Acta Scientific NUTRITIONAL HEALTH (ISSN:2582-1423)

Volume 8 Issue 11 November 2024

Review Article

Landfill Site Selection with the Assistance of GIS And Multi-Criteria Decision-Making AHP Methods: A Review

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Received: September 16, 2024

Published: October 04, 2024

Abstract

Growing urbanisation and population growth have a positive correlation with municipal solid waste generation and challenges as well. Geographic Information Systems (GIS) are quite helpful in meeting these challenges since they offer the ability to store, organise, administer, and analyse large amounts of data. Solid waste management refers to the organised collection, removal, transportation, disposal and recycling of solid waste generated by human activities to lessen their detrimental impacts on the environment and public health. Since choosing landfill locations is crucial for sustainable waste disposal, sophisticated methods integrating Geographic Information System (GIS) and Multi-Criteria Decision Making (MCDM) methodologies are gaining traction. The present study examines how the Analytic Hierarchy Process (AHP) and Geographic Information System (GIS) may work together to identify landfill sites while considering social, economic, and environmental factors. GIS gives decision-making procedures a spatial component and makes it possible to analyse various factors methodically, including ecological sensitivity, land use patterns, and proximity to settlements. Weighted preferences may be derived via pairwise comparisons and qualitative criteria can be quantified using AHP, a popular MCDM approach. Through the integration of multiple methodologies, decision-makers are now equipped to evaluate potential landfill sites utilizing diverse criteria. This paper has critically analyzed the current advancements, challenges, and applications of GIS-AHP integration in landfill site selection. It emphasizes the significance of reliable data, stakeholder involvement, and the utilization of adaptable decision-making frameworks to ensure that selected locations effectively address the evolving requirements of waste management in dynamic urban environments. The results add to the discussion on environment-friendly waste management techniques and guide scholars, professionals, and decision-makers in optimising landfill site selection.

Keywords: Municipal Solid Waste Management; Geographic Information System; Multi-Criteria Decision Making; Analytic Hierarchy Process

Introduction

The management of solid wastes resulting from human activities includes the gathering, handling, and elimination of waste [1]. It seeks to reduce the harmful impacts of trash on the environment, human health, and aesthetics [2]. There are several components to the complete management of solid waste, each of which addresses a particular waste treatment step or area [3]. Municipal solid waste management directly impacts the increasing urbanisation and population [4]. The amount and texture of generated waste have changed over time. Emerging countries like India have experienced logistical challenges due to the significant increase in the production of municipal solid garbage in recent decades [5]. Municipal solid waste is considered one of the major issues threatening the quality of the environment in rising countries, both in urban and rural regions. The primary causes include changes in consumer patterns, rapid urbanisation, and population expansion, which have increased the amount of solid garbage [6]. As a result, using an appropriate waste treatment method becomes essential.

Geographical Information Systems (GIS) provide data storage, management, and analysis capacity, which is a tremendous help when defining problems [7]. Due to its geographical component, the spatial multi-criteria analysis stands out clearly from conventional multi-criteria decision-making processes [8]. The multi-criteria decision-making (MCDM) methodologies offer a potent instrument to facilitate and speed up any siting procedure and provide an appropriate answer for planning and policy-making [9]. Making decisions is a procedure that begins with the issue of detection and includes actions taken up until the recommendation [10]. Every decision-making process starts with the identification and diagnosis of a choice problem.

A general measuring theorem is the Analytic Hierarchy Process (AHP), one of the multi-criteria decision-making techniques [11]. It has been widely utilised in numerous decision- and planning-related initiatives. The rationality of AHP, concentrating on the goal of problem-solving, creating an integrated model of the relationship and effects of the problem [12]; knowing and experiencing those who have a dominant and prior influence among the relations in the structure; and coming to the best agreement by allowing for differences [13]. Most of nations in the world now use sanitary landfills because it is the most affordable way to dispose of municipal solid waste (MSW). However, choosing an optimum landfill disposal site (LDS) is challenging because the identification and selection procedure comprises several variables and stringent guidelines [14].

Managing solid waste produced by human activity involves several critical components that collectively aim to mitigate the negative impacts of waste on the environment, human health, and aesthetics [15,16]. Waste management commences with waste collection, wherein waste is gathered from diverse sources including residential areas, industrial facilities, commercial establishments, institutional entities, and construction sites [17]. Understanding the types and quantities of waste generated is essential for effective planning and implementation of management strategies [18]. The next stage is waste storage where waste is temporarily stored at or near the point of generation before being gathered and transported [19]. Lastly, methods of transportation are used to dispose of the trash outside of the city.

Proper storage containers, timely collection schedules, and efficient collection methods are vital to prevent health hazards and environmental contamination [20]. Subsequently, waste transportation involves moving the collected waste from transfer stations to treatment facilities, or disposal sites [21]. Vehicles must be suitable for the type of waste and operate in a cost-effective, safe, and environmentally benign manner [22]. Waste processing and recovery focus on treating waste to recover usable materials, reduce its volume, or make it safer for disposal through recycling, composting, and other resource recovery methods [23]. The technologies and methods used must be efficient and sustainable, emphasizing maximum resource recovery and minimal environmental impact [24].

Waste treatment encompasses the application of physical, chemical, or biological processes to modify the characteristics of waste, with the objective of reducing its volume, toxicity, or hazardous properties [25]. Appropriate treatment technologies should align with regulatory requirements and environmental standards. Finally, waste disposal is the stage where waste is placed or destroyed, typically in landfills or through incineration [26]. As the least preferred option in the waste management hierarchy, disposal methods must be safe and environmentally sound, with measures to mitigate potential pollution and health risks [27]. Each of these components plays a crucial role in the comprehensive management of solid waste, ensuring a systematic approach to minimizing its adverse effects [28].

Research regarding the selection of sites for solid waste treatment facilities indicates that decision-making criteria across various nations aim to achieve comparable objectives, encompassing environmental, economic, and social suitability [29]. The decision-making process in solid waste management is inherently complex due to the multitude of variables involved. Various researchers have employed different criteria depending on their specific case studies. Multiple criteria have been utilized in solid waste management studies for decision-making purposes. For instance, Abedi-Varaki and Davtalab (2016) considered natural factors such as geology, distance from farms and forests, proximity to rivers, depth of water areas, and economic factors like distance from urban centres and main streets. Ferretti and Pomarico (2012) included criteria such as distance to protected areas, elevation, water quality, naturalness index, flood and landslide areas, land use, proximity to dangerous industries and roads, population density, and distance to water sources and human settlements for solid waste incinerator site selection. Tavares, Zsigraiová, and Semiao [30] examined global factors such as waste transportation costs, distance from the electrical grid and coastline, fly ash transportation costs, potable water demand, land orientation, and land cover, as well as local factors like proximity to road networks, coastline, terrain slope, and elevation, urban centres, land-use type, air pollution impact, and visibility impact.

Data and Methodology

The planning, execution, and analysis phases of the systematic review technique are all part of an organised process that is described by Guessi. The study protocol is established during the planning stage, criteria and concerns are clarified, and research platforms are determined. Initial and final selection, database search, importation of bibliographic references and abstracts, and extraction of full articles are all part of the execution step. Compiling reports, statistical analysis, and summarising and classifying the results comprise the last phase. ACM, IEEE, Scopus, Science Direct, Web Knowledge, Web of Science, and other bibliographic platforms were used for this review.

Trends in yearly publications

Several attempts were made to integrate GIS for landfill site selection using the MCDA method in the late of 1990s and the early 2000s, and these occurred in the propagation phase of GIS. The propagation stage is described through user trends toward growing GIS knowledge, which has resulted in a colossal number of GIS applications as well as landfill site selection (LSS) problems. The data shown in Figure 1 shows a clear increase trend in research production as publication numbers show substantial growth from 1990 to 2023. At first, research effort was minimal, spanning from 1990 to 2005. Nonetheless, there was a noticeable rise in publication frequency after 2005, with a notable peak in 2006. The papers continued to climb in the following years, with sporadic peaks and troughs that suggested variations in the productivity of the study. However, the overall trend remained favourable, indicating that research output has grown steadily. Figure 1 illustrates the notable increase in publication frequency from 2015 to the present. This pattern suggests a sustained period of increased intellectual and journalistic work across time and a discernible rise in the distribution of knowledge.

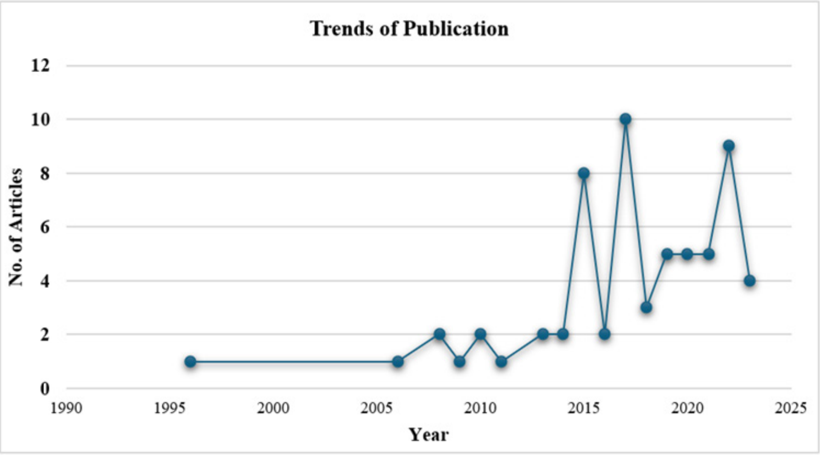

Figure 1: No. of Articles Used for Research.

Spatial frequency of articles

An examination of publishing patterns shows that research is conducted worldwide, with certain nations experiencing significant increases. A number of countries, including Ethiopia, Iran, Iraq, and Thailand, show increasing rates of academic output. Malaysia and Turkey are essential epicentres, demonstrating their crucial roles in influencing research environments (Figure 2). India is one of the dynamic hubs that significantly contributes to the changing research landscape. Turkey and Malaysia stand out among the diverse study topics, indicating their continued significance in promoting scholarly inquiry. As the terrain of knowledge creation changes, India continues to be a dynamic force. Substantial research progress has been made in areas other than these focus areas, including Ghana, Nigeria, Italy, and Canada, demonstrating a wide range of involvement in academic activities.

As an increasing number of nations contribute to the expanding corpus of knowledge, the global landscape of research is undergoing transformation, challenging preconceived notions. This trend underscores the growing significance of conducting research on a global scale, which fosters collaboration and mutual comprehension. A collaborative effort to promote knowledge and address global concerns is demonstrated by the active engagement of many geographical locations, from Africa to Europe and North America. The international scientific community benefits from the synergy of ideas as research becomes more accessible and networked, highlighting the collaborative character of modern academic endeavours. The continuous globalisation and variety of research endeavours indicate a promising direction for knowledge progress on a global scale.

Significant research publications

The distribution of papers published across various publishing institutions and the total number of research published in each publication are depicted in figure 3. Using GIS and Multi-Criteria Decision-Making AHP techniques, our database analysis shows that Elsevier is the top publisher with the most published articles on landfill site selection. Springer also strongly emphasises landfill site selection, extending this dominance in publishing beyond Elsevier. Moreover, contributions from multidisciplinary study fields greatly influence the diversity of published works on this topic. Looking more closely, the data emphasises Elsevier's leadership role and demonstrates its dedication to expanding the knowledge on landfill site selection by utilising GIS and Multi-Criteria Decision Making AHP techniques. Springer's continued involvement underscores the community's attempts to spread research on this topic through publishing. Further evidence of the interdisciplinary nature of studies on landfill site selection comes from the notable participation of multidisciplinary research areas. A thorough picture of the distribution and trends in published papers across vari-

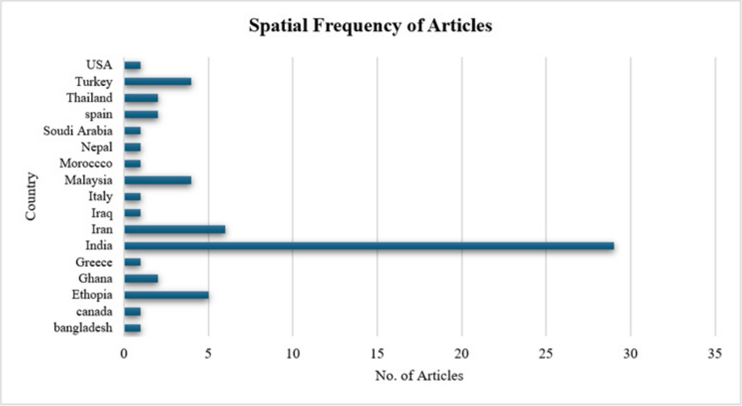

Figure 2: Spatial Frequency of Articles.

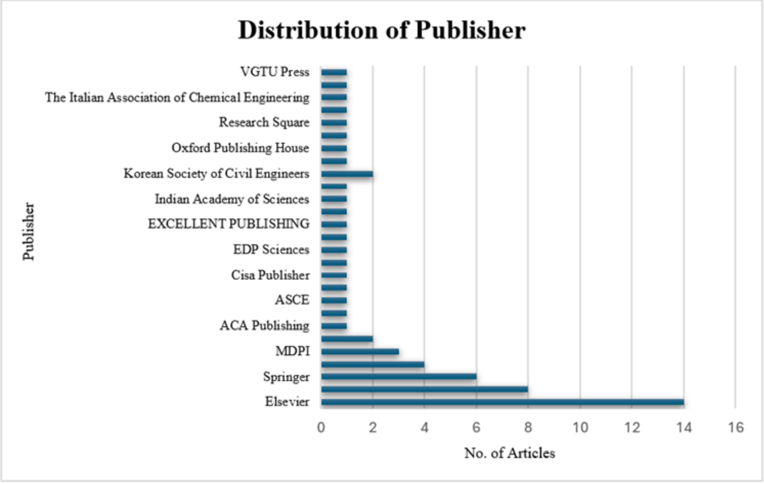

Figure 3: Articles Published in Different Journals.

ous Publishing Institutions is provided by removing years without publications, which guarantees a focused examination.

Most commonly used MCDA methods

Numerous techniques have been suggested in the literature for configuring GIS-LSS-MCDA models. The common element of the entire process for choosing the final site that was extracted and concluded from the earlier models is referred to by the standard name GIS-MCDA. Notwithstanding the variations in the GIS-LSS-MCDA frameworks, five general phases can be distinguished: (i) input of spatial and attribute criteria [encompassing data gathering and geo-processing]; (ii) factor and constraint map reclassification, standardisation, or normalisation; (iii) weight selection; (iv) objective balancing; and (v) overlaying or aggregating the inputs using decision rule algorithms. Figure 4 shows the overall GIS-MCDA architecture and method used in the LSS processes of the earlier models. To enhance the efficiency of the entire procedure, this study evaluated the third and fifth stages. Consequently, this evaluation can be categorized into two aspects: (i) the most prevalent GIS-MCDA methodology for weight selection and (ii) the most commonly employed GIS-MCDA decision rules.

Most commonly used selection of weights methods and their objectives (Stage 3)

The selection of weights is a particular term that means determining the weights of the input criteria. Table 1 illustrates the frequency of the most commonly used selection of weight method in previous LSS models, which indicates that most of the papers fall under the selection of weights method used in previous LSS models, and expert knowledge from focus groups using questionnaires.

Most commonly used GIS-MCDA decision rules (Stage 5)

Decision rules are defined in some proceedings as enabling the decision-makers to evaluate the available alternatives for selection based on their appropriateness. In the literature, several types of decision rules are offered in the GIS-MCDA, such as association rule, decision tree, classification, feature selection, support vector machine (SVM), a priori algorithm, clustering, genetic algorithm, customer relationship management [3], multi-objective linear programming (LP), genetic programming [9], cost-benefit analysis (CBA), and fuzzy inference systems. However, the utilization of

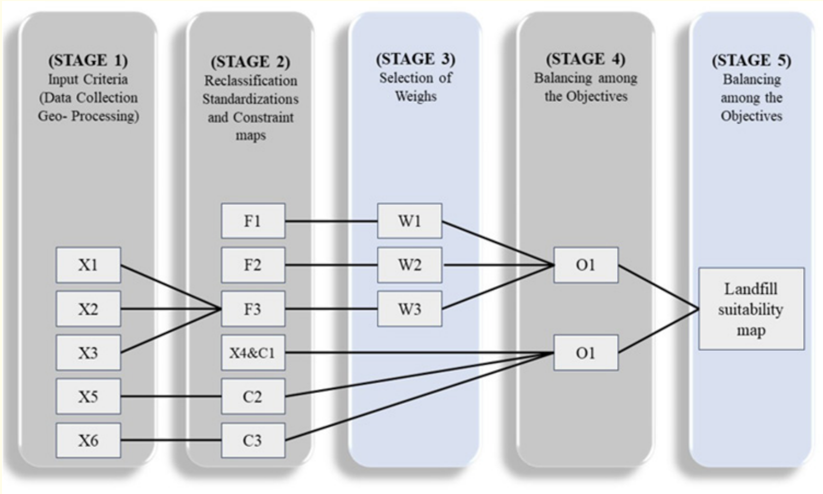

Figure 4: General framework of the GIS-MCDA decision rules in the LSS process.

S. No.	Author	Objectives	Method	Study Area
1.	Zewdie and Yeshanew, 2023	Investigation of suitable waste disposal site	GIS and AHP techniques of multicriteria decision-making	Dejen town, Ethiopia
2.	Javed Mallick, 2021	landfill suitability site	fuzzy-AHP-MCDA	Asir Region Saudi Arabia
3.	Muheeb and Bashir, 2021	identification of potential landfill sites	MCE and AHP	Srinagar City
4.	Ali., *et al.* 2020	Selection of a landfill site	GIS and AHP, FTOPSIS	Memari Municipality, India
5.	Hazarika and Saikia, 2020	To provide alternative sites in the Guwahati Metropolitan Area	GIS, and MCDA-based AHP	Guwahati Metropolitan Area
6.	Karakuş., *et al.* 2020	Locating sanitary permanent landfill	GIS, AHP–CODAS and SAW–CODAS	Sivas City, Turkey
7.	Mojtaba., *et al.* 2019	to determine municipal solid waste [MSW] landfills	Fuzzy logic and Boolean logic	SaharKhiz Region, Iran
8.	Gautam., *et al.* 2019	identification of possible landfill sites and its expansion	g vector data and remote sensing [RS]	Coimbatore, India
9.	Ajibade., *et al.* 2019	Finding appropriate locations for managing and disposing of solid waste	GIS and MCDA	Akure, Ondo State
10.	Kamdar., *et al.* 2019	identifying appropriate landfill sites	GIS and AHP	Songkhla, Thailand
11.	Karimi., *et al.* 2019	Landfill site selection	GIS and MCDA, AHP-based pairwise comparison	Javanrood County in Iran
12.	Khodaparast., *et al.* 2018	Municipal solid waste landfill siting	GIS and AHP	
13.	Rahmat., *et al.* 2017	Landfill site selection	GIS and AHP	Behbahan, Iran
14.	Yaldirim., *et al.* 2017	Landfill site selection	GIS and TOPSIS	Bursa Province, Turkey
15.	Alanbari., *et al.* 2014	Landfill site selection	GIS and MCDA	Al-Hashimyah Qadaa
16	Gbanie et al., 2012	Identification of municipal landfill sites	Multi-criteria GIS approach, Weighted Linear Combination and Ordered Weighted Averaging.	Bo, Southern Sierra Leone
17.	Gorsevski., *et al.* 2012	Landfill site selection	GIS, Fuzzy membership functions, AHP, OWA	Polog Region, Macedonia
18.	Al-Hanbali, 2011	Landfill siting	GIS-Based Weighted Linear Combination and RS	Mafraq City, Jordan
19.	Guiqin., *et al.* 2009	Selection of the appropriate solid waste landfill site	GIS and AHP	Beijing, China
20.	Mahini and Gholamalifard, 2006	Landfill site location	WLC in a GIS, AHP	Gorgan City [Iran]

Table 1: Frequency of the most commonly used selection of weight method in previous LSS models.

the decision rules for LSS research has been constrained to a small number of familiar methods under two major GIS-MCDA methods, namely multi-attribute decision rules (MADR) (including Boolean logic, WLC SAW, FMCDA, FSAW, OWA, and IPM) and multi-objective decision rules (including CP and TOPSIS) (Table 1). Moreover, the results show no previous models investigating or applying the ANNs in the LSS process, with a clarification that fuzzy logic is used to standardize the input criteria.

Factors influencing effective solid waste management practices

The integration of recycling systems is imperative in developing nations due to the significant problem of managing municipal solid waste. Institutional components such as laws and regulations are essential for solid waste management to be effective. Necessary measures include defining government tasks, establishing national or provincial policies, and providing financial support to local governments. Cultural norms influence trash management and need ongoing public education. Important financial variables include financing sources and economic results.

Financial factors and SWM

A system dynamics-based model for financial planning in community-based solid waste management in Phnom Penh, Cambodia, is proposed by Kum., *et al*. [31], who demonstrate its implementation in the Boeng Keng Kang area. The study emphasises how system dynamics might help with localised waste management budget planning. A study of 120 solid waste recycling programs in Thailand carried out in 2008 by Suttibak., *et al*. [32] identified factors influencing the effectiveness of the different program types. Programme effectiveness is significantly impacted by administrator knowledge, source separation, financial incentives, and cost concerns, underscoring the significance of customised tactics. Lohri., *et al*. [33] found a troubling financial shortfall in their study on municipal solid waste management (SWM) in Bahir Dar, Ethiopia, from July 2009 to June 2011.

The public-private partnership is in danger because expenses, especially those related to garbage transportation, have increased, and waste pickup fees have not generated enough money since home fee collection efficiency is poor. The authors emphasise the need for a thorough cost structure study to be conducted either by the private sector or with the assistance of local government to address the financial imbalance quickly. Pérez-López., *et al*. [34] use a theme-frontier strategy to address cost efficiency in municipal solid waste services. Their research of several management models challenge earlier notions by showing that formulae which create collaboration are typically more successful. According to the study, cooperative strategies complement efficient garbage collection services. Waste management services and funding in Spain are the main topics of Chamizo-Gonzalez., *et al*. [35]. They disprove that home prices and garbage production correlate, illuminating the prevalence of flat charge structures. The research highlights the necessity of obtaining more precise trash generation data and raises concerns about Madrid's lack of a Pay as You Throw system.

Technical factors and SWM

The management of municipal solid waste in Bangladesh was thoroughly examined by Roy., *et al*. (2022), who highlighted the potential of thermal treatment-based waste-to-energy (WTE) technologies, including gasification and incineration. The study tackled the regulatory, environmental, and economic facets while creating solutions for high construction costs and deficient infrastructure. They predicted power and carbon credit sales would bring in USD 751 million for Dhaka and Chittagong by 2050. Ohri [36] employed an Environmental Decision Support System to highlight the significance of appropriate trash segregation in Varanasi, India. The study showed that local, as opposed to central, municipal solid waste segregation produced three times the benefits and paid related expenses via recycling.

Information and communication technologies (ICTs) used in solid waste management systems were examined critically by Hannan [37], who divided them into four categories: data transmission, data collecting, spatial identification, and identification. By summarising the principles of the ICTs that are now accessible, the study seeks to direct the development of sustainable SWM systems. The solid waste management situation in India was described by Shahab [37], who also suggested an artificial intelligence (AI) method for detecting illegal dumps while highlighting the difficulties. The research raised awareness of issues, including the lack of citizen-facing portals and real-time monitoring, by proposing a multipath convolutional neural network (mp-CNN) model for garbage dump identification in picture data. Regarding energy, economy, and ecology, Suryavanshi., *et al*. [38] researched waste-to-energy technology in Surat, India. The study compared incineration with anaerobic digestion (AD), emphasising energy recovery, economic concerns, and environmental implications. Incineration was shown to be a more cost-effective and environmentally responsible option than AD since it produced more energy and reduced the risk of acidification and global warming.

Social factor and SWM

Staley., *et al*. (2009) study looked at how the location of municipal garbage incineration affected local reactions and found elements that influenced them. Opposition was connected with social and demographic factors, such as age, education, employment, and closeness. Prominent discussions exacerbated opposition, highlighting the necessity for authorities to prepare for increased community resistance. The socioeconomic aspects influencing South Delhi's municipal solid waste were the main subject of Kala., *et al*. [39] investigation. They discovered that trash generation was highly predicted by family size, employment, education, and monthly income using SPSS. Their information helps with legislative efforts, facility building, and resource planning for effective waste management. Srivastava., *et al*. [40] predict municipal solid waste in Prayagraj, India, using LSTM, ARIMA, and IIM models integrated with nine socioeconomic characteristics. Changes in the number of households, employment levels, and population density significantly influenced waste generation. Compared to ARIMA and IIM, LSTM predicted a 70.6% increase in trash generation by 2031.

Lakioti., *et al*. [41] examined sustainable solid waste management, emphasising public support and economic viability. They emphasised the necessity of using integrated strategies to address socioeconomic and environmental issues that involve the public, corporations, and government. The population increase and creation of solid garbage in Erode, Tamil Nadu, were examined by Udhayabanu., *et al*. Despite population changes, solid trash output rose from 135 MT/day in 2008 to 275 MT/day in 2018. The study underscored the impact of open dumping sites on the local community and environment. Trend analysis predicted continued waste production despite population fluctuations.

Use of GIS in solid waste management

The articles under discussion thoroughly analyse landfill site selection processes, mainly using multi-criteria decision-making and Geographic Information Systems (GIS). GIS and the Analytic Hierarchy Process (AHP) were used by researchers like Majid., *et al*. [42] and Guler., *et al*. [43] to identify landfill sites while taking economic and environmental factors into account. Complying with regulatory standards is made more accessible by simultaneously assessing several aspects made possible by integrating GIS and multi-criteria evaluation. The use of GIS-based multi-criteria decision-making was expanded by studies like Dashtian., *et al*. [44] and Karakuş (2020), which included techniques like Combinative Distance-Based Assessment (CODAS) and Simple Additive Weighting (SAW). This research assessed factors such as groundwater depth, transportation, and geological structure, providing a detailed view of the preferences for sanitary landfill sites.

Numerous studies, such as Duve., *et al*. [45] in Maharashtra and Rahmat., *et al*. [46] in Behbahan, Iran, highlighted the significance of localised techniques in waste management by focusing on particular locations. Ramu., *et al*. [47] combined GIS and AHP in Srikakulam District, Andhra Pradesh, to comprehensively evaluate variables including slope, soil type, and historical regions. In implementing GIS-based modelling with AHP, Deswal., *et al*. [48] emphasised the importance of societal acceptability when choosing a landfill location in Rohtak City. Asori., *et al*. [49] improved the landfill site suitability study by focusing on the Ashanti Region of Ghana and incorporating factors like wind speed and hydraulic conductivity. In Lucknow, Uttar Pradesh, Kumar., *et al*. [50] used remote sensing, GIS, and AHP to demonstrate how important it is to consider various factors when choosing a landfill site, including groundwater, soil texture, and land use. The studies show how landfill site selection techniques have changed, highlighting the importance of GIS and multi-criteria decision-making in addressing social, economic, and environmental considerations. Including cutting-edge technology such as remote sensing further improves the accuracy of site suitability evaluations.

Use of multi-criteria in landfill site location

Utilizing Geographic Information System (GIS) and Multi-Criteria Decision Analysis (MCDA), the study examined various methodologies and protocols for the selection of solid waste disposal sites, specifically landfill locations. Considering societal, economic, and environmental aspects, this research attempted to solve the difficulties in selecting appropriate sites for garbage disposal. A guide for upcoming waste management academics and decision-makers, Jayprakash., *et al*. (2015) concentrated on examining GIS approaches for solid waste and landfill site allocation. Prioritising criteria for the placement of municipal solid waste incinerator power plants in Iran was done by Feyzi., *et al*. [51] using GIS in conjunction with the DEMATEL and FANP methodologies.

Majumdar [52] presented a multi-criteria decision-making technique for choosing landfill sites in Kolkata, India, utilising the Analytical Hierarchy Process (AHP). In North Sinai, Egypt, Effat., *et al*. [53] identified possible landfill locations while considering environmental and legal factors. Dolui., *et al*. [54] selected landfill sites in Kharagpur City, West Bengal, with an eye towards ecological and economic viability, using AHP, Fuzzy AHP, SRS, and RSW Weightage techniques. In Selangor, Malaysia, Younes., *et al*. [55] incorporated several parameters, highlighting an engineering strategy for sanitary landfill size and site selection.

In their 2014 study, Maria., *et al*. examined the prospects and challenges of turning urban garbage into electricity in the Kathmandu Valley. Tayyebi., *et al*. [56] took expert opinion uncertainty into account while combining DST and MCDM for landfill site selection in Zanjan, Iran. Considering public opposition and environmental deterioration, Etraj., *et al*. [57] combined the AHP and DEMATEL approaches for multi-criteria site selection in Chennai, India. In Dehradun City, India, where limited land resources provide constraints, Krishna., *et al*. [58] used a geospatial multicriteria method for solid waste disposal site selection.

Findings

Examining the literature, it is evident that the selection of landfill site locations presents a complex challenge, with diverse methodologies employed to identify optimal landfilling sites. The appropriate sizing and siting of landfills have been subjects of considerable discourse in the solid waste management process, resulting in missed opportunities to mitigate the environmental and health impacts associated with landfill construction and operation. Geographic Information Systems (GIS), Multi-Criteria Decision Analysis (MCDA), and Analytic Hierarchy Process (AHP) are prominent techniques utilized by various scholars to facilitate the landfill site selection process. Financial, technical, and social factors are also critical considerations in waste management. Many developing countries, including India, face significant financial and technical challenges that lead to inadequate urban service delivery, including suboptimal solid waste management services. The burden of population and household-based waste poses a substantial challenge that necessitates comprehensive research and exploration for viable solutions. Consequently, social factors play a crucial role in effective waste management, as the inclusion and participation of residents are widely acknowledged as essential. Furthermore, the transportation aspect of solid waste management remains an underexplored area, warranting further investigation and attention to develop more efficient and sustainable practices.

Conclusion

Rapid urbanization, population growth, and evolving consumer behaviours are among the factors contributing to the complex and multidimensional challenges of municipal solid waste management. The increasing volume of waste generated, particularly in developing nations such as India, necessitates judicious and pragmatic approaches to landfill site selection and waste disposal. Consequently, Geographic Information Systems (GIS) and Multi-Criteria Decision Analysis (MCDA) have become essential tools for addressing these issues, owing to their capabilities in data management, analysis, and storage.

The study under examination highlights the significance of considering diverse factors in landfill site selection decision-making, encompassing social, economic, and environmental aspects. The inherent complexity of solid waste management is evidenced by numerous studies that have employed various criteria based on their respective case studies. The integration of MCDA and GIS has evolved over time, indicating a shift towards more sophisticated methodologies for determining site suitability.

Future research should focus on addressing these gaps to enhance the sustainability and efficacy of solid waste management strategies. Collaboration among researchers, policymakers, and practitioners is imperative to develop innovative approaches that can mitigate the adverse impacts of waste management on the environment and public health while promoting energy efficiency and sustainable urban development. Only through concerted efforts can a balance between urbanization and environmental conservation be achieved within the context of solid waste management.

Acknowledgments

This study was funded by the Indian Council of Social Science Research (ICSSR), New Delhi, under the Post-Doctoral Fellowship for the Year 2022–2023 with the F. No. 3-138/2022-2023/PDF/GEN, awarded to the First Author.

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