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Evaluation of Rural Urban Waste Management : Integrating Logic Model and GIS Approach in Pemalang, Central Java, Indonesia

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ABSTRAK

Untuk menjalankan anamat Peraturan Presiden Nomor 97 Tahun 2017 tentang Kebijakan dan Strategi Pengelolaan Sampah Rumah Tangga dan Sampah Sejenis Rumah Tangga, Pemerintah Kabupten Pemalang, mengeluarkan Peraturan Bupati Nomor 60 Tahun 2018. Peraturan tersebut mengatur program penguatan pengelolaan sampah yang terbagi dalam program pengurangan sampah dengan target 30% dan penanganan sampah, dengan target 70%. Studi ini bertujuan untuk mengevaluasi program tersebut. Metoda yang digunakan adalah Logic Model dan GIS. Logic model mengevaluasi input proses output dan outcome program, sedangkan GIS untuk mengevaluasi geospatial ketercapaian program. Total terdapat ada 8 Indikator yang dievaluasi, terbagi dalam 3 indikator untuk program pengurangan dan 5 indikator untu program penanganan. Untuk program pengurangan, 3 (tiga) indicator yang di nilai yaitu 1) Pengembangan bank sampah; 2) Pengembangan rumah kompos dan 3) Pengembangan TPS3R. Sementara itu Untuk program penanganan 5 (lima) indictor yang dianalisis yaitu 1). Pemilahan; 2) Pengumpulan; 3) Pengangkutan; 4) Pengolahan; 5). Pemrosesan Akhir. Penilaian selama 2 tahun (2021-2023) menunjukkan untuk program pengurangan ditemukan 1). Jumlah bank sampah meningkat 32 unit dari 63 menjadi 95 unit; 2) Fasilitas komposting meningkat 2 unit dari 1 menjadi dan 3) fasilitas TPS3R meningkat 3 unit dari 3 menjadi 6. Secara geospatial, program pengurangan sampah mayoritas di laksanakan di wilayah perkotaan. Untuk program penanganan, sebanyak 84,92% sampah telah tertangani sedangkan 15,08 % belum tertangani. Jumlah TPS untuk pengumpulan meningkat 18 unit dari 116 unit, menjadi 134 unit. Untuk pemilahan dan pengangkutan belum ada perubahan yang signifikan. Pada tahun 2023 terjadi kebakaran TPA yang menunjukkan fasiltas pengolahan akhir sampah (TPA) belum optimal.

***Kata kunci*:** Evaluasi, Pengelolaan Sampah, Logic Model, GIS, Pemalang

ABSTRACT

To carry out the mandate of Presidential Regulation Number 97 of 2017 concerning Household Waste Management Policies and Strategies, the Pemalang Regency Government issued Regent Regulation Number 60 of 2018. This policy consists of 2 (two) main programs, namely the waste reduction program with a target of 30% and waste treatment, with a target 70%. This study aims to evaluate the program. The methods used are logic model and GIS. Logic models evaluate input process output and program outcomes, while GIS evaluates geospatial program achievements. Total of 8 indicators were evaluated, consisting of 3 (three) indicators for the reduction program and 5(five) indicators for the treatment program. For waste reduction program, 3 (three) indicators that are assessed, namely 1) Development of waste banks; 2) Development of compost houses and 3) development of TPS3R. In handling, 5 (five) indicators were analyzed, namely 1). Sorting; 2) Collection; 3) Transportation; 4) Itermediate Treatment; 5). Final treatment. Assessment for 2 years (2021-2023) shows 1). The number of waste banks increased by 32 units from 63 to 95 units; 2) Composting facilities increased by 2 units from 1 to 3) TPS3R facilities increased by 3 units from 3 to 6. GIS analysis showt that waste reduction programs are implemented mostly in urban areas. For treatment program, 84.92% of waste has been handled while 15.08% has not yet. The number of TPS for collection increased by 18 units from 116 units, to 134 units. There have been no significant changes regarding sorting and transportation and Intermediate treatment. In 2023, a landfill fire occurred, indicating that the final processing facilities were not yet optimal.

***Keywords*:** Evaluation, Waste Management, Logic Model, GIS, Pemalang

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1. INTRODUCTION

Waste management programs require evaluation, namely the process to measuring achievements. Wilson (1985) argued that evaluation is an important stage in long-term waste management planning, especially to assess the changing of internal and external indicators of such as changes in political, economic, technical and environmental aspects. Evaluation is needed to giving feedback of the the positive integration between hard and soft infrastructure (Dyer M, et al. 2019) and between rural and urban areas especially in developing countries. In the perspective of planning theory, Hostovsky, C. (2000) addressing hard infrastructure is associated with technical engineering while some soft parameter such as social, economic, law.

In the aspect of technical engineering or hard infrastructure can be devide by two groups upstream and downstream hard infrastructure. The first one can be addressing for the separation and collection; tranfer and transport; intermediate treatment. While the second one can be measuring of temporary storage location, and final treatment. While from the perspective of soft infrastructure, evaluation can exploring from the perspective of law enforcement; financial; institutional arrangements and coordination; community participation. The design and setting of indicators will vary depending on the measurement target. Cervantes et al., (2018) estimated there were 377 different indicators, can be explored to address waste management performance.

In detail the indicator setting for separation and collection system can be more exploring from the study in chile by Llanquileo et al (Llanquileo-Melgarejo et al, 2021), in Sweden by Rousta (Rousta et al, 2015) and in Italia by Musella (Musella et al, 2019). Setting indicator for evaluation of tranfer and transport Performance of waste management can be describe by study from wada (wada et al, 2009), while example of setting indicator for intermediate treatment such as recycling prosess has been studied 3 decades previously such as by powell (Powell, 1996). Study of evaluation for temporary storage can be explore from the study from Ibrahim (Ibrahim et al, 2013). While to set indicator of final disposal can be exploring from study by wada (wada et al, 2008).

Setting indicators to evaluate soft infrastructure in waste management also unique and depending on the goal and target. For example study concerning to setting indicator of law enforcement by D'Amato (D'Amato el al, 2018) ; setting indicator evaluation for financial of waste management by Seydel (Sydel et al, 2002) ; setting indicator evaluation for institutional arrangements and coordination by Dalmas (Dalmas, 2022) ; and setting indicator for community participation by Heydari (Haydari, 2020).

According to location and spatial perspective evaluation of waste management can be set from the waste management in urban, rural area. It is also can be defined according to the land use such as industrial waste agricultural waste, mining waste, hospital waste. To set standard of evalatuion, indicator can be perform by using previous study. Study of urban waste management for example running by Hasome (Hasome et al, 2001). Study concerning to evaluation of waste management in rural areas for example running by El-Messery (El-Messery et al, 2009). Study for evaluation of waste management in industrial zone for example conducted by Farzadkia (Farzadkia et al, 2020). Study for evaluation of agricultural has been running by Koul (Kaul et al, 2022).

Beside in peace time or normal time, waste management should considering in disaster event. Indicator of disaster waste management could be explored from the study by brown (brown et al, 2011), study by Maryono (Maryono, 2015). Evaluation can be set from the characteristic such as organic waste and non organic waste. Moreover evaluation can be set at develop and developing countries.

This study aims to evaluate Pemalang Regency government concerning to the mandate of Presidential Regulation Number 97 of 2017 about Household Waste Management Policies and Strategies. This study measuring the Pemalang Regency Government issued Regent Regulation Number 60 of 2018, which consists of 2 (two) main programs, namely the waste reduction program with a target of 30% and waste treatment, with a target 70%. This study set 8 (eight) indicators which, consists of 3 (three) indicators for the reduction program and 5 (five) indicators for the treatment program. For waste reduction program, 3 (three) indicators that are assessed, namely 1) Development of waste banks; 2) Development of compost houses and 3) development of TPS3R. In handling, 5 (five) indicators were analyzed, namely 1). Sorting; 2) Collection; 3) Transportation; 4) Itermediate Treatment; 5). Final treatment.

2. METHOD

This study integrating logic model and GIS approach. The logic models evaluate input process output and program outcomes. It is an evaluation concerning with quality and quantity of the program including hard and soft infrastructure. GIS approach is used to evaluate geospatial program achievements. This approach assessing program in rural and urban area of pemalang regency.

2.1 Logic Model Aprroach for Waste management Evaluation

Logic model was one of the method which used to evaluate program and development achievement. In year 1989 Trochim, introducing the concept mapping for planning and evaluation which consist of input, process output and outcome component/indicator (Trochim, 1989). This model also initiated discussing in 1995 (Julian et al, 1995). Then Julian exproring laveling and scoping of the logic model in 1997 (Julian, 1997). In waste management, this model used by

Azizah for Medical waste management evaluation (Azizah et al, 2019). Moreover, in practice and daily services, US EPA utilized this logic model to control waste management and industrial waste management in USA (US EPA, 2010). Moreover the logic model also use un UK government to control waste management program (Departement of Food Environment and Rural Affair UK, 2020)

To illustrate the various components of the waste management Program and to inform the development of specific evaluation questions, the logic model was developed to understand the components attached in program development. This study utilized the logic model approach to understanding the performance of waste management program in Pemalang Regency. The key components of the model include input, activities, outputs, outcomes, and impacts (Kellog, 2004).

- Input – the resources needed to execute the program activities
- Activities – the specific processes used to achieve program goals
- Outputs – the immediate products that result from activities and are often used to measure short-term progress, that is casually linked to waste reductions and waste treatment programs
- Short-term outcomes – change in number resulting from outputs
- Medium-term outcomes – changes in behavior that are broader in scope than short-term outcomes. Medium-term outcomes often build upon the progress achieved in the short-term.
- Impacts or Long-term outcomes – the overarching goals of the program, which in this case include the community's capacity to manage waste generation independently, better waste management systems, and improvements in waste management for further utilization.

Evaluation questions are established from the logic model, which will depend in part on the purpose for which taken (Hills, 2010). In this research, the evaluations focus on both processes and outcomes. Regarding the process evaluation, logic model served to represent the stakeholders' thinking model of how the program expected to work, by showing interrelationships between inputs, activities, outputs, and outcomes. While the outcomes evaluation was used inductively as a tool for documenting the activities and outcomes expected of the waste management system in Pemalang regency. The following questions guided the evaluations for the process and outcomes stages.

Process related questions

- To what extent is the waste reductions and waste treatment in line with delivery targets?
- Were the development progress increased consistently

Outcomes evaluation questions

- To what extent were the target population reached by the intervention/adopted by target organizations
- Was the program effective in reaching and engaging the community
- Are the outcomes maintained in the longer term in order the anticipated impacts

2.2 GIS for Geospatial Waste Management

To analysis spatial performance of waste management reduction and waste management treatment in Pemalang Regency, this study utilizes geographic information system.

The utilization of GIS in Statistical survey have been discussed by Arbia (Arbia, 1993). The utilization of GIS approaches in waste management evaluation has been world wilde. For example Khan & Samadder (2014) exploring the using of Geographical Information System in waste management. GIS mostly utilized to analysis location of waste management hard infrastructure such as route (Ghose et al, 2006), temporary location (Ohri & Singh 2010), and landfill site location (Sumathi et al, 2008).

In this study, GIS will be utilized for analysis the geospatial of waste reduction program namely 1) geospatial performance of waste banks development; 2) geospatial of compost facility development and geospatial of integrated temporary storage development in Pemalang Regency. It is also will be used to understanding the trend of development base in rural urban area in Pemalang Regency.

2.3. Data Sources

The evaluations using several data collections to complete each component and information needed.

- Literature review
  Sources included peer-reviewed journal articles, reports from reputable organizations
- Document review
  Evaluations conducted with the main component from the government plan regarding the waste management system plan, which can be found in the Regional Medium-Term Development Planning and Regional Action Plan of Pemalang Regency
- Administrative data review

Apart from using the public documents, administrative data review is also used to understand several information which unmentioned in public documents, such as the progress achievements of program implementations.

3. RESULT AND DISCUSSION

3.1 Logic Model Perfomance of Waste Reduction program in Pemalang

This study developed 6 (six) column for reduction waste program in pemalang Regency. The framework modified mamping concept which initited by Throchim (Throchim, 1989) dan US EPA (US EPA, 2010). **Figure 1.** Describes the result of logic model performance of waste reduction program in Regency.

The analysis shown the correlation between main activites, input of activities, output and outcomes.

Pemalang. This study indicator which devided in input, activities, output, and outcomes in pemalang

The first column relates to the resources needed to implement the activities. In the first column identified some input for hard infrastructure to running reducsction waste activities such as waste bank, composting, integrated temporary storage (3R TPS). While for soft infrastructure this study mamping the sub indocator such as communication, financial.

The second column in logic models shows the specific activities that reflect the implementation of the programs. The activities column consists of the activities mentioned in the Regional Medium-Term Development Planning and Regional Action Plan of Pemalang Regency. The rank time for analysis data between year 2021-2023.

The third column or output column became the immediate product, which here is the waste management program, namely waste reduction program as the main ouput of the program. The target of the main ouput is 30% of total waste generated in Pemalang regency. The waste reduction is the main indicator in this column, which is to be a central analysis of this study. The reduction of waste analysis by the first, second, third and fourth column.

The fourth column consists of three derivative columns that show the intended changes for a different period, categorized as short-term, medium-term, and long-term, or can be understood as impacts. As the short-term waste reduction and waste treatment bonded to the activities, short-term outcomes lead to the immediate result for each activity and so, the general short-term outcomes are the increasing percentage number of waste reductions and waste treatments. Medium-term outcomes that build upon the short-term outcomes accumulate the progress implementations of each activity and output. As for the waste reduction program consists of three different main activities such as waste banks, composting houses, and 3R, the medium-term outcomes tend to look at the functionality of each facility to the broader community. As for the waste treatment program, the different activities tend to become one entity, so that the medium-term outcomes occur to become the accumulating result of the waste treatment program which is expected to reach the majority of the community in Pemalang Regency. Long-term outcomes or impacts that overarching the main goals of the waste management system in Pemalang Regency include the capacity of the community to manage waste independently, covering services of waste management systems in Pemalang Regency, and further utilization of waste generation in Pemalang Regency.

3.2 Logic Model Perfomance of Waste treatment program in Pemalang

Program of waste management treatment in 2023 indicates that 84.92% of waste generation in Pemalang Regency has been successfully managed. However, there is still 15.08% of waste that has not been managed. This is still a problem that needs to be resolved by the Pemalang Regency government. **Figure 2.** describe the result of logic model performance of waste treatment program in Pemalang.

This logic model framework for waste treatment program in Pemalang developed base on the condition of Regional Medium-Term Development Planning and Regional Action Plan of Pemalang. The framework also consists of 6 (six) column as of wastes reduction program previously.

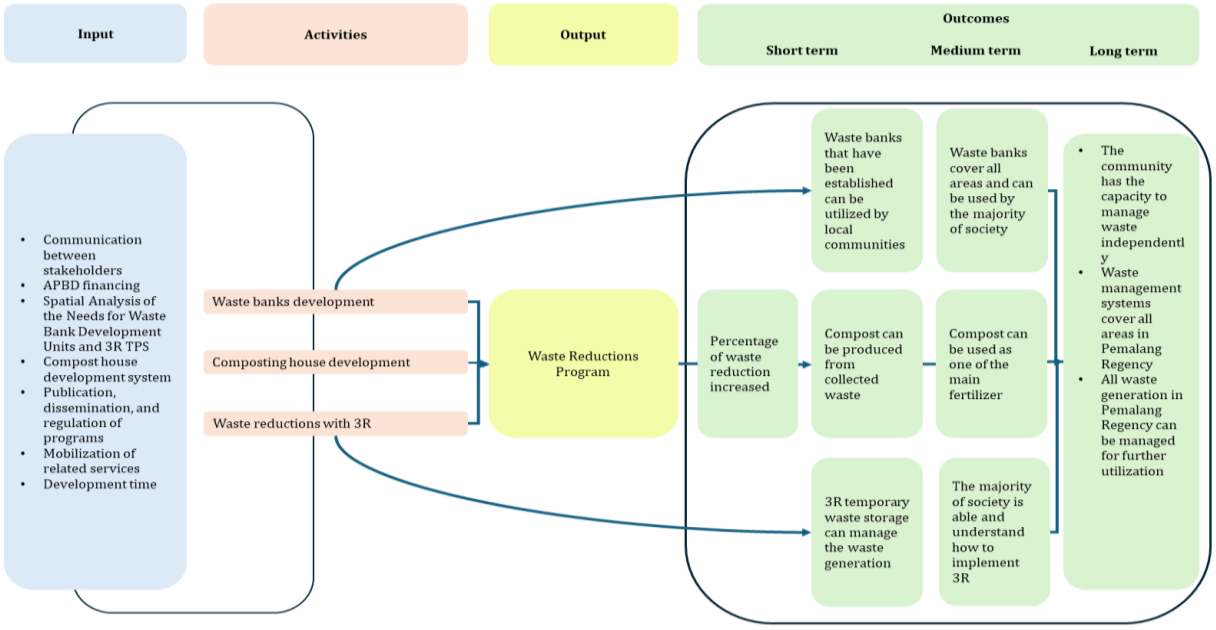

Figure 1. Logic Model of Waste Reductions Program

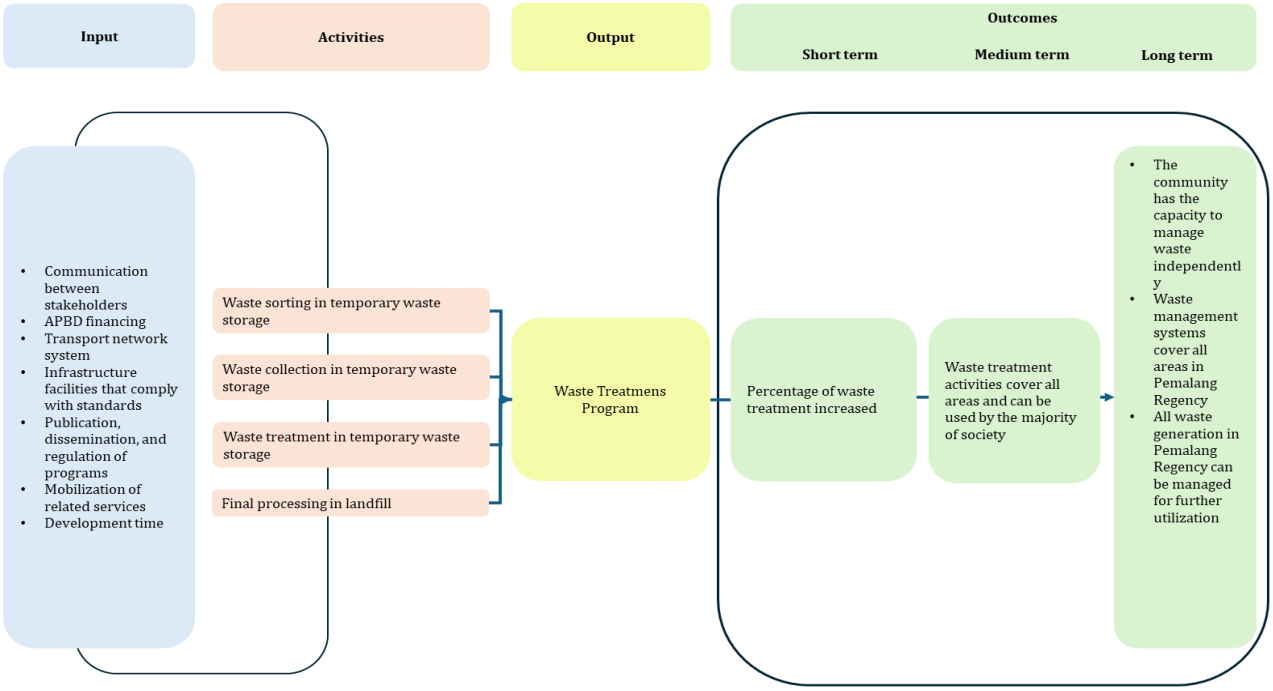

Figure 2. Logic Model of Waste Treatment Program

3.3 Information Mappings

The information required to assess progress toward the objectives from the logic model produced can be seen in the table below. Information mapping is developed to understand each program and actions taken to implement waste management. Information mappings can be used as a framework to increase focus in each activity which being evaluated. As in the logic model that has been developed, the position of the process stages consists of the activity components that are important to see the achievements and developments to date. The development of these achievements is carried out by mapping the number of information on baseline conditions, existing conditions, and expected conditions in developing program implementation. The general achievement targets for developing waste management through waste reduction and waste treatment programs are based on the JAKSTRADA (Policy and strategi for waste managaement in local state). document, while the achievement targets for each activity are based on the affordability analysis at each related facility.

As can be seen on the information mapping, waste reduction and waste treatment have experienced an increase in percentage from the baseline condition with increasement in each program reaching 2-3% within 2 years. This increase in achievements indicates that the implementation of waste management provides positive direct results in waste management in Pemalang Regency. However, in order to achieve the general target for waste management in accordance with the JAKSTRADA (Policy and strategi for waste managaement in local state). document, it can be seen that within 2 years, the government of Pemalang Regency needs to achieve an increase of around 4% in the waste reduction program, and 11% in the waste reduction treatment program. Due to limited access to waste management facilities, the disparity of local awareness in the implementation of waste management in Pemalang Regency varies for each sub-district. Increasing access range of facilities in implementing derivative activities is important in meeting the expected general achievement targets for waste reduction.

Meanwhile, for the outcomes component, it is known that the existing outcome conditions that have been successfully fulfilled are still in the form of short-term outcomes related to direct results obtained from program implementation, which in this case relates to products resulting from the implementation of waste management activities. The medium-term and long-term outcomes achievement components which are composed of more qualitative achievements require more effort with the assumption that all targets mentioned in each activity can be achieved first. This is intended to reach the entire majority of the population which is targeted to reach all areas in Pemalang Regency. Table 1. Describe information mapping program for waste reduction and treatment in pemalang regency.

Table 1. Information Mapping of Waste Management Reduction and Treatment in Pemalang Central Java 2021-2023

Actions Taken	Baseline (2021)	Target (2025)	Existing (2023)	Assumptions	Short-term	Med-term	Long-term
Waste Reductions	24% of waste reductions	30% of waste reductions	26% of waste reductions	All the targets mentioned are achieved	Percentage of waste reduction increased	Waste banks cover all areas and can be used by the majority of society	- The community has the capacity to manage waste independently - Waste management systems cover all areas in Pemalang Regency - All waste generation in Pemalang Regency can be managed for further utilization
Waste banks development	There are 63 units of waste banks in 59 sub-districts	There are 222 units of waste banks located in each sub-district	There are 94 units of waste banks 76 sub-district		Waste banks that have been established can be utilized by local communities		
Composting house development	There is a unit of composting house	There are 12 units of 3R temporary waste storage in each district	There are 19 units of neighborhood scale, 3 units of regional scale, and 1 composting house		Compost can be produced from collected waste	Compost can be used as one of the main fertilizer	
Waste reductions with 3R	There are 4 units in 2 district	There are 12 units of 3R temporary waste storage in each district	There are 7 units in 3 district		3R temporary waste storage can manage the waste generation	The majority of society is able and understand how to implement 3R	
Waste Treatment							
Waste sorting in temporary waste storage Waste collection in temporary waste storage Waste treatment in temporary waste storage Final processing in landfill	56% of waste generation can be treated	70% of waste generation can be treated	59% of waste generation can be treated	All the targets mentioned are achieved	Percentage of waste treatment increased	Waste treatment activities cover all areas and can be used by the majority of society	

3.4 Geospatial of Waste Reduction and Treatment Program in Pemalang, Central Java

One of the activities in the waste reduction program is the waste bank development. Waste banks have a role in reducing the volume of waste that is ultimately transported to landfill (Budihardjo et al, 2019; Yudiatmaja et al, 2021). The distribution of waste banks in Pemalang Regency in 2021 and 2023 is shown in Figure 3. A comparison between Figures 3a and 3b illustrates spatial changes in the availability of waste bank facilities across villages over time. Areas marked in green indicate the existence of waste bank facilities, while areas colored white indicate that the village does not yet have waste bank facilities. In addition, the red and blue dots represent the type of waste bank facility, where the red color represents the main waste bank and the blue color represents the unit waste bank.

Based on this image, it can be seen that most of the waste bank locations are spread across the northern part of Pemalang Regency, especially in the central urban area. Meanwhile, on the south side, there are few waste bank facilities, especially in areas that still have rural characteristics. This shows that the waste reduction program through new waste bank activities is focused on urban areas, while rural areas still receive less attention. From an ideal point of view, it is important for waste bank facilities to be evenly distributed throughout the village to encourage an overall reduction in waste generation (Fatmawati, 2022). Therefore, evaluating the distribution of waste banks and efforts to expand the reach of waste bank services to rural areas could be steps that need to be considered in increasing the effectiveness of waste reduction.

Comparison of image 3a and image 3b shows that there are more and more green areas. The picture and image shows that the distribution of waste bank facilities has increased in the period 2021 to 2023. data from the information system of national waste management system in ministry of environment shows that the number of waste banks in 2021 was 63 units, while in 2023 it was 95 units. This indicates that during this period, the Pemalang Regency government has attempted to increase the number of waste banks with an increase of 32 units or 33.7%.

Apart from increasing the number of waste bank units, the area of waste bank service areas has also increased. The area of waste bank services is represented by the availability of at least one waste bank unit in each village. The areas served by waste banks in 2021 will be 59 villages, while in 2023 there will be 76 villages. Even though the waste bank service area has increased, this number cannot yet serve half of the total villages in Pemalang Regency. The waste bank service area in 2023 will only cover 76 villages or 34% of all villages in Pemalang Regency. There are still 146 villages or 77% of areas that have not been

served by waste bank facilities. This shows that the Pemalang Regency government still has a heavy burden to increase the number and service area of waste bank facilities.

Recycling organic waste is also an important part of the strategy to reduce waste generation in Pemalang Regency. By contributing a percentage of 40% of the total waste generation in Pemalang Regency, organic waste is one of the main aspects that requires attention in waste management efforts. In this context, organic waste recycling activities are a strategic step to achieve waste reduction program targets. Recycling organic waste in Pemalang Regency includes composting activities and maggot cultivation. Composting activities are carried out by changing organic waste into organic fertilizer which can be reused in agricultural and plantation activities. Meanwhile, maggot cultivation is carried out by converting organic waste into protein raw materials in the animal and fish feed industry.

The distribution of composting facilities in Pemalang Regency in 2021 and 2023 is shown in Figure 4. These two Figures depict the distribution of locations and development of composting facility service areas in supporting the waste reduction program. Based on this image, the location of the composting facility is only on the north side or center of the urban area of Pemalang Regency. Meanwhile, on the south side, which is characterized as a rural area, there are no composting facilities. This is in accordance with research by Ferronato & Torretta (2019) which explains that city residents experience difficulties in processing organic waste because they do not have sufficient land to recycle waste. In contrast to urban communities, most rural communities still have land that can be used to recycle organic waste by throwing it in dug holes or dumping it on agricultural land.

Comparison of Figures 4a and 4b shows the development of the distribution of composting facilities in the period 2021 and 2023. However, the development of the distribution of composting facilities is not that significant. This can be seen based on SIPSN data, composting facilities in 2021 will consist of 20 RT/RW scale composting units, 1 compost house unit, and 1 organic processing center (POO) unit, while in 2023 they will consist of 20 RT scale composting units. /RW, 1 compost house unit, and 3 organic processing center units (POO). During this period, the development of composting facilities only increased at organic processing centers (POO) by 2 units. This indicates that the government is not focusing on developing composting facilities in its waste reduction program. In research, Septiani et al (2019) explained that recycling organic waste into compost does not have large financial benefits for the government. This could be one of the reasons why the Pemalang district government is not very interested in developing compost facilities.

Apart from waste reduction programs through waste banking and composting activities, there are also other activities aimed at effectively reducing waste generation, namely through the development of 3R TPS facilities. Previously, TPS were often only considered as temporary collection points for household waste before being transported to the landfill, without any further processing or intervention for the collected waste. This paradigm represents an old way of thinking in waste management.

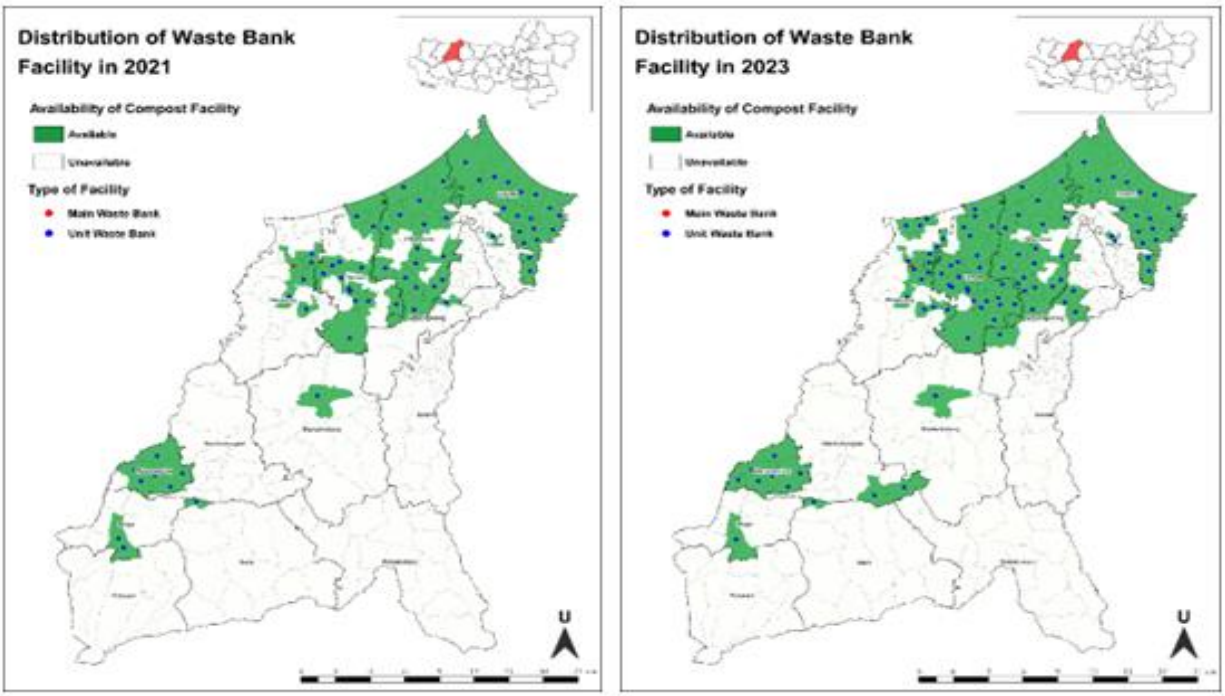

Figure 3. Waste Bank Facility Distribution in Pemalang year 2021 (a) and year 2023 (b)

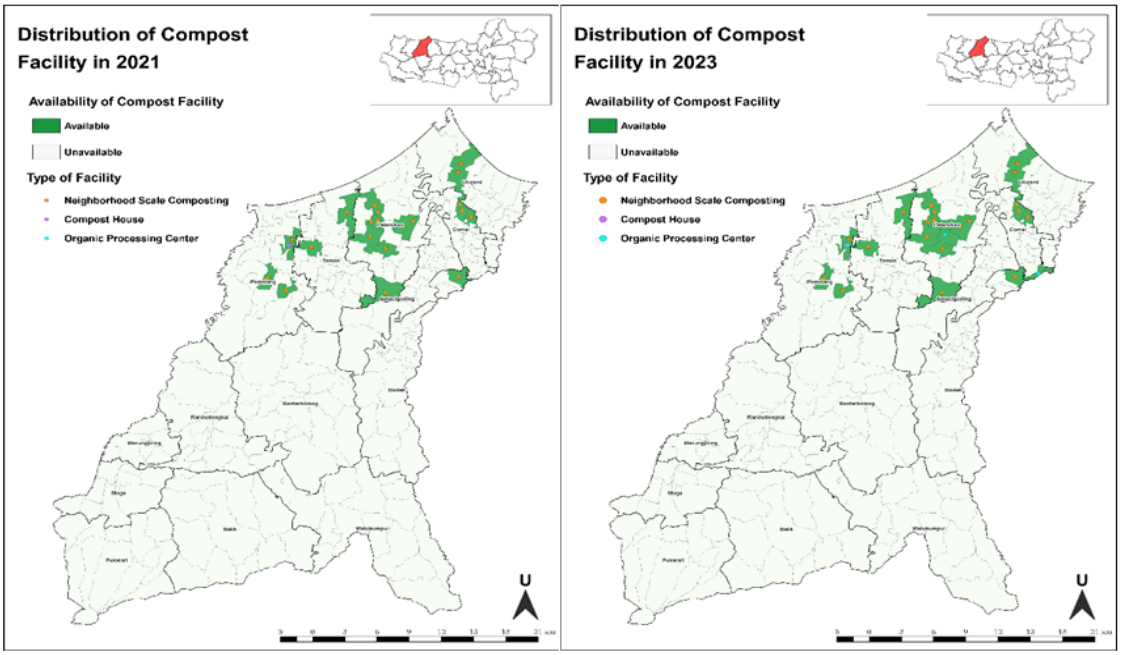

Figure 4. Composting Facility Distribution in Pemalang year 2021 (a) and year 2023 (b)

However, currently the waste management paradigm has shifted. The focus is no longer just on collection and disposal, but also on efforts to recycle waste into other materials that can be reused or materials that will not damage the environment. In line with this approach, the Pemalang Regency Government has implemented a strategy by developing waste recycling facilities in the form of TPS 3R. TPS 3R is a facility that is not just a temporary collection point, but is also equipped with infrastructure and technology to carry out the waste recycling process (Trisnawati & Agustana, 2018). Through TPS 3R, waste can be sorted, processed and recycled so as to reduce the generation of waste transported to the landfill.

The distribution of 3R TPS facilities in Pemalang Regency in 2021 and 2023 is shown in Figure 5. A comparison of Figures 5a and 5b shows the development of the provision of 3R TPS facilities in each village. In 2021, there are only 3 3R TPS units available, plus one Recycling Center facility. These four facilities are distributed in two sub-districts, namely Pemalang District and Petarukan District. However, in 2023, there will be an increase of 3 TPS 3R units with additional service coverage in Comal District.

Even though there is an increase in the number of 3R TPS facilities, this Figure does not show a significant increase in the provision of waste recycling facilities. This indicates that the Pemalang Regency government may not have fully focused their efforts on achieving the waste reduction target through the waste recycling program. Apart from that, the construction costs and operational costs of building TPS 3R are considered to take up quite a large budget. Lack of careful planning in the construction of TPS 3R can result in less than optimal facility performance, as happened at TPS 3R Citepus, Bandung Regency (Sunardi & Akiyah, 2023). This could be one factor in the government's lack of attention to developing 3R TPS facilities.

Waste management in Pemalang Regency, in accordance with the mandate stated in Regent Regulation Number 60 of 2018, also involves a waste management program. This program includes a series of activities starting from sorting, collecting, transporting, processing, to final processing of waste. Waste sorting can be done by households by differentiating waste according to its type, both organic and inorganic. To support this sorting process, the government can provide various facilities such as organic and inorganic waste bins in every household, residential areas, commercial areas, industrial areas, special areas, public facilities, social facilities and other facilities.

After sorting is carried out at the waste source, the sorted waste is then collected at the TPS. According to Pemalang Regency Regional Regulation Number 13 of 2012, the waste collection process after sorting is expected to remain segregated according to type. However, in reality, the waste that has been sorted will be mixed again during transportation so that the waste collected at the TPS is mixed waste.

To support waste collection activities, the government has provided waste collection facilities in the form of TPS as in Figure 5. From this figure, it can be observed that most of the TPS are located in the northern part of Pemalang Regency, especially in the urban center. Meanwhile, there are only a very small number of TPS facilities in the southern part of Pemalang Regency. In fact, during the period from 2021 to 2023, there are two sub-districts that do not have TPS at all, namely Watukumpul Subdistrict and Bodeh Subdistrict.

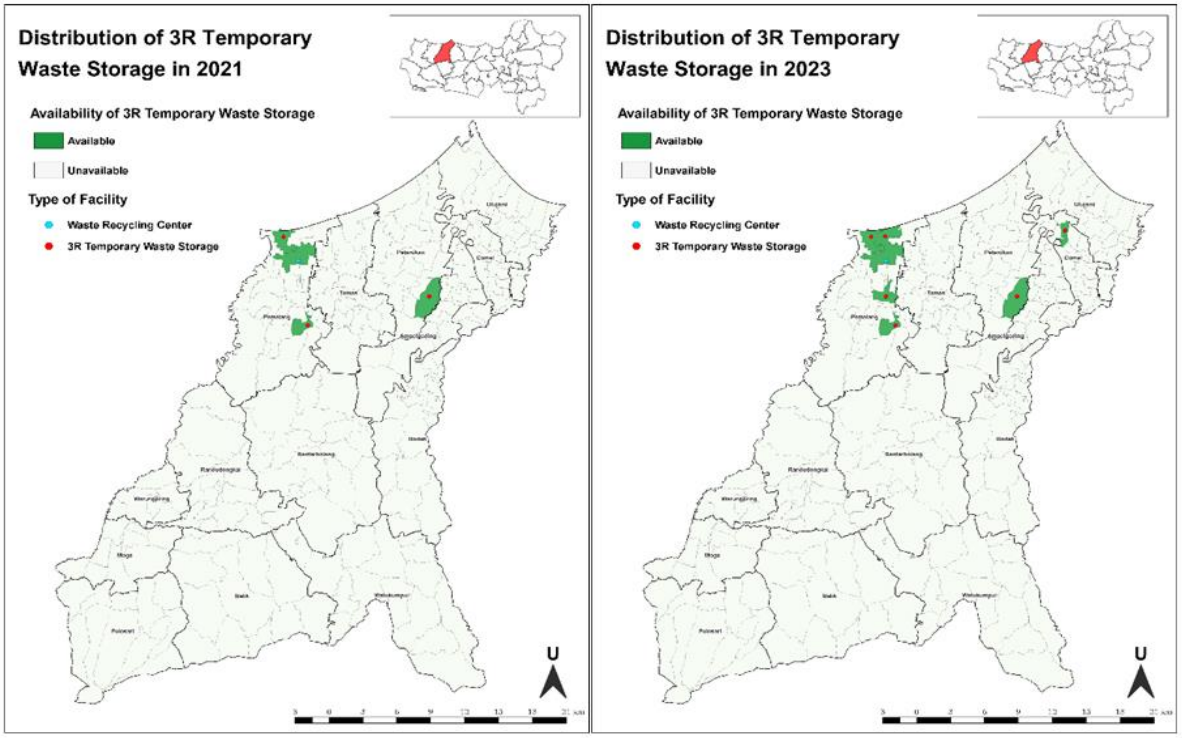

Figure 5. 3R Temporary Storage Facility Distribution in Pemalang year 2021 (a) and year 2023 (b)

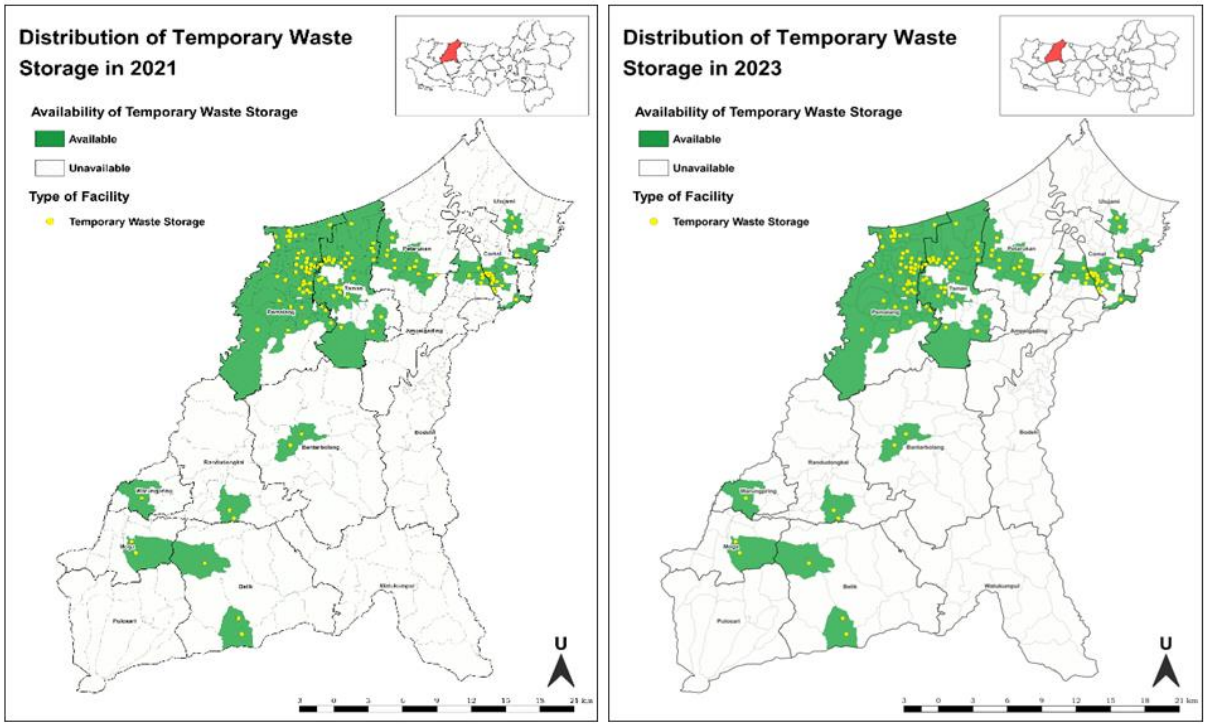

Figure 6. Temporary Storage Facility Distribution in Pemalang year 2021 (a) and year 2023 (b)

An increase in the number of TPS is needed to expand the service area of the waste handling program, especially in waste collection activities. During this period, the Pemalang Regency Government has made efforts to increase the number of TPS in various locations. Statistical data presented by the Pemalang Regency Central Statistics Agency (BPS) shows that the number of TPS in 2021 reached 116 units, while in 2023 it increased to 134 units. This figure shows that the number of TPS in Pemalang Regency has increased. The addition of 18 units indicates an increase of 15% of the total number of TPS in 2021.

Even though there will be an increase in the number of TPS in 2023, this does not cover the fact that waste collection services are not evenly

distributed throughout the Pemalang Regency area. Even though the number of TPS reached 134 units that year, their distribution was still limited to only a few villages. From the data collected, only 52 villages are served by the new TPS, while there are still 167 other villages that have not received TPS facility services.

This condition shows that the government still has a big responsibility in improving waste collection facilities, especially in the form of TPS, in most areas of Pemalang Regency. With 75% of the Pemalang Regency area still not being served by TPS facilities in 2023, strategic steps need to be taken immediately to expand the coverage of this service to areas that have not yet been reached.

The collected waste will then be transported to the landfill for final processing. Transporting waste from public facilities, social facilities, or TPS to TPA is the responsibility of the regional government. Meanwhile, transporting waste from residential, commercial, industrial and special areas to the TPS or TPA is the responsibility of the area manager. The facilities for transporting waste from the TPS to the TPA provided by the Pemalang Regency regional government are 4 units of trash trucks, 31 units of dump trucks and 4 units of arm roll trucks.

Final processing in Pemalang Regency is carried out at the Pegongsoran TPA with the amount of waste coming in being 261 tons/day. Currently in Pemalang Regency there is a waste emergency due to the closure of the Pegongsoran TPA due to the burning of the TPA. However, long before that, the people of Pegongsoran Village had demanded that the regional government of Pemalang Regency close the landfill. This demand is based on the large amount of waste that is scattered because the landfill has exceeded its waste storage capacity. The Pemalang Regency Government plans to build a new landfill in Purana Village, Bantarbolang District to deal with the waste emergency in Pemalang Regency. The TPA construction plan was discussed at the Pemalang Regency Emergency Waste Management Task Force Coordination Meeting.

4. CONCLUSION

This study utilized logic model and GIS to evaluate waste management program in Pemalang Regency. This study asess several indicators in waste management reduction and treatment. Thi study measure 2 years (2021-2023) data for mapping waste management program.

Evaluation result for waste reduction program shown 3 (three) indicator as follow 1). The number of waste banks increased by 32 units from 63 to 95 units; 2) Composting facilities increased by 2 units from 1 to 3) TPS3R facilities increased by 3 units from 3 to 6.

Evaluation result for the waste treatment program, shown Evaluation result 84.92% of waste has been handled while 15.08% has not yet. The number of TPS for collection increased by 18 units from 116 units to 134 units. GIS analysis showt that waste reduction programs are implemented mostly in urban areas. There have been no significant changes regarding sorting and transportation and Intermediate treatment. In 2023, a landfill fire occurred, indicating that the final processing facilities were not yet optimal.

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