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Creating Alternative Model to Developed Municipal Solid Waste Management Pratices for Local Governments Organization with Analytical Hierarchy Process

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Abstract

This study aimed to find factors used in the selection of appropriate waste management systems and guidelines of Lam Ta Sao municipality, Lamtasao town municipality, Ayutthaya province, Thailand to create a choice of project formats that guide the future of municipal solid waste development. The Analytical Hierarchy Process (AHP) is used to analyze important factors and the results of prioritization are used to determine guidelines for creating final municipal solid waste management system options. The study found that personnel and cognitive factors have the highest priority (14.95%), followed by cooperation and process factors (14.34%), area conditions factors (12.90%), strategic waste management support factors (11.03%), economic factors (10.36%), social conditions factors (9.56%), waste management systems factors (8.53%), personnel potential factors (8.38%), budget factors (5.14%) and material factor (4.81%) respectively. The results of prioritizing factors can be used to create alternative models to develop waste management guidelines, which can be divided into 5 characteristics: (1) Options for determining personnel development guidelines. (2) Choice of various methods and processes for waste disposal to support the disposal of each type of waste. (3) Appropriate waste management options through participatory processes. (4) Options for setting waste management guidelines in multiple situations with a spatially integrated method and (5) Choice of concepts and working principles that are consistent with the waste management strategy. The factors obtained from this study can be used as the main guideline for selecting a waste management model in the study area. Other related spatial data can also be added as supplementary data for determining the other necessary details. However, this study still requires the use of many working mechanisms, especially those of the government sector. Moreover, this study also requires the use of up-to-date studies of all dimensions of data to be able to develop better efficiency.

Keywords : waste management; Analytic Hierarchy Process; alternative model

Introduction

At present, the waste management model that is often chosen in various areas is usually chosen according to the characteristics of the area in which particular activity is the only main activity and there are not many choices to choose. General methods include generally area where solid waste categorized into agricultural waste, municipal waste, industrial waste, house hold waste, and special waste (e-waste, medical waste, plastic waste, and construction waste) [1]. All around the world solid waste management is a challenge for the cities' authorities in developing countries mainly due to the increasing generation of waste, the burden posed on the municipal budget as a result of the high costs associated to its management, the diversity of factors that affect the different stages of waste management and linkages necessary to enable the entire handling system's functioning [2]. Most developed countries have effectively implemented the solid waste management (SWM) hierarchy and are now focusing heavily on reducing, reusing, and recycling of MSW. On the other hand, SWM has become very serious in low-income and low-middle-income countries because most of the MSW are open dumping and most countries are dependent on inadequate waste infrastructure [3]. The amount of municipal solid waste will rapidly increase in each area or in each city and it will inevitably affect the various aspects, especially in areas which have more people and many activities. These wastes have a negative impact on humans and the environment. There are difficulties in managing the environmental impact. Spatial management is therefore an important factor in solving environmental problems [4].

The environmental quality situation in Thailand in 2020, it was found that the solid waste situation generated was approximately 25.37 million tons, a decrease of 4% from 2019. Hazardous waste from the community generated approximately 658,651 tons, an increase of 1.6% from 2019. Infectious waste was generated at 47,962 tons, a decrease of 10 percent from 2019 in which 8.36 million tons of waste has been reused. Solid waste properly disposed was 9.13 million tons. 7.88 million tons of improperly disposed solid waste and 4.25 million tons of residual waste were classified, according to management, as being usable by 33%, correct disposal by 36% and incorrect disposal by 31.1%. Bangkok, the capital city of Thailand, has given importance to waste management from the past to the present. It has been found that the densely populated capital uses a large amount of budget to manage solid waste [5]. The above information, it is shown that the government has to spend a large amount of money to manage the community solid waste problem. Budget expenditures are for development and normal operations according to the classification by work type (2012-2021) of the National Statistical Office in the Government Finance Statistics (GFS) standards of 2001. In 2021, the environmental budget amounts to 16, 143.4 million baht. Preparation of annual expenditure budget for fiscal year 2020 of the Budget Office for fiscal year 2021. The government has given importance to carrying out missions to drive the national strategy according to the master plan. National strategies and government policies have been established with the goal of reducing inequality, promoting the quality of life, strengthen the domestic economy to create development while protecting the environment. This creates a balanced development in terms of economy, society, culture, security, natural resources and the environment. In waste management, every country, especially developing countries including Thailand, is facing waste management problems. This is because, in many areas, it was found out that there was a problem of residual garbage. This will cause a large amount of garbage to remain in the area and increase every year, causing the problem of garbage overflowing in the city [6]. Phra Nakhon Si Ayutthaya Province is located in the central region. The province's Gross Provincial Product (GPP) value is the third highest within the country and is classified as an important industrial economic zone. The resulting in the amount of solid waste generated in the province. In 2021, there was 1,287 tons/day of waste, divided into 197 tons/day of solid waste that was recycled 644 tons/day of correctly disposed solid waste, and 446 tons/day of incorrectly disposed waste. In 2021, the Environment Office Region 6, Phra Nakhon Si Ayutthaya Province, has

taken steps to promote and develop efficient and appropriate management of waste disposal sites according to academic principles. It was found out that in Phra Nakhon Si Ayutthaya province, waste separation is promoted from the sources and decomposed wastes are used for their maximum benefit such as plastic waste, metal, glass are used for recycling and some food scraps are used for household compost or sold for extra income. The government agencies should issue measures or policies on waste separation to promote a clear and strict community such as promoting people for waste separation by themselves. This will help reduce waste disposal costs of responsible agencies.

Lam Ta Sao Municipality is located in the Wang Noi District area, Phra Nakhon Si Ayutthaya Province. It is located approximately 65 kilometers from Bangkok along Phahonyothin Road. The area consists of 4 sub-districts and 17 villages, with a total population of 21,510 people. The municipality's waste management model involves collection of waste, generated by the community and various sources, to a waste disposal site and the disposal of municipal solid waste using a hygienic landfill method for areas under the responsibility of the municipality. It consists of land use zones with a wide range of activities. The important activities are industrial area. The area has a dense population due to the increase in industrial factories and other activities that follow from having an industrial community. For analyze key factors for waste management in this study, the analytical hierarchy process (AHP) was used in considering guidelines for selecting a waste management system. The study data can be developed and used for further consideration of alternatives and waste management methods which may lead to studies of other related dimensions. Overall, this can eventually lead to an effective action plan or setting up of a project to request an operating budget.

Material and Methods

Tools and data collection

Tools for collecting primary data include using a hierarchical analysis process assessment form from experts for considering and deciding on alternative methods for solid waste management. It was used to group the importance of factors in evaluating waste management systems of Lam Ta Sao Municipality, Wang Noi District, Phra Nakhon Si Ayutthaya Province. The theory, concepts, research, and various related documents data collection was done in 2 main formats as follows: (1) Primary Data, data collection was carried out and selecting relevant factors from the documents to summarize before sending to 8 experts and grouping them to priority. (2) Secondary Data, collects information from a literature review, including theories, concepts, researchs, and various related documents of relevant agencies.

Data analysis

For this study, an analytical tool was used to determine the Index of Item Objective Congruence (IOC) to check the quality of research tools including a survey of factors used in selecting waste management methods. 5 experts were asked to check the accuracy of the instrument using the IOC as the consistency index between factors affecting solid waste management. Factors that are consistent with scores greater than 0.6-1.0 were used in the hierarchical analysis process, which can be grouped into 10 main factors and consisted of 38 secondary factors. They are people with qualifications related to solid waste management. A total of 5 people having 2 groups of experts complete the questionnaire, divided into solid waste management experts and engagement experts.

Hierarchical analysis process

This study collected data from a survey area. Study information from documents were studied and analyzed for important factors of the solid waste management system of Lam Ta Sao subdistrict Municipality, Wang Noi district, Phra Nakhon Si Ayutthaya province. Data were analyzed by experts who evaluate important factors in waste management in order to use important factors to create guidelines for selecting appropriate management models. The importance value for comparing each factor which can be converted to numbers Between 1 and 9 results from each pair of comparisons when completed the weight of each factor can be calculated as a number to clearly show the

importance of each factor using the technique of hierarchical analysis process. (This is the average score from 8 experts) The analysis steps are as follows.

Step 1 : Determine the purpose of the problem to be decided, study documents and review literature by considering guidelines, principles, adetermining options and factors affecting solid waste management of Lam Ta Sao Municipality, Wang Noi District, Phra Nakhon Si Ayutthaya Province.

Step 2 : determine the factors used as decision criteria for using in the hierarchical analysis process. The selection of criteria or key factors, to be used in the analytical hierarchy process, are based on the results of the current data analysis of the study area and this is done by selecting criteria or factors related to solid waste management of Lam Ta Sao Municipality, Wang Noi District, Phra Nakhon Si Ayutthaya province from related theories and literature review in the field of solid waste management. Then, the collect criteria or factors related to solid waste management of Lam Ta Sao Municipality, Wang Noi District, Phra Nakhon Si Ayutthaya province came out which can be grouped into 10 main factors and 38 secondary factors as shown in Figure 1.

Step 3 : Data factors, used in analytical hierarchical process analysis, consists of primary and secondary factors and were defined from studying related theories and literature review. These factors were then used to create a hierarchy chart in solid waste management field. The top layer is the objective. Next are the main factors affecting the choice of method. The second order is even lower and the secondary factors was a component of the main factors. Summary of factors was obtained to prioritize the solid waste management system of Lam Ta Sao Municipality, Wang Noi District, Pranakhon Si Ayutthaya province. To prioritize each factor, factors are created into groups and analyzed for their importance by experts with the hierarchical analysis process (AHP) using a questionnaire as a tool and the principle of pairwise comparison (Pairwise Comparison) of factors, in which it is divided into ratings of the importance of the comparison between the two factors. By replacing values with numbers 1 to 9, it shows that the first factor is more important than the factors being compared at the low level, the medium level, the high level, and the highest level. The questionnaire was sent to 8 experts to evaluate and rate the created questionnaire. For the results, the average weight score are calculated for the main factors, secondary factors and priorities in developing the waste management system of Lam Ta Sao municipality, Wang Noi district, Phra Nakhon Si Ayutthaya province.

Analysis of the results of scores from expert questionnaire evaluation using the Expert Choice 11 program. It is a tool to support multi-criteria decision making based on a hierarchical analysis process. The scores obtained from the assessment show the importance of the main factors. The results of important factors from the analysis are ranked by using the prioritization process. There are ten main factor groups, which are divided into the secondary factors as shown in the picture.

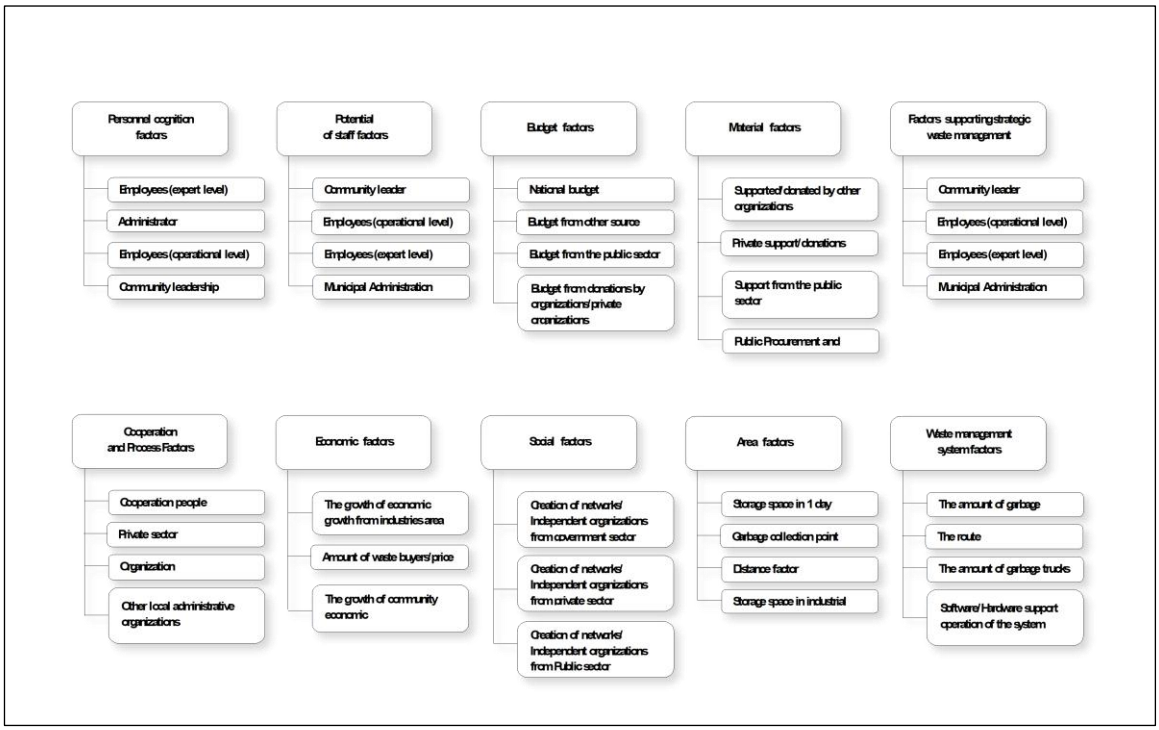

Figure 1 Factors related to urban waste management systems of Lam Ta Sao Municipality, Wang Noi District, Phra Nakhon Si Ayutthaya Province

Results and Discussion

The important factors of the waste management system of Lam Ta Sao Municipality, Wang Noi District, Phra Nakhon Si Ayutthaya province are analyzed by using a hierarchical analysis process to find guidelines for application. By analytical hierarchical process using a questionnaire that has passed the tool quality checking process. The questionnaire was sent to experts for consideration and in-depth interviews of 8 people from main factor analysis using the Expert Choice 11 program. The results of the analysis were obtained as follows: 1. Analysis results of main factors for urban waste management system in Lam Ta Sao Municipality, Wang Noi District, Phra Nakhon Si Ayutthaya province are as follows: A = Personnel cognition factors, B = Potential of staff factors, C = Budget factor, D = Material factor, E = Factors supporting strategic waste management, F = Cooperation and process factors, G = Economic factors, H = Social factors, I = Area factor and J = Waste management system factors.

1. Results of weight analysis and prioritization for main factors. The data obtained from questionnaire responses from 8 experts and from the analytical hierarchy process using the Expert Choice 11 program that is used to calculate the importance of the main factors. It can be seen that personnel factors cognition has the highest importance value of 14.95% compared to other factors. The second highest important factor is the cooperation factor and process (14.34%). It was followed by the area conditions factor (12.90%), waste management support factor according to strategy (11.03%), economic factors (10.36%), social conditions factors (9.56%), waste management system factors (8.53%), personnel potential factor (8.38%), budget factor (5.14%) and material equipment factor (4.81%), respectively.

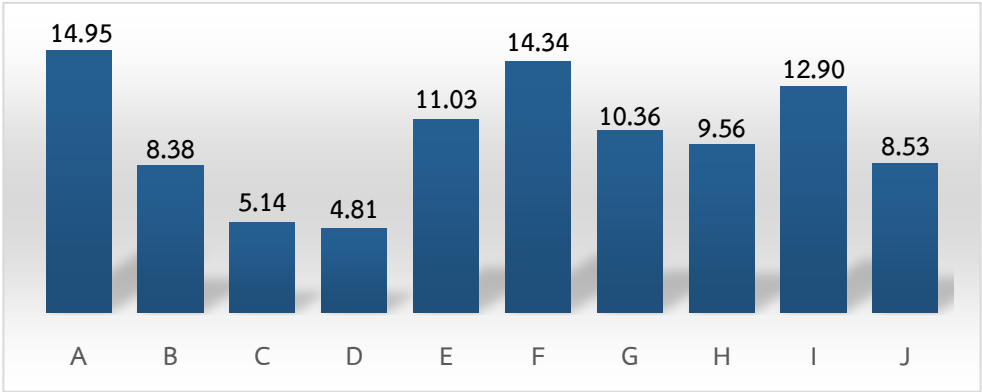

Figure 2 Bar chart showing the priority of key factor groups

2. Results of weight analysis and prioritization of secondary factors

1) For secondary factors under the main personnel factor cognition, it was found that the employee factors (Expert level) has the highest importance value of 38.68% compared to other factors, followed by municipal administrators' factors at 31.35%, employee factors (operational level) (15.05%) and community leadership factors (14.94%), respectively.

2) In terms of the secondary factors under the main potential factors Personnel aspect, it was found that the factors of municipal administrators has the highest importance value (40.06%) when compared to other factors next is the employee factor (expert level) (32.73%), employee factors (Operational level) (14.01%), and community leadership factors (13.21%), respectively.

3) Regarding the secondary factors under budget factor, it was found that the national budget factor has the highest importance value of 49.63% compared to other factors. Followed by budget factors from donations by organizations/private organizations at 22.09%. Budget factors from other channels and from the public sector were 15.88% and 12.38%, respectively.

4) For secondary factors under material and equipment factors, it was found that factors from purchasing according to budget regulations. It has the highest importance value of 30.03% compared to other factors. This was followed by factors from support from the public sector (26.33%), factors from support/donations by the private sector (22.99%) and from support/donations by other organizations/ independent/networks (20.65%) respectively.

5) For secondary factors under the factor of supporting strategic waste management, it was found that the agency policy factor has the highest importance value of 30.61% compared to other factors, and was followed by local development plan factors at 30.38%, the agency's municipal ordinance factor at 21.46%, and the regulations/practice factor at 17.55%, respectively.

6) In terms of secondary factors section under the side factors Collaboration and process support, It was found that factors from the people has the highest importance value of 33.74% compared to other factors. It was followed by agency/departmental/organizational factors (22.86%), private sector factors (21.86%), and surrounding local government factors (21.54%) respectively.

7) Regarding the secondary factors under economic factors, it was found that the economic growth factor is from having industry in the area. It has the highest importance value of 49% compared to other factors. Followed by the factor of number of waste purchasers/price at 29.26% and community economic growth factors of 21.73%, respectively.

8) As per social factors score information for secondary factors, it was found that the factors for creating networks/independent organizations from the public sector has the highest importance value of 41.25% compared to other factors Followed by the factor of creating networks/independent organizations from the

private sector at 30.78% and factors for creating networks/independent organizations from the government sector 27.91%, respectively.

9) For area factors conditions score information for secondary factors, it was found that the number of fur collection areas in 1 day is a factor, the highest importance value of 31.54% compared to other factors. The second highest importance factor is the factor of garbage collection points (garbage resting points), waiting for collection (29.26%), distance factor between the municipality and waste management site (26.11%), and the factors of collecting hair in a specific area (industrial zone) (13.08%), respectively.

10) For factors of waste management system score information for secondary factors, it was found that factor for software/ hardware support of system operation has the highest importance value of 30.45 % compared to other factors, followed by the bus route factor at 28.21%, the factor of the number of garbage collection vehicles is 26.33% and the number of garbage collection employees is 15%, respectively.

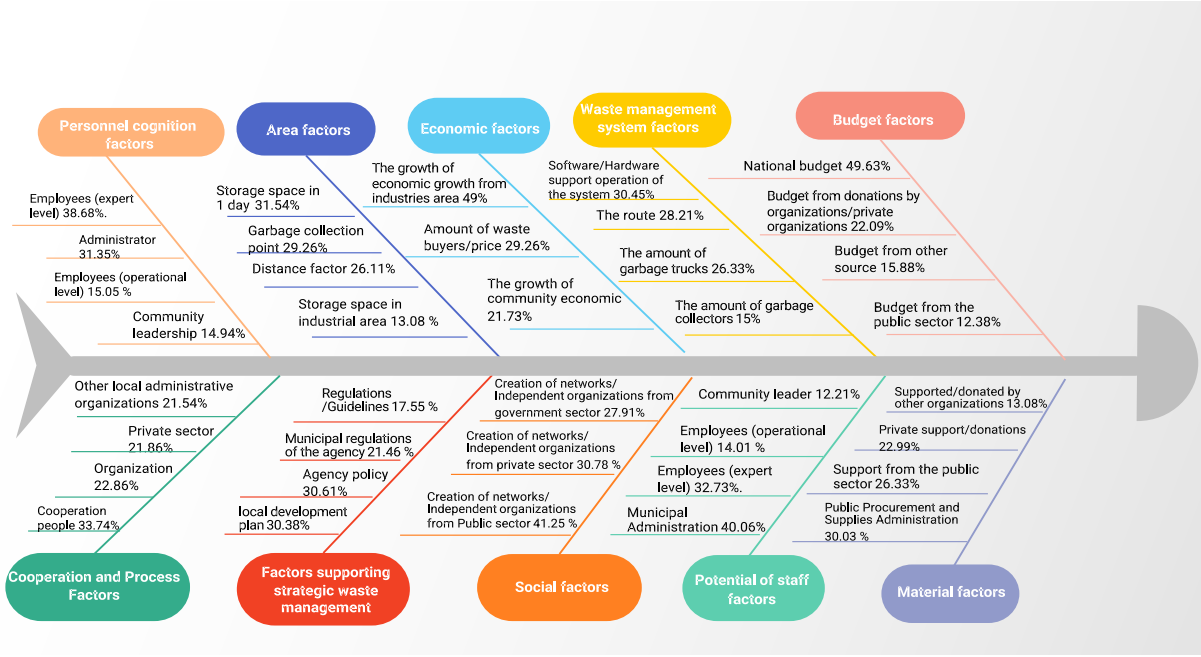

Figure 3 Analysis of factors used in managing waste management systems of Lam Ta Sao Municipality, Wang Noi District, Phra Nakhon Si Ayutthaya province

The study analysis of factors used in managing waste management systems of Lam Ta Sao Municipality, Wang Noi District, Phra Nakhon Si Ayutthaya province using the analytical hierarchy process. In analyzing important factors examine the analysis results using the analytical hierarchy method to be used to consider guidelines and solid waste management systems. The prioritize the main factors with importance to use as an appropriate waste management guideline, it was found that the main factors with the highest average importance values were (1) Personnel factors cognition It has the highest importance value of 14.95% compared to other factors, followed by Cooperation and process factors (14.34%), Area condition factor (12.90%), Factors supporting waste management according to strategy (11.03%), Economic factors (10.36%), Social factors (9.56%), Waste management system factor (8.53%), Personnel potential factor (8.38%), Budget factor (5.14%), and Materials and equipment factors (4.81%), respectively.

For the secondary factors under the main factors with the highest averages, the top 3 factors are as follows : Personnel factors cognition has the highest priority value with the average of the secondary factors of employees which has an importance value of 38.68%, the highest compared to other factors followed by municipal administrators' factors at 31.35 % and employee factors, (Operational level) (15.05%), and community leadership factors (14.94%) respectively.

For the ranking 2, secondary factors under the main factors are cooperation and process factors by the average of the secondary factors in the part of cooperation from the people factor, it has the highest importance value of 33.74%, followed by the factors of organization factor (22.86%), private sector factor (21.86%) and the other local administrative organization factors (21.54%) respectively. The next one is the main factor of area factors, there was an average of the secondary factors in terms of storage space in 1 day factor (31.54%), followed by the factor of garbage collection points (29.26%). The factor of distance between the municipality and the waste management facility, and collecting hair in a specific area (industrial zone) were 26.11% and 13.08% respectively. The research results, the main factors with the highest average importance values from the ratings by experts is the personnel factor. Cognition the second factor with the highest average importance is the employee factors (expert level) with an average value of 38.68%. The study of theories, concepts, research, and various related documents, it was found that the research results were consistent with the SWOT analysis in the local development plan with 2023-2027 year of Lam Ta Sao Municipality. From the analysis of strategy number 1: infrastructure development, number 2: development of quality of life and environment, which are obstacles (Threat) in work or projects that require special expertise Lam Ta Sao Municipality does not have the expertise and personnel. Therefore, it can be concluded that the important factors that will affect the success of waste management are: Focusing on developing personnel to work with understanding and has direct expertise in waste management and executives must have a broad vision and systematic thinking Including allowing people to participate in operations.

The results of prioritizing factors can be used to create alternative models to develop waste management guidelines, which can be divided into 5 characteristics: (1) Options for determining personnel development guidelines, (2) Choice of various methods and processes for waste disposal to support the disposal of each type of waste, (3) Appropriate waste management options through participatory processes, (4) Options for setting waste management guidelines in multiple situations with a spatially integrated method and (5) Choice of concepts and working principles that are consistent with the waste management strategy.

1. Options for determining personnel development guidelines using main factors to determine development guidelines. The results of the study of the main factors found that the 3 main factors are most important: (1) personnel cognition factors, (2) cooperation and process factors and (3) area factors. It can be seen that supporting and encouraging personnel to develop their potential is important. If personnel have activities or continuous development of their potential, especially workers, it will create a process of development of cooperation and working with good results. Activities for developing personnel to be effective may not just include study tours but may also include promoting workers to have the opportunity to increase their knowledge and abilities in the field.

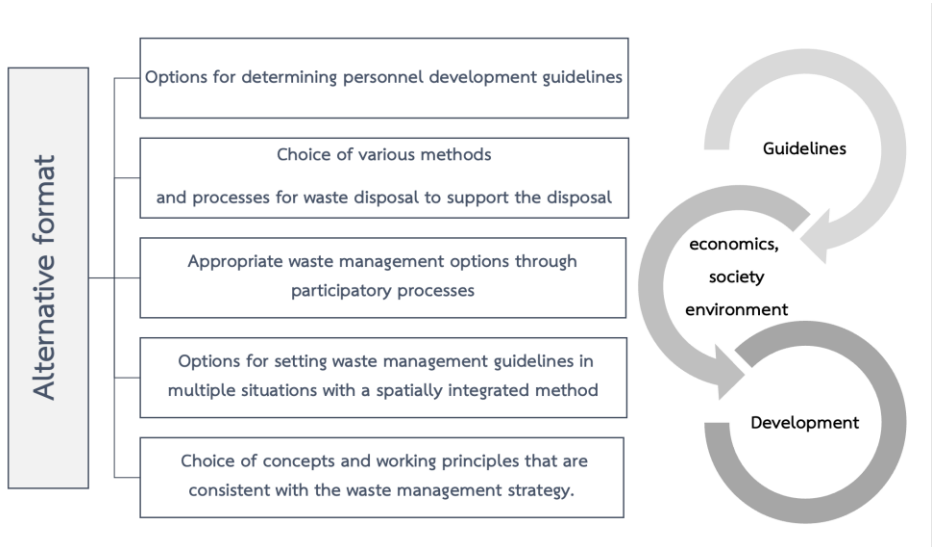

Figure 3 Alternative waste management models to develop waste management systems

2. Choice of various methods and processes for waste disposal to support the disposal of each type of waste that has different quantities and proportions in each connected area. Selecting a disposal method can integrate more than just one method. There are various methods of elimination. In some processes, it may not require a large budget but is highly efficient. And some methods can invest in creating a system that is not too expensive but can manage waste in the long term. This will be beneficial to areas that have a variety of activities as a result of the activities of people in the area, such as urban area with industries, town with tourist attractions, city with large agricultural, operations port or economic city. A city that has a unique context for economic development in various dimensions [7].

3. Appropriate waste management options through participatory processes. It is necessary to study the current management conditions in order to extract lessons and use the results of the study to develop other models. Lesson taking process by using relevant people, if the same methods or management styles are used, problems and limitations can be analyzed more accurately than using just one department [8].

4. Options for setting waste management guidelines in multiple situations with a spatially integrated method. Determining situations that are likely to occur, such as migration for work in industrial areas will inevitably cause dense communities concentrated in the area or the outbreak of certain types of diseases in community areas. Industrial zones must have measures to support specific areas. However, having various types of spatial data will allow formulas or guidelines for waste management to be determined based on such spatial data [9].

5. Choice of concepts and working principles that are consistent with the waste management strategy. An important point for selecting concepts or principles is that although concepts can be practically implemented according to the local context, it should be selected in order to be consistent with the physical characteristics of the area, topography, and people's way of life, which is considered an important part in development [10]. Because the selection of waste management principles and concepts must be appropriate to the local context in order to make waste management reach its goals more quickly. Applying various principles should choose an approach that has a variety of methods. Being able to be flexible according to the situation will allow work to be adjusted in different periods of time, which is an advantage of having a work process that is constantly changing which is suitable for diverse areas and can make waste management sustainable [11].

Although the results of data analysis can lead to options of creating a waste management system, the process of determining the details of the system still requires to study their suitability in many other related parts [12]. This requires important statistical data to be up to

date so that the data can be connected and found relationships among each variable [13]. The planning to create a management system with good options may choose to carry out more than one option if it is not beyond the potential of the operating agency and the operator can drive it [14]. This can be done by adding secondary options or sub-alternatives that may be able to support or enhance the potential of the main system options obtained from this study or there can be further development of other alternative studies that can be done with reliable educational information to support them [15].

Conclusion

The decision on the form and method of waste management of local administrative organizations in areas, with a variety of activities and high economic growth, is a challenge. There are a number of limitations in the area that may pose risks and result in management and operational failures. Even though the government has a policy with a clear operational plan, selecting a management method for spatial problems may be considered a burden that the agency must manage on its own. Using up-to-date, accurate and reliable information and having a high possibility of action makes a very attractive option for small organizations to choose an integrated waste management approach. Obtaining guidelines for choosing a waste management model is, therefore, very important in terms of management because it is relevant to future work. In addition, the appropriate management style still need to rely on various data sets to consider various processes that do not include social processes. Creating the right guidelines can help the organization develop in the right direction, answers various policies and strategies very well, and it can also raise the organization's ability to keep up with the situation. It is considered one of the achievements in environmental management of the local government.

References

[1] Jebaranjitham, J. N., Christyraj, J. D. S., Prasannan, A., Rajagopalan, K., Chelladurai, K. S. and Gnanaraja, J. K. J. S. 2022. Current scenario of solid waste management techniques and challenges in Covid-19-A review. Heliyon.

[2] Guerrero, L. A., Maas, G. and Hogland, W. 2013. Solid waste management challenges for cities in developing countries. Waste Management, 33(1): 220-232.

[3] Sharma, K. D. and Jain, S. 2020. Municipal solid waste generation, composition, and management: the global scenario. Social Responsibility Journal, 16(6): 917-948.

[4] Manomaivibool, P. Wasteful tourism in developing economy? A present situation andsustainable scenarios. Resources, Conservation and Recycling. 2015; 103: 69-76.

[5] Luanratana, W. and Visvanathan, C. 2017. Sustainable Waste Management: A Case Study of the Bangkok Metropolitan Authority. In Sustainable Development Policy and Administration (pp. 353-371). Routledge.

[6] Areeprasert, C., Asingsamanunt, J., Srisawat, S., Kaharn, J., Inseemeesak, B., Phasee, P., ... and Chiemchaisri, C. 2017. Municipal plastic waste composition study at transfer station of Bangkok and possibility of its energy recovery by pyrolysis. Energy Procedia, 107, 222-226.

[7] Sukholthaman, P. and Shirahada, K. 2015. Technological challenges for effective development towards sustainable waste man.

[8] Hornsby, C., Ripa, M., Vassillo, C. and Ulgiati, S. 2017. A roadmap towards integrated assessment and participatory strategies in support of decision-making processes. The case of urban waste management. Journal of Cleaner Production, 142, 157-172.

[9] Keser, S., Duzgun, S. and Aksoy, A. Application of spatial and non-spatial data analysis in determination of the factors that impact municipal solid waste generation rates in Turkey. Waste Manag. 2012; 32(3): 359-71.

[10] Camarillo, M. E. and Bellotindos, L. M. 2021. A Study of Policy Implementation and Community Participation in the Municipal Solid Waste Management in the Philippines. Applied Environmental Research, 43(2): 30-45.

[11] Aceleanu, M. I., Şerban, A. C., Suciu, M. C. and Bioiu, T. I. 2019. The management of municipal waste through circular

economy in the context of smart cities development. IEEE Access, 7, 133602-133614.

[12] Kongroy, P., Kaewkamthong, P., Pinawet, T., Tungsuwan, I. and Noikondee, R. 2021. Knowledge, needs and satisfaction with the waste recycling bank project Phetchabun Rajabhat University. Journal of Science and Technology Phetchabun Rajabhat University, 1(1): 75-85.

[13] Wongthongdeepeekaew, P., Tabucanon, A. S. and Sereenonchai, S. 2023. Strategic Environmental Assessment: A Case Study of Mueang Lopburi District, Lopburi Province, Thailand. Thai Environmental Engineering Journal, 37(1): 73-88.

[14] Salguero-Puerta, L., Leyva-Díaz, J. C., Cortés-García, F. J. and Molina-Moreno, V. 2019. Sustainability indicators concerning waste management for implementation of the circular economy model on the University of Lome (Togo) Campus. International journal of environmental research and public health, 16(12): 2234.

[15] Fagnani, E. and Guimarães, J. R. 2017. Waste management plan for higher education institutions in developing countries: The Continuous Improvement Cycle model. Journal of cleaner production, 147, 108-118.