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AN INTEGRATED APPROACH OF DEMATEL AND AHP FOR RISK EVALUATION POLICY OF LANDFILL MANAGEMENT AT KHULNA CITY

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ABSTRACT

Waste from domestic, industrial or any other sources contain various solid waste and plastic waste. Those may be harmful or useful for the environment and human depends on its dumping process. The process of dumping of undesirable domestic waste that include plastic waste, solid waste and industrial waste from cities or areas depends on selection of new landfills and its management. This whole process can be harmful or can be useful for the society/area/city how it's been selected and which method it's been approved also how it is viable, reasonable, and well managed. For this risk evaluation policy is very important to sort out the waste disposal drawbacks in cities. This study is a Fuzzy AHP, and Decision-Making Trial and Evaluation Laboratory (DEMATEL) approach aim to perform systematic landfill site selection and its management finding the research gap and taking the experts opinion by developing a risk evaluation policy support system for sustainable household waste management using a value focused multi criteria methods. For this purpose, Khulna city, Bangladesh was selected as study area. The study shows how effectively multi criteria discission methods is in handling wide range of domains involved in developing risk evaluation policy while selecting landfill sites and its managements.

Keywords: Landfill, Policy, Khulna City, Fuzzy AHP, DEMATEL, Authority, Viability, Reasoning, Management

1. Introduction

The unmanageable development of Khulna city, Bangladesh has created a problem due to the irresistible waste generation. This is happening due to over population of this region without effective policy and habit of overthrowing rules and ineffective implementation of policy. Moreover, waste collection is carried out following a predetermined course. Therefore, landfill management is an issue. Landfill always naturally gives us health and environmental hazard. As per environmental policy, landfill should have few principles those are protection, compliance, conservation, communication, suspension of violation of law or waste management core value (Taylor, 2009). The fuzzy AHP is a decision-making tool. This tool, decompose a complex problem into a multi-level hierarchical structure, that include the objectives, criteria, sub criteria and alternatives also describe overall performance of the decision. A study conducted by Saaty (1990) and presented fuzzy AHP method to determine the priority of the relative importance of options and features in multi-criteria decision issues. One of the strength points of the fuzzy AHP model is ease of use. In addition, fuzzy AHP method can effectively handle both qualitative and quantitative data simultaneously in the decision-making process. Though the purpose of fuzzy AHP is to capture the expert's knowledge but the conventional fuzzy AHP still cannot (Cebeci, 2009) reflect the human thinking style (Kahraman et al., 2003). Fuzzy AHP method is often criticized due to its use of unbalanced scale of judgments and inability (Si et al., 2018) to resolve the inherent ambiguity, that's why to validate and balance it DEMATEL process has been included in this study. The DEMATEL technique first developed by the Geneva Research Centre of the Battelle Memorial Institute to visualize the structure of complicated causal relationships through matrixes (Gabus and Fontela, 1972). As a kind of structural modeling

approach, it is especially useful in analyzing the cause-and-effect relationships among components of a system. The DEMATEL can confirm interdependence among factors and aid in the development of a map to reflect relative relationships within them and can be used for investigating and solving complicated and intertwined problems (Soltani et al., 2017).This method not only converts the interdependency relationships into a cause-and-effect group via matrixes but also finds the critical factors of a complex structure system with the help of an impact relation diagram.

With that backdrop, this study will framework and going to set the risk evaluation policy waste landfill management in Khulna city basing on those principals. Therefore, adjusting the principals are thought-provoking opportunity to work with this study. The motivation of this study is to find out the research gap in selection of new landfill and its management by taking the expert view from questioner's survey in present context. After that, the future proposal for risk evaluation policy will be done using Fuzzy Analytical Hierarchy Process (fuzzy AHP) and later on will be validated through Decision Making Trial and Evaluation Laboratory (DEMATEL).

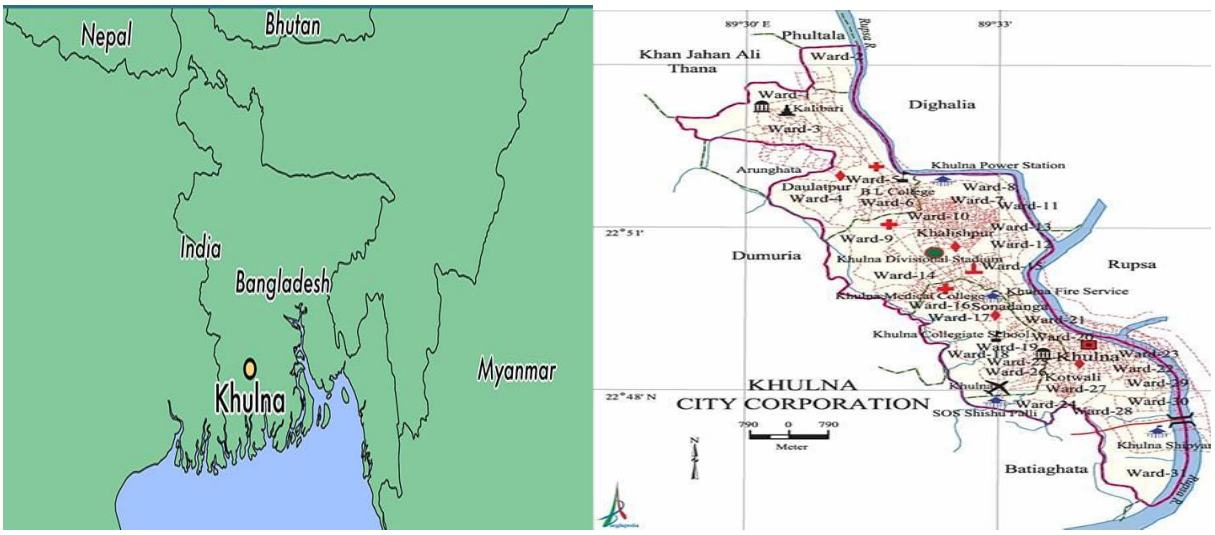


Fig-1: Khulna City Location Map

2.1 Study Area

Khulna is a well-developed city of Bangladesh. The population of this area is 950232 as per recent census in 2022 and growth rate is 0.11%. Which is 3rd in Bangladesh,394th in Asia and 638th in world. The projected population will be 1,25,1172 (2041). Waste generation rate: 0.33 kg/cap/day (1% increase/year). But there are three landfill sites in Khulna City under Khulna City Corporation (KCC). Those are Rajbandh-l, Rajbandh-2, and Solua.Rajband-1 established in 1961, total area is 20 acres, all types of waste can be disposed. The distance from city to Rajband-1 is 7km having open dumping system with partial waste segregation. Waste can be disposed 315 tons/day. In Rajaband-2, total area is 5 acres and established in 2002.FS and medical waste can be disposed in this landfill which is 8 km way from city having open dumping practice with no segregation facilities. It can dispose 2-3 ton/day waste. Figure shown the area of Rajband -1 landfill.

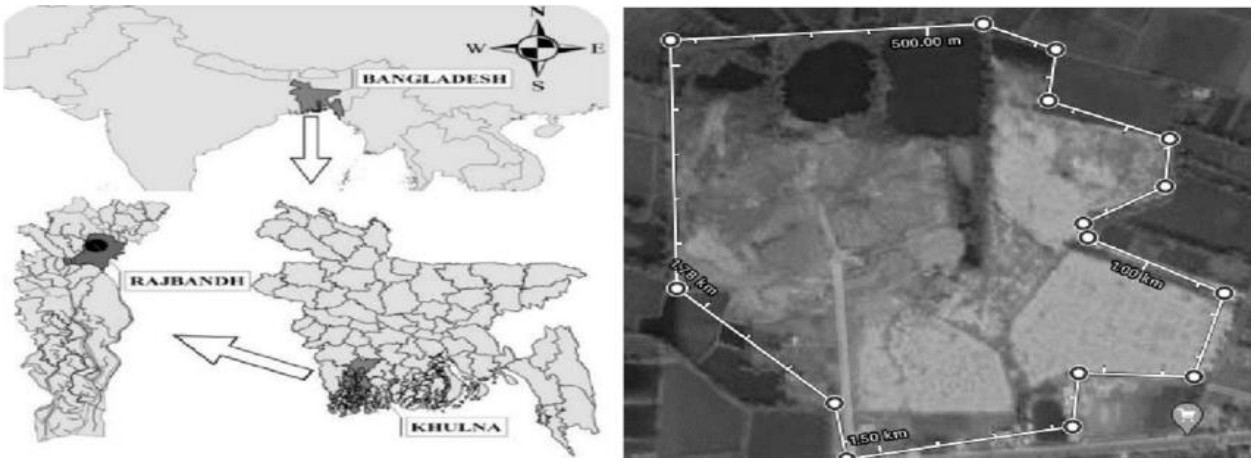


Fig-3: Location Map and area of landfill Rajband-1 Khulna City, Bangladesh

Solua landfill established in 2011 due to growing waste generation of Khulna City. Total area of this Landfill is 17 acres having Municipal Solid waste disposal facility with landfill and RR dumping practice. This is 15 km away from Khulna City.

2.2 Existing Policy, Law, and Act of Landfill Management

Landfill managements systems are governed by following rules, acts, and policies those are as follows:

a. Environment Conservation Act, 1995
b. National Sanitation Strategy, 2005
c. 8th Five Year Plan
d. Nationally Determined Contribution (NDC), 2015
e. Draft Final Solid Waste Management Rules, 2020
f. Single Use Plastic Management Work Plan, 2021

Here are the few important **Environment Conservation Acts-1995** related to this study has given below:

a. “Waste" means any solid, liquid, gaseous, radioactive substance, the discharge, disposal and dumping of which may cause harmful change to the environment.
b. Conservation of environment" means improvement of the qualitative and quantitative characteristics of different components of environment as well as prevention of degradation of those components.
c. Environmental Clearance Certificate - No industrial unit or project shall be established or undertaken without obtaining, in the manner prescribed by rules, an Environmental Clearance Certificate from the Director General.
d. Formulation of environmental guidelines. - The Government may, by notification in the official Gazette from time to time, formulate and publish environmental guidelines relating to the control and mitigation of environmental pollution, conservation, and improvement of the environment.
e. Claim for compensation. - Where a person or a group of persons or the public suffers loss due to violation of a provision of this Act or the rules made thereunder or a direction issued under section7, the Director General may file a suit for compensation on behalf of that person, group, or the public.

From the Acts-1995, it has been found that “conservation” of environment has been empathized more. Provision for “compensation” for effected people and “authority” need to exercise power before formulation of guideline also been highlighted.

Here are the few points related to this study from **8th Five Year Plan** perspective has given below:

a. Khulna City Corporation: Construction and development of 145 kms roads, 328.60 kms drains, installation of 130000 energy saving lamps, construction of a sanitary landfill, beautification of the city and fountains, construction of 8 ward offices were completed up-to 2018. To improve the sanitation situation, 790 sanitary latrines were constructed.

b. In the area of solid waste management, the traditional approach to collecting solid waste and burying them in a landfill dump is giving way to more scientific and environmentally safe approach to complete solution method.

c. The complete solution method includes integrated waste management system that includes transfer station, compost plant, biogas plant, controlled landfill cell, fecal sludge management etc.
d. Policy makers to mobilize collective efforts for inclusive and sustainable urban development.

The 8th Five Year Plan puts special emphasis on formulation of landfill and how scientifically it needs to construct by seeing the “viability” and seeing the correct safe approach also by “reasoning” out logically. It reminded “authority” (policy makers) to take collective efforts before taking decisions. It’s also highlighted integrated management system that is “total operational management.”

The **Solid Waste Management Regulations 2021** were published in Bangladesh on December 23, 2021, under the Bangladesh Environmental Protection Act, 1995. The Regulations define the responsibilities of businesses involved in solid waste management and impose collection, recycling, and disposal obligations according to **Extended Producer Responsibility (EPR)** on manufacturers of non-biodegradable products such as glass, plastic, and bottles. The Regulations also include provisions for the treatment of solid waste such as composting and energy recovery. The main provisions of the Regulations are as follows:

a. When recovering resources from waste, the principles of management that consider the waste hierarchy, such as the 3Rs, segregation, and reduction, must be followed at all stages from waste generation to final disposal.
b. Responsibilities of waste generators, consumers, and users:
    i. Dispose of waste in accordance with the regulations of authorities including local government.
    ii. Dispose of waste separately.
    iii. Do not dump, store, or burn waste outdoors.

c. Responsibilities of manufacturers (*not defined) and importers of products.
d. Collect non-biodegradable products such as glass, plastic, polyethylene, multi-layered packaging, bottles, and cans from consumers and recycle or dispose of them if appropriate.
e. Determine work plans and implementation procedures for recycling and disposal. Ensure that EPR is properly implemented.
f. Submit an annual report to the Department of Environment (DOE) on the amount of plastic recycled.
g. Raise public awareness of proper waste management.

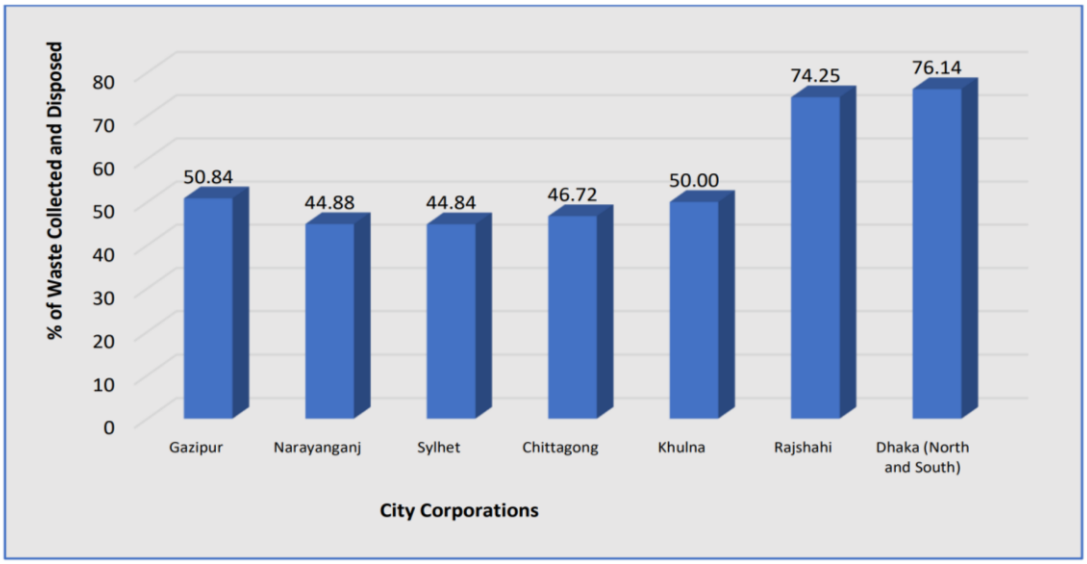


Fig-4: Waste collection efficiency of various city corporation

Source: CEGIS: Baseline survey on waste generation-2013; BIGD state of cities: Solid waste management in Khulna City Corporation 2020

2.3 `Authority: Authority is nothing but a government agency or public office responsible for an area of regulation. Here shown the Authoritative sources relationship with Management framework:

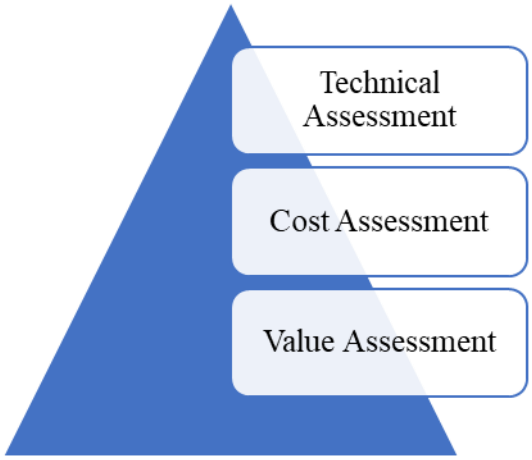


Fig-5 & 6 Authoritative sources relationship with Management framework, & Ladder of Viability Assessment

2.4 Viability: The viability study is not about whether something is doable, but rather whether it is worth doing**.** Common areas under a viability study include studies on the market, technical aspects of any case. Three aspects of Viability assessment those are.

2.5 Reasoning: Reasoning is the ability to assess things rationally by applying logic based on new or existing information when planning or solving a problem. Reasoning comes in diverse forms, from everyday decision-making processes to powerful algorithms. There are 7 types of reasonings, those are as follows: (Rovins et al., n.d.)

2.6. Management: Management is the practice of planning, controlling, leading a department or team to achieve the business goals. There are several types of managements.

a. **Risk management:** Identification and management of potential outcome that threaten the organization goal. Risk Management is the process of identifying, assessing, reducing, and accepting risk. Effort to avoid, mitigate and transfer risk can produce significant return. It's also led to accepting risk rather to avoid it. Project management is heavily focused on risk management.(Rovins et al., n.d.)

b. **Change Management:** The practice of leading organizational change. Typically focused on human factor such as resistance to change.

c. **Operational Management:** Management of the core process of business.

3. RESEARCH METHODOLOGY

In this study, Fuzzy AHP and DEMATEL approaches will be combined in a decision model, however, it will be implemented independently (Si et al., 2018). Based on the basic definitions and operations of fuzzy sets, fuzzy logic and DEMATEL methodology will be developed. Firstly, it will evaluate the mutual influences between factors using fuzzy linguistic scale. Secondly, it will establish a fuzzy linguistic scale to assess the causal relationships among factors (Naveena et al., 2019). In order to tackle the vagueness and imprecision in assessments, the linguistic terms "No, Very Low, Low, High, Very High" will be expressed in triangular fuzzy numbers that will be used for the linguistic variable "influence". As a result, the individual direct-influence fuzzy matrix will be acquired for each of the respondents. To operationalize this study, various methods and approaches has been endeavored. Extensive books and articles of previous researchers will be consulted. This method will help in research findings, analyses, limitations, and formulation of the proposal. A qualitative analysis will be carried out in this method.Date will be collected from primary and secondary sources as well as from experts' opinions. Those data will be utilized for quantitative analysis.

Modeling: This will use data to develop a model through fuzzy AHP and DEMATEL approaches. After modelling, output data will be analyzed to develop policy. The research methodology diagram is given in Figure 1.

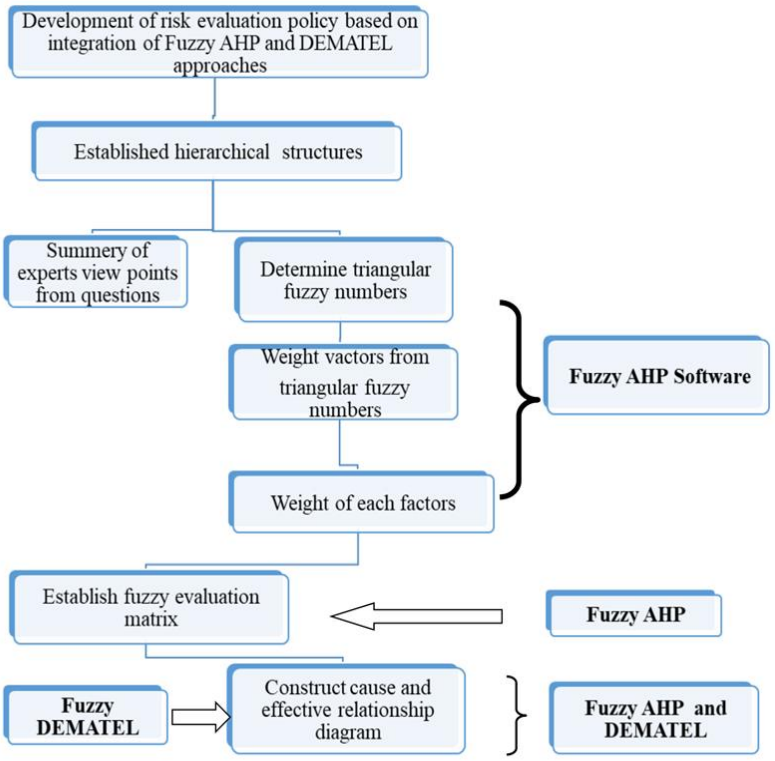
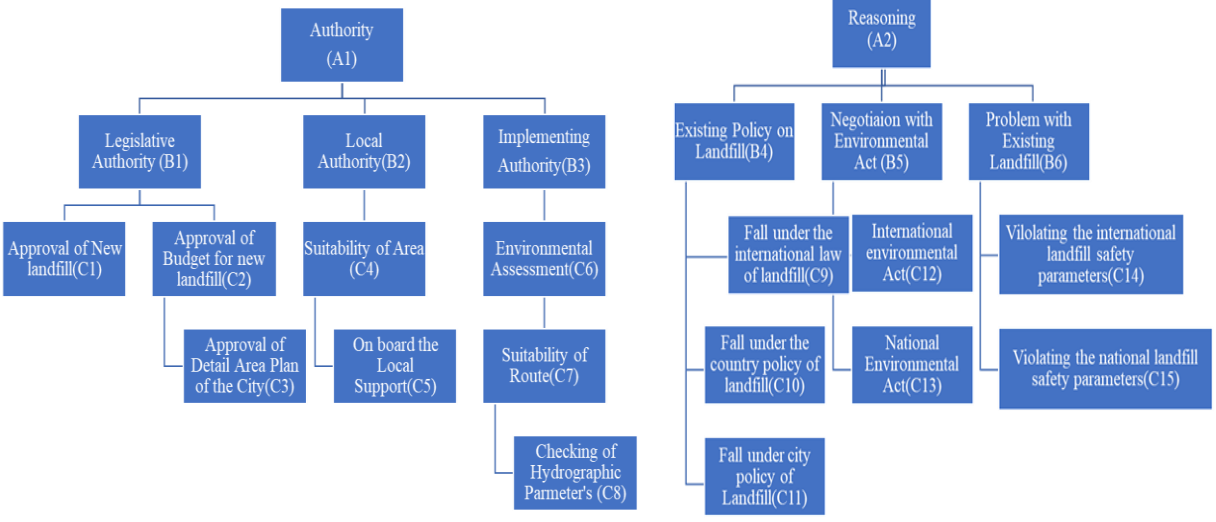


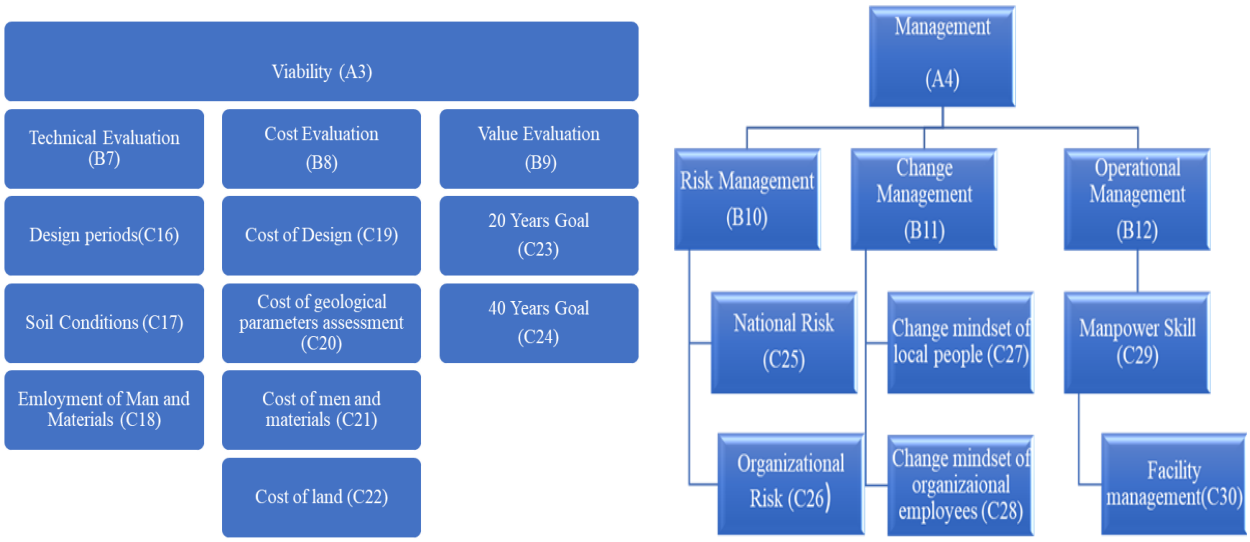
Fig 7: Overall research methodology of this study

4. RESULTS AND DISCUSSION

4.1 Establishment of Hierarchical Structures: As per literature review it has been found that researcher mostly ignored following domain like authority, reasoning, viability, and few management tools while selecting the new landfill. Here we put the hierarchical structures of all domains.



(a) **(b)**



(c) **(d)**

Fig-8 (a, b,c,d) Hierarchical Structures of “Authority”, “Reasoning”, “Viability”, “ Management”

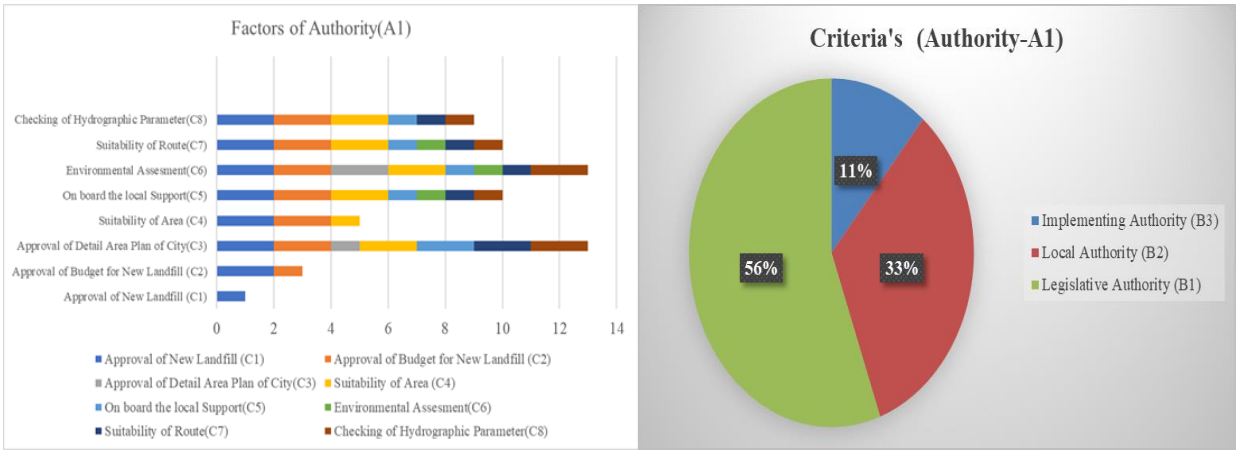
4.2 Authority: Here the “Authority” is the First Domain, which is denoted by A1. The Criteria of this domains are Legislative Authority, Local Authority, and Implementing Authority. Those criterions are denoted by B1, B2, B3 respectively. Again all the criterions are subdivided by factors C1, C2, C3,C4,C5,C6,C7 shown in tree format.

4.3 Reasoning: “Reasoning” is the Second Domain, which is denoted by A2. The Criteria of this domains are Existing Policy on Landfill, Negotiation with Environmental Act, Problem with Existing Landfill. Those criterions are denoted by B4, B5, B6 respectively. Again, all the criterions are subdivided by factors C8, C9, C10, C11, C12, C13, C14, C15 shown in tree format.

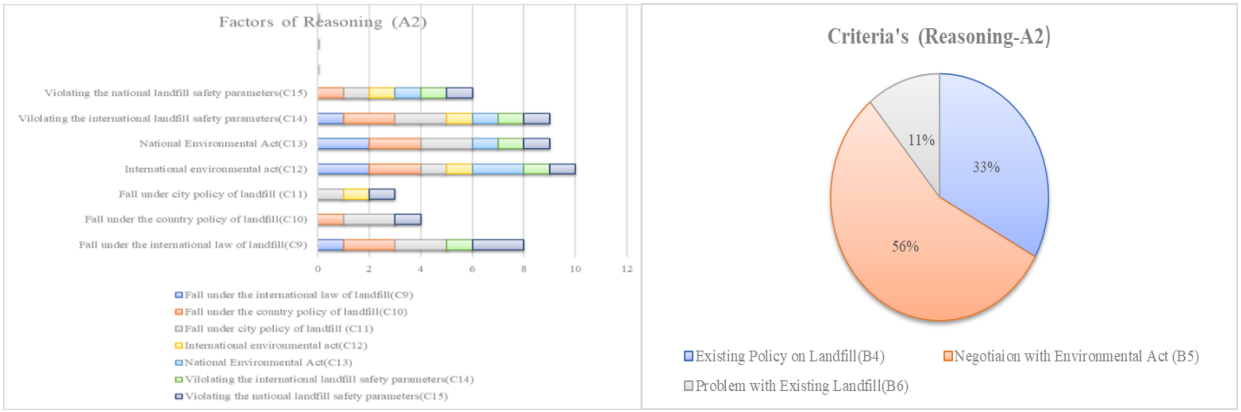
4.4 Viability: “Viability” is the Third Domain, which is denoted by A3. The Criterions of this domains are Technical Evaluation, Cost Evaluation and Value Evaluation. Those criterions are denoted by B7, B8, B9 respectively. Again, all the criterions are subdivided by factors C16, C17, C18, C19, C20, C21, C22 respectively shown in tree format.

4.5. Management: “Viability” is the Forth Domain, which is denoted by A4. The Criterions of this domain are Risk Management, Change Management and Operational Management. Those criterions are denoted by B10, B11, B12 respectively. Again, all the criterions are subdivided by factors National Risk, Organizational Risk, change mindset of local people, Change mind set of organizational employee, Manpower Skill and facility management are denoted as C23, C24, C25, C26, C27, C28, C29 respectively.

4.6 Summary of experts’ opinions by pairwise comparison method: We took 20 experts from universities (Khulna University of Engineering and Technology, Jashore University of Science and Technology also Military institute of Science and Technology and organizations (Khulna City Corporation) related to landfill management. We have given importance of their answers basing on their experience on this field. We put their opinions on comparison Matrix to get the hierarchy value of all factors and criterions. The hierarchy of all those criterions and factors are shown below chronologically.



(a) (b)



(c) (d)

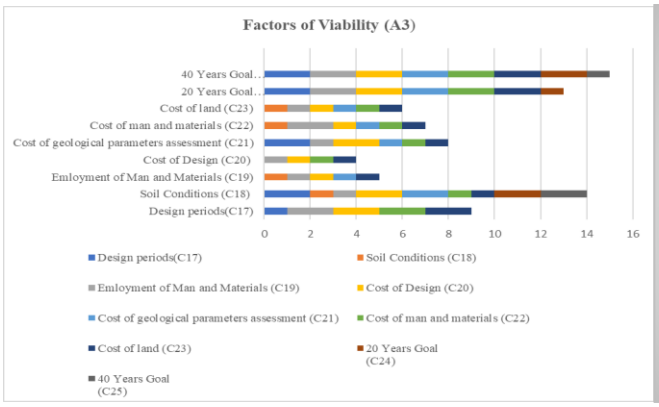
Fig-9 (a, b,c,d) Pairwise comparison method (Factors and Criterions of Authority, Reasoning)

4.7 Authority (A1): Here we have taken the experts opinions. Firstly, we have given the importance on ranging the opinions from 1 to 7. Basing on those opinions we have got the importance of individual answer shown in appendix 1. Basing on those importance we put the ranging in pairwise comparison matrix using the rules “0” is the criteria when importance of row is less than column again “2”is the criteria when row is more important than column and “1” is the criteria when both have equal importance. From pairwise comparison matrix we get the importance value of factors. Here in Fig-R1 we, can see the factor C6 and factor C3 is most important factors among the seven factors having the weight of 20% each. Next important values are C7(16%), C5(16%), C8(14%), C4(8%),C2(5%) and C1 (2%) respectively. If we project, it in real scenario we can find that, “Environment Assessment” and “Approval of detail area plan” is most important factors and foremost factors for selection of new landfill. Again, considering the criteria, from the experts’ opinions and putting it in comparison matrix we find that criteria B1 is most important than other two criteria. In practical scenario we can also relate that the “legislative authority(B1)” is the most important criteria while selecting a new landfill.

4.8 Reasoning (A2): Here we have taken the experts opinions. Same way, we have given the importance on ranging the opinions from 1 to 7. Basing on those opinions we have got the importance of individual answer shown in appendix 2. Basing on those importance we put the ranging in pairwise comparison matrix. From pairwise comparison matrix we get the importance value of factors. Here in Fig-14 we, can see the factor C12 is the most important factors among the seven factors having the weight of 22.45% each. Next important values are C14(20.41%), C13 (20.41%), C9 (16.33%), C16(8.16%), then

C10 and C11respectively. If we put it in real scenario, we can find that, International Environmental Act is the most important factors and foremost factors for selection of new landfill followed by violation of international landfill safety parameters can be the most important reason for poor management of existing any landfill which need to be address first and then we need to give more importance to the National Environmental Act for selecting a new landfill. Again, considering the criteria, from the experts' opinions and putting it in comparison matrix we find that criteria B5 is most important than other two criteria. In practical scenario we can also relate that the "Negotiations with Environmental Act" can be the reasons for poor landfill management system which need to be address while selecting the new landfill.

4.9 Viability (A3) : For the domain "Viability" we have also taken the expert opinion by giving the importance on ranging the opinions from 1 to 7. Basing on those opinions we have got the importance of individual answer shown in appendix 3. Basing on those importance we put the ranging in pairwise comparison matrix using the rules "0" is the criteria when importance of row is less than column again "2"is the criteria when row is more important than column and "1" is the criteria when both have equal importance. From pairwise comparison matrix we get the importance value of factors. Here in Fig-16 we, can see the factor C25 is most important factors among the nine factors having the weight of 18.52%. Next important factors are C18(17.28%), C24(16.05%), followed by C17> C21>C22>C23>C19>C20. If we see in real scenario, we find that "40 years goal"(C25) is the most important factor of Viability domain also for selection of any new landfill. Again, considering the criteria, from the experts' opinions and putting it in comparison matrix we find that criteria B9(56%) shown in figure 17 is most important than other two criteria. In practical scenario we can also relate that the "Value Evaluation (B9)" is a most important criteria for selection of new landfill.



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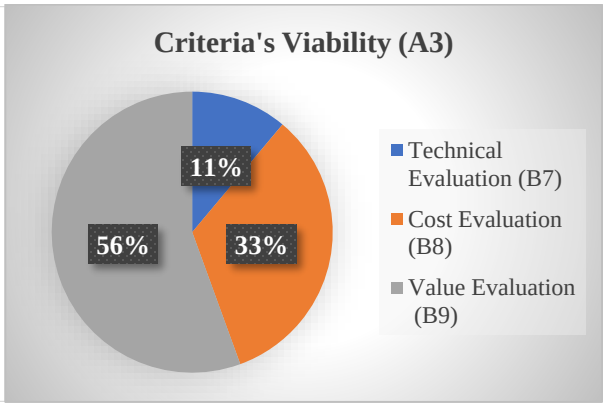

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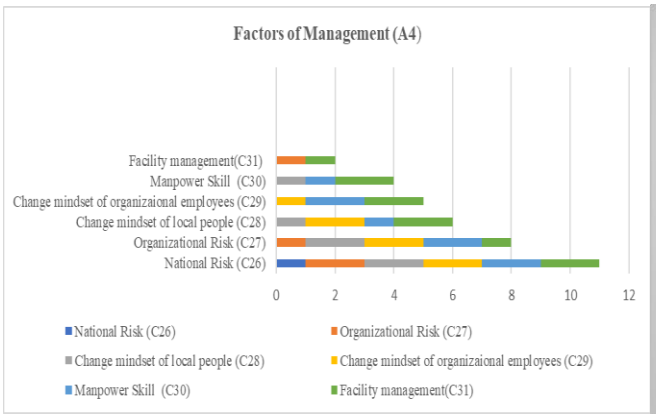

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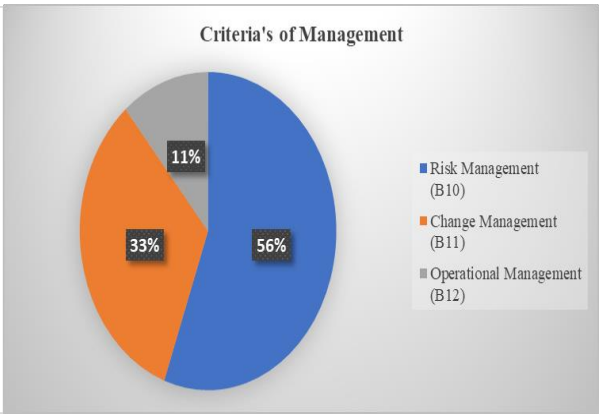

(d)

Fig-10: Pairwise comparison method (Factors and Criterions of Viability, Management)

4.10 Management (A4): Here we have taken the experts opinions. We have given the importance on ranging the opinions from 1 to 7. Basing on those opinions we have got the importance of individual answer shown in appendix 1. Basing on those importance we put the ranging in pairwise comparison matrix using the rules "0" is the criteria when importance of row is less than column again "2"is the criteria when row is more important than column and "1" is the criteria when both have equal importance. From pairwise comparison matrix we get the importance value of factors. Here in Fig-18 we, can see the factor C26 is the most important factors among the six factors. Then C27>C28>C29>C30>C31 respectively. If we project, it in real scenario we can find that, "National Risk " is most important factor while considering for selection of new landfill. Again, considering the criteria, from the experts' opinions and putting it in comparison matrix we find that criteria B10(56%) shown in figure 19 is the most important than other two criteria. In practical scenario we can also relate that the "Risk Management (B10)" is a most important criteria for selection of new landfill and landfill management.

4.11 Determination of Fuzzy Numbers, weight of each factors and criterions by Using Fuzzy AHP.

Now putting the value of expert's options in Fuzzy AHP software we will evaluate the domain of risk with respect to criterions and factors by finding the fuzzy numbers and weights.

4.12 Risk Evaluation with respect to Authority (A1):

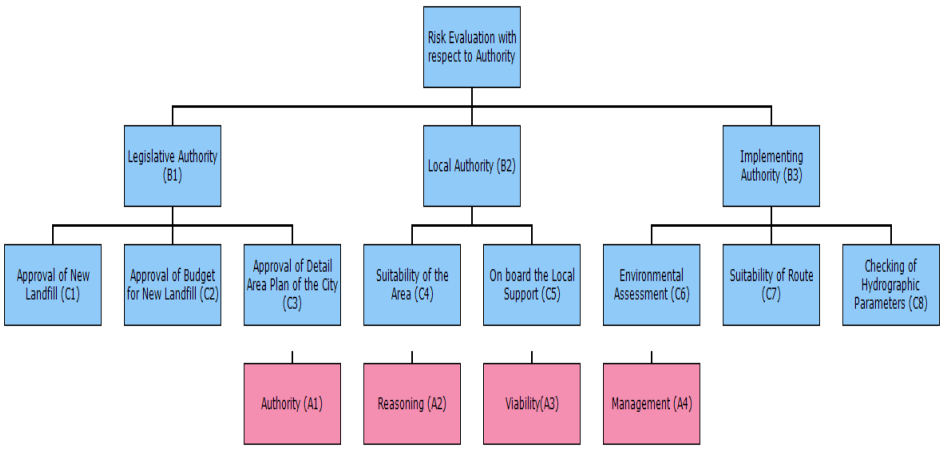

Fig-11 Risk Evaluation with respect to Authority

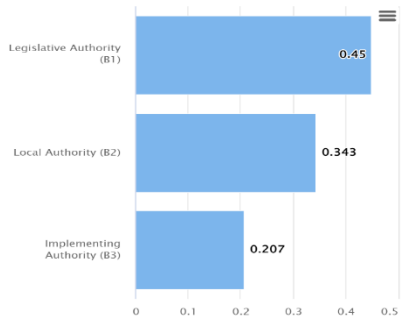

Fig-12

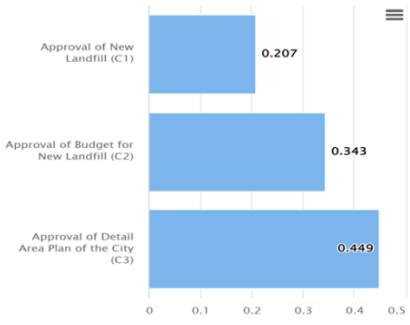

Fig-13

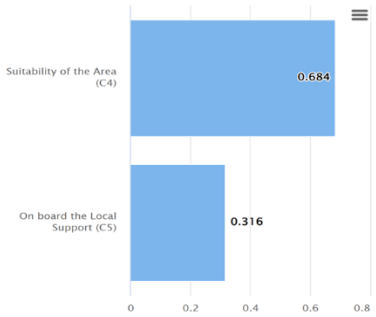

Fig-14

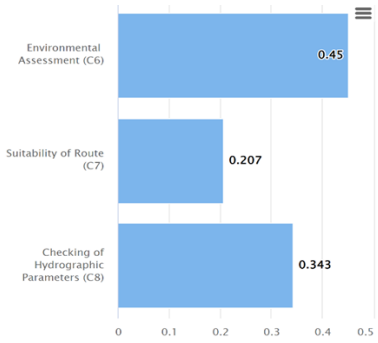

Fig-15

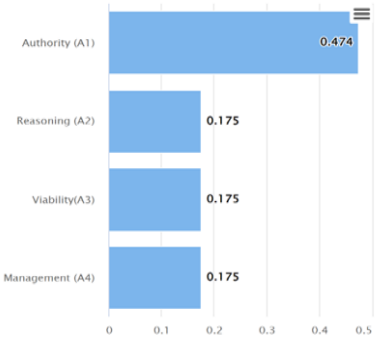

Fig-16

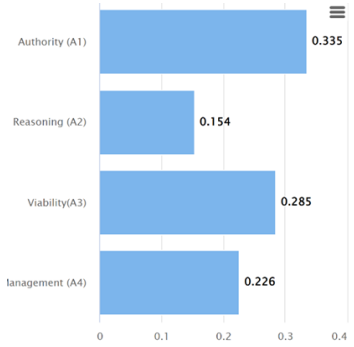

Fig- 17

Fig-18

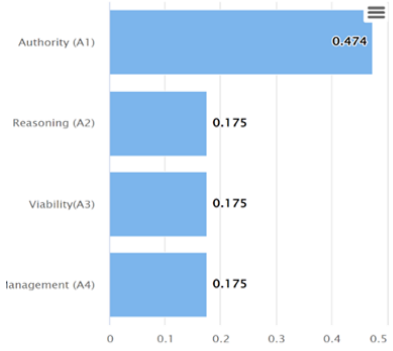

Fig-19

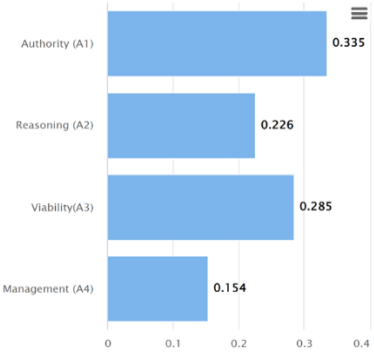

Fig-20

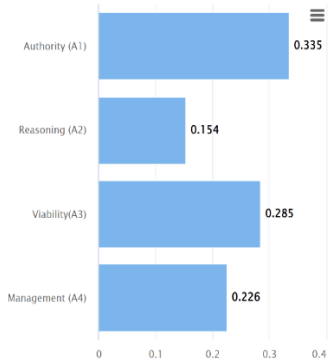

Fig-21

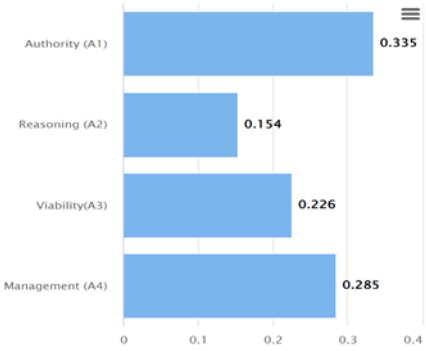

Fig-22

Fig-23

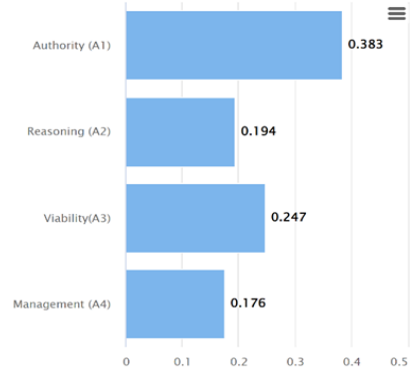

Fig-24

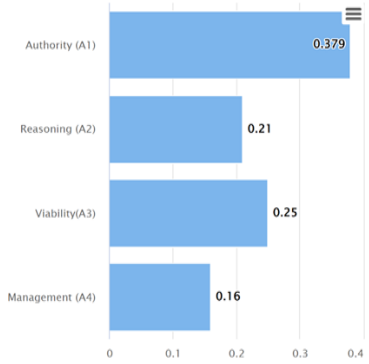

Fig-25

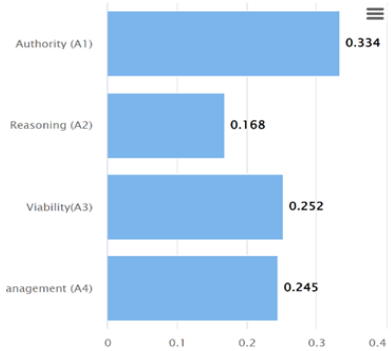

Fig-26

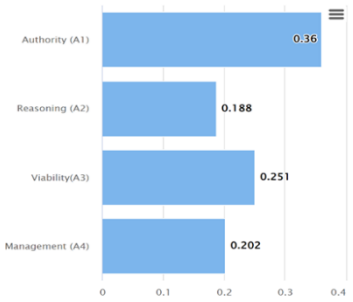

Fig-27

Rank	Criterion name	Criterion weight
1	Legislative Authority (B1)	0.45
2	Local Authority (B2)	0.343
3	Implementing Authority (B3)	0.207

Rank	Criterion name	Criterion weight
3	Approval of New Landfill (C1)	0.207
2	Approval of Budget for New Landfill (C2)	0.343
1	Approval of Detail Area Plan of the City (C3)	0.449

T1

T2

Rank	Criterion name	Criterion weight
1	Suitability of the Area (C4)	0.684
2	On board the Local Support (C5)	0.316

Rank	Criterion name	Criterion weight
1	Environmental Assessment (C6)	0.45
3	Suitability of Route (C7)	0.207
2	Checking of Hydrographic Parameters (C8)	0.343

T3

T4

Rank	Criterion name	Criterion weight
1	Authority (A1)	0.474
2	Reasoning (A2)	0.175
2	Viability(A3)	0.175
2	Management (A4)	0.175

Rank	Criterion name	Criterion weight
1	Authority (A1)	0.335
4	Reasoning (A2)	0.154
2	Viability(A3)	0.285
3	Management (A4)	0.226

T5

T6

Rank	Criterion name	Criterion weight
1	Authority (A1)	0.335
3	Reasoning (A2)	0.226
2	Viability(A3)	0.285
4	Management (A4)	0.154

Rank	Criterion name	Criterion weight
1	Authority (A1)	0.474
2	Reasoning (A2)	0.175
2	Viability(A3)	0.175
2	Management (A4)	0.175

T7

T8

Rank	Criterion name	Criterion weight
1	Authority (A1)	0.335
3	Reasoning (A2)	0.226
2	Viability(A3)	0.285
4	Management (A4)	0.154

Rank	Criterion name	Criterion weight
1	Authority (A1)	0.335
4	Reasoning (A2)	0.154
2	Viability(A3)	0.285
3	Management (A4)	0.226

T9

T10

Rank	Criterion name	Criterion weight
1	Authority (A1)	0.335
4	Reasoning (A2)	0.154
3	Viability(A3)	0.226
2	Management (A4)	0.285

Rank	Criterion name	Criterion weight
1	Authority (A1)	0.331
2	Reasoning (A2)	0.223
2	Viability(A3)	0.223
2	Management (A4)	0.223

T11 T12

Rank	Criterion name	Criterion weight
1	Authority (A1)	0.383
3	Reasoning (A2)	0.194
2	Viability(A3)	0.247
4	Management (A4)	0.176

Rank	Criterion name	Criterion weight
1	Authority (A1)	0.379
3	Reasoning (A2)	0.21
2	Viability(A3)	0.25
4	Management (A4)	0.16

T13 T14

Rank	Criterion name	Criterion weight
1	Authority (A1)	0.334
4	Reasoning (A2)	0.168
2	Viability(A3)	0.252
3	Management (A4)	0.245

Rank	Criterion name	Criterion weight
1	Authority (A1)	0.36
4	Reasoning (A2)	0.188
2	Viability(A3)	0.251
3	Management (A4)	0.202

T15 T16

As shown in the table T-1and Fig-12, above, according to the Risk Evaluation with respect to Authority, Legislative Authority (B1) is the first priority. Next priorities are assigned to Local Authority (B2) and Implementing Authority (B3) according to the obtained weightsAs shown in the table T-2 and Fig-13 above, according to the Legislative Authority (B1), Approval of Detail Area Plan of the City (C3) is the first priority. Next priorities are assigned to Approval of Budget for New Landfill (C2) and Approval of New Landfill (C1) according to the obtained weights. As shown in the table T-3 and Fig-14 above, according to the Local Authority (B2), Suitability of the Area (C4) is the first priority. Next priorities are assigned to on board the Local Support (C5) according to the obtained weights. As shown in the table T-4 and Fig-15 above, according to the Implementing Authority (B3), Environmental Assessment (C6) is the first priority. Next priorities are assigned to Checking of Hydrographic Parameters (C8) and Suitability of Route (C7) according to the obtained weights. As shown in the table T5 and Fig-16 above, according to the Checking of Hydrographic Parameters (C8), Authority (A1) is the first priority. Next priorities are assigned to Reasoning (A2) according to the obtained weights. AS shown in the table T6 and Fig-17 above, According to the Suitability of Route (C7), Authority (A1) is the first priority. Next priorities are assigned to Viability(A3), Management (A4) and Reasoning (A2) according to the obtained weights. AS shown in the table T-7 and Fig-18 above, According to the Environmental Assessment (C6), Authority (A1) is the first priority. Next priorities are assigned to Viability(A3), Reasoning (A2) and Management (A4) according to the obtained weights. AS shown in the table T8 and Fig-19 above, according to the On board the Local Support (C5), Authority (A1) is the first priority. Next priorities are assigned to Reasoning (A2) according to the obtained weights. Priorities with respect to On board the Local Support (C5)As shown in the table T-9 and Fig-20 above, according to the Suitability of the Area (C4), Authority (A1) is the first priority. Next priorities are assigned to Viability(A3), Reasoning (A2) and Management (A4) according to the obtained weights. AS shown in the table T10 and Fig-21 above, According to the Approval of Detail Area Plan of the City (C3), Authority (A1) is the first priority. Next priorities are assigned to Viability(A3), Management (A4) and Reasoning (A2) according to the obtained weights. AS shown in the table T-11and Fig-22 above, According to the Approval of Budget for New Landfill (C2), Authority (A1) is the first priority. Next priorities are assigned to Management (A4), Viability(A3) and Reasoning (A2) according to the obtained weights. AS shown in the table T-12and Fig-23 above, According to the Approval of New Landfill (C1), Authority (A1) is the first priority. Next priorities are assigned to Reasoning (A2) according to the obtained weights. As shown in the table T- 13 and Fig-24above, According to the Implementing Authority (B3), Authority (A1) is the first priority. Next priorities are assigned to Viability(A3), Reasoning (A2) and

Management (A4) according to the obtained weights. AS shown in the table T-14 and Fig-25 above, according to the Local Authority (B2), Authority (A1) is the first priority. Next priorities are assigned to Viability(A3), Reasoning (A2) and Management (A4) according to the obtained weights. As shown in the table T-15and Fig-26 above, according to the Legislative Authority (B1), Authority (A1) is the first priority. Next priorities are assigned to Viability(A3), Management (A4) and Reasoning (A2) according to the obtained weights. AS shown in the table T-16 and Fig-27 above, According to the Risk Evaluation with respect to Authority , Authority (A1) is the first priority. Next priorities are assigned to Viability(A3), Management (A4) and Reasoning (A2) according to the obtained weights. Similarly we get the value of risk evaluation with respect to Reasoning, Viability and Management.

4.13 Summary of the result:

Fig-29. Risk Evaluation with respect to Factors and Criterions

From the above figure Risk evaluation with respect to factors we get, A1>A3>A4>A3.From this result we get a policy that Authority>Viability>Management>Reasoning needs to be prioritized for Landfill Management and its correct selection .Similar way From the above figure Risk evaluation with respect to criterions we get, A1>A3>A4>A3.From this result we get a policy that Authority>Viability>Management>Reasoning needs to be prioritized before selection a New Landfill and its Management as whole.

4.14 Validation by DEMETAL: DEMATEL (Decision Making Trial and Evaluation) is a decision making technique based on pairwise comparisons. The DEMATEL method can be used to identify the model of causal relations between the variables. It shows causal relations and the factors' exerted influences. The advantage of this method is that experts are able to be more fluent in expressing their opinions about the effects (direction and severity of effects) between factors.

4.15 Direct relation matrix, normalized direct-relation matrix

	Authority (A1)	Reasoning (A2)	Viability (A3)	Management (A4)
Authority (A1)	0	2.2	3	3.65
Reasoning (A2)	2.3	0	2.35	1.3
Viability (A3)	3	2.35	0	2
Management (A4)	3.7	1.3	2	0

	Authority (A1)	Reasoning (A2)	Viability (A3)	Management (A)(
Authority (A1)	0	0.249	0.339	0.412
Reasoning (A2)	0.26	0	0.266	0.147
Viability (A3)	0.339	0.266	0	0.226
Management (A4)	0.418	0.147	0.226	0

4.16 The total relation matrix and Set the threshold value

The threshold value must be obtained in order to calculate the internal relations matrix.

In this study, the threshold value is equal to 1.266

All the values in matrix T which are smaller than 1.266 are set to zero, that is, the causal relation mentioned above is not considered. The model of significant relations is presented in the following table.

	Authority (A1)	Reasoning (A2)	Viability (A3)	Management (A4)
Authority (A1)	1.502	1.26	1.536	1.564
Reasoning (A2)	1.295	0.783	1.151	1.056
Viability (A3)	1.551	1.137	1.118	1.285
Management (A4)	1.587	1.045	1.29	1.099

	Authority (A1)	Reasoning (A2)	Viability (A3)	Management (A4)
Authority (A1)	1.502	0	1.536	1.564
Reasoning (A2)	1.295	0	0	0
Viability (A3)	1.551	0	0	1.285
Management (A4)	1.587	0	1.29	0

4.17. The final output

	R	D	D+R	D-R
Authority (A1)	5.934	5.861	11.795	-0.073
Reasoning (A2)	4.224	4.285	8.509	0.061
Viability (A3)	5.095	5.09	10.185	-0.005
Management (A4)	5.004	5.021	10.026	0.017

4.18 Interpret the results.

According to the diagram and table above, each factor can be assessed based on the following aspects: Horizontal vector (D + R) represents the degree of importance between each factor plays in the entire system. In other words, (D + R) indicates both factor i's impact on the whole system and other system factors' impact on the factor. in terms of degree of importance, Authority (A1) is ranked in first place and Viability (A3), Management (A4) and Reasoning (A2), are ranked in the next places. The vertical vector (D-R) represents the degree of a factor's influence on system. In general, the positive value of D-R represents a causal variable, and the negative value of D-R represents an effect. In this study, Reasoning (A2), Management (A4) are considered to be as a causal variable, Authority (A1), Viability (A3) are regarded as an effect which validate developed policy

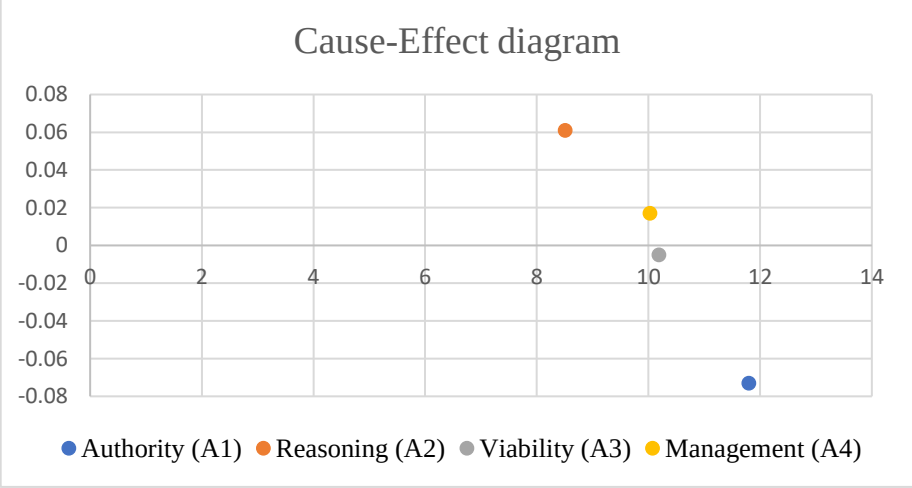

Figure 30. Cause-Effect diagram

5. Conclusion:

The Fuzzy AHP and DEMATEL was successfully applied to develop the risk evaluation policy on landfill management. The major findings are summarized as follows:

5.1 A set of risk evaluation model has been established from the research gap.

5..2 A set of risk evaluation indexes system was established based on experts' opinions using the proposed method.

5.3. A risk analysis of the developed policy model illustrated the efficiency and validity of the Fuzzy AHP-DEMATEL in the risk evaluation on new Landfill Management.

5.4. The feasibility of checking risk before selection of landfill and its future management of that particular area got more attention.

5.5. It can better prevent risk in advance on the evaluation result of Landfill Management and its proper implementation.

6. Recommendation of Study: The contribution of this paper shows that:

6.1. The application of Fuzzy AHP in risk evaluation of landfill management is effective, Although Fuzzy AHP has vast application risk evaluation of many project but the applicability of Fuzzy AHP in Landfill management is still unclear. The system can be determined and also can priorities the risks from the various perspective including internal Landfill Management.

6.2. The Fuzzy AHP-DEMATEL methodology enriches management means of risk evaluation policy in landfill management system. It is helpful for relevant sectors to established a strict management system of work safety for internal landfill management based on the risk assessment results. The Fuzzy AHP use triangular fuzzy number instead of crisp number which overcome the basic AHP methods. It's overcome the deficiency of simple weighted method and improve the fault of the model. At the end its breaks the limitations of traditional risk assessment methods through DEMATEL.

7. References

Cebeci, U. (2009). Fuzzy AHP-based decision support system for selecting ERP systems in textile industry by using balanced scorecard. *Expert Systems with Applications*, *36*(5), 8900–8909. https://doi.org/10.1016/j.eswa.2008.11.046

Gabus, A., & Fontela, E. (1972). *World Problems, An Invitation to Further Thought within the Framework of DEMATEL*.

Islam, M., Kashem, S., & Morshed, S. (2020). Integrating spatial information technologies and fuzzy analytic hierarchy process (F-AHP) approach for landfill siting. *City and Environment Interactions*, *7*. https://doi.org/10.1016/j.cacint.2020.100045

Kahraman, C., Cebeci, U., & Ulukan, Z. (2003). Multi-criteria supplier selection using fuzzy AHP. *Logistics Information Management*, *16*, 382–394. https://doi.org/10.1108/09576050310503367

Karmoker, N., & Rafizul, I. M. '. (2022). Application of Fuzzy Logic to Evaluate the Operational Phase of a Sanitary Landfill . *Proceedings of the 6th International Conference on Civil Engineering for Sustainable Development (ICCESD 2022)*.

Peng, G., Han, L., Liu, Z., Guo, Y., Yan, J., & Jia, X. (2021). An Application of Fuzzy Analytic Hierarchy Process in Risk Evaluation Model. *Frontiers in Psychology*, *12*. https://doi.org/10.3389/fpsyg.2021.715003

Rouhani, S., Ashrafi, A., & Afshari, S. (2013). Segmenting critical success factors for ERP implementation using an integrated fuzzy AHP and fuzzy DEMATEL approach. *World Applied Sciences Journal*, *22*(8), 1066–1079. https://doi.org/10.5829/idosi.wasj.2013.22.08.631

Rovins, J. E. (Jane E.), Wilson, T. M. (Thomas M., Hayes, J. (Joshua), Jensen, S. J. (Steven J., Dohaney, J. (Jacqueline), Mitchell, J., Johnston, D. M. (David M., Davies, A. J. (Alistair J.), & GNS Science (N.Z.). (n.d.). *Risk assessment handbook.*

Saaty, T. L. (1990). How to make a decision: The analytic hierarchy process. *European Journal of Operational Research*, *48*(1), 9–26. https://doi.org/10.1016/0377-2217(90)90057-I

Seo, S., Aramaki, T., Hwang, Y.-W., & Hanaki, K. (2003). Evaluation of Solid Waste Management System using Fuzzy Composition. *Journal of Environmental Engineering*, *129*, 520–531.

Si, S. L., You, X. Y., Liu, H. C., & Zhang, P. (2018). DEMATEL Technique: A Systematic Review of the State-of-the-Art Literature on Methodologies and Applications. In *Mathematical Problems in Engineering* (Vol. 2018). Hindawi Limited. https://doi.org/10.1155/2018/3696457

Soltani, A., Sadiq, R., & Hewage, K. (2017). The impacts of decision uncertainty on municipal solid waste management. *Journal of Environmental Management*, *197*, 305–315. https://doi.org/10.1016/J.JENVMAN.2017.03.079

Taylor, P. (2009). *WM's Local Operations Recognized for Environmental Work Habitat, Education and Cleanup Work Cited by Local, International Organizations*.