proses. Due to the consideration of social benefit from the residents or community sides, the cost of buying waste from private waste bank in SC-3 also added as benefit because the cost of buying waste has the same meaning as income for the residents since in SC-3, private waste bank have to pay directly to the residents who brought their waste. In order to that, in this cost benefit comparison per year, cost of buying waste considered to be added as benefits. **Table 4.13** shows the comparison of cost and benefit per year among all scenarios.

Table 4.13 Comparison of cost and benefit per year among all scenarios

Code	SC-0		SC-1		SC-2		SC-3	
	Cost	Benefit	Cost	Benefit	Cost	Benefit	Cost	Benefit
B1	-	1,364,640,000	-	1,364,640,000	-	1,364,640,000		1,364,640,000
C1	687,202,863	-	687,202,863	-	501,281,262	-	501,281,262	-
C2	31,514,000	-	31,514,000	-	31,514,000	-	31,514,000	-
C3	3,654,532,466	-	5,291,658,756	-	4,658,182,302	-	4,658,182,302	-
C4	5,117,987,956	-	27,657,609,614	-	26,672,242,989	-	26,672,242,989	-
B2	-	1,196,582,632	-	1,196,582,632	-	10,364,001,080	-	1,196,582,632
C5	133,508,333	-	133,508,333	-	1,201,574,997	-	133,508,333	-
B3	-	-		-	-	-		9,169,618,258
C6	-	-		-	-	-	7,794,538,281	7,794,538,281
C7	-	-		-	-	-	1,019,999,997	-
C8	4,092,501	-	4,092,501	-	2,493,070	-	2,493,070	-
C9	332,474,359	-	540,614,274	-	466,780,335	-	466,780,335	-
C10 & B4	42,394,321,073	2,057,183,793	42,394,321,073	2,057,183,793	39,714,444,904	4,048,042,672	39,714,444,904	4,048,042,672
Total (IDR/ year/)	**52,355,633,551**	**4,618,406,425**	**76,740,521,414**	**4,618,406,425**	**73,248,513,859**	**15,776,683,752**	**80,994,985,473**	**25,573,421,843**

According to the comparison table of total cost and total benefit per year, the total cost of each scenario is relatively high compared to the benefit each scenario. The high cost occurred because this study considering external cost which consisted of emission caused by waste management activities that converted into monetary value and these external cost indicator has the most expensive cost value in each scenarios. The total cost of external cost each scenario contribute more than 50% of the total cost in each scenario. Based on the calculation, SC-3 has the highest cost and benefit among all scenarios. The calculation of the benefit minus cost in each scenario were conducted to investigate which alternative scenario has the best values to be implemented. Based on the benefit minus cost comparison among all alternative scenarios, the smallest minus value among all alternative scenarios considered as preferable scenario to be implemented in Cimahi city. The smallest benefit minus cost value among alternative scenarios is SC-3 with the value of –IDR 57,421,563,630. According to these comparison results, both comparison from cost and benefit efficiency all scenarios per year per tonne waste managed compared with cost and benefit per year all scenarios has the similar results that indicated SC-3 is the best alternative scenarios with the addition of government and private waste bank and preferable to be implemented in municipal waste management. The comparison of benefit minus cost values per year among all scenarios presented in **Fig. 4.12.**

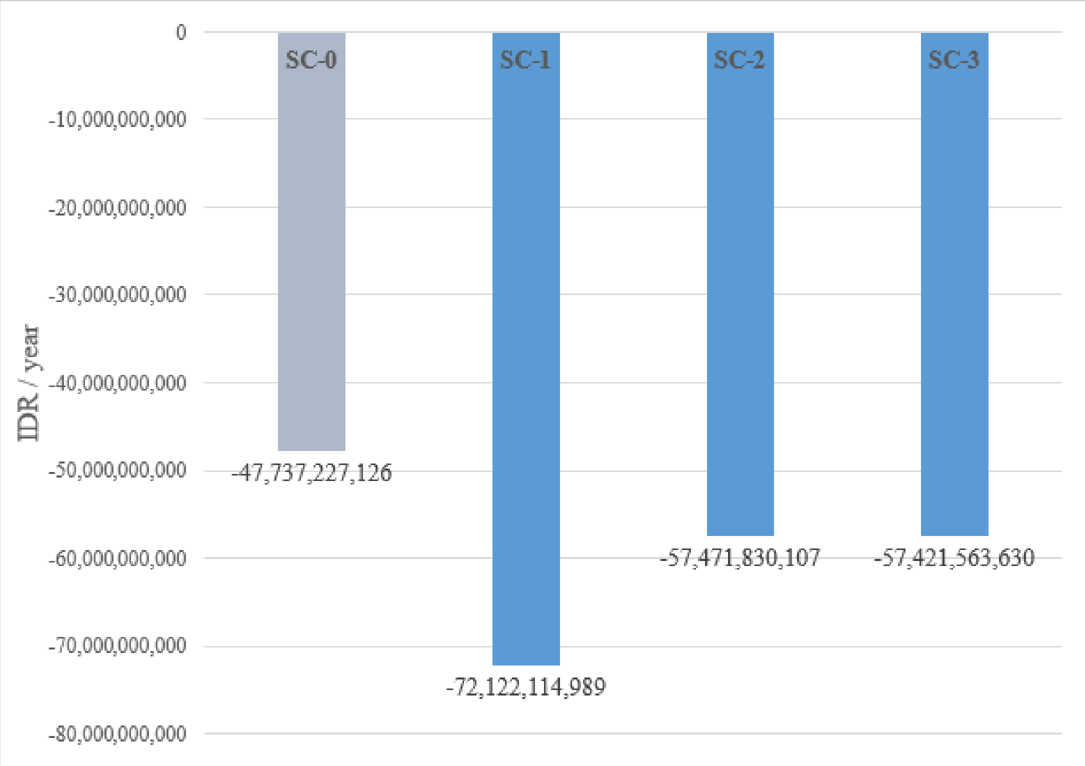

Fig. 4.12 Comparison values of benefit minus cost per year among all scenarios

4.3.5 Discussion

Cimahi government needs to pay more attention to waste treatment. By utilizing more waste banks, it would be possible to spend less and gain both environmental and economic benefits. The municipality should prioritize waste treatment rather than waste disposal, as this approach has a higher total benefit, and the measure is in line with the national policy on waste management (Chaerul & Rahayu, 2019). According to the finding in this study, the addition of a waste bank provided an increased benefit, although the amount was not significant. This finding is in line with a previous study that although the number of people who benefit from such waste banks is not large, their impact is felt directly and the surroundings become clean and green (Wulandari et al., 2017). Efforts in waste management that require participation from residents should receive support from and be coordinated with the local government to ensure that they persist (Puspasari & Mussadun, 2017). Subsidiary waste banks can be established in the neighborhood or institution (Yustiani, 2019). Utilizing institutions to establish a waste bank has a downside, which is that the flow of waste is not constant, and the amount will be less than that from a community-based waste bank. Promoting at-source waste sorting is important; however, appropriate end-of-pipe technologies for the treatment of MSW are also required (Aprilia, Tezuka, & Spaargare, 2012). According to studies on waste utilization, recycling through waste bank activities can reduce waste disposed to landfills and extend the lifetime of landfills (Isharyati, Prasetya, & Cahyono, 2019). This will affect the investment reduction cost for landfills. In Indonesia, scavengers also play a major role in solid waste management in cities and can be promoted to store solid waste for recycling by assisting the government in the appropriate management of solid waste (Prasetyanti, 2014).

Furthermore, waste banks can become more efficient and capable in managing large quantities of wastes by incorporating innovative tools because of the vast potential for recyclable wastes (Khair, Siregar, et al., 2019). According to the findings of this study, the addition of a waste bank both by government and residents initiatives could be an alternative to reduce the cost of waste disposal and reduce greenhouse gas emissions. It is would be easier to establish a waste bank through local government policy and mixed with the initiatives of the residents. The Cimahi City government and every region in Indonesia should consider building community-based waste management resources integrated with the government because of their wide benefits.

4.4 Summary

In this study, we found that the switch from Sarimukti landfill to Legok Nangka landfill as the landfill site contributed to an increase in the total CO2e emitted, although this difference was not significant despite the distance being nearly twice that of the previous site. The primary contributor to CO2e emissions from the final treatment is organic waste. The addition of waste banks contributes to reducing emissions from fuel consumed by transportation steps and landfilling. SC-2 and SC-3 resulted in a similar reduction in terms of CO2e emission in the environment compared with SC-1.

Increasing the number of waste banks could be an alternative to reduce the cost of disposing waste to landfills. Increment of waste treated by the waste bank to 3% will lower the overall cost per tonne of waste compared to baseline scenario SC-0 and SC-1, and simultaneously increase the total benefit per tonne of waste managed. Compared to SC-1, SC-3 obtained the highest benefit per year per tonne waste managed, while increasing the overall cost. According to the NPV comparison for cost and benefit efficiency all scenarios, SC-3 provided the highest NPV value equal to IDR 1,626,162 per year per tonne waste managed. Meanwhile, according to the total values per year benefit minus cost among all scenarios, SC-3 provided the smallest minus values with the value equal to IDR 57,421,563,630 per year.

Considering the environmental and economic value and efficiency aspects, SC-3 is the most preferable to be implemented in Cimahi City. This study concluded that the government needs to be more concerned about waste treatment and utilizing more waste banks provided by government and encourage residents initiative's to build private waste bank. By the addition of more waste banks, it would be possible to spend less and gain both environmental and economic benefits. Increasing the number of waste banks should be followed by educating the residents on the importance of recycling waste.

4.5 Future task

This study has a limitation only considers waste banks as an alternative recycling activity. Future research should investigate the potential environmental and economic aspects of other waste treatment options. Cost-benefit analysis in this study also has limitation only considering running cost, future research should consider and add initial cost for cost-benefit analysis.

4.6 Notes

This chapter were adapted from the peer-reviewed journal written by author that already published in Journal of Environmental Science and Sustainable Development, Vol. 4., No.1., pp 69-96 entitled "Life Cycle Assessment and Cost Benefit Analysis of Municipal Waste Management Strategies". Author made several improvements for this dissertation including the addition of several figures and tables consisting of emission factor, study boundary, carbon cost, waste flow of municipal waste management and waste bank each scenarios. Several analysis improvement also made consisting of calculation of each scenario, waste bank operational cost and comparison of cost and benefit per year. The results of analysis and sentences in the published journal and this dissertation may be differ due to the improvements.

Chapter 5 Community-Based Waste Management (Waste Bank) as Intention Recycling Behavior Predictor Using Structural Equation Modeling in Semarang City

5.1 Background

The phenomenon of waste is a consequence of human activities. Each human activity generates waste or garbage, and therefore, waste management cannot be separated from the lifestyle of society. A population's growth and lifestyle significantly influence the volume of waste. The mishandling of waste causes many problems related to both the environment and health. Waste management is not solely performed by the authorities. It can, and must, be done by all. Managing waste independently would bring many benefits to people and their surrounding environment; however, many people are less concerned or less knowledgeable about beneficial and effective methods to process waste. City authorities need to provide an infrastructure to address rapid population growth and keep pace with increasing volumes of waste (Amoah & Kosoe, 2014). A new, effective way to manage waste is for local communities to organize waste bank. Waste bank is an alternative waste management system implemented to reduce waste and improve the local economy (Wulandari et al., 2017). It can be implemented in developing countries where the local government has inadequate capability to manage waste (Purba et al., 2014).

To respond to increasing waste generation, waste minimization requires efficient waste management (Minelgaitė & Liobikienė, 2019). Waste bank is one option that addresses the increasing volume of waste in landfills and reduces greenhouse gas emissions. Informal solid waste recycling has the potential to reduce climate change (Botello-Álvarez et al., 2018). Waste bank possesses economic, social, educational, and technological tools that can establish self-reliance in a community (Wijayanti & Suryani, 2015). This research explore the intention to recycling behavior of waste management by the local community with waste bank. This study analyzes the characteristic of the waste bank participants through the exploration of waste management knowledge, behavior, recognition of the waste bank and social economic status. Solid waste management should be evaluated based on its economic feasibility (Das et al., 2019). Semarang is a metropolitan area in Indonesia and is the capital of the Central Java province. One of the main factors that affects the amount of waste in this city is its high population growth. If the present amount of garbage generated cannot be pressed, the 46-hectare landfill in Semarang will be full in a short period of time (JatengTribun, 2019). Waste bank is a mechanism that is intended for a group of waste-conscious citizens, with the goal of reducing the volume of waste, managing waste as a source of additional income, and reducing greenhouse gas emissions from waste disposal. This would operate separately from municipal solid waste management.

The main objective of this study is to find the key descriptors of intention to recycling behavior among the waste bank community in Semarang. Recycling programs have been implemented in many cities worldwide, and their contribution to recycling intention behavior using structural equation modeling (SEM) needs to be further explored. SEM is a method for finding relationships among variables of framework theory. This study uses the TPB approach to determine the recycling behavior of the community and present waste bank as a waste management by community that can affect the recycling behavior to preserve the environmental sustainability. Effectiveness recognition of waste bank is introduced as an additional construct of situational factors among attitudes, subjective norms, and perceived behavioral control as the original theory of planned behavior predictors (Ajzen, 1991). Based on these factors, a study of intention to recycling behavior among the waste bank community in the city of Semarang was conducted using SEM, with the TPB theory as a framework instrument.

5.2 Method

5.2.1 Study location overview

The city of Semarang, the capital of Central Java Province, has a population of approximately 1.6 million people and encompasses an area of approximately 373.8 km^2. Located on the main route of Jakarta to Surabaya, the position of Semarang is strategic because it is the main node of Central Java Province on the north side. Administratively, it consists of 16 sub-districts. According to data from the Semarang Environmental Agency, the waste generated in the city of Semarang is currently approximately 1,000 tonnes, while the volume of waste transported per day is 700–800 tonnes. It consists of garbage from residents, commerce, protocol, and public facilities. Implemented separation strategies have reduced the greenhouse gas load and ozone formation caused by municipal solid waste (Tanskanen, 2000). Waste bank is alternative waste management conducted and organized by the community. The position of waste bank in the general scheme of waste management by the community is shown in **Fig. 5.1**. The process of utilizing waste bank includes the segregation of waste by the community, submission of waste to the waste bank, weighing of the waste, recording waste in the customer passbook, and implementing a system for conducting the sale of waste. Factors affecting participation attitudes regarding solid waste management should be addressed (Lakioti et al., 2017).

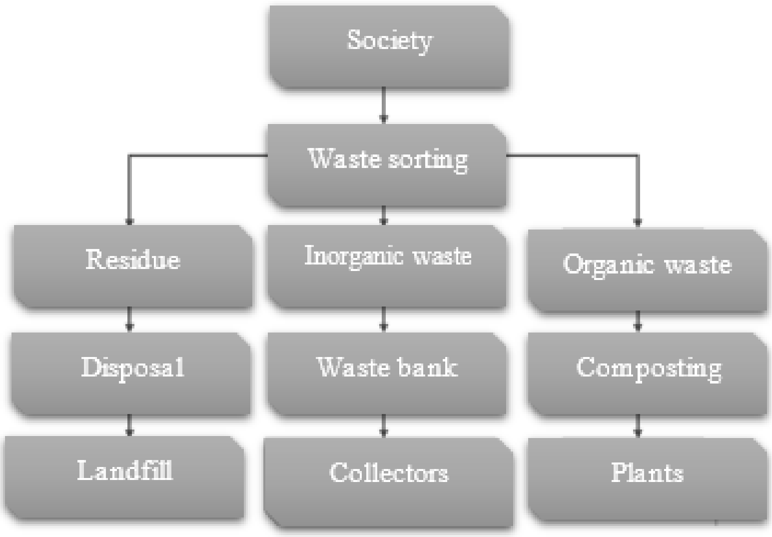

Fig. 5. 1 Society waste management framework

The existence of waste bank in the city of Semarang can be characterized as a tide that has subsided in the community. The ebb and flow are influenced by several factors, including a lack of public awareness of the importance of sorting out waste, and community ignorance regarding the existence of waste bank. Waste bank emphasizes the role of a community in improving the local economy both as a customer, and a manager of the waste bank (Wulandari et al., 2017). Waste bank generates income, raises community awareness about environmentally sound waste management principles, and increases harmony among the members of the waste bank community (Indrianti, 2016). Enhancing knowledge, understanding, and participation among community members to address the problems of solid waste management is vital to promoting changes toward better solid waste management in the cities (Yousif & Scott, 2007).

5.2.2 Theory of planned behavior (TPB)

The TPB is an extension of the theory of reasoned action (Ajzen & Fishbein, 1980; Fishbein & Ajzen, 1975). A central factor in the TPB is the individual's intention to perform a given behavior. Intentions are assumed to capture the motivational factors that influence them to perform the behavior (Ajzen, 1991). In this case study, the TPB provides a theoretical framework for systematically identifying the factors that influence waste recycling intention, and has been widely used to investigate waste management behaviors. According to the theory (**Fig. 5.2**), an individual's behavior is based on his or her readiness to perform that behavior (i.e., intention). Intention is based on three factors: (1) attitude, which is the individual's positive or negative perception of performing a behavior, (2) subjective norm, which is the individual's perception of social pressure to engage or not, in a behavior, and (3) perceived behavioral control, which is the individual's perception ability to perform a given behavior. The original framework of TPB can be seen in **Fig. 5.2**.

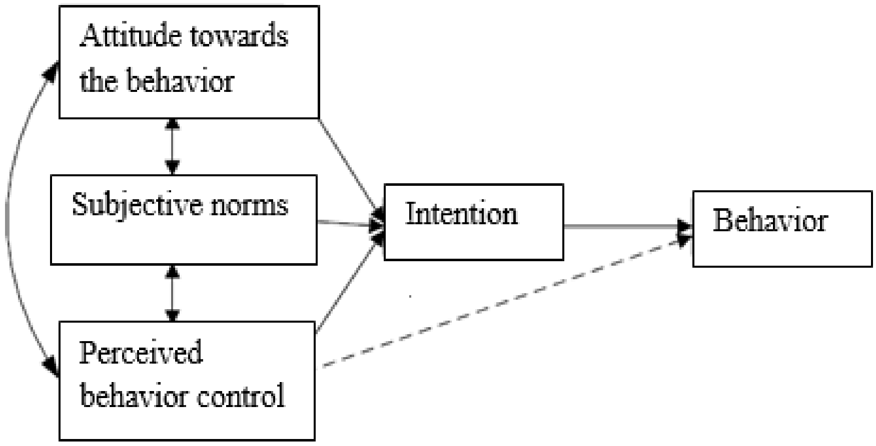

Fig. 5.2 Theory of planned behavior
(Ajzen, 1991)

Within the context of the TPB, more attention should be given to identifying the factors that influence recycling behaviors. Several studies have recommended adding more variables to improve the predictive validity of the TPB (Zhang et al., 2015), and situational factors are likely to be important to recycling behavior (Boldero, 1995). In this study, a new variable has been added to extend the TPB framework. This new variable is considered as a situational factor of the respondents who are the participants of the waste bank community. The new addition variable, named "effectiveness recognition of waste bank" was built based on the beneficial characteristics of waste bank itself. Waste bank is beneficial for waste reduction in the environment and an economic benefit for participants (Wulandari et al., 2017). The purpose of this variable is to examine the effectiveness recognition of waste bank by the community, and whether it affects intention to recycling behavior among waste bank communities. With effectiveness recognition of waste bank as a new variable, this research consisted of five construct variables including attitude, subjective norms, perceived behavior control, and intention to recycling. This study has limitation using theory of planned behavior without behavior as variable and focusing on the intention to behavior.

The research questions for this investigation of waste bank communities are: what are the factors that have positive influences on intention to recycling behavior, and how strong are the relationships of these factors to intention to recycling behavior.

5.2.3 Research hypothesis

The first and main purpose of this research is to investigate whether effectiveness recognition of waste bank will affect intention to recycling behavior in the waste bank community. The second purpose is to determine which factors have most significance in affecting intention to recycling behavior in the community. The following research hypotheses were self-developed and based on literature related to recycling behavior:

(1) H1. Attitude has a positive influence on intention to recycling behavior.

One's attitudes based on one's perception and knowledge of a behavior as positive or negative, right or wrong, pleasant or unpleasant, or interesting or boring.

(2) H2. Subjective norms have a positive influence on intention to recycling behavior.

Subjective norms are social factors that include perceived social pressures to engage or not in a certain behavior. Possible sources of these social factors include pressure from family, neighbors, peers, or the community.

(3) H3. Perceived behavioral control has a positive influence on intention to recycling behavior.

Perceived behavioral control reflects an individual's past experience and anticipates obstacles. The more resources and opportunities a person perceives in performing a specific behavior, and the fewer the expected obstacles, the stronger the perceived behavioral control, making the behavior more likely to occur.

(4) H4. Effectiveness recognition of waste bank has a positive influence on intention to recycling behavior.

Waste bank considered as situational factors affecting individuals' objective environment when they perform a particular behavior. The external situational variable is used to assess the extent to which respondents' factors (Latif, Omar, Bidin, & Awang, 2012), such as effectiveness recognition of waste bank to performing waste intention to recycling behavior.

To test the hypotheses, the SEM framework, with the effectiveness recognition of waste bank as an additional situational factor for predictor of intention to recycling behavior, is shown in **Fig. 5.3**.

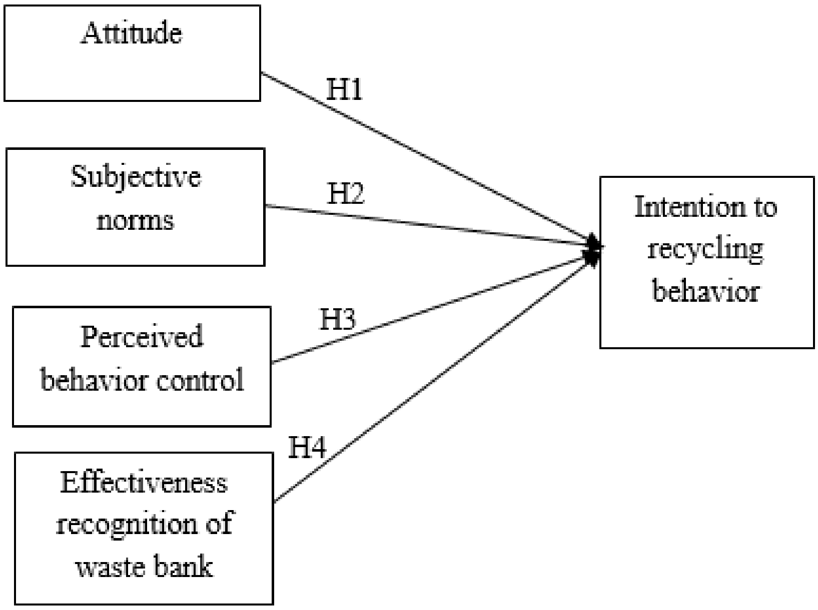

Fig. 5.3 SEM research framework

5.2.4 Sampling method

Sampling was performed using the purposive sampling method, which specifies the characteristics that are suitable for the purpose of the study. The specific features referred to are contained in Indonesian regulation PERMEN LH No 13 year 2012 concerning the implementation of 3R (reduce, reuse, recycle) through waste bank activities (MENLHK Indonesia, 2013). The study was conducted using waste bank data owned by the Semarang City Environmental Agency and the Semarang Waste Bank Association. The data revealed that there are 35 waste banks that could be tracked and are actively managing waste in their environment. According to previous research (Wijayanti & Suryani, 2015) the waste bank contains tools that can establish self-reliance in a community. In addition, waste bank can change the paradigm regarding the notion that waste is solely useless and instead, promote the benefits of waste (Winarso & Larasati, 2011) while encouraging the community to increase awareness and knowledge through its participation in managing a clean environment (Asteria & Heruman, 2016).

The first part of the study's questionnaire consists of demographic characteristics such as age, educational level, and monthly revenue, and are intended to determine the social-economic status of the respondents as waste bank participants. To build the model and determine the factors that affect the behavioral intention of waste bank participants, the second part of the questionnaire focuses on the main question of measurement construct of the variables in the model regarding attitude, subjective norms, perceived behavioral control, intention to recycling behavior, and effectiveness recognition of waste bank as an extended factor of TPB. The Likert scale, which is frequently used in social science research (Joshi et al., 2015), was applied to analyze the responses to the questionnaire. The response options were: strongly agree, agree, uncertain/neutral, disagree, and strongly disagree. Numbers from one to five were used to analyze the results of the questionnaire. Each indicator used a different notation to distinguish between the variables.

The variable construct in this research questionnaire was built based on a literature review of previous research, combined with self-developed measurements. In structural equation modeling, single indicator variables are referred to as observed variables or question indicators in this research, while multi indicator variables are referred to as latent variables. A latent variable is a hypothetical construct that is invoked to explain observed variables. This study consists of five latent variables, which are, attitudes, subjective norms, perceived behavior control, effectiveness recognition of waste bank, and intention to recycling behavior. Each latent variable consists of several observed variables that are included in the questionnaire indicators. All variables constructs used for building the structural model to obtain the relationship among each variables and hypothesis testing are based on the development of the TPB. Details of the question indicators for each variable construct are shown in **Table 5.1**.

5.2.5 Data analysis

The analysis of this research uses SEM, through which each question in the questionnaire indicator is analyzed. SEM is a methodology for representing, estimating, and testing the relationship between variables (Suhr, 2006). The objective of SEM is to understand the patterns of correlation among a set of variables. Observed variables are variables that impact the score of the latent variable. In this model, observed variables consists of the questions for each latent variable. From the result of the questionnaire, the score for each variable can then be obtained. For this study, a confirmatory factor analysis (CFA) used for the variable construct validation as the part of SEM. The CFA consisted of construct reliability (CR) and average variance extracted (AVE) to determine the reliability and validity of the variables construct. Hypothesis testing was then conducted to analyze the structural relationship between the variables and determine the factors affecting waste bank participants' recycling intention behavior. A descriptive analysis, including frequencies, percentages, and correlation of the social economic status of waste bank participants from the questionnaire results were performed. Convergent validity, discriminant validity, and Cronbach's alpha test were other methods used to analyze the reliability of each construct of measurement variable. A commonly accepted rule of thumb is that a Cronbach's alpha value of 0.6 is considered as acceptable reliability and 0.8 or higher illustrates good reliability. The data were statistically analyzed using the AMOS 23.0 and SPSS 23.0 software packages. **Table 5.1** shows the variable constructs used in this research.

Table 5.1 Variable Constructs

Variable Construct	Question Indicator	Notation
Attitude	I understand the types of household waste	ATTD1
	I understand the sense of organic and inorganic waste	ATTD2
	I understand the impact on the environment if organic and inorganic waste is burned or dumped carelessly into rivers or public roads	ATTD3
	I understand that food scraps, leaves, twigs, vegetables, and fruits can be recycled independently to be composted	ATTD4
	I understand that the plastic bottles, waste paper, cardboard, cans, and glass can be recycled	ATTD5
Subjective norms	An independent waste processing program needs to be held in communities	SN1
	People invited or encouraged me to process waste, recycle or collect waste paper, plastic, and cans for resale	SN2
	People think trash scattered in the environment can lead people to a low social level	SN3
Perceived behavior control	I need to provide appropriate bins at home	PBC1
	I always dispose of waste in the right place	PBC2
	I think disposing of waste in the right place is a commendable action	PBC
	I think disposing of waste in the right place is an easy job for me	PBC4
Effectiveness recognition of waste bank	I know waste bank activities	ERWB1
	I wish to participate in the activities of waste bank	ERWB2
	I know that waste bank is useful for the reduction of urban waste	ERWB3
	There is an economic impact after joining waste bank	ERWB4

Variable Construct	Question Indicator	Notation
Intention to recycling behavior	I would like to bring my own bags when shopping at traditional markets and supermarkets to reduce the use of plastic bags	IRB1
	I would like to conducted independent composting of food scraps, leaves, vegetables, and fruit	IRB2
	I would like to reuse or recycle products such as plastic bottles, plastic bags, paper, cans, and glass	IRB3
	I would like to support a solid waste management program in the society	IRB4

5.3 Results

5.3.1 Questionnaire survey

The questionnaire was conducted by surveying the waste bank community in the city of Semarang to obtain the observed variables data and demographic data. The survey was conducted from the middle of March to the middle of April, 2019. For this study, 35 waste bank communities, from 11 sub-districts in Semarang were visited. Valid data obtained from this questionnaire were received from 361 respondents. **Fig. 5.4** shows the territory of the surveyed waste bank in Semarang city, Indonesia.

Fig. 5.4 Map of surveyed location in Semarang city

5.3.2 Descriptive demographic statistics

Among the waste bank participants, most were between 41–50 years of age (42.4%, n = 152) with the least number of participants less than 20 years of age (0.8%, n = 3). Most participants had senior high school educational levels (43.2%, n = 156), with the least number of participants having no formal education (0.8%, n = 3). Most participants had a revenue of between Indonesian Rupiah (IDR) 1.500.001 –2.999.999 (38%, n = 137), and the least number of participants had a revenue of above Rp. 10.000.000 (1.1%, n = 4). There were 25.5% of participants below the minimum standard revenue. It was concluded that waste bank participants had various levels of social economic status. The detailed descriptive demographic statistics are shown in **Table 5.2**.

A correlation analysis was conducted to reveal the relationship between attributes of waste bank community in Semarang. There were two significant relationships between attributes indicators in the surveyed Semarang waste bank community with significance values less than 0.05. A significant correlation is age toward education and education towards revenue. Age has a significant negative correlation with education, with a correlation coefficient value of -0.122. This means that an older aged waste bank participant in Semarang city has a lower educational level. Education has a significant positive correlation with revenue, with a correlation coefficient value of 0.452. This means that a more highly educated waste bank community member in Semarang city has a higher monthly revenue. The remaining attribute variables have no significant correlations with each other.

Table 5.2 Descriptive demographics statistics

Indicator	Type Range	Frequency	Percentage %
Age	< 20	3	0.8
	21-30	23	6.4
	31-40	87	24.1
	41-50	153	42.4
	51-60	78	21.6
	> 60	17	4.7
Education	No Education	3	0.8
	Elementary School	40	11.1
	Junior High School	62	17.2
	Senior High School	156	43.2

Indicator	Type Range	Frequency	Percentage %
	Associate degree	32	8.9
	Bachelor / Graduate	68	18.8
Revenue	< Rp. 1.500.000	92	25.5
	IDR 1.500.001 - 2.999.999	137	38.0
	IDR 3.000.000 - 4.999.999	88	24.4
	IDR 5.000.000 - 9.999.999	40	11.1
	> IDR 10.000.000	4	1.1

5.3.3 Confirmatory factor analysis

Prior to building the model for hypothesis testing, we conducted a CFA to examine the reliability of the dataset for hypothesis testing. The CFA was conducted using the observed variables data obtained from the questionnaire. It consisted of construct reliability (CR), average variance extracted (AVE), and Cronbach's Alpha to determined reliability and validity of the variables construct. The results indicated that Cronbach's α value for all variables was greater than 0.7, from 0.748 in the subjective norms variable to 0.891 in the attitude variable. According to Hair (Hair, 2010), Cronbach's α value should be greater than 0.700. The construct validity of the CR value also exceeded the recommended threshold of 0.6, as stated by Bagozzi (Bagozzi & Yi, 1988). The convergent validity of the construct was examined by AVE value. The AVE values for each construct were above 0.5 (Fornell & Larcker, 1981), which indicates that the latent variables have good validities. It was concluded that all variables were reliable to use in this study. The detailed results of construct reliability are shown in **Table 5.3**.

Table 5.3 Composite reliability and convergent validity of variables construct

Variable Construct	Notation	Factor Loading	Cronbach's Alpha	CR	AVE
Attitude	ATTD1	0.815	0.891	0.899	0.642
	ATTD2	0.879			
	ATTD3	0.682			
	ATTD4	0.893			
	ATTD5	0.715			
Subjective norms	SN1	0.789	0.748	0.784	0.549
	SN2	0.774			
	SN3	0.653			

Variable Construct	Notation	Factor Loading	Cronbach's Alpha	CR	AVE
Perceived behavior control	PBC1	0.687	0.860	0.865	0.616
	PBC2	0.835			
	PBC3	0.813			
	PBC4	0.796			
Effectiveness recognition of waste bank	ERWB1	0.861	0.848	0.869	0.630
	ERWB2	0.896			
	ERWB3	0.798			
	ERWB4	0.581			
Intention to recycling behavior	IRB1	0.765	0.757	0.826	0.550
	IRB2	0.796			
	IRB3	0.514			
	IRB4	0.846			

5.3.4 Structural model hypothesis testing

The structural model based on the TPB was built to examine the hypothesis test of this study after CFA had been conducted. A goodness of fit was conducted to evaluate the fit of the hypothesis testing structural model. The goodness-of-fit index (GFI), comparative fit index (CFI), root mean squared error approximation (RMSEA), and minimum discrepancy per degree of freedom (CMIN/DF) were 0.904, 0.942, 0.068, and 2.685, respectively. These results were greater than the acceptance level (Hair et al., 2009), indicating that every measurement of the structural model had a good fit. The detail model fit measurement of the structural model are shown in **Table 5.4**.

Table 5.4 Model fit measurements

Measure	Cut-off for good fit	Model result	Model fit
GFI	>0.90	0.904	Good fit
CFI	≥.90	0.942	Good fit
RMSEA	0.03 - 0.08	0.068	Good fit
CMIN/DF	2-5	2.685	Good fit

Fig. 5.5 shows the structural model results of the variables construct for hypothesis testing. The path of this model was built according to the TPB framework. Each indicator of variable

construct has a standard estimate or loading factor value. The standardized estimate for attitude variable in each indicator is 0.82, 0.88, 0.68, 0.89, and 0.71 respectively. The subjective norms variable is 0.77, 0.79, and 0.64, respectively the perceived behavior control variable is 0.69, 0.84, 0.81, and 0.80, respectively The effectiveness recognition of the waste bank variable is 0.87, 0.88, 0.81, and 0.64, respectively. The standardized estimate value of the intention to recycling behavior is 0.52, 0.51, 0.54, and 0.77, respectively.

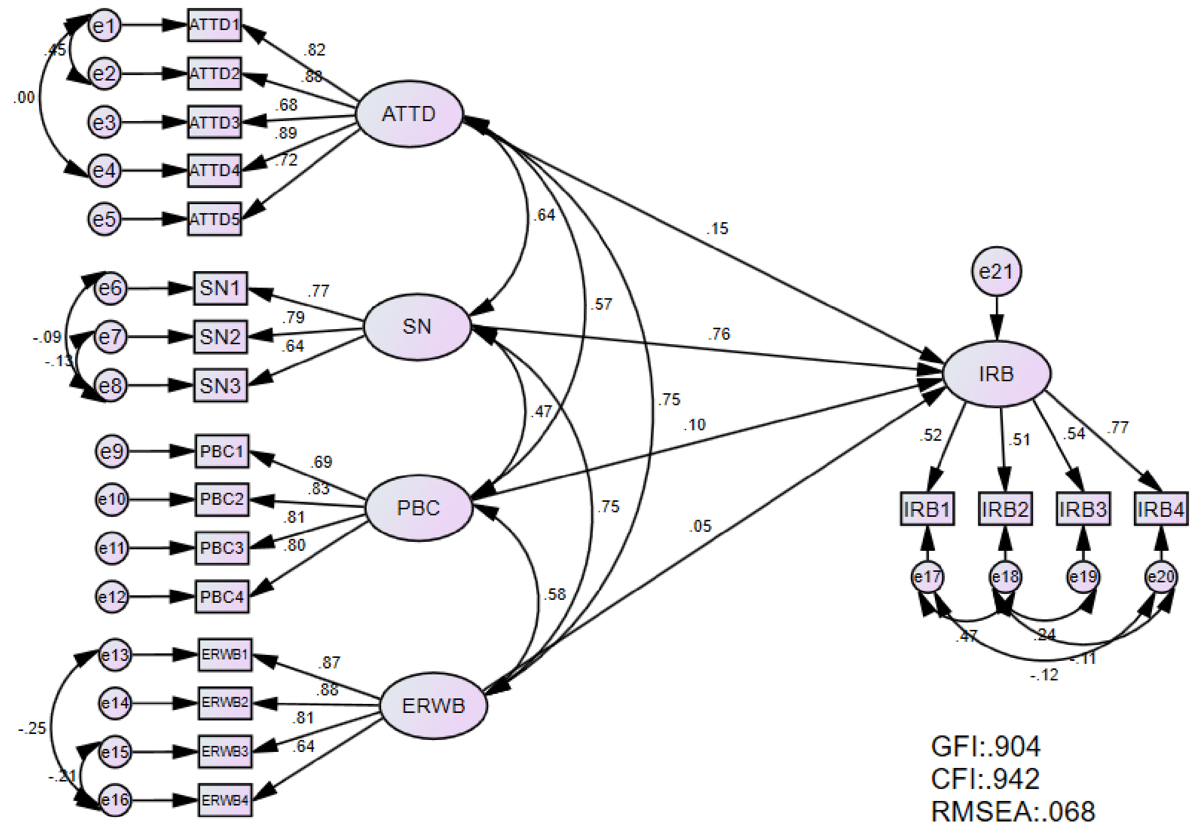

Fig. 5.5 Structural model of variable constructs

The hypothesis test results and standardized estimation path coefficient values of each latent variable are shown in **Table 5.5**. All variables, including attitude, subjective norms, perceived behavior control, and effectiveness recognition of waste bank have a positive impact on intention to recycling behavior among the waste bank community. Hypotheses H1, H2, H3, and H4 were supported, but were not statistically significant. The only variable that had a positively significant impact on intention to recycling behavior was subjective norms. P-value of less than 0.05 is statistically significant, and while all factors have a positive impact on intention to recycling behavior, they are statistically not significant. The results of the SEM analysis indicate that subjective norms have a strong positive influence, with a standardized estimate coefficient of 0.764. It also plays the most significant role, with p-value of less than

0.05. Attitude is the second most significant variable that positively affects intention to recycle, with a standardized estimate coefficient of 0.149 and a p-value of 0.058. This is followed by perceived behavioral control, with a standardized estimate coefficient of 0.101 and a p-value of 0.095 and effectiveness recognition of waste bank has the least positive impact on intention to recycling behavior, with a standardized estimate coefficient of 0.050 and a p-value of 0.631. The situational factor, which is effectiveness recognition of waste bank related to intention to recycling behavior supports the hypothesis (Latif et al., 2012).

Table 5.5 Hypothesis Test Results

Hypothesis	Path correlation	Standardized estimate	p-value	Impact to intention
H1	ATTD -> IRB	0.149	0.058	Positive, not significant
H2	SN -> IRB	0.764	***	Positive, significant
H3	PBC -> IRB	0.101	0.095	Positive, not significant
H4	ERWB -> IRB	0.050	0.631	Positive, not significant

***: p<0.001

5.3.5 Discussion

The present study shows that subjective norms play the most significant role in a waste bank community's intention to recycling behavior. Moreover, this finding concords with the actual situation in Indonesia, whereby people care what other people think, affecting intention to recycling behavior. People in Indonesia are more likely to socialize with other people and form community activities. Waste bank is a community activity that makes a participant socialize more with others. The small influence of attitude on intention to recycle concords with findings of previous research in developing countries (Strydom, 2018). Based on the demographics statistic, the average educational level of waste bank communities is senior high school. This factor could be affecting the small influence of attitude towards intention to recycling behavior among the communities. Perceived behavior control also has a small positive influence on intention to recycling behavior. This result agrees with previous research that found that PBC did not contribute significantly to the intention behavior (Boldero, 1995). The situational factor effectiveness recognition of waste bank also has least small affect as predictor of intention to recycling behavior among waste bank communities. This finding suggests that waste bank management needs to be improved to increase the understanding and awareness of society regarding recycling activities.

5.4 Summary

This study found that effectiveness recognition of waste bank has the least impact on intention to recycling behavior, with a standardized estimate coefficient of 0.050 and a p-value of 0.631. This finding shows that effectiveness recognition of waste bank as an additional construct on intention to recycling behavior among waste bank communities has a positive impact, but is not significant. All variables, including attitude, subjective norms, perceived behavior control, and effectiveness recognition of waste bank have positive impacts on intention to recycling behavior among waste bank communities. The only factor that had statistically significant positive impacts on intention to recycling behavior was subjective norms, with a standardized estimate coefficient value of 0.764 and a p- value of less than 0.05.

From the demographics descriptive results, waste bank participants have various levels of social economic status. Most participants were between 41–50 years of age, had senior high school educational levels, and had revenues between IDR 1.500.001–2.999.999, which is under the standard minimum salary in Semarang city. Effectiveness recognition of waste bank had the least impact on predicting intention to recycling behavior among the waste bank community.

5.5 Notes

This chapter were adapted from the peer-reviewed journal written by author that already published in Journal of Human and Environmental Symbiosis, Vol.37., No.1., pp 24-35. Entitled "Community-Based Waste Management (Waste Bank) as Intention Recycling Behavior Predictor Using Structural Equation Modeling in Semarang City, Indonesia". Author made improvements for this dissertation consist of modification of the model in **Fig. 5.5**. Initially, the standardized estimate value of the intention to recycling behavior in IRB1, IRB2, IRB3, and IRB4 were 0.63, 0.63, 0.70, and 1.01 respectively. Due to the IRB4 have value greater than 1.00, IRB4 has to be modified into the less than 1.00. The modification slightly affecting the values of the others loading factors but not significant. The result of modified model value of IRB1, IRB2, IRB3, and IRB4 in this dissertation is 0.52, 0.51, 0.54, and 0.77 respectively. The results of analysis and sentences in the published journal and this dissertation may be differ due to the improvements.

Chapter 6 Conclusion

6.1 Summary

Indonesia is the fourth most populous country in the world. Uncontrolled waste generation has been a continuous problem for both the environment and humans. For developed countries, waste has become an important part of a management and recycle industry. However, this is not the case with developing countries, where they are still experiencing difficulties in handling waste problems. In developing countries, government waste management is often inadequate. The Ministry of Environment and Forestry Indonesia admits that in 2020 the total national waste production has reached 67.8 million tonnes. This means that around 185,753 tonnes of waste are produced every day by 270 million residents from 514 districts/cities. Or each resident produces about 0.68 kilograms of waste per day. This figure has increased compared to previous years. In 2018, national waste production has reached 64 million tonnes from 267 million people. Waste bank is an alternative waste management system implemented to reduce waste and improve the local economy and It can be implemented in developing countries where the local government has inadequate capability to manage waste. Waste bank is one option that can reduces greenhouse gas emissions and possesses economic, social, educational, and technological tools that can establish self-reliance in a community. The existence of a waste bank in Indonesia is supported by the Regulation of the Minister of Environment of the Republic of Indonesia No. 13 of 2012.

This study has main objectives to investigate the role of waste bank as community-based waste management for the municipal waste management in several regions in Indonesia. The first objective is to investigate the roles of waste banks in reducing waste generation and the correlation between social attributes toward knowledge behavior regarding waste management among the waste bank implementer residents. The second objective of this study was to analyze the environmental assessment and cost-benefit impact from the addition of waste banks to the management of municipal waste. This study also aiming to find the key descriptors of intention to recycling behavior among the waste bank community using theory of planned behavior (TPB) approach and structural equation modeling (SEM).

First study conducted analysis of household waste generation and social attributes correlation towards environmental awareness in Rewwin residential area as a waste bank implementer in Sidoarjo Regency. This study found that waste bank as community-based waste management can encourage the number of waste reductions and benefit their participants in the form of economic value. Rewwin residential area in Sidoarjo regency is considered an example of a community that independently manages waste in its local environment. Rewwin residential areas generate approximately 0.205 kg/person/day of household waste. The waste generation levels were lower than the national standard of Indonesia. The BSMS waste bank in Rewwin can reduce the total waste generation in the Rewwin residential area by 2.8 %. Regarding the characteristics of Rewwin residents, this study found that younger residents feel proud to maintain environmental cleanliness. This research indicated that the various level social attributes in community did not have significant effect towards the environmental awareness as long as the communities consistent to participate in the activities to protect the environment.

Second study conducted life cycle assessment and cost benefit analysis of waste management strategies in Cimahi City. The addition of waste banks contributes in reducing emission from fuel consumed by collection and transportation in waste disposal process to the landfill. Increasing the number of waste bank could be an alternative to reduce cost needed to dispose waste to landfill. Considering environmental and economic aspects, the government and private waste banks addition is most preferable to be implemented. The government needs to more concern regarding waste treatment. By utilizing more waste bank, it would be possible to spent less and gain benefit both environmental and economic. Increasing the number of waste bank should be followed by education to the residents about the importance of recycling waste.

Third study conducted waste bank as intention recycling behavior predictor using structural equation modeling in Semarang City. The effectiveness recognition of waste bank has least impact on intention to recycling behavior, with a standardized estimate coefficient of 0.050 and a p-value of 0.631. This finding shows that effectiveness recognition of waste bank as an additional construct on intention to recycling behavior among waste bank communities has insignificant positive impact. Subjective norms has the most positive significant impact toward intention to recycling behavior among waste bank communities.

6.2 Conclusion

This study concluded that waste bank has roles to enhancing sustainable waste management in Indonesia. The study found that waste bank as community-based waste management can encourage the number of waste reductions and benefit their participants in form of economic value. The various level social attributes in community did not have significant effect towards the environmental awareness as long as the communities consistent to participate in the activities to protect the environment.

The addition of waste banks contributes in reducing emission and reduce the cost from waste disposal process to the landfill. The effectiveness recognition of waste bank as an additional construct has a least positive impact on intention to recycling behavior among waste bank communities. The factor that encourage people to join waste bank is subjective norms which play significant role to predicting recycling behavior among waste bank communities. Furthermore, waste bank system needs to be maintained to obtain optimal opportunities as municipal solid waste management by communities. Government should fully support and have a program to strengthen the human resources of waste bank to improve the innovation of waste bank as a community recycling activity.

6.3 Future strategies and research

Future strategies are needed to enhance community awareness in Indonesia regarding the sustainability of waste bank as a recycling activity and waste bank as a community-based municipal waste management to reduce the amount of waste disposal into landfill and keep the environment become zero waste. Government should have an assessment program with a reward and punishment system for those who perform accomplishments or violations regarding waste management. Each waste bank Manager could provide self-branding improvement in performance, which would yield a reward; therefore, competition would exist in each waste bank to provide better community-based waste management. Strategies for strengthening the human resources of the waste bank to evaluate and monitor also have important roles in improving the innovation of waste bank management. Government can conduct assistance activities including training and socialization such as implementing a waste bank system in educational institutions and businesses field such as food stalls and supermarkets. Besides collecting valuable waste, there are additional activities that can improve the benefits of waste bank output, such as making handicrafts and exchanging waste for the opportunity to obtain a loan, health insurance, and other benefits. Business strategies through waste bank depending on the necessity of the waste bank community in each region.

Future research has a potential to investigate the potential benefit of environmental and economic aspects from the other waste treatment. Other variables regarding environmental awareness need to be investigate among society. Indonesia is the populous and big country with tons of culture and socio-economic characteristics in every region. The field of research regarding waste management need to be more explore from the smaller scale on the village level until the biggest scale on the metropolitan area level. From researches in waste management field, government can be able to calibrate policy regarding waste management that suitable among every region in Indonesia.

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