

# Combating Urban Waste Through The Development of A City Scale Waste Bank Readiness Index

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**Abstract** - One main issue in solid waste management of densely populated cities is the short lifetime of the landfill as its final disposal. This happens because in many cities solid waste is collected from its sources without sorting and treatment prior to the disposal. A waste bank is an alternative instrument to address the issue as it reduces the amount of waste being disposed to landfills, utilising Reduce-Reuse and Recycle (3R) approach. However, currently the management of waste banks in Indonesia is undertaken sporadically. A significant reduction of waste disposal to landfills can only be achieved through integrated waste bank management at the city scale. This study aims at developing an index to assess potential waste bank in a city to be promoted as a city scale waste bank. The index developed in this study is comprised of components, indicators and sub-indicators, which are mainly taken from existing regulations and guidance in Indonesia related to waste management and bank waste. These components, indicators and sub-indicators are then given different weights based on their relative importances. At the end, as many as 3 components, 20 indicators and 84 sub-indicators are identified. Further, the results of this study will be applied to assess the readiness of 3 waste banks in cities in Indonesia, as part of the verification process of the index.

**Keywords:** waste bank, index, component, indicator, sub-indicator

## I. INTRODUCTION

Waste management paradigm in Indonesia has changed significantly with the establishment of the National Government Regulation Number 18/2008 on Waste Management [1][2]. With this regulation, the focus of waste management in Indonesia is no longer on the final disposal but has been shifted to 3R (reduce, reuse, recycle) activities: reduction in the amount of solid waste from various sources, utilisation of waste material for original or other uses, as well as the utilisation of waste materials into new products of various purposes. In order for this paradigm change to be successful, it has to be supported by various stakeholders, as well as instruments to stimulate people taking actions on 3R programs. One of the instruments that can be used is waste bank,

which is an economic instrument associated with 3R activities [3].

Known as a social engineering technique, the operation of the waste bank aims at changing the behavior of the community to contribute to the overall urban waste management. The role of the waste bank in Indonesia becomes increasingly important with the issue of the National Government Regulation Number 81/2012 on Solid Waste Management at Household Level and Alike, which requires producers of goods to use packaging that is easily decomposed by natural processes, to select raw materials that can be recycled, and to re-collect wastes from the customers for reusing or recycling [2].

As the waste bank is one component in an overall urban solid waste management, it cannot operate by its own, but should be integrated with the other components. It should also be considered as the partner for manufacturers of products for recollection of their product materials. This way, government responsibilities in solid waste management are shared. At the end, it is expected that the operation of waste banks at the city scale will reduce the volume of solid waste disposed to landfill [4].

Based on the data from the Ministry of Environment and Forestry (2012), there is an improvement of 1,136 waste banks with 96,203 customers throughout Indonesia. The highest number of waste banks is found in Malang City with 230 waste banks, followed by Surabaya, Lamongan and Bantul cities, with more than 100 waste banks. Meanwhile, the number of customers was mostly found in Malang with 19,312 customers, followed by Yogyakarta, Padang and Surabaya cities with more than 10,000 customers [5-8]. The initiation of these waste banks came from different parties, which include the community, government bodies, NGOs, political parties and private parties. Some of the waste banks formed collaborations among themselves to create a larger scale waste bank, and received fundings from donor bodies [9].

However, it is important to be noted that these community initiatives in most big cities in Indonesia are implemented sporadically without appropriate integration with their urban solid waste management [10]. In consequence, up to this stage, the reduction of solid waste in those cities is not yet significant. A more substantial reduction of the waste can only be achieved if the waste bank programs are implemented at a city scale in cooperation with local government sanitation departments. A

city scale waste bank will overcome all of the weaknesses of the existing waste bank operation and open up all of the opportunity it needed to be developed. It also will support its sustainability and its integration to the urban municipal solid waste management. The effort in waste reduction of the urban municipal solid waste management will be supported by the existence of city scale waste bank. Unfortunately, in Indonesia there is no available guidance on how to assess the performance of the existing waste banks to be developed as the city scale waste bank. The information on how good these waste banks to serve as a city scale waste bank will be very valuable. Once these waste banks meet the criteria of a city scale waste bank, they can be included in the overall solid waste management of respective cities.

This study aims at developing an index to assess existing waste banks in Indonesia to be promoted as a city scale waste bank. The study is undertaken in Bandung, one of the big cities in Indonesia, and the results of the study is expected to be applicable to other cities as well. After it is applied, the index will provide analysis of current waste bank conditions to be considered as a city scale waste bank.

## II. LITERATURE REVIEW

As indicated earlier, the National Government Regulation No. 18/2008 on Waste Management and Government Decree No. 81/2012 on Solid Waste Management at Household Level and Alike urge the paradigm changes in the waste management, through Reduce, Reuse dan Recycle (3R). However, in most cities in Indonesia the implementation of 3R has not been successful. The most prominent obstacle in implementing the 3R is the community awareness for sorting their wastes at the source (household level). One of the solutions to address these issues is through the development of waste bank. The development of waste banks can be used as a momentum to build community view and awareness towards solid wastes[2][11].

A waste bank is a part of solid waste management system, which collectively urges community to actively involve in managing solid waste. This system collects, sorts and distributes waste with economic values to various markets. In principal, the waste bank is operated by community and for the benefits of the community. Along with the reduction of waste disposed in landfill, the waste bank also potentially provides economic benefits to the community, particularly its customers. Waste banks are also in accordance with the implementation of UU No. 18/2008 with regards to sorting the solid waste at the source, as waste banks purchase waste from the customers based on different types of the solid waste. This way, the waste bank is also considered as a social engineering instrument to create better waste management in the community scale[12][13].

As indicated earlier, the city with the most waste bank is in Malang City with 230 waste banks, followed by Surabaya, Lamongan and Bantul City. In terms of the total collection of waste by the waste bank, in 2012 an average of 41.150 kg per month was collected throughout Indonesia, with the most waste collected in Denpasar with 540,749 kg of waste per month, followed by Malang, Yogyakarta, Surabaya, Bantul and Padang

with more than 100.000 kg of waste collected per month[2]. However, extensive effort is still needed to reach the national target of 20% waste reduction through 3R program. Based on current waste bank operation, obstacles in the practice of waste bank in Indonesia are:

**Facility.** In most places, the operators of waste banks cannot provide land to be used as storage area for collected waste, before the waste is sold to other parties (small or large industries). This has led the operators to limit the waste collected from customers. **Operasional.** Another issue found in the operation of existing waste bank is related to the waste sorting. There are some cases where customers do not properly sort the waste before taken to a waste bank. This has forced the operators to sort the waste, and in consequence delayed other activities. **Management.** Most waste banks were initiated by communities, which are managed on voluntary basis. To improve their performances, it is expected that in the future the waste banks should be managed on professional merits.

### *Indicator-based Assessment*

An indicator-based assessment aims at identifying indicators to measure specific phenomenon, which can be either qualitative or quantitative, or conditions of various issues. When they are regularly observed, the indicators can be used to monitor changes during an agreed timeline[14]. In many cases, these indicators are grouped to create a component, whilst at the same time some indicators might be extended into sub-indicators. These groups of indicators and/or components are called index [15]. Ideally, an index is expected to explain more than one dimensional notion that are difficult to be measured by an indicator or sub-indicator [14]. Two main important elements of developing an index are the selection of indicator (and/or component and/or sub-indicator) and aggregation of the identified indicators.

It is commonly agreed that indicators, and for some cases components and sub-indicators, are the core of an index. Thus, when developing an index, selecting indicators and their respective components sub indicators has to be prioritised[16][17]. The initial selection of indicators is mainly done through reviewing existing literatures. Later, this initial set of indicators are verified and refined through discussion with relevant key stakeholders [17]. Some criteria for selecting indicators are given by Liverman & Hanson [18] as follow: Time sensitive; a chosen indicator should be able to be monitored for certain data series. If not, related issues to the indicator(s) cannot be explained appropriately. Space or group sensitive; an indicator is expected to change when it is applied to different spaces or groups. If not, it will not be useful to measure particular issues in different conditions. Anticipatory; in relation with waste bank, an indicator is expected to predict or anticipate any issues related to waste bank in the future. It should cover not only the current issues related to waste bank, but also future concerns.

1. *Availability of threshold/reference values*; an indicator will be useless if the reference value of the indicator is not available. At one point during its application, a selected indicator will be assessed based on its relevant data. Thus, when reference value of the indicator is not available, the indicator cannot be assessed.

2. *Unbiased*; some factor might lead to biases in selecting indicators such as: previous knowledge of the index author, political interest and different context given in existing literatures. In reality, it is nearly impossible to avoid all these biases, however it is possible to be aware of the biases and put as much effort possible to avoid these biases.
3. *Data transformation appropriateness*; there are some methods available to transform data into same scale value. It is important to select appropriate method to transform data of the indicators as different methods might lead to different index values.

Another important aspect of index development is the aggregation process. In an index development, aggregation can be done in different stages as illustrated in Figure 1, assuming an index has components, indicators and sub-indicators.

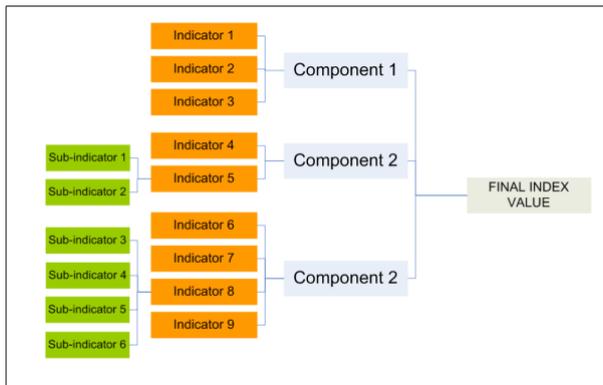


Figure 1. Illustration of Index Values Aggregation

It shows that the values of sub-indicators are combined to obtain the values of indicators. Then, the values of indicators are combined to obtain the values of components. At the end, these values of components are combined to obtain the value of the final index. This common practice might be different from other practices where the final index is directly obtained from the aggregation of its indicators or sub-indicators. For example, the value of Environmental Sustainability Index is obtained through aggregation of its indicators instead of aggregation of its components. There are mainly two main methods for the aggregation of sub-index values, they are arithmetic and geometric methods. The arithmetic method is used for indices such as Environmental Quality Index (Indeks Kualitas Lingkungan Hidup - IKLH)[19], Human Development Index (HDI)[20], Canadian Water Sustainability Index (CWSI)[21], Water Poverty Index (WPI)[22], Watershed Sustainability Index (WSI)[23] and others. Simply, this method is done by the summation of (weighted) sub-index values[14], as shown in Eq. 1.

$$I = \sum_{i=1}^N w_i S_i \quad (1)$$

where  $I$  represents the aggregated index,  $N$  is the number of indicators to be aggregated,  $S_i$  is the sub-index for indicator  $i$  and  $w$  is the weight of indicator  $i$ .

This method ensures perfect substitutability and compensability among its components, indicators and sub-indicators<sup>[14]</sup>, which means that low values of some components, indicators and sub-indicators are recompensated by high values of other components, indicators and sub-indicators. In consequence, it is quite impossible for two conditions to have the same final index value even though the indicator values for these two conditions differ significantly. For example, consider two conditions with different set of indicators. In the first condition, values of the indicators are 40 and 40 (maximum scale of 100) and in the second condition the sub-index values are 10 and 70. When the arithmetic method is used, both conditions will have the final index values of 40. The significant difference of the two indicators in the second case (10 and 70) are compensated each other to come up with the final index value of 40.

The other less common method for aggregation is the geometric method, which does not allow perfect compensability and substitutability. This method is applied through multiplication of its sub-index values, as shown in Eq. 2 [24].

$$I = \sum_{i=1}^N S_i^{w_i} \quad (2)$$

where  $I$  represents the aggregated index,  $N$  is the number of indicators to be aggregated,  $S_i$  is the sub-index for indicator  $i$  and  $w$  is the weight of indicator  $i$ . Unlike the arithmetic method, this method does not allow perfect substitutability and compensability among the components, indicators and/or sub-indicators. In consequence, if there are two cases with extreme difference in their indicator values, they will have different final index values even though their averaged indicator values are identical.

### III. METHODOLOGY

In general, the development steps of this city scale waste bank readiness index are shown in Figure 2.



Figure 2. Scheme of the Development of a City Scale Waste Bank Readiness Index

Figure 2 shows that the development of the city scale waste bank readiness index is initiated by literature study, in particular by integrating and evaluating potential indicators found in the Ministry of Environment Regulation No. 13/2012 on the Guidance for Reduce Reuse and Recycle, Report on City Scale Waste Bank published by Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH and Ministry of Public Works Regulation No. 03/2013 on the Operational of Waste Management and Handling at the Household Level. This step is of utmost important as the baseline for developing the indicators for the index. At the end of this step, potential indicators for the index are developed, which are then verified through interviews and Focus Group Discussion with relevant stakeholders.

**IV. DISCUSSIONS**

The first process of selecting indicators for the index was the identification of indicators with similar ideas from relevant regulations and guidance. Ministry of Public Works Regulation No. 03/2013 stated that there are three indicators for a waste bank as the 3R Transfer Depo that should be complied which are the area and appropriate location of waste bank and construction quality. Based on GIZ GmbH, the foundation of waste city bank in city scale has five basic components; they are the establishment, the organization, the management, the financing and business development, and the integration to the municipal solid waste. The last, from the Ministry of Environment Regulation No. 13/2012, in order to build the waste bank, it needs to have four components, which are construction quality, the management, the waste bank operation and methods. These indicators are then grouped under different

components. After this step, three components are formed: Quality of Buildings, Management System and Operational System. Under the Quality of Buildings, included are indicators of waste bank location, type of facility requirement, facilities area, storage room and office facility. Then, for each listed indicator, related sub-indicators are identified. For example, for the waste bank location indicator, related sub-indicators include: landuse compliance and legal aspect of the acquired land.

The next component is Management System, which include indicators of governance, asset, organisational structure, job description, human resources, partnerships, dissemination and promotional activities, and integration with city management on solid waste. Similar to the previous component, each indicator under this component is also accompanied with related sub-indicators. For example, for the indicator of organisational structure, the following sub-indicators were identified: director, secretary, treasurer, management division and operational division. The final component for the index is Operational System, which comprises of the following indicators: customers, waste type, operational facilities, waste management, weighing and records, and occupational health and safety. As the other two components, each indicator under this component is also accompanied by sub-indicators. For instance, for the indicator of customers, their sub-indicators are individual, community, institution, and commercial customer. The complete set of the index, which comprises of components, indicators and sub-indicators, is presented in Table 1.

<i>Component</i>	<i>Indicator</i>	<i>Sub-indicator</i>
<b>I. Quality of Buildings (33%)</b>	Waste bank location (20%)	Landuse compliance (50%); legal aspect of the acquired land (50%)
	Type of facility requirement (20%)	Storage (15%); customer area (10%); sorting and waste treatment (15%); residual area (10%); parking lot (10%); praying room (10%); water supply (15%); drainage (15%)
	Facilities area (30%)	Storage = 40% x total area (40%); customer area = 10% x total area (10%); sorting and treatment = 30% x total area (30%); residual area = 5% x total area (5%); parking lot = 10% x total area (10%); praying room = 5% x total area (5%)
	Storage room (15%)	Building (25%); wall (15%); ventilation (15%); pest-free (15%)
	Office facilities (15%)	Roof (10%); door (10%); electricity(5%); fire extinguisher (5%); building (25%); wall (12.5%); ventilation (12.5%); pest-free (10%); water supply(15%);employee room (2.5%)
<b>II. Management (33%)</b>	Governance (20%)	Legal basis (25%); financial management (25%); organisational structure (25%); renumeration system (25%);
	Asset (20%)	Percentage of operational activities (100%)

<i>Component</i>	<i>Indicator</i>	<i>Sub-indicator</i>
	Organisational structure (10%)	Director (20%); secretary (20%); treasurer (20%); management division (20%); operational division (20%);
	Job Description(JD) (5%)	JD of director (20%); JD of secretary (20%); JD of treasurer (20%); JD of management division (20%); JD of operational division (20%)
	Human resources (5%)	Relevant training(s) for employees (100%)
	Partnerships (10%)	National government (20%); provincial government (20%); local (city) government (20%); industry (20%); community basic needs supplier (water, electricity, communication) (20%)
	Dissemination and promotional activities (10%)	With government (40%); with industry (30%); with community group(s) (30%)
	Integration with city management on solid waste (20%)	Synchronised target with government (50%); cooperation with sanitation department of respective city (50%)
<b>III. Operational (34%)</b>	Customer (15%)	Individualcustomer (25%); group customer (25%); institutional customer (25%); commercial customer (25%)
	Waste type (15%)	Organic waste(30%); anorganic waste (20%); organic and anorganic waste (50%);
	Operational facilities(15%)	Computerised record facility (20%); weighing facility (20%); sorting facility (20%); service facility (20%); operational vehicle (10%); waste treatment (such as plastic/cardboard )(10%)
	Waste management (12.5%)	Scheduled opening hours (20%); waste collection timetable (20%); waste sorting guidance for customer (15%); clear rules on waste types to be accepted (15%); advance sorting by employee (10%); re-selling to industries (20%)
	Weighing and records (12.5%)	Minimum weight (30%); clear price (35%); computerised records (35%)
	Health and safety (15%)	Clear health and safety rules (25%); standard procedures for all activities (25%); the use of protective equipments(mask and gloves at the least) (25%); emergency procedure (25%)
	Monitoring and Evaluation (15%)	Monitoring and evaluation implementation (50%); follow up to monitoring and evaluation (25%); records on evaluation and monitoring (25%)

**Weights and Points**

*Weights*

All three selected components, which are Quality of Buildings, Management System and Operational System, are then given equal weights due to their equal importance. However, to simplify the calculation for rounding up to 100%, one of the components is given a slightly higher weight in percentage.

Quality of Buildings, Management System and Operational System are given 33%, 33% and 34% of the total 100% respectively.

Further, each indicator and sub-indicator under all components is also given weight, respective to its contribution to the overall index value. For example, the storage room area sub-indicator is considered more importance and provides more contribution to the readiness index compared to residual area sub-indicator. This is justified by the fact that storage room requires more area

to store the waste before they can be distributed or undergo further treatment, compared to the residual area. Thus, the storage room area sub-indicator is given higher weight than the residual area sub-indicator. Similar analysis was undertaken for all indicators under the same component, as well as all sub-indicators under the same indicator.

#### Points

##### Maximum Value of Component

The maximum value of a component is obtained from the multiplication of component weight and the value of 100, as shown in the Eq. 3.

$$\text{Maximum value of component} = \text{\% of component weight} \times 100 \quad (3)$$

##### Maximum Value of Indicator

The maximum value of an indicator is obtained from the multiplication of indicator weight and the maximum value of its respective component, as shown in Eq. 4.

$$\text{Maximum value of indicator} = \text{\% of indicator weight} \times \text{maximum value of component} \quad (4)$$

##### Maximum value of Sub-indicator

The maximum value of a sub-indicator is obtained from the multiplication of sub-indicator weight and the maximum value of its respective indicator, as shown in eq. 5.

$$\text{Maximum value of sub-indicator} = \text{\% of sub-indicator weight} \times \text{maximum value of indicator} \quad (5)$$

##### Minimum Value for the Readiness Index

The minimum value for a waste bank to be considered ready to be developed as a city scale waste bank is to have the minimum total value of the index 55.20. This minimum value is obtained from the addition of maximum values of indicators with the highest value in each component (9.9 of the Quality of Buildings component, 19.80 of the Management component and 25.50 of the Operational component).

##### Total Readiness Index Value Calculation

In this index, it is proposed that the final index value is calculated using the arithmetic method. Thus, the final index value will be obtained by simply adding the value of sub-indicators to obtain the value of indicators. Then, these indicator values are added together to obtain the value of the components. Finally, the readiness index is obtained by adding the values of all the components. For example, consider a waste bank which is located in a legal acquired land, as well as complied to all landuse regulations for the land. Thus, related to the waste bank location indicator (under the component of Quality of Buildings), the calculation of the sub-indicators values of the waste bank will be as follow. For the sub-indicator

of landuse compliance, as it complies with all landuse regulations, then it is given the maximum value for that sub-indicator:

$$\text{Land use compliance} = 50\% \times 6.6 = 3.3$$

Similarly for the sub-indicator of legal aspect of the acquired land, as it follows all related regulations, then it is given the maximum value for that sub-indicator:

$$\text{Legal aspect of the acquired land} = 50\% \times 6.6 = 3.3$$

Once all the values of the sub-indicators are obtained, the value of respective indicator (in this case the value of waste bank location indicator) is calculated by adding the values of its sub-indicators. Thus, in this example, the value of waste bank location indicator is calculated as follow:

$$\begin{aligned} \text{Waste bank location} &= \sum \text{land use compliance} \\ &+ \text{legal aspect of the acquired land} \\ &= 3.3 + 3.3 \\ &= 6.6 \end{aligned}$$

Further, to calculate the component value of the respective component, which is the Quality of Buildings component, the values of all indicators under the Quality of Building component are added together. For example, the values of other indicators (type of facility requirement, facilities area, storage room and office facilities) in the example are 5.5; 8.0; 4.5 and 4.2 respectively, then the value of the component is:

$$\begin{aligned} \text{Quality of Buildings} &= \sum \text{sub-indicator values} \\ &= 6.6 + 5.5 + 8.0 + 4.5 + 4.2 \\ &= 28.8 \end{aligned}$$

Therefore, in this example, the selected waste bank will receive the value of 28.8 of the maximum value of 33 for the component of Quality of Buildings. Then, similar to the calculation for this component, the values of the other two components are also calculated. Hypotetically, the values for the other two components (Management and Operational components) are 30 and 27, then final value of the readiness index can simply be calculated as follow:

$$\begin{aligned} \text{Readiness Index Value} &= \sum \text{component values} \\ &= 28.8 + 30 + 27 \\ &= 85.8 \end{aligned}$$

## V. CONCLUSIONS

1. The development of a city scale waste bank readiness index, which will be used to assess the readiness of a waste bank, is completed in this study through integration of indicators adopted from different regulations and guidance
2. The completed index has 3 components, 20 indicators and 84 sub-indicators, which each component, indicator and sub-indicator is assigned weight based on its importance
3. Interviews with stakeholders show that the index is important and needed by waste bank manager, in order to improve waste bank performance
4. To check its applicability, this completed index needs to be tested through application of the index in various waste banks in different cities

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