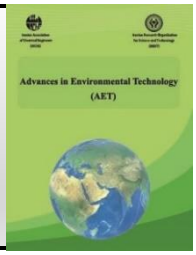
Advances in Environmental Technology 2 (2019) 77-96

Advances in Environmental Technology

Journal homepage: http.aet.irost.ir




# Providing a practical model of the waste management master plan with emphasis on public participation using the SWOT method, the QSPM matrix and the FAHP method

**Farhad Afshar[a], Madjid Abbaspour [b], Akram al-Muluk Lahijanian [c*]**

[a] *Faculty of Natural Resources and Environment, Science and Research Branch, Islamic Azad University, Tehran, Iran*
[b] *Mechanical Engineering Department, School of Mechanical Engineering, Sharif University of Technology Tehran Iran*
[c] *Faculty of Natural Resources and Environment, Science and Research Branch, Islamic Azad University, Tehran, Iran*

**ARTICLE INFO**

*Article history:*
Received 26 December 2019
Received in revised form
23 April 2020
Accepted 4 May 2020

**Keywords:**
Waste management master plan
SWOT
QSPM
FAHP

**ABSTRACT**

The purpose of this study was to present a practical model of strategic waste management via two Strength, Weakness, Opportunity, and Threats (SWOT) models and hierarchical analysis. In this regard, the strengths and weaknesses of the present situation and the factors affecting waste management in Tehran were investigated. In this study, the importance of public participation in waste management was investigated by means of the Delphi method and the Fuzzy Analytic Hierarchy Process (FAHP). Based on the results of the SWOT analysis, a team of experts identified the internal and external factors and rated the primary factors; each factor was weighted, then according to their scores, the proposed waste management framework was developed. Finally, the strategies were quantitatively prioritized by the planning matrix. Then, using the analysis method, the hierarchy was used in this study as a SWOT supplement. The results of two questionnaires designed in this study identified the socio-economic, educational, cultural, and political factors as first to fourth, respectively. The most viable strategies, which were selected based on the analysis, include the potential use of social networks to encourage society to reduce waste and to promote the separation of waste as well as compliance with the proposed comprehensive waste management program; another choice strategy was providing economic incentives to maximize social participation in reducing waste production waste sorting.

## 1. Introduction

According to the topics presented at the Istanbul-Turkey Summit (1996) at the Biomass Summit (Second Habitat), the challenges of municipal waste management and citizen participation are the key issues of urban management, especially in metropolitan development [1-3].For this reason, citing and drawing on the experiences of cities in developed countries is imperative; the appropriate and optimal use of the abilities and talents of citizens in the implementation of participatory programs has always been emphasized. Rapid population growth, industrial development, technological advancement, increased use of disposable plastics, and increasing volumes of waste, especially in urban areas, have added to the complexity of the conditions and manner of waste collection and disposal. Waste production today is one of the challenges of urban and environmental management because waste is a major source of damage. People, regardless of these issues, produce waste in different ways, but if the waste is not properly managed, it will endanger the health of the community [4,5]. Therefore, controlling environmental contaminants such as solid wastes constitutes an important part of this issue, which has a special place in the new sciences and technologies due to health and economic principles and standards [6-9]. The waste produced in Iran includes medical (hospital), agricultural, industrial, ordinary and special waste. According to the Waste Management Act

*Corresponding author.
E-mail address: lahijanian@hotmail.com
DOI: 1022104.aet.2020.399.1200

of 2004, any storage, mixing, collection, transportation, purchase and sale, and disposal of waste must be carried out in accordance with the standards set by the Department of Environment (DOE) in collaboration with the Ministries of Health, Medical and Medical Education, Industry and Mining, Energy, Oil and Agricultural [10-13]. The concept of sustainable development is one of the topics that is considered by many economic, political, cultural, and environmental experts today. Sustainable development meets the needs of the present generation without limiting the ability of the next generation to meet their needs. Obviously, human beings need to use natural resources to meet their needs, but methods such as increasing resource efficiency and using renewable or clean energy can minimize the use of natural resources [14-18]. It is imperative to control and prevent the consequences of the poor management of municipal waste to safeguard the environment, protect the health and safety of citizens, and prevent the loss of national capital [19]. Citizens play a crucial role in improving the health of urban environments and implementing programs [20-22] .Protecting the environment from destruction, as well as helping citizens to maintain a clean city, is an inevitable principle that will neglect these important effects [23,24]. The lack of public participation in the design, implementation, and evaluation of comprehensive waste management programs provides the basis for their failure in urban areas; therefore, the shortcomings should be addressed, and the factors affecting citizens' participation identified [25]. According to a comprehensive study by the World Health Organization, waste and non-waste management may cause 32 environmental problems [26]. Communities in developing countries often turn to waste disposal methods such as open dumping and burning (or unregulated landfills), which have been proven to be destructive to humans and the environment, because they feel they have no other options to manage their solid waste [27-31]. Accordingly, waste management is an important necessity that requires comprehensive scientific and practical investigations with regard to its various dimensions. Participation is the cooperation of knowledgeable, volunteer, creative and committed individuals and groups in decision-making, planning and activity of professional and local or regional associations and organizations on the one hand; and on the other hand, it has a role to play in social and economic decisions and activities and in the political life of society. [32-34]. Marshall, who has presented one of the most prominent theories of partnership, states that partnership is given to all individuals who are full members of their community. They all have appropriate positions, rights, and duties; citizenship rights and duties are guaranteed by law [35]. Today, the motto of all urban sociologists includes the word citizen partnership, that is to say, one's own in city like to participate in lot of urban activity such as environmental, social and; it is in these conditions that one can live better. Undoubtedly, in the realization of the term citizenship, education has a key role in informing society of its rights and the rights of the urban system. However, citizens are considered as social capital in a city, as Krajnik states. Citizenship is a category that needs to be learned, and this happens when appropriate opportunities exist [36]. Some of the most important factors affecting people's participation are awareness, training, and motivation via different motivational tools; however, awareness alone is not effective because long-term awareness has to be achieved by changing attitudes, which in turn changes behavior and action [37-39]. Participation is possible; in traditional teaching methods, people are told what to do, and they follow directions, but in new approaches, people play an active role and even voluntarily participate in decision-making [40,41]. Therefore, it is important to give special attention to public participation in waste management decisions and policies [42,43]. The establishment of a waste management and disposal system is one of the most important issues in controlling the production of waste and its collection. The efficiency of the system should be consistent with health issues, economics, and environmental engineering and planned according to the other general conditions of society. In this regard, the involvement of local communities at the district and city level is of particular importance [44,45].

## 2. Literature review

Karla (2020) investigated community participation and waste management. The study emphasized the role of community in waste management and overviewed the significance of community participation in waste management; it proposed a social capital and integrated waste management model [46]. Noufal et al. (2020) found that waste separation practices were carried out by local communities for economic benefits and had no prior knowledge of its environmental benefits. In addition, residents had to resort to improper methods to remove their waste from residential areas where waste collection services were inadequate and unreliable [47]. Babel et al. (2020) analyzed the challenges of waste management in Thailand and revealed that many issues prevented the proper implementation of a successful waste management system. The lack of awareness and low culture of environmental protection of the local community, as well as weakness in the application of technology at the municipal level, are the main causes of unsuccessful waste management in Thailand. There are also weaknesses in public participation processes, policy implementation, and institutional support [48]. Banerjee and Sarkhel (2020) proposed the creation of an efficient and effective waste management market by separating the cost of waste processing with the participation of households in primary disposal as well as private individuals or NGOs; as well, the needed economic tools should be incorporated. Alongside

this collaborative process, the emphasis is on offering environmental education to local communities to understand the environmental benefits of waste management [49]. Pariatamby et al. (2020) summarized the current state of waste management practices in developing countries in their study. Waste management is thought to be more difficult for developing countries because effective regulations and policies for their proper implementation have not been established. Therefore, there are major issues with inefficient waste collection, free dumping, free burning, and over-reliance on landfills [50]. Zorpas (2020) provided a holistic approach to develop, implement, monitor, and improve a waste management strategy at the local or central level. The proposed method was a useful tool for any policymaker, consultant, expert, urban planner, academic etc. The proposed framework aimed at protecting and enhancing the European Union's natural capital and transforming the European Union into a low-carbon economy with the benefit of economic, green and competitive resources in the near future, taking into account the credibility of the European Green Deal. Some of these strategic frameworks are presented in Figure 1 [51].

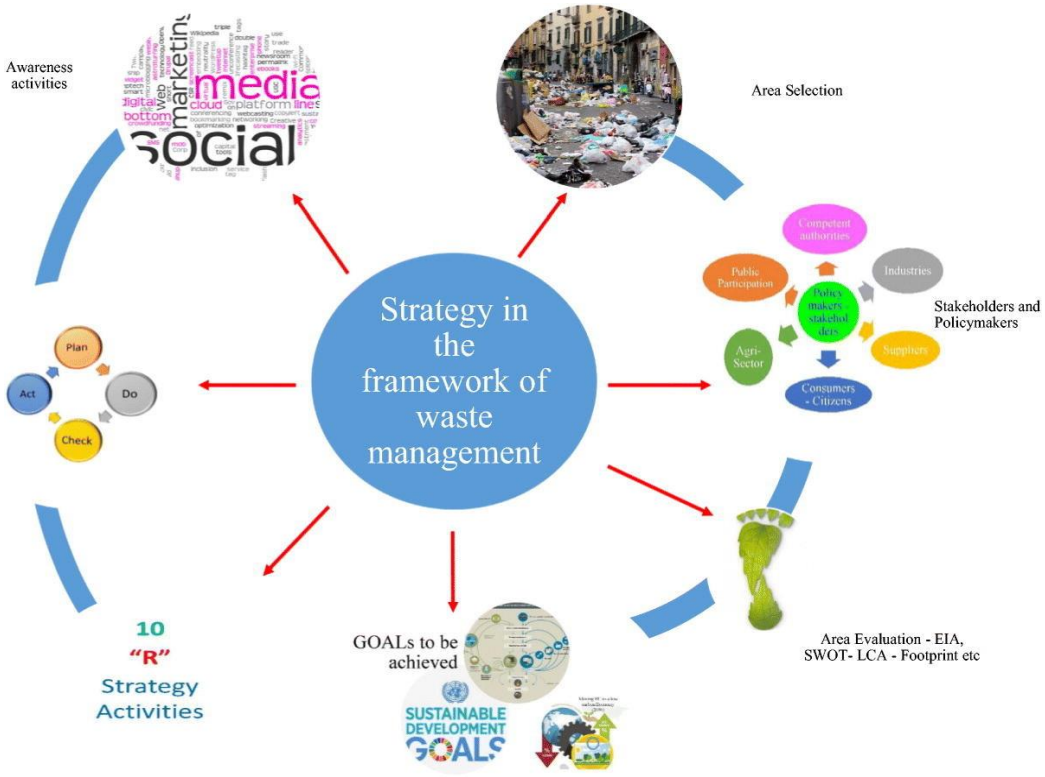



**Fig. 1.** Strategic frameworks of waste management [51].

El Sheltawy (2019) examined the impact of effective public participation without implementing waste management standards and regulations. In this study, stakeholder responsibility, awareness-raising programs, and alternative tools were considered important. The benefits of public participation in the design, implementation, and review of by-laws related to waste management and its implementation were considered [52]. Han et al., (2019), considered the two issues of Widespread and Sustainable People's Pay (WTP) and Willingness to Participate (WTPP) to be the basis of successful internal waste management. They concluded that public WTP and the desire to dispose of waste increased with increasing frequency. Service costs and delivery intervals declined exponentially, but with rising wages, logarithmic growth was expected in the general trend to work [53]. Vassanadumrongdee and Kittipongvises (2018), in their research entitled "Factors influencing source separation intention and willingness to pay for improving waste management in Bangkok, Thailand", extended the theory of planned behavior to explore the effects of both internal and external factors. Their survey highlighted perceived inconvenience and mistrust on Municipal Solid Waste (MSW) collection as being major barriers to carrying out source separation in Bangkok [54]. Xiao et al. (2017) promoted a model which was useful for identifying causal relationships and ranking influencing factors in terms of their importance. The results indicated a waste policy hierarchy in Chinese cities, and future waste management should change from the current legislative-centered strategy. The results can be used to inform decision-makers to find locally effective strategies to improve public participation in waste management per socioeconomic and

cultural conditions in China [42]. Ma et al. (2017) analyzed the analytical results of the status of waste segregation and factors affecting implementation; they made useful suggestions for decision-makers in China and, in general, in industrialized countries to design publicity programs and educational campaigns with the participation of the public [55]. Majlessi et al. (2015), in their study called “Strategic management of solid waste in Tehran: A case study in District No. 1” indicated that the evaluation matrix of internal and external factors in the city of Tehran for waste management had weak internal factors. Meanwhile, evaluation points of external factors showed that in the current situation, SWOT could achieve good results. Waste management systems involve different multi-disciplinary factors; therefore, trends in the development of waste treatment technologies have been led by various social, economic, and environmental drivers in Tehran [56]. Al-Khatib et al. (2015) focused on the educational gap, and their results revealed interesting trends in a significant relationship between the respondents’ educational attainment and their awareness of hazardous waste (hazard perception); the results indicated the measures required to avoid accidents occurring in those regions (burns from toxins, cuts from sharp objects, etc.). National policy and legislation based on the research outcomes will ensure that equitable and accessible services are in place in order to move towards a healthier environment [57]. Tarawneh and Saidan (2013) indicated in their research entitled "Households awareness, behaviors, and willingness to participate in E-waste management in Jordan" that the prevailing public opinion (more than 90%) showed enthusiasm for managing the E-waste. The prevalent view was that recycling companies and electronics producers.traders must be financially responsible for the E-waste management program [58].

## 3. Materials and methods

This study was conducted in Tehran, with a population of about 8 million people and an area of about 730 km$^2$. Tehran is located in the north and northeast parts of the southern highlands of the central Alborz Mountains; it is bounded on the west by the Savojbolagh Plain and the south by the Ray and Bibi Shahrbanou Mountains and the salt desert plains. So the altitude of different areas of Tehran ranges from 1700 meters in the north to 1000 meters in the south [59]. The city is divided into 22 districts by the municipality of Tehran, with an area of about 730 km2 to optimize the provision of urban management services (Figure 2).

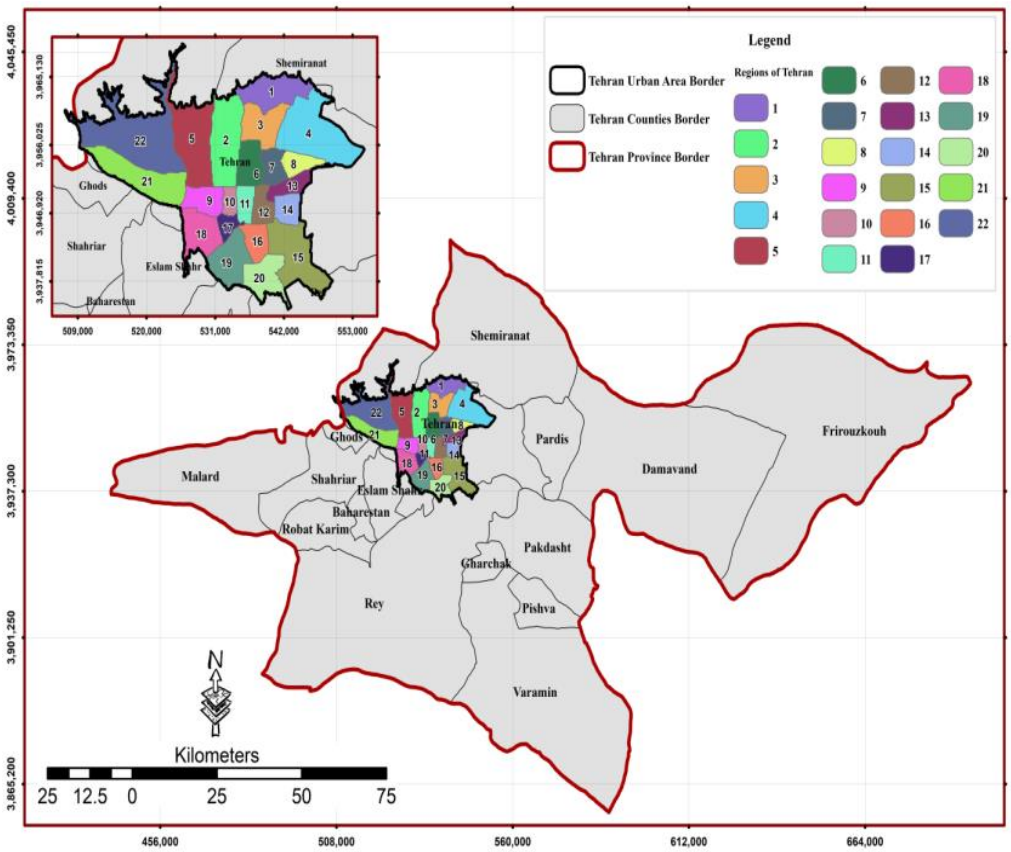



**Fig. 2.** Location map of the research site within the Tehran province.

The general framework of this research for presenting a practical model of waste management with an emphasis on public participation consists of two main parts, as shown in Figure 3.

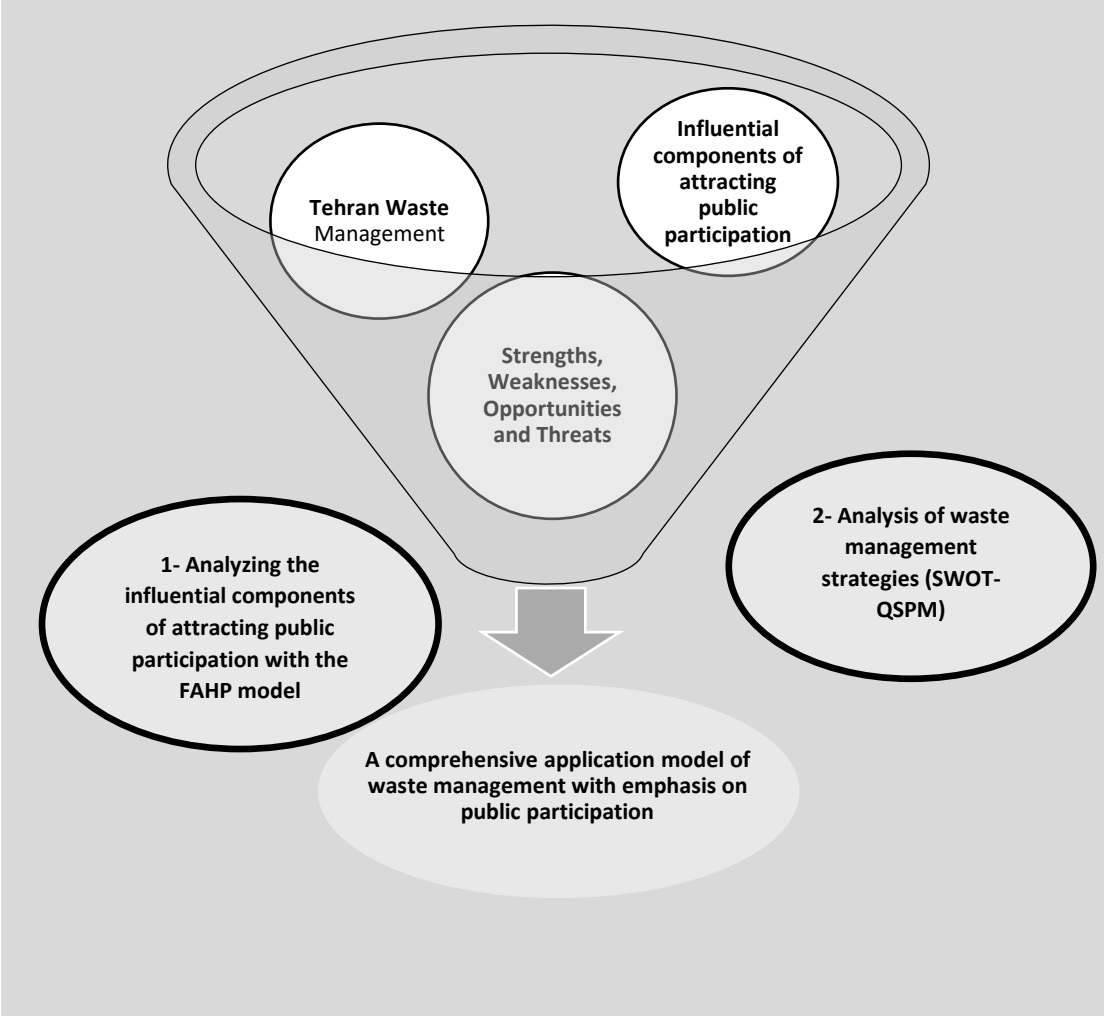



**Fig. 3.** General research framework to present a comprehensive waste management application model with emphasis on public participation.

### *3.1. Framework of component analysis of influential components of FAHP modeling*

In this section, the opinion of 65 experts were used to prioritize the components and factors influencing public participation in reducing the production and separation of waste via two different types of questionnaires. To perform these pairwise comparisons based on an hourly scale (Table 1), after obtaining expert opinion points based on Questionnaire No.2 and analyzing expert opinions based on consensus frequency equal to or greater than 50%, the final list of components and relevant factors were identified [60-64].

**Table 1.** The verbal scale and their corresponding numerical values based on the hourly scale [65].

| Verbal scale | Not important | Minor important | A little important | A little important to important | Important | Important to very important | Very important | Very important to important | Quite important |
|---|---|---|---|---|---|---|---|---|---|
| Corresponding Numbers | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |

Following the "hourly scale" and applying FAHP techniques developed by Chang, the steps (1-7) are as follows, indicated:

Step 1: Draw hierarchical diagrams (Note that the hierarchical diagrams are computed to compare the level of the elements relative to each other, so that the relative

importance of the elements is expressed using fuzzy numbers).

Step 2: Define fuzzy numbers for paired comparisons (Figure 4).

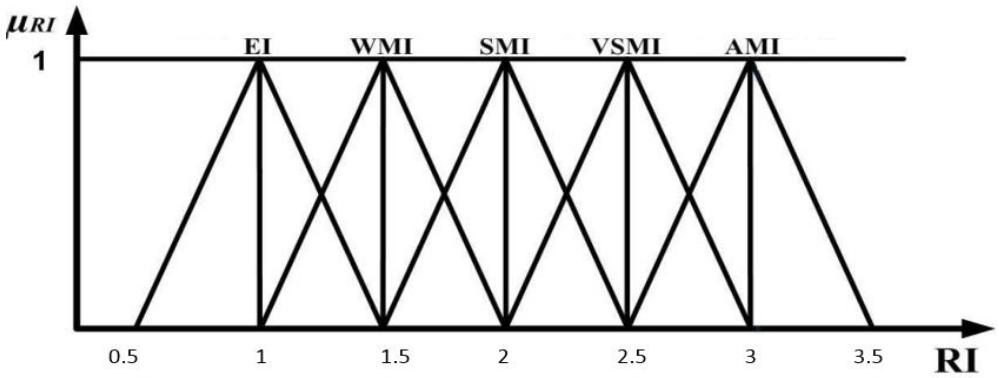



**Fig. 4.** Expressing the degree of fuzzy relevance based on linguistic scales.

Since the FAHP technique was used in this study to increase the certainty of the results, the fuzzy numerical results of each of the components, criteria, sub-criteria, and indices based on the scaling method are presented in the result

$$\tilde{D} = \begin{bmatrix} 1 & \tilde{x}_{12} & \cdots & \tilde{x}_{1n} \\ \tilde{x}_{21} & 1 & \dots & \tilde{x}_{2n} \\ \vdots & \vdots & \cdots & \vdots \\ \tilde{x}_{n1} & \tilde{x}_{n2} & \dots & 1 \end{bmatrix} \quad (1)$$

[66]. Also the fuzzy pair comparison matrix of components based on the fuzzy triangle method is presented in Table 2. It is necessary to explain that in cases where multiple decision-makers are used in the decision making, the elements of the comprehensive pairwise comparison matrix used in the fuzzy hierarchical analysis method must be a triangular fuzzy number. So that from left to right, the first component is the minimum scale or spectral number of polls, the second component is the average poll, and the third component is the maximum poll.

Step 3: Formulate a pairwise comparison matrix using fuzzy numbers (Equation 1).

**Table 2**. Numeric values based on the Chang FAHP's model [67].

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|
| 1,1,1 | 1,2,3 | 2,3,4 | 3,4,5 | 4,5,6 | 5,6,7 | 6,7,8 | 7,8,9 | 8,9,9 |
| L,M,U | L,M,U | L,M,U | L,M,U | L,M,U | L,M,U | L,M,U | L,M,U | L,M,U |
| Not important | Minor important | A little important | A little important to important | important | important to very important | very important | very important to important | Quite important |

L: low level, M: middle, U: high level

Step 4. Calculate Si for each of the matrix rows of a pair that is itself a triangular fuzzy number and is calculated from Equation (2):

$$\sum_{j=1}^{m} M_{gi}^{j} \otimes \left[\sum_{i=1}^{n}\sum_{j=1}^{m} M_{gi}^{j}\right]^{-1} \quad (2)$$

In this respect, **i** represents the row number and **j** represents the column number, $M_{gi}^{j}$, where the triangular are fuzzy numbers of the pairwise comparison matrices. The following equations are used to calculate other values (3, 4, 5):

$$\sum_{j=1}^{m} M_{gi}^{j} = \left(\sum_{j=1}^{m} l_j, \sum_{j=1}^{m} m_j, \sum_{j=1}^{m} u_j\right) \quad (3)$$

$$\sum_{i=1}^{n}\sum_{j=1}^{m} M_{gi}^{j} = \left(\sum_{i=1}^{n} l_i, \sum_{i=1}^{n} m_i, \sum_{i=1}^{n} u_i\right) \quad (4)$$

$$\left[\sum_{i=1}^{n}\sum_{j=1}^{m} M_{gi}^{j}\right]^{-1} = \left(\frac{1}{\sum_{i=1}^{n} u_i}, \frac{1}{\sum_{i=1}^{n} m_i}, \frac{1}{\sum_{i=1}^{n} l_i}\right) \quad (5)$$

In the above equations li, mi, and ui are the first to third components of fuzzy numbers, respectively.

Step 5: Calculate the degree of Si, relative to each other.

In general, if M1 = (l1, m1, u1) and M2 = (l2, m2, u2) are two triangular fuzzy numbers, according to Figure 5, the magnitude of M1 relative to M2 is defined as follows (Equation 6).

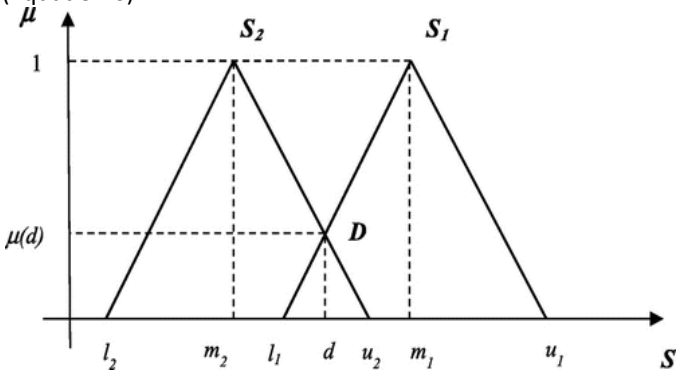



**Fig. 5.** Si degree of magnitude relative to each other.

$$V(M_2 \geq M_1)=hgr(M_1 \cap M_2)=\mu_{M_2}(d) = M1, M2 \quad (6)$$

On the other hand, the magnitude of one triangular fuzzy number from K to another triangular fuzzy number is obtained from the following relation (Equation 7,8):

$$V(M \geq M_1, M_2, \dots, M_k)= V[(M \geq M1) \text{and} (M \geq M2) \text{ and } \dots (M \geq Mk)] = \text{Min } V(M \geq Mi) i = 1,2, \dots, k \quad (7)$$

$$V(M \geq M_1, M_2, \dots, M_k)= V[(M \geq M1) \text{and} (M \geq M2) \text{ and } \dots (M \geq Mk)] = \text{Min } V(M \geq Mi) i = 1,2, \dots, k \quad (8)$$

Step 6: Calculate weight of criteria and options in paired comparison matrices. The following equation is used for this purpose (Equation 9):

$$d' (D_i)= \text{Min } V (S_i \geq Sk) \; K= 1,2,3,\dots,n \quad , \quad k \neq i \quad (9)$$

So the unweighted weight vector is as follows (Equation 10):

$$W'=( d' (D1 ), d' (D2 ),\dots , d' (Dn ))T \quad Di \; (i=1,2, \dots,n) \quad (10)$$

Step 7: Calculate the final weight vector.
To calculate the final weight vector, the weight calculated in the previous step should be normalized as follows (Equations 11,12).

$$W=( d (D1 ), d (D2 ),\dots , d (Dn ))T \quad (11)$$

$$W'=( d' (D1 ), d' (D2 ),\dots , d' (Dn ))T \quad Di \; (i=1,2, \dots,n) \quad (12)$$

Accordingly, they are ranked after the final weights of the criteria or sub-criteria have been determined.

### *3.2. Research framework in analyzing waste management strategies*

In short, a SWOT analysis technique is a system that systematically analyzes each of the strengths, weaknesses, opportunities, and threats, and reflects strategies appropriate to the situation [65-74]. In this method, after listing each of the factors of strengths, weaknesses, opportunities, and threats and writing them in their respective cells according to weighted order, each of their strategies will be derived from the intersection. Therefore, this matrix always generates four ST, WT, WO, SO strategies [30,65,74]. After identifying the strengths and weaknesses of the organization, as well as their opportunities and threats, specific management strategies are presented. The SWOT technique or model is one of the strategic tools for adapting intra-system strengths and weaknesses to opportunities and threats [75,76]. The SWOT model provides a systematic analysis for identifying these factors and selecting the strategy that best fits them. From this point of view, an appropriate strategy maximizes the strengths and opportunities and minimizes the weaknesses and threats. To this end, the strengths.weaknesses and opportunities.threats are linked in four general modes (SO, WO, ST and WT), and strategic options are selected [30,74]. This section uses the advice of 70 experts. The summary of the SWOT process in this study is as follows:

A) Implementation of matrix construction of Strengths, Weaknesses, Opportunities and Threats

- Provide a list of the major opportunities that exist in the organization's external environment.
- Provide a list of major threats to the environment.
- Provide a list of internal and major strengths.
- Provide a list of major internal weaknesses.
- Comparison of internal strengths and external opportunities and determination of SO strategies.
- Comparing internal weaknesses and external opportunities and identifying WO strategies.
- Compare internal strengths with external threats and identify ST strategies.
- Comparing internal weaknesses with external threats and identifying WT strategies.

B) Evaluate internal and external strategic factors

Not all intrinsic and extrinsic factors are of equal importance, so it is necessary to evaluate all of these factors and identify the most important and more important factors to prioritize them. The IFE and EFE matrices are used to evaluate internal and external strategic factors [30,74].

B-1) Preparation of Internal Factors Evaluation Matrix (IFE).

Intuitive judgments and expert opinion polls can be used to prepare the internal factors evaluation matrix, which are as follows:

- Provide a list of identified internal factors, identified strengths and weaknesses.
- Assign a weighting coefficient between zero (unimportant) to one (very important) to any factor, criterion, or index whose sum of these points must be equal to one.
- Calculate the "status quo for internal factors" based on a score of 1 to 4 according to the following criteria:

If the strengths facing an organization are excellent, it receives 4 points, a normal strength gets 3 points, a typical weakness is 2 points, and a critical weakness score has 1 point.

Therefore, the scoring process in the internal and external factor evaluation matrices is such that the more the exceptional opportunity, the more serious the threat, and the lower the score, with the lower score from 4 to 1.

B-2) Preparation of External Factors Evaluation Matrix (EFE) as follows:

- Provide a list of identified internal factors, strengths, and weaknesses.
- Assign a weighting coefficient between zero (unimportant) to one (very important) to any factor, criterion, or index whose sum of these points must be equal to one.
- Calculate the "Status Score for External Factors" based on a score assignment of 1 to 4 according to the following criteria:

If the opportunities facing the organization are an exceptional opportunity, they receive a score of 4, a typical

opportunity gets a score of 3, a common threat receives a score of 2, and a serious threat is a score of 1. The weighted score of each factor or criterion and index must be calculated. For this purpose, the score of each row of the intrinsic factors influencing the region is multiplied by its normalized weight. It is inserted in the table of the EFE matrix. It should be noted that once the IFE and EFE tables are completed, the strategies table is drawn. This table compares internal and external factors and develops strategies to strengthen the weaknesses and eliminate the threats, as well as strategies to strengthen the strengths using opportunities. In the last step, Quantitative Strategic Planning Matrices (QSPM) is used to prioritize strategies [30,77].

C) QSPM matrix formation

In the QSPM matrix, the information obtained at various stages of strategic management and planning is used. The steps of forming a QSPM matrix are as follows:

- Introduce internal strategic external factors including all threats and opportunities and strategic factors using the contents of the IFE and EFE matrices in the first column of the matrix.
- Insert the weighted score of each strategic factor using the contents of the IFE and EFE matrices into the second column of the matrix.
- Include all the strategies included in the SWOT matrix (including the four WO, ST, WT, and SO strategies) in the subsequent columns of the matrix, respectively.
- Divide each of the columns related to the different types of strategies into two sub-columns, including the Attractive Scores (AS) column and the Total Attractive Score (TAS) sub-column and complete them [30,74,78]. A summary of the research framework for analyzing waste management strategies is presented in Figure 6.

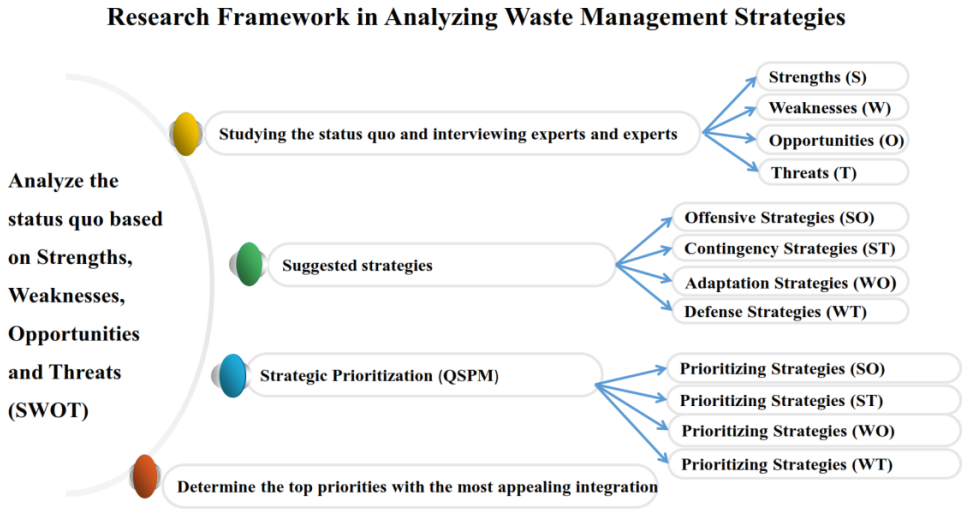



**Fig. 6.** Research Framework in Analyzing Waste Management Strategies.

## 4. Results

According to the latest Tehran Municipal Waste Management Organization statistics, the amount of waste production in Tehran is about 8291 tons per day (equivalent to 3240749 tons per year) [79,80,81]. In the latest results of the physical-chemical analysis of waste composition of the city of Tehran in 2018, it was found that about 62.33% of its waste at the Aradkoh entrance (waste processing and disposal complex) constituted more solid waste. Despite the planning and implementation of a separation plan for the origin of wet and dry waste and the co-operation of many citizens in its implementation, the amount of mixed (dry and wet) waste at the site of production is still considerable, which is shipped daily to and stored within 53,000 mechanized tanks. It is evacuated throughout the city of Tehran. The mixed wastes in these tanks are collected daily by the Utilization Mechanization Fleet and transported to 11 existing regional transfer stations in Tehran. The waste of the11 transfer stations will also be transferred to the Aradkoh Processing and Disposal Complex after the waste is compressed. It is noteworthy that over the past decade, the Tehran Municipal Waste Management Organization has implemented a waste separation plan from the source; it has also implemented various programs and projects across 22 districts.

### *4.1. Results from FAHP*

The results of the screening of the factors and factors affecting the participation of people in the separation of waste origin that are based on questionnaire 2 include:

• ***Social component subscale***: Gender, age, education, and occupation (4 factors).

• ***Economic component***: Forecasting and allocation of necessary financial credit and average monthly income. (2 factors).

• ***Educational and cultural component***: Implementation of educational and cultural programs for different strata to increase the awareness of the environmental impacts of plastic waste, as well as waste management and its different process categories, and making people aware of the effects and benefits of waste sorting and implementation of promotional programs (4 factors).

• ***Rules and regulations component***: Enacting laws in various areas related to the implementation of public participation programs and developing rules for monitoring and evaluating participation programs (2 factors).

The total consists of 4 components and 12 factors.

The results of scoring based on the pair-wise comparison of the components and factors, using a fuzzy hierarchical analysis method or model, were provided by experts collaborating in the screening of the components and factors in the form of questionnaire 3, which used the triangular fuzzy hour scale in Table 2. Obviously, the results of the pairwise comparisons of the effective components for each component are very high, so this is an example of a pairwise comparison of the effective components in separating the waste source with the participation of the people (Table 3).

**Table 3**. Paired Comparison of Effective Components of Separation of Waste Source with Public Participation.

| **9** | **8** | **7** | **6** | **5** | **4** | **3** | **2** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| The Left criterion is more prioritized. | | | | | | | | | The Right criterion is more prioritized. | | | | | | | | Total number of experts | |
| Component | Absolutely more important | intermediate | much more important | intermediate | relatively important | intermediate | slightly more | intermediate | Equally | intermediate | slightly more important | intermediate | relatively | intermediate | much more | intermediate | Absolutely more important | Component |
| A | | | | | | | 3 | 3 | 1 | 1 | 2 | | | | | | B | 65 |
| A | | | | | | | 1 | 1 | 1 | 1 | 3 | 1 | 2 | | | | C | 65 |
| A | | | | | | | 2 | 2 | 2 | 2 | 2 | | | | | | D | 65 |
| B | | | | | | | 1 | 2 | 4 | 1 | 2 | | | | | | C | 65 |
| B | | | | | | | 2 | 2 | 1 | 1 | 1 | 3 | | | | | D | 65 |
| C | | | | | | 2 | 2 | 2 | 1 | 1 | 1 | 1 | | | | | D | 65 |

* A: social, B: Economic, C: Educational and Cultural, D: Laws and Regulations

**Continued Table 3-1.** Fuzzy Pairwise Comparison Matrix Results for Ranking Effective Components in Separation of Waste Source with Participation.

| | **A** | | | **B** | | |
|---|---|---|---|---|---|---|
| **A** | 1 | 1 | 1 | 0.6988 | 1.0915 | 1.5971 |
| **B** | 0.6261 | 0.9162 | 1.4310 | 1 | 1 | 1 |
| **C** | 1.1962 | 1.6438 | 2.1778 | 0.8027 | 1.0414 | 1.3741 |
| **D** | 0.6988 | 1.0000 | 1.4310 | 0.9066 | 1.2671 | 1.8089 |

**Continued Table 3-2.** Fuzzy Pairwise Comparison Matrix Results for Ranking Effective Components in Separation of Waste Source with Participation.

| **C** | | | **D** | | |
|---|---|---|---|---|---|
| 0.4592 | 0.6084 | 0.8360 | 0.6988 | 1.0000 | 1.4310 |
| 0.7277 | 0.9603 | 1.2457 | 0.5528 | 0.7892 | 1.1031 |
| 1 | 1 | 1 | 0.6000 | 24.0000 | 3.0000 |
| 0.0017 | 0.0417 | 1.6667 | 1 | 1 | 1 |

**Continued Table 3-3.** Fuzzy Pairwise Comparison Matrix Results for Ranking Effective Components in Separation of Waste Source with Participation.

| | **The fuzzy sum of each row** | | | **Fuzzy compound expansion** | | |
|---|---|---|---|---|---|---|
| | 2.8568 | 3.6999 | 4.8641 | 0.1237 | 0.2706 | 0.4064 |
| | 2.9067 | 3.6657 | 4.7798 | 0.1258 | 0.2681 | 0.3993 |
| | 3.5990 | 3.0000 | 7.5519 | 0.1558 | 0.2194 | 0.6309 |
| | 2.6071 | 3.3087 | 5.9065 | 0.1128 | 0.2420 | 0.4935 |
| sum | 11.9696 | 13.6743 | 23.1022 | | | |
| | 0.0835 | 0.0731 | 0.0433 | | | |

**Continued Table 3-4.** Fuzzy Pairwise Comparison Matrix Results for Ranking Effective Components in Separation of Waste Source with Participation.

| Components | Ranking | Component weight | Normalization of preferences | Degree of preference | | Preference Degree Si over Sk | |
|---|---|---|---|---|---|---|---|
| A | 1 | 0.261 | 0.2613 | 1.000 | 1.000 | 1.000 | |
| B | 2 | 0.259 | 0.2589 | 0.991 | 1.000 | 1.000 | 0.991 |
| C | 3 | 0.247 | 0.2373 | 0.908 | 0.958 | 0.912 | 0.908 |
| D | 4 | 0.233 | 0.2425 | 0.928 | 1.000 | 0.934 | 0.928 |

* A: Social, B: Economic, C: Educational and Cultural, D: Laws and Regulations

| Incompatibility Rate | |
|---|---|
| CRm | CRg |
| 0.024227 | 0.058787 |

| situation | Compatible |
|---|---|

As can be seen from Table 3-4, the social component with a weight of 0.261 is ranked first and the economic component is ranked second. The incompatibility rate and situation are illustrated with table. The educational-cultural components and the laws and regulations are ranked next.

Taking into account the results of the ranking of each component and the factors related to each of them, the prioritization of the components and factors affecting the separation of the waste source with the participation of the people is described in Table 4.

**Table 4.** Prioritize the components and factors influencing the separation of waste origin with the experts' participation.

| Component | Rating | Relative priority | Factor | Rating | Relative Priority |
|---|---|---|---|---|---|
| Social | 1 | 1.0 | Gender | 1 | 2.7 |
| | | | Age | 2 | 1.1 |
| | | | Level of education | 3 | 1 |
| | | | Job | 4 | - |
| Economical | 2 | 1.0 | Predict and allocate the necessary financial credit | 1 | 1.7 |
| | | | Average monthly income | 2 | - |
| Educational & Cultural | 3 | 1.1 | Run program for promotional | 1 | 1.2 |
| | | | Run the educational and cultural programs for different strata to increase awareness of the benefits of waste separation | 2 | 1.1 |
| | | | Run programs for different strata on increasing awareness of the environmental impact of plastic waste | 3 | 1 |
| | | | Run the educational and cultural programs for different strata to increase awareness of waste management and its process | 4 | - |
| Political | 4 | - | Law enforcement in various fields by implementing public participation programs. | 1 | 2.6 |
| | | | Developing regulations for monitoring and evaluating people's participation. | 2 | - |

### *4.2. Analysis results formulate and prioritize strategies*

#### *4.2.1. Determining SWOT*

In this study, in order to identify strengths, weaknesses, opportunities and threats, it was conducted through surveys and brainstorming sessions with relevant experts and officials. Also, the background of periodic reports and studies were considered in the analysis and evaluation of the final results of the output at this stage of the research. The purpose of this part of the research was to analyze the strengths, weaknesses, opportunities, and threats related to waste management in Tehran via the SWOT technique.

**Table 5**. Internal factor evolution matrix IFE.

| Internal strategic factors | Weight (0-20) | Normalized weight | Status quo (1-4) | Weight points |
|---|---|---|---|---|
| **Strengths** | | | | |
| 1-Preparing the early separation conditions by distributing and installing waste separation tanks in commercial and residential zones. | 17 | 0.07 | 4 | 0.28 |
| 2-Existence of experienced contractors in some districts of Tehran | 16 | 0.07 | 4 | 0.28 |
| 3-Decrease in waste production due to rising costs based on waste statistics | 14 | 0.06 | 3 | 0.18 |
| 4-Implement special education programs separating waste at school for students. | 17 | 0.07 | 4 | 0.28 |
| 5-Use machinery to transport waste | 16 | 0.07 | 3 | 0.21 |
| 6-Raising the awareness of educated people and families about waste separation from the source. | 17 | 0.07 | 4 | 0.28 |
| **Weaknesses** | | | | |
| 1-Lack of expert staffing plan, low staffing efficiency. | 17 | 0.07 | 2 | 0.14 |
| 2-Mixture of wet and dry waste by citizens. | 19 | 0.08 | 1 | 0.08 |
| 3-Citizen unwillingness to keep long term dry waste at home and lack of dry waste collection facilities at local level and timely collection dry waste by waste contractor. | 16 | 0.07 | 2 | 0.14 |
| 4-Lack of allocation of funds and financial resources to carry out the new training and information methods and facilities needed. | 17 | 0.07 | 1 | 0.07 |
| 5-No collision with scavenge | 15 | 0.06 | 2 | 0.12 |
| 6-Lack of proper education and culture | 17 | 0.07 | 2 | 0.14 |
| 7-Failure to provide proper vehicle by recycling contractor | 16 | 0.07 | 2 | 0.14 |
| 8-There is no punitive and incentive | 18 | 0.08 | 2 | 0.16 |
| **Sum** | **232** | **1** | | **2.5** |

**Table 6.** External factor evolution matrix EFE.

| External strategic factors | Weight (0-20) | Normalized weight | Status quo (1-4) | Weight points |
|---|---|---|---|---|
| **Opportunities** | | | | |
| 1-Global experience and smart application usage in waste management | 17 | 0.07 | 3 | 0.21 |
| 2-The potential of cultural center in neighborhoods and municipalities' Shahrbanoo center | 18 | 0.08 | 4 | 0.32 |
| 3-Existence of high level research center and university. | 16 | 0.07 | 3 | 0.21 |
| 4-Powerful and experienced private companies and investors in waste management project | 18 | 0.08 | 4 | 0.32 |
| 5-The economic attractiveness of waste separation for people and social groups such as youth and adolescent. | 15 | 0.06 | 3 | 0.18 |
| 6-Employment and income generation | 18 | 0.08 | 4 | 0.32 |
| 7-Modern methods of environmental advertising and social network to promote recycling culture. | 17 | 0.07 | 4 | 0.28 |
| **Threats** | | | | |
| 1-Lack of public awareness of the waste crisis and its environmental damage | 19 | 0.08 | 1 | 0.08 |
| 2-Presence of floating population in Tehran and waste generation by them | 11 | 0.05 | 2 | 0.10 |
| 3-Lack of legislative planners in enacting deterrent law | 18 | 0.08 | 1 | 0.08 |
| 4-Weak cooperation and lack of confidence to positive result of waste management | 17 | 0.07 | 2 | 0.14 |
| 5- Increasing the scavenge phenomenon | 17 | 0.07 | 1 | 0.07 |
| 6- Increasing unauthorized separation center | 15 | 0.06 | 2 | 0.12 |
| 7-Change the life style and promote the pattern of consumption. | 15 | 0.06 | 2 | 0.12 |
| **Sum** | **231** | **1** | | **2.55** |

### *4.2.2. Determination of Optimal Waste Management System Strategies in Tehran*

According to the results of the research, strategies for a waste management system in Tehran were developed based on the findings and comparisons made between the strengths and weaknesses with the opportunities and threats. Table 7 shows the results of this matching. As it can be seen, eight strategies as SO type, seven strategies as WO type, four strategies as ST type, and three strategies as WT type have been identified.

**Table 7.** Integration of internal and external factors.

| | **Strengths (S)** | **Weaknesses (W)** |
|---|---|---|
| **Strategic strategies** | S1: Prepare initial separation conditions by distributing and installing dedicated waste separation tanks in commercial and residential units commensurate with area population, offices and organizations<br>S2: Existence of experienced contractors in some parts of Tehran<br>S3: Reducing waste generation due to rising costs and based on waste organization statistics<br>S4: Implementing school waste separation training programs for students<br>S5: Using appropriate machinery and equipment to collect and transport waste<br>S6: Increase awareness, educated people and families about waste separation from the source | W1: Lack of staffing, lack of expert and expert staffing, and low staffing efficiency W2: Mixing wet and dry waste by citizens W3: Citizens' unwillingness to store dry waste in the long run. Home and shortage of dry waste collection facilities at local level and lack of timely collection of dry waste by recycling contractors<br>W4: Lack of funding and resources for new training and information, facilities, supplies<br>W5: Lack of control over waste pits W6: Inadequate education of inadequate information to families and lack of proper culture<br>w7: Lack of sufficient vehicles to collect dry waste from recycling contractors<br>w8: Lack of incentive and punitive rules |
| **Opportunities (O)**<br>O1: Smarting up and using the app wastes and startups in waste management<br>O2: Cultural potentials of neighborhoods and municipalities in regions<br>O3: Existence of universities and valuable higher education and research centers<br>O4: Use of private sector Power to Invest in Waste Management Projects<br>O5: Motivate creating economic attraction for people and social groups such as teens and youth<br>O6: Employment and earnings O7: New ways of media and environmental advertising and social networking capabilities in culture maker | **(SO) Strategies**<br>1- Attempts to enforce strict laws regarding the reduction of waste generation primarily and the separation of waste at source by groups, grassroots, NGOs, and universities.<br>2- Using the potential of social networks and urban advertising to encourage the community to reduce waste generation and promote segregation of origin, as well as adhering to waste disposal schedules, etc.<br>3- Applying location information systems to waste collection containers at the regional level to expedite waste collection.<br>4- Use of legal tools to reform production structures and encourage industries to produce less waste products.<br>5- Applying the capabilities of research centers and higher education to provide applications related to waste management.<br>6- Providing economic incentives to maximize citizens' participation in waste generation and separation from dry waste origin (such as annual waste tax reductions, online purchases, book purchases, citizen card recharge, etc.).<br>7- Implementation of the law on waste separation and commitment from all commercial centers for its effective implementation.<br>8-Surveying people and inviting educated people interested in consultative teamwork | **(WO) Strategies**<br>1- Public awareness of citizens on the modification of consumption patterns and their significant effects on reducing environmental costs through social networks and national media.<br>2- Using the potential of cultural centers and holding training courses to educate housewives with the aim of separating waste from dry.<br>3- Develop specialized training courses and courses for waste management staff and contractors, with the help of academic centers.<br>4- Encouraging the private sector to devote part of the proceeds to efficient training and staffing.<br>5- Making the best use of smartphone technology and scheduling traffic information for dry and wet waste collection vehicles to cover poor vehicle and equipment shortages and proper waste management.<br>6- Organize, train, and equip unofficial waste and utilize part of these forces in recycling plants.<br>7- Collaborate with academics to develop study and implementation plans and support top-level implementation plans. |

**Continued Table 7.**

| **Threats (T)** | **(ST) Strategies** | **(WT) Strategies** |
|---|---|---|
| T1: Lack of awareness and awareness of waste crisis and serious environmental damage resulting from it<br>T2: Presence of floating population in Tehran and waste generation by this population.<br>T3: Prohibition of the use of disposable bags and ...<br>T4: Weak cooperation and lack of confidence in the positive results of participation in waste management<br>T5: Increased waste dumping<br>T6: Increase in unauthorized segregation centers<br>T7: Lifestyle change | 1- Educate and inform about environmental crises in schools and target groups.<br>2- Increase the installation of tanks as well as environmental advertising in areas that are receptive to floating populations such as central and emergency areas.<br>3- Obliging citizens and contractors to adhere to timelines to avoid inappropriate landscapes and pollution.<br>4-Disseminate the culture of using recycled products | 1-Low cost creative recreational programs; Entertain in neighborhoods and parks for public culture to learn about the environment.<br>2- Painting festivals for children and adolescents and photography for adults with a focus on waste, urban beauty, and recyclables.<br>3- Introducing dry waste collection kiosks to the public and informing citizens of attractive incentives.<br>4- Demonstrate the economic benefits of less consumption and no waste to households.<br>. |

*4.2.3. Prioritize strategies (QSPM)*

The results of the Quantitative Strategic Planning Matrices (QSPM) indicate that among the strategies drawn, the most attractive include the potential of social networks and urban advertising to encourage the community to reduce waste generation, promote segregation of waste, and adhere to the waste disposal schedule. The least attractive strategy with a score of 9 is collaborating with academics in formulating a waste management study and supporting the top plans. Based on the results of the Strategic Quantitative Matrix, the following strategies in Table 8 can be considered to manage Tehran's municipal waste more effectively.

The order and priority of the strategies are based on their overall weight, respectively; the top ten include:

- Using the potential of social networks to encourage society to reduce waste and promote segregation of origin and compliance with the schedule (SO2).
- Providing economic incentives to maximize citizen participation in lowering waste generation and separating them from the dry waste origin: discounts on annual waste rates, online purchases, book purchases, citizen card charging, etc. (SO6).
- Optimal use of smartphone technology and timing information for dry and wet waste collection vehicles to cover vehicle shortages, equipment, and proper waste collection management (WO5).
- Require citizens and contractors to comply with timelines to prevent inappropriate landscapes and pollution (ST3).
- Public awareness of citizens through social networks and national media regarding the modification of consumption patterns and their important effects on reducing environmental costs (WO1).
- Using the potential of cultural centers and training courses to educate housewives with the aim of separating wet waste from dry waste (WO2).
- Applying the capabilities of research and higher education centers to deliver applications related to waste management (SO5)
- Introducing dry waste collection cabins to the public and informing citizens of attractive incentives (WT3).
- Low-cost creative recreation and entertainment programs in neighborhoods and parks for public environmental awareness (WT1).
- Organize, train, and equip unofficial waste personnel and utilize part of these forces in recycling plants (WO6).

**Table 8**. Prioritize (SO) Strategies.

| | | SO strategies | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Agents** | **Weight** | **Strategy 1** | | **Strategy 2** | | **Strategy 3** | | **Strategy 4** | | **Strategy 5** | | **Strategy 6** | | **Strategy 7** | | **Strategy 8** | |
| | | **AS** | **TAS** | **AS** | **TAS** | **AS** | **TAS** | **AS** | **TAS** | **AS** | **TAS** | **AS** | **TAS** | **AS** | **TAS** | **AS** | **TAS** |
| S1 | 0.28 | 1 | 0.28 | 3 | 0.84 | 2 | 0.56 | 1 | 0.3 | 1 | 0.28 | 4 | 1.12 | 4 | 1.1 | 1 | 0.3 |
| S2 | 0.28 | 1 | 0.28 | 3 | 0.84 | 3 | 0.84 | 2 | 0.6 | 3 | 0.84 | 3 | 0.84 | 2 | 0.6 | 2 | 0.6 |
| S3 | 0.18 | 1 | 0.18 | 2 | 0.36 | 1 | 0.18 | 1 | 0.2 | 1 | 0.18 | 1 | 0.18 | 1 | 0.2 | 1 | 0.2 |
| S4 | 0.28 | 2 | 0.56 | 4 | 1.12 | 2 | 0.56 | 4 | 1.1 | 3 | 0.84 | 2 | 0.56 | 1 | 0.3 | 3 | 0.8 |
| S5 | 0.21 | 1 | 0.21 | 1 | 0.21 | 1 | 0.21 | 1 | 0.2 | 1 | 0.21 | 1 | 0.21 | 1 | 0.2 | 1 | 0.2 |
| S6 | 0.28 | 4 | 1.12 | 4 | 1.12 | 2 | 0.56 | 4 | 1.1 | 4 | 1.12 | 4 | 1.12 | 4 | 1.1 | 4 | 1.1 |
| W1 | 0.14 | 1 | 0.14 | 1 | 0.14 | 1 | 0.14 | 1 | 0.1 | 1 | 0.14 | 1 | 0.14 | 1 | 0.1 | 1 | 0.1 |
| W2 | 0.08 | 1 | 0.08 | 1 | 0.08 | 1 | 0.08 | 1 | 0.1 | 1 | 0.08 | 1 | 0.08 | 1 | 0.1 | 1 | 0.1 |
| W3 | 0.14 | 1 | 0.14 | 1 | 0.14 | 4 | 0.56 | 2 | 0.3 | 2 | 0.28 | 4 | 0.56 | 2 | 0.3 | 1 | 0.1 |
| W4 | 0.07 | 2 | 0.14 | 1 | 0.07 | 1 | 0.07 | 2 | 0.1 | 1 | 0.07 | 1 | 0.07 | 1 | 0.1 | 1 | 0.1 |
| W5 | 0.12 | 1 | 0.12 | 1 | 0.12 | 2 | 0.24 | 1 | 0.1 | 1 | 0.12 | 1 | 0.12 | 1 | 0.1 | 1 | 0.1 |
| W6 | 0.14 | 1 | 0.14 | 1 | 0.14 | 1 | 0.14 | 1 | 0.1 | 1 | 0.14 | 1 | 0.14 | 1 | 0.1 | 1 | 0.1 |
| W7 | 0.14 | 1 | 0.14 | 1 | 0.14 | 1 | 0.14 | 1 | 0.1 | 1 | 0.14 | 1 | 0.14 | 1 | 0.1 | 1 | 0.1 |
| W8 | 0.16 | 4 | 0.64 | 1 | 0.16 | 1 | 0.16 | 1 | 0.2 | 3 | 0.48 | 1 | 0.16 | 1 | 0.2 | 1 | 0.2 |
| O1 | 0.21 | 1 | 0.21 | 2 | 0.42 | 4 | 0.84 | 3 | 0.6 | 4 | 0.84 | 4 | 0.84 | 3 | 0.6 | 4 | 0.8 |
| O2 | 0.32 | 2 | 0.64 | 4 | 1.28 | 1 | 0.32 | 2 | 0.6 | 2 | 0.64 | 3 | 0.96 | 3 | 1 | 4 | 1.3 |
| O3 | 0.21 | 4 | 0.84 | 4 | 0.84 | 4 | 0.84 | 3 | 0.6 | 4 | 0.84 | 2 | 0.42 | 3 | 0.6 | 3 | 0.6 |
| O4 | 0.32 | 2 | 0.64 | 4 | 1.28 | 4 | 1.28 | 1 | 0.3 | 4 | 1.28 | 4 | 1.28 | 4 | 1.3 | 3 | 1 |
| O5 | 0.18 | 1 | 0.18 | 4 | 0.72 | 2 | 0.36 | 1 | 0.2 | 2 | 0.36 | 4 | 0.72 | 4 | 0.7 | 3 | 0.5 |
| O6 | 0.32 | 1 | 0.32 | 4 | 1.28 | 4 | 1.28 | 3 | 1 | 4 | 1.28 | 4 | 1.28 | 3 | 1 | 3 | 1 |
| O7 | 0.28 | 4 | 1.12 | 4 | 1.12 | 3 | 0.84 | 4 | 1.1 | 4 | 1.12 | 4 | 1.12 | 3 | 0.8 | 4 | 1.1 |
| T1 | 0.08 | 1 | 0.08 | 1 | 0.08 | 1 | 0.08 | 1 | 0.1 | 1 | 0.08 | 1 | 0.08 | 1 | 0.1 | 2 | 0.2 |
| T2 | 0.1 | 1 | 0.1 | 1 | 0.1 | 1 | 0.1 | 1 | 0.1 | 1 | 0.1 | 1 | 0.1 | 1 | 0.1 | 1 | 0.1 |
| T3 | 0.08 | 4 | 0.32 | 1 | 0.08 | 1 | 0.08 | 1 | 0.1 | 2 | 0.16 | 1 | 0.08 | 1 | 0.1 | 1 | 0.1 |
| T4 | 0.14 | 1 | 0.14 | 2 | 0.28 | 1 | 0.14 | 1 | 0.1 | 1 | 0.14 | 1 | 0.14 | 1 | 0.1 | 4 | 0.6 |
| T5 | 0.07 | 1 | 0.07 | 1 | 0.07 | 3 | 0.21 | 1 | 0.1 | 1 | 0.07 | 1 | 0.07 | 2 | 0.1 | 1 | 0.1 |
| T6 | 0.12 | 1 | 0.12 | 1 | 0.12 | 1 | 0.12 | 1 | 0.1 | 2 | 0.24 | 3 | 0.36 | 1 | 0.1 | 1 | 0.1 |
| T7 | 0.12 | 1 | 0.12 | 3 | 0.36 | 3 | 0.36 | 1 | 0.1 | 1 | 0.12 | 4 | 0.48 | 4 | 0.5 | 1 | 0.1 |
| sum TAS | | | 9.07 | | 13.5 | | 11.3 | | 9.9 | | 12.2 | | 13.4 | | 12 | | 12 |

*It should be noted that periodization of (WT, WO & ST) strategies.

## 5. Discussions

In general, the WMMP identifies a set of transparent and targeted actions that, through convergence and focus on waste management oversight and enforcement, reduce pressure on the environment, promote public and community health, and create appropriate conditions for development. New technologies can help in the reduction

of waste generation and promotion of the separation of dry waste origin; Its indicators include organizational structure, planning activities, determining responsibilities, defining methods and processes, providing the resources needed to prepare, implement, review and maintain environmental policies; But the important point is that there is a comprehensive waste management program, which needs to investigate and identify the problems, find the root causes of the problems in achieving corrective action, audit and how to implement the plan, to ensure its effective implementation. The results of the research indicate that public participation is one of the most important parts of the WMMP. Neglecting it makes it impossible for the project to be comprehensive and achieve its goals because of the essential role of the citizen participating (not only as beneficiaries of the project but as its inherent partners) at the expected and desired level. Reducing the production of waste and increasing recycling capacity through waste sorting with the involvement of citizens at different levels are among the effective factors in a comprehensive waste management plan. An applied modeling approach is needed to analyze this issue. In other words, it is necessary to implement a comprehensive waste management plan based on the environmental, social, political, economic, and geographical conditions of every city, including the Tehran metropolis, with particular emphasis on citizen participation. According to the results of the FAHP analysis, the conceptual framework for comprehensive waste management focuses on the participation of people in the social, economic, political (legal), and environmental contexts with three goals: design and management, waste generation, and waste management (Figure. 7).

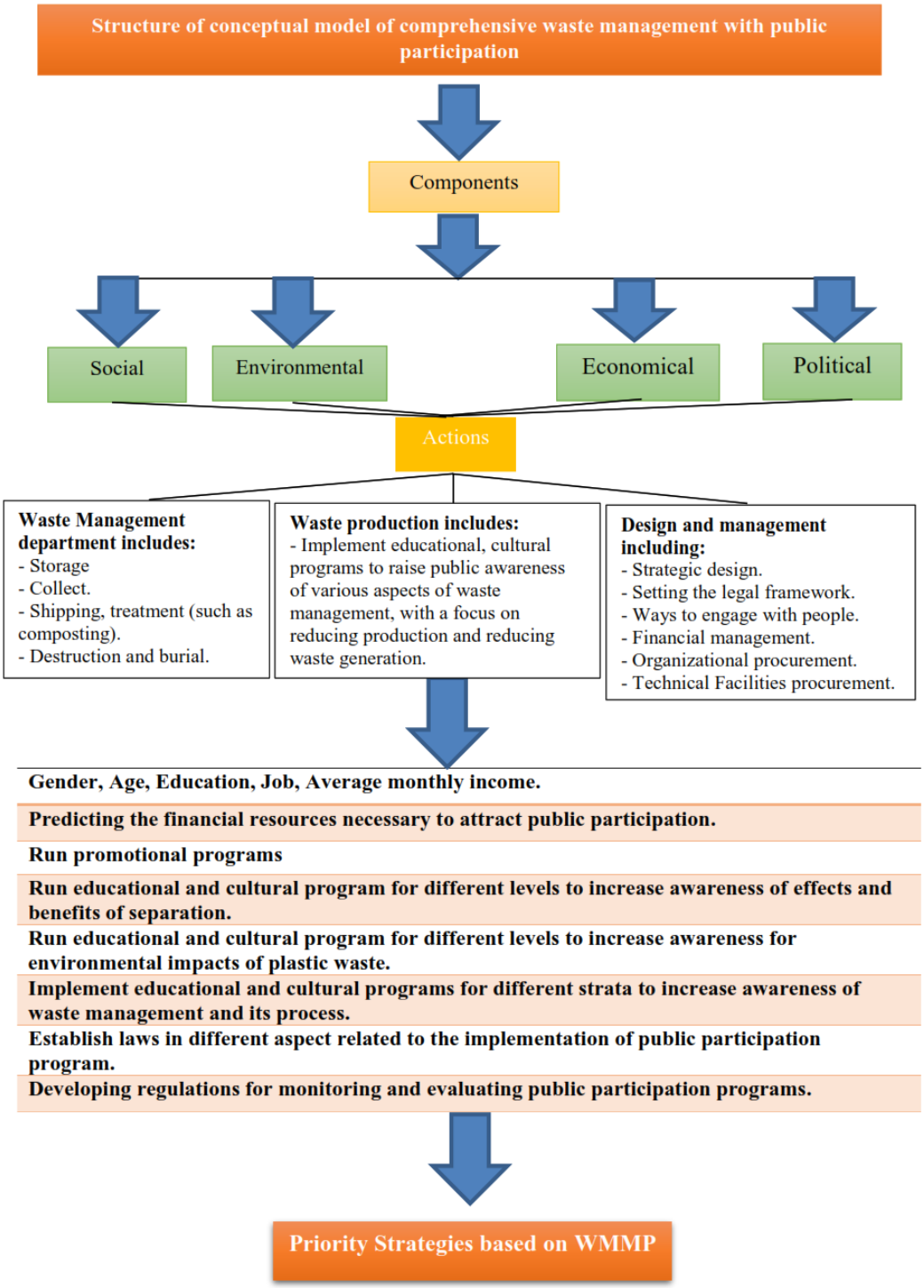



**Fig. 7.** Structure of conceptual model of comprehensive waste management with public participation.

Accordingly, in Figure 8, the conceptual model of the factors affecting public participation in reducing waste production and separating the source of dry waste is presented in relation to the conceptual model of comprehensive municipal waste management. Based on this conceptual model structure in Figure 7, it is possible to extend the conceptual model for each of the processes in the waste management program.

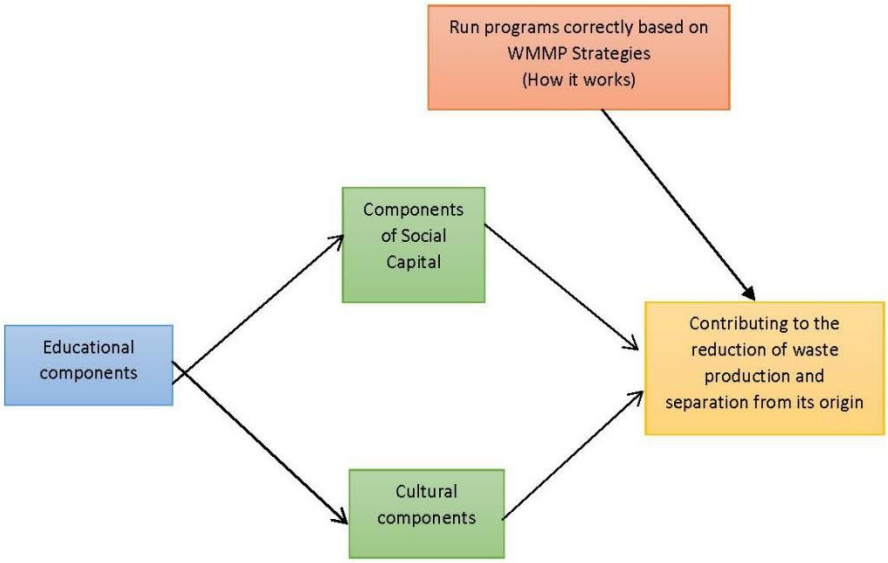



**Fig.8.** Conceptual model of the components of households (citizens) participation in reducing production and increasing the separation of origin

The results of the QSPM indicate that among the strategies drawn, the most attractive is the potential of social networks and urban advertising to encourage the community to reduce waste generation, promote segregation of waste, and adhere to the waste disposal schedule; it received a score of 13.5. Next, with a score of 13.4, is creating economic incentives to maximize citizen participation: discounts on annual solid waste, online purchases, book purchases, citizen card charging, etc. (SO6). The optimal use of smartphone technology and timing information on dry and wet waste collection vehicles, covering vehicle shortage and equipment, and proper waste management (WO5) scored a 13.1 and are among the strategic waste management planning priorities. These strategies show the need for intelligent participation by people in the WMMP and demonstrate a close relationship with the proposed implementation plans derived from the analysis of the influential components of popular participation.

## Conclusions

Waste production in Tehran is about 8291 tons per day (equivalent to 3240749 tons per year) with a per capita of about 800 grams per day, which is a significant volume. As it is clear from these figures, public participation is not at an acceptable level. On the one hand, this indicates the need to address the issue of waste production, and on the other hand, it shows the demand for separation from the source of waste, which cannot be achieved without public participation. This study investigated the strengths and weaknesses of the present situation and the factors affecting waste management in Tehran via SWOT models and hierarchical analysis. The Delphi method and the Fuzzy Analytic Hierarchy Process (FAHP) were used to investigate public participation in waste management. The socio-economic, educational, cultural, and political factors were identified through 2 questionnaires. Our results indicate that the use of social networks and providing economic incentives are the best strategies to promote public participation in waste reduction and waste sorting programs.

## References

[1] Aydın, C. İ. (2019). Identifying Ecological Distribution Conflicts Around the Inter-regional Flow of Energy in Turkey: A Mapping Exercise. *Frontiers in energy research*, *7*, 33.

[2] Ekinci, M., Kul, R., Turan, M., Yildirim, E. (2019). Effects of humic acid applications on mineral content of garden cress roots under heavy metal stress. *International conference on food, agriculture and animal sciences 2019*, 239.

[3] Demirel, N., Zengin, M., Ulman, A. (2020). First Large-Scale Eastern Mediterranean and Black Sea Stock Assessment Reveals a Dramatic Decline. *Frontiers in Marine Science*, *7*, 103,

[4] Kraft, M. E. (2017). *Environmental policy and politics*. Taylor and Francis.

[5] Jackson, G. (2018). *Consumer electronic waste: Multiple-case study of environmental and social attitudes towards recycling and refurbishment* (Doctoral dissertation, Northcentral University).

[6] Mmereki, D., Baldwin, A., Li, B., Liu, M. (2017). Healthcare waste management in Botswana: storage, collection, treatment and disposal system. *Journal of material cycles and waste management*, *19*(1), 351-365.

[7] Boechat, C. L., de Santana Arauco, A. M., Duda, R. M., de Sena, A. F. S., de Souza, M. E. L., Brito, A. C. C. (2017). Solid waste in agricultural soils: an approach based on environmental principles, human health, and food security. *Solid waste management in rural areas*, 81.

[8] Dutta, T., Kim, K. H., Deep, A., Szulejko, J. E., Vellingiri, K., Kumar, S., Yun, S. T. (2018). Recovery of nanomaterials from battery and electronic wastes: A new paradigm of environmental waste management. *Renewable and sustainable energy reviews*, *82*, 3694-3704.

[9] Asibey, M. O., Amponsah, O., Yeboah, V. (2019). Solid waste management in informal urban neighbourhoods. Occupational safety and health practices among tricycle operators in Kumasi, Ghana. *International journal of environmental health research*, *29*(6), 702-717.

[10] Alavi, N., Geravandi, S., Sadri Delik, M., Mohammadi, M. J. (2017). Minimization of Medical Waste in Health Care Centers of Dehdasht, Iran 2012-2013. *Occupational and environmental health*, *3*(2), 137-146 (in Persian).

[11] Abbasi, M., Kamalan, H. R. (2018). Waste management planning in Amirkabir petrochemical complex. *Environmental energy and economic Research*, *2*(1), 63-74.

[12] Vahidi, H., Nematollahi, H., Padash, A., Sadeghi, B., RiyaziNejad, M. (2017). Comparison of rural solid waste management in two central provinces of Iran. *Environmental energy and economic research*, *1*(2), 195-206.

[13] Vahidi, H., Rastikerdar, A. (2018). Evaluation of the life cycle of household waste management scenarios in moderate Iranian cities; case study Sirjan city. *Environmental energy and economic research*, 2(2), 111-121.

[14] Rodić, L., Wilson, D. C. (2017). Resolving governance issues to achieve priority sustainable development goals related to solid waste management in developing countries. *Sustainability*, *9*(3), 404.

[15] Adeniran, A. E., Nubi, A. T., Adelopo, A. O. (2017). Solid waste generation and characterization in the University of Lagos for a sustainable waste management. *Waste management*, *67*, 3-10.

[16] Liu, K. M., Lin, S. H., Hsieh, J. C., Tzeng, G. H. (2018). Improving the food waste composting facilities site selection for sustainable development using a hybrid modified MADM model. *Waste management*, *75*, 44-59.

[17] Pujara, Y., Pathak, P., Sharma, A., Govani, J. (2019). Review on Indian municipal solid waste management practices for reduction of environmental impacts to achieve sustainable development goals. *Journal of environmental management*, *248*, 109238.

[18] Shukla, V., Kumar, N. (Eds.). (2019). *Environmental concerns and sustainable Development: Volume 2: Biodiversity, soil and waste management*. Springer.

[19] Padash, A., Khodaparast, M., Zahirian, A., Nejadian, A. K. (2011, November). Green sustainable island by implementation of environmental; health; safety and energy strategy in KISH trading-Industrial free zones-IRAN. In *world renewable energy congress-Sweden; 8-13 May; 2011; Linköping; Sweden* (No. 057, pp. 3034-3041). Linköping university electronic press.

[20] Vitunskaite, M., He, Y., Brandstetter, T., Janicke, H. (2019). Smart cities and cyber security: Are we there yet? A comparative study on the role of standards, third party risk management and security ownership. *Computers and security*, *83*, 313-331.

[21] Kattoua, M. G., Al-Khatib, I. A., Kontogianni, S. (2019). Barriers on the propagation of household solid waste recycling practices in developing countries: State of Palestine example. *Journal of material cycles and waste management*, *21*(4), 774-785

[22] Rai, R. K., Nepal, M., Khadayat, M. S., Bhardwaj, B. (2019). Improving municipal solid waste collection services in developing countries: a case of Bharatpur Metropolitan city, Nepal. *Sustainability*, *11*(11), 3010.

[23] Johns, R. A., Pontes, R. (2019). Environmental education in India: Constructing environmental citizens through narratives of optimism. *Education research highlights in mathematics, science and technology 2019*, 163.

[24] Bulatović, J., & Rajović, G. (2018). Environmental awareness population in city municipality of Zvezdara (Belgrade)–for the sustainable Zvezdarske forest. *World news of natural sciences*, *16*, 1-17.

[25] Nami, M. (2013). M.Sc., Explaining the effective factors of citizen participation on optimal management of municipal waste (Case study: district 2, district 17 of Tehran municipality).

[26] World Health Organization (WHO). (2017). *Safe management of wastes from health-care activities: a summary* (No. WHO.FWC.WSH.17.05). World Health Organization

[27] Kim, K. H., Kabir, E., Kabir, S. (2015). A review on the human health impact of airborne particulate matter. *Environment international*, *74*, 136-143.

[28] Whitmee, S., Haines, A., Beyrer, C., Boltz, F., Capon, A. G., de Souza Dias, B. F., Horton, R. (2015). Safeguarding human health in the Anthropocene epoch: Report of the Rockefeller foundation–lancet commission on planetary health. *The Lancet*, *386*(10007), 1973-2028.

[29] Padash, A., Jozi, S. A., Nabavi, S. M. B., Dehzad, B. (2016). Stepwise strategic environmental management in marine protected area. *Global journal of environmental science and management*, *2*(1), 49-60.

[30] Padash, A. (2017). Modeling of environmental impact assessment based on RIAM and TOPSIS for desalination and operating units. *Environmental energy and economic research*, *1*(1), 75-88.

[31] Daskal, S., Ayalon, O., Shechter, M. (2019). Closing the loop: The challenges of regulation in municipal solid waste management. *Detritus*, 5, 3-10.

[32] Ozoike-Dennis, P., Spaling, H., Sinclair, A. J., Walker, H. M. (2019). SEA, urban plans and solid waste management in Kenya: participation and learning for sustainable cities. *Journal of environmental assessment policy and management*, 1950018.

[33] Lovan, W. R., Murray, M., Shaffer, R. (2017). *Participatory governance: planning, conflict mediation and public decision-making in civil society*. Routledge.

[34] Fahmy, E. (2017). *Young citizens: young people's involvement in politics and decision making*. Routledge.

[35] Marshall, J. E. (2015). *Skin in the game: Partnership in establishing and maintaining global security and stability*. NDU Press.

[36] Kummitha, R. K. R. (2019). Smart cities and entrepreneurship: An agenda for future research. *Technological forecasting and social change*, *149*, 119763.

[37] Zhao, H. (2018, October). Analysis of factors influencing the cultivation of physical exercise habits of college Students in Tianjin. In *2018 international conference on social science and education reform (ICSSER 2018)*. Atlantis Press.

[38] Raufirad, V., Hunter, R., Khalili, R., Bagheri, S. (2017). Drivers of local people's participation in sustainable natural resource management: A case study in central Iran. *Local environment*, *22*(7), 880-893.

[39] Tong, K. K., Hung, E. P., Lei, C. M., Wu, A. M. (2018). Public awareness and practice of responsible gambling in Macao. *Journal of gambling studies*, *34*(4), 1261-1280.

[40] Kirkman, R., Voulvoulis, N. (2017). The role of public communication in decision making for waste management infrastructure. *Journal of environmental management*, *203*, 640-647.

[41] Chu, Z., Wu, B., He, Z., Zhuang, J., Wang, W. (2019). The policy-making trend analysis of municipal solid waste in China. Waste management & research, 1980–2015.

[42] Xiao, L., Zhang, G., Zhu, Y., & Lin, T. (2017). Promoting public participation in household waste management: A survey based method and case study in Xiamen city, China. *Journal of cleaner production*, *144*, 313-322.

[43] Linzalone, N., Coi, A., Lauriola, P., Luise, D., Pedone, A., Romizi, R., Maurello, M. T. (2017). Participatory health impact assessment used to support decision-making in waste management planning: A replicable experience from Italy. *Waste management*, *59*, 557-566.

[44]Padash, P., Jozi, A. (2007). Local strategy in solid waste management and waste management. *Third National Conference on Waste Management and its Place in Urban Planning*, Tehran, Iran.

[45]Asefi, H., Lim, S. (2017). A novel multi-dimensional modeling approach to integrated municipal solid waste management. *Journal of cleaner production*, *166*, 1131-1143.

[46] Kalra, N. (2020). Community participation and waste management. In s*ustainable waste management: policies and case studies* (pp. 115-123). Springer, Singapore.

[47] Noufal, M., Maalla, Z., Adipah, S. (2020). Households' participation in solid waste management system of Homs city, Syria. *GeoJournal*, 1-23.

[48] Babel, S., Ta, A. T., Liyanage, T. U. H. (2020). Current situation and challenges of waste management in Thailand. In *sustainable waste management challenges in developing countries* (pp. 409-440). IGI Global.

[49] Banerjee, S., Sarkhel, P. (2020). Municipal solid waste management, household and local government participation: a cross country analysis. *Journal of environmental planning and management*, *63*(2), 210-235.

[50] Pariatamby, A., Bhatti, M. S., Hamid, F. S. (2020). Waste management in developing countries: An overview. In *sustainable waste management challenges in developing countries* (pp. 494-519). IGI Global.

[51] Zorpas, A. A. (2020). Strategy development in the framework of waste management. *Science of the total environment*, *716*, 137088.

[52] El Sheltawy, S. T., Boghdady, N., Fouad, M. M. K. (2019). Improvement of solid waste management code of practice development through effective public consultation. In *waste management and resource efficiency* (pp. 147-157). Springer, Singapore.

[53] Han, Z., Zeng, D., Li, Q., Cheng, C., Shi, G., Mou, Z. (2019). Public willingness to pay and participate in domestic waste management in rural areas ofChina. Resources, conservation and recycling, 140, 166-174.

[54] Vassanadumrongdee, S., Kittipongvises, S. (2018). Factors influencing source separation intention and willingness to pay for improving waste management in Bangkok, Thailand. *Sustainable environment research*, *28*(2), 90-99.

[55] Ma, J., Hipel, K. W., Hanson, M. L. (2017). Public participation in municipal solid waste source-separated collection in Guilin, China: status and influencing factors. *Journal of environmental planning and management*, *60*(12), 2174-2191.

[56] Majlessi, M., Vaezi, A., Mehdipour, M. (2015). Strategic management of solid waste in Tehran: A case study in district no. 1. *Environmental health engineering and management journal*, *2*(2), 59-66.

[57] Al-Khatib, I. A., Kontogianni, S., Nabaa, H. A., Al-Sari, M. I. (2015). Public perception of hazardousness caused

by current trends of municipal solid waste management. *Waste management*, *36*, 323-330.

[58] Tarawneh, A., Saidan, M. (2013). Households awareness, behaviors, and willingness to participate in E-waste management in Jordan. *International journal of ecosystem*, *3*(5), 124-131.

[59] Kheyroddin, R., Ghaderi, M. (2020). New towns as deconcentration or another concentration in the metropolis: evidence from Parand new town in the Tehran metropolitan area. *International journal of urban sciences*, *24*(1), 69-87.

[60] Padash, A., Ataee, S. (2019). Prioritization of environmental sensitive spots in studies of environmental impact assessment to select the preferred option, based on AHP and GIS compound in the gas pipeline project. *Pollution*, *5*(3), 671-685.

[61] Hoveidi, H., Nasehi, S., Imanpour, N., Nohegar, A. (2019). Strategic planning based on environmental spatial assessment, using SWOT and GIS to locate sustainable industrial areas (Case study: Tehran province). *Pollution*, *5*(3), 569-583.

[62] Adar, E., Karatop, B., İnce, M., Bilgili, M. S. (2016). Comparison of methods for sustainable energy management with sewage sludge in Turkey based on SWOT-FAHP analysis. *Renewable and sustainable energy reviews*, *62*, 429-440.

[63] Ho, C. C. (2011). Optimal evaluation of infectious medical waste disposal companies using the fuzzy analytic hierarchy process. *Waste management*, *31*(7), 1553-1559.

[64] Hui, S., Manfei, W., Zuoling, S., Hongfei, Y. (2019). Analysis of operating mode of electronic product reverse supply chain based on FAHP. *International journal of intelligent information systems*, *7*(5), 42.

[65] Giusti, A., Maggini, M., Colaceci, S. (2020). The burden of chronic diseases across Europe: what policies and programs to address diabetes? A SWOT analysis. *Health research policy and systems*, *18*(1), 1-7.

[66] Lo, H. W., Liou, J. J., Huang, C. N., Chuang, Y. C., Tzeng, G. H. (2020). A new soft computing approach for analyzing the influential relationships of critical infrastructures. *International journal of critical infrastructure protection*, *28*, 100336.

[67] Ghodsi Pour, S. H. (2007). Analytical hierarchy process AHP, 5th edition: University of Amir Kabir (Tehran polytechnic), Tehran.

[68] Nepal, B., Yadav, O. P., Murat, A. (2010). A fuzzy-AHP approach to prioritization of CS attributes in target planning for automotive product development. *Expert systems with applications*, *37*(10), 6775-6786.

[69] Zhu, K. J., Jing, Y., Chang, D. Y. (1999). A discussion on extent analysis method and applications of fuzzy AHP. *European journal of operational research*, *116*(2), 450-456.

[70] Martha, B. A., Vacchi, C. D. O., Fattori, R. A., Macagnan, F. E. (2020). Effect of physical exercise on the functional capacity of children and adolescents submitted to transplantation of hematopoietic stem cells—A systematic review with meta-analysis. *Journal of child health care*, 24 (1), 1-13.

[71] Zhu, Y., Zhong, N., Su, H., Ruan, X., Bao, J., Zhang, L., Zhao, M. (2019). Strengths, weaknesses, opportunities and threats (SWOT) analysis of reinitiation into methamphetamine abusers: qualitative findings from an exploration of methamphetamine abusers in Shanghai, China. *General psychiatry*, *32*(3), e100062.

[72] Phadermrod, B., Crowder, R. M., Wills, G. B. (2019). Importance-performance analysis based SWOT analysis. *International journal of information management*, *44*, 194-203.

[73] Paes, L. A. B., Bezerra, B. S., Deus, R. M., Jugend, D., & Battistelle, R. A. G. (2019). Organic solid waste management in a circular economy perspective–A systematic review and SWOT analysis. *Journal of cleaner production*, *239*, 118086.

[74] Padash, A., Ghatari, A. R. (2020). Toward an innovative green strategic formulation methodology: Empowerment of corporate social, health, safety and environment. *Journal of cleaner production*, 121075.

[75] Ahmadi, M. R., Maleki, D., Ahmadi, A. (2019). SMC-SPMV: A new strategic management model for cloud computing based on SWOT.PESTEL multi view. *African journal of engineering research*, *7*(1), 17-32.

[76] Zakeri, S., Yang, Y., Hashemi, M. (2019). Grey strategies interaction model. *Journal of strategy and management*, *11* (4), 1-24.

[77] Barak, S., Javanmard, S. (2019). Outsourcing modelling using a novel interval-valued fuzzy quantitative strategic planning matrix (QSPM) and multiple criteria decision-making (MCDMs). *International journal of production economics*, 107494.

[78] David, F., Kovács, T. (2020). Introducing QSPM analysis to agribusiness firms. *55th Croatian & 15th International Symposium on Agriculture*, 158-161.

[79] Afshar, F., Abbaspour, M., Lahijanian, A. A. M. (2020). Evaluation of affecting factors on citizen participation in comprehensive waste management (Case study of districts 8 and 12 in Tehran). *Environmental energy and economic research*, *4*(2), 155-164.

[80] Majlessi, M., Zamanzadeh, M., Alavi, N., Amanidaz, N., Bakhshoodeh, R. (2019). Generation rates and current management of municipal, construction and demolition wastes in Tehran. *Journal of material cycles and waste management*, *21*(1), 191-200.

[81] Khoshand, A., Rahimi, K., Ehteshami, M., Gharaei, S. (2019). Fuzzy AHP approach for prioritizing electronic waste management options: a case study of Tehran, Iran. *Environmental science and pollution research*, *26*(10), 9649-9660.