Landfill Site Selection Using GIS and AHP Method: Case Study of Bandar Lampung Municipality

Agustinus OLOAN[1)], Yutaka DOTE[2)], Tomoo SEKITO[3)], Teti Armiati ARGO[4)]

Abstract

Landfill site selection is a complicated and time-consuming process. That is because the process must start from predicting how much land will be needed for a landfill site, combining social, environmental, and technical parameters and also considering the regulations. This study tries to predict how much land will be needed for a landfill site by considering aspects specific to developing countries, such as leakage by scavengers and then continues with landfill site selection, which reflects the guidelines of the Indonesian National Standard (SNI) 03-3241-1994 using GIS software and the AHP method.

The results showed that the Bandar Lampung Municipality needed 18.8 ha of land for a landfill site over the next 20 years. Meanwhile, results from the Regional Criteria showed that the area that could be used for a landfill site was 5,011 ha; which is equal to 25.97% of the total Bandar Lampung area. In Elimination Criteria, two scenarios were developed in order to evaluate the sensitivity of criterion preferences. The results showed that in scenario 1 the most suitable area was 174 ha, a suitable area was 2,138 ha, a fairly suitable area was 2,453 ha, and a less suitable area was 246 ha for a landfill site. And for scenario 2 there was no most suitable area for a landfill site, and the results for suitable, fairly suitable and less suitable were 647 ha, 3,331 ha, and 1,302 ha, respectively.

Keywords: Waste generation, Landfill site selection, GIS, AHP

1. INTRODUCTION

Bandar Lampung is the capital city of Lampung Province, which makes Bandar Lampung the center of government activity, as well as social, political, educational, cultural and economic activities in the Lampung Province. Growth of investment and the development of urban activities have encouraged the emergence of new growth centers in the city of Bandar Lampung. In the past, there were three dominant activity centers within the urban service economy of Bandar Lampung, namely Tanjung Karang, Teluk Betung and Panjang. Now several new activity centers that have become citywide service areas themselves, such as Sukarame, Tanjung Senang and other areas in Bandar Lampung. In addition, Bandar Lampung is located close to Jakarta, which is a metropolitan city, and has a significant effect on the consumption patterns and lifestyles of Bandar Lampung city dwellers. Like other large cities in developing countries, the city of Bandar Lampung has seen an increased in the number of people followed by an increase in the production of waste from the community.

Population growth and changes in consumption patterns and people's lifestyles have increased the amount of waste generation, type and diversity characteristics of the waste. These conditions require proper management to avoid any negative impact on human health or the environment.

A municipal solid waste (MSW) management system uses one or more techniques of solid waste management such as land filling, thermal treatment, biological treatment, and recycling[1)]. Landfill is an essential part of any waste management system. Nowadays best practices for sustainable management of urban solid wastes involve integrated systems of waste management based on the following hierarchy: (i) waste minimization in the production process; (ii) reuse of products to prolong their usefulness before entering the waste stream; (iii) recovery of materials and energy from the waste (e.g. recycling, composting, heat from combustion); and (iv) placing the remaining material in landfills[2)].

Even if a combination of the above or other management techniques is utilized and policies of waste reduction and reuse are applied, the existence of a sanitary landfill is necessary to a MSW management system[1)]. The use of landfill can be significantly reduced by diverting part of the generated waste to recovery operations, and by minimizing the generation of waste at the source. However, landfills cannot be completely avoided. There is always some waste generation which cannot be avoided or for which there is no technology available for processing and recovery. In spite of the fact that landfills have been taken to the bottom of the hierarchy of options for waste disposal, it has been the most widely used method for urban solid waste disposal.

Landfill sitting is a complicated process because it must combine social, environmental, and technical

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parameters[3]. According to Sener[4], the site selection method is applied in two stages. In the first stage, the potential landfill sites are identified based on evaluations of geology, hydrogeology, and morphological properties using GIS techniques. In the second stage, a number of potential landfill sites are assessed considering various criteria in three fundamental dimensions namely site suitability, location factors, and public acceptability.

In general, the GIS-supported landfill site selection process contains two primary screening steps: (1) exclusion of areas unsuitable for landfill (pre-screening or GIS step), and (2) weighting (ranking) of remaining areas (i.e., decision analyses step[5), 6), 7)]). The major GIS map analyses functions are buffer zoning, neighboring computation, cost distance, and overlay analysis, which are frequently used for landfill sitting[8]. In order to find the most suitable area for landfill sitting, GIS can be integrated with AHP. The integration of GIS and AHP is a powerful tool to solve the landfill site selection problem[5), 9)].

The present study focuses on optimized GIS and AHP as tools in landfill site selection using the Bandar Lampung Municipality as a case study and to evaluate the sensitivity of criterion preferences in landfill site selection.

2. WASTE GENERATION

In order to find a location for landfill, the first step is to find out how much land is needed for landfill. According to Tchbanoglous[1], the simplest way to calculate how much land will be need for landfill is by considering the size of population, waste production per capita, and waste compaction in the landfill.

In this study, several limitations and assumptions were established to estimate the volume of waste in a landfill site.

a) Since the rate of waste generation per capita in Bandar Lampung was not available and due to the limited time to conduct the field survey, waste generation was calculated based on the assumptions provided by SNI 19-3964-1994[10].

b) The population projection was conducted by using the exponential growth model. This model was suitable for the conditions in Bandar Lampung Municipality which still growing and according to Oppenheim[11], this model is more relevant when the growth per year is not fixed, but proportional to the existing level of population. The equation for exponential growth model at the time n is expressed as follows:

$$P_n = (1+r)^n P_0 \qquad (1)$$

Where:

P_n: population in the year n

P_0 : population in the base year

n : number of years

r : rate of change

c) It was assumed that composting, as one of the methods to overcome the waste problem will be done at the waste source or at the final disposal landfill. According to Pratama[12], composting organic waste communally in Cimahi Municipality decreased the volume of city waste generation by 2.67% per day. So, waste generation after being reduced by composting can be calculated by Eq.3.

$$G = P_n \times P_c \qquad \text{......................} (2)$$

$$G_c = G(1-C) \qquad \text{......................} (3)$$

Where:

G : waste generation (m^3/day/capita),

G_c : waste generation after composting (m^3/day/capita),

P_n : population in year n,

P_c : waste production per capita (2.5 liter/day)

C : composting (2.67%)

d) In this study to calculate the volume of waste dumped into the disposal site we used a service level increase of 1% per year, when in 2009 it was 28.69%[13]. It was made with the assumption that the city government seeks to increase the level of service, which while not a priority, can be sustained by an increase of 1% per year.

e) Compaction and scavenger activity will be calculated as the impact of a decrease in volume and height of waste. Based on a previous study, scavenger activity produced a 20% leakage of inorganic waste (plastic and paper)[14].

f) Volume of waste that is dumped into landfill can be calculated using Eq.4 and the volume of waste after leakage using Eq.5.

$$D_w = G_c \times SL \qquad (4)$$

$$V_l = D_w - (D_w \times PP \times L) \qquad (5)$$

Where

D_w : volume of waste which dumped (m^3/day),

SL : % of service level

V_l : volume of waste in landfill (m^3/day),

PP : % of plastic and paper composition (18.04%),

L : % of leakage by scavenger (20%)

3. LANDFILL SITE SELECTION

SNI 03-3241-1994[15] stated 3 criteria for selection of landfill sites. There are Regional Criteria, Elimination Criteria and Decision Criteria.

Regional criteria are applied by using the spatial analyst tool (GIS software) to obtain information on the areas that can be used as a landfill site. To obtain this information we prepared the sub-criteria for a thematic map (fault, soil permeability, groundwater, river, slope, existing residential area, conservation areas, and floodplains) and then transformed of each map into an exclusion area map by buffering thematic maps conforming to the rules and regulations. Then by using the overlay method between these exclusion area maps we obtained the areas that were suitable as a landfill area.

Elimination criteria consisted of 7 criterion (distance from rivers, rain intensity, slope, distance to roads, distance to residential areas, administration boundaries, and distance to highways and railways) and 44-sub criterion. These criterion and sub criterion were derived from SNI 03-3241-1994 and relevant literature and then applied to the area based on the result of the Regional Criteria analysis. In the elimination criteria, to identify which were the most suitable areas for landfill sites, all of the criterion and sub-criterion should have a value that indicates the level of importance for each criterion.

Decision criteria are the criteria used by the competent authority to approve and set a selected location in accordance with agency policy and regulations.

Table 1. The comparison scale in AHP (Saaty[16]).

Intensity of importance	Definition	Explanation
1	Equal importance	Two activities contribute equally to the objective
3	Weak importance of one over another	Experience and judgment slightly favor one activity over another
5	Essential or strong importance	Experience and judgment strongly favor one activity over another
7	Demonstrated importance	An activity is strongly favored, and its dominance is demonstrated in practice
9	Absolute importance	The evidence favoring one activity over another is of the highest possible order of affirmation
2,4,6,8	Intermediate values between two adjacent judgments	When compromise is needed
Reciprocals of above nonzero	If activity i has one of the above nonzero numbers assigned to it when compared with activity j, then j has the reciprocal value when compared with i	

Saaty[16] proposed the Analytic Hierarchy Process (AHP), where the basic idea of the approach is to convert subjective assessments of the relative importance to a set of overall scores or weights. AHP is one of the more widely applied multi attribute decision-making methods. The methodology of AHP is based on pairwise comparisons of the following type; 'How important is criterion Ci relative to criterion Cj?' Questions of this type are used to establish the weights for criterion and similar questions are to be answered to assess the performance scores for alternatives on the subjective (judgmental) criterion.

The 9-point scale used in typical analytic hierarchy studies ranges from 1 (indifference or equal importance) to 9 (extreme preference or absolute importance; Table 1). This pairwise comparison enables the decision maker to evaluate the contribution of each factor to the objective independently, thereby simplifying the decision-making process[4].

In AHP, each pair of factors in a particular factor group is examined in terms of their relative importance. A pairwise comparison matrix is formed in which $aii = 1$ and $aij = 1/ai$. The weight coefficients of the ranking criteria and the decision sub criteria are calculated using the right eigenvector, which is calculated from the maximum absolute eigenvalue (λ_{max}, 1,2). The grading values of all the criteria are normalized to 1.

$$\lambda_{max} = \frac{1}{n}\sum_{wi}^{n}\frac{(AW)i}{wi} \tag{6}$$

$$AW = \begin{pmatrix} a11 & a12 & \ldots & \ldots & a1n \\ a21 & a22 & \ldots & \ldots & a2n \\ \ldots & \ldots & \ldots & \ldots & \ldots \\ \ldots & \ldots & \ldots & \ldots & \ldots \\ an1 & an2 & \ldots & \ldots & ann \end{pmatrix} x \begin{pmatrix} w1 \\ w1 \\ \ldots \\ \ldots \\ wj \end{pmatrix} \tag{7}$$

Where W is the corresponding eigenvector of λ_{max} and wi ($i = 1,2,\ldots,n$) is the weighted value for ranking. The consistency of the judgment matrix should be tested with the calculation of the consistency index (CI), which is defined as;

$$CI = \frac{\lambda_{max} - n}{n-1} \tag{8}$$

Where CI is the consistency index, λ_{max} is the largest or principal Eigen value of the matrix and could be easily calculated from the matrix, and n is the order of the matrix[6]. The consistency ratio (CR) coefficients are calculated according to the methodology proposed by Saaty[16]. The CR coefficients should be less than 0.1, indicating the overall consistency of the pairwise comparison matrix[4), 6]. CR is defined as;

$$CR = \frac{CI}{RI} \quad (9)$$

Where RI is the average of the resulting consistency index depending on the matrix[4), 9)].

After the values for all the criterion and sub criterion were identified, then the formula was used to generate the overall score of the alternatives in the GIS environment, and the landfill suitability index (LSI) was calculated by means of multiplication of each criteria weight with each sub-criterion weight.

LSI is defined as

$$LSI = (R_{Cw} \times R_{SCwi}) + (RI_{Cw} \times RI_{SCwi}) + (S_{Cw} \times S_{SCwi}) + (RD_{Cw} \times RD_{SCwi}) + (RA_{Cw} \times RA_{SCwi}) + (AB_{Cw} \times AB_{SCwi}) + (HR_{Cw} \times HR_{SCwi})$$

Where

LSI	: Landfill suitability index
RCw	: Weight index of the distance from rivers criterion
RSCwi	: Weight index of the distance from rivers sub-criterion
RICw	: Weight index of the rain intensity criterion
RISCwi	: Weight index of the rain intensity sub-criterion
SCw	: Weight index of the slope criterion
SSCwi	: Weight index of the slope sub-criterion
RDCw	: Weight index of the distance to roads criterion
RDSCwi	: Weight index of the distance to roads sub-criterion
RACw	: Weight index of the distance to residential areas criterion
RASCwi	: Weight index of the distance to residential areas sub-criterion
ABCw	: Weight index of the administration boundaries criterion
ABSCwi	: Weight index of the administration boundaries sub-criterion
HRCw	: Weight index of the distance to highways and railways criterion
HRSCwi	: Weight index of the distance to highways and railways sub-criterion

3.1 Regional criteria

In this study, the regional criteria consisted of 4 main criteria (geology, hydrogeology, topography, and restricted area) and 9 sub criteria in order to screen the areas that can be use as landfill sites.

Fault

Based on the Bandar Lampung Spatial Planning Regulation[17)], in general, the Lampung and surrounding areas are located on a seismic line with a zone of high seismicity. This region is crossed by a few minor faults/micro, which are part of an active fault, located on the Sumatra Island. For this reason, buffer zones of 1000 m along both sides of the faults were assigned, to prevent the sitting of the proposed landfill on or too close to known active faults.

Soil Permeability

Considering the environment, human health and cost, a landfill site should be located in an area that can protect groundwater from runoff and leaching from the landfill. According to regulations[15)], landfill areas should be placed in an area with a soil permeability $\leq 10^{-6}$ cm/sec.

Groundwater

To avoid groundwater pollution, groundwater depth was taken into account as an exclusion criterion. According to regulation[15)], landfill sites are prohibited in areas with a groundwater depth less than 3 meters.

Rivers

The Bandar Lampung Municipality has two major rivers, namely the Way Kuala and Way Kuripan, and 23 small rivers; all rivers are part of the watershed that is located in the area of Bandar Lampung and most of the estuary in the Lampung Gulf. Regulation[15)] requires that landfill sites cannot be placed within 100 meters of a river.

Slope

Bandar Lampung topography is very diverse, ranging from coastal plains to hills and mountains, with an altitude between 0 to 500 m above sea level. Areas with hills to mountains stretch up from the west to the east with the highest peak on Mount Betung on the west side and Mount Dibalau and Batu Serampok Hills on the east side. Topography of each region in Bandar Lampung is as follows:

- Beach areas around Teluk Betung and Panjang and the small islands in the southern section.
- Plateau areas around Kedaton and north side of Sukarame.
- The hilly areas are found around the northern part of Teluk Betung.
- Highland areas and mountainous regions can be found on the western part of the surrounding Tanjung Karang area, namely Mount Betung, and Mount Dibalau Mountain Serampok and on the eastern side.

Based on the physiographic area, Bandar Lampung has features of hills to young volcanic mountains with an average slope of 5-25% covering 60% of the area, plain areas with a slope 0-5% along the coast of the Lampung Gulf covering around 30%, and steep areas with a slope of <25% with an approximate area of 4%[18)].

Slope is an important factor when there are risks of landfill slide and leachate pollution since higher slope would increase runoff of pollutants from landfill[19)]. According to regulation[15)], the suitable area for landfill is an area with a slope <20%.

Residential Area

According to regulation[15)], a landfill site cannot be placed in a residential area. An existing residential map was provided in the Bandar Lampung Spatial Plan. In this analysis residential areas will be excluded.

Conservation Areas

Bandar Lampung Spatial Planning Regulation[17)] prohibits all forms of activities that could disturb/change the function of conservation areas. These are areas used as areas that provide protection to the region subordinates, local conservation, nature reserves and cultural reserves.

Floodplains

Regulation[15)] requires that landfill sites should not be located in floodplain areas. In this analysis all areas that has are prone to flooding will be excluded.

Airport

The nearest airport is located in Lampung Selatan Regency, and the distance from Bandar Lampung to Raden Inten Airport is about 30 km, so this sub-criterion will not considered.

3.2 Elimination criteria

Distance from Rivers

SNI 03-3241-1994[15)] only requires that a landfill cannot be placed within 100 m from a river body and it was applied in the regional criteria as a restricted area. In addition, the selected site must not be adjacent to a river. According to Sumathi[17)], a safe distance from a river was determined to be 100 m (Table 3).

Table 2. Summary of exclusion areas in regional criteria.

Criteria	Sub Criteria	Buffering
Geology	Fault Zone Soil Permeability	1000 m buffer zone Exclude area with permeability >10^{-6}
Hydrogeology	Groundwater River	Exclude area < 3 m 100 m buffer zone
Topography	Land slope	Exclude area over 20%
Restricted Area	Existing Residential Area Conservation Area	Exclude Residential Area Exclude Conservation area
	Floodplains	Exclude flood area

Table 3. Total weight of the sub-criterion for each preference.

Criterion (C)	Sub criterion (SC)	Scenario 1 Weight (Cw)	Scenario 1 Subweight (SCwi)	Scenario 1 Total Weight (TW)	Scenario 2 Weight (Cw)	Scenario 2 Subweight (SCwi)	Scenario 2 Total Weight (TW)
Distance from rivers	0 - 250 m	0.260	0.1	0.026	0.294	0.1	0.029
	250 - 500 m		0.2	0.052		0.2	0.059
	500 - 750 m		0.3	0.078		0.3	0.088
	> 750 m		0.4	0.104		0.4	0.117
Rain intensity	0 - 500 mm/year	0.114	0.4	0.046	0.2894	0.4	0.117
	500 - 1000 mm/year		0.3	0.034		0.3	0.088
	1000 - 1500 mm/year		0.2	0.023		0.2	0.059
	> 1500 mm/year		0.1	0.011		0.1	0.029
Slope	0 – 5 %	0.146	0.4	0.058	0.108	0.4	0.043
	5 - 10 %		0.3	0.044		0.3	0.032
	10 - 15 %		0.2	0.029		0.2	0.022
	15 - 20 %		0.1	0.015		0.1	0.011
Distance to roads	0 - 200 m	0.272	0.4	0.109	0.168	0.4	0.067
	200 - 300 m		0.3	0.081		0.3	0.050
	300 - 400 m		0.2	0.054		0.2	0.034
	> 500 m		0.1	0.027		0.1	0.017
Distance to residential areas	0 - 500 m	0.125	0.1	0.013	0.055	0.1	0.005
	500 - 1000 m		0.2	0.025		0.2	0.011
	1000 - 1500 m		0.3	0.038		0.3	0.016
	> 1500 m		0.4	0.050		0.4	0.022
Administration boundaries	Within 1 villages	0.046	0.4	0.019	0.059	0.4	0.024
	Within 2 villages		0.3	0.014		0.3	0.018
	Within 3 villages		0.2	0.009		0.2	0.012
	Within > 3 villages		0.1	0.005		0.1	0.006
Distance to highways and railways	< 500 m	0.037	0.1	0.004	0.023	0.1	0.002
	> 500 m		0.9	0.033		0.9	0.021

Rain Intensity

High rainfall intensity will cause an increase in the volume of leachate and also may cause landslides on the heap of garbage in a landfill. According to SNI 03-3241-1994[15], the most favorable rain intensity in any selected area it should be 0 – 500 mm/year and the higher the rain intensity, the less favorable it is.

Slope

The slope of the land surface is a crucial factor as far as construction costs are concerned, where very steep slopes will lead to higher excavation costs. The slope of the land surface was calculated on a pixel basis using the digital elevation model (DEM) of the study area, as a percentage ranging from 0 to 20%. Then the above values of the slope of the land surface were transformed to a scale of 0.1–0.4[3]. Function membership of areas that had a value of 15–20% was 0.1 (lowest suitability), and that of other areas, which had the value of 0–5% were 0.4 (highest suitability).

Distance to roads

Sumathi[7] describe that roads, other than highways and railways, were treated as contraries; the closer the distance the higher the score. Additional costs for road construction in areas far away from present roads make them less attractive. So the closer the distance the higher the score; the highest score was 0.4.

Distance to residential areas

NIMBY syndrome should be considered when placing a landfill site in an area. Mutluturk and Karaguzel[20] describe that public opposition decays exponentially with increasing distance of a landfill site from residential areas. Suitability, in turn, increases with decreasing public opposition. Then, the highest score of 0.4 is applied if > 1500 m from the residential area and 0.1 if < 500 m away.

Administration boundaries

According to SNI 03-3241-1994[15], administrative boundaries in the elimination criteria are taken into account due to problems associated with landfill management. Landfill located on 2 or more villages will create management difficulties. Therefore, a landfill located in 1 village is preferred.

Distance to Highways and Railways

The consideration of aesthetics in order to avoid smoke and smell disorders would be a recommended practice for good planning, and based on this principle, landfills shall not be located within 500 m of any highways or railways[3]. A weighting of 0.9 is applied if >500 m from a highway or railway and 0.1 if <500 m away.

4. RESULT AND DISCUSSION

The result of waste generation showed that the population in Bandar Lampung would produce waste at the rate of 2,518.40 m^3/day (**Fig. 1**). From this amount, the volume that will be discharged into a landfill site would be 1,031.18 m^3/day and this volume will require a land area of 18.8 Ha for period of service 20 years.

In regional criteria, all parameter for exclusion and buffering was transform into a thematic map and processed using a spatial analysis tool in the GIS environment, the result showed that using the Regional Criteria only 5,011.91 ha was suitable for landfill sites, which is 25.97 % of the total Bandar Lampung Municipality area (Figure 2).

In this study, criterion preference of elimination criteria were established and divided into 2 scenarios; the first scenario is preference based on guidelines (SNI 03-3241-1994) and literature and the second scenario gave more weight to environmental aspects (distance to rivers and rain intensity). Each scenario was assessed using the pairwise comparison (AHP method) in order to appraise the importance of each criterion among the others. And the results demonstrated the contribution of each criterion, which is shown in Table 4.

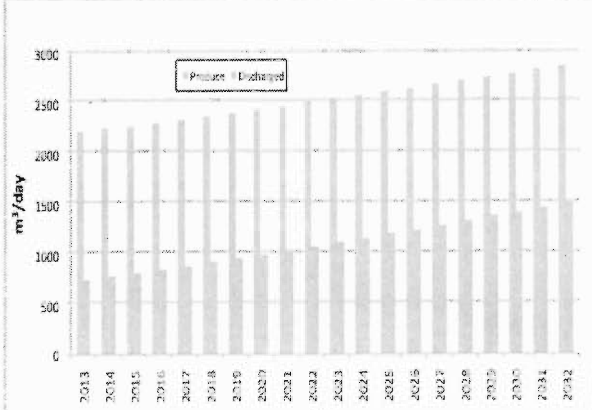

Fig. 1. Waste produce vs. waste discharge.

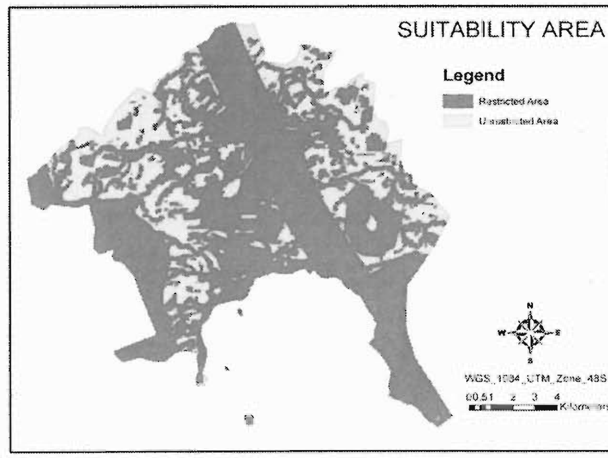

Fig. 2. Suitable area for landfill site.

Table 4. Comparison matrix and significance weight of criterion for each preference

	Scenario 1								Scenario 2							
	A	B	C	D	E	F	G	Weight	A	B	C	D	E	F	G	Weight
A	1	2	3	1	3	6	4	0.260	1	1	4	2	6	6	8	0.294
B	1/2	1	1	1/2	1/2	2	4	0.114	1	1	4	2	6	6	8	0.294
C	1/3	1	1	1/3	3	4	4	0.146	1/4	1/4	1	1/2	2	4	6	0.108
D	1	2	3	1	3	6	6	0.272	1/2	1/2	2	1	4	4	6	0.168
E	1/3	2	1/3	1/3	1	4	4	0.125	1/6	1/6	1/2	1/4	1	1	4	0.055
F	1/6	1/2	1/4	1/6	1/4	1	2	0.046	1/6	1/6	1/4	1/4	1	1	6	0.059
G	1/4	1/4	1/4	1/6	1/4	1/2	1	0.037	1/8	1/8	1/6	1/6	1/4	1/6	1	0.023

A: Distance from rivers, B: Rain intensity, C: Slope, D: Distance to roads, E: Distance to residential areas, F: Adm boundaries, G: Distance to highways and railways
Control Scenario 1: $\lambda_{max} = 7.558$; CI= 0.093; RI= 1.320; CR= 0.070 < 0.1
Control Scenario 2: $\lambda_{max} = 7.537$; CI= 0.090; RI= 1.320; CR= 0.068 < 0.1

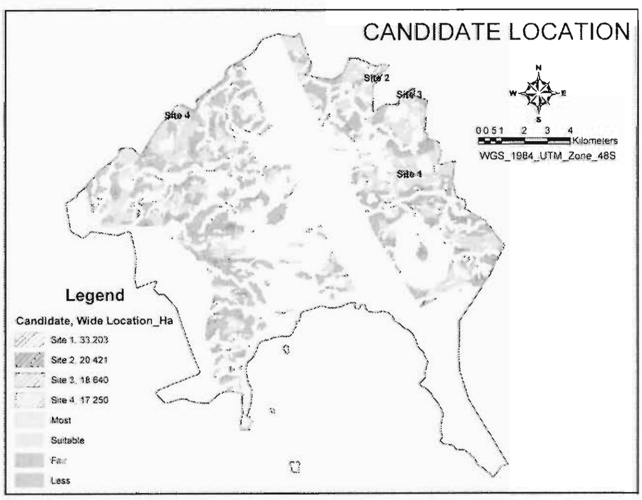

Fig. 3. Result of Scenario 1 and candidates Location.

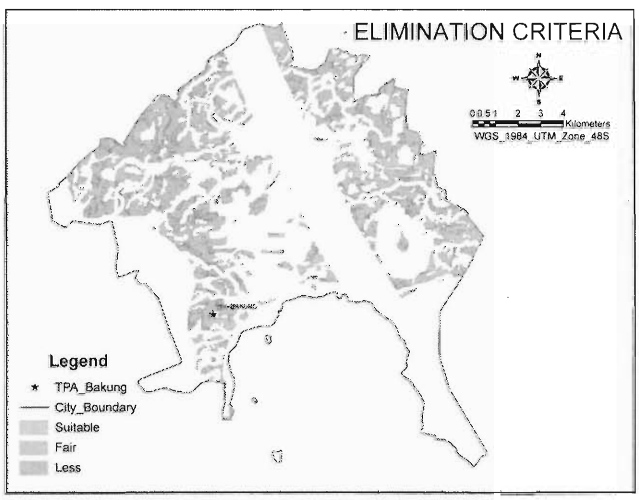

Fig. 4. Result of Scenario 2.

All criterions were weighed using the AHP method and mapped by the GIS techniques. The result shows that in scenario 1 (Figure 3) the most suitable area is 174.05 Ha, suitable area is 2,138.52 Ha, fair suitable area is 2,453.31 Ha, and less suitable area is 246.04 Ha. Meanwhile, in scenario 2 (Figure 4) there is no most suitable area for landfill site, the result only for suitable, fair suitable and less suitable with the wide respectively is 647.56 Ha, 3,331.94 Ha, and 1,302.41 Ha.

Based on result of scenario 1, there were 4 candidates identified for landfill sites where wide of each locations are, sequentially from site 1, 33.203 ha, 20.421 ha, 18.640 ha, and 17.250 ha. Sites 3 and 4 had wide less than the minimum requirement. They were still considered as candidates because the margin was not too large and also the surrounding area had suitable conditions. Sites 2, 3, and 4 shared very similar characteristics: they are very close to the municipality boundary. Sites 2 and 3 are located in areas that are allocated as settlement area in the future.

5. CONCLUSION

- The increasing generation of municipal solid waste in Bandar Lampung is one of the greatest challenges faced by governmental authorities. This study assessed the land needed for the next 20 years of service for a landfill site that is 18.8 ha with an average daily waste discharge to the landfill site of about 1,031.18 m^3.
- By comparing scenario 1 and 2, it showed that environmental preference became a limitation for landfill site selection in the Bandar Lampung Municipality.
- AHP offered an objective weight assignment process and also used the set of weights provided with great flexibility in the aggregation procedure.
- Four candidates for a landfill site were found in scenario 1 and they still needed to be evaluated to

find the location effectiveness in connection with the distance from the site to the center of the waste.

- This study offers a sitting methodology and essential support to the decision-makers in solving the waste management problem.
- Integrating the GIS and AHP methods was very helpful to select the landfill site in the Bandar Lampung Municipality.

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