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SWOT-Based Assessment of the Maintenance Management of the Wastewater Treatment Plants in Iraq

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HIGHLIGHTS

- The developed SWOT analysis model is a beneficial tool for evaluating WWTPs.
- The developed SWOT analysis can evaluate other projects like irrigation projects and water treatment plants.
- There is a need for new plans for managing human resources development.

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ABSTRACT

In Iraq, due to WWTPs being old and outdated, an evaluation of the maintenance management is needed to highlight the points of weaknesses and strengths of the plants. In this paper, the strength, weakness, Opportunities, and Threats (SWOT) analysis model is designed with the Delphi Technique and Liker-scale and applied to the old Rustumiya project in Iraq (ORP). The design and application of this model are based on the design, operation and maintenance drawings and reports, and field visits to the ORP. In addition, three rounds of the questionnaire were sent to more than 80 experts varied in qualification and experience, considering the SWOT elements of the methods, materials, and human resources issues. The weight, relative importance, and implementation of each item in each SWOT element and the SWOT elements and issues were computed. The results showed that in the internal elements, the degree of importance of the weakness has a higher value of importance than the strength. In the external elements, the opportunities are considered more important. For the four issues, methods have the lowest weight while the materials have the highest. This alerts the major development required in this sector for a new plan for selecting and preparing maintenance materials. However, human resources come after the materials in terms of importance. The developed SWOT analysis model is beneficial for evaluating WWTPs with simplified and realistic results. Further, it can evaluate other projects like irrigation projects and water treatment plants.

1. Introduction

One of the main challenges worldwide is water scarcity, which means that freshwater is no longer enough to satisfy water demand. Thus, water treatment is a key action to save large amounts of water for reuse or discharge into the natural water bodies to overcome these crises. By applying this action, water is saved, and health is maintained by eliminating contaminants and viruses. Treatment of wastewater can contribute to overcoming water scarcity by providing a considerable amount of reusable water and preventing pollution of the available water sources. Therefore, wastewater treatment plants (WWTPs) are a significant part of society. It is considered the protective side from the risk of environmental pollution resulting from the accumulation of sewage waste. Realizing the desired benefit from these projects requires efficient management. Achieving integrated and efficient management requires the availability of management requirements (operation and maintenance) in terms of methods, materials, and human resources. In addition, it must be ensured that these requirements remain ready. This imposes the importance of having systems to continuously monitor and evaluate these systems' efficiency and define the priorities and updates required to keep pace with the aging of projects and the development of methods and technologies. There are various methods for evaluating the performance of WWTPs; some of them are the cost-benefit analysis (CBA), multi-criteria decision analysis (MCDA), life-cycle assessment (LCA), social life-cycle assessment (SLCA), artificial neural networks (ANN), and the Strength, Weakness, Opportunities and Threats analysis (SWOT). The Life Cycle Assessment (LCA) is used as a tool for recognizing and developing new technologies for a plant. It might be used to compare a variety of plants with different technologies [1]. Gob et al. [2] used the ANN to sense the growth of pollutants concentrations under the act of

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radiation through diversity. Meanwhile, Settee and Chelan [3] utilized ANN to anticipate the future failure of membranes used in the decontamination of polluted waters. ANN design was directed to comprise physical-based measures to be implemented with ease and accuracy. Cañar[4] used the Coonan self-organizing feature maps (KSOFM) to define the WWTP's performance characteristics and to identify and study the plant's operational obstacles and how to solve them. Also, Hanbay et al. [5] used the ANN mixed with wavelet packet analysis and entropy to assess the Total Suspended Solids (TSS) by evaluating certain characteristics from previous data. Jones et al. [6] used CBA to evaluate the infrastructure of transportation projects and choose the most economical way to distribute the financial budget. Scott et al. [7] reviewed the usage of MCDA in the energy field. Also, MCDA is utilized by Ribeiro et al. [8] to assess future options in operating power generation in Portuguese. Furthermore, Jacyna-Gołda and Izdebski [9] used MCDA to choose the best location for the warehouse. From another side of view, one of the most important tools for evaluating the projects is the SWOT. Novicevic et al. [10] worked on a dual-perspective SWOT framework, and the logical inconsistencies facing the managers in markets represent the new dimension. Then Van et al. [11] used the SWOT analysis in the health care sector to prove that SWOT analysis is not adequate for this sector and then proposed a developed SWOT analysis, four case studies in the Netherlands. In the same year, a hybrid model combining SWOT analysis with the Delphi Technique (DT) was introduced by Tavana et al. [12] as a solution for evaluating and selecting the best alternative route for transporting the oil and gas of the landlocked Caspian Sea basin internationally for international markets. Furthermore, Brad and Brad [13] designed a SWOT analysis framework including TRIZ-based tools to find suitable solutions for problems coming from SWOT elements. TRIZ is the Russian acronym for the "Theory of Inventive Problem Solving. According to Silber and Fishy [14], a SWOT analysis can be applied for several cases, including: (1) studying the impact of internal and external factors on the performance and their influences on the organization's achieved results; (2) recognizing the features that add to or minimize the effectiveness of the organization; (3) analyzing the future of practice and assess which of them should be continued or developed and which should be terminated; (4) developing a new SWOT analysis over time and compare it with old ones as a way of organizations performance assessment. Also, the DT can be applied in different fields, as mentioned by Securer [15], such as collecting non-accurate nor available data, assessing projects budgeting, inspecting plans, exploring the advantages and disadvantages of certain policies, and uncovering real human motivations. Out of limitations in the previous research studies which hardly address the evaluation of the management of wastewater treatment projects in the world. In Iraq, most wastewater treatment projects are old and need continuous maintenance. This highlights the importance of conducting an assessment of the reality of maintenance methods, materials, and human resources. This must be achieved via using recent technologies that can be applied in cases of lack of clear and specific methodologies for maintenance, the absence of detailed data on maintenance programs and activities applied in old and severely damaged projects. This paper aims to assess the reality of the state of maintenance management of WWTPs in Iraq through a case study. Also, to determine the actions and procedures required to be taken to develop programs for the maintenance management of WWTPs in Iraq in a manner that ensures the continuation of its work within the acceptable limits of efficiency. Achieving this aim was depended on the use of the SWOT analysis methodology and the application of the Delphi technique, as it is an effective technique to use in cases of lack of clear and specific methodologies on maintenance and the scarcity of detailed data on the maintenance programs and activities applied for old and vulnerable projects such as wastewater treatment projects in Iraq.

2. Materials and Methods

WWTP is equipment for purifying wastewater from its major pollutants by using a series of physical, chemical, and biological processes that usually come in two or more steps. A primary step is to remove the naturally occurring settable solids in addition to the removal of floating materials. In the second step, another settling process is achieved after adding chemicals. This step is sometimes followed by biological treatment steps [16]. In Iraq, most of the WWTPs are old and operating outside their life span. Therefore, it needs a lot of maintenance activities to bring it back to the required work efficiency and thus a lot of maintenance costs. To manage maintenance costs and operations, the management plans are created based on the reports and the results of the complete evaluation of the plant in terms of strengths, weaknesses, and exploiting and developing its resources. Some of the several reasons for using WWTPs assessment are to test the effluent water quality with the local standards and regulations for an overall evaluation of the plant's capability for the incoming loadings and to check on different sides of the plant, like its maintenance plans and the financial budgeting to determine if it needs to be updated. A plant's evaluation is sometimes considered a means to study the future possibilities for developing the plant if it is in terms of updating the existing parts or adding new elements and plans for the plan [17]. Evaluating the plant starts by studying the design (plans and detailed drawings) of WWTPs in general and for a selected case study as a sample. The investigated design elements should include the type and method of work of the units inside the plant, the layout of the entire planet, and the operation and maintenance manuals. In this paper, the old Rustumiya Wastewater Treatment Plant, the biggest and oldest WWTP in Iraq, was considered a case study. This step is followed by visiting the selected case study, which involves two activities. The first is a direct interview with those responsible for managing, operating, and maintaining the plant to utilize their experience and opinions to clarify the station's work. The second is to collect all the available information related to maintenance and operation inside the plant.

SWOT analysis analyzes information and choice for assessment and making decisions in strategic planning for its simple application and the flexibility to manage its elements. Using a SWOT analysis has its advantages. It is an interactive analysis tool used for the general evaluation of projects by studying their internal and external strengths and weaknesses and thus studying all factors that affect positively or negatively the system. This analysis is usually used to help organizations uncover opportunities that can grow them and eliminate threats to create a strong organization for competition. SWOT analysis utilizes other methods and theories for analysis, such as the Delphi Technique (DT) and Porter's Five Forces Model. It encourages teamwork to make decisions through exchanging ideas, brainstorming, and group meetings [18].

The DT is used as a tool in a SWOT analysis to design a mechanism for collecting expert opinions, the advantages of using the DT as mentioned by Yousuf [19] and through previous studies by Helmer[20], Tinstone, and Turnoff [15], and Dalkey[21]. It was agreed that the most important feature of the DT is to obtain consensus from experts in one form. Another advantage of this technique is that it is simple to use and does not require complex mathematical calculations to design, implement, and analyze responses. Also, confidentiality gives experts the freedom to express their opinions without external influences or bias. DT is paired with the Liker scale, which is a scale that contains multiple options to help experts express their opinions more clearly. The response is obtained quickly from the largest number of experts from its characteristics. Different methods can be used to analyze, present, and compare the results [22]. In addition, Liker scale characteristics can be used to facilitate the obtaining of consensus through questionnaire rounds.

2.1 Study Area

The WWTPs in Iraq are mostly exhausted, outdated, outgrown by the population [23], and need development, as shown in Table 1. The largest part of WWTPs is located in Baghdad Governorate. The old Rustumiya WWTP is one of the most important WWTP for studies and research, as it is one of the largest and oldest stations in Iraq[24][25]. It is located on the southern side of the Baghdad Governorate and was selected to be the case study, see Figure 1. This project was constructed in the 1960s from a single line of WWTP and developed in the 1980s to include three lines of WWTPs inside stations 0, 1, and 2. It serves most of the east side of Baghdad City, to the left side of the Tigris River. This project was designed to serve a total population of 1500000 capita and an effluent of 20 mg/l BOD and 30 mg/l TSS to comply with Iraqi national standards and regulations.

Table 1: The design capacity of WWTPs in the governorates of Iraq [26]

Governorate	Design capacity(m3/day)
Baghdad/New Rustumiya treatment plant	300,000
Baghdad/Old Rustumiya treatment plant	175,000
Baghdad/Karkh treatment plant	205,000
Najaf	42,000
Karbala	48,000
Maysan	14,000
Babylon	12,000
Dhi-Qar	17,000
Salah Al-din	20,000
Al-Qadisiyyah	12,000

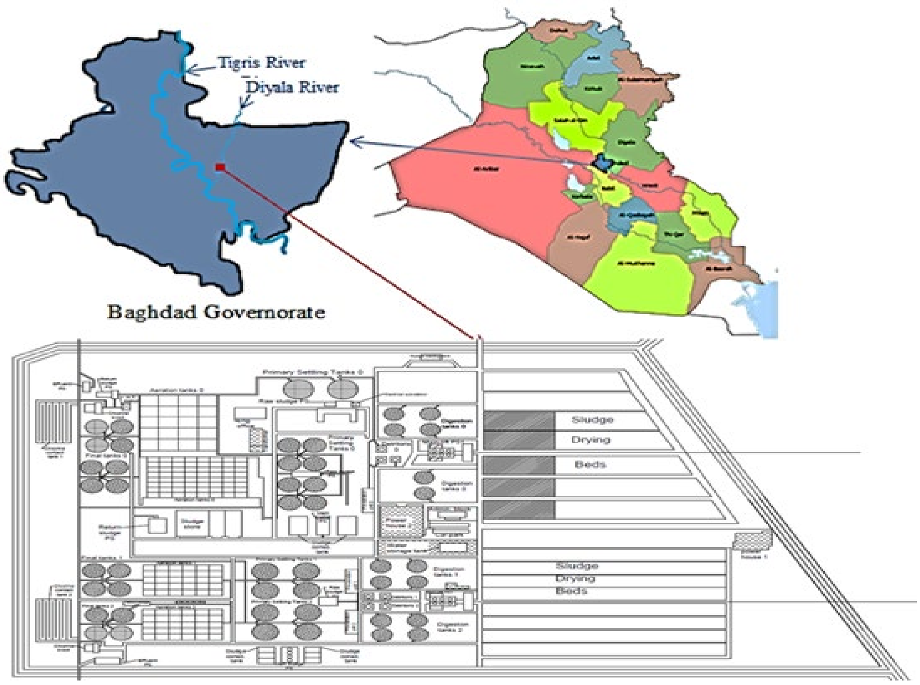

Figure 1: Location and layout of the Rustumiya WWTP

2.2 SWOT Analysis

The SWOT analysis can be defined as an instrument used in organizations for managing and planning strategies. In a way, every organization is found in two environments. The first is represented by the organization itself, and the second is represented by the environment surrounding this organization. The process of studying organizations and their environments is called SWOT analysis. It consists of two categories external (Opportunities and Threats) and internal (Strength and weakness), as shown in Figure 2. GÜREL and TAT [18] and another definition of SWOT analysis start the same by describing it as a tool for strategic planning while comparing internal and external components of the whole organization [27].

The internal and external factors can be explained according to Silber and Fishy [14] as follows:

- Strength: an internal factor positively affects competition and represents a beneficial resource.
- Weakness: an internal factor effects negatively in competition.
- Opportunities: an external factor that can be invested to improve the performance of an organization.
- Threats: an external factor that can inhibit an organization's performance.

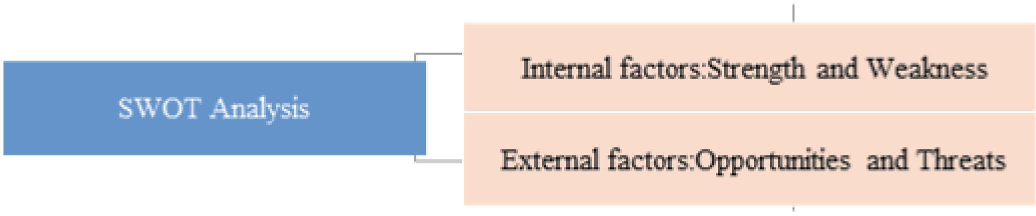

Figure 2: Elements of the SWOT analysis GÜREL and TAT (2017)[18]

The application and analysis of the SWOT analysis are made using the DT. DT can be defined as a group interaction among several people well-chosen, which are called the experts, by a mean of a questionnaire that usually consists of 3-rounds or more [28]. The primary purpose of the DT is to reach the most credible consensus from the experts' responses through the series of questionnaires [29]. This can be established by sending a questionnaire to a group of experts. Then, the results and responses are analyzed and sent back to the experts' group with the question of their responses need to be altered. These steps are repeated till a consensus is reached, and the group's final response can be reported. The DT is considered a great approach for decision-making related to many experts through the use of recent technologies like emails and online questionnaire options. This facilitates contacting experts in different locations and makes the collection and analysis of responses much more easily [14]. Liker-scale is used in research that focuses on the evaluation and ranking of objects, and it is usually used in line with the DT to collect experts' opinions. There is a five-point scale seven-point scale (Figure 3), and sometimes it is developed into a nine-point scale with two linguistic scales on both ends "strongly agree" and "strongly disagree" [30].

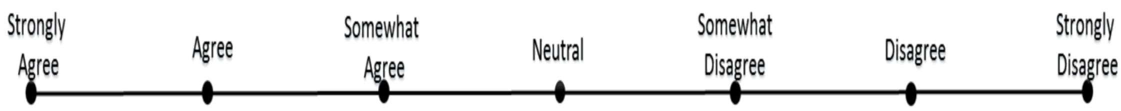

Figure 3: Sample of seven-points Liker-scale used

In this study, the seven-point Liker scale was selected due to its advantage in obtaining better performance than a five-point scale via supplying more choice options and providing the opportunity for a better expression of opinion [31]. Considering the Rustumiya WWTP as a case study, the SWOT method for assessing the WWTPs in Iraq is applied using the DT and adopting the seven-point Liker-scale. Three rounds of the questionnaire were conducted, starting from creating the requirements of the experts' group in terms of qualification, general and precise specialization, years of experience, and the number of experts in the group. Then, the questionnaire was sent and collected to gather the opinion of experts. The following step was followed to analyze the responses and determine the consensus level. If consensus is not achieved, then another round is sent. This step is repeated until consensus is achieved.

2.2.1 A- Composition and panel size of experts

The first step in applying the DT and implementing the research work is the design of an expert panel. This step began by targeting experts within the specializations close to the field of research. After the sample size of experts was determined, it was found that the experts belong to various work sectors such as the Ministry of Higher Education, Ministry of Water Resources, and Ministry of Municipalities. The experts' work positions vary from department managers, professors, and designers to operation and maintenance workers inside the plants themselves. To this end, a group of tables was formed to summarize the experts' information and numbers in the panel. The first table involved the sector name and number of experts in each sector; the second table involved the academic qualification and the number of experts in each academic qualification. The included academic qualifications were Technical Diploma, Bachelor, Higher Diploma, Master, and Doctorate; the third table involved the years of experience and the number of experts in each category of years of experience. The years of experience were divided into five categories: <10, 10-20, 20-30, 30-40, and >40.

2.2.2 B- Gathering expert's opinions

In this step, the questionnaire was distributed among experts, and responses were collected to measure the achieved level of consensus for each round.

2.2.2.1 First questionnaire

This questionnaire was an open type to give the experts more freedom to express their opinions in locating the significant items of SWOT elements. It contained five sections: personal information of the experts, Strengths, Weaknesses, Opportunities, and Threats.

2.2.2.2 Second questionnaire

This questionnaire was a closed type to reveal the groups of SWOT elements resulting from the first questionnaire. This is to confirm that the selected groups of the SWOT elements truly depict the purpose and objectives of the research. In addition, to give a chance to measure the importance of an element more than the other or to add, remove, and replace elements, taking into account that the questionnaire's content should be reviewed by experts specializing in this field to ensure complete clarity in asking questions and ideas. Finally, a group of tables was performed to arrange and evaluate experts' responses in preparation for the next questionnaire round. These tables are divided into two parts. The first part contains a table for each element of the SWOT analysis to show its Issues. The second group contains tables with three evaluations (A, B, and C) for each item of the SWOT analysis to arrange the results of the previous questionnaire using the Liker-scale. The rating group A represents the responses with high points from the Liker-scale (6, 7), the B rating group represents responses with medium points (5, 4, 3), and the C evaluation group represents the responses with the lowest points (1, 2).

2.2.2.3 Third questionnaire

This questionnaire is designed based on the second round's results in a closed type of questionnaire in a different rating form depending on the following scale (7, 5, 3, 1), where 7 is given to the most significant items of the SWOT elements and 1 to the least. The benefit of this rating is to measure the degree of importance and the relative importance for each item in the SWOT elements as well as for the aggregates, followed by the formation of dual comparison matrices first between the items of the SWOT elements and second between the SWOT elements themselves.

2.2.3 As a result, the third questionnaire ends by:

The first step is generating the dual comparison matrices for each SWOT element to compare the items inside the group. So there is a dual comparison matrix for every SWOT element and a dual comparison matrix for the element’s issues. The second step generates the dual comparison matrices between the SWOT elements and the calculation of weights of items in each group of the SWOT elements and their relative importance. Weights were calculated for each element according to Eq. (1) and performed a matrix marital comparison of the SWOT issue. By including the weight of each issue by Eq. (3), the relative importance of each component compared with all of the elements within the four issues is calculated according to Eq. (4).

$$Wi = {}^{Xi}/_{n} \quad (1)$$

$$Xi = \sum_{i=1}^{n} xi \quad (2)$$

Where x_i, Xi, n, i represents the weight element i in the issue that belongs, the sum of the values of the comparison of the marital element i within the issue which belongs, the number of elements of the issue that belongs element I, the element i in the issue respectively.

$$\mu i = \frac{\sum_{i=1}^{n} \alpha i}{4} \quad (3)$$

Where μi, αi represent: the weight of issue I, the sum of the comparison issue's marital I values, respectively.

$$\omega i = \mu i * Xi \quad (4)$$

Where ωi represents the relative importance of the element i.

According to these results, these elements are recognized in two main groups:

- First group: It comprises all the elements that got the highest degree of importance of the probability of occurrence of each element (the possibility of a single element, 1⁄n where n is the total elements in four groups)
- The second group: includes all the elements that got the degree of importance of the less likelihood of each element.

2.2.4 Displaying the results of the evaluation:

The result may be presented in many ways, but charts especially bar charts, might be the most suitable because they are presented comparatively.

3. Results and Discussions

3.1 Analysis of panel and Experts' Information

Qualification, general and precise specialization, work sector, and years of experience of the experts' sample, which includes 84 experts, are illustrated in Figure 4. First, this figure shows the major part of the qualifications of the expert's panel is occupied by the doctoral degree. Secondly, the figure displays the diversity of the general specialization of the expert panel, as the largest part is occupied by the civil engineering specialization (55%), followed by mechanical (12%) and environmental engineering (8%), which is the most important specialization in the process of designing and maintaining wastewater treatment plants. Finally, for electrical engineering, the percentage is less than required, despite the importance of electrical maintenance for the various parts of the plant.

From Figure 5, it can be seen that despite the major part of the general specialization of the experts being civil engineering, the important precise specializations for designing, maintaining, and operating the plant are less than necessary. Examples of these specializations are sanitary engineering and water quality. Environmental engineering remains in the largest position, followed by water resources engineering. Therefore, experts with different affiliations were targeted in Figure 6, such as higher education professors, lecturers, designers from the Ministry of Water Resources, etc., with years of service ranging from one year to more than 40 years. The sample of experts included the various Iraqi governorates. Still, the largest part was from the share of Baghdad Governorate, as it is the region concerned for this study, in addition to the variation in work positions, where the heads of departments, designers, maintenance planners, and personnel involved in the operation process were included as shown in Figure 7.

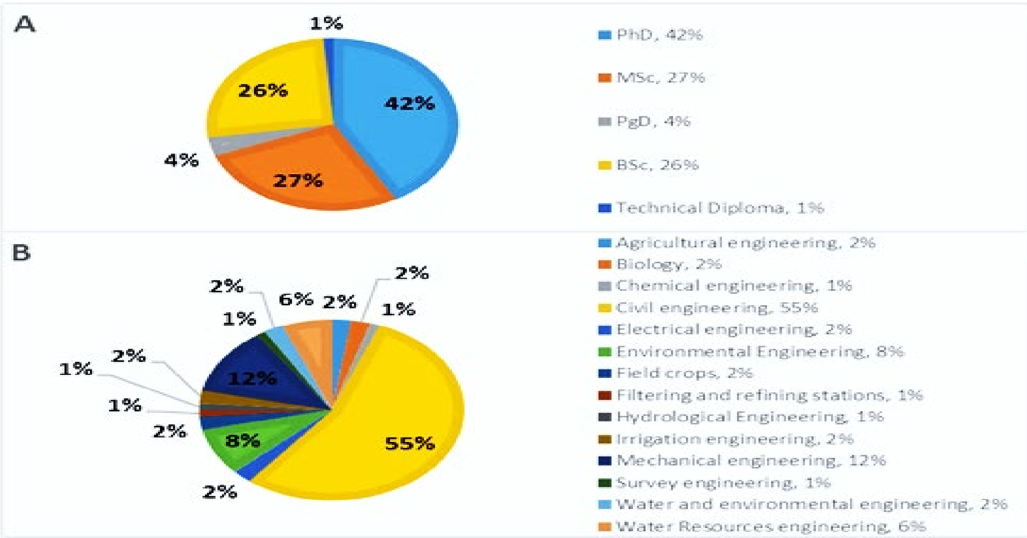

Figure 4: Analysis of the experts' sample A) Qualification, B) General specialization

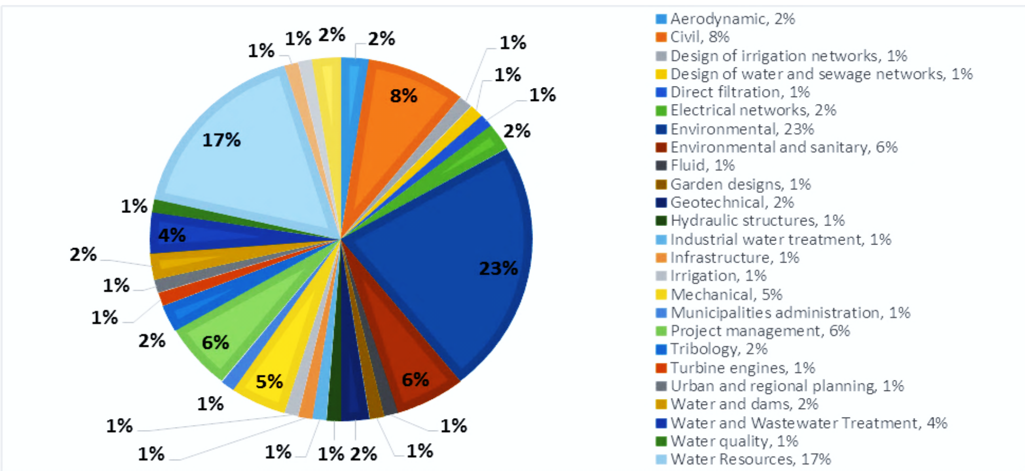

Figure 5: Analysis of the experts' sample precise specialization

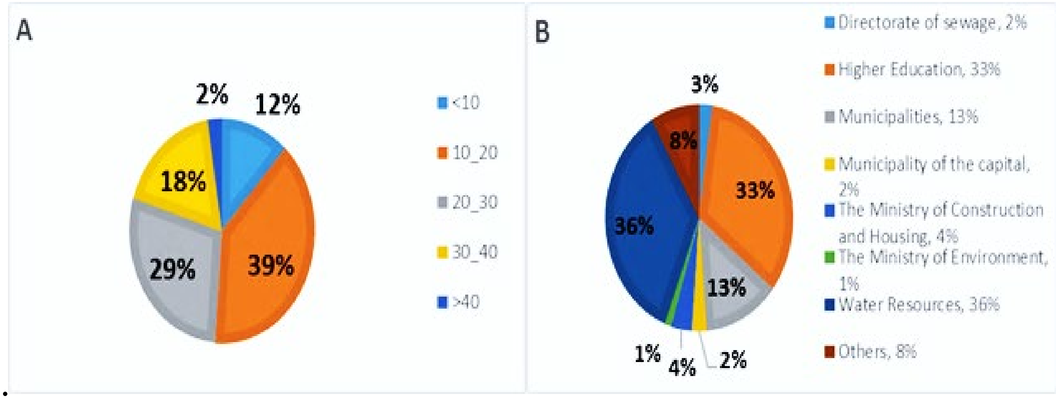

Figure 6: Analysis of the experts' sample: A) Years of experience, B) Affiliation

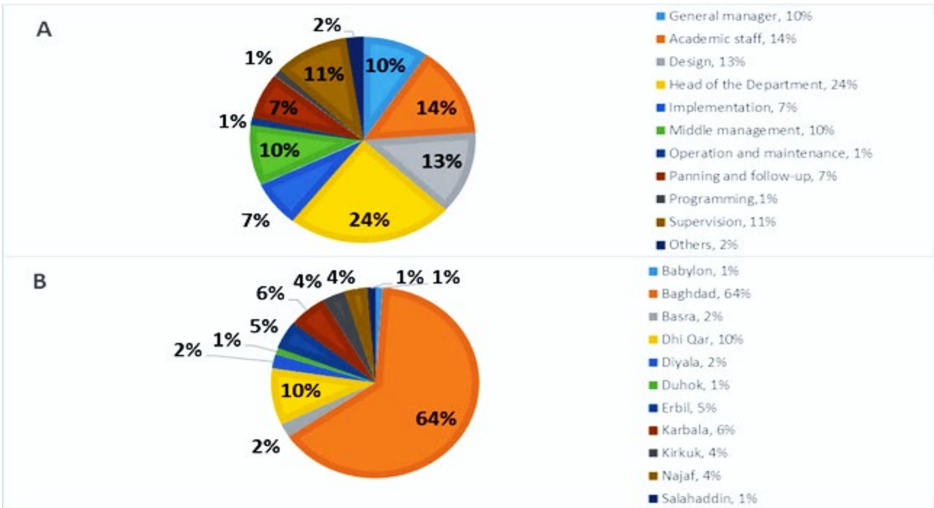

Figure 7: Analysis of the experts' sample: A) Administrative position, B) Work location

3.2 Results of Questionnaires Rounds

3.2.1 A- The first round of questionnaires

The divisions and questions of the first questionnaire were designed as an open questionnaire by the researchers and then inspected by senior experts in this field to ensure the clarity of the questions. It includes five sections: The first section is concerned with full information of experts in terms of qualification, years of experience, general and precise specialization, and work sector, while the other four sections represent the SOWT elements of the plant in a detailed way to gain all information possible from experts on each item in the SWOT elements. Then, this questionnaire was converted into an electronic version via the Google Form to facilitate sending and receiving it to and from the experts to ensure the preservation of time. Almost 34 experts participated in the first questionnaire, which determined the items in each group of the SWOT elements (Strength, Weakness, Opportunities, and Threats) in the method, material, and human resources issues.

3.2.2 B- The second round of questionnaires

The design of the second questionnaire is based on the analysis of the responses to the first questionnaire. It is designed in the form of a closed questionnaire to verify the accuracy of the experts' answers in the first questionnaire. Questions are repeated to the experts with a narrow response range to obtain clearer responses that facilitate rating all items in the SWOT elements through a seven-point Liker-scale with two linguistic variables, "Strongly Agree" and "Strongly Disagree," located on both ends of the scale. Over 85 experts participated in the second questionnaire resulted in determining the issues of each element of the SWOT groups, categorizing the SWOT elements into agreed on, disagreed on, and neither. The changes proposed by the experts are implemented in the design of the third questionnaire. This approach was made by preserving the questions rated (A) for more than 67% and excluding the questions rated (C) for more than 67%. The results of the second questionnaire are illustrated in Tables 2 to 5.

Table 2: Topics and strength elements

Issue	Sequence	Strength Elements	A	B	C
Methods	1	There is a plan to manage the maintenance work of the wastewater treatment plants.	27	42	15
	2	There is a plan to monitor the water quality and the performance of the wastewater network.	34	36	14
	3	Effective and appropriate legislation protects and develops wastewater networks and stations.	30	32	22
	4	There is a real and sufficient database on wastewater networks and stations.	29	40	15
	5	Maintenance priorities are set within the maintenance plan and approved in implementing the maintenance plan.	33	37	14
	6	There are standards, limitations, and methods to determine maintenance priorities.	34	36	14
	7	A distinction is made between the importance and weight of the maintenance items, and there are mechanisms used to determine this.	35	35	14
	8	There is a clear plan and criteria for determining the maintenance budget and distributing it to the maintenance items.	27	46	11
	9	Recent software and techniques are used to manage and implement the maintenance plan.	20	33	31
	10	Recent software and techniques are used in reviewing project parts and conducting evaluation and decision-making.	23	30	31
	11	The economic feasibility study is carried out, and the preference is determined between the rehabilitation and development of a previous project and the establishment of a new project.	28	37	19
	12	There is a clear methodology for studying the integrated feasibility of wastewater treatment plants and including the methodology for implementing comprehensive maintenance.	23	45	16
	13	Considering the infrastructure near the project area and the ways to make the most of it in implementing comprehensive maintenance programs.	30	40	14
	14	The characteristics of the project area, its advantages, and disadvantages are taken into consideration to ensure the benefit from these advantages and reduce the defects	30	44	10
	15	An appropriate database concerns the quantities, types, sources, and costs of maintenance materials, construction materials, and other materials in the project area.	26	41	17
	16	Maintenance materials, construction materials, and other materials are identified and classified in the project area.	24	52	8
	17	There is a plan to manage maintenance and construction materials in the project.	23	50	11
Materials	18	There is a plan to administer the examinations and control and ensure the quality.	27	43	14
	19	There is a plan to manage the waste of maintenance materials, construction materials, and waste of maintenance work.	23	31	30
	20	Materials that have a negative effect on the surrounding environment are identified and controlled, and their use is restricted.	28	33	23
	21	The role of quantity surveying and estimate engineering in the project will be activated concerning the use of maintenance and construction materials in the project area.	28	36	20
	22	The renewable materials are identified in the project area, and a plan for their use is developed.	24	31	29
	23	The team is well versed and clearly familiar with the elements of sustainable design to reduce maintenance work.	29	37	18
	24	The requirements and design standards are confirmed clearly and in detail, considering the implementation of maintenance work in the future.	27	46	11
Human Resources	25	A summary or flowchart is prepared for the methods used in the design, including future maintenance work.	28	37	19
	26	The organizational structure of the project authority is consistent with the duties assigned to them or needs amendments.	25	52	7
	27	The human resources in the project are proportional to their size and allocations with the work assigned to them.	30	39	15
	28	There is a job description for employees who work in responsible positions.	33	30	21
	29	The administrative level responsible for developing and approving the maintenance plan is appropriate.	28	41	15
	30	The administrative level responsible for distributing the maintenance budget to the activities is appropriate.	20	46	18
	31	There is a specific program to train and develop employees, especially in the area of comprehensive maintenance methodology.	20	43	21
	32	There is a program for awareness and guidance for users (residents) regarding the importance of wastewater treatment networks and stations and the need to preserve them as one of the pillars of health and a sustainable environment.	18	42	24
	33	Periodical brochures are issued on concepts and applications of comprehensive maintenance towards sustainable development related to wastewater treatment networks and plants.	16	36	32

Table 2: Continued

Issue	Sequence	Strength Elements	A	B	C
	34	According to specific programs for the comprehensive maintenance of wastewater treatment networks and stations, communication with civil society organizations is carried out.	21	38	25
	35	International consulting companies are used to prepare integrated programs to maintain wastewater treatment networks and plants.	28	34	22
	36	Wastewater treatment networks and stations are always implemented by specialized and experienced companies preparing a comprehensive operation and maintenance manual.	31	34	19
	37	International and local companies and consultancy offices are used to update previous designs, provide solutions and advice to operational problems, or evaluate work skills or laboratory testing.	24	46	14
	38	There is a clear methodology for the succession and replacement process for employees.	19	38	27
	39	There is a consistent methodology for assigning employees to positions of responsibility.	22	31	31

Table 3: Topics and Weakness elements

Issue	Sequence	Weakness Elements	A	B	C
Methods	1	The control and management of wastewater treatment networks and plants are still done manually and on-site by traditional methods, and no recent technology has been introduced in this field.	53	28	3
	2	There is no relationship between managing and operating wastewater treatment networks and stations and carrying out maintenance work.	38	41	5
	3	There is no specific plan to rehabilitate the sewage networks in line with the maintenance priorities of the wastewater treatment plants.	44	35	5
	4	Misuse and neglect of maintenance are among the most important factors that disrupt and destroy the wastewater networks and treatment plants.	63	18	3
	5	Preparing sustainable designs is an obstacle to the implementation of wastewater treatment networks and plants.	34	38	12
	6	There are problems associated with a financial allocation that hinder the implementation and maintenance of wastewater treatment networks and stations and their maintenance.	54	23	7
	7	Segmentation of maintenance work for wastewater treatment networks and stations in stages and operating parts of the system before completing the other phases.	41	36	7
	8	The drought and climate change phenomenon imposes restrictions and limitations on wastewater treatment networks and stations and the associated maintenance work.	27	40	17
	9	Climate change plays a role in obstructing the implementation of maintenance programs.	17	38	29
	10	The lack of diversity in energy sources used in operating networks and wastewater treatment plants during implementation, operation, and maintenance represent major weaknesses.	49	28	7
	11	There is no acceptable treatment for dirty energy waste used to carry out maintenance work.	54	29	1
	12	There are networks and wastewater treatment plant projects that have completely or partially failed due to lack of operation and maintenance due to the Shortage of electrical power.	35	39	10
Materials	13	Unavailability of the materials used in the operation and maintenance of the project in the project area in their normal form. Even if they are available, it is most likely that some operations are needed to make them suitable for use.	37	43	4
	14	The transportation of maintenance and construction materials to the project site faces problems and difficulties, especially with large and special loads.	24	47	13
	15	Quality control and assurance processes face problems and obstacles, especially in remote areas.	51	28	5
	16	There is a weakness in managing the waste of maintenance materials and construction materials during the implementation of maintenance work.	57	27	0
	17	There is a weakness in using recent software and tools for design, operation, and sustainable maintenance.	55	29	0
	18	The workers 'lack of knowledge of sustainable and value engineering concepts is a hindrance when designing networks and wastewater treatment plants and implementing operation and maintenance programs.	56	26	2
	19	The surrounding environment and its resources place constraints on project designs and the implementation of maintenance programs and their priorities.	48	33	3
	20	There is a weakness and imbalance in the organizational structure for managing, operating, and maintaining sewage water treatment plants and networks.	40	43	1
Human Resources	21	The failure of the administrative leadership of some wastewater treatment plants and networks.	47	32	5
	22	Training courses are not appropriate in terms of their content and number.	43	38	3
	23	There is no incentive and encouragement system designated for workers in wastewater water treatment plants and networks.	49	33	2
	24	There is no workable plan for the occupational health and safety of the project.	60	23	1
	25	The qualifications and job description are not adhered to appoint employees to work in positions of responsibility and leadership.	64	18	2
	26	There is a need to pass new laws and legislation or amend previous laws concerning the institutional organization and management of human resources in wastewater treatment networks and plants.	61	21	2

Table 4: Topics and Opportunities elements

Issue	Sequence	Opportunities Elements	A	B	C
Methods	1	Maintenance costs should be calculated by choosing modern management systems for the operation and maintenance of projects.	64	20	0
	2	Coordination must occur with other relevant ministries in the field of renewable energy use in implementing maintenance programs and setting up a permanent work approach for that.	71	13	0
Materials	3	The use of the materials available in the project area must be activated, especially the renewable ones.	69	15	0
	4	The reuse and recycling process must be activated.	73	11	0
Human Resources	5	Technological development and software should be taken advantage of in managing supply and processing workers and controlling storage.	72	10	2

Table 5: Topics and Threats elements

Issue	Sequence	Threats Elements	A	B	C
Methods	1	Climate changes and the lack of available water resources affect the management and maintenance of wastewater treatment networks and plants.	40	36	8
	2	The increase in population and population density in cities affects the management and maintenance of wastewater treatment networks and plants.	70	12	2
Materials	3	The high pollution rates in the incoming water affect the infrastructure of sewage treatment networks and plants.	65	19	0
	4	The increase in trespassing on sanitation networks affects the operation and maintenance of wastewater treatment networks and stations.	76	8	0
Human Resources	5	Weakness in supporting senior departments to implement maintenance programs.	62	21	1
	6	The absence of laws or instructions regulating or specifying the times and places for implementing maintenance programs.	52	28	4
	7	The absence of environmental or social determinants that regulate or specify times and places for implementing maintenance programs.	52	29	3

Table 6: Dual comparison matrix of the SWOT elements

	SWOT elements	**S**	**W**	**O**	**T**
SWOT elements	Group weight	0.208	0.292	0.292	0.208
S	0.208	1.00	0.714	0.714	1.000
W	0.292	1.40	1.00	1.00	1.40
O	0.292	1.40	1.00	1.00	1.40
T	0.208	1.00	0.71	0.71	1.00

Starting from the experts' responses to the strengths element shown in Table 2, most of the agreement on the decision can be felt on the questions that belong to the Methods Issue. In this issue, some key points were supported, such as "the existence of a master plan to monitor the quality of the outgoing water and the plant's performance, taking into consideration the advantages of the plant's area and how to benefit from it". The most agreed on among the strengths element items is “A distinction is made between the importance and weight of the maintenance items, and there are mechanisms used to determine this” which truly represents one of the most important strengths within the plant in terms of maintenance and operation activities. Among the strength element items that the experts strongly rejected lies within the issue of Human Resources, which is the periodic distributions of brochures of the principles and applications of comprehensive maintenance through the theories of sustainability of wastewater treatment plants. For the weakness element. Table III, most of its items were agreed on, like operation and maintenance activities inside the wastewater treatment plants are still being accomplished manually. It is one of the weaknesses that has been agreed upon by more than 50 experts, especially when the positions of leadership and responsibility aren't filled upon experience and specialization. However, the only point that was disapproved strongly is that climate change can obstruct maintenance activities which is mainly true considering the weather in Iraq is extremely hot and dry. For the opportunities element illustrated in Table 4, the experts agreed on most of the involved elements. Also, they strongly agreed that reuse and recycling processes must be activated. However, in the threats element, Table 5, it was agreed on its points in general and especially the point "the increase in trespassing on sanitation networks affects the operation and maintenance of wastewater treatment networks and stations" which is actually destroying most of the treatment of the plants because the water loses its quality before reaching the destined points of usage.

3.2.3 C The third round of the questionnaire

At last, the weights of all items of SWOT elements groups and the weight of the groups themselves are computed. By looking at Figure 8a, it can be noticed that in all issues, the strength element have the same weights due to the individual importance of each one of the topics. The same applies to the Opportunities element in all issues, Figures 8c. Also, the methods possess the least weight for the weakness element shown in Figure 8b because the Iraqi plant keeps pace with the world. Still, they lack modernity and development in materials and human resources. Consequently, these two issues are equal in weight. Finally, the threats element in all issues, Figure 8d and varies in weights, where the materials take the higher importance and weight, unlike the human resources issue, which holds the lowest weight. While Figure 9 depicts the degree of importance of the SWOT elements. In the internal elements (Strength, Weakness), the weakness element has a higher importance value. However, the opportunities element is considered more important than the external elements (Opportunities, Threats). The dual comparison matrix of the SWOT elements, see Table 6, gives a detailed idea when comparing the SWOT elements with one another. The 1.4 is the highest value that appeared more than once, like in comparing weakness and threats elements. This gives the advantage in importance to the weakness. Whereas the lowest value is 0.71 by comparing, for example, the strength and opportunities elements. Therefore, the opportunities element is the more important between the two elements. The final result of the research can be explained in detail through the double comparison matrices. A matrix has been created for each element of the SWOT analysis to compare the items of the element one by one based on the value of the relative importance of the items. The highest values are highlighted in yellow and the lowest in red. The dual comparison of the Strength Element is shown in Tables 7 and 8. It can be seen from these tables that the highest comparison value was 4.31 while the lowest was 0.23. The highest value proves that having a plan for managing and controlling the effluent quality is more important than having standards and limitations for setting the maintenance priorities. Whereas the lowest value reveals the importance of recognizing the renewable materials in the area to include them as a resource over deciding whether to develop an existing project or build a new one. The dual comparison matrix of the Weakness element is shown in Tables 9 and10. These tables show that the highest recorded value was 4.40 and the lowest was 0.23, as a way to facilitate the understanding of the implementation of maintenance and operation activities manually is worse than the obstruction of the surrounding for the plant's design. The opportunities element dual comparison matrix, Table11, shows that 2.00 was the highest and 0.50 was the lowest. For example, the comparison between

item1 and 5 Clarify that using software and modern application for managing the plant components and controlling the maintenance and operation activities is a better step to follow than calculating costs by modern management systems for the operation and maintenance of projects. Finally, the Threats element's dual comparison matrix, shown in Table 12, shows that 4.28 was the highest value and 0.23 was the lowest. This displays that climate changes and the lack of available water resources are more threatening than the lack of environmental determinants that regulate times and places for implementing maintenance programs for managing and maintaining wastewater treatment networks and plants.

Figure 8: Degree of the importance of the SWOT elements

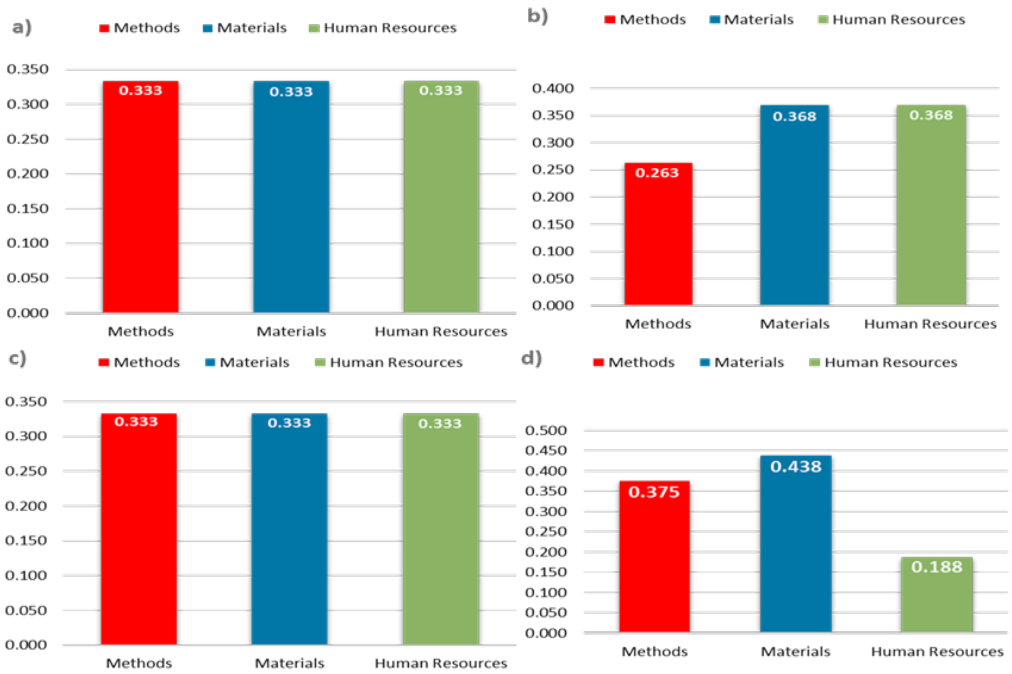

Figure 9: Topics' weights a) Strength element, b) Weakness element, c) Opportunities element, d) Threat element

Table 7: Dual comparison matrix of the strength elements part 1

	RI	0.022	0.022	0.022	0.022	0.022	0.013	0.022	0.022	0.013	0.013	0.013	0.013	0.022	0.022	0.022	0.022	0.022	0.057	0.034
RI	sequence	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
0.022	1	1.00	1.00	1.00	1.00	1.00	1.67	1.00	1.00	1.67	1.67	1.67	1.67	1.00	1.00	1.00	1.00	1.00	0.39	0.64
0.022	2	1.00	1.00	1.00	1.00	1.00	1.67	1.00	1.00	1.67	1.67	1.67	1.67	1.00	1.00	1.00	1.00	1.00	0.39	0.64
0.022	3	1.00	1.00	1.00	1.00	1.00	1.67	1.00	1.00	1.67	1.67	1.67	1.67	1.00	1.00	1.00	1.00	1.00	0.39	0.64
0.022	4	1.00	1.00	1.00	1.00	1.00	1.67	1.00	1.00	1.67	1.67	1.67	1.67	1.00	1.00	1.00	1.00	1.00	0.39	0.64
0.022	5	1.00	1.00	1.00	1.00	1.00	1.67	1.00	1.00	1.67	1.67	1.67	1.67	1.00	1.00	1.00	1.00	1.00	0.39	0.64
0.013	6	0.60	0.60	0.60	0.60	0.60	1.00	0.60	0.60	1.00	1.00	1.00	1.00	0.60	0.60	0.60	0.60	0.60	0.23	0.39
0.022	7	1.00	1.00	1.00	1.00	1.00	1.67	1.00	1.00	1.67	1.67	1.67	1.67	1.00	1.00	1.00	1.00	1.00	0.39	0.64
0.022	8	1.00	1.00	1.00	1.00	1.00	1.67	1.00	1.00	1.67	1.67	1.67	1.67	1.00	1.00	1.00	1.00	1.00	0.39	0.64
0.013	9	0.60	0.60	0.60	0.60	0.60	1.00	0.60	0.60	1.00	1.00	1.00	1.00	0.60	0.60	0.60	0.60	0.60	0.23	0.39
0.013	10	0.60	0.60	0.60	0.60	0.60	1.00	0.60	0.60	1.00	1.00	1.00	1.00	0.60	0.60	0.60	0.60	0.60	0.23	0.39
0.013	11	0.60	0.60	0.60	0.60	0.60	1.00	0.60	0.60	1.00	1.00	1.00	1.00	0.60	0.60	0.60	0.60	0.60	0.23	0.39
0.013	12	0.60	0.60	0.60	0.60	0.60	1.00	0.60	0.60	1.00	1.00	1.00	1.00	0.60	0.60	0.60	0.60	0.60	0.23	0.39
0.022	13	1.00	1.00	1.00	1.00	1.00	1.67	1.00	1.00	1.67	1.67	1.67	1.67	1.00	1.00	1.00	1.00	1.00	0.39	0.64
0.022	14	1.00	1.00	1.00	1.00	1.00	1.67	1.00	1.00	1.67	1.67	1.67	1.67	1.00	1.00	1.00	1.00	1.00	0.39	0.64
0.022	15	1.00	1.00	1.00	1.00	1.00	1.67	1.00	1.00	1.67	1.67	1.67	1.67	1.00	1.00	1.00	1.00	1.00	0.39	0.64
0.022	16	1.00	1.00	1.00	1.00	1.00	1.67	1.00	1.00	1.67	1.67	1.67	1.67	1.00	1.00	1.00	1.00	1.00	0.39	0.64
0.022	17	1.00	1.00	1.00	1.00	1.00	1.67	1.00	1.00	1.67	1.67	1.67	1.67	1.00	1.00	1.00	1.00	1.00	0.39	0.64
0.057	18	2.59	2.59	2.59	2.59	2.59	4.31	2.59	2.59	4.31	4.31	4.31	4.31	2.59	2.59	2.59	2.59	2.59	1.00	1.67

Table 7: Continued

	RI	0.022	0.022	0.022	0.022	0.022	0.013	0.022	0.022	0.013	0.013	0.013	0.013	0.022	0.022	0.022	0.022	0.022	0.057	0.034
RI	sequence	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
0.034	19	1.55	1.55	1.55	1.55	1.55	2.59	1.55	1.55	2.59	2.59	2.59	2.59	1.55	1.55	1.55	1.55	1.55	0.60	1.00
0.057	20	2.59	2.59	2.59	2.59	2.59	4.31	2.59	2.59	4.31	4.31	4.31	4.31	2.59	2.59	2.59	2.59	2.59	1.00	1.67
0.034	21	1.55	1.55	1.55	1.55	1.55	2.59	1.55	1.55	2.59	2.59	2.59	2.59	1.55	1.55	1.55	1.55	1.55	0.60	1.00
0.057	22	2.59	2.59	2.59	2.59	2.59	4.31	2.59	2.59	4.31	4.31	4.31	4.31	2.59	2.59	2.59	2.59	2.59	1.00	1.67
0.057	23	2.59	2.59	2.59	2.59	2.59	4.31	2.59	2.59	4.31	4.31	4.31	4.31	2.59	2.59	2.59	2.59	2.59	1.00	1.67
0.034	24	1.55	1.55	1.55	1.55	1.55	2.59	1.55	1.55	2.59	2.59	2.59	2.59	1.55	1.55	1.55	1.55	1.55	0.60	1.00
0.026	25	1.19	1.19	1.19	1.19	1.19	1.98	1.19	1.19	1.98	1.98	1.98	1.98	1.19	1.19	1.19	1.19	1.19	0.46	0.77
0.026	26	1.19	1.19	1.19	1.19	1.19	1.98	1.19	1.19	1.98	1.98	1.98	1.98	1.19	1.19	1.19	1.19	1.19	0.46	0.77
0.026	27	1.19	1.19	1.19	1.19	1.19	1.98	1.19	1.19	1.98	1.98	1.98	1.98	1.19	1.19	1.19	1.19	1.19	0.46	0.77
0.026	28	1.19	1.19	1.19	1.19	1.19	1.98	1.19	1.19	1.98	1.98	1.98	1.98	1.19	1.19	1.19	1.19	1.19	0.46	0.77
0.026	29	1.19	1.19	1.19	1.19	1.19	1.98	1.19	1.19	1.98	1.98	1.98	1.98	1.19	1.19	1.19	1.19	1.19	0.46	0.77
0.026	30	1.19	1.19	1.19	1.19	1.19	1.98	1.19	1.19	1.98	1.98	1.98	1.98	1.19	1.19	1.19	1.19	1.19	0.46	0.77
0.016	31	0.71	0.71	0.71	0.71	0.71	1.19	0.71	0.71	1.19	1.19	1.19	1.19	0.71	0.71	0.71	0.71	0.71	0.28	0.46
0.016	32	0.71	0.71	0.71	0.71	0.71	1.19	0.71	0.71	1.19	1.19	1.19	1.19	0.71	0.71	0.71	0.71	0.71	0.28	0.46
0.016	33	0.71	0.71	0.71	0.71	0.71	1.19	0.71	0.71	1.19	1.19	1.19	1.19	0.71	0.71	0.71	0.71	0.71	0.28	0.46
0.016	34	0.71	0.71	0.71	0.71	0.71	1.19	0.71	0.71	1.19	1.19	1.19	1.19	0.71	0.71	0.71	0.71	0.71	0.28	0.46
0.016	35	0.71	0.71	0.71	0.71	0.71	1.19	0.71	0.71	1.19	1.19	1.19	1.19	0.71	0.71	0.71	0.71	0.71	0.28	0.46
0.026	36	1.19	1.19	1.19	1.19	1.19	1.98	1.19	1.19	1.98	1.98	1.98	1.98	1.19	1.19	1.19	1.19	1.19	0.46	0.77
0.026	37	1.19	1.19	1.19	1.19	1.19	1.98	1.19	1.19	1.98	1.98	1.98	1.98	1.19	1.19	1.19	1.19	1.19	0.46	0.77
0.026	38	1.19	1.19	1.19	1.19	1.19	1.98	1.19	1.19	1.98	1.98	1.98	1.98	1.19	1.19	1.19	1.19	1.19	0.46	0.77
0.016	39	0.71	0.71	0.71	0.71	0.71	1.19	0.71	0.71	1.19	1.19	1.19	1.19	0.71	0.71	0.71	0.71	0.71	0.28	0.46

Table 8: Dual comparison matrix of the strength elements part 2

	RI	0.057	0.034	0.057	0.057	0.034	0.026	0.026	0.026	0.026	0.026	0.026	0.016	0.016	0.016	0.016	0.016	0.026	0.026	0.026	0.016
RI	sequence	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39
0.022	1	0.39	0.64	0.39	0.39	0.64	0.84	0.84	0.84	0.84	0.84	0.84	1.40	1.40	1.40	1.40	1.40	0.84	0.84	0.84	1.40
0.022	2	0.39	0.64	0.39	0.39	0.64	0.84	0.84	0.84	0.84	0.84	0.84	1.40	1.40	1.40	1.40	1.40	0.84	0.84	0.84	1.40
0.022	3	0.39	0.64	0.39	0.39	0.64	0.84	0.84	0.84	0.84	0.84	0.84	1.40	1.40	1.40	1.40	1.40	0.84	0.84	0.84	1.40
0.022	4	0.39	0.64	0.39	0.39	0.64	0.84	0.84	0.84	0.84	0.84	0.84	1.40	1.40	1.40	1.40	1.40	0.84	0.84	0.84	1.40
0.022	5	0.39	0.64	0.39	0.39	0.64	0.84	0.84	0.84	0.84	0.84	0.84	1.40	1.40	1.40	1.40	1.40	0.84	0.84	0.84	1.40
0.013	6	0.23	0.39	0.23	0.23	0.39	0.50	0.50	0.50	0.50	0.50	0.50	0.84	0.84	0.84	0.84	0.84	0.50	0.50	0.50	0.84
0.022	7	0.39	0.64	0.39	0.39	0.64	0.84	0.84	0.84	0.84	0.84	0.84	1.40	1.40	1.40	1.40	1.40	0.84	0.84	0.84	1.40
0.022	8	0.39	0.64	0.39	0.39	0.64	0.84	0.84	0.84	0.84	0.84	0.84	1.40	1.40	1.40	1.40	1.40	0.84	0.84	0.84	1.40
0.013	9	**0.23**	**0.39**	**0.23**	**0.23**	**0.39**	**0.50**	**0.50**	**0.50**	**0.50**	**0.50**	**0.50**	**0.84**	**0.84**	**0.84**	**0.84**	**0.84**	**0.50**	**0.50**	**0.50**	**0.84**

Table 8: Continued

	RI	0.057	0.034	0.057	0.057	0.034	0.026	0.026	0.026	0.026	0.026	0.026	0.016	0.016	0.016	0.016	0.016	0.026	0.026	0.026	0.016
RI	sequence	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39
0.013	10	0.23	0.39	0.23	0.23	0.39	0.50	0.50	0.50	0.50	0.50	0.50	0.84	0.84	0.84	0.84	0.84	0.50	0.50	0.50	0.84
0.013	11	0.23	0.39	0.23	0.23	0.39	0.50	0.50	0.50	0.50	0.50	0.50	0.84	0.84	0.84	0.84	0.84	0.50	0.50	0.50	0.84
0.013	12	0.23	0.39	0.23	0.23	0.39	0.50	0.50	0.50	0.50	0.50	0.50	0.84	0.84	0.84	0.84	0.84	0.50	0.50	0.50	0.84
0.022	13	0.39	0.64	0.39	0.39	0.64	0.84	0.84	0.84	0.84	0.84	0.84	1.40	1.40	1.40	1.40	1.40	0.84	0.84	0.84	1.40
0.022	14	0.39	0.64	0.39	0.39	0.64	0.84	0.84	0.84	0.84	0.84	0.84	1.40	1.40	1.40	1.40	1.40	0.84	0.84	0.84	1.40
0.022	15	0.39	0.64	0.39	0.39	0.64	0.84	0.84	0.84	0.84	0.84	0.84	1.40	1.40	1.40	1.40	1.40	0.84	0.84	0.84	1.40
0.022	16	0.39	0.64	0.39	0.39	0.64	0.84	0.84	0.84	0.84	0.84	0.84	1.40	1.40	1.40	1.40	1.40	0.84	0.84	0.84	1.40
0.022	17	0.39	0.64	0.39	0.39	0.64	0.84	0.84	0.84	0.84	0.84	0.84	1.40	1.40	1.40	1.40	1.40	0.84	0.84	0.84	1.40
0.057	18	1.00	1.67	1.00	1.00	1.67	2.17	2.17	2.17	2.17	2.17	2.17	3.62	3.62	3.62	3.62	3.62	2.17	2.17	2.17	3.62
0.034	19	0.60	1.00	0.60	0.60	1.00	1.30	1.30	1.30	1.30	1.30	1.30	2.17	2.17	2.17	2.17	2.17	1.30	1.30	1.30	2.17
0.057	20	1.00	1.67	1.00	1.00	1.67	2.17	2.17	2.17	2.17	2.17	2.17	3.62	3.62	3.62	3.62	3.62	2.17	2.17	2.17	3.62
0.034	21	0.60	1.00	0.60	0.60	1.00	1.30	1.30	1.30	1.30	1.30	1.30	2.17	2.17	2.17	2.17	2.17	1.30	1.30	1.30	2.17
0.057	22	1.00	1.67	1.00	1.00	1.67	2.17	2.17	2.17	2.17	2.17	2.17	3.62	3.62	3.62	3.62	3.62	2.17	2.17	2.17	3.62
0.057	23	1.00	1.67	1.00	1.00	1.67	2.17	2.17	2.17	2.17	2.17	2.17	3.62	3.62	3.62	3.62	3.62	2.17	2.17	2.17	3.62
0.034	24	0.60	1.00	0.60	0.60	1.00	1.30	1.30	1.30	1.30	1.30	1.30	2.17	2.17	2.17	2.17	2.17	1.30	1.30	1.30	2.17
0.026	25	0.46	0.77	0.46	0.46	0.77	1.00	1.00	1.00	1.00	1.00	1.00	1.67	1.67	1.67	1.67	1.67	1.00	1.00	1.00	1.67
0.026	26	0.46	0.77	0.46	0.46	0.77	1.00	1.00	1.00	1.00	1.00	1.00	1.67	1.67	1.67	1.67	1.67	1.00	1.00	1.00	1.67
0.026	27	0.46	0.77	0.46	0.46	0.77	1.00	1.00	1.00	1.00	1.00	1.00	1.67	1.67	1.67	1.67	1.67	1.00	1.00	1.00	1.67
0.026	28	0.46	0.77	0.46	0.46	0.77	1.00	1.00	1.00	1.00	1.00	1.00	1.67	1.67	1.67	1.67	1.67	1.00	1.00	1.00	1.67
0.026	29	0.46	0.77	0.46	0.46	0.77	1.00	1.00	1.00	1.00	1.00	1.00	1.67	1.67	1.67	1.67	1.67	1.00	1.00	1.00	1.67
0.026	30	0.46	0.77	0.46	0.46	0.77	1.00	1.00	1.00	1.00	1.00	1.00	1.67	1.67	1.67	1.67	1.67	1.00	1.00	1.00	1.67
0.016	31	0.28	0.46	0.28	0.28	0.46	0.60	0.60	0.60	0.60	0.60	0.60	1.00	1.00	1.00	1.00	1.00	0.60	0.60	0.60	1.00
0.016	32	0.28	0.46	0.28	0.28	0.46	0.60	0.60	0.60	0.60	0.60	0.60	1.00	1.00	1.00	1.00	1.00	0.60	0.60	0.60	1.00
0.016	33	0.28	0.46	0.28	0.28	0.46	0.60	0.60	0.60	0.60	0.60	0.60	1.00	1.00	1.00	1.00	1.00	0.60	0.60	0.60	1.00
0.016	34	0.28	0.46	0.28	0.28	0.46	0.60	0.60	0.60	0.60	0.60	0.60	1.00	1.00	1.00	1.00	1.00	0.60	0.60	0.60	1.00
0.016	35	0.28	0.46	0.28	0.28	0.46	0.60	0.60	0.60	0.60	0.60	0.60	1.00	1.00	1.00	1.00	1.00	0.60	0.60	0.60	1.00
0.026	36	0.46	0.77	0.46	0.46	0.77	1.00	1.00	1.00	1.00	1.00	1.00	1.67	1.67	1.67	1.67	1.67	1.00	1.00	1.00	1.67
0.026	37	0.46	0.77	0.46	0.46	0.77	1.00	1.00	1.00	1.00	1.00	1.00	1.67	1.67	1.67	1.67	1.67	1.00	1.00	1.00	1.67
0.026	38	0.46	0.77	0.46	0.46	0.77	1.00	1.00	1.00	1.00	1.00	1.00	1.67	1.67	1.67	1.67	1.67	1.00	1.00	1.00	1.67
0.016	39	0.28	0.46	0.28	0.28	0.46	0.60	0.60	0.60	0.60	0.60	0.60	1.00	1.00	1.00	1.00	1.00	0.60	0.60	0.60	1.00

Table 9: Dual comparison matrix of the Weakness elements part 1

	RI	0.041	0.029	0.041	0.041	0.018	0.029	0.018	0.018	0.018	0.017	0.017	0.024	0.017
RI	sequence	1	2	3	4	5	6	7	8	9	10	11	12	13
0.041	1	1.00	1.40	1.00	1.00	2.33	1.40	2.33	2.33	2.33	2.40	2.40	1.71	2.40
0.029	2	0.71	1.00	0.71	0.71	1.67	1.00	1.67	1.67	1.67	1.71	1.71	1.22	1.71
0.041	3	1.00	1.40	1.00	1.00	2.33	1.40	2.33	2.33	2.33	2.40	2.40	1.71	2.40
0.041	4	1.00	1.40	1.00	1.00	2.33	1.40	2.33	2.33	2.33	2.40	2.40	1.71	2.40
0.018	5	0.43	0.60	0.43	0.43	1.00	0.60	1.00	1.00	1.00	1.03	1.03	0.73	1.03
0.029	6	0.71	1.00	0.71	0.71	1.67	1.00	1.67	1.67	1.67	1.71	1.71	1.22	1.71
0.018	7	0.43	0.60	0.43	0.43	1.00	0.60	1.00	1.00	1.00	1.03	1.03	0.73	1.03
0.018	8	0.43	0.60	0.43	0.43	1.00	0.60	1.00	1.00	1.00	1.03	1.03	0.73	1.03
0.018	9	0.43	0.60	0.43	0.43	1.00	0.60	1.00	1.00	1.00	1.03	1.03	0.73	1.03
0.017	10	0.42	0.58	0.42	0.42	0.97	0.58	0.97	0.97	0.97	1.00	1.00	0.71	1.00
0.017	11	0.42	0.58	0.42	0.42	0.97	0.58	0.97	0.97	0.97	1.00	1.00	0.71	1.00
0.024	12	0.58	0.82	0.58	0.58	1.36	0.82	1.36	1.36	1.36	1.40	1.40	1.00	1.40
0.017	13	0.42	0.58	0.42	0.42	0.97	0.58	0.97	0.97	0.97	1.00	1.00	0.71	1.00
0.010	14	0.25	0.35	0.25	0.25	0.58	0.35	0.58	0.58	0.58	0.60	0.60	0.43	0.60
0.024	15	0.58	0.82	0.58	0.58	1.36	0.82	1.36	1.36	1.36	1.40	1.40	1.00	1.40
0.024	16	0.58	0.82	0.58	0.58	1.36	0.82	1.36	1.36	1.36	1.40	1.40	1.00	1.40
0.017	17	0.42	0.58	0.42	0.42	0.97	0.58	0.97	0.97	0.97	1.00	1.00	0.71	1.00
0.013	18	0.32	0.45	0.32	0.32	0.74	0.45	0.74	0.74	0.74	0.76	0.76	0.55	0.76
0.009	19	0.23	0.32	0.23	0.23	0.53	0.32	0.53	0.53	0.53	0.55	0.55	0.39	0.55
0.009	20	0.23	0.32	0.23	0.23	0.53	0.32	0.53	0.53	0.53	0.55	0.55	0.39	0.55
0.013	21	0.32	0.45	0.32	0.32	0.74	0.45	0.74	0.74	0.74	0.76	0.76	0.55	0.76
0.013	22	0.32	0.45	0.32	0.32	0.74	0.45	0.74	0.74	0.74	0.76	0.76	0.55	0.76
0.009	23	0.23	0.32	0.23	0.23	0.53	0.32	0.53	0.53	0.53	0.55	0.55	0.39	0.55
0.009	24	0.23	0.32	0.23	0.23	0.53	0.32	0.53	0.53	0.53	0.55	0.55	0.39	0.55
0.009	25	0.23	0.32	0.23	0.23	0.53	0.32	0.53	0.53	0.53	0.55	0.55	0.39	0.55
0.013	26	0.32	0.45	0.32	0.32	0.74	0.45	0.74	0.74	0.74	0.76	0.76	0.55	0.76

Table 10: Dual comparison matrix of the Weakness elements part 2

	RI	0.010	0.024	0.024	0.017	0.013	0.009	0.009	0.013	0.013	0.009	0.009	0.009	0.013
RI	sequence	14	15	16	17	18	19	20	21	22	23	24	25	26
0.041	1	4.00	1.71	1.71	2.40	3.14	4.40	4.40	3.14	3.14	4.40	4.40	4.40	3.14
0.029	2	2.86	1.22	1.22	1.71	2.24	3.14	3.14	2.24	2.24	3.14	3.14	3.14	2.24
0.041	3	4.00	1.71	1.71	2.40	3.14	4.40	4.40	3.14	3.14	4.40	4.40	4.40	3.14
0.041	4	4.00	1.71	1.71	2.40	3.14	4.40	4.40	3.14	3.14	4.40	4.40	4.40	3.14
0.018	5	1.71	0.73	0.73	1.03	1.35	1.89	1.89	1.35	1.35	1.89	1.89	1.89	1.35
0.029	6	2.86	1.22	1.22	1.71	2.24	3.14	3.14	2.24	2.24	3.14	3.14	3.14	2.24
0.018	7	1.71	0.73	0.73	1.03	1.35	1.89	1.89	1.35	1.35	1.89	1.89	1.89	1.35
0.018	8	1.71	0.73	0.73	1.03	1.35	1.89	1.89	1.35	1.35	1.89	1.89	1.89	1.35
0.018	9	1.71	0.73	0.73	1.03	1.35	1.89	1.89	1.35	1.35	1.89	1.89	1.89	1.35
0.017	10	1.67	0.71	0.71	1.00	1.31	1.83	1.83	1.31	1.31	1.83	1.83	1.83	1.31
0.017	11	1.67	0.71	0.71	1.00	1.31	1.83	1.83	1.31	1.31	1.83	1.83	1.83	1.31
0.024	12	2.33	1.00	1.00	1.40	1.83	2.57	2.57	1.83	1.83	2.57	2.57	2.57	1.83
0.017	13	1.67	0.71	0.71	1.00	1.31	1.83	1.83	1.31	1.31	1.83	1.83	1.83	1.31
0.010	14	1.00	0.43	0.43	0.60	0.79	1.10	1.10	0.79	0.79	1.10	1.10	1.10	0.79
0.024	15	2.33	1.00	1.00	1.40	1.83	2.57	2.57	1.83	1.83	2.57	2.57	2.57	1.83
0.024	16	2.33	1.00	1.00	1.40	1.83	2.57	2.57	1.83	1.83	2.57	2.57	2.57	1.83
0.017	17	1.67	0.71	0.71	1.00	1.31	1.83	1.83	1.31	1.31	1.83	1.83	1.83	1.31
0.013	18	1.27	0.55	0.55	0.76	1.00	1.40	1.40	1.00	1.00	1.40	1.40	1.40	1.00
0.009	19	0.91	0.39	0.39	0.55	0.71	1.00	1.00	0.71	0.71	1.00	1.00	1.00	0.71
0.009	20	0.91	0.39	0.39	0.55	0.71	1.00	1.00	0.71	0.71	1.00	1.00	1.00	0.71
0.013	21	1.27	0.55	0.55	0.76	1.00	1.40	1.40	1.00	1.00	1.40	1.40	1.40	1.00
0.013	22	1.27	0.55	0.55	0.76	1.00	1.40	1.40	1.00	1.00	1.40	1.40	1.40	1.00
0.009	23	0.91	0.39	0.39	0.55	0.71	1.00	1.00	0.71	0.71	1.00	1.00	1.00	0.71
0.009	24	0.91	0.39	0.39	0.55	0.71	1.00	1.00	0.71	0.71	1.00	1.00	1.00	0.71
0.009	25	0.91	0.39	0.39	0.55	0.71	1.00	1.00	0.71	0.71	1.00	1.00	1.00	0.71
0.013	26	1.27	0.55	0.55	0.76	1.00	1.40	1.40	1.00	1.00	1.40	1.40	1.40	1.00

Table 11: Dual comparison matrix of the Opportunities elements

	RI	**0.167**	**0.167**	**0.167**	**0.167**	**0.333**
RI	sequence	1	2	3	4	5
0.167	1	1.00	1.00	1.00	1.00	0.50
0.167	2	1.00	1.00	1.00	1.00	0.50
0.167	3	1.00	1.00	1.00	1.00	0.50
0.167	4	1.00	1.00	1.00	1.00	0.50
0.333	5	2.00	2.00	2.00	2.00	1.00

Table 12: Dual comparison matrix of the Threats elements

	RI	**0.219**	**0.156**	**0.219**	**0.219**	**0.051**	**0.085**	**0.051**
RI	sequence	1	2	3	4	5	6	7
0.219	1	1.00	1.40	1.00	1.00	4.28	2.57	4.28
0.156	2	0.71	1.00	0.71	0.71	3.06	1.83	3.06
0.219	3	1.00	1.40	1.00	1.00	4.28	2.57	4.28
0.219	4	1.00	1.40	1.00	1.00	4.28	2.57	4.28
0.051	5	0.23	0.33	0.23	0.23	1.00	0.60	1.00
0.085	6	0.39	0.55	0.39	0.39	1.67	1.00	1.67
0.051	7	0.23	0.33	0.23	0.23	1.00	0.60	1.00

4. Conclusions

This research proposes a SWOT analysis for evaluating wastewater treatment plants (WWTPs) and applying this tool to the old Rustumiya wastewater treatment plant. In various aspects of management and analysis of the results, it can be concluded that the plants' vulnerability lies in the methods and human resources issue like the quality of used and imported materials and their mismatch with the design specifications, in addition to the lack of human resources development. However, one of the major strength elements is the existence of a plan to differentiate the degree of importance of the maintenance activities. Likewise, the idea that climate change's impact on the maintenance plan is non to zero due to the hot, dry weather all around the year. On the other hand, the lack of continuous human resource education regarding sustainability theories and comprehensive maintenance is one of the strongest weaknesses in plant maintenance management. The positions of responsibility and leadership are not filled upon qualifications and experience. In addition, the main threat faced by the plant is the heavy pollution of the influent water and its effect on the plant's structure and components despite the frequent trespassing of the water networks, which leads to contamination before they reach the required destination. The use of SWOT analysis with the aid of the Delphi technique and the seven-point Liker scale facilitated the process of containing most aspects of management. This is due to the flexibility that gave the model a simplified way to calculate the weights and degree of importance for each maintenance management activity within the considered project. In addition, the double comparison matrix analysis method gives detailed weights for comparing all elements with each other. Therefore, it is considered an effective method and can be used successfully to evaluate the maintenance work of wastewater treatment plants.

Furthermore, the obtained results have a high degree of reality, as was seen from the documents, field visits to the project, and meetings with the project administration of the Rustumiya plant. Also, this model can be used as an evaluation tool for other projects such as water treatment plants, irrigation projects, and pumping stations. Finally, there is a need for new plans for managing human resources development, such as continuous training courses for workers and teamwork to identify problems inside the station and eliminate them from other Modern side software to manage maintenance inside the station.

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Author contribution

All authors contributed equally to this work.

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Data availability statement

The data that support the findings of this study are available on request from the corresponding author.

Conflicts of interest

The authors declare that there is no conflict of interest.

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