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A Sustainable Model for Engineering Project - a Stakeholder's Perspective

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ABSTRACT

For earning sustainable SMSWM many environmental, economical, social, institutional, and technical challenges have to be met in the SMSWM pathway. In developing countries like Pakistan, MSWM is a gigantic task because of mismanagement, lack of proper funds, loss of cover and recovery options, bad serial and disposal, lack of information, and an ineffective delivery system. The project is therefore geared at enhancing such a model concerning 5 tenets in the sustainability of the environment that is technical, institutional, monetary, Environmental, and social. By implication, a solid waste management system that will favor a sustainable environment relating to the above factors will be determined from reading literature doing discipline visits, and engaging in stakeholder surveys. Based on five sprint factors of sustainability, the complete work has been done and all the components have been connected and have a certain ratio. When major factors and their sub-factors are identified, specific surveys are conducted for prioritization scoring of such elements, mainly based on the importance of each issue and closer to the inputs of different stakeholders considered. A conceptual model has been developed and refined into a final format for all municipal strong waste control projects to test the model's sustainability. The rating/weights assigned to each element are purely and utterly to the opinion of the various stakeholders from a given field.

1. Introduction

The problem of solid waste management is reported in all our lives ranging from kitchen waste, industrial waste products, or disposed of used medical equipment among others. This waste can originate from any establishment like homes, businesses, hospitals, and factories and most of this waste finds its way to the landfill or they are dumped there. There is nothing untrue about solid waste being the unwanted and undesirable materials that can be disposed of; it encompasses all categories of waste from organic food leftovers, decayed animal remains, papers, plastics, hazardous chemicals, and many more. How it is disposed of has great effects on the health of the population and other aspects of the environment [5].

Thus, for waste that is not managed, the consequences can be damaging. At the local level, poor disposal can cause environmental nuisances or even insanitation whereas at the regional level, it can lead to the emission of air and soil pollution. At the global level, these problems contribute to aggravating climate change and pollution [6]. For instance, in the urban centers of the developing world, particularly in such cities as Peshawar, Pakistan, the issues of waste disposal are most pronounced. Here, general waste collection intervention and optimal routing arrangements are also lacking, so wastes are often left uncollected leading to pollution and health-related diseases [8][9].

This is further aggravated by the fact that the cost of waste management consumes most of cities budget. However, there is a worrying outbreak of inadequate waste collection and disposal in many regions even when such expenses have been incurred [10]. This situation is made worse by the environmental costs of collection and transportation of the waste, including high fuel costs which in turn contribute to pollution [11].

Solving these problems cannot be solved only by enhancing the techniques of waste collection, it calls for an integrated sustainable approach to SWM. This entails not only discovering new and improved methods of dealing with waste but also that each of the above-mentioned players must be engaged in the process [12][13].

New studies highlight the fact that these issues require the development of new more effective strategies. Similarly, multi-criteria decision analysis and the Analytic Hierarchy Process can be used to design a more efficient SWMS for understanding how different factors impact and interact with waste management. This research intends to offer not only recommendations but also practical strategies for waste management's improvement in terms of sustainability and effectiveness [14][15].

2. Research Methodology

2.1 Aims and Objectives

The main objective of this research was to review the various interests of various stakeholders in developing the appropriate SWM system. To do this, it was necessary to obtain the relative importance ratings from various stakeholders for different components of sustainability. Finally, based on the weights provided by the stakeholders, we incorporated these priorities by employing the Analytic Hierarchy Process (AHP) algorithm proposed by Saaty (2008).

The participants were contacted by email, social networking sites, face to face contact, and both online and physical questionnaires were administered. The responses that were taken on paper were later typed and made to fit into the computer for uniformity. Along with their comparisons, respondents provided the following information: Along with their comparisons, respondents provided the following information:

- Name
- Professional experience
- Country
- Contact details
- Affiliated organization
- Their perspective (Technical, Environmental, Economic, Social, or Institutional)

2.2 Stakeholder Classification

To ensure a comprehensive view, we categorized stakeholders into five main groups: To ensure a comprehensive view, we categorized stakeholders into five main groups:

2.2.1 Technical Stakeholders

This group refers to engineers and technicians who take part in the planning and implementation of waste management activities, whereby they are involved in the determination of how wastes should be collected, transferred, disposed or how the landfills should be managed.

2.2.2 Environmental Stakeholders

The information about these professionals shows that they are specialized in the field of waste management and its effect on the environment. These are involved in the research and development of products that deal with the reduction of waste, recycling, and combating pollution.

2.2.3 Economic Stakeholders

This group comprises financial people that include financiers, economists, and accountants who deal with the financial side of properly disposing of waste. It also entails representatives of organizations or individuals who finance waste management projects.

2.2.4 Social Stakeholders

This shall include social scientists who deal with the social aspects related to the management of waste, social workers, and other members of the community. Another category in this regard is the local government representatives who have also received higher education.

2.2.5 Institutional Stakeholders

Organizational stakeholders consist of administrative staff within waste management agencies/ firms and officials from non-governmental organizations that in one way or the other engage in training or supporting the waste management structures.

2.3 Factors Identification from Literature Review

We have discussed advanced and developing countries' sustainable solid waste management systems. This was quite useful in helping set directions to aspects that are deemed critical in sustaining the progress made. In our analysis, closed-loop systems were acknowledged as the critical components in driving sustainability throughout the business.

Table 1: Key Performance Indicators (KPIs) for Solid Waste Management

Status	KPI	Reference	Description
Technical	Cost Reduction	UNDP Procurement Notices	Measures how much money is saved, indicating better resource utilization.
Technical	Improved Customer Requirements	UNDP Procurement Notices	Evaluates enhancements in equipment to meet customer needs.
Technical	Capacity of Cell	Bebassampah	The maximum waste capacity of disposal units.
Environmental	Energy	Slide Team	Measures energy consumption and generation from waste.

2.4 Questionnaire Development

2.4.1 Finalizing List of Factors and Sub-factors

Originally, a draft survey was developed based on carrying out the literature review, defining primary and secondary components, factors, and sub-factors. Subsequently, we refined these five components, ten factors, and twenty-six sub-factors to the final version with the background knowledge of the experts.

Table 2: Final List of Factors and Sub-factors

Component	Factor	Sub-factors
Technical	Cost Reduction	Disposal efficiency, equipment maintenance
Environmental	Energy	Energy use, greenhouse gas mitigation

2.4.2 Finalizing Number of Comparisons

To keep the comparison, process manageable, we limited the number of pairwise comparisons to the primary components and factors. This approach ensured feasibility while maintaining accuracy.

2.5 Data Collection

Thus, we addressed approximately 80 stakeholders by email, a request to join the platform or personal calls. It was possible for participants to either complete the survey online, by accessing a hyperlink to the survey on the website or through a printed version that was posted on the website. The purpose of the proposed questionnaire was to be maximal and unambiguously defined, allowing for efficient gathering of data.

2.6 Data Analysis

Having collected the survey data, the authors applied Multi-Criteria Analysis and the AHP method, according to Saaty (2008). This made it easier to identify the priority given to the different sustainability components and factors; incorporated into a framework that can be used to review and evaluate SWMS.

2.7 Group Decision Making

The concerned factors and sub-factors were also refined in consultation with experts of different disciplines. Thus, a more inclusive and varied approach to dealing with issues is guaranteed.

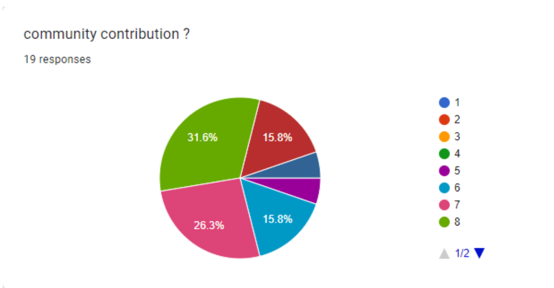
2.8 Stakeholder Weightage

The survey was conducted in several cycles that implied the scoring of the respondents. First of all, the respondents provided an evaluation of the sustainability components. In the other rounds, they added the values of different factors and sub-factors according to the researcher's importance scale. These comprehensive procedures helped in gaining detailed insights about the stakeholders.

3. Results

3.1 Initial Survey Results

As a result of this, in the first part of the questionnaire, we sought to define, on a rather superficial level, the components considered to be essential in attaining a sustainable SWM system. In their responses, the degree of consensus was high and dramatic—86 of the stakeholders concurred with the proposition that every part is critical to attaining sustainability. Such a strong positive correlation means that there must be an integrated approach when dealing with sustainability in solid waste management.



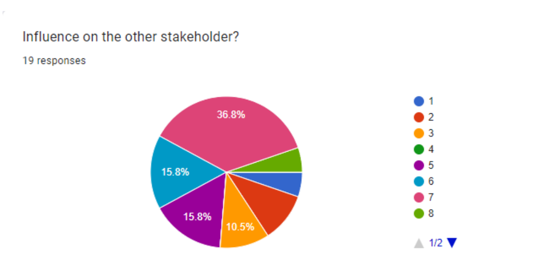


Figure 1 Community Contribution and Influence Scoring: a. Community Contribution, and b. Influence Scoring

To quantify the survey data, we calculated average scores for key factors. The results are summarized in Table 4.1, revealing that active community involvement and accessibility to decision-making processes were rated particularly high, with scores of 8.95 and 8.42, respectively.

Table 3: Current Average Scores for Factors

Table 5: Weightage Percentage of Factors

Factors	Average Score (out of 10)
Accessibility to the decision-making process	8.42
Accessibility to media	8.00
Active contribution to the community	8.95
Influence on other stakeholders	7.89
Active involvement in field operations	6.84

3.2 Findings from the Second Survey

The second survey instead offered a rude shock by pointing out areas of failure that indicate that the current system is a long way off from the ideal scenario. The scenario analyzed indicated that the current system presented only 50-60 percent of the ideal components of sustainability, outlining several problem areas.

The average scores of these factors are provided in Table 4, signifying that accessibility of media and decision-making, is comparatively lower than it was in the first survey.

Table 4: Factor Average Scores

Factors	Average Score (out of 10)
Accessibility to the decision-making process	5.5
Accessibility to media	4.3
Active contribution to the community	5.4
Influence on other stakeholders	5.49
Active involvement in field operations	6.2

3.3 Insights from the Third Survey

In the third survey which was carried out in two dossiers, the objective was to establish the proportionate significance of the five factors that define sustainability. These are presented in Table 5 below and depict environmental concerns as the most weighted factor than the institutional and social factors. This also helped in identifying the relationships between the main elements and sub-factors Finally, this survey also helped in defining the interrelationship of these aspects in the context of solid waste management in Peshawar.

Factors	Weightage (%)
Technical	4.2%
Environmental	39.6%
Economic	16.7%
Social	18.8%
Institutional	20.8%

Due to no model for sustainability set in Peshawar earlier, this survey's findings are essential in formulating a framework that would be of use in the future. In Table 6, we analyzed the percentage distribution of the total factors as well as the sub-factors of the internal environment of L'Oreal and Nestle.

Table 6: Percentage Distribution of the Factors

Factors	Weights (%)	Sub-factors	Weights (%)
Material recovery	0.67	Efficient use of technology	0.5
		Segregation	0.5
Waste processing	0.70	MSW diverted at the source	0.5
		Incentives for recycling	0.5
Effective use of technology	0.73	Efficiency of implemented technology	0.5
		Level of technical skills	0.5
Waste disposal	0.82	Dumping	0.5
		Land suitability	0.5
Impact on Environment	0.83	Pollution control	0.5
		Benefits to the environment	0.5
Financial Independence	0.79	Cost recovery	0.5
		Reliability	0.5
Financial benefits	0.79	Processing of waste	0.5
		Minimum waste to landfill	0.5
Public awareness	0.80	Level of awareness	0.5
		Level of interest	0.5
Community contribution	0.76	Willingness to pay	0.5
		Willingness to participate	0.5
Operational efficiency	0.73	MSW collected by the municipality	0.5
		Level of customer/user satisfaction	0.5
Governance	0.77	Incentive and benefits sharing	0.5
		Enforcement of policies	0.5
Capacity	0.78	Technical capacity	0.5
		Performance and delivery of services	0.5

3.4 Development of the Final Model

With the help of survey results and input from various stakeholders, we created a general model of SWM projects' sustainability assessment. This model has an ordinal risk representation of up to 100% with possible enhancement of the tool for future project evaluations corresponding to the project's context.

Thus, the innovation of the presented work is the presence of two approaches to evaluate the knowledge – the scores of the stakeholders involved and the assessments of the experts in this field of sustainability. The findings present clear and practical conclusions on how to enhance the sustainability of solid waste management interventions, which makes this approach helpful to both individuals who analyze data and those who make recommendations.

4. Practical Implementation

In this way, the given research reveals how stakeholders rank various aspects of sustainable SWM and helps policymakers and planners improve options for managing waste. Thus, the topic for this study reflects the relevance of evaluating environmental, financial, institutional, and technical factors to design effective waste management systems. As a result, the proposed framework can be applied to determine the measures and interventions for the improvement of S&M and hence, the overall sustainability of the community and environment.

5. Conclusion

The following conclusions can be drawn from the conducted study: The following conclusions can be drawn from the conducted study:

1.. In the study, the environmental dimension of sustainable SWM was deemed as the most important by the stakeholders, which was trailed by the economic dimension.

2.. Stakeholder requirements were sorted according to their priority with financial being in third place, institutional in fourth place, and technical taking fourth place.

3.. Assessing the perceptions of stakeholders, the factors of waste transport and disposal, water pollution, revenue generation, public awareness, and management were regarded to be of the same degree of utility by all the respondents.

4. In this sense, the research contributes to the creation of a framework to evaluate the sustainability of SWM, which can be improved by future research works.

The results obtained here provide significant support for the assessment of the constituents' concerns for sustainable solid waste management. Future research should also examine the developmental nature of the different sub-factors within this framework.

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