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Development and application of a prioritization and rehabilitation decision support tool for uncontrolled waste disposal sites in developing countries

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Abstract

The uncontrolled dumping of solid waste is widespread in many developing countries with most of all generated wastes being indiscriminately disposed of in an unsanitary manner that entails significant environmental and public health risks. It is imperative to prioritize dumpsites based on their relative risks so that the necessary control and remedial measures can be undertaken. This research aimed to formulate a pragmatic prioritization and rehabilitation decision tool that can be utilized in low- and middle-income countries to guide decision makers in prioritizing dumpsites for remediation and in identifying the most suitable rehabilitation option for municipal as well as construction and demolition waste. The established prioritization model presents an integrated, risk-based approach to developing a decision-making tool for dumpsite prioritization and rehabilitation. The rehabilitation tool drew on a decision tree module to develop the appropriate remedial measures required for each site. The model proved to be effective in prioritizing uncontrolled solid waste disposal sites in Lebanon and for adopting control and remedial measures that can considerably improve decision-making. The improper disposal of solid waste adversely affects public health and the environment in, to a greater or lesser extent, almost all low- and middle-income countries. Considering that it is unfeasible to remediate all uncontrolled solid waste disposal sites at once, the proposed model facilitates the evaluation process by prioritizing sites for closure and remediation based on their relative risks. *Integr Environ Assess Manag* 2023;19:436–445. © 2022 SETAC

KEYWORDS: Developing countries; Prioritization tool; Rehabilitation tool; Uncontrolled dumps

INTRODUCTION

Solid waste management is one of the pressing issues in developing countries because of the ineffective and inefficient waste management systems, with uncontrolled waste disposal sites being very common (Bundhoo, 2018; Rodić & Wilson, 2017; Zurbrügg & Schertenleib, 1998). Undoubtedly, the improper management of solid waste will make it difficult for countries to achieve the 2030 UN Sustainable Development Goals (SDGs). It is necessary to close and rehabilitate uncontrolled disposal sites to reduce environmental and public health impacts. In addition to reducing environmental degradation, rehabilitating these sites accrues additional benefits, such as recovering recyclables and land appreciation. Municipalities in developing countries spend up to 50% of their total operational budgets on collecting, transporting, and disposing of locally generated refuse (Zohoori & Ghani, 2017). The operational costs involved in maintaining the sector are seldom recovered given that cost recovery mechanisms, should they even exist, tend to be inefficient, and the activities of the informal sector strip waste streams of recoverable valuables (Elnaas, 2015; Wilson et al., 2012). Consequently, decision makers often find the cost efficacy of disposal-oriented solutions effective, attractive, and convenient. Accordingly, landfills and dumpsites are heavily relied on because they tend to be inexpensive options. This has led to roughly 90% of the municipal solid waste (MSW) collected in low-income countries being openly dumped or burned (World Bank, 2018). Haphazardly disposed wastes affect public health and the environment by dispersing pollutants into the immediate environment in the form of leachate that seeps into nearby soil media and groundwater aquifers, and

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gaseous emissions such as particulate matter, sulfides, nitrides, and greenhouse gases, which dissipate into the atmosphere (Joseph et al., 2005). Moreover, the solid waste sector is often regarded as one of the leading anthropogenic sources of greenhouse gas (GHG) emissions ranking as the third largest human-induced source of greenhouse gases (Pujara et al., 2019). The management of solid waste can directly affect 12 of the 17 SDGs due to the social, economic, and environmental implications that the sector holds, which positions it as a major determinant of sustainable development (Rodić & Wilson, 2017). Accordingly, the rehabilitation of uncontrolled waste disposal sites is urgently required to control the aforementioned adverse effects and for the progress of the SDGs.

In Lebanon, the mismanagement of the solid waste sector over the years has led to severe negative repercussions on the country's environmental health, with reports linking improper waste management to the loss of biodiversity, air and water pollution, and decreased land productivity (MOE/UNDP/ECODIT, 2011). The pressure placed on Lebanon's solid waste management infrastructure was further inflated by the Syrian crisis, which caused the influx of approximately 1.5 million refugees, resulting in a 15% increase in waste volume, half of which was reportedly openly dumped or burned (MOE/EU/UNDP, 2014). The increase in the amount of waste being openly dumped has caused the number of uncontrolled disposal sites to increase from 670 in 2010 to 941 in 2016 (MOE-UNDP, 2017). Accordingly, it is crucial to develop an approach that can provide decision makers with the necessary information for the selection of the dumpsites among the large number of sites that urgently require control and remedial measures.

A major challenge that decision makers face primarily in developing countries is the lack of credible and evidence-based data for making informed waste management decisions. The process of rehabilitating open dumpsites involves technical investigation, estimation of the potential adverse impacts, and scientific assessment of risks (Joseph et al., 2005). The assessment of the various technical, operative, environmental, social, and economic factors provides the basis to prioritize sites requiring rehabilitation. Accordingly, prioritization and rehabilitation decision tools (PDT and RDT) for uncontrolled dumpsites should provide robust and reliable information that can enhance sound decision-making. Several models and approaches have been applied to the environmental assessment, prioritization, and rehabilitation of uncontrolled dumps that depend on complex physical models and probabilistic concepts that are normally difficult to use, involve large amounts of data, and thus are time consuming and costly (Singh et al., 2010; Zhang et al., 2016). This research aimed to formulate a pragmatic PDT and RDT that can be utilized in low- and middle-income countries to guide decision makers in prioritizing sites for remediation and in identifying the most suitable rehabilitation option for MSW and construction and demolition waste (CDW) dumpsites. It is based on the report: "Updated Master Plan for the Closure and Rehabilitation of Uncontrolled Dumpsites Throughout the Country of Lebanon" (MOE-UNDP, 2017).

METHODOLOGICAL FRAMEWORK

Study design

A PDT and a RDT were developed to identify uncontrolled dumpsites of highest risk and propose rehabilitation options. The needed information and data were taken from an existing database (MOE-UNDP, 2011) in addition to field visits and interviews with the concerned municipal officials to generate an updated database of current conditions for 941 uncontrolled disposal sites (MOE-UNDP, 2017). A methodological process of the study is presented in Figure 1. Quality assurance and quality control (QA/QC) were carried out at every step of the process.

Prioritization model development

The PDT was formulated to prioritize uncontrolled solid waste disposal sites based on a risk sensitivity index (RSI) that was derived from several approaches. These include, but are not limited to, the use of a modified fuzzy multiple criteria analysis for the selection of appropriate solid waste disposal sites (Ekmekçioğlu et al., 2010) and the analytic hierarchy process (AHP) used for ranking disposal sites (Junggoth et al., 2008) and determining the most suitable site (Şener et al., 2010). Several attributes were utilized for the prioritization process and each was given a weight that reflects the relative significance of their associated environmental impact. Each attribute was then assigned a sensitivity grade divided into four ranges. The selection of attributes is based primarily on the literature and mostly expert opinion. Interviews were held with these experts to draw on their opinions and suggestions in fine tuning the model. The RSI was then calculated by adding all attributes, after multiplying each sensitivity grade by its respective weight. As the RSI score of a dumpsite decreases, the priority for its rehabilitation decreases (MOE-UNDP, 2017). Figure 2 depicts the process of developing the prioritization model. Still, data could not be merged unless they measured the same values. For example, data signifying measured values in years cannot be combined with values indicating quantities of waste dumped. Moreover, categorical data were reclassified, and numerical floating values were either plotted linearly or exponentially to unify the rating categories and assigned utilities for each class in its related attribute. The adopted approach reframes and relates important parameters for dumpsite prioritization under the GIS umbrella.

Rehabilitation model development

The RDT provides a methodological approach that describes and compares various remediation scenarios. Primarily, it allows the description and comparison of the postremediation site use and associated socioeconomic benefits, remediation plan and costs, and the reduction in risks by identifying the advantages and disadvantages of

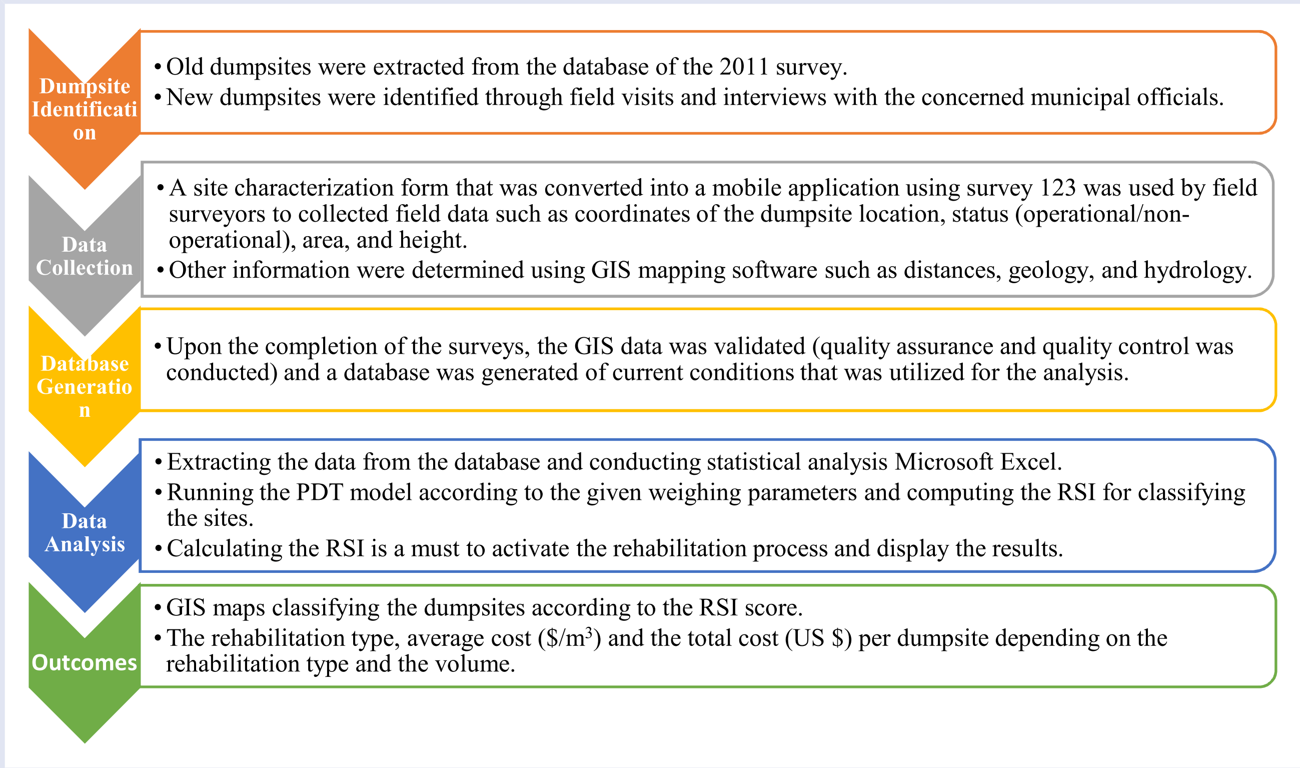

FIGURE 1 Methodological framework of the study

each scenario. Generally, depending on site conditions and the availability of alternative waste management solutions, the remedial measures are established. Figure 3 depicts the remedial measures that were considered for MSW and CDW dumpsites. Calculating the RSI is necessary to activate the rehabilitation process button and to display the results. A set of indices determines the advantages and drawbacks of each scenario, such as the socioeconomic benefits of the chosen postremediation land use, technological and logistical quality of the technological set, residual risk, total cost and duration of interventions, and environmental impacts. Accordingly, a decision tree based on a set of yes/no questions was developed to indicate the remedial measure necessary for each uncontrolled solid waste disposal site based on its characteristics (Figure 4).

The decision tree was built on a set of parameters; each was given a certain rank and weight depending on the morphometric-geological characteristic and environmental nature of the Lebanese territories. Within the Graphical User Interface (GUI) one can either adopt or adapt the model by changing the weighting and ranking of the parameters utilized. Moreover, because the model was based on an open source using Python, with few advances in scripting, users can modify and tune the designed model to best fit their needs by adding and removing certain parameters or modifying and changing their RDT. The proposed tool is designed for environmental experts and can serve other cases around the world by proposing optimal solutions.

Research setting

In Lebanon, years of waste mismanagement have created multiple open dumpsites that are widespread throughout the country. The uncontrolled waste disposal sites account for approximately 2 million square meters of Lebanon's area. There are approximately 617 and 324 uncontrolled dumpsites for MSW and CDW, respectively. Approximately 55% of the MSW and CDW dumpsites are operational and 45% are nonoperational. Moreover, citizens residing in low-income and rural areas in Lebanon suffer from an elevated burden of disease, because practices such as open dumping and burning constitute the main methods for the treatment and disposal of hazardous and nonhazardous wastes by local administrations, resulting in the contamination of natural resources. A study conducted by Soubra et al. (2021) demonstrated that various heavy metals were prevalent in samples collected form dumpsites in southern Lebanon, and many soil parameters were altered, which might have a direct effect on soil fertility, disrupt crop yield, and affect human health. A long-term strategy for the solid waste sector remains unavailable as low diversion rates continue to be recorded, decentralization efforts remain insufficient, hundreds of open dumpsites have yet to be rehabilitated, a constant reliance of ad hoc emergency strategies persists, and the adoption of a publicly unpopular waste-to-energy strategy continues to be touted by the government. Given that many challenges are still preventing the development of long-term sustainable solutions, these dumpsites are expected to increase especially because municipal solid

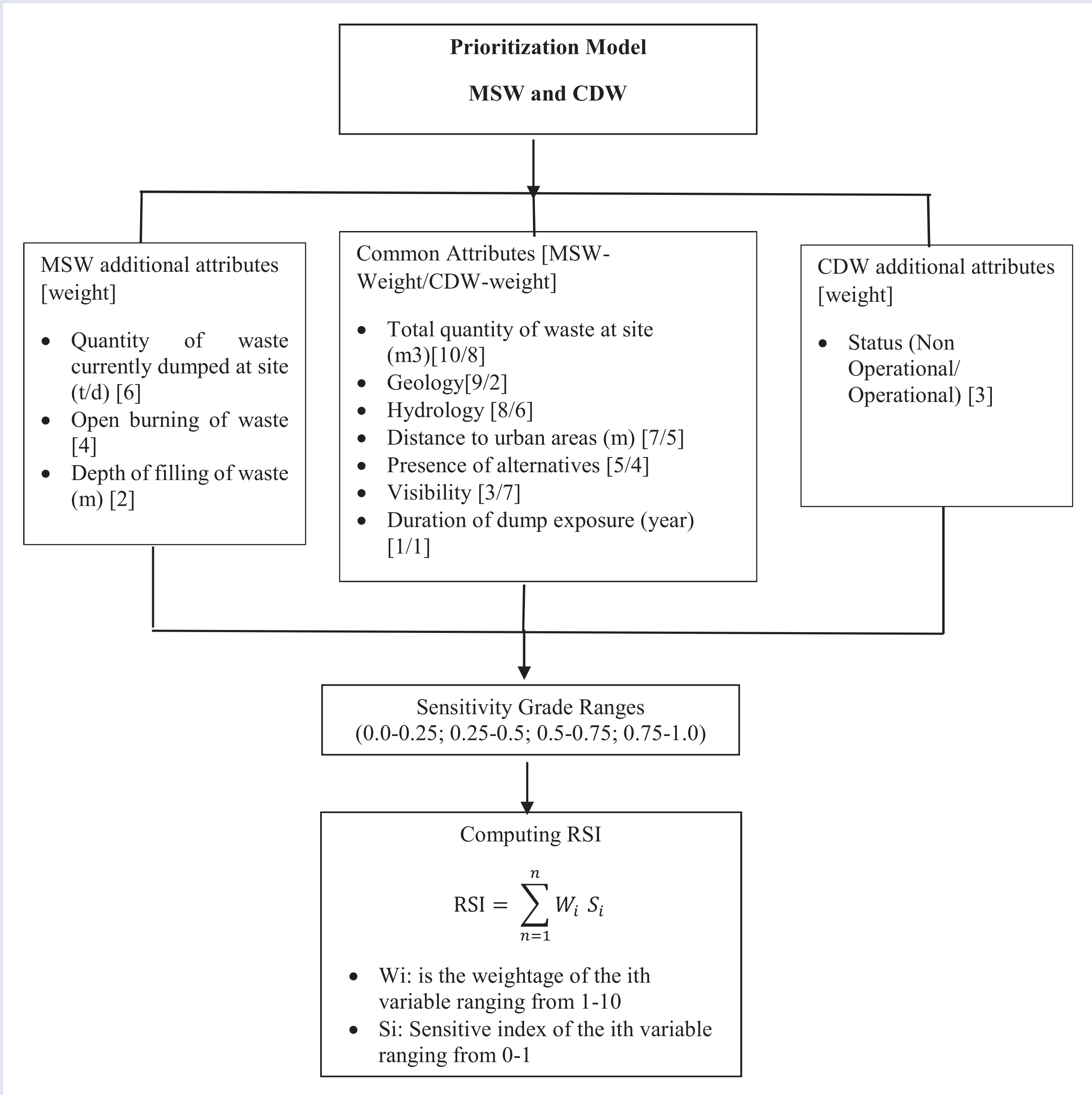

FIGURE 2 The process of developing the prioritization model

waste projections reflect a steady increase in total waste generation.

RESULTS AND DISCUSSION

Prioritizing uncontrolled solid waste disposal sites for rehabilitation is an arduous procedure that involves the processing of a large amount of spatial data, while considering several social, environmental, and technical parameters. Almost all attributes for the prioritization process were collected from field surveys except for geology and hydrogeology that required modeling using GIS. The RSI was then calculated and a sensitivity analysis was conducted. The sensitivity analysis consisted of interchanging weighing factors among attributes to assess the impact on the outcome and conducting several tests accordingly. Once the prioritization model was run, dumpsites could be classified and represented on digital maps as per their RSI (Figure 5). The PDT model served to categorically stratify uncontrolled municipal waste disposal sites into different classifications based on the RSI, which indicates the risk to the environment and the need for intervention. Disposal sites were grouped into five classes: very high risk (RSI > 30), high risk

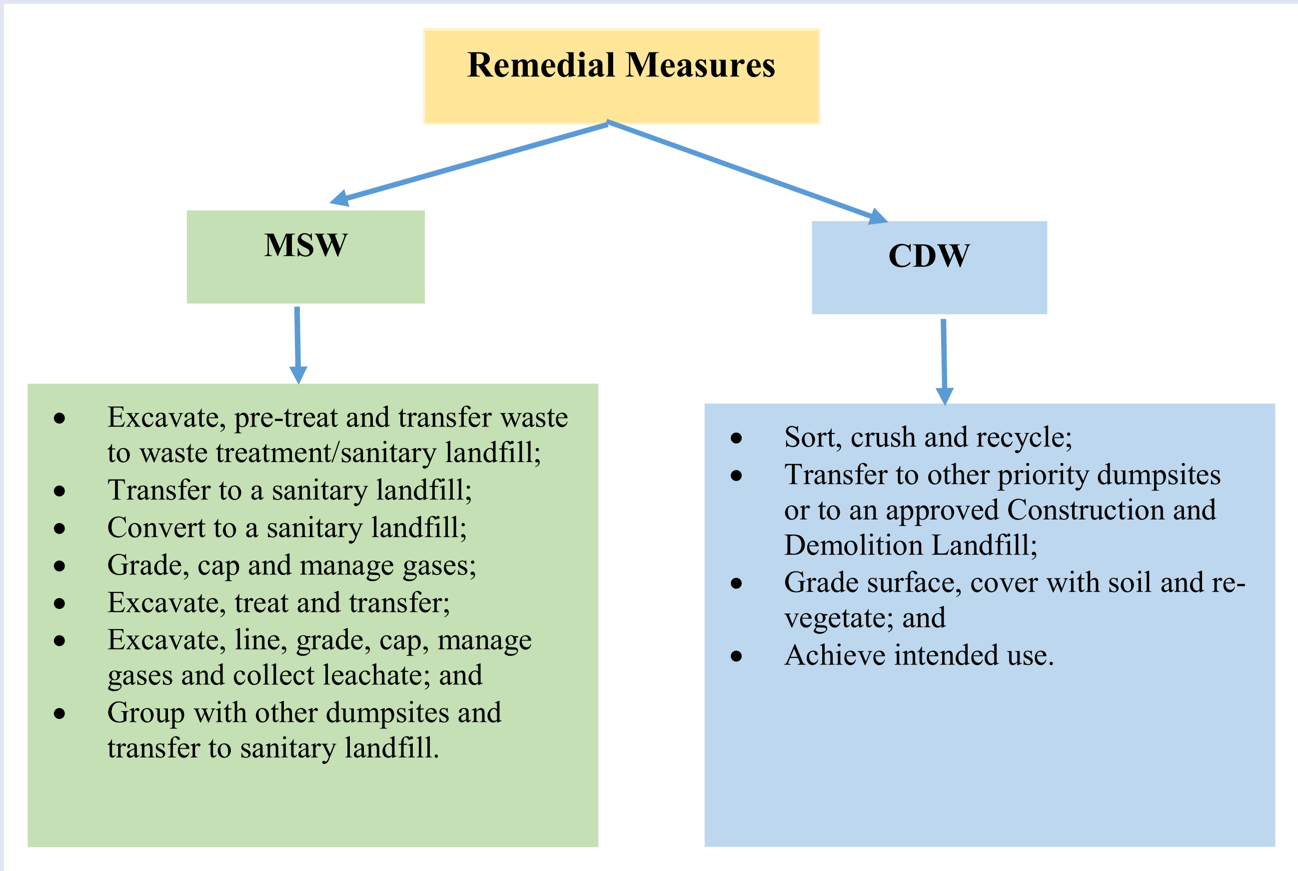

FIGURE 3 Remedial measures considered for municipal solid waste (MSW) and construction and demolition waste (CDW) dumpsites

(25 < RSI > 30), moderate risk (20 < RSI > 25), low risk (15 < RSI > 20), and minimal risk (RSI < 15). As the total RSI score of a dumpsite decreases, the priority for its rehabilitation declines. The higher the level of risk associated with a dumpsite denotes that the benefits and advantages resulting from its closure or rehabilitation are even greater.

The easy-to-use PDT model can be used to facilitate the decisions that many municipal authorities have to make when it comes to prioritizing dumpsites for remediation and adopting an appropriate remediation plan. Yet, closing or remediating a dumpsite is not straightforward. Several factors should be considered, such as socio-economic benefits, total cost and duration of the intervention, and environmental impacts. With limited resources and a large number of uncontrolled solid waste disposal sites that need to be rehabilitated, higher priority is assigned to dumpsites with higher risks and lower rehabilitation costs. Accordingly, the RDT determines the most appropriate rehabilitation option based on the characteristics of each dumpsite. Results are presented in an Excel sheet indicating the dumpsite ID, coordinates, location, RSI score, rehabilitation decision, and the total cost. Figures 5 and 6 provide a sample PDT application interface and results as presented in an Excel sheet and an RSI map of MSW dumpsites in Lebanon.

In the absence of national guidelines and standards to act as evaluation tools, the PDT and RDT provide a knowledge-based system that can facilitate the evaluation process for governmental officials who seek to enact interventions that are aimed at transforming inadequate local uncontrolled solid waste disposal sites into ones that are environmentally and economically viable. The PDT and RDT are decision support tools that are customized depending on the context. Both tools and the generated database were integrated in a digital GIS form, and an easy access interface was created for both MSW and CDW dumpsites using a freeware application that supports various GIS formats. Being user friendly, both tools direct the user through the entire process of the prioritization and allow the user to complete several tasks immediately and without difficulty. Table 1 summarizes the steps in prioritizing dumpsites and recommending the appropriate remedial and control measures.

Given the large number of uncontrolled disposal sites in many developing countries and the lack of resources, it is essential to prioritize dumpsites based on their relative risks and identify appropriate and economical rehabilitation options. The proposed PDT and the RDT tools could be very effective in the planning stages of closure and rehabilitation and ensure transparency of the decision-making process.

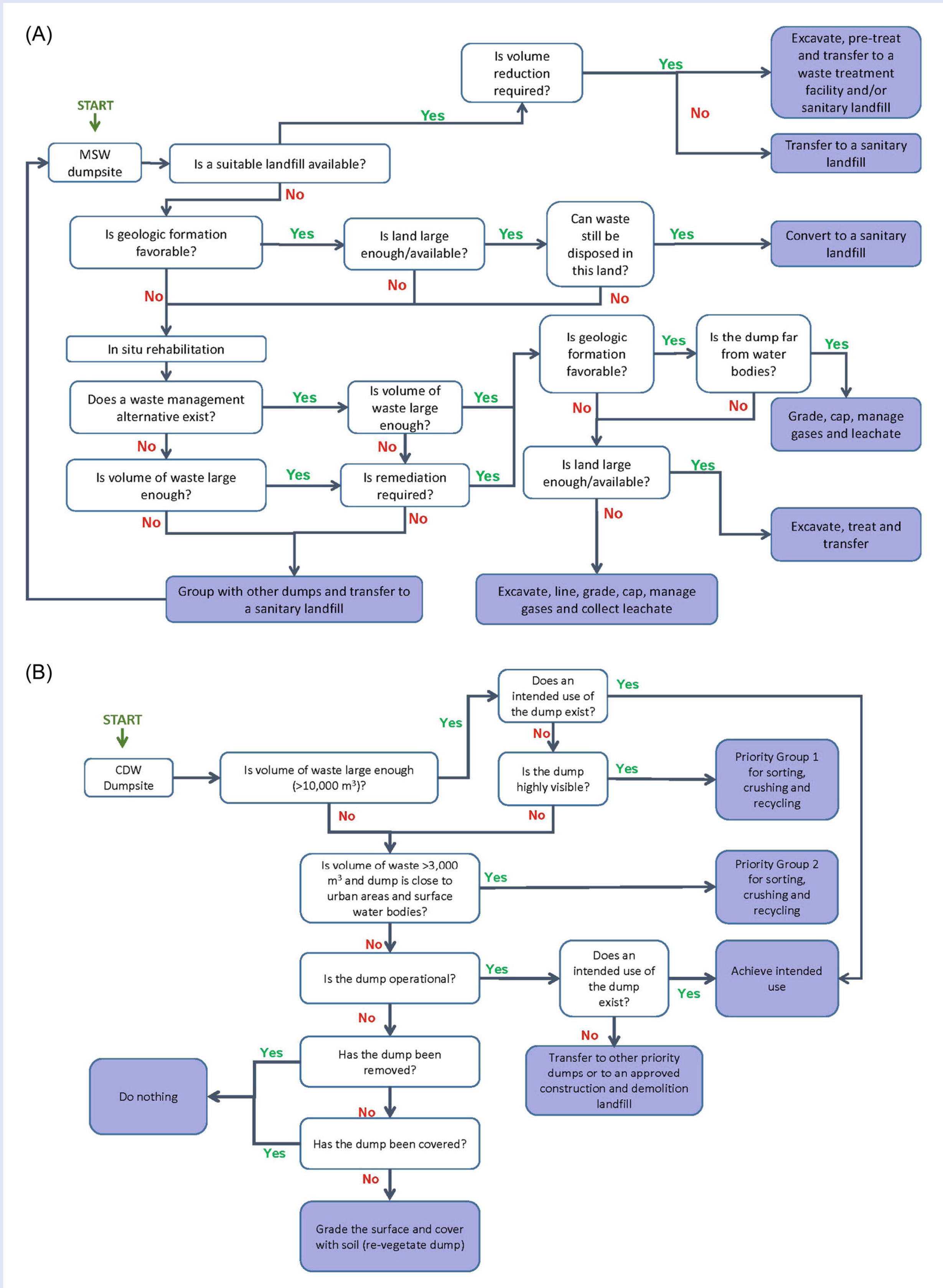

FIGURE 4 Decision tree for dumpsites rehabilitation (A) municipal solid waste (MSW) and (B) construction and demolition waste (CDW)

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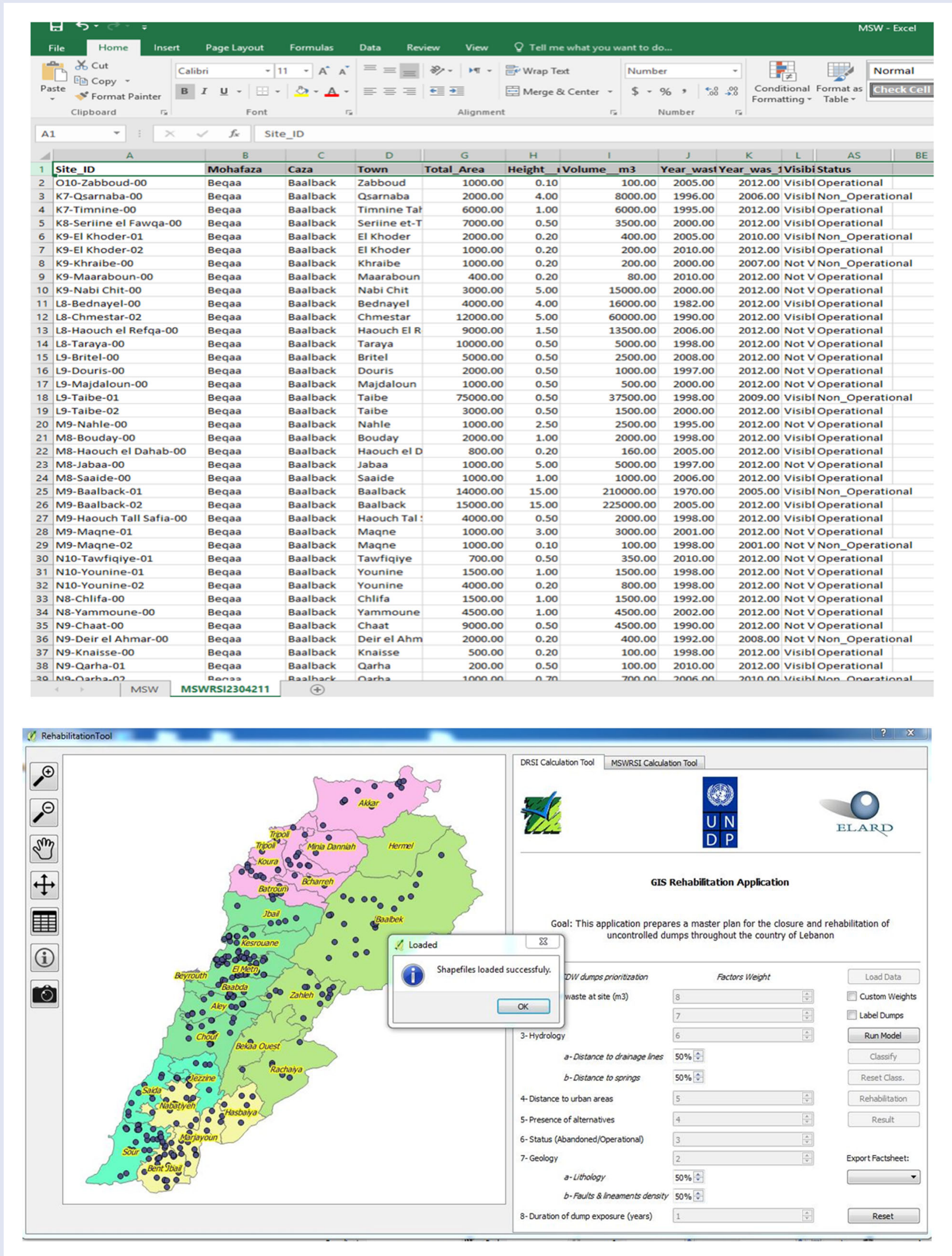
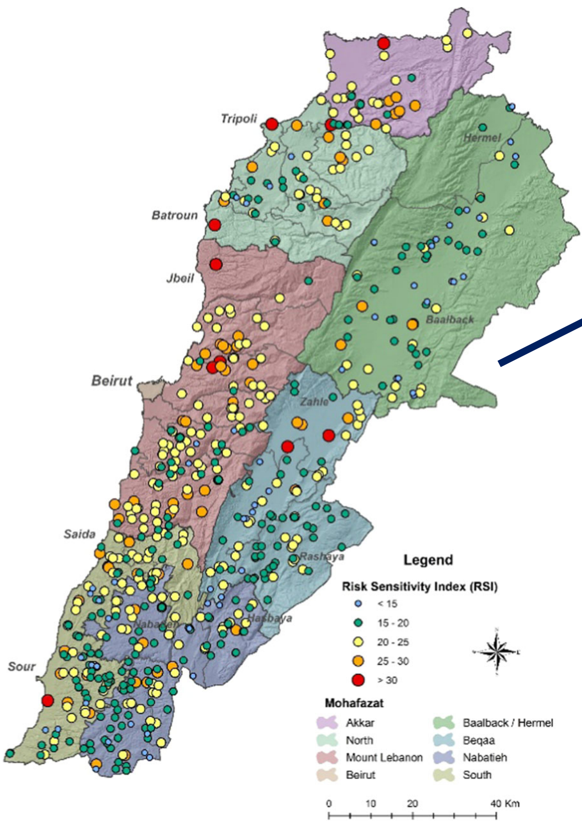


Site_ID	Mohafaza	Caza	Town	Total_Area	Height__i	Volume__m3	Year_wast	Year_was_1	Visibi	Status
O10-Zabboud-00	Beqaa	Baalback	Zabboud	1000.00	0.10	100.00	2005.00	2012.00	Visibl	Operational
K7-Qsarnaba-00	Beqaa	Baalback	Qsarnaba	2000.00	4.00	8000.00	1996.00	2006.00	Visibl	Non_Operational
K7-Timnine-00	Beqaa	Baalback	Timnine Tal	6000.00	1.00	6000.00	1995.00	2012.00	Visibl	Operational
K8-Seriine el Fawqa-00	Beqaa	Baalback	Seriine et-T	7000.00	0.50	3500.00	2000.00	2012.00	Visibl	Operational
K9-El Khoder-01	Beqaa	Baalback	El Khoder	2000.00	0.20	400.00	2005.00	2010.00	Visibl	Non_Operational
K9-El Khoder-02	Beqaa	Baalback	El Khoder	1000.00	0.20	200.00	2010.00	2012.00	Visibl	Operational
K9-Khraibe-00	Beqaa	Baalback	Khraibe	1000.00	0.20	200.00	2000.00	2007.00	Not V	Non_Operational
K9-Maaraboun-00	Beqaa	Baalback	Maaraboun	400.00	0.20	80.00	2010.00	2012.00	Not V	Operational
K9-Nabi Chit-00	Beqaa	Baalback	Nabi Chit	3000.00	5.00	15000.00	2000.00	2012.00	Not V	Operational
L8-Bednayel-00	Beqaa	Baalback	Bednayel	4000.00	4.00	16000.00	1982.00	2012.00	Visibl	Operational
L8-Chmestar-02	Beqaa	Baalback	Chmestar	12000.00	5.00	60000.00	1990.00	2012.00	Visibl	Operational
L8-Haouch el Refqa-00	Beqaa	Baalback	Haouch El R	9000.00	1.50	13500.00	2006.00	2012.00	Not V	Operational
L8-Taraya-00	Beqaa	Baalback	Taraya	10000.00	0.50	5000.00	1998.00	2012.00	Not V	Operational
L9-Britel-00	Beqaa	Baalback	Britel	5000.00	0.50	2500.00	2008.00	2012.00	Not V	Operational
L9-Douris-00	Beqaa	Baalback	Douris	2000.00	0.50	1000.00	1997.00	2012.00	Not V	Operational
L9-Majdaloun-00	Beqaa	Baalback	Majdaloun	1000.00	0.50	500.00	2000.00	2012.00	Not V	Operational
L9-Taibe-01	Beqaa	Baalback	Taibe	75000.00	0.50	37500.00	1998.00	2009.00	Visibl	Non_Operational
L9-Taibe-02	Beqaa	Baalback	Taibe	3000.00	0.50	1500.00	2000.00	2012.00	Visibl	Operational
M9-Nahle-00	Beqaa	Baalback	Nahle	1000.00	2.50	2500.00	1995.00	2012.00	Not V	Operational
M8-Bouday-00	Beqaa	Baalback	Bouday	2000.00	1.00	2000.00	1998.00	2012.00	Visibl	Operational
M8-Haouch el Dahab-00	Beqaa	Baalback	Haouch el D	800.00	0.20	160.00	2005.00	2012.00	Visibl	Operational
M8-Jabaa-00	Beqaa	Baalback	Jabaa	1000.00	5.00	5000.00	1997.00	2012.00	Not V	Operational
M8-Saaide-00	Beqaa	Baalback	Saaide	1000.00	1.00	1000.00	2006.00	2012.00	Visibl	Operational
M9-Baalback-01	Beqaa	Baalback	Baalback	14000.00	15.00	210000.00	1970.00	2005.00	Visibl	Non_Operational
M9-Baalback-02	Beqaa	Baalback	Baalback	15000.00	15.00	225000.00	2005.00	2012.00	Visibl	Operational
M9-Haouch Tall Safia-00	Beqaa	Baalback	Haouch Tal :	4000.00	0.50	2000.00	1998.00	2012.00	Visibl	Operational
M9-Maqne-01	Beqaa	Baalback	Maqne	1000.00	3.00	3000.00	2001.00	2012.00	Not V	Operational
M9-Maqne-02	Beqaa	Baalback	Maqne	1000.00	0.10	100.00	1998.00	2001.00	Not V	Non_Operational
N10-Tawfiqiye-01	Beqaa	Baalback	Tawfiqiye	700.00	0.50	350.00	2010.00	2012.00	Not V	Operational
N10-Younine-01	Beqaa	Baalback	Younine	1500.00	1.00	1500.00	1998.00	2012.00	Not V	Operational
N10-Younine-02	Beqaa	Baalback	Younine	4000.00	0.20	800.00	1998.00	2012.00	Not V	Operational
N8-Chlifa-00	Beqaa	Baalback	Chlifa	1500.00	1.00	1500.00	1992.00	2012.00	Not V	Operational
N8-Yammoune-00	Beqaa	Baalback	Yammoune	4500.00	1.00	4500.00	2002.00	2012.00	Not V	Operational
N9-Chaat-00	Beqaa	Baalback	Chaat	9000.00	0.50	4500.00	1990.00	2012.00	Not V	Operational
N9-Deir el Ahmar-00	Beqaa	Baalback	Deir el Ahm	2000.00	0.20	400.00	1992.00	2008.00	Not V	Non_Operational
N9-Knaisse-00	Beqaa	Baalback	Knaisse	500.00	0.20	100.00	1998.00	2012.00	Visibl	Operational
N9-Qarha-01	Beqaa	Baalback	Qarha	200.00	0.50	100.00	2010.00	2012.00	Visibl	Operational

FIGURE 5 Prioritization decision tool (PDT) application interface

Site ID	Mohafaza	Caza	Status	Category	Subcategory	Volume (m^3)	MSWRSI	Priority Rank
R6-Tripoli-0	North	Tripoli	Operational			1,200,000	40.734	1
N5-Hbaline-0	Mount Lebanon	Jbeil	Operational			600,000	40.317	2
R7-Adweh-0	North	Minieh-Dannieh	Operational			255,372	34.763	3
P5-Batroun-0	North	Batroun	Operational			55,000	34.600	4
T9-Srar-0	North	Akkar	Operational			570,000	34.279	5
J6-Qabb Elias-00	Beqaa	Zahle	Operational			219,000	32.503	6
C1-Deir Qanoun El-Aain-01	South	Sour	Non-operational	Not Rehabilitated		300,000	31.429	7
L5-Balloune-3	Mount Lebanon	Kesrouane	Operational			14,000	30.323	8
L5- Beit Chabab- 1n	Mount Lebanon	Maten	Operational			10,000	30.205	9
J7-Barr Elias-00	Beqaa	Zahle	Operational			200,000	30.158	10
R9-Fnaydek-0	North	Akkar	Operational			72,000	29.839	11
F2-Sarafand-01	South	Saida	Operational			33,000	29.647	12
G4-Jezzine-00	South	Jezzine	Operational			16,000	29.032	13
D2-Abbesye-03	South	Sour	Operational			35,000	28.961	14
M9-Baalback-02	Beqaa	Baalback	Operational			75,000	28.905	15
R9-Mishmesh-0	North	Akkar	Operational			6,000	28.392	16
G2-Ghaziye-00	South	Saida	Non-operational	Not Rehabilitated		32,000	28.356	17
E3-Kfour En-Nabatieh-00	Nabatieh	Nabatieh	Operational			42,000	28.130	18
G2- Saida -1n	South	Saida	Operational			50,000	28.088	19
R7-Kfar Chellane-0	North	Minieh-Dannieh	Operational			11,500	28.052	20
R9-Beit Ayyoub-1	North	Akkar	Non-operational	Not Rehabilitated		32,000	28.038	21
B3-Bent Jbayl-00	Nabatieh	Bent Jbeil	Non-operational	Not Rehabilitated		4,000	27.906	22
J7-Terbol-00	Beqaa	Zahle	Operational			7,500	27.891	23
L6-Aain El Qabou-0	Mount Lebanon	Maten	Operational			360	27.695	24



RSI Range	# of Dumpsites
> 30	10
25 - 30	69
20 -25	245
15 - 20	248
< 15	45
Total	**617**

FIGURE 6 Results as presented in Excel sheet and a risk sensitivity index (RSI) map of municipal solid waste (MSW) dumpsites in Lebanon

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TABLE 1 The steps of prioritizing dumpsites and recommending the appropriate remedial and control measures

1	Loading data	The required GIS layers are imported automatically into the map canvas and the "run model" button is enabled.
2	Locating data	In the event the data are not found by the application, the tool displays a message box indicating the missing parameters and gives the option to locate them manually.
3	Adjusting weighing parameters	Users are given the choice to alter the weighing factor of each parameter and assess the effect on the total RSI scoring.
4	Running RSI model	Calculating the RSI can be done by clicking the "run model" button, which is necessary to activate the rehabilitation process button and to display the results.
5	Classifying dumpsites	Dumpsites can be classified (based on color) according to the RSI scores.
6	Running rehabilitation model	The rehabilitation button applies the decision tree model consisting of alternative executions, chained conditionals, conditional execution, Boolean expressions, and logical operators. When all statements are justified in the decision tree, the designed model automatically calculates the average cost ($\$/m^3$) and the total cost ($US) per dumpsite depending on the rehabilitation type and the volume.
7	Navigating through maps	Using the map toolbar, users can navigate through the map (zoom in, zoom out, etc.).
8	Visualizing results	The results are displayed in a standalone table. Can be visualized in Excel format independent of the model. The dumpsite ID, its coordinates, the district and region, the RSI score, rehabilitation type, average cost and total cost are displayed.
9	Exporting datasheets	Printable datasheets for each dumpsite can be exported detailing the site name and location, type, estimated volume, priority ranking for rehabilitation and preferred rehabilitation option, technical requirements to be used for TORs, responsibility, legal requirements if any, monitoring requirements, operation and maintenance requirements, estimated cost, and possible funding sources.

Abbreviation: RSI, risk sensitivity index.

CONCLUSION

The present study presented a pragmatic prioritization model to prioritize dumpsites based on RSI with two different tools to address MSW and CDW dumpsites. The RSI was calculated for each of the 941 MSW and CDW dumpsites in Lebanon by adding all attributes, after multiplying each sensitivity grade by its respective weight. A site with a higher RSI indicates more risk to the environment and indicates that it requires intervention more urgently. Conversely, when the total RSI score of a dumpsite decreases, the priority for its rehabilitation decreases. A sensitivity analysis exercise was tested on the PDT model to verify and confirm its validity. The model proved to be very stable whereby the outcome of the model was for most dumps the same as the original setup. The RDT provides a methodological framework that describes and compares different remediation scenarios depending on the RSI. It relies on a decision tree module to determine the most appropriate rehabilitation option for MSW and CDW uncontrolled solid waste disposal sites based on a set of yes/no questions. Both the PDT and RDT were integrated in a digital GIS application that proved to be effective in prioritizing waste dumps and for adopting control and remedial measures that can considerably improve decision-making. It will facilitate the evaluation process for governmental officials who seek to enact public interventions that are aimed at transforming uncontrolled solid waste disposal sites into ones that are more environmentally viable.

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DATA AVAILABILITY STATEMENT

Data, associated metadata, and calculation tools are available from Ricardo Khoury (rkhoury@elard-group.com).

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