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Multicriteria Decision Analysis (MCDA) and Geographic Information System (GIS) in Construction and Demolition Waste (CDW) Management

Raphael Lúcio Reis dos Santos[1], Conrado de Souza Rodrigues[2], Armando Belato Pereira[3], João Marcos Guimarães Rabelo[4]
[1,2,3,4]Centro Federal de Educação Tecnológica de Minas Gerais (CEFET-MG)
([1]raphael.santos@cefetmg.br, [2]crodrigues@civil.cefetmg.br, [3]armandobelato@cefetmg.br, [4]joaomarcos@cefetmg.br)

***Abstract*-** Identifying deposition areas for Construction and Demolition Waste (CDW) and managing it properly ensuring compliance with environmental, economic and social factors is a challenging task for many developing countries. The management of CDW has become more complex and expensive with the rapid socioeconomic development and the increase in the volume of waste. Planning a sustainable regional waste management strategy is a critical step for decision makers. This paper seeks to present the state of the art of the use of multicriteria decision analysis tools (MCDA) and geographic information system (GIS) in solving problems of location of construction and demolition waste, by systematic bibliographic review. The results indicated that the tools were used in an integrated manner in several studies for the location of suitable locations for the disposal of CDW, such as landfills. The identification of suitable locations for the destination of waste contributes to the implementation of infrastructure that respects the environmental, economic and social aspects; important aid to decision makers. However, it was noted the absence of studies using these tools applied to CDW. Thus, it is recommended to apply MCDA and GIS to solve problems of localization of wastes generated by civil construction.

***Keywords*-** *Construction and Demolition Waste, Geographic Information System, Multicriteria Decision Analysis, Waste Management*

I. INTRODUCTION

According to [1], the increase in the generation of solid waste (SW) is one of the main problems that public administrations face due to the increase in the population and the increase in consumption patterns in recent years. Therefore, according to [2], the final disposition of waste in urban centers needs to be seriously discussed, considering that, in general, solid waste causes public health problems, occupation of space, degradation of natural resources and environmental imbalances [3] [4].

Solid waste has as final destination sanitary landfills, controlled landfills and dumps [5] [6]; or in many cases they are deposited irregularly, such as: in vacant lots, close to roads, public roads and water courses [7] [8].

The traditional treatment of waste and its disposal has some important environmental challenges [9], mainly due to concerns for environmental health [10]. Such environmental challenges, combined with economic and social aspects, as well as the availability of land, are relevant in indicating areas for reception and disposal of solid waste [11].

Proper management and recycling of waste is beneficial to the environment, as it leads to a reduction in the consumption of natural resources and the volume of waste sent for deposition [12]. According to [10], the management of urban solid waste has become a major concern for city authorities and planners due to the increase in population, urbanization and also due to the reduced available area.

A fundamental part of the correct management of CDW is the choice of the appropriate places to deposit them, as it is a complex task, since it is necessary to analyze a large territorial area in order to identify areas suitable for environmental criteria, and social factors used for selection [13].

The multicriteria decision analysis (MCDA) tool has been widely used to aid decision making, especially when there are several criteria considered for a decision [14]. [15] concluded that through the MCDA it is possible to analyze different scenarios, which involve several criteria, and in a joint way; which favors its application in problems related to the environment. Thus, MCDA has been widely used in problems related to the location of infrastructures used in the management of solid waste [16] [17] [18] [19] [20].

According to [21], the application of tools in the management and analysis of information of any nature, which depend on location, whether spatial or geographical, is the main characteristic of Geographic Information Systems (GIS). [22] states that for the performance of judicious analyzes, involving the crossing and overlapping of data and, also, the presentation of the results through different formats (for example: images, maps, texts, graphs, symbols, mathematical expressions and statistics) the use of a GIS is essential. Therefore, the use of the Geographic Information Systems tool in the selection of locations, especially those that assist decision makers through a multicriteria approach, enables the performance of complex assessments in vast territorial extensions, allowing for better efficiency and quality in the results presented [13].

According to [11], the integrated use of MCDA resources with Geographic Information Systems uses weighted criteria and spatial data to produce more valuable information for decision making. The method of integration between the technological tools MCDA and GIS is flexible in relation to the determination of criteria, which may be restrictive or preferential, in addition, it is possible to expand it to reduce uncertainty through the inclusion of more criteria [23].

Therefore, the objective of this paper is to present the state of the art of using integrated MCDA and GIS as tools to aid the management of construction and demolition waste.

II. METHODOLOGY

The methodological structure proposed by [24] [25] was defined:

1. Research objective: Exploratory;
2. Nature of the research: Conceptual;
3. Research logic: Inductive and Deductive;
4. Research process: Qualitative;
5. Search result: Basic;
6. Technical procedures: Bibliographic research;
7. Instruments: Books, articles, reports and management plans.

Bibliographic research was carried out in different databases (Science Direct and Scopus). A search was made for combinations of keywords that allowed the selection of works that presented applications of the tools of multicriteria decision analysis and geographic information system applied to the resolution of problems of CDW management.

The results presented in this article include only studies published in peer-reviewed scientific journals, with the aim of ensuring data quality and ease of access. In this research, the articles used were obtained covering publications between the years 1990 and 2019.

A total of 123 articles on applications of multicriteria decision analysis (MCDA) and Geographic Information System (GIS) in construction and demolition waste management (RCD) were compiled for the present study. Table I shows the works that were selected based on keyword research.

For each selected article, the year of publication and data related to the scope of the study were recorded, in addition to the tool used in the management of CDW. In addition, characteristics were verified, such as the objective of the work, allowing the identification of the theme and objective of the research related to the management of CDW.

After the selection process of the papers, to facilitate the global assessment of the data and provide a quantitative measure of the information obtained, a frequency analysis was performed to determine the number of applications of each tool, according to the purpose of the studies. In this way, the critical analysis was performed based on the information compiled and the results of the frequency study.

TABLE I. ARTICLES SELECTED IN THE SEARCH FOR KEYWORDS

THEME	KEYWORDS	NUMBER OF PUBLICATIONS
MCDA + CDW	"MCDA" or "Multicriteria" or "Multiobjective" or "Multiattribute" and "CDW" or "Construction waste" or "Construction and demolition waste"	29
GIS + CDW	"GIS" or "Geographic information system" e "CDW" or "Construction waste" or "Construction and demolition waste"	92
MCDA + GIS + CDW	"MCDA" or "Multicriteria" or "Multiobjective" or "Multiattribute" and "GIS" e "CDW" or "Construction waste" or "Construction and demolition waste"	2

This critical analysis focuses on the discussion of the main deficiencies of the approaches presented in the selected articles. Finally, according to the strengths and disadvantages identified in the analyzed articles, recommendations were made for future work in the area of construction and demolition waste management with applications of MCDA and GIS.

III. RESULTS AND ANALYSYS

The articles selected through the search for keywords in the databases indicated the predominance of the use of the Geographic Information System tool under the multicriteria decision analysis when applied in the management of construction and demolition waste. Table II shows the annual distribution of publications using the two tools.

It is noted that the GIS tool has a larger number of articles published in the area of RCD management than the MCDA tool. This predominance is also observed when analyzing the publications year by year. Only in 6 years (1992, 1993, 1999, 2003, 2006 and 2012) there was the same number of publications using the MCDA and GIS tools. The publication of more articles from MCDA than from GIS, related to RCD management, occurred only in the year 2000.

In both tools, the main areas of application of the studies were Environmental Science (with 15 and 31 publications for MCDA and SIG, respectively) and Engineering (13 publications for MCDA and 16 articles published using the GIS tool).

TABLE II. ANNUAL PUBLICATIONS OF MCDA AND SIG

YEAR	MCDA + CDW PUBLICATIONS	SIG + CDW PUBLICATIONS
1991	0	1
1992	0	0
1993	0	0
1994	0	1
1995	0	2
1996	0	3
1997	0	2
1998	0	2
1999	1	1
2000	1	0
2001	0	4
2002	0	2
2003	0	0
2004	0	2
2005	0	4
2006	2	2
2007	1	3
2008	1	3
2009	1	5
2010	1	4
2011	2	5
2012	3	3
2013	0	2
2014	1	2
2015	2	3
2016	1	6
2017	3	8
2018	4	9
2019	5	13

Of the 29 articles obtained in the bibliographic search related to the application of the MCDA tool, 10 sought to solve problems of location of infrastructures used in the management of CDW. The other topics covered in the articles involved process modeling (4 articles); in addition to the identification of places with irregular deposition of CDW, lifting of limitations in the management of CDW and estimation of the quantity of CDW generated (each of these themes with 1 paper). Another 12 articles were excluded for not having a direct relationship with the scope of this research (applications of the MCDA tool in RCD management).

The main articles selected using the multicriteria decision analysis tool are presented in Table III and discussed below in the text.

TABLE III. SELECTED ARTICLES WITH APPLICATION OF MCDA IN THE MANAGEMENT OF CDW

AUTHORS AND TITLES
[26] Site selection of construction waste recycling plant
[27] Multiobjective Location Model Design Based on Government Subsidy in the Recycling of CDW
[28] Multicriteria optimization of natural and recycled aggregate concrete for structural use
[29] Application of Multi-Criteria decision-making tool to locate construction and demolition waste (C&DW) recycling facilities in a northern Spanish region
[30] Assessing multiple criteria for the optimal location of a construction and demolition waste management facility
[31] Multicriteria decision making applied to waste recycling in Brazil

[26] used MCDA to solve problem of location of infrastructures used in the management of CDW in China. The authors indicated suitable locations for the implementation of a CDW recycling plant. The survey results can provide the government with a theoretical basis for selecting construction and demolition waste recycling facilities.

Model based on the location of infrastructure for recycling the CDW and the routes for transporting waste were developed by [27]. The authors performed a sensitivity analysis to conclude the effectiveness and applicability of the model developed in the research.

[28] carried out a study with the objective of verifying the use of aggregates, including those from CDW, in concrete, through MCDA optimization and taking into account environmental, economic and technical limits and restrictions. The authors cite that one of the main ways of using recycled CDW is in the form of aggregates in recycled concrete, contributing to the reduction of the volume of CDW and the use of natural mineral aggregates.

The study carried out in Spain to identify locations suitable for receiving recycling plants obtained satisfactory results, as reported by [29]. Also, according to the authors, analyzes of the sensitivity and uncertainty of the results were carried out to investigate the robustness of the solutions obtained. The research results showed the applicability of the methodology to select the appropriate locations of CDW recycling plants.

[30] developed a study using environmental, economic and social criteria to identify suitable locations for the installation of infrastructures used in the management of CDW in Greece. According to the authors, it is essential to perform sensitivity analysis, since the values of the applied parameters originate from estimates that sometimes may not be completely reliable.

Finally, performance evaluation of CDW recycling plants installed using the MCDA tool in consultation with professionals in the area was carried out in the work developed by [31].

As noted, the authors of the studies cited above reported satisfactory results for the application of the multicriteria decision analysis tool applied in the management of construction and demolition waste. The use of sensitivity analysis is extremely important to assess the robustness of the model, which is defined as the characteristic of the model to be insensitive to small changes in the input parameters [32].

Regarding the 92 selected articles that applied the GIS tool in CDW management, it was observed that 65 articles were not directly related to the theme of this research, and, therefore, were excluded from the analysis. Of the remaining 27 articles, 8 are related to the solution of infrastructure location problems used in the management of CDW. The other topics covered in the articles involved process modeling (7 articles), estimation of the quantity of CDW generated (7 articles), identification of places with irregular deposition of CDW (3 articles) and lifting of limitations in the management of CDW (2 articles).

Table IV shows the main articles that used the Geographic Information System tool in the management of Construction and Demolition Waste. Then, a brief report of each article is made.

TABLE IV. SELECTED ARTICLES WITH APPLICATION OF GIS IN THE MANAGEMENT OF CDW

AUTHORS AND TITLES
[33] Using GIS and optimization to manage construction and demolition waste: The case of abandoned quarries in Lebanon
[8] GIS-based planning system for managing the flow of construction and demolition waste in Brazil
[34] Identifying areas under potential risk of illegal construction and demolition waste dumping using GIS tools
[35] Using change detection data to assess amount and composition of demolition waste from buildings in Vienna
[36] Mapping of Construction Waste Illegal Dumping Using Geographical Information System (GIS)
[37] Application of integrated GPS and GIS technology for reducing construction waste and improving construction efficiency

[33] conducted a study using the GIS tool to identify and evaluate the recovery of quarries for the implementation of infrastructure to be used in the management of CDW. 148 quarries were identified, of which 2 were selected as most suitable. GIS was essential for efficiency in data collection and result analysis.

[8] used Quantum GIS to map 565 points of irregular deposition of CDW in the city of Recife. The authors based themselves on physical, socio-environmental and compliance criteria to assess the points of voluntary delivery of CDW present in the municipality. According to the authors, there is a need to expand and relocate the points of voluntary delivery so that there is a reduction in irregular deposition and, consequently, an increase in recycling.

A study carried out in Israel by [34] used a Geographic Information System and geo-statistical modeling to identify areas at risk of irregular deposition of CDW. According to the authors, the proposed approach can be useful for law enforcement environmental authorities, helping them to focus on specific sites for inspection, save resources and act more efficiently against offenders.

[35] used GIS to quantify the generation of CDW in Vienna. The results indicated that the city statistics pointed to lower values of CDW generated in comparison with the data collected through the spatial analysis tool used in the research. Thus, according to the authors, the approach presented is not only a useful tool for validating existing data on demolition and CDW generation statistics, but can also be used when these data sets do not exist.

The irregular deposition of construction and demolition waste was mapped using GIS in the study carried out by [36]. To quantify the CDW in irregular locations, two methods were used; the first method based on the shape of the residues (pyramids or squares), while the second method was based on the weighing approach.

The study developed by [37] presented a method that used a GIS integrated with GPS system as tools in the management of construction and demolition waste. The results presented by the authors indicated that the methodology used contributed to the reduction of the generated CDW.

As observed in the works in which the multicriteria decision analysis was applied as a tool in the management of CDW, it is also observed that the authors of the studies carried out with GIS indicated satisfactory results of the application of the tool in the management of CDW, especially in the studies that sought to solve problems of location of infrastructures focused on the management of CDW.

Based on the search for keywords carried out in the databases, only 2 published scientific articles were obtained. One of them is not in the scope of this research and was excluded. The other is the article entitled "Managing emergency construction and demolition waste in Syria using GIS". In the scientific article published by [38], a methodology was developed with the application of the MCDA tool integrated with GIS in order to determine the amount of RCD generated and propose areas for the recycling of waste with the least possible movement of the material. The authors developed the model and applied Syria as a case study, a country that has faced wars for the past 7 years, which consequently has generated a large amount of CDW. The country was divided into 8 areas, in which areas for the implementation of recycling sites were planned, ordered by suitability between 18% and 64% according to environmental factors and also in relation to topography, geology and infrastructure.

The use of multicriteria decision analysis tools integrated with the Geographic Information System is widespread for solving localization problems related to the implantation of adequate municipal solid waste disposal sites [39] [40]. However, there are still few studies aimed at solving location

problems involving construction and demolition waste [30] [41].

IV. CONCLUSION

This research accomplished its objectives by presenting the state of the art and conducting a critical analysis of the applications of the tools of multicriteria decision analysis and Geographic Information System applied in the management of Construction and Demolition Waste.

Note that these technological tools are currently in wide use, individually, in the context of construction and demolition waste management and have previously been used in several studies. It is also possible to verify that they were used to solve different problems related to CDW management, the main one being location problems to identify suitable areas for the reception and recycling of CDW.

However, it is still possible to verify that the tools are little used in an integrated way, which eliminates the advantages that could occur from using them together. There were also limitations in the studies regarding the performance of sensitivity analysis, considering that only a small number of studies carried out this type of analysis.

Thus, based on the overview provided in this article, the following recommendations are provided as suggestions for future work in the area of CDW management:

• Use MCDA integrated with GIS to solve problems involving CDW management;

• Explore study location problems involving facilities other than a recycling plant, such as, for example, Voluntary Delivery Points and Treatment Plants;

• Combine the location of infrastructure and the management strategy in the same study;

• Expand MCDA applications in CDW streams;

• Include the community (local associations and residents), as well as experts and authorities in multicriteria decision analysis that involve the opinion of interested parties.

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REFERENCES

[1] PIRES, C. S. O tratamento dos resíduos orgânicos como cumprimento da Política Nacional de Resíduos Sólidos: Análise dos planos municipais da bacia do Alto Tietê. 2013.126 f. Dissertação (Mestre em Ciências) - Engenharia Hidráulica e Saneamento, Universidade de São Carlos, São Carlos. 2013.

[2] NETO, R. Banco de dados georreferenciado para aterros sanitários de resíduos sólidos urbanos (AS-RSU) no estado da Bahia. 2009.

[3] OLIVEIRA; V. F. O papel da indústria da construção civil na organização do espaço e do desenvolvimento regional. The 4th International Congresse University Industry Cooperation. Taubaté, 2012.

[4] NAGAPAN, S. et al. Study's of sites construction waste in Batu Paha, Johor. Procedia engineering. Malásia, n. 53, p. 99-103, 2013.

[5] JUCÁ, J. F. T. Disposição final dos resíduos sólidos urbanos no Brasil. In: Congresso brasileiro de geotecnia ambiental - REGEO. 2003.

[6] JACOBI, P. R.; BESEN, G. R. Gestão de resíduos sólidos em São Paulo: desafios da sustentabilidade. Estudos avançados, v. 25, n. 71, p. 135-158, 2011.

[7] SOUZA, U. E. L. et al. Diagnóstico e combate à geração de resíduos na produção de obras de construção de edifícios: uma abordagem progressiva. Ambiente construído, v. 4, n. 4, p. 33-46, 2004.

[8] PAZ, D. H. F. et al. GIS-based planning system for managing the flow of construction and demolition waste in Brazil. Waste Management & Research, v. 36, n. 6, p. 541-549, 2018.

[9] OJHA, C.S. et al. Applying Fuzzy logic and the point count system to select landfill sites. Environmental monitoring and assessment, v. 135, n. 1-3, p. 99-106, 2007.

[10] JAVAHERI, H. et al. Site selection of municipal solid waste landfills using analytical hierarchy process method in a geographical information technology environment in giroft. Journal of environmental health science & engineering, v. 3, n. 3, p. 177-184, 2006.

[11] KHAN, M. M. et al. Optimal siting of solid waste-to-value-added facilities through a GIS-based assessment. Science of the total environment, v. 610, p. 1065-1075, 2018.

[12] COCHRAN, K. et al. Estimation of regional building-related C&D debris generation and composition: Case study for Florida, US. Waste management, v. 27, n. 7, p. 921-931, 2007.

[13] BOHNENBERGER, J. C. et al. Identificação de áreas para implantação de usina de reciclagem de resíduos da construção e demolição com uso de análise multicritério. Ambiente Construído, v. 18, n. 1, p. 299-311, 2018.

[14] SCHAMNE, A. N. Avaliação do potencial de aplicação dos preceitos da logística reversa de resíduos sólidos ao setor da construção civil em Curitiba, Paraná. Dissertação (Mestrado) – Programa de Pós-Graduação em Engenharia Civil, Universidade Tecnológica Federal do Paraná. Curitiba, 2016.

[15] VUCIJAK, B. et al. Multicriteria decision making in selecting best solid waste management scenario: a municipal case study from Bosnia and Herzegovina. Journal of cleaner production, v. 130, p. 166-174, 2016.

[16] SIDDIQUI, M. Z. et al. Landfill siting using geographic information systems: a demonstration. Journal of environmental engineering, v. 122, n. 6, p. 515-523, 1996.

[17] KONTOS, T. D. et al. Siting MSW landfills on Lesvos island with a GIS-based methodology. Waste management & research, v. 21, n. 3, p. 262-277, 2003.

[18] HIGGS, G. Integrating multi-criteria techniques with geographical information systems in waste facility location to enhance public participation. Waste management & research, v. 24, n. 2, p. 105-117, 2006.

[19] CHANG, N. et al. Combining GIS with fuzzy multicriteria decision-making for landfill siting in a fast-growing urban region. Journal of environmental management, v. 87, n. 1, p. 139-153, 2008.

[20] SENER, S. et al. Combining AHP with GIS for landfill site selection: a case study in the Lake Beyşehir catchment area (Konya, Turkey). Waste management, v. 30, n. 11, p. 2037-2046, 2010.

[21] ROCHA, J. S. Mapeamento por SIG e Random Forest do impacto dos resíduos da suinocultura na qualidade das águas da Bacia do Rio Piranga-MG. 2016.

[22] AUGUSTO, O. Sistemas de informações geográficas aplicados à engenharia ambiental. Engenharia Ambiental: conceitos, tecnologia e gestão. Rio de Janeiro: Elsevier, 2013.

[23] TAVARES, G. et al. Optimization of MSW collection routes for minimum fuel consumption using 3D GIS modelling. Waste management, v. 29, n. 3, p. 1176-1185, 2009.

[24] ENSSLIN, L.; ENSSLIN, S. R. Notas de aula. Disciplina de Avaliação de Desempenho do Programa de Pós-Graduação em Engenharia da Produção. UFSC, 2008.

[25] AZEVEDO, R. C. Um modelo para gestão de risco na incorporação de imóveis usando a metodologia multicritério para apoio a decisão construtivista (MCDA-C). Tese (Doutorado em Engenharia Civil), Universidade Federal de Santa Catarina, Florianópolis, 2013.

[26] SHI, Q. et al. Site selection of construction waste recycling plant. Journal of cleaner production, v. 227, p. 532-542, 2019.

[27] FU, P. et al. Multiobjective location model design based on government subsidy in the recycling of CDW. Mathematical problems in engineering, v. 2017, 2017.

[28] TOSIC, N. et al. Multicriteria optimization of natural and recycled aggregate concrete for structural use. Journal of cleaner production, v. 87, p. 766-776, 2015.

[29] DOSAL, E. et al. Application of multi-criteria decision-making tool to locate construction and demolition waste (C&DW) recycling facilities in a northern Spanish region. Environmental engineering & management journal, v. 11, n. 3, 2012.

[30] BANIAS, G. et al. Assessing multiple criteria for the optimal location of a construction and demolition waste management facility. Building and environment, v. 45, n. 10, p. 2317-2326, 2010.

[31] GOMES, C. F. S. et al. Multicriteria decision making applied to waste recycling in Brazil. Omega, v. 36, n. 3, p. 395-404, 2008.

[32] MUCCILLO, M. et al. Multi-objective optimization and sensitivity analysis of a cogeneration system for a hospital facility. Energy procedia, v. 81, p. 585-596, 2015.

[33] ALZAGHRINI, N. et al. Using GIS and optimization to manage construction and demolition waste: The case of abandoned quarries in Lebanon. Waste Management, v. 95, p. 139-149, 2019.

[34] SEROR, N.; PORTNOV, B. A. Identifying areas under potential risk of illegal construction and demolition waste dumping using GIS tools. Waste management, v. 75, p. 22-29, 2018.

[35] KLEEMANN, F. et al. Using change detection data to assess amount and composition of demolition waste from buildings in Vienna. Resources, conservation and recycling, v. 123, p. 37-46, 2017.

[36] ZAINUN, N. Y. et al. Mapping of construction waste illegal dumping using geographical information system (GIS). In: IOP Conference Series: Materials science and engineering. IOP Publishing, 2016.

[37] LI, H. et al. Application of integrated GPS and GIS technology for reducing construction waste and improving construction efficiency. Automation in Construction, v. 14, n. 3, p. 323-331, 2005.

[38] MADI, N.; SROUR, I. Managing emergency construction and demolition waste in Syria using GIS. Resources, conservation and recycling, v. 141, p. 163-175, 2019.

[39] CALIJURI, M. L. et al. Identificação de áreas alternativas para disposição de resíduos sólidos na região do Baixo Ribeira do Iguape-SP. Engenharia sanitária e ambiental, v. 12, n. 3, p. 335-342, 2007.

[40] CASTRO, J. et al. Utilização de SIG e análise multicritério para seleção de áreas com potencial para a construção de universidades e loteamentos universitários. Boletim de ciências geodésicas, v. 21, n. 3, 2015.

[41] ALDANA, J.; SERPELL, A. Temas y tendencias sobre residuos de construcción y demolición: un metaanálisis. Revista de la Construcción, v. 11, n. 2, p. 04-16, 2012.

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