The criteria for selecting the landfill sites in Baghdad governorate

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Abstract. Administering and managing solid waste are complicated and challengeable tasks for the local government of Baghdad city. In this area, the landfills site does not satisfy the required local and international criteria. As well as, in Baghdad, selecting the geographical location of Landfill sites is a complex process due to the enormous number of variables that need to be analyzed and considered. This study aims to identify the criteria for landfill site selection in Baghdad governorate. To do so, this study has considered and analyzed three of the main criteria, (which are environmental, political and economic criteria) to make recommendations of selecting the location of the landfills site in Baghdad. Within the three main criteria, thirty sub-criteria of the most important criteria were selected for this purpose. From ministries (fieldwork) and theoretical study. In this study, (IBM,SPSS,V23) program was used to analyze the main criteria and sub-criteria and rank them from top-bottom based on their values of Relative Importance Index (RII) technique. The results of this study have reviled that the economic criteria is the most significant main criteria and tenure of land are the most significant sub criteria, which must be significantly considered to make recommendations of selecting the location of the landfills’ sites in Iraq.

Keywords: Relative importance index, Political criteria, Environment criteria, Economic criteria

1. Introduction
Solid waste is one of the most significant environmental problems which the world faces including municipal, industrial, agricultural and hazardous waste [1]. It has been increasing with the population growth and the of the rising commercial and industrial human actions [2]. In most cases, the local municipals deal with the solid waste from its source of generation until its final disposal [3]. Soil west management is one of the main difficulties in several urbanization cities worldwide [4]. Such a problem is especially severe in developing states, which have issues with urban development plans, fast population growth rates, inadequate forecasting of the conditions in the future, and the absence of scientific methods contribute to the manage the soil west in the poor cities [5]. Furthermore, the fast urbanization and requires a better-quality waste management facility, in other words, a MSW facility must be ecologically and economically sound (from the technical point of view) as well as socially accepted to fulfil the requirements of the urbanization development [6]. MSW management is not just an environmental duty but it includes numerous technical and social and economic criteria. Such as
reuse waste, recycling waste, reducing waste, energy recovery from waste, and disposal landfill [7]. Moreover, a safe disposal landfill of solid waste management is required for right MSW. In numerous nations, despite of unwanted environmental effects, waste disposal land using unsanitary landfilling sitting and an open dumping location is in practice as it is humble and relatively low-cost [8]. The siting of the safe, best landfill site is a significant phase which includes and affects the economical, ecological, and the environmental criteria [9]. Categorizing appropriate places for landfilling sitting is the most problematic and contentious step for most of the local cities’ authorities worldwide. The stakeholders in the solid west management systems should be able to predict and classify landfill sites that are accepted by the local society as well as matches the international criteria and standards. Such as, the economical, technical and environmental criteria at stages and operation stages of landfill projects. The main objective of the landfill site location selection process is to make sure that the disposal land facility is located at the good site possible with a minimum negative impact to the environment or to the population possible [10]. For landfill siting, a substantial assessment procedure is wanted to classify the ideal available disposal place which meets the requirements of government regulations and best reduces economic, environmental, health, and social costs [11]. Therefore, an analysis of the potential changes in the original plans is typically needed to be taken into consideration before coming up with a list of potential sites [12].

2. Study area
Baghdad is the capital of Iraq. It is located in the centre of the country, and it is among Iraq's most densely populated cities in Iraq. City of Baghdad has an area of about 885 square kilometres and lies between latitudes (33° 14° to 33° 25° North) and longitudes (44° 31° to 44°17° East). Baghdad Governorate can be distinguished into two parts, Rusafa, which is the western side of the city and Karkh, Rusafa, which is the eastern side of Baghdad. There are 14 municipalities in Baghdad Governorate and 135 districts with an average population of 8,089,570 in 2018. The generation of solid west in Baghdad is rapidly increasing with time passes, mainly because of the rapid population growth and lifestyle developments [13]. The population of the governorate of Baghdad represented 21.2% of the population in 2018 year according to population projections while the capital’s surface only represents 1% of the country's space [7]. To reduce the environmental and health risks that arise from these wastes, they must be contained and properly disposed of in landfills to ensure a healthy and disease-free environment. Therefore, the municipally of solid waste in Baghdad governorate becomes more challengeable and requires more efforts, work and money every [14].

3. Objectives of Research
The research objective with the following:
1. Identify the main criteria that need to be analyzed and considered for recommending the location of the landfill sites in Baghdad Governorate;
2. Identify the sub-criteria that need to be analyzed and considered for recommending the location of the landfill sites in Baghdad Governorate; and
3. Ranking of main criteria and sub-criteria by their values of Relative Important Index (RII).

4. Methodology of Research
Methodology of research can be briefly illustrated by the following steps:
1. Gathering the required information during theoretical study and field work about the study topic based the research plan that is used to find the main and sub criteria in landfill site in Baghdad city.
2. Use the open questionnaire to gathering the data from group of experts from field work.
3. Use the closed questionnaire to gathering the data from open questionnaire and theatrical study to find main criteria and sub criteria and selection the study sample for research.
4. Ranking the main criteria and sub-criteria that should be considered during the process of selecting the locations of landfill sites in Baghdad Governorate.
5. Field work (Case study)
In this study, the field work current in Baghdad Mayoralty, Ministry of Health and Environmental and Baghdad Governorate to find the criteria that is used to selection the landfill in Baghdad city.

5.1. Baghdad Mayoralty
Baghdad Mayoralty divided into two departments, Department of Solid Waste and Environmental and Department of Design.

5.2. Ministry of Health and Environmental
Ministry of Health and Environmental divided to two departments, Technical Department and Solid Waste Management Department

5.3. Baghdad Governorate
Baghdad Governorate has only one department which is the Department of Environment. In the beginning, the study sample was chosen within the spatial boundaries of the study, which is the Baghdad city in Iraq. The sample included the Baghdad Mayoralty with all the above-mentioned departments, the Ministry of Health and Environment with all the previously mentioned departments, and the Baghdad Governorate with the Environment Department (field work).

In this study, the researcher made an open questionnaire by a group of experts working in the Iraqi ministries. The reason for use the open questionnaire to find the criteria that these ministries used in selecting the landfill. Also, the reason for choosing the open questionnaire is to be the entries for the closed questionnaire. Closed questionnaire consists of three parts: The first part contains the individuals of the study sample, while the second part contains an evaluation of the main criteria. That effectively to selecting a landfill site. The third part consists of the evaluation of secondary criteria. As well as to find a relative importance index (RII) for each of the major and minor criteria.

6. Pilot Study
Use the pilot study to validate and evaluate questionnaire forms. A pilot study provides an investigational questionnaire run that contains testing question formulation, identifying confusing questions, and testing the technique that is used to gather the information [15]. The purpose of this stage is to discovery whether the questions are understandable or not, and to get any difficulties that may arise though filling out the closed questionnaire. About the questionnaire, the pilot study was steered by distributing the questionnaire to a group of specialists for the purpose of assessment; They have at least 15 years of long experience in a solid waste management project. Specialists were contacted to evaluate the validity of the questionnaire form and requested to verify the validity of the items of the questionnaire form and their suitability for the research goals. All comments and suggestions have been gathering and rated. All comments and proposed modifications were discussion with the supervisor and evaluated prior to their consideration. At the finish of this procedure, some changes, modifications, and additions were made to the questionnaire and the final questionnaire was created. At this step, the questionnaires form was carefully discussion with the supervisor until to reaching the finishing agreed version.

7. Questionnaire Distribution
Questionnaire distributed (70) questionnaire forms. To the chosen sample, (60) of questionnaire forms were gathering, and (18) samples were excluded for several causes, containing incomplete. Final outcome was (42) questionnaire forms were gathering and analyzed as a part of closed questionnaire forms:
8. Data Analysis of Quantitative
Quantitative data collected was analyzed by (IBM/SPSS.V23) a statically program. factors were measured for ranking by Relative Importance Index (RII) technique. These factors were category in three major criteria (main) and thirty minor criteria (sub).

8.1. Relative Importance Index (RII) Technique
Analysis of data gotten by using the Relative Importance Index technique, equation (1) as using to find the relative importance of criteria (main; sub). For landfill site, some questions were intended to captured background information of respondents [11].

\[
\text{RII} = \sum_{k=0}^{N} \left( X_1 \times S_1 + X_2 \times S_2 + X_3 \times S_3 + \cdots X_n \times S_n \right) / (N \times A)
\]

Where:
RII: Relative Importance Index.
S: Weights given to each criterion by responders and rang from 1 to 5; where 1 is less significant and 5 is high significant.
X: Frequency of any rating for each criteria or selection
N: Number of total of responses for that criteria or selection
A: Highest weights (i.e. in this case 5)

8.2. Mean Score Ranking Technique
Mean score for any criteria or options was computed by using the following equation [12].

\[
\text{Ms} = \frac{\sum_{k=0}^{N} \left( X_1 \times S_1 + X_2 \times S_2 + X_3 \times S_3 + \cdots X_n \times S_n \right)}{N}
\]

Where:
Ms = Mean Score (1 ≤ MS ≤ 5)

9. Psychometric Characteristics
Basis of all robust probe designs. Use psychologically sound measuring tools. Confirmation of the reliability and validity of the tools is a prerequisite for ensuring the validity of the study results. Knowing what kind of psychometric characteristics to examine, what statistical tools examinations mean, or what kind of evidence are sufficient can be problematic.

9.1. Validity of Questionnaires
Validity is the degree to which an examination actions what it claims to measure. Validity is not founded by a single statistic tools, but via a figure of study that clarifies the link between the test and the behavior it aims to measure. It is imperative that the test be valid to apply and interpret the results accurately.

9.2. Reliability of Questionnaires
Reliability is definite as a measurement to true outcomes and contains stability and equality checks. Reliability is a required but not enough elements of tool viability; It indicates the ability of the instrument to continuously measure the criteria.

9.3. Cronbach’s Alpha
Most social science study situations use the Cronbach’s alpha. Reliability coefficient of (0.70) or higher is consider "acceptable" [16].
10. Criteria for landfill site selection
Different academics used different factors (criteria). Regarding the location of the landfill, it is mostly due to the fact that different criteria apply to different and different areas nearby. There are a number of criteria here. For selecting a landfill site, which are environmental, political, and economic criteria.

10.1. Environmental criteria
Main objective of environment criteria is reducing pollutions with desirable and lowest use of resources that its consequence is perfect output with extra production and a smaller amount of waste. the environment criteria divided in to (12) sub criteria. The environmental sub-criteria showed in table 1 below [17].

| No. | Environmental sub-criteria                                      |
|-----|-----------------------------------------------------------------|
| 1   | Annoying odors and dust                                         |
| 2   | Odours and dust nuisances                                       |
| 3   | Nuisance via the traffic generation                             |
| 4   | Dangers for explosion                                           |
| 5   | Nuisance for neighbouring zone                                  |
| 6   | Ecological value of scientific zones                            |
| 7   | Slope of locations                                              |
| 8   | Streams of locations                                            |
| 9   | Surface water of locations                                      |
| 10  | The distance from faults                                        |
| 11  | The distance to historical regions                              |
| 12  | The distance to cemeteries locations                            |
| 13  | Fencing the site before starting to exploit it                  |

10.2. Political criteria.
Political criteria it is very significant criteria, many states have accepted laws and policies to regulator the quantities of solid waste generated. The improper solid waste management and its bad influence on the environmental, social and economic criteria. That has gathered the care of many governments around the state [18]. Political sub-criteria of showed in table 2 below.

| No. | Political sub-criteria                                       |
|-----|----------------------------------------------------------------|
| 1   | Approval via local municipalities                            |
| 2   | Approval via pressure groups                                 |
| 3   | Landfill area Property                                       |
| 4   | Military area                                                |
| 5   | National border                                              |
10.3. Economical criteria
Economic criteria is one of greatest significant criterion for landfill location, and the aim can be achieved with careful planning. Due to the high cost of landfill containing transportation of garbage and garbage to landfill, energy consumption, and land tenure; Economic standards should be used well as they are economical. important sub-criteria used in the seating process [19]. Economical sub- criteria are shown in Table 3 below.

| No. | Economic sub- criteria                          |
|-----|------------------------------------------------|
| 1   | tenure of land                                  |
| 2   | Value of land                                   |
| 3   | Use of land                                     |
| 4   | Elevation of land                               |
| 5   | Distance to main ways                           |
| 6   | Distance to sub ways                            |
| 7   | Distance to transfers station waste             |
| 8   | Personnel and maintenance cost                  |
| 9   | Aftercare cost                                  |
| 10  | Access of the landfill cost                     |
| 11  | Transports cost                                 |
| 12  | Construction cost for out and inside roads       |

11. Discussion of Statistic Examination
(IBM/SPSS-V23) statistical program is used to have the head test factors through this analysis. For a simple and understandable manner, they have been provided in the form of tables. The next step after distributing and collecting the questionnaire forms, is to find a specified method for statistical methods and procedures were used to complete calculations and data analysis.

12. Cronbach’s Alpha of Questionnaires
By using (IBM/SPSS-V23), the value of Cronbach’s Alpha for the identification of the total questionnaire as shown in table 4, equal to (0.910), and the factor of the stability in the resolution is high.

| Criteria      | Cronbach’s Alpha | No. of Elements |
|---------------|------------------|-----------------|
| Environmental | 0.899            | 13              |
| Political     | 0.794            | 5               |
| Economic      | 0.815            | 12              |
| Total         | 0.910            | 30              |

From table above, Cronbach's Alpha coefficient for the first main criteria environmental equal (0.899) and the second main criteria for political equal (0.794), and the third main criteria economic equal (0.815). Coefficient of Cronbach’s alpha of 0.70 or greater is considered acceptable.
13. Reliability and Validity of Questionnaires

By using (IBM/SPSS-V23), the value of Reliability and Validity for the identification of the total questionnaire as shown in table 5, equal to (0.810), and the factor of the stability in the resolution is high.

Table 5. Reliability and Validity of Questionnaires

| Criteria       | Reliability | Validity | No. of Elements |
|----------------|-------------|----------|-----------------|
| Environmental  | 0.872       | 0.933    | 13              |
| Political      | 0.840       | 0.916    | 5               |
| Economic       | 0.922       | 0.960    | 12              |
| Total questionnaire | 0.810   | 0.900    | 30              |

14. Closed questionnaire analysis

Closed questionnaire divided into three parts, first part a description of the members of the sample General experience. Second part of main criteria and third part of sub - criteria. Respondents were asked to mark the main criteria and sub - criteria which they believed were suitable for their selection. In part two and part three requested from respondents to selection the items from main criteria and sub-criteria from the closed questionnaire. Closed questionnaire contains of three major parts; environmental criteria, political criteria and economic criteria. Each main part includes a set of secondary factors. In this study, the arithmetic mean and relative importance index were extracted. For each main part to find which major part is the most significant then ranking the main criteria from highest to lowest. Also, the sub-criteria ranking from top to down by arithmetic mean and (RII). For this study the closed questionnaire includes two types of criteria main criteria and sub-criteria. First main criteria include 13 factors, second main criteria consist 5 factors finally third main criteria made up 12 factors environment.

14.1. First part of the questionnaire (General experience)

General experience for a simple in closed questionnaire forms presented in three items, that include:

14.1.1. Best identification. Best identification of samples that (54.76%) of respondents working as engineer, in this portion engineering working in solid waste management projects, and some of them working inside the Department. While (16.67%) are working as Academics in universities, like university of Technology and the university of Baghdad, (11.90%) are working as Administrative Personnel, while (9.52%) are Legal personnel. showed in table 6.

Table 6. Best identification

| Best Identification | Percent % |
|---------------------|-----------|
| Academics           | 16.67 %   |
| Consultant          | 7.14 %    |
| Engineers           | 54.76 %   |
| Administrative Personnel | 11.90 % |
| Legal Personnel     | 9.52 %    |
14.1.2 Years of Experience. Those respondents that were selected have not less than (15) year knowledge in solid waste Management project field. showed in table 7.

| Years of experience | Percent % |
|---------------------|-----------|
| 5-10 years          | 11.90%    |
| 11-15 years         | 23.80 %   |
| 16-20 years         | 28.58 %   |
| 20-30 years         | 35.72 %   |

14.1.3 Academics Degree. 47.619 % have BSc, 28.571 % have MSc, and 23.809% have PhD, this is showed by the table 8 below.

| Academics degree | Percent % |
|------------------|-----------|
| BSc              | 47.619%   |
| MSc              | 28.571 %  |
| PhD              | 23.809 %  |

14.2 Second part of the questionnaire (main criteria)
Second part of the question involved a request for assessment of three major criteria upon from the selection of the landfill site were getting from the theoretical and filed work. The assessment technique was founded by five-point Likert scale, and mean. In this study, analysis the main criteria according to arithmetic mean and relative importance index (RII) by use the (IBM/SPSS-V23) Showed in table 9.

| Main criteria | Mean   | RII    |
|---------------|--------|--------|
| Environmental | 3.738  | 74.762 |
| Political     | 3.595  | 71.904 |
| Economic      | 3.952  | 79.048 |

Table above shows the answers of sample members of respondents about main criteria of closed questionnaire results. obtained from analysis via used the mean and RII

14.3. Third part of the questionnaire (sub-criteria)
In this study, analysis the sub-criteria according to arithmetic mean and relative importance index (RII) by use the (IBM / SPSS-V23) program. In terms of statistics, the factors of sub-criteria that can be taken to get the importance of the index is greater than 60%. And the criteria of sub-criteria that got less than 60% will rejection. The sub-criteria divided in to thirty criteria, in this study, grouped these criteria in to three groups. First group contain 12 criteria, second group consists 13 criteria and third group include 5 criteria.
14.3.1 First group of sub-criteria: Table 10 shows resulted of analysis of first group of economic sub-criteria from upper to bottom values.

| Economic sub-criteria          | Mean | RII   |
|--------------------------------|------|-------|
| tenure of land                 | 4.071| 81.428|
| Value of land                  | 3.952| 79.048|
| Use of land                    | 3.738| 74.762|
| Elevation of land              | 3.500| 70.000|
| Distance to main ways          | 3.429| 68.572|
| Distance to sub ways           | 3.381| 67.620|
| Distance to transfers station waste | 3.214| 64.286|
| Personnel and maintenance costs| 2.762| 55.238|
| Aftercare cost                 | 2.762| 55.238|
| Access of the landfill costs   | 2.619| 52.380|
| Transports Costs               | 2.548| 50.952|
| Construction cost for out and inside roads | 2.405| 48.096|

The results were obtained from analysis by used the mean and relative importance index. Mean between 4.071 - 2.405 and the relative important index was between the numbers 81.428% - 48.096%.

14.3.2 Second group of sub-criteria. Table 11 shows the resulted of analysis of second group of environment sub-criteria from top to bottom values.

| Environment sub-criteria          | Mean | RII   |
|-----------------------------------|------|-------|
| The distance to historical regions | 3.952| 79.048|
| Ecological value of scientific zones | 3.833| 76.666|
| Annoying odors and dust           | 3.738| 74.762|
| The distance to cemeteries locations | 3.643| 72.858|
| Nuisance for neighbouring zone    | 3.595| 71.904|
| Nuisance via the traffic generation | 3.143| 62.858|
| Slope of locations                | 2.999| 60.000|
| The distance from faults          | 2.952| 59.048|
| Surface water of locations        | 2.857| 57.142|
| Dangers for explosion             | 2.762| 55.238|
| Odors and dusts nuisances         | 2.619| 52.380|
| Fencing the site before starting to exploit it | 2.548| 50.952|

Results were obtained from analysis by used the mean and relative importance index. Mean between 3.952 - 2.548 and the relative important index was between the numbers 79.048 % - 50.952 %. 
14.3.3. Third group of sub-criteria. Table 12 shows the resulted of analysis of third group of political sub-criteria from peak to lowest values.

| Political sub-criteria            | Mean  | RII    |
|-----------------------------------|-------|--------|
| Approval via local municipalities | 3.738 | 74.762 |
| Approval via pressure groups      | 3.643 | 72.858 |
| Landfill area Property            | 2.762 | 55.238 |
| Military area                     | 2.619 | 52.380 |
| National border                   | 2.405 | 48.096 |

Outcomes were gotten from analysis by used the mean and relative important index. Mean between 3.738- 2.405 and the relative important index was between numbers 74.762% - 48.096%.

15. Final statistics results for second part of the questionnaire (main criteria)

Table 13 shows the final analysis for main criteria conducted by used the (IBM/SPSS-V23) program ranking criteria from top to bottom.

| Main Criteria   | Mean  | RII    | Ranking |
|-----------------|-------|--------|---------|
| Economic        | 3.952 | 79.048 | 1       |
| Environmental   | 3.738 | 74.762 | 2       |
| Political       | 3.595 | 71.904 | 3       |

From table above we noticed that high main criteria were to economic by 79.048% and ranking in first position and low criteria was political by 71.904% and ranking in last position.

16. Final statistics results for third axis of the questionnaire (sub-criteria)

Tables 14, 15 and 16 show the final ranking factors of final statistics results for first, second and third groups of sub-criteria.

| Economic sub-criteria | Mean | RII    | Ranking |
|-----------------------|------|--------|---------|
| tenure of land        | 4.071| 81.428 | 1       |
| Value of land         | 3.952| 79.048 | 2       |
| Use of land           | 3.738| 74.762 | 3       |
| Distance to main ways | 3.500| 70.000 | 4       |
| Transports Costs      | 3.429| 68.572 | 5       |
| Access of the landfill costs | 3.381 | 67.620 | 6       |
| Elevation of land     | 3.214| 64.286 | 7       |
From table 14 we noticed that high sub-criteria from first group was land possession by 81.428% and ranking in first position and low criteria was land elevation by 64.286% and ranking in last position. Final statistics for environment sub-criteria for first group.

### Table 15. Final statistics results for environment sub-criteria

| Environment sub-criteria | Mean  | RII      | Ranking |
|--------------------------|-------|----------|---------|
| The distance to historical regions | 3.952 | 79.048   | 1       |
| Ecological value of scientific zones | 3.833 | 76.666   | 2       |
| Annoying odors and dust | 3.738 | 74.762   | 3       |
| The distance to cemeteries locations | 3.643 | 72.858   | 4       |
| Nuisance for neighbouring zone | 3.595 | 71.904   | 5       |
| Nuisance via the traffic generation | 3.143 | 62.858   | 6       |

From table 15 we noticed that, high sub-criteria from second group was distance to historical areas by 79.048% and ranking in first position. and low sub-criteria was nuisance by traffic generation by 62.858% and ranking in last position. This the final statistics for sub-criteria of environmental for second group.

### Table 16. Final statistics results for political sub-criteria

| Political sub-criteria         | Mean  | RII      | Ranking |
|--------------------------------|-------|----------|---------|
| Approval via local municipalities | 3.738 | 74.762   | 1       |
| Approval via pressure groups   | 3.643 | 72.858   | 2       |

From table 16 we noticed that high sub-criteria from third group was acceptance by local municipalities by 74.762% and ranking in first position. and low sub-criteria was Military area 72.858% and ranking in last position. This the final statistics for sub-criteria of political for third group.

17. Result

In this study, the landfill site selection in Baghdad governorate rely from many criteria like, environment criteria and political criteria and economic criteria. And each main criterion has a sub-criterion. Thirty sub-criteria founded in this study, comparing with many studies conducted in same environmental and founded the criteria was very minimum. When analysis the main and sub-criteria by (SPSS V23) the criteria ranking from higher to bottom and exclusive the value less than 60% from these criteria. Therefor the sub-criteria become fifteen criteria. Also, used the value of Cronbach's Alpha for the identification of the total questionnaire equal to (0.910), and the factor of the stability in the resolution is high. And validity and reliability of closed questionnaires was done in this study and founded (0.810), (0.900) as respective.

18. Conclusion

The current waste disposal locations in Baghdad Governorate do not follow to the environment and scientific factors. And it affects human’s health. Baghdad city suffers from a large spread of solid waste and the absence of regular landfill site in line with international and local standards. Therefore, this research presents a set of criteria (main and sub) drawn from previous studies and field work. The goal of the present study, is to identification the most appropriate criteria for landfill sites in the Baghdad governorate, with the environmental criteria, political criteria and economy criteria that is used to selection of landfills site. All criteria for main and sub analysis by (SPSS V23) program, to find the higher relative importance index.
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