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REVIEW OF THE INFLUENCING FACTORS OF INTEGRATED WASTE MANAGEMENT

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ABSTRACT: Solid waste management (SWM) in various cities around the world is still a serious and complex problem. Currently, SWM causes problems not only in an environmental context but also in social and economic contexts. Therefore, integrated waste management (IWM) is an option that needs to be explored in municipal SWM. In this regard, it is necessary to develop models of an IWM system to integrate the formal system (government) with non-formal systems (informal sector/IS and community-based activity). To integrate all three groups' roles in an integrated system, as theoretically there are 59 factors that influence IWM. However, not all factors are relevant to the implementation in Bandung municipality because every city and country has different situations and priority problems. For the case in Bandung municipality, based on studies, there are only 17 factors that influence IWM, i.e. waste generation, infrastructure, handled waste, reduction of waste, residual handling, final processing site, population/source of waste, mind-set and lifestyle, socialisation, recognition of IS, organisation of IS, clarity for the role of all stakeholders, accessibility of waste, quantity and quality of recyclable waste, price of recyclable material, waste picker income, and incentives or financial loans.

Keywords: Recycling, Informal enterprise sectors, Community-based, Waste bank

1. INTRODUCTION

Waste is one of the problems encountered in relation to environmental management. Waste is a logical consequence of the progressive increase in the of the population, especially in urban areas due to urbanization, as well as the problems of industrialization and people's lifestyles that contribute to the generation rate of waste [1]–[4]. Some of the problems faced in developing countries in particular, in relation to the problem of waste include: the level of service is low, financing is still low, poor environmental controls, and inadequate institutional understanding of an increasingly complex system [5]. Rivers and other water resources also suffer as a result of waste disposal from existing activities on their banks [6]. Domestic and non-domestic activities generate waste which is discharged into urban rivers [7].

The problem of waste today is no longer a single issue that considers waste as a waste material, but also deals with other issues such as public health, aesthetics, land use, natural resource management, and even economic activities [8]–[10]. Therefore, it creates the idea of certain economic types of waste management, where the waste is not only an environmental issue but also a source of money [11]. The phenomenon of waste pickers, collectors, and agents taking certain types of waste to be sold to the recycling industry is an indicator of waste as a resource [12]. In Indonesia, there are groups of people who collect recycled materials for the waste savings system, cooperation unions, and health insurance, which are called waste banks.

Due to the more complex conditions of waste management, the integrated management system is required. Therefore, the concept of integrated waste management (IWM), integrating the ecological, economical, and social concepts, have become the choice that is often used for waste management in various countries [13]–[15]. Based on the actors, essentially the IWM is integrated with formal system activity (government), IS enterprise activity, and community-based activity of solid waste management. These three groups of actors are influenced by various factors. This paper examines the factors that influence integrations of formal systems (government), IS enterprises, and community-based activities in the IWM.

2. CONCEPTUAL OF IWM

The IWM concept is theoretically very diverse, but nevertheless, the general characteristics are as follows:

a. The combination of waste management from the waste sources to final treatment [13], [14], [16].
b. The combination of the ecological and economic concepts [17].

c. The integration of the waste management hierarchy with a direct impact such as transportation, collection, final disposal site (TPA), as well as the impact of indirect energy and material use [18].
d. Any involvement of various stakeholders [19].
e. Aim to reduce the amount of waste dumped in landfills [16].

For IWM, with regard to waste management from upstream to final treatment, there are three keywords; waste reduction/materials removed, reuse of waste that can still be exploited, and waste recovery both in terms of materials (recycling and composting) and for energy [13]. In relation to the IWM paradigm, especially in developing countries, it is necessary to balance the three dimensions: environmental effectiveness, social acceptability, and economic affordability [20]. To reduce environmental impacts and to save costs, the IWM system must be integrated (in the case of waste material, waste sources, and waste treatment), market-oriented (for example, energy and material that can be used by the end user), and flexible for continuous improvement [20]. The IWM system needs to be tailored to the local community of interest, both from the perspective of stakeholders and the needs of the local context (ranging from technical issues such as waste characteristics to cultural, politics, social, economic, and institutional environments), and optimization [20].

3. FACTORS AFFECTING OF IWM

Previous studies on the development of IWM using the systems approach mentioned by Marshal [20] showed that the IWM paradigms are influenced by three main factors, i.e., environmental effectiveness, social acceptability, and economic affordability. Marshal [20] identified seven factors (contexts) in IWM development, i.e., environment (1), politics (2), institutional (3), social (4), cultural (5), engineering (6), and economic (7). This study is still discussed in relation to the factors that influence the IWM. For example, for environment factor can be detailed for specific issues like the amount of waste generation, capacity of the handling system, treatment of waste, etc.

Research has been carried out on the integration efforts between the IS and the formal system (government) in Bandung City, especially the IS in intermediate disposal, called *TPS 3R* [21]. It proposed four alternatives, namely: facilitation of the formal system to the informal enterprises sector (8); integration between the formal system and waste pickers, involving waste agents (9); payroll application for the informal integration system and waste pickers (10); and consolidation of the role of formal system (11). Based on these studies, the facilitation of formal systems to the informal enterprise sector is the alternative chosen by the IS [21]. However, these studies have not shown how to integrate the IS as a whole, because IS activity is not only affiliated with *TPS 3R* but also with community-based business.

Factors that influence the elements of waste management systems, according to Guerrero [19], are divided according to environmental, economic, and social aspects, consisting of factors that affect individual elements and the whole system. Factors affecting the individual elements consist of generation and separation (12), collection, transfer and transport (13), treatment (14), disposal (15), and recycling (16). The factors affecting the whole waste management system consist of technical (17), environmental (18), financial and economical (19), socio-cultural (20), institutional/ organizational (21), and political/legal (22) [19]. This study describes the factors associated with a complete IWM. However, every city and country may have a different situation, regarding which factors are the most important and which are less important.

Recycling activity is an important part of the IWM system [22]. The success of recycling in the IWM system is influenced by several factors, such as the organisation of the IS (waste pickers, collectors, agents) (23), encouragement of the recycling market (24), increased professionalism in recycling companies (25), financial support for recycling (26), waste pickers' collection and recycling business in the surroundings (27), the existence of drop-off and buy-back centres (28), the distance to the bring bank (29), collection of recyclables supported by companies (30), efficiency of collection system (31), and presence of low-cost recycling technologies (32). In Indonesia, and in many developing countries, most recycling activity is done by the IS. The research can't separate which factors influence the IS, and which factors influence the formal system.

Taiwo [23] mentioned that sorting at the source of the waste is very important in applying the IWM concept. The IWM system also needs to be supported by the environmental education of the citizenry and information campaigns (33), home composting as part of environmental campaigns (34), and reuse and recycling campaigns at the source (35). However, the research did not explain in detail how the concept was integrated into operations since the proposed idea is still normative.

In relation to the integration of the informal enterprise sector as a part of recycling activity in the formal system of waste management, social inclusion is very important [24]. According to Sembiring [24], the conceptual approach refers to five factors (forms of capital): financial capital (36), physical capital (37), human capital (38), public infrastructure capital (39), and social capital (40), as a precondition of social inclusion.

However, the above view does not discuss the mechanism of IS involvement in the formal system (government) of waste management. The value of physical capital may not fall entirely on the material price because the value of waste materials tends to be lower than the initial material as feedstock. The implementation of incentives imposed on producers is another alternative for financial strengthening for the IS, which is the extended producer responsibility (EPR) program.

Medina [3] considered the importance of waste pickers as a business actor of the IS, and as a part of IWM. Therefore, waste picker activity should be supported, especially in terms of: legalising the activities of waste pickers (41), national policy to encourage recycling (42), supporting the establishment of waste pickers as small and medium business (43), enabling the legal and institutional standpoint of their existence and function of community-based waste collection (44), allowing for financial loans for community-based waste management (45), and using micro-credit schemes to create jobs and reduce poverty (46).

IWM system can be integrated with formal sector, informal business sector and the community. A comprehensive study on the influencing factor of the IMW system development can be derived by the interaction between these sectors. Velis [25] identified many factors related to the integration of the formal system and the IS. These factors (Velis [25] called them intervention points) are related to three important interfaces, namely: the waste management interface, material interface and value chain, and social interface; and one organization and empowerment i.e. enabling actions. In the waste management interface, there are four factors (groups of interventions), namely: access to waste (47), recognizing the role of the IS in SWM (48), protecting public health and the environment (49), and strengthening interfaces (50). In the materials and value chain interface, there are three factors (groups of interventions), namely: improving the quality of materials for recycling at their source (51), adding value to the secondary raw materials/products sold (52), and improving linkages along the value chain (53). For the social aspects and interfaces with society, there are three factors (a group of interventions), namely: facilitating recognition and acceptance of the IS (54), work around children, education, and gender equality and inclusivity (55), and occupational health and safety (56). Related to enabling actions— organization and empowerment, there are three factors (groups of interventions), namely: organization of the IS (57), financial viability (58), and capacity building (59). Summarises the overall analytical framework and typology of intervention between three interfaces i.e. solid waste management (formal system), material and value chance interface (IS system) and social interface (social system) can be shown at Fig. 1.

Based on the above view, IWM is basically a waste management system that takes into account three important dimensions such as environment, social, and economic dimensions. These three important dimensions are important factors for realizing the sustainable integrated waste management system.

4. CASE STUDY OF BANDUNG MUNICIPALITY

4.1 Waste Management System by Formal System (Government)

Based on the city regulation of Bandung City No.8/2016 on the Establishment and Composition of Organisations of Bandung Municipality, the formal institution managing the waste in Bandung City is the Office of Environmental and Cleanliness Services (DLHK). For operational activities, especially collecting from temporary disposal sites, delivery to the final processing site, and street sweeping activities, there is a designated Cleanliness Regional Company (PDK). For final processing, the site cooperated with West Java Regional Waste Management Agency (BPSR).

Operational techniques of waste management in Bandung City have been regulated by Law No. 18/2008, which includes two things, namely reduction and handling. Reductions consist of prevention efforts (reduce), reusing, and recycling. Meanwhile, waste handling includes separation, collection, transportation, processing, and disposal.

Waste handling activities start with the sorting of waste at source. Sorting of waste at source is especially important to support the reuse and recycling programs. Based on classification and composition of waste, i.e. organic (63%), recyclable (23%), residual & hazardous (14%), estimation of waste generation in Bandung City in the last five years as shown in Table 1.

Table 1: Waste Generation in Bandung City

Year	Waste generation (ton/day)			
	Total	Organic	Recyclable	Residual
2013	1.475	929	339	207
2014	1.482	934	341	208
2015	1.489	938	342	208
2016	1.494	941	344	209
2017	1.500	945	345	210

Source: Calculation

The financial demands of waste management in Bandung municipality increase year by year. The cost during 2015 was IDR 110.3 billion, or an increase of 26.68%, in 2016 it was IDR 146.2 billion, or an increase of 24.56%, 2017 has been set at IDR 158.56 billion, or an increase of only 8%.

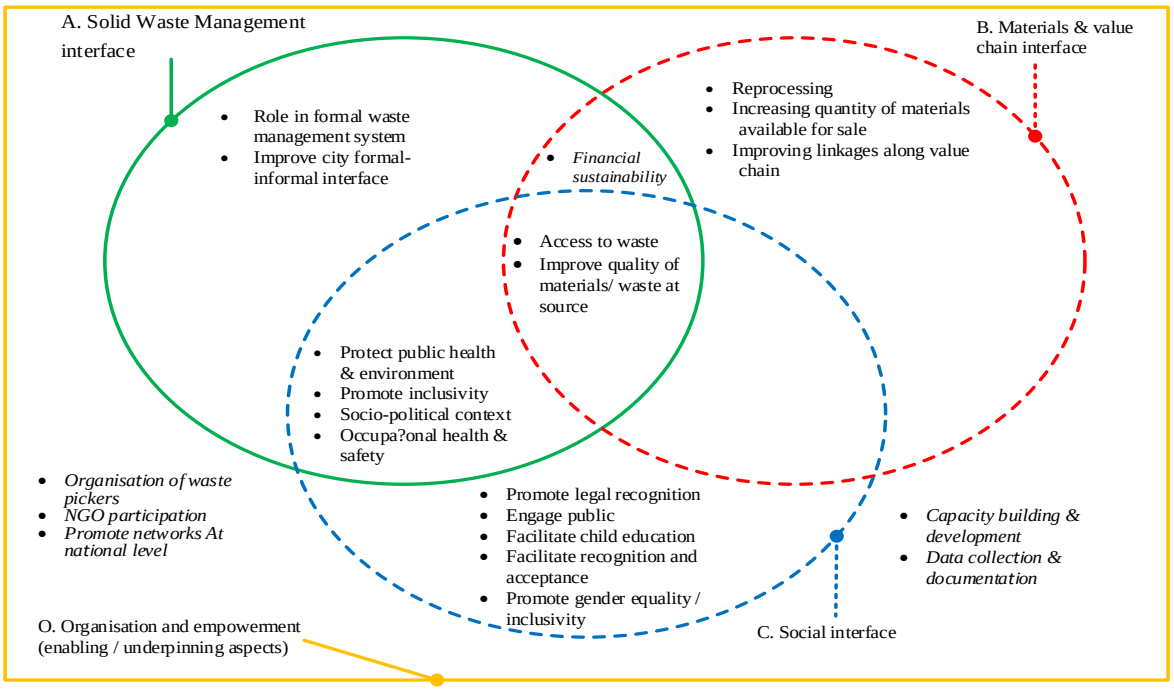

Fig. 1: Summarises the overall analytical framework and typology of intervention between three interfaces:. solid waste management (formal system), material and value chance interface (IS system) and social interface (social system) [25].

The financing of the Bandung waste management comes from the Bandung City Government (BCG) budget and non-government fund. BCG has increased from year to year. In 2016, the budget from BCG was IDR 105 billion, or an increase of 18.24% from the previous year, which was only IDR 88.8 billion. For 2017, it has been set at IDR 125 billion rupiah, an increase of 19%. The funding allocation consists of the cost of transportation (40%), street sweeping (26%), public administration (12%), expenses for the final disposal site (10%), invoice expenses (9%), and other main expenses (3%).

4.2 Waste Management System by Non-Government Organisations

4.2.1 Informal Sector in SWM

The waste management in Bandung municipality is carried out not only by government agencies, in this case, the Bandung SWM Company—an institution formally appointed by the government, but also by the IS. The Bandung SWM Company has a mission to manage waste as part of the environmental program, while the IS exploits the economic potential of the waste [12], [26]. The existence of the IS in waste management is a common phenomenon in developing countries, where they collect certain types of waste as recycled materials [26]. The presence of the IS in the community, especially in urban areas, is also not free from the problems of urbanization and urban unemployment, because waste can be a solution for making a living [12].

The existence of the IS indirectly contributes to the reduction of waste going into final disposal sites. In its activities, the IS generally establishes strong business networks. The most upstream positions are waste pickers. Generally, the waste pickers who pick up waste are divided into three groups: (a) the waste pickers who collect waste house to house, by taking the waste from the trash cans in front of houses, roadsides, or public facilities; (b) the waste pickers who usually collect the waste at temporary disposal sites; and (c) the waste pickers who usually collect at final disposal sites. Generally, the waste pickers are under the coordination of collectors to accommodate and purchase waste materials [24]. The collectors then sell the waste materials to specific agents, such as PET plastic, paper, metal, and many more. The agents then treat the waste, typically into semi-finished materials ready to be processed by the recycling industry.

Although the existence of the IS contributes to the reduction of waste and unemployment, in the social context it is often ignored or marginalized. Generally, the waste pickers are migrants, and their existences are often considered to be a social problem because they are not settled and live in abandoned places [12]. Another characteristic of the IS in waste management is unlisted business ventures, set to work individually or as groups of small businesses [24]. The informal enterprise sector is also synonymous with intensive low-

income labor and simple technology [10], and is often regarded as a sordid and disgusting effort [26].

4.2.2 Community-based 3R activity

In addition to the inclusion of the IS, waste management in Bandung municipality also involves the community. Community linkages in waste management involve two things: (a) society as a producer of waste that generates both heaps in quantity and waste characteristics [27], and (b) related to participation in SWM individually, or as a group [28]. Based on the research, the role of society in waste management is very important, particularly in relation to human behavior as the key to sustainable SWM [29].

The role of Indonesian communities in SWM is regulated by Law No.18/2008 verse 12, which is divided into obligatory and voluntary, as follows: "Everyone in household waste management and the same kind of household waste is mandated to reduce and handle waste problems with environmental insight". Meanwhile, based on Indonesia government regulation No. PP. 81/2012, verse 10 mentioned: "Everyone is obligated to reduce and to handle waste". According to this government regulation, a person is an individual, group of people, and/or legal body. Therefore, the community could be meant as an individual in the home, or a group of people such as business, office, school or university, public facilities management such as a hospital, and so on. The obligatory role of the community as a waste producer is the sorting of waste into its types (Government Regulation PP No.81/2012, verse 17).

Besides the compulsory role, the role of community participation could be realized in voluntary form, and government partners as formal management or an appointed authority to manage the waste. The voluntary activities and individual partners in the waste reduction effort could, among others, be done through organic composting, depositing valuable economic trash at the local waste bank, or donating to the waste pickers.

4.3 Factors Affecting IWM in Bandung City

There are 59 factors identified from the previous study. These factors were then being used as the main topic in an FGD involving all stakeholders. The discussion gives 17 factors as the high priority aspects in managing solid waste which can affect the IWM of Bandung municipality. Those factors classified as formal system, IS system and social system. The formal system consists of (1) waste generation, (2) infrastructure of IWM, (3) handling of waste, (4) reduction of waste, (5) residual handling (mixed waste), and (6) final processing site (TPA). The social system consists of (7) waste generation, (8) infrastructure of IWM, (9) handling of waste, (10) reduction of waste, (11) residual handling (mixed waste), and (12) final processing site (TPA). IS system consists of (13) accessibility of waste, (14) amount and quality of recyclable waste, (15) price of recyclable material, (16) waste pickers' income, and (17) incentive or financial loans. Interaction among those factors in IWM and related with the master plan of SWM shown at Pig. 2. Percentage of correlation among environment, social and economic dimension with each factor based on the discussion were conducted of the focus group discussion are shown at Table 2, Table 3 and Table 4.

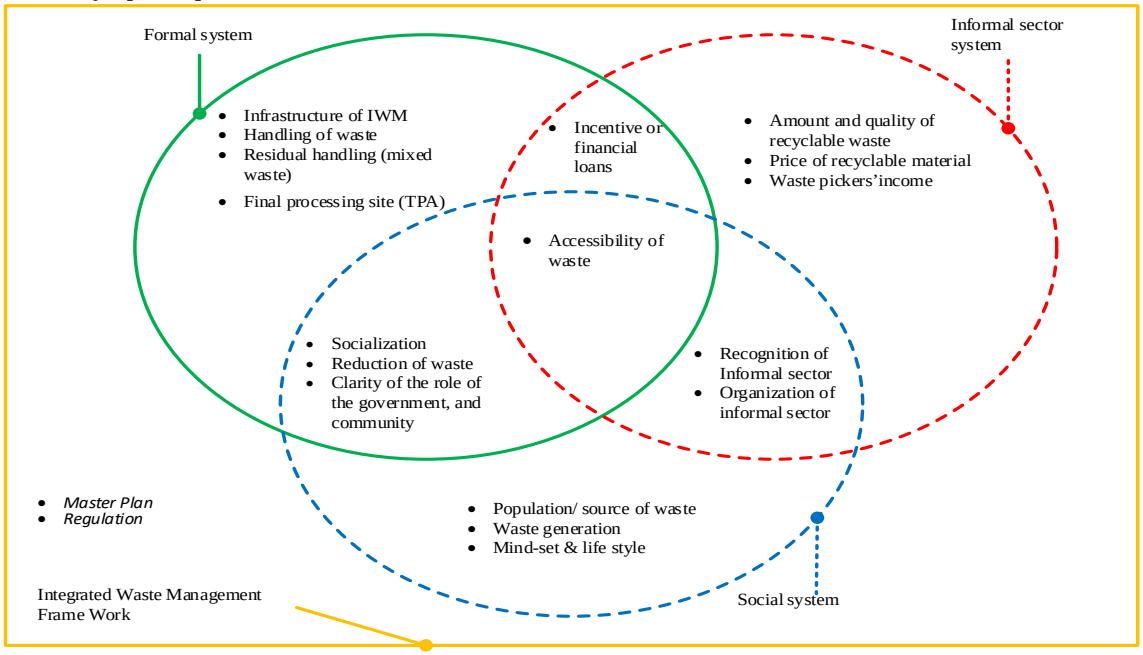

Fig. 2: Factors Affecting of Bandung IWM

Table 2: The factors influencing Environmental Dimension of IWM

Important factors for IWM, theoretically	Justification and discussion	Important factors	Social Relation	Economic Relation
Environment; engineering; generation and separation; collection, transfer and transport; treatment; disposal; recycling; technical.	From the environmental perspective, the most important factor in Bandung City SWM is related to waste generation, which will encourage city government budgeting. SWM in Bandung City is based on regulations consisting of reduction and handling.	Waste generation	40 %	60 %
		Infrastructure of IWM	20 %	80 %
		Handling of waste	20 %	80 %
		Reduction of waste	90 %	10 %
		Residual handling (mixed waste	70 %	30 %
		Final processing site (TPA)	60 %	40 %

Table 3: The factors influencing Social Dimension of IWM

Important factors for IWM, theoretically	Justification and discussion	Important factors	Environ-mental Relation	Economic Relation
Politics; institutional; social; cultural;consolidation of the role of the formal system; socio-cultural; institutional/organisational; political/legal; organisation of the IS; environmental; education of citizenry and information campaigns; home composting as part of environmental campaigns; reuse and recycling campaigns at source; human capital; social capital; legalising the activity of waste pickers; national policy to encourage recycling activity; enabling the legal and institutional standpoint of the existence and function of community-based waste collection; recognising the role of the IS in SWM; protecting public health and the environment; strengthening interfaces; facilitating recognition and acceptance of the IS; work around children; education, gender equality and inclusivity; occupational health and safety; capacity building; and organisation of the IS.	The social dimension is the most complex of SWM. Many factors, which are identified in previous research are similar to one another. In Bandung municipality, the important factors of SWM consist of two things, i.e., the community as a waste source, and the community as the informal business sector of recycling. In the community, one important thing is the mind set of waste, and in the IS one important thing is the recognition of their activities as part of waste management, both socially and politically.	Population/ source of waste	50 %	50 %
		Mind-set and life style	60 %	40 %
		Socialisation	70 %	30 %
		Recognition of IS (social and political)	70 %	30 %
		Organisation of IS	50 %	50%
		Clarity of the role of the government, social/ community, and IS	50 %	50 %

Table 4: The factors influencing Economic Dimension of IWM

Important factors for IWM, theoretically	Justification and discussion	Important factors	Environ-mental Relation	Social Relation
Economic context, facilitation of the formal system to the informal enterprise sector, integration between formal system and waste pickers involving waste agents, payroll application for the informal integration system and waste pickers, financial and economical, encourage the recycling market, increase professionalism in recycling companies, financial support for recycling, waste pickers' collection and recycling businesses in the surroundings, existence of drop-off and buy-back centres, distance to the bring bank, collection of recyclables supported by companies, efficiency of the collection system, presence of low-cost recycling technologies, financial capital, physical capital, public infrastructure capital, supporting the establishment of waste pickers as small and medium businesses, allowing for financial loans for community-based waste management, using micro-credit schemes to create jobs and reduce poverty, improving the quality of materials for recycling at their source, adding value to the secondary raw materials/products sold, improving linkages along the value chain; access to waste; financial viability.	Similar to the social dimension, the economic dimension of IWM is very complex. The complexity of the economic dimension is related to the new paradigm that waste is not only an environmental problem but is also an economic problem. Many people in Indonesia, especially in Bandung municipality, has turned to waste as an income source, i.e. waste pickers and their networks. One important aspect of this dimension is how to increase the quantity and quality of recyclables which can be collected, and how to get equal income between each actor.	Accessibility of waste	20 %	80 %
		Amount and quality of recyclable waste	20 %	80 %
		Price of recyclable material	20 %	80 %
		Waste pickers' income Incentive or financial loans	20 %	80 %

5. CONCLUSION

Based on the results of this study, the following can be concluded:

a. Integrated waste management between government and non-government (informal enterprise sector and community) bodies is needed to overcome the waste problem in Indonesia, especially in Bandung City.
b. Integrated waste management can be achieved not only through environmental approaches, but also social and economic approaches.
c. Roles can be played by (i) government—design the waste management system, prepare the

necessary infrastructure, and process the residue, toxic and hazardous waste; (ii) IS—collect and manage the waste to become recycled material; (iii) the community—sort the waste at source, support the collection of recycled waste, and process the organic waste.

d. To integrate the three actors (government, IS, community) there are 17 factors that must be managed, because they will affect the performance of waste management, namely: waste generation, infrastructure, handling of waste, reduction of waste, residual handling, final processing site, population/source of waste, mind-set and life style, socialisation, recognition of the IS, organisation of the IS, clarity of the role of all stakeholders, accessibility of waste, quantity and quality of recyclable waste, price of recyclable material, waste pickers' income, and incentives or financial loans.

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