Waste Reduction Strategy in Upstream Through Community Participation and Modernisation of Waste Bank in Depok City, West Java Province, Indonesia

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Abstract

Depok city with more than 2 million people is an example of a city in a developing country facing complex urban problems. Solid waste handling is one of the critical issues in the city. More than 1,500 tons of waste are generated every day, and currently, the leading landfill site receives approximately 70% of the waste in the city. The purpose of this paper is to present a comprehensive waste management strategy for waste reduction in Depok City through community participation and modernisation of the local waste bank. The study combined qualitative data collection; interviews and direct observation in the two (2) waste bank, quantitative survey (Multinomial Logistic Regression method) with 319 waste bank managers, and 423 respondents from 11 sub-districts in Depok City. Infrastructures and socialisation are the two (2) variables that affect significantly towards modernisation of the waste bank. Meanwhile, in the context of community participation, only 36% of the respondents process their own household waste. Studies on the waste management subject are extensive, but this paper only discusses two (2) elements; community participation and modernisation of the waste bank. Extending more relevant elements of waste management will have contributed to the sustainability of the environment. This research complements references from previous studies that discuss sustainable waste management. It is hoped that the sustainable waste management strategy in Depok City can be an excellent example for other cities in other developing countries.

Keywords: *Waste Management, Community Participation, Waste Bank, Cipayung Landfill Site, Depok City.*

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A. INTRODUCTION

Depok City, as one of the satellite cities located to the south of Jakarta Capital City has an area of 200.29 km^2 and a population of 2,056,335 people in the year 2020 (BPS, 2021). Population growth and socio-economic activities in urban areas naturally correlate with rising in both the amount and type of waste generated (Suntari *et al.*, 2018). Regarding data from Environmental Agency (DLHK) of Depok City, waste production in Depok City every day is about 1,565 tons. Currently, 70% of waste is disposed of at Cipayung Landfill Site (Cipayung TPA), while the rest is considered can be handled by the communities (DED Cipayung TPA, 2020). The existing of Cipayung TPA only occupies an area of 11.2 hectares, which can only accommodate waste capacity of 2,500,000 m^3, while the current volume of waste is about 3,000,000 m^3. It means that the buried waste formed at the Cipayung TPA has exceeded its capacity. Therefore, it should not be allowed to accept waste loading to the Cipayung

TPA any longer. Even though it has used a landfill control system, it has not overcome the problem of high waste piled up, with the risks of landslides, leachate leaks that damage pond construction structures, river pollution, soil pollution, water, and air pollution. Maulana *et al.,* (2020) disclosed that such a system is not a suitable alternative since it will cause environmental problems.

According to the Depok City Regional Regulation number 13 of year 2018 concerning Waste Management, waste is the residue from daily human activities and natural processes in solid form. Kodoatie (2003) and Surani (2014) defined that waste as solid or semi-solid form, which is a side product of urban activities or the life cycle of humans, animals, and plants. The waste handling in Depok City is conducted comprehensively from upstream, middle to downstream, with a handling pattern as shown in Figure 1.

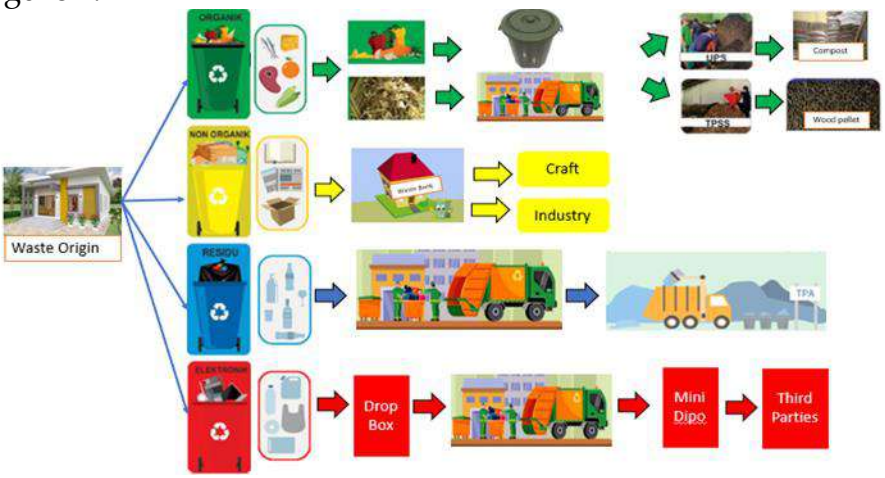


Figure 1. Waste Management Patterns in Depok City

Source: DLHK Depok City, 2020

There are several aspects in handling waste, including technical, economic, and social. Suranih (2014) stated several aspects in waste management, such as institutional aspects, financing, regulation, community participation, and operational techniques. Community participation in waste management starts from the planning, implementation, and supervision stage so that it is beneficial in handling waste upstream, but this role may not work if community participation is meager (Adawiah *et al.,* 2011). Community participation may be increased if changes in the behavior of residents who manage their waste independently are accompanied by community organizing at the Citizen Assosication (RW) level, so that, in this case, the existence of a waste bank is essential. The waste bank is a strategy to build public awareness, which in turn they will become 'friends with waste' to earn direct economic and social benefits from good waste management (Purbasari, 2014). In its implementation, the existence of waste bank can reduce the volume of waste in the communities and in TPA.

B. METHOD

According to Sugiyono (2016), research method is a scientific way to obtain data with specific goals and uses. This study uses mixed-method approaches, a

combination of qualitative and quantitative methods. Regarding Cresswell (2010), mixed methods are two forms of methods that are mutually integrated in combining, linking, and unifying data, where this study begins with qualitative data collection and analysis and then continues with quantitative data collection and analysis. Qualitative data collection can be done by field observations, interviews with related parties, literature, and policy studies (Suntari, 2018). Meanwhile, quantitative data were carried out using a questionnaire survey method to 319 units of waste bank and 423 people in Depok City.

The results of the collected questionnaire filled out from field observation were processed and analyzed using the Multinomial Logistic Regression method to determine the factors that influence the modernisation of the development of waste banks to serve customers during the covid-19 pandemic. First of all, the validity and reliability tests were carried out on the results of the collected questionnaire, where data processing in this study was done using SPSS software. This method is used because the modernisation of waste bank development as the dependent variable is a categorical variable with more than two categories. Meanwhile, the form of independent variables for waste bank incomes, facilities and infrastructures, the number of volunteers, the number of customers, socialisation, the origin of capital, distribution of waste bank products, and innovation as an indicator of waste bank modernisation was also determined as categorical variables. In this study, Multinomial Logistic Regression was carried out based on hypothesis testing to determine the effect of each independent variable on the dependent variable. The several hypotheses tested in this study are shown as follows:

H1: The income of waste bank affects the modernisation of the waste bank
H2: Facilities and infrastructures affect the modernisation of waste bank
H3: The number of volunteers affects the modernisation of waste bank
H4: The number of customers affects the modernisation of waste bank
H5: Socialisation affects the modernisation of waste bank
H6: The origin of the waste bank capital affects the modernisation of the waste bank
H7: Distribution of processed products affects the modernisation of waste bank
H8: Innovation affects the modernisation of waste bank

C. RESULTS AND DISCUSSION

One of the principles in developing waste management is that 3R, namely Reduce, Reuse and Recycle (Sakai et al., 2011). According to data from DLHK in year 2020, the amount of waste reduced through 3R activities at UPS in Depok City reached 17.63% from the target set at 17.28%, while the realisation of waste handling reached 76.60% from the target set at 74.18%. This reached percentage showed that the buried waste was successfully reduced through processing organic waste in 32 UPS 3R and handling non-organic waste at 317 units of waste bank and two units of the main waste bank located to community association (RT) and RW levels spread over 11 sub-districts in Depok City. The distribution map for UPS and waste bank can be shown in Figure 2.

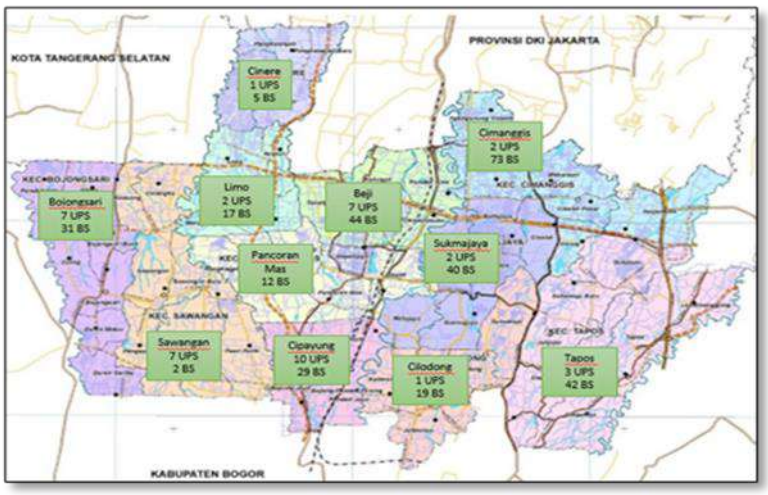


Figure 2. Distribution Map for UPS and Waste Bank in Depok City

Source: DLHK Depok City, 2020

The results of direct observations and interviews among two waste banks in Depok City are reported as follows:

1. Main Waste Bank of Depok Hijau

The Main Waste Bank of Depok Hijau was established in 2014, currently has 21 employees, and there are 317 members of waste bank units. However, every month the main waste bank must pay about IDR 100,000,000 (± USD 7,000) to bear all existence of waste bank units. Almost all the collected waste is sold to a recycling plant, and the constraints are that funding and infrastructure since the condition of the existing place is not representative (Hendra Sogir, Owner of the Main Waste Bank of Depok Hijau). The following is the condition of the main waste bank in Depok Hijau.



Figure 3. Main Waste Bank of Depok Hijau

Based on Figure 3, the condition of the Depok Hijau Main Waste Bank has been relatively developed, although the current location is not representative and its facilities and infrastructure are not yet complete so that it becomes a priority requirement for waste bank managers.

2. Waste Bank of Villa Tanah Baru

Waste bank of Villa Tanah Baru was established in the year 2017, originally the number of customers was 30 houses, but due to the covid-19 pandemic, only 15 houses remained. All products are sold and sent to the main waste bank. The capital and

operations costs of the waste bank are sourced from the RT's cash fund. Assistance from the government in the form of incentives and infrastructure is very needed. Besides that, it is also necessary to make rules to regulate waste management by requiring all residents to sort waste and encourage producers who produce waste to replace their product's material with more environmentally friendly ones. (Ima, Owner of waste bank of Tanah Baru).



Figure 4. Waste Bank of Villa Tanah Baru

Based on the picture above, the Villa Tanah Baru waste bank needed a stimulus grant from the government in the form of funding for waste bank operations and needed weighing facilities. The waste bank is an independent system consisting of waste saving activities (Dhokikhah *et al.*, 2015) which as part of zero waste management.

This study also carried out observations toward 319 managers of the waste bank through questionnaire method. There were several questions related to the condition of the waste bank during the covid-19 pandemic, technology, and innovation, hopes, and constraints. The following are the results of the questionnaire.

Before processing and analyzing data that has been collected further, it is necessary to test validity and reliability. A questionnaire is considered valid if the questions on the questionnaire can reveal something that exists and can be measured by the questionnaire itself and the significance value obtained is less than the specified alpha value, which is defined less than 0.05. The results of the validity test are as follows:

Table 1. Validity Test Result

Correlations											
		Q1	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Q7**	**Q8**	**Q9**	**TOTAL**
Q1	Pearson Correlation	1	.049	.279**	.382**	.117*	-.081	.077	.064	.018	.592**
	Sig. (2-tailed)		.383	.000	.000	.036	.149	.170	.254	.750	.000
	N	319	319	319	319	319	319	319	319	319	319
Q2	Pearson Correlation	.049	1	-.013	.018	.302**	-.006	-.041	-.031	.245**	.288**
	Sig. (2-tailed)	.383		.811	.752	.000	.909	.468	.586	.000	.000
	N	319	319	319	319	319	319	319	319	319	319
Q3	Pearson Correlation	.279**	-.013	1	.387**	.106	-.014	-.101	.009	.027	.528**
	Sig. (2-tailed)	.000	.811		.000	.058	.799	.073	.873	.629	.000
	N	319	319	319	319	319	319	319	319	319	319

Q4	Pearson Correlation	.382**	.018	.387**	1	.122*	.056	.097	.124*	.010	.652**
	Sig. (2-tailed)	.000	.752	.000		.029	.322	.084	.027	.853	.000
	N	319	319	319	319	319	319	319	319	319	319
Q5	Pearson Correlation	.117*	.302**	.106	.122*	1	-.109	.011	.067	.706**	.436**
	Sig. (2-tailed)	.036	.000	.058	.029		.051	.842	.232	.000	.000
	N	319	319	319	319	319	319	319	319	319	319
Q6	Pearson Correlation	-.081	-.006	-.014	.056	-.109	1	.012	-.020	-.043	.249**
	Sig. (2-tailed)	.149	.909	.799	.322	.051		.837	.717	.443	.000
	N	319	319	319	319	319	319	319	319	319	319
Q7	Pearson Correlation	.077	-.041	-.101	.097	.011	.012	1	.008	.093	.324**
	Sig. (2-tailed)	.170	.468	.073	.084	.842	.837		.894	.098	.000
	N	319	319	319	319	319	319	319	319	319	319
Q8	Pearson Correlation	.064	-.031	.009	.124*	.067	-.020	.008	1	.098	.281**
	Sig. (2-tailed)	.254	.586	.873	.027	.232	.717	.894		.080	.000
	N	319	319	319	319	319	319	319	319	319	319
Q9	Pearson Correlation	.018	.245**	.027	.010	.706**	-.043	.093	.098	1	.319**
	Sig. (2-tailed)	.750	.000	.629	.853	.000	.443	.098	.080		.000
	N	319	319	319	319	319	319	319	319	319	319
TOTAL	Pearson Correlation	.592**	.288**	.528**	.652**	.436**	.249**	.324**	.281**	.319**	1
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000	.000	.000	.000	
	N	319	319	319	319	319	319	319	319	319	319

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Based on the table above, it can be seen that the Pearson Correlation value at the far right end value (r count) obtained for all question indicators is more than r table value (r table = 0.113 in r table product moment for a significant test of 0.05) so that it can be proven that all indicators are valid.

Table 2. Reliability Test Result

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.442	.452	9

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Q1	4.80	3.949	.288	.187	.363
Q2	5.00	4.792	.121	.104	.434
Q3	4.52	4.301	.224	.198	.396

Q4	5.18	3.782	.396	.271	.311
Q5	4.64	4.268	.314	.543	.363
Q6	5.52	5.068	-.051	.031	.504
Q7	5.38	4.757	.042	.058	.473
Q8	5.46	4.941	.087	.032	.443
Q9	5.55	4.638	.298	.521	.387

The table above shows that the Corrected Item-Total Correlation value in Q6, Q7, and Q8 are less than r table 0.113, so that this question item was invalid and there was no need to look at the reliability value. Meanwhile, the rest of the other question items used in this study have the Corrected Item-Total Correlation value of more than r table 0.113, and the value of Cronbach's Alpha if Item Deleted is more than r table 0.113, meaning that the question items are reliable.

A Simultaneous test is a measurement used to test the role of independent variables in the model simultaneously, as shown in the following table.

Table 3. Simultaneous Test Output

Model Fitting Information

Model	Model Fitting Criteria	Likelihood Ratio Tests		
	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	274.077			
Final	36.466	237.611	13	.000

The simultaneous test results found that the resulting significance value was 0.000 where this value was smaller than alpha value of 0.05. Among the several independent variables used, at least one influences the decision to modernize waste bank. Then the percentage of independent variables that affect the dependent variable is identified which can be seen in the following table.

Table 4. Simultaneous Test Percentage Output

Pseudo R-Square

Cox and Snell	.525
Nagelkerke	.822
McFadden	.731

The table above shows that the coefficient of determination of Nagelkerke obtained is 0,822, which means that 82,2% of the independent variables affect the modernisation of the waste bank.

After passing the simultaneous test, the next step is the partial test. Decision making for hypothesis testing is based on the significance value obtained with an alpha value of 0.05. Partial test results can be seen in the following table.

Table 5. Partial Test Output

Likelihood Ratio Tests

Effect	Model Fitting Criteria	Likelihood Ratio Tests		
	-2 Log Likelihood of Reduced Model	Chi-Square	df	Sig.
Intercept	36.466[a]	.000	0	.
Income	39.016	2.549	3	.466

Facilities and infrastructure	**59.145**	**22.678**	**2**	**.000**
Volunteer	40.740	4.274	3	.233
Customer	39.859	3.392	3	.335
Socialisation	**209.739**	**173.273**	**2**	**.000**

From the results of the partial tests above, there are two variables, namely infrastructure and socialisation, that statistically significantly affect the dependent variable, namely the modernisation of the waste bank. This can also be seen from the significance value of each independent variable smaller than 0.05, which is 0.000 for infrastructure and socialisation respectively to serve waste bank customers during the covid-19 pandemic. The infrastructure variable affects the modernisation of the waste bank; this was appropriate because to change the quality of the waste bank to a modern one. Besides that, socialisation to the community is needed to develop the modernisation of waste bank so that customers increase and waste can be reduced upstream.

In addition to the waste bank manager, the field survey also had been distributed questionnaires to the public in 11 sub-districts and 63 urban villages with a total response of 423 people. According to the questionnaire results, only 36% of people process their household waste by sorting, eco-bric, eco-enzyme, composting through bio-pore holes, while the remaining 64% of people still use conventional disposal and transport methods. According to Maulana *et al.,* (2020), this method has the advantage of relatively faster waste management time since it only goes through 3 stages. However, it is still inefficient because the transported waste is still mixed between organic and non-organic. The unavailability of facilities and infrastructure such as trash cans that separate organic, non-organic, and residual waste is one of the factors causing people not carry out 3R activity in their living environment; namely only 29% of the community have been carried out 3R activity. In addition, the availability of waste bank locations in each RW is still rare. Based on the results of a survey conducted to the community, the number of availability of waste banks and socialisation in each RW is as follows:

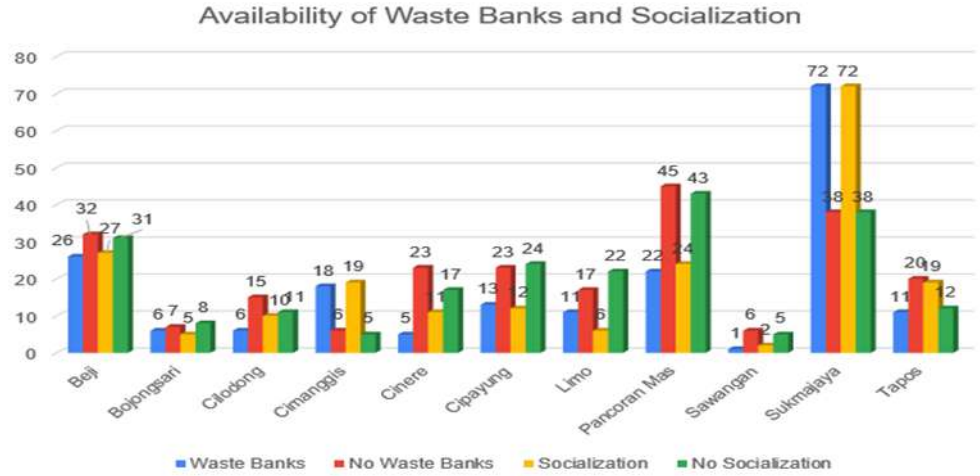


Figure 5. Graph of waste bank availability and socialisation in each RW

The graph above shows that Sukmajaya and Cimanggis are the sub-districts that have the most waste bank and that often carry out socialisation of 3R activity

compared. This is in accordance with data from DLHK that Sukmajaya and Cimanggis sub-districts have contributed to waste reduction in Depok City, where Sukmajaya by 5% with 117 units of waste bank, and Cimanggis by 3% with 67 units of waste bank. The communities expect that waste generated can be adequately processed, which in turn it becomes economic value such as fertilizers, recycled goods that can be sold or reused. However, the participation of the communities in 3R activity is not progress yet, so it is necessary to socialise and provide at least 1 unit of the waste bank in every RW. During the Covid-19 pandemic, they agreed that innovations were made in the form of a sorted garbage pick-up home service and providing human resources as needed. In addition, they also consider that the regulation of waste processing is being good. However, it still requires supervision in its implementation, and the government must also provide incentives to people who have done waste sorting.

Waste management is an issue that cannot be separated from the budget issued by the Depok City government. The budget issued by the government is used for human resources involved in waste handling, consisting of salaries for road cleaners, garbage transporters, and also for procurement of waste facilities and infrastructure, such as garbage trucks, backhoes, garbage carts in the form of motorbikes or carts pulled by humans. The realization of capital expenditures for the Depok City Government in 2015-2019 is an average of IDR 2.72 trillion per year, while the realization of spending for the waste management sector is an average of IDR 117.9 billion per year. In addition, during the year 2015 - 2019 waste retribution revenue is an average of IDR 2.14 billion per year or 1.24% of the waste expenditure allocation. Therefore, the total budget issued by the government for the waste management sector is IDR 115.8 billion per year. The following is a graph of expenditures and subsidies issued to the waste management sector

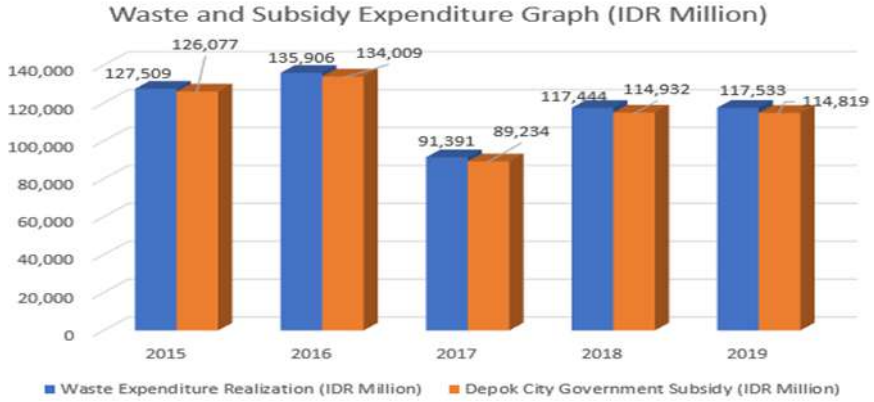


Figure 6. Graph for Expenditures and Subsidies

To reduce waste upstream, the Depok city government has carried out various activities and budget interventions, such as the implementation of regional-scale waste management, socialisation of waste management, clean action movements, development of environmental cadres and communities and fostering of environmentally cultured schools. The budget given for the waste processing and hygiene program is relatively more significant when compared to the TPA improvement program as follows:

Table 6. Realization of Waste Management Program in Depok City

Year	Program		Total
	Waste Management and Cleanliness	Improved Landfill Treatment	
2015	IDR 79,097,223,766	IDR 12,372,590,506	IDR 91,469,814,272
2016	IDR 81,594,407,526	IDR 10,771,926,000	IDR 92,366,333,526
2017	IDR 80,660,929,435	IDR 10,730,533,021	IDR 91,391,462,456
2018	IDR 104,511,522,874	IDR 12,932,050,031	IDR 117,443,572,905
2019	IDR 104,153,082,208	IDR 13,380,246,638	IDR 117,533,328,846

Source: DLHK Depok City, 2020

The Depok City Government has set a target for increasing the coverage of solid waste handling services from year to year by issuing the Depok Mayor's Regulation number 65 of year 2016 concerning Depok City's Policies and Strategies (Jakstrada) in the Management of Household Waste and Other Types of Household Waste. The government regulates waste reduction and handling as follows:

Table 7. Depok City's Policies and Strategies in the Management of Household Waste and other Types of Household Waste

Year	Indicator		
	Potential of Depok City Waste Generation (tons/year)	Waste Reduction Target	Waste Handling Target
2018	536.466	18 %	73 %
2019	555.135	20 %	80 %
2020	574.454	22 %	75 %
2021	594.445	24 %	74 %
2022	615.131	26 %	73 %
2023	636.538	27 %	72 %
2024	658.690	28 %	71 %
2025	681.612	30 %	70 %

Source: DLHK Depok City, 2020

Sustainable waste management needs to be done to realize good, responsible, and sustainable environmental management. Based on the Depok City Regional Regulation Number 2 of year 2019 concerning the Implementation of Smart Cities, one of the zero waste programs is that management from upstream to downstream waste management involves several elements in the implementation of its activities. The strategies for the next five (5) years are shown in table bellow:

Table 8. Strategy in Waste Management

2020	Activation of the waste sorting movement
	Provision of segregated garbage pick-up service
2021	Collaborating with a community that cares about waste
	Making waste management techniques and educating a. Reprocessing waste into valuable/functional products (paving blocks),

	b. Processing of organic waste by methods: maggot, vermi, composting, and ecoenzim. c. The economic empowerment of residents in managing the environment is by establishing a waste bank cooperative and saving with used cooking oil. d. Processing plastic waste with machines.
	Digital platform provision
2022	Build a waste processing center
	Provision of a sales center for processed goods (showroom)

Source: Depok City Regional Regulation Number 2 of year 2019

The Depok City Government also takes various approaches in handling and processing community-based waste management. The program is an effort to change the old paradigm of waste management, namely collect-transport-disposal to be collect-process-benefit. Waste can be used as a value-added product if it is insufficient quantity and can be processed as recycled raw material (Prabowo, 2018). A single unit of UPS that can handle 30 m^3 of waste per day will produce 2.4 m^3 of recycled materials such as metal, paper and plastic that still have economic value, and compost with equivalent to 1 ton per day. The management of UPS and waste bank involves all society components such as housewives, RT, RW, Community Empowerment Institutions (LPM) in urban village level, job seekers, etc. The following is a plan for the pattern of waste management upstream:

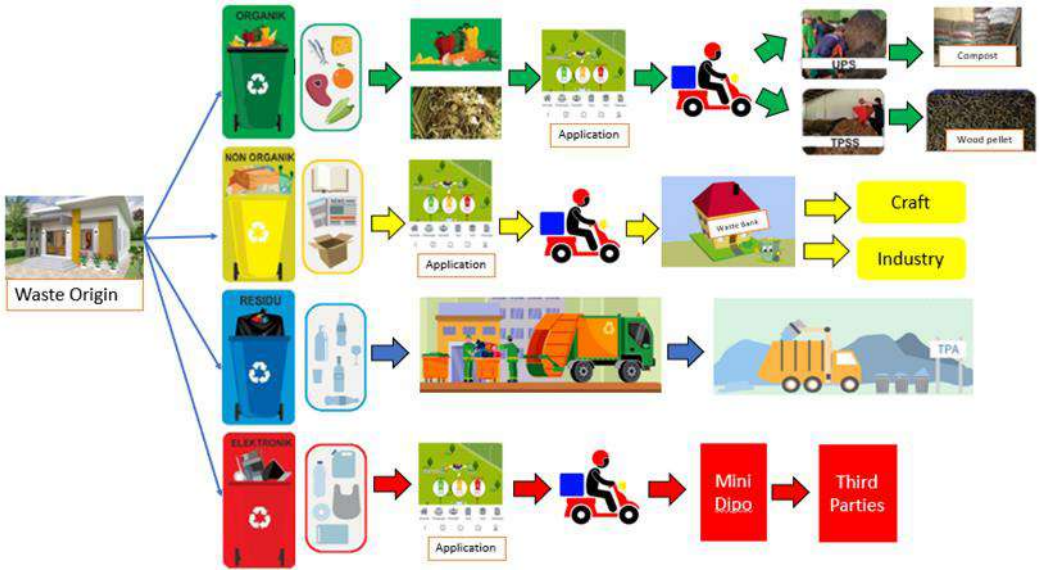


Figure 7. Planned Pattern of Waste Management in Upstream

Based on the picture above, each waste is handled differently. During the Covid-19 period, to increase public interest in waste sorting, it is necessary to modernize the waste bank in the form of a garbage pick-up service. The household waste pick-up application can make it easy for the public or customers to provide information related to their household waste, check the balance and price of each latest type of waste, can make exchanges, and provide convenience to the waste bank manager in recording and waste bank data management (Kusrini *et al.*, 2019). The

results of sorting and processing organic waste can be used as superior products, such as compost and wood pellets. (Fatah, 2010). While the non-organic waste the results will be managed into handicrafts or the used cooking oil industry, the results of which can be sold to the public, government, or third parties. This way, it is hoped that only residual waste may enter the Cipayung TPA.

D. CONCLUSION

Reducing waste from the source is a new paradigm of waste management that no longer relies on the end of the pipe system. It is intended to reduce the volume of waste that should be transported and disposed of to the Cipayung TPA and also can make optimal use of materials that can be recycled. Garbage is no longer an item to be feared or a disaster, but it is even a blessing since it has economic value. For instance, plastic waste can be sold to the plastic seed processing factory; organic waste can be used as fertilizer, and even other economic goods such as maggot for livestock and fish feed. Besides saving on the use of Cipayung TPA, reducing waste upstream can also reduce the amount of waste transportation and produce more reasonably good quality of recycled material since it is not mixed with other waste. Therefore, community participation is essential, both as producers or members of the community producing and processing waste. The government also needs to take several policy steps in handling waste upstream, including:

1. Giving incentives to existing human resources as an agent for processing and sorting waste in each RW;
2. Increasing human resources for processing and sorting waste in each RW;
3. Establishing waste bank in each RW;
4. Increasing the performance of the waste bank to process organic waste;
5. Development of waste processing applications that have economic value during the Covid-19 pandemic;
6. To increase the success of waste handling upstream, the Depok City government, through village funds, provides additional stimulus funds to waste banks of IDR. 50,000,000/waste bank for each sub-districts;
7. The government is gradually reducing the budget for the Cipayung TPA to be transferred to the community so that the community really works in managing waste upstream.

This scheme hopes that the Cipayung TPA will no longer be a final waste disposal site or landfill, but will be allowed only as a place for 15% of residual waste loading to Cipayung TPA. For future research, it will be made an application for the pattern of waste delivery and the calculation of the cost required for optimizing the handling of waste upstream.

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