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A Population-Growth Model for the Optimal Disposal of Urban Waste in Qaemshahr City

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ABSTRACT

The present study aims to present a population-growth-based model for the optimal disposal of urban waste in the city of Qaemshahr, Iran, so that demographic change and consumption patterns can be linked to waste-management planning. The research is applied in terms of purpose, exploratory in terms of data collection and mixed in terms of the nature of the data. In the qualitative part, data were collected through interviews and analysed using thematic analysis in the quantitative part, a questionnaire and structural equation modelling with the partial-least-squares approach were used. The thematic analysis identified 48 initial codes, organised into seven components under the main theme "effective waste management": identifying consumption patterns, developing waste-management infrastructure, raising public awareness, social participation, the use of new technologies, creating economic incentives, and regulating laws and regulations. The PLS structural model confirmed that all seven components have a positive and significant effect on urban waste management; developing waste-management infrastructure had the strongest effect, followed by identifying consumption patterns and regulating laws and regulations. The results show a direct, significant relationship between population growth and waste generation, and that the optimal management of urban waste requires a comprehensive, multidimensional approach combining infrastructural, social, technological, economic and regulatory measures. The proposed model can serve as an effective, novel approach for optimising urban-waste management and improving citizens' quality of life in Qaemshahr and other cities with similar conditions.

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INTRODUCTION

Urban-waste management, as one of the fundamental challenges of sustainable development and environmental protection, requires new, scientific approaches that can help to optimise this process. Given population growth and the increase in waste generation, the necessity of designing effective waste-management models is felt more than ever. In this regard, presenting a population-growth model for the optimal disposal of urban waste can help to reduce the environmental burden and improve citizens' quality of life. Population growth is directly related to the increase in waste generation: the larger a city's population, the greater the volume of waste produced. This situation calls for special attention to waste management and the design of effective models for waste disposal and recycling (Davis, 2023). One important dimension of this management is the identification of patterns of waste generation and consumption in society, which given demographic characteristics can be analysed scientifically and systematically (Vieira & Matheus, 2021). A population-growth model refers to an analytical framework by which demographic changes and patterns of consumption and waste generation can be predicted and managed. Such a model can help decision-makers to plan the necessary infrastructure, allocate resources and implement waste-management strategies; it can also identify the needs and challenges of waste management and offer optimal solutions. The important point to note is the relationship between population growth and waste generation: an increase in population naturally leads to increased consumption of resources and, consequently, greater waste generation. This situation not only places pressure on natural resources but can also lead to problems such as environmental pollution and threats to public health. Designing a comprehensive model for urban-waste management that attends to demographic characteristics is therefore essential (Guerrero et al., 2013). Given the importance of the subject, the main problem of the present research is how, by designing a scientific, comprehensive model, the management of urban waste in the city of Qaemshahr can be optimised. The necessity of this research arises because, despite the rapid growth of population and the increase in waste generation, efficient and comprehensive models for the management of this waste in Iranian cities are still lacking. Moreover, the absence of an efficient waste-management model can lead to numerous environmental, social and economic problems, including increased pollution, a decline in citizens' quality of life and higher waste-management costs. The present research can therefore serve as a starting point for developing effective urban-waste-management models in other cities as well. The main research question is: "How can the management of urban waste in the city of Qaemshahr be optimised using population-growth models?"

MATERIALS AND METHODS

The concept of urban-waste management

Urban-waste management refers to the process of collecting, transporting, processing and disposing of the waste generated in cities, encompassing all stages from waste generation to final disposal. Owing to population growth, industrialisation and changing consumption patterns, waste generation has increased dramatically and its management has become a necessity; the improper management of waste can lead to environmental pollution, threats to public health and higher economic costs (Kaza et al., 2018). Urban waste includes various types of material household, industrial, hazardous and medical each requiring specific management methods such as recycling, composting, incineration and landfilling. Recycling, for example, can help to reduce the volume of waste and conserve natural resources; research has shown that the use of new technologies and management approaches can help to optimise waste-management processes (Brown & Green, 2022). Population growth refers to changes in the population of a given area over time, arising from factors such as births, deaths and migration. Understanding these changes helps urban managers to design effective waste-management programmes and improve citizens' quality of life. Population growth, especially in large cities, can place considerable pressure on infrastructure and public services, including waste management; as population increases, waste generation naturally increases, which requires special attention to urban planning and resource management. Examining and analysing patterns of population growth can therefore help to identify the needs and challenges of waste management and assist decision-makers in offering effective solutions (Vieira & Matheus, 2021).

Dimensions of urban-waste management

Urban-waste management comprises three main dimensions. The environmental dimension concerns the effects of waste on air, soil and groundwater pollution; unmanaged waste can lead to environmental pollution and negatively affect ecosystems, so that implementing proper management programmes can help to reduce these negative effects and safeguard community health. The social dimension refers to the social effects of waste management on the community and on citizens' quality of life; effective interaction between citizens and waste management can increase public awareness and cooperation, and educational and cultural programmes can raise people's awareness of the importance of waste management and correct disposal methods. The economic dimension concerns the costs associated with the collection, processing and disposal of waste, which can affect city budgets; optimising these processes can reduce public costs and increase urban revenues, and effective waste management can create new economic opportunities, such as jobs in the recycling and waste-management industry (Miller & Smith, 2023). Several key theories and models exist for the effective management of urban waste. Sustainable-development theory emphasises the need to balance economic, social and environmental needs and can serve as a basis for waste management aimed at protecting the environment and improving citizens' quality of life; sustainable development means meeting the needs of the present generation without compromising the ability of future generations to meet their own needs. The life-cycle model analyses the complete cycle of a product from production to waste disposal and can help to identify weaknesses and optimise processes by evaluating the environmental effects of each stage of a product's life. The integrated-waste-management model emphasises coordination among the different parts of waste management collection, processing and disposal and can improve efficiency and reduce costs by examining all stages in an integrated, coordinated way (Kaza et al., 2018).

Research background

Among domestic studies, Aghaei et al. (2023) assessed the quality of water resources around the municipal-waste landfill of Langroud and found that water turbidity in all samples exceeded the desirable level, underscoring the importance of proper waste management and its effect on water resources (Aghaei et al., 2023). Heydari Hamaneh (2023) examined the role of women in the source-separation of dry municipal waste and found a relationship between socio-economic status and the history of urbanisation on the one hand and dry-waste-separation management on the other, identifying increased publicity as a main driver of participation (Heydari Hamaneh, 2023). Rakhshaninasab and Safari (2022), in a study on the strategic planning of waste management based on the urban-growth overflow of Zahedan, introduced government cooperation and support as the most important strategy in allocating credits (Rakhshaninasab & Safari, 2022). Valizadeh and Shokri (2021) examined the application of the Iranian Leopold matrix in assessing the environmental impacts of waste-management options in Birjand and introduced the construction of a composting plant as the most rational option (Valizadeh & Shokri, 2021). Pouramraei et al. (2020) addressed the siting of the municipal-solid-waste landfill of Kuhdasht using a combined ANP–WLC model and identified factors such as population increase and changes in dietary habits as effective in raising the volume of generated waste, finding that only 19% of the study area was suitable for waste landfilling (Pouramraei et al., 2020).

Among international studies, Ayodele et al. (2018) showed that the use of recyclable waste materials can lead to savings in electricity consumption and significant economic benefits in Nigeria, underscoring the importance of recycling and resource management (Ayodele et al., 2018). A life-cycle-assessment study in Rio de Janeiro concluded that the most sustainable strategies focus on the separate collection and recycling of waste, emphasising the need for appropriate infrastructure and increased social awareness (Goulart Coelho & Lang, 2017). A study in São Paulo found that inequality acts as the most important factor in the generation of municipal solid waste (Vieira & Matheus, 2021). Afroz et al. (2020) examined the socio-economic effects on the recycling behaviour of household women in Malaysia and concluded that environmental education and awareness campaigns are essential for improving waste management (Aqel et al., 2020). Moya et al. (2017) examined solid-waste management through a public–private partnership model and introduced this approach as the best method for waste collection and recycling (Moya et al., 2017). Guerrero et al. (2013) examined the challenges of solid-waste management in developing countries and pointed to the various dimensions and the multiple stakeholders in the waste-management system (Guerrero et al., 2013). Building on this body of work, the present research presents a locally grounded, behaviourally oriented model of urban-waste management for the city of Qaemshahr; using a mixed-methods design thematic analysis in the qualitative part and PLS structural equation modelling in the quantitative part it increases the precision and comprehensiveness of the findings and provides a practical framework for advancing the goals of sustainable development in the urban environment.

Methodology

The aim of the present research is to present a model of urban-waste management with attention to population growth in the city of Qaemshahr. Accordingly, the research is applied in terms of purpose, exploratory in terms of the data-collection method, and mixed (qualitative–quantitative) in terms of the nature of the data. In the qualitative part, data were collected through interviews and analysed using thematic analysis; in the quantitative part, a questionnaire and structural equation modelling with the partial-least-squares (PLS) approach were used. The participants in the qualitative part comprised experts, specialists and academics in the fields of management, urban planning and the environment. Sampling was carried out by the non-probability snowball method: the researcher first prepared a list of capable individuals in the relevant fields and then, where they were willing, conducted interviews; when an interviewee introduced another person with expertise relevant to the present research, that person was interviewed as well where necessary. In line with the qualitative-research process, an effort was made to interview diverse groups of experts from the aforementioned disciplines in order to enrich the data and avoid data bias. Sampling and interviewing continued until the adequacy and saturation of the data were reached and the researcher no longer encountered distinct new information; on this basis, the number of participants reached 15 and the interviews lasted between 30 and 60 minutes. To ensure the reliability of the interview results, initial coding was carried out and, after a short interval, the codings were reviewed. Table 1 shows the demographic characteristics of the interviewees in the qualitative part. (Tab. 1)

In the quantitative part, the sample size was determined using Cochran's formula for large populations and set at 384 citizens of Qaemshahr, selected by convenience sampling; a researcher-made questionnaire measured on a five-point Likert scale was used, and the measurement and structural models were evaluated using the partial-least-squares (PLS) approach.

Table 1: Demographic characteristics of the interviewees (qualitative part).

No.	Indicator	Level	Count	%
1	Gender	Female	5	33.33
		Male	10	66.67
2	Age	35–40 years	4	26.67
		41–45 years	5	33.33
		46–50 years	3	20.00
		Over 51 years	3	20.00
3	Education	Bachelor's	1	6.67
		Master's	6	40.00
		Doctorate	8	53.33
4	Experience	10–15 years	3	20.00
		16–20 years	6	40.00
		21–25 years	4	26.67
		Over 26 years	2	13.33

FINDINGS AND DISCUSSION

Qualitative findings (thematic analysis)

As noted in the methodology, interviews and thematic analysis were used to collect and analyse the qualitative data. After reviewing the relevant literature, a framework was developed for designing the interview questions, and 15 experts and specialists in waste management and urban planning were interviewed. In the second phase, the interviews were coded using Braun and Clarke's (2006) six-phase inductive thematic-analysis approach. In the familiarisation phase, the verbal evidence identified from the interview transcripts was labelled with 48 initial codes; the initial codes were then classified into sub-themes and, finally, organised under the main theme. Figure 1 shows an example of the familiarisation and labelling of the data (Braun & Clarke, 2006). (Fig. 1)

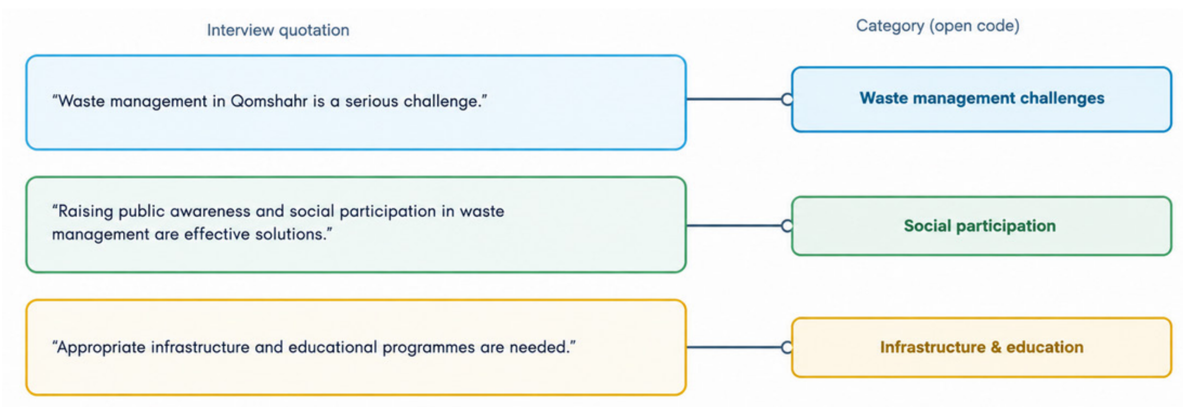

Figure 1: Example of the data-familiarisation and labelling process.

Next, the initial codes were examined, and codes that were close in meaning and concept (i.e., that had semantic affinity) were grouped together, with the researcher creating new meanings and terms; in effect, the codes were classified into sub-themes. Table 2 presents an example of how the initial codes were classified to form a sub-theme. (Tab. 2)

Table 2: Example of classifying the initial codes to form a sub-theme.

Sub-theme	Initial coding	Sample of verbal evidence from the interviews
Effective waste management	Identifying consumption patterns	"Identifying consumption patterns helps us know which products are consumed most and what waste results. e.g., our surveys showed a sharp rise in household plastic use."
	Developing waste-management infrastructure	"Effective management needs up-to-date, efficient infrastructure; recycling stations across the city can aid waste separation and cut landfilled volume."
	Raising public awareness	"Educational campaigns in schools and neighbourhoods can raise public awareness; people must learn how to separate their waste correctly."
	Social participation	"Encouraging citizens to cooperate is effective.e.g., forming local groups for waste separation and collection and building shared responsibility."
	Use of new technologies	"Smart apps and sensors can improve processes reminding citizens when to set out waste and helping to identify and separate waste."
	Creating economic incentives	"Financial incentives and discounts for households that separate or reduce waste can strongly motivate participation."
	Regulating laws and regulations	"Strict, seriously enforced rules and monitoring of waste separation can markedly improve the situation."

As Table 2 shows, the components of identifying consumption patterns, developing waste-management infrastructure, raising public awareness, social participation, the use of new technologies, creating economic incentives, and regulating laws and regulations were grouped under the main theme "effective waste management." The final results of this classification (a summary of the thematic analysis) are presented in Table 3 and depicted in the thematic model in Figure 2. (Tab. 3)

Table 3: Summary of the thematic-analysis results.

Main theme (dimension)	Sub-theme (component)	Initial codes
Effective waste management	Identifying consumption patterns	identifying consumption habits; identifying waste-generation patterns; analysing plastic-product consumption; examining the effect of advertising on consumer behaviour; identifying peak-consumption times; assessing unnecessary purchasing behaviour
	Developing waste-management infrastructure	need for appropriate infrastructure; updating recycling equipment and sites; creating separation stations across the city; funding infrastructure development; improving waste-storage conditions; using new collection technologies
	Raising public awareness	running educational campaigns; school programmes; distributing educational brochures; adult workshops; using social media for outreach

Effective waste	Social participation	encouraging cooperation; forming local groups; volunteer collection programmes; separation contests; citizen support networks
	management	smart apps; new technologies; sensor-based waste identification; waste-management software; smart systems at collection stations
	Creating economic incentives	rewards for separation; lower waste-management costs; recycling incentive schemes; financial discounts for participating households; incentives to reduce generation
	Regulating laws and regulations	strict rules; serious enforcement of recycling laws; monitoring by responsible bodies; fines for non-compliance; protective rules for hazardous waste

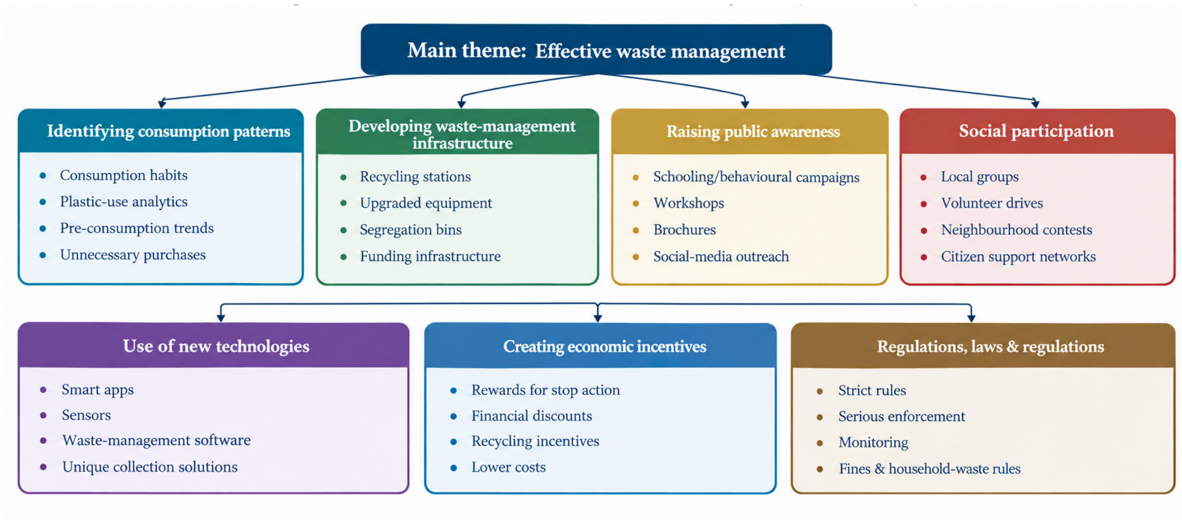

Figure 2: Thematic model of effective urban-waste management in Qaemshahr.

Validation of the research model (PLS-SEM)

In this section, the measurement (outer) model and the structural (inner) model were evaluated using the partial-least-squares (PLS) approach. The distribution of the sample (384 respondents) showed that 322 respondents were men (84%) and 62 were women (16%). By age, 223 respondents (58%) were 35–40 years old, 138 (36%) were 41–45, and 23 (6%) were over 46. By education, 180 respondents (47%) held a bachelor's degree, 169 (44%) a master's and 35 (9%) a doctorate. By work experience (academic teaching, managerial or executive), 100 respondents (26%) had 5–10 years, 165 (43%) had 10–20 years, 108 (28%) had 20–30 years, and 11 (3%) had over 30 years. Table 4 presents the demographic characteristics of the quantitative sample. (Tab. 4)

Table 4: Demographic characteristics of the respondents (quantitative part)

Variable	Level	Frequency	%
Gender	Male	322	84
	Female	62	16
Age	35–40 years	223	58
	41–45 years	138	36
	Over 46 years	23	6

Work experience	5–10 years	100	26
	10–20 years	165	43
	20–30 years	108	28
	Over 30 years	11	3
Education	Bachelor's	180	47
	Master's	169	44
	Doctorate	35	9

Table 5 reports the composite reliability and convergent validity of the measurement models. All variables had composite reliability above 0.7 indicating high internal consistency with the highest value for "social participation" (0.88). The average variance extracted (AVE) values were all above 0.5, confirming acceptable convergent validity, with the highest for "raising public awareness" (0.70). Overall, the measurement models possess good reliability and validity. (Tab. 5)

Table 5: Fit of the measurement models

Variable	Composite reliability ($\alpha > 0.7$)	Convergent validity (AVE > 0.5)
Identifying consumption patterns	0.85	0.65
Developing waste-management infrastructure	0.78	0.58
Raising public awareness	0.82	0.70
Social participation	0.88	0.72
Use of new technologies	0.80	0.66
Creating economic incentives	0.79	0.60
Regulating laws and regulations	0.84	0.68

Table 6 presents the results of the structural model. All paths were positive and statistically significant ($T > 1.96$, $p < 0.05$). The path "developing waste-management infrastructure" had the strongest effect on waste management ($\beta = 0.40$), followed by "identifying consumption patterns" ($\beta = 0.35$) and "regulating laws and regulations" ($\beta = 0.32$). The low standard errors (e.g., 0.03 for "use of new technologies") indicate the stability and reliability of the results, and the high T-statistics (all above 4.0) confirm the strong significance of these effects. Figure 3 depicts the structural model with the standardised path coefficients. (Tab. 6, Fig. 3)

Table 6: Results of the structural-model estimation.

Path	Path coeff.	Std. error	T-statistic	p-value
Identifying consumption patterns → waste management	0.35	0.05	7.00	0.000
Developing waste-management infrastructure → waste management	0.40	0.06	6.67	0.000
Raising public awareness → waste management	0.25	0.04	6.25	0.000
Social participation → waste management	0.30	0.05	6.00	0.000
Use of new technologies → waste management	0.20	0.03	5.50	0.000
Creating economic incentives → waste management	0.15	0.04	4.00	0.001
Regulating laws and regulations → waste management	0.32	0.05	6.80	0.000

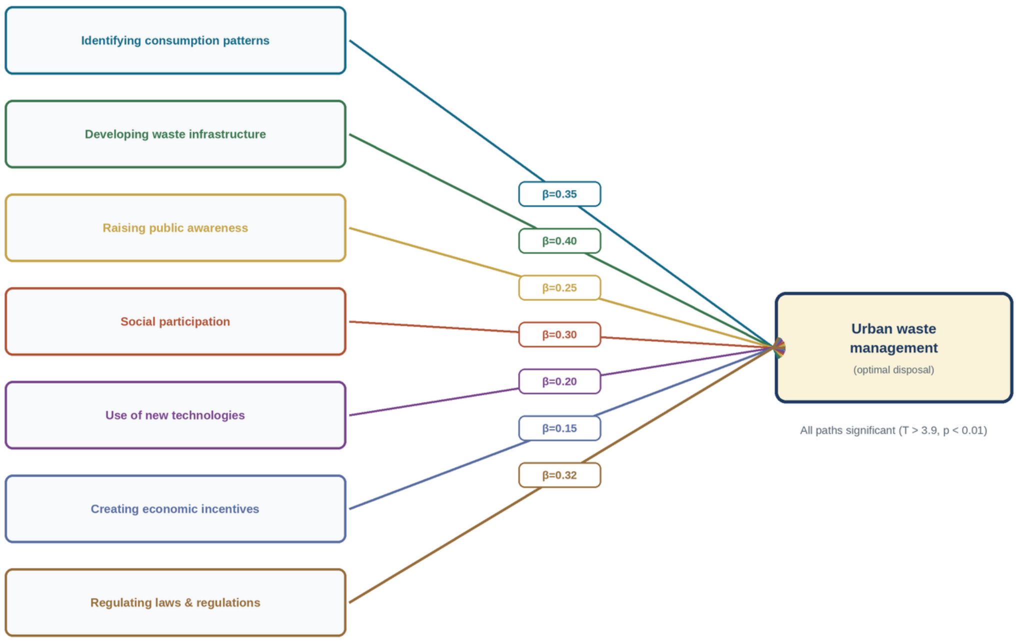

Figure 3: Structural (PLS-SEM) model with standardised path coefficients (* $p < 0.01$).

RESULTS AND CONCLUSION

Urban-waste management, as one of the important challenges of the present era—especially in developing cities requires attention and new, scientific approaches. The present study aimed to present a comprehensive model for optimising waste management in Qaemshahr. The results showed a direct, significant relationship between population growth and waste generation: as the population increases, the volume of generated waste increases significantly, making the design and implementation of effective waste-management models more necessary than ever. The proposed model comprised the dimensions of identifying consumption patterns, developing waste-management infrastructure, raising public awareness, social participation, the use of new technologies, creating economic incentives, and regulating laws and regulations. The analyses showed that all these dimensions significantly affect the improvement of waste management; developing waste-management infrastructure, with a path coefficient of 0.40, had the strongest effect, indicating that improving infrastructure can directly enhance the quality of waste management. Raising public awareness and social participation were also key dimensions, and the results showed that running educational campaigns and encouraging citizens to cooperate in waste-management programmes can increase participation and improve consumption behaviour; social participation, with a coefficient of 0.30, had a considerable effect on waste management, indicating the importance of citizen cooperation in the waste-management process. The use of new technologies was also identified as an effective tool for optimising waste management; technologies such as smart apps and smart collection systems can help to identify and separate waste and optimise processes. In addition, creating economic incentives for those who participate in waste separation and management can provide greater motivation for citizens, and the results showed that offering financial rewards and discounts can effectively help to reduce waste generation, indicating that economic approaches should be used alongside social and environmental ones. Finally, the regulation and strict enforcement of waste-management rules was identified as a key factor; the serious implementation of and monitoring of laws can improve the state of waste management in the city. The study thus clearly shows that a comprehensive, multidimensional approach to urban-waste management is essential and can improve environmental conditions and citizens' quality of life. Compared with previous studies—such as Aghaei et al. (2023) on the effect of waste management on water resources, Heydari Hamaneh (2023) on the importance of social participation, and Pouramraei et al. (2020) on landfill siting in relation to population growth the present findings are consistent and, in addition, offer a comprehensive, applicable model that can serve as a template for other cities. As a case study of a single city, the generalisation of the findings to other cities should be done with caution, since demographic, cultural and infrastructural conditions differ. Future research is recommended to test the proposed model in other Iranian cities and to examine the effect of demographic dynamics (birth, death and migration) on waste generation over time using longitudinal data, so that the population-growth dimension of the model can be operationalised more fully; the use of geographic-information-system (GIS) analyses for landfill siting and route optimisation, and comparative studies of the model across cities of different sizes, are also recommended.

REFERENCES

Aghaei, M., et al. (2023). Investigating the quality of water resources around the municipal-waste landfill of Langroud. Journal of Environmental Science and Technology, 25(1), 45–60. [In Persian]

Afroz R, Muhibbullah M, Farhana P, Morshed MN (2020), "Analyzing the intention of the households to drop off mobile phones to the collection boxes: empirical study in Malaysia". Ecofeminism and Climate Change, Vol. 1 No. 1 pp. 3–20, doi: https://doi.org/10.1108/EFCC-03-2020-0004

Ayodele, T. R., Alao, M. A., & Ogunjuyigbe, A. S. O. (2018). Recyclable resources from municipal solid waste: Assessment of its energy, economic and environmental benefits in Nigeria. Resources, Conservation and Recycling, 176, 105903. https://doi.org/10.1016/j.resconrec.2018.03.017

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. Qualitative Research in Psychology, 3(2), 77–101. https://doi.org/10.1191/1478088706qp063oa

Guerrero, L. A., Maas, G., & Hogland, W. (2013). Solid waste management challenges for cities in developing countries. Waste Management, 33(1), 220–232. https://doi.org/10.1016/j.wasman.2012.09.008

Heydari Hamaneh, M. (2023). Evaluating the role of women in the source-separation of dry municipal waste. Journal of Urban Environmental Planning, 6(2), 71–88. [In Persian]

Kaza, S., Yao, L., Bhada-Tata, P., & Van Woerden, F. (2018). What a waste 2.0: A global snapshot of solid waste management to 2050. World Bank. https://doi.org/10.1596/978-1-4648-1329-0

Goulart Coelho & Lange (2017). Applying life cycle assessment to support environmentally sustainable waste management strategies in Brazil. Journal of Cleaner Production, 355, 131763. https://doi.org/10.1016/j.resconrec.2016.09.026

Moya, D., Aldas, C., Jaramillo, D., Jativa, E., & Kaparaju, P. (2017). Waste-to-energy technologies: An opportunity of energy recovery from municipal solid waste using a public–private partnership model. Energy Procedia, 134, 286–295. https://doi.org/10.1016/j.egypro.2017.09.618

Moya, D., Aldás, C., Jaramillo, D., Játiva, E., & Kaparaju, P. (2017). Waste-To-Energy Technologies: an opportunity of energy recovery from Municipal Solid Waste, using Quito - Ecuador as case study. Energy Procedia, 134, 327–336. https://doi.org/10.1016/J.EGYPRO.2017.09.537

Pouramraei, E., et al. (2020). Siting the municipal-solid-waste landfill of Kuhdasht using a combined ANP–WLC model. Journal of Geogra-

phy and Environmental Planning, 31(2), 55–74. [In Persian]

Rakhshaninasab, H., & Safari, M. (2022). Strategic planning of waste management based on the urban-growth overflow of Zahedan. Journal of Urban Research and Planning, 13(1), 33–50. [In Persian]

Valizadeh, S., & Shokri, S. (2021). Application of the Iranian Leopold matrix in assessing the environmental impacts of waste-management options in Birjand. Journal of Environmental Science Studies, 6(4), 233–245. [In Persian]

Vieira, V. H. A. de M., & Matheus, D. R. (2021). The impact of socioeconomic factors on municipal solid waste generation in São Paulo, Brazil. Waste Management & Research, 39(3), 460–469. https://doi.org/10.1177/0734242x17744039

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