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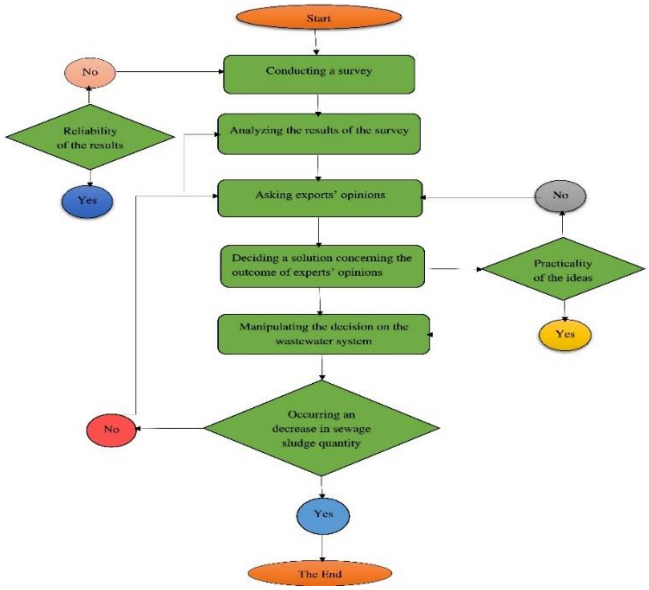
# Sustainable environmental management and solid waste control in the Ekbatan wastewater treatment plant (EWTP), Tehran, Iran

**Mohammad Ali Zahed[1,*], Aeen Eftekhari[2], Hassan Hoveidi[3], Faranak Hejabi[1]**

*[1]Department of Cell and Molecular Biology, Faculty of Biological Sciences, Kharazmi University, Tehran, Iran.*
*[2]Department of Civil, Environmental, and Geomatic Engineering (BAUG), Swiss Federal Institute of Technology (ETHZ), Stefano-Franscini-Platz 5, 8093 Zürich, Switzerland.*
*[3]Department of Environmental Management, College of Engineering, University of Tehran, Tehran, Iran.*

## GRAPHICAL ABSTRACT

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## ABSTRACT

Sustainable development highly depends on how we manage various parts of the industry, and it plays a significant role in the sewage purge system to pay attention to the clutch reducer elements. Complementary procedures and technologies are needed to resolve water governance concerns, urging a rapid alteration of the economics, engineering, and administration agendas to determine our generation's water challenges. Ekbatan Wastewater Treatment Plant (EWTP) confronts several problems that necessitate comprehensive and strategic planning and management. An analysis of strength-weakness-opportunity-threat (SWOT) and quantitative strategic planning matrix (QSPM) methods were used to investigate strategic factors. For scoring the proposed strategies, a group of experts who are familiar with environmental management was selected. Environmental factors were recognized and investigated. According to experts' opinions, important and unimportant factors were identified and prioritized. The most effective strategy to further strengthen the current situation is "expanding the treatment plant activities such as internal infrastructure and urban utilities to manage more waste."



## 1. Introduction

Due to physical lack or pollution, water scarcity has become one of the most vital issues worldwide, a matter of social, financial, and environmental insecurity. Achieving water security is one of the significant global challenges in the age of climate change, urbanization, and population growth (Pandey. 2020). The most significant issues are

*Corresponding author Email: zahed51@yahoo.com

environmental problems, including treatment and disposal, pollution control and prevention, wastes recycling, and wastewater reuse (Kalamdhad. 2020). There is a knowledge gap in this crucial issue. The inadequate and limited frameworks need to assess, evaluate, and re-evaluate the menace of plastic pollution and entrainments into consumable water and wastewater treatment plants (Iroegbu. 2020). In environmental management, it is crucial to remove pollution to reach environmental standards (Rodriguez-Garcia et al. 2011). The amendment to the Waste Act aims to strengthen the waste hierarchy and clarify the responsibilities and calculation of waste management. Therefore, different waste management systems were analyzed using the SWOT tool and the qualitative comparison method.

Sustainable Development Goal (SDG) 6, addressing water resources' sustainability, "Ensures availability and sustainable management of water and sanitation for all." In the realms of Climate change effect, pollution, economic and population growth, water security is valuable to society when observed through the Sustainable Development Goals (SDGs) (Ortigara. 2018). Several solid waste control systems in the wastewater treatment plants were proposed (Loos et al. 2013; Yoshida et al. 2015; Koch et al. 2016). A massive amount of solid waste was generated from sewage physical treatment plants. Generally, it is transferred to landfills. These wastes are concentrated wastewater and contain large amounts of organics, sand, and a high percent of latex. In addition, storing these materials in the treatment process confronts several problems. Transferring the seeds from the Wastewater Treatment Plant (WTP) to an unknown destination without municipalities and waste management organizations' cooperation will follow numerous health and environmental problems, especially land and groundwater pollutions (Giusti. 2009). Before discharging wastes from WTP, using proper waste management methods are essential. Another problem related to wastewater treatments is gases emitted from aerobic and anaerobic basins. The proper planning and management to deal with the mentioned problem can be implemented by developing strategies. The implemented plan can reduce the impacts of gases on the staffs' and residents' health near WTPs (Dashti et al. 2020).

An output of WTP is sludge. Lack of quality monitoring of sludge from all WTPs, in most cases, leads to the entrance of the raw form of sludge into nature, which causes environmental problems. Inappropriate disposal or reuse of sludge in agriculture severely endangers general public health (Cherubini et al. 2008). In addition to agriculture usage, inappropriate disposal and reuse of untreated sludge lead to disturbing the host environment's performance and damaging other environmental aspects associated with this ecosystem. These would cause a change in soil composition, soil pollution, vegetation changes, manufactured product pollution, and several other issues (Ammar et al. 2020). The lack of proper management in reusing treated wastewater is a complicated challenge in EWTP. According to the definition, the strategy is a way to improve the present mode to optimum mode.

The government of developing counties should design sustainable management systems to guide sludge management's rationalization and implementation (Wei et al. 2020).

The Delphi-survey method is utilized to collect data from a panel of experts. The Delphi procedure has been applied repeatedly across many diverse domains (Belton et al. 2019). Bui et al. (2020) has used this method to indicate the significant barriers that result in poor SSWM. Kamali et al. (2019) determined the importance of sustainability criteria for conventional and innovative technologies to treat industrial wastes in a general strategy using the fuzzy-Delphi method. Shahbod et al. (2020) used the Delphi method to identify relevant criteria, sub-criteria, and indicators, then model environmental performance assessment in urban medical centers.

This research aims to develop a strategic and comprehensive environmental management of EWTP wastes and outputs. Two applicable methods, quantitative strategic planning matrix (QSPM) and strength-weakness-opportunity-threat (SWOT) are proposed.

## 2. Materials and methods

### 2.1. Study area

WTP of Ekbatan residential town is one of the WTPs for human wastewater treatment between the first and second phases of Ekbatan Town, Tehran, Iran. Initial wastewater exits as effluent after passing a three-stage cycle: preliminary, biological, and advanced treatment. The effluent is discharged. This WTP mechanism is based on extended aeration activated biological sludge process (Metcalf. 2014). Like many others, the mentioned WTP has problems that make comprehensive and strategic planning and management essential to improve the performance and address the purposes as much as possible.

### 2.2. Data analysis tools

In this article, the Delphi method was used, which is consisted of six steps. In the first step, the particular issue that we wish to gain experts' opinions on was selected. Then, the appropriate selection of panelists by their domain knowledge in the relevant topic area was designed. Also, the practicalities of a Delphi should be considered before embarking on the process. In the second step, question items and response scales were developed concerning the aims of this study. When the Delphi survey has been deliberately designed, the way of administering the survey was considered. The fourth step is to provide panelists with feedback after the first round. The participants were able to commit adequate time to the whole process, as it should be done in the fifth stage. The last step is to analyze and present the Delphi data and eventually report the results (Belton et al. 2019).

Each research hypothesis (the first and second research questions become hypotheses) has been tested and validated by statistical analysis. For this purpose, a questionnaire was prepared and completed by carefully chosen experts. Each pair of questions and answers were analyzed using frequency percentage distribution separately. Afterward, Chi-Squared (Chi-2) was employed to validate the hypotheses. The significant difference of responses indicated how independent the responses are, which results in the meaningfulness of the hypotheses.

### 2.3. Investigation of experts' attitude and hypothesis test

The available statistical community with the knowledge in wastewater treatment and environmental planning and management in Ekbatan treatment (managers, the staff of EWTP, university professors, and experts in environment, water, and wastewater) was gathered. The Cochran formula was used to obtain the number of statistical samples. Afterward, to investigate the reliability of the mentioned questionnaire answered by ten experts (EWTP staff and professors and Ph.D. students in the faculty of the environment at the University of Tehran), the same respondents were asked to respond the second time. Then the Spearman test was employed to investigate the correlation between questions. It should be noticed that the Pearson correlation coefficient is only appropriate for continuous quantity data. For nominal and ordinal data, other indicators should be used. If variables are ordinal type, Spearman correlation coefficient tests (rs) or Tau Kandal are appropriate. It is worth noting that the Spearman correlation coefficient is not limited only to the ordinal data (Mirzadeh, 2009). To check the questionnaire's reliability, we used the Cronbach's alpha coefficient (it measures the number of mono-dimensional attitudes, judgments, and other categories that are not easy to measure). This factor helps investigate how similar the respondent's perceptions were (Mansourfar. 2009).

### 2.4. Statistical analysis

The use of the Cronbach's alpha coefficient is applicable by using SPSS statistical software. If Cronbach's alpha is more than 0.75, it is considered 0.7 (Luo et al., 2017), and the internal validity of the research is confirmed. For this purpose, ten respondents' opinions who answered the questionnaire in its reliability investigation phase were used. Cronbach's alpha was calculated by entering responses to SPSS software.

## 3. Results and discussion

SDG's 6th target is dedicated to clean water and sanitation since it is considered one of the crucial focuses of Sustainable Development Goals (Moumen et al. 2019). Many factors can influence the sewage sludge quantity in wastewater, and several articles have been written on this subject and how to improve it (Zhao. 2020; Zeinolabedini. 2019; Zhang. 2020; Jagaba. 2019; El Houari. 2020).

The best strategy that considers all aspects of treatment management is using matrices, especially the SWOT matrix. The questionnaire of this research contains three main questions. The first two questions investigate and reveal the necessity, importance, and need for environmental criteria in EWTP management and strategic management and planning for comprehensive management and proper development. To this end, the management system of EWTP was investigated by a group of experts (23 persons), and their opinions were



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analyzed statistically. After investigating and identifying environmental factors (internal and external), a list of the most important strengths, weaknesses, opportunities, and threats were prepared using IFE and EFE matrices. Analysis, evaluation, and determining the score of EWTP were implemented too. In the next stage, employing the IFE and EFE matrices results, the current situation of wastewater treatment was specified. The quantitative strategic planning matrix (QSPM), a high-level strategic management approach, is utilized to evaluate potential strategies. In this matrix, the data gained at several stages of strategic management and planning is applied (Afshar et al. 2019). Liu et al. (2019) has published the Development Strategy of China's Technology Transfer based on the SWOT-QSPM model. Kardani-Yazd et al. (2019) used expert analyzes of QSPM matrixes to attain the strategic approaches revitalizing a novel greenbelt plan in Mashhad, Iran.

The results obtained from the questionnaire reliability investigation using the Spearman test indicated that the correlation coefficient is higher than 90. This test shows a degree in which, anytime a measurement tool (questionnaire) is used, it provides nearly the same result. The following internal reliability (validity of questionnaire) was investigated using SPSS software that the number 8 was obtained for Cronbach's alpha, which indicates the validity of the questionnaire is acceptable. Thirty people familiar with wastewater treatment and environmental management were selected from the available statistical community, and through the Cochran formula, the number of statistical samples was 23, so surveys were done among these 23 people. Since the studied community are experts familiar with the topic and area, the number of members (N) equals 30, in 95% confidence level, the number equals 1.96, by assuming equivalent, the probability of sampling equals 0.5 and the tolerance in sampling (d) equals 0.1. By using the above values, n = 23 was calculated. Each research hypothesis is tested and proved or disproved by using statistical analyses. Every problem and their selections were calculated separately by using frequency percentage distribution. The significant difference was investigated on some questions to prove or disprove hypotheses through the Pearson correlation test. By identifying the meaningfulness of differences among respondents, it becomes clear how far these questions' frequency is independent of each other.

On the other hand, the strengths, weaknesses, opportunities, and threats related to EWTP were collected through the Delphi surveys model and using experts and management. After preparing the initial list, the above items were reviewed, and duplicated items were eliminated again. They were then provided to the expert group and corrected, and irrelevant and worthless items were eliminated. Finally, the required list was prepared in the SWOT model form which are presented separately in table 1 and 2 for both internal and external environments.

**Table 1.** Internal factors related to the presentation of the strategic management plan of EWTP.

| Strengths | Weaknesses |
|---|---|
| ❖ Upgrading treatment system from activated sludge to $A_2O$ | ❖ Lack of suitable protecting wall around the EWTP |
| ❖ Good efficiency of $A_2O$ system | ❖ Existence of many weeds in green space of WTP and drying them in the summer and increasing the risk of fire |
| ❖ Daily measuring and controlling effluent quality parameters | ❖ Being the sludge treatment system out of circuit and existence of technical defects in this section |
| ❖ Existence of a system for monitoring effluent quality | ❖ Lack of odors and gases measurement system |
| ❖ The existence of depth aerators of fine bubble in the aeration basin to improve the aeration process | ❖ Lack of suitable system for destruction or organizing wastes and seeds in getting seed stage |
| ❖ Lack of complaints from residents outside of wastewater treatment plant | ❖ Proximity to residential areas |
| ❖ The existence of bleach liquid or liquid chlorine is superior to chlorine powder because of being cheaper and more available | ❖ Lack of integrated and appropriate organizing of telemetry system |
| ❖ Existence of integrated policy for wastes and produced effluent | ❖ Existence of obstacles in order to improve environmental performance |
| ❖ Necessary awareness of those involved with chemicals | ❖ Loss of measuring and controlling some important effluent parameters |
| ❖ Existence of solid chlorine as complementary and alternative of liquid chlorine at emergency and required times | ❖ The ugly and polluted situation around WTP |
| ❖ Using the appropriate treatment method | ❖ Lack of laboratory equipment |
| ❖ Observance of safety items in units | ❖ Rising some effluent parameters in the rainy season |
| ❖ Use of experienced and skilled experts | ❖ Leachate penetration of solids and their impact on soil and public health |
| ❖ Management awareness of treatment from rules, regulations, and instructions | ❖ Remoteness of affluent consumption sources |
| ❖ Observance of safety items by staffs | ❖ Loss of holding training courses and updating staffs' information |
| ❖ Passing first aid and safety courses by staffs | ❖ Lack of environmental management establishment of ISO 14000 |
| ❖ Proximity to areas of effluent production | ❖ Lack of establishment of research and development (R&D) system |
| ❖ The employees' satisfaction | ❖ High treatment costs |
| ❖ Continuous monitoring of management on staffs' protection and safety | |
| ❖ Organizational structure appropriate to describe treatment activities | |
| ❖ Registration and documenting information and reporting them monthly | |
| ❖ Observance of standards and existence of strict rules to control the effluent quality | |
| ❖ Doing both specious observations and laboratory control to determine treatment performance | |
| ❖ Existence of necessary online devices of controlling parameters in effluent quality | |
| ❖ Existence of chemical and biological quality laboratory of effluent as Local in the WTP that the laboratory is accredited by the environment, health and water, and wastewater organizations | |
| ❖ Using treated effluent of treatment to irrigate green space of WTP | |
| ❖ Existence of wide-open space about 5.5 hectares around WTP and prevention of exiting odor and pollutant gases to environs residential areas | |
| ❖ Compliance of environmental performance concerning measuring parameters with environmental regulations and standards | |
| ❖ Effluent inlet with household composition | |
| ❖ Lack of peak hour of chemical pollutants | |
| ❖ Efficiency higher than 90 % for nitrogen removal | |

Many cases complex the problem and make its analysis difficult and lead utilizing the process have a problem in experts' opinions. In the questionnaire, the Likert scale was used for surveying. Responsive, based on Likert scale scoring (5-point measurement scale includes statement 1: very low, 2: low, 3: medium, 4: high, 5: very high), assigned the highest score to factors having the most importance and the least score to factors with low importance. In this stage, factors that got an average score of greater than four were selected as practical factors to determine the Ekbatan wastewater treatment plant's management strategy. Thirty-four cases from 94 identified cases have participated in the final process.



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The results of existing documents and visiting the area and expert group opinion lead to investigating the area's internal and external environment and identifying the most important strengths and weaknesses (internal strategic factors) and opportunities and threats (external strategic factors). After selecting strategic factors, these factors were entered into the internal factors' evaluation matrix and external factors' evaluation matrix to evaluate.

Experts gave weight to all factors from 1 (unimportant) to 10 (very important) in the matrixes. After normalizing, weights were changed to numbers from 0 (unimportant) to 1 (very important) that the sum of internal factors weight equals 1 and external factors equals 1. It was then assigned to each of the strategic factors of the current situation score (attractiveness for performing in EWTP) that its number range was from 1 to 4.

The scoring process in evaluation matrixes of internal and external factors is how the exceptional opportunity moves toward a severe threat, the score was lower and decreased from 4 to 1, and the final score is obtained by multiplying these numbers.

The sum of weighted scores of internal strategic factors (IFE) was calculated at 3.154, and it indicates that strengths are more than weaknesses and internal strategic factors management related to EWTP improve the performance of this WTP and awareness of current problems and try to resolve them. Furthermore, the final score average of the external factors' matrix shows the number 2.905. It indicates that maneuvers opportunities related to EWTP are more than their threatening factors, and external strategic factors management about using opportunities and dealing with threats has an acceptable performance. Its reason can be attributed to the appropriate situation of this WTP and receive the only household effluent alongside the excellent quality of effluent. Demand increasing for the effluent of this WTP because of a lack of hazardous industrial pollutants is another reason that can have a role in this crucial issue.

**Table 2.** External factors related to the presentation of the strategic management plan of EWTP.

| Opportunities | Threats |
|---|---|
| ❖ Existence of appropriate infrastructures and installation for refinery sludge treatment and production of sludge cake | ❖ Possibility of throwing cigarette and incendiary material into green space and burning dried weeds |
| ❖ Using sludge cake for secondary use (such as organic fertilities, compost) | ❖ A high volume of depot seeds and wastes, accumulation of insects and vermin |
| ❖ Existence of adequate infrastructure to develop treatment activity | ❖ The illegal entrance of pollutants and industrial wastewaters along Firuzabad Stream that treated effluent of EWTP entered it, leading to pollution in treated effluent and river water before entering agricultural land |
| ❖ Increasing demand for treated effluent | |
| ❖ Proximity to Mehrabad airport and the possibility of selling effluent for non-drinking purposes | |
| ❖ Possibility of taking advantage of academic researches | ❖ Changing the quality of purchased chlorine because of sanctions and consequently reduction of effluent quality |
| ❖ Possibility of selling treated effluent to the municipality to irrigate green space and industrial uses | ❖ Lack of measurement and refining pollutant and harmful gases emitted from WTP that may have dangerous consequences for human health in the long term |
| ❖ Existence of enough land to bury seeds and wastes | |
| ❖ Possibility of using treated effluent to irrigate green space of Ekbatan town | ❖ Lack of necessary training of WTP pollutions to residents and the lack of holding national and international environmental seminars to inform residents around the WTP |
| ❖ Possibility of using open space of WTP in order to install solar panels to generate the required electricity | |
| ❖ Possibility of building a greenhouse for growing plants and monetized plant products | ❖ Discharging refined effluent to surface water |
| ❖ Managers' familiarity with technologies and different wastewater treatment systems | ❖ Possibility of contaminating due to discharge effluent to surface water |
| ❖ Possibility of using appropriate environmental technologies | ❖ Lack of making culture to residents in order to improve influent |
| ❖ Managers Have necessary experience in recognition of environmental issues | ❖ Restriction on purchasing laboratory devices and equipment |
| ❖ Possibility of holding environmental training courses to increase environmental culture | ❖ Climate conditions in the area in the rainy season |
| ❖ High rate of staffs' environmental research and skill | ❖ Inactivity of nongovernmental organizations and environmental NGOs |
| ❖ Policy coordination with organization purposes and mission | ❖ Lack of budget and financial restrictions |
| ❖ Having proper formation to perform environmental research | ❖ The unwillingness of the private sector and people in the WTP development process |
| ❖ Possibility of using new technologies | |
| ❖ Possibility of participation of the private sector to transfer wastes | ❖ Lack of necessary investment to develop covered population |
| ❖ Possibility of income supplying through changing to a university laboratory | ❖ Development of constructions around WTP |
| ❖ Possibility of expanding population covered because of increasing population and urban expansion | ❖ Change of people's attitude toward WTP |
| ❖ Using the capital out of the organization to develop and equip WTP | ❖ Lack of optimal use of human sources and company facilities |
| ❖ Promotion of knowledge and information level than purposes (such as partners, competitors, stakeholders) | |

After identifying environmental factors (opportunities and threats) and internal factors (strengths and weaknesses) and distinguishing key factors from non-key factors, the time of strategy suggestion and selection starts. SWOT model usually contains a two-dimensional coordinates table that each of four regions of it shows a strategy category. Yavuz Alkan (2020) has recently used the SWOT method for research on a sustainable urban scale in Çanakkale.

Four strategy categories are presented in this model. It is desirable to determine the situation and location of EWTP to take a step with more strength toward the codification of strategies and finally begin to prioritize strategies. However, in this research, all possible strategies in four strategic regions are codified (Grobalak. 2019).

The first concern of this paper is whether the implementation of environmental criteria in EWTP management can significantly change the structure, performance, and quality of wastewater treatment. The questionnaire structure was designed as a Likert range so that respondents have more range to choose from. The macro hypothesis is for evaluating experts' opinions about the relevance of implementing environmental criteria in three cases: structure (corporate sector), performance (process sector), and quality of EWTP. Simultaneously, the respondents answered these questions by considering all three cases as combinational and comprehensively. The hypotheses were tested by using the Chi-squared test (test of well-fitting). The results showed meaningfulness between obtained frequency and expected frequency in each of four hypotheses (the first macro hypothesis and three subsidiary ones), which means that all four studied hypotheses were not rejected. Experts believe that implementing environmental criteria in EWTP management can create significant changes in structure, performance, and quality of treatment.

The second issue is whether strategic management and planning can reduce the environmental impacts of EWTP. Well-fitting test results showed that the test statistic's numerical values are not located in the critical area. Therefore, there are not enough reasons to reject the H0 hypothesis (reduction ad absurdum), and the second macro hypothesis is not rejected and concludes that theoretical and experimental frequencies are identical (monotonic distribution). Experts believe that strategic management and planning in EWTP will lead to reducing its environmental impacts.

The last issue is about the most critical priorities of EWTP for strategic and comprehensive management in experts' opinions. QSPM matrix



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shows that threats can be changed to opportunities, and weaknesses can be changed to strengths by using strengths in EWTP. Arrangement of strategies priority is based on their total weight in modifying and moving towards sustainable development. According to the QSPM matrix, nine strategies were evaluated (see the table below) and presented with a score or total attractiveness score. Each strategy with a higher total attractiveness score was the priority. As seen in Table 3, the S-ST7 strategy (developing treatment activities such as internal infrastructure and urban installation for transferring more wastewater to WTP) has the highest score sum (4.944) and is suggested as the best strategy in the times of studying.

**Table 3.** Prioritized strategies.

| Priority | Abbreviation symbol | Strategies | Final score |
|---|---|---|---|
| 1 | S-ST7 | Developing treatment activities include internal infrastructure and urban installations to transfer more wastewater to WTP | 4.944 |
| ۲ | S-ST4 | Interaction with municipalities to sell treated effluent for non-potable uses | ٤,٨٨٢ |
| 3 | S-ST1 | Appropriate utilization of available facilities and technical knowledge to complete wastewater treatment cycle | 4.732 |
| 4 | S-ST3 | Repairing and constructing a retaining wall around the WTP | 4.32 |
| 5 | S-ST8 | 11ST- using new technologies to create a system of controlling and measuring gases | 4.244 |
| 6 | S-ST2 | Receiving amounts of money from residents of the covered area through cooperation with water organization | 4.216 |
| 7 | S-ST6 | Utilization of updated environmental technologies to have more compatibility with the environment and new standards | 3.782 |
| 8 | S-ST5 | Create an appropriate system to organize physical effluents through using lands and WTP staffs' specialties | 3.756 |
| 9 | S-ST9 | Preparing programs to educate citizens and residents of covered area to reduce internal seeds and a planned program to transfer and bury timely | 3.485 |

## 4. Conclusions

It is crucial to plan and manage WTPs, specifically EWTP. The entrance of only one type of urban wastewater, increasing the need of municipality for water, environmental awareness, environmental pollution concerns, attracting public cooperation, nearby residents' satisfaction, and gaining their trust, existence of some potentials that can have both negative and positive aspects and finally the existence of weaknesses in WTP. In total, 30 strategies were introduced. These strategies were provided to experts' group and treatment management to determine the most important strategies concerning the current situation of EWTP and prevent unwanted complexity. Ultimately, nine strategies were selected as attractive and desirable strategies for expert groups and management. Since implementing the strategies is not possible due to financial and time restrictions, strategy priority is avoided. In QSPM, nine strategies to their weights in IFE and EFE matrices were provided for the expert group, and an attractiveness score was accrued to them. By numerical summation of obtained scores, nine strategies were prioritized to get sustainable development and consider socio-economic and environmental issues.

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