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RESEARCH ARTICLE

Comparison of different methods of MCDM to assess GWQ suitability for different purposes: Case study of Al-Hamdania Area

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ABSTRACT

This research aims to compare different methods of Multi Criteria Decision Making (MCDM) named SDI, PROMETHEE II, and ELECTRE III with the standard method NSFI to rank and score the Groundwater Quality (GWQ) of 26 wells in the Al-Hamdaniya area, Nineva governorate, Iraq, during 2019–2020. The final maps of each method and ranking of suitable areas for different uses of drinking, irrigation, and livestock are done by the GIS program with the help of the Analytical Hierarchy Process (AHP) technique, which is needed to extract the required weights of the variables. In order to check the results, a validation test named Similarity Coefficient (SC) is made between the methods to show their accuracy. For a general look, it was seen from the final maps that the eastern regions of the study area had good GWQ of all methods, and worsened further as we went to the west of the region The resulted maps showed that there are great convergence values between the SDI and the NSF methods, while both the PROMETHEE II and ELECTRE IV methods showed somewhat high divergence values with the NSF method. The used methods can be classified based on their convergence to the reference method NSF are as follows: SDI, PROMETHEE II and in the last is ELECTRE III.

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INTRODUCTION

Groundwater is the world's most significant supply of fresh water in locations where surface water supplies are inadequate, and one-third of the world's population depends on it [1], especially in arid and semi-arid regions. It has become important to regularly monitor the groundwater quality GWQ and to follow methods of protection from pollution. In the recent period, many studies have been conducted aimed at assessing and monitoring the GWQ using GIS by creating spatial distribution maps [2]. Multi Criteria Decision Making (MCDM) methods may be used to implement Water Quality (WQ), and in recent times, these strategies have been crucial in resolving relevant WQ assessment issues. [3]. There are many national and international research evaluate GWQ by using various methods and techniques as following; The research of [4] evaluated GWQ in the Khaperkheda district, Maharashtra, India, by evaluating twenty-two distinct locations over three seasons from 2005 to 2006 using the National Sanitation Foundation's NSF method. The study concluded that all the sites under study are heavily polluted. Another study [5] assessed the GWQ of Baramati city, Maharashtra, India, during two seasons in 2010 by using the NSF method. The study concluded that the study area was bad to medium for irrigation purposes but unsuitable for drinking. In the study of [6], evaluate GWQ located in the north-east of Algeria for different purposes by using on the NSF method. The research finding shows that the overall GWQ of the rejoin is medium to good and can be used for different purposes after convenient treatment. Another study [7] attempted to draw inferences from two different methods (weight arithmetic WA and NSF) to calculate the GWQIs in Vishrambag, Sangli, India. The researchers studied 16 wells at four sites within the study area. The research concludes that GWQ, according to the WA technique, is not suitable for drinking, while NSF gives medium suitability. The researchers [8] evaluated GWQ in An Giang Province, Vietnam, during the period 2009–2018 by using GWQI based on the fuzzy-AHP method. The research concluded that GWQ in the south and north had the worst quality because they had high concentrations of arsenic. In a study conducted by [9] analyze GWQ for 12 wells located on the left side of Mosul city by using NSF method. The study concluded that the GW had low quality and that is due to the presence of high values of each of; TDS, NO3 ions and a high total number of fecal coli-forming bacteria, which refers to the probability of domestic surface percolation. The study of, [10] pointed out the GWQ of the Sheikhan area, west of the city of Mosul, during the

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2019 year. The AHP technique and GIS programs were utilized to create a completion map to determine the GW suitability areas for different purposes. The results show that the north-eastern part of the studied area is suitable for irrigation and livestock only. The researcher [11] investigated the GWQ of the Al-Mahlabiya area, which is located west of Mosul, during 2019. Ten weeks separated the two samples that were collected from each of the four desalination plants. To display the performance analysis, eleven variables were examined for every sample. TOPSIS and Simple Additive Weighted SAW methods were the WQ indicators that were employed. The finding shows that the GWQ is highly affected by the following variables: TDS, total hardness, and sulfate. The study refers to this increase as belonging to geological formation. The study concluded that the SAW provided a more accurate assessment of the performance than the other method. Researchers,[12]]& [38] evaluate GWQ for drinking purposes at Beheshtabad Basin, Iran for the period 2014–2015. The results showed that most wells are suitable, but there are some well samples that are unhealthy in the rainy season because of the microbial content. The results also indicated that some of the GW samples have very low quality due to the weathering of saline rocks.

Although there are various MCDM methods, few research have assessed the level of closeness or divergence between the outcomes and validated them in a specific case study to decide which is best and most realistic of reality. This was one of the motivators for conducting this research. The current study attempts to evaluate several MCDM methods and determine the optimal one that can assess the GWQ of the Al-Hamdaniya area for different purposes.

METHODOLOGY

Study Area

Megacities are a product of continuous urbanization, typically defined as metropolitan areas with a total population of more than 10 million people. They stand apart from global cities due to their rapid growth [2]. According to [6], there are 32 megacities in the world, each with a population exceeding 10 million. Of these, 29 are located in developing countries, while only three of the megacities including Tokyo, Osaka (Japan) and Paris (France) are in developed countries. Furthermore, megacities are categorized into three groups based on income levels. These groups are high-income (developed) countries, upper-middle-income and lower-middle-income and (developing) countries (Table 1).

Data Analysis

Many physical and chemical properties of the GW samples from the selected wells were examined during the years 2019–2020 according to standard testing materials [13]. The achieved data was compared with national [14]and international standards [15]& [16], as in Table 2.

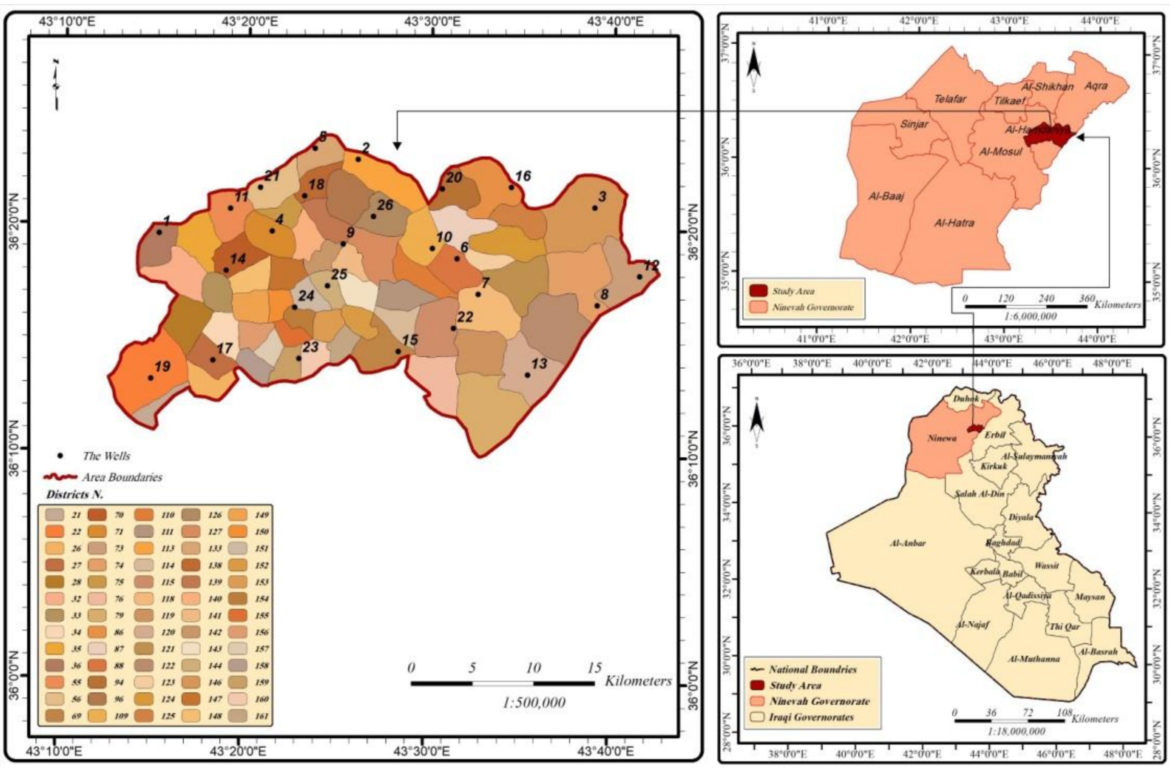


Figure 1. The study area within Nineveh Governorate and the selected 26 wellsites projected on it.

Table 1. Locations of the selected wells and their depth

NO.	Longitude	Latitude	depth	NO.	Longitude	Latitude	depth
1	43.2537	36.3271	70	14	43.3152	36.3002	150
2	43.4336	36.3831	140	15	43.4728	36.2426	139
3	43.6500	36.3500	80	16	43.5738	36.3643	114
4	43.3564	36.3296	100	17	43.3045	36.2342	90
5	43.3945	36.3909	162	18	43.3856	36.3558	195
6	43.5251	36.3113	180	19	43.2483	36.2201	193
7	43.5448	36.2854	200	20	43.5107	36.3624	144
8	43.6533	36.2783	111	21	43.3452	36.3616	154
9	43.4213	36.3209	90	22	43.5229	36.2601	144
10	43.5024	36.3186	170	23	43.3828	36.2364	84
11	43.3181	36.3459	180	24	43.3781	36.2738	40
12	43.6917	36.3000	102	25	43.4075	36.2900	150
13	43.5909	36.2266	103	26	43.4485	36.3414	90

Table 2. national and international standard values adopted for the variables under study

Drinking parameters	Drinking standards	Irrigation parameters	Irrigation standards	Livestock parameters	livestock standards
Ca	200	Na	200	TDS	7000
Mg	100	HCO3	500	EC	5000
Na	200	SAR	10	NO3	440
HCO3	300	Cl	350	SO4	3000
SO4	400	SO4	200	Ca	800
Cl	600	TDS	1750	Na	2000
NO3	45	EC	2250	Cl	3000
TDS	1000	Ca	450	Mg	500
pH	6.5-8.5	Mg	355	TH	4000
EC	1500	TH	300		
TH	200	NO3	30		
K	12				

Note: All variables units in mg/l except pH (unit less) , EC (μhos/cm), TH & ALK. (mg/l as CaCO3)

Table 3. RI adopted to calculate CR

10	9	8	7	6	5	4	3	2	1	n
1.49	1.45	1.41	1.32	1.24	1.12	0.9	0. 58	1	1	RI

Exctracting The Weights of The Variables

Analytical Hierarchical Process (AHP) is an important technique in making decisions for multiple criteria as it allows to give the weights of the different parameters and thus gives the possibility to determine the priorities of selection for the studied criteria [17]. The steps of the this technique passes in many steps, as follows: The first step is to arrange the variable hierarchy according to the importance of each variable; the next step is to build the compare-wise matrix of the variables; and the final step is to check the accuracy of the relative weights resulted from the compare wise matrix by calculating the consistency Index (CI) and consistency ratio (CR). The ratio (CR) must be less than number 0.1, other less, it must be recalculated [18, 19]. The following equations illustrate how to calculate CI & CR.

$$CI = \frac{(\lambda_{max} - n)}{n-1} \quad (1)$$

Where: λ_max represents the principal values and the symbol n represents the matrix size.

$$CR = \frac{CI}{RI} \quad (2)$$

Where: RI random index thatcan be used from Table (3)

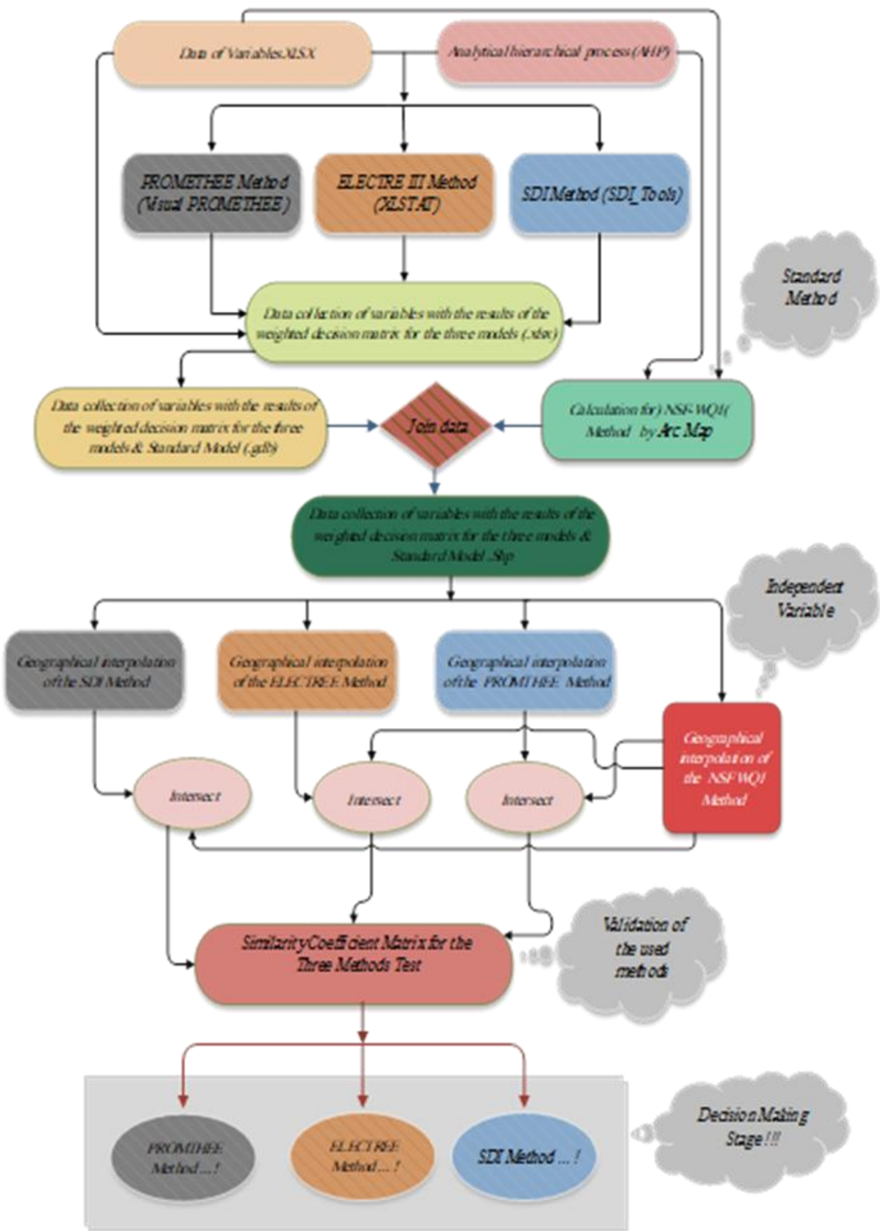


Figure 2. The flowchart of the operations shows the methods used, the means of verifying them, and representing them on maps using GIS program

Details of The Used Methods and Programs

Four internationally approved methods named SDI, PROMETHEE II, ELECTRE III, and NSF were chosen to calculate the Water Quality Index WQI. The values of the indicators in each method were represented in the GIS (virgin, 10.8) program. The National Sanitation Foundation NSF method was relied upon as a basis for evaluating the rest of the others. The weights for each variable were calculated using the Analytical Hierarchical Process AHP technique, and these weights were introduced in the tools in the GIS program. To verify the weight values, the value of the Consistency Ratio CR was found to be less than 0.1. Different programs were used for each method to facilitate the calculation process for each method, as recorded in the explanation of each method within the next paragraphs. Finally, the Similarity Coefficient SC was used to check the validation between these four methods. It is a geographical indicator that shows the degree of convergence between the chasses of each map with the classes of the base map drawn by NSI method. The closer to the number one, the more identical it is, and vice versa. The flowchart in Figure (2) provides an explanation of the process steps and methods used to obtain the final classes maps for each purpose.

In the following, the details of the different methods used in the study:

PROMETHEE: (Preference Ranking Organization Method for Enrichment Evaluation)

This method was created by [20] and debuted at a conference held at the University of Laval in Laval, Quebec, Canada [21]. It has had a lot of uses in recent times since it is based on a comprehensive arrangement of a set of alternatives, taking into account some parameters provided by the decision-makers, such as the weights of the criteria. It depends on comparisons of pair-wise variables, and the outcomes of these comparisons express the superlative formulas between pairs of variables that will be examined using all criteria [22]. This method of processing can be completed in five steps, as follows [23].

Stage 1. Determining deviations based on comparisons between spouses

$$\boldsymbol{dj}(\boldsymbol{a},\boldsymbol{b})=\boldsymbol{gj}(\boldsymbol{a})-\boldsymbol{gj}(\boldsymbol{b}) \quad (3)$$

Where $\boldsymbol{dj}(\boldsymbol{a},\boldsymbol{b})$ represents the difference in ratings between $\boldsymbol{a}$ and $\boldsymbol{b}$ for each criterion.

Stage 2: Applying the preference tasks

$$\boldsymbol{Pj}(\boldsymbol{a},\boldsymbol{b})=\boldsymbol{Fj}[\boldsymbol{dj}(\boldsymbol{a},\boldsymbol{b})]\boldsymbol{j}=\boldsymbol{1},\ldots,\boldsymbol{k} \quad (4)$$

Where; $(\boldsymbol{a},b)$ represents the preference of alternative $\boldsymbol{a}$ over alternative $\boldsymbol{b}$ on each criterion, as a function of $\boldsymbol{dj}(\boldsymbol{a},\boldsymbol{b})$.)

Stage 3. Calculate a preference index: This index is used to quantitatively assess alternatives in pairs, taking all criteria into consideration.

$$\forall a, b \in A, \pi(a,b) = \sum_{j=1}^{k} P_j(a,b)wj \quad (5)$$

Where (a,b) is defined as the weighted sum $P(a,b)$ of for each criterion, and wj is the weight associated with jth criterion.

Stage 4. Calculation of higher ranked flows/ PROMETHEE II. PARTIAL ORDER

$$\boldsymbol{\varphi^+(a)} = \sum_{\mathbf{x \in A}} \boldsymbol{\pi(a,b)} \quad , \quad \boldsymbol{\varphi^-(a)} = \sum_{\mathbf{x \in A}} \boldsymbol{\pi(a,b)} \quad (6)$$

The terms **φ^+ (a) and φ^- (a)** refers to the positive and negative higher orders, respectively, for every option.

Stage 5. Compute top rank net flow /complete rank PROMETHEE II.

$$\boldsymbol{\varphi(a)} = \boldsymbol{\varphi^+(a)} - \boldsymbol{\varphi^-(a)} \quad (7)$$

where φ(a) represents each alternative's net outranking flow. (PROMETHEE version1.4.0) is used to simplify the calculations of this method

ELECTRE III: (Electric Elimination and Choice Translating Algorithm)

This method depends on the order of the evaluated variables by the specified criteria and based on the preferential data specified in the indifference threshold, veto threshold, and preference threshold [24]. ELECTRE method includes many family (I, II, III, IV, IS, and TRI) [25, 26]. Although there are many ELECTER methods, they are similar in explaining the concepts, and their difference is in the type of decision problems. It can be said that ELECTER I is favorable for solving selection problems, while ELECTER TRI is favorable for assignment problems, and the others is for solving order problems.

The ELECTER III method is defined as a method of compiling multiple criteria based on differences, which is a direct and non-compensatory mechanism, through pair wise comparisons between alternatives, in addition to that the results obtained are not final results in making decisions, as they are analyzed by doing a step called robustness analysis. This method can be adopted to solve many problems in MCDM. Accordingly. It has been proven that ELECTRE III is the most suitable for prioritization and it can be applied in several fields. The steps of this method can be described as follows [27].

Step 1. Calculation of Compatibility Matrix

where,

$$C(a,b) = \frac{1}{W}\sum_{j=1}^{n} w_j c_j(a,b) \quad (8)$$

$$W = \sum_{i=1}^{n} w_i$$

$$C_j(a,b) = \begin{cases} \frac{1,}{P_j - q_j}, & -q_j > \text{ diff } > -P_j \\ 0, & \text{diff } \geq -q_j \end{cases} \quad (9)$$

Step 2. Calculation of Discordance Matrix

$$D_j(a,b) = \begin{cases} 1, & \text{diff } \geq v_j \\ \frac{\text{diff } - P_j}{v_j - P_j}, & P_j \leq \text{ diff } \leq q_j \\ 0, & \text{diff } \geq P_j \end{cases} \quad (10)$$

Step 3. Calculation of Credibility Matrix

$$S_j(a,b) = \begin{cases} C(a,b), & \text{if } D_j(a,b) \leq C(a,b) \forall j \\ C(a,b) \cdot \pi_{i \in j(a,b)} \frac{1 - D_i(a,b)}{1 - C(a,b)} & \end{cases} \quad (11)$$

Where $\pi(a,b)$ is the set of criteria for which $D_j(a,b) > C_j(a,b)$

Step 4. Descending or ascending order of the alternatives
Step 5. Suggested prioritization approach

The results of descending order and ascending order are combined to build the final sequence of alternatives [28].

SDI: Statistical Design Institute

The working mechanism of the SDI method is based on estimating the degree of fitting. Alternatives are designed for comparisons of quantitative procedures. After the degree of the alternatives is calculated as a weighted total, the alternative that achieves the highest degree of differentiation is considered the best that is closest to the requirements of the standards [29]. The most prominent features of this model are its diverse standards scoring methods, which adapt to the nature of the data and enable the highest degrees of differentiation for all alternatives [30]. Design alternatives and criteria are arranged in a matrix. In the following steps of computing the results:

1. Give each condition a numerical value.
2. Enter the LSL, target, and/or USL values for each criterion from the known requirements.
3. Fill in the design choice information for every criterion.
4. Decide on the criterion scoring method: 1-PNC, minimize, maximize, quadratic in spec, in/out spec, or linear in spec.
5. Compute and assess results.

(Stat Design, 2018) [31] Software is used in this method.

NSF: Standard Method (National Sanitation Foundation)

The NSF model has been adopted within the recommended water parameters and in accordance with quality standards. To calculate the sub-indicator values linearly[32]. The water quality index is measured after calculating the values of the sub-indicators for all variables, and accordingly, the water quality is calculated according to this model by multiplying the value of the secondary index by the weight of each variable. What distinguishes this model is its response to changes in the properties of water quality [33] . The Delphi technique, which is based on the weight (Wi) and sub-indices (Si) of the primary water quality measures, is typically used to compute this index [34]. The results obtained from the calculation of WQI were then compared with the WQ criteria. This model can be applied through the following equations: [35] [36].

$$WQI=\Sigma\ ni=Si \quad (12)$$

$$WQI=\Sigma\ ni=Wi\times Si \quad (13)$$

$$0 \leq Si \leq 100 \quad (14)$$

WQI =the sum of the values of the indicators; Si = they represent the secondary or sub-indicator values; Wi = weight of values; n = number of parameter indicators. Converting each parameter into five scales between 0 and 100 is used to determine values as follows: (0-10) Very bad (25–50) Bad, (50-70) Moderate, (70-90) good, (>100) very good by using sub-index curves, which can be either linear or nonlinear. A separate worksheet in Excel is used to simplify the calculations.

Checking the Validation

The calculation of the Similarity Coefficient SC is used to check the validation**.** This coefficient depends on the presence or absence of the common property between the results of the two methods, by using a Boolean matrix as follows:

If the property (J) is found in the observation Xi Xij = 1

If the property (J) disappears in the observation Xi Xij = 0

The similarity coefficient can be expressed by using the following equation:

$$SC = \frac{(CA-SA)}{STA} \quad (15)$$

Where (SC) denotes the similarity coefficient

Where (CA) denotes the common areas

Where (STA) denotes the areas are not shared, while (STA) denotes the sum of the two areas.

In the study, the Similarity Coefficient (SC) was adopted in the process of verifying the accuracy of the results of the used methods by comparing the approved standard method (NSF) with the other methods. The intersect tool in the (ARC toolbox) program is used to find the intersecting common and non-shared areas between the maps of each method and the NSF method. The SC domain is usually between (0, 1), and the closer the result is to one, the greater the similarity between the results of the methods, and vice versa, [37].

RESULTS AND DISCUSSION

Deriving Rlative Weights From The Analysis of AHP Technique

The weights of the variables for the three purposes were calculated according to the AHP technique and tabulated as in Table 4. The weights of the parameters were exported to the GIS program to draw the suitability maps for each method. The accuracy of the weights resulting from the AHP technique was verified by finding the value of the consistency ratio (CR), which was 0.03. This value is much less than the value (0.1). This indicates the accuracy of the importance given to each variable and the result of the pair wise comparison matrix.

Drawing The Suitability Maps

Two stages are done to have an interpolation of the resultant methods as flows:

Stage one: After extracting the weighted decision matrix for the three methods, the results are unified in the separate Excel worksheet and then joined with the basic parameters with the results of the standard method (NSF).

Stage two: Building completion maps from the method results through the Geostatistical Analyst appendix and after comparing the relative experimental performance of the completion methods used, the appropriate method is chosen.

Several statistical criteria are used to evaluate which one is appropriate. These criteria are: the mean error, the difference between the square root of the mean errors, the rate of standard errors, and Root-Mean Square-Standard error [39].

The suitability maps are drawn in Figures (3 ,4 & 5) where Figure (3) represents the results of the classes of areas that are suitable for drinking purposes. There is a great similarity between the results of the SDI method with the standard method NSF, noting that the fifth category of classification results did not appear in both maps. On the contrary, the fifth category appeared in both the ELECTER III and the PROMETHREE

Figure (4) shows the classes of suitability areas for irrigation purposes. It is also noted that there is a significant similarity between the two distribution maps for the classes between SDI and the standard methods. The limits of the fifth category also did not appear in the results in both of them, and on the contrary, the limits of all categories of GWQ classification appeared in each of the ELECTRE III and PROMETHREE maps, noting that there is a difference between the minimum category limits, especially in the map of the PROMETHREE

Figure (5), represents classes of suitability areas for livestock purposes, which was observed in the SDI & ELECTER III maps and the map of the standard model. The appearance of all categories of WQ classification limits in these maps, with a very large convergence between the two maps of the SDI and the map of the NSF.

The ELECTER III map recorded convergence, but to a lesser extent, with the standard NSF method map and for all category boundaries except for the first category (lowest category). The same does not apply to the PROMETHREE map, where the first category of the classification did not appear, and it recorded a large discrepancy with the results of each method and with the standard in particular.

Table 4. The relative weights of variables resulted from AHP technique

The Variables for drinking	Relative drinking weights %	The Variables for irrigation	Relative irrigation weightds %	The Variables for livestock	Relative livestock weights %
TDS	18.33	TDS	20.28	TDS	22.52
EC	14.00	SAR	15.81	EC	17.57
SO_4	11.97	EC	15.21	SO_4	16.22
TH	10.35	Na	10.34	Na	11.11
NO_3	9.59	Ca	8.00	Ca	8.86
Ca	7.21	SO_4	5.96	Cl	7.66
Na	6.19	Mg	5.62	Mg	6.23
HCO_3	5.94	TH	5.37	TH	5.86
Mg	5.43	HCO_3	5.32	NO_3	3.98
Cl	4.84	Cl	5.02		
K	3.07	NO_3	3.08		
pH	3.07				

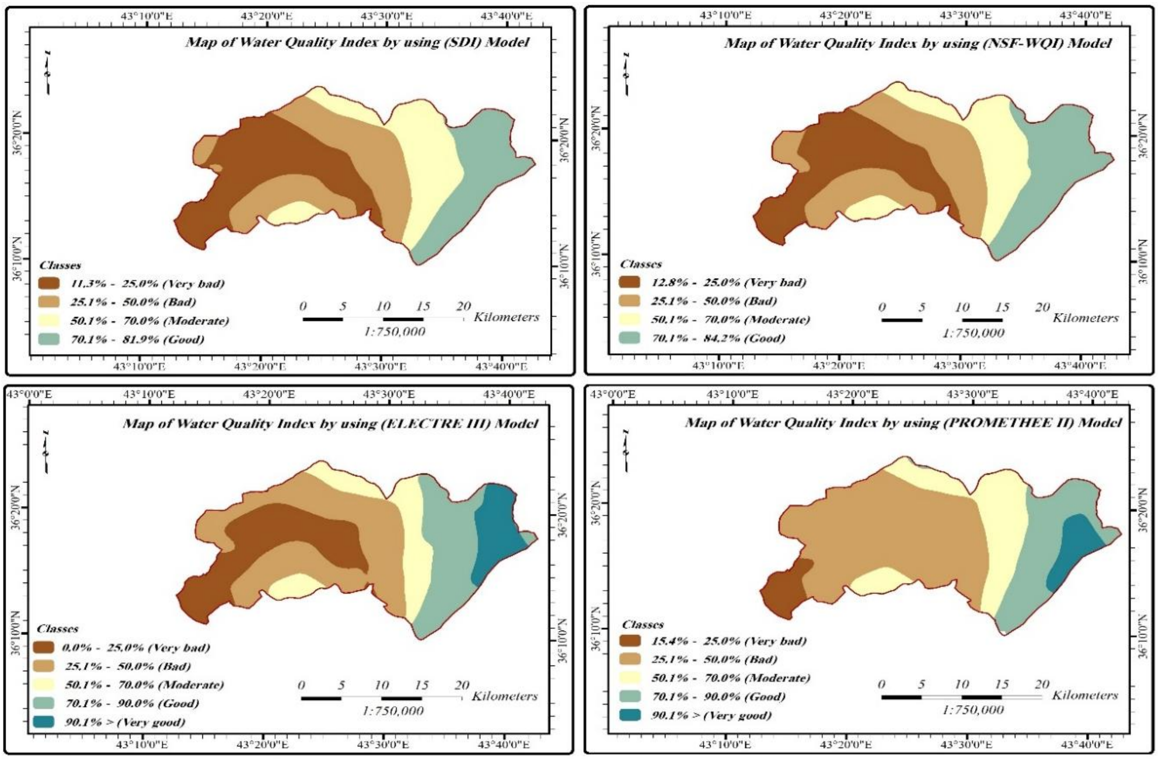
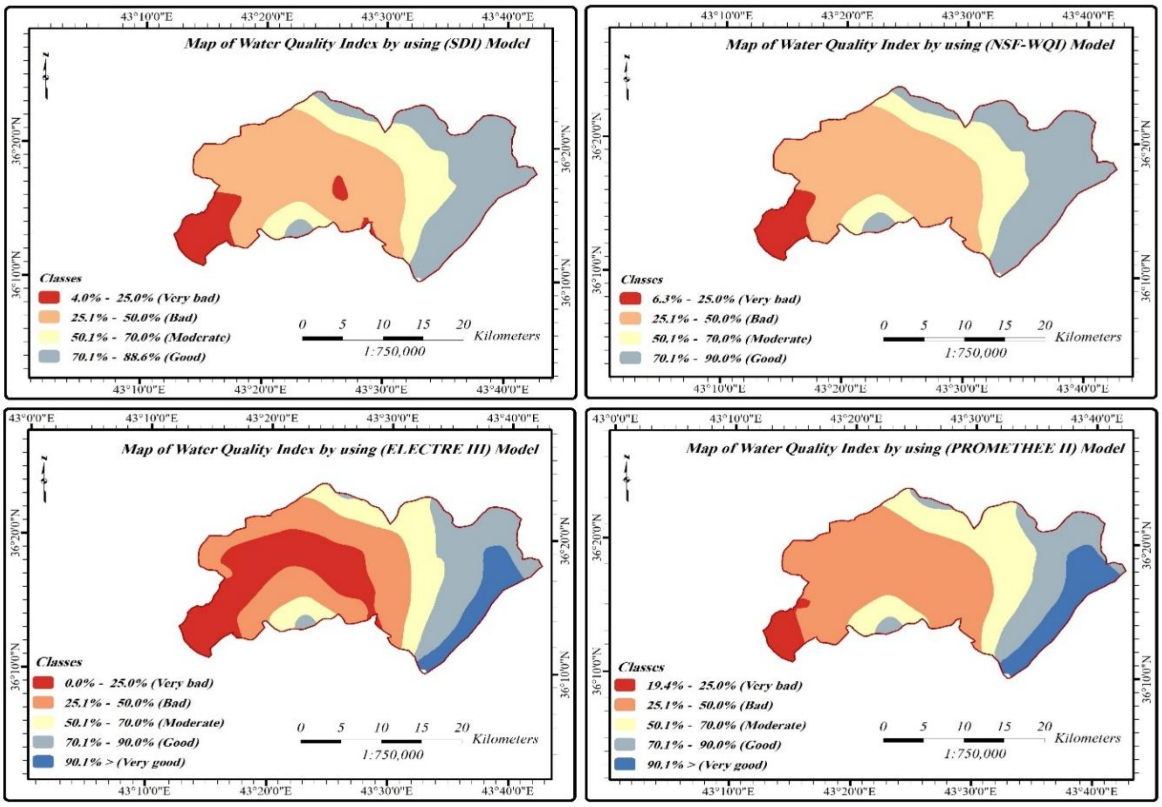


Figure 3. Classes of suitably areas according to the four methods for drinking purposes



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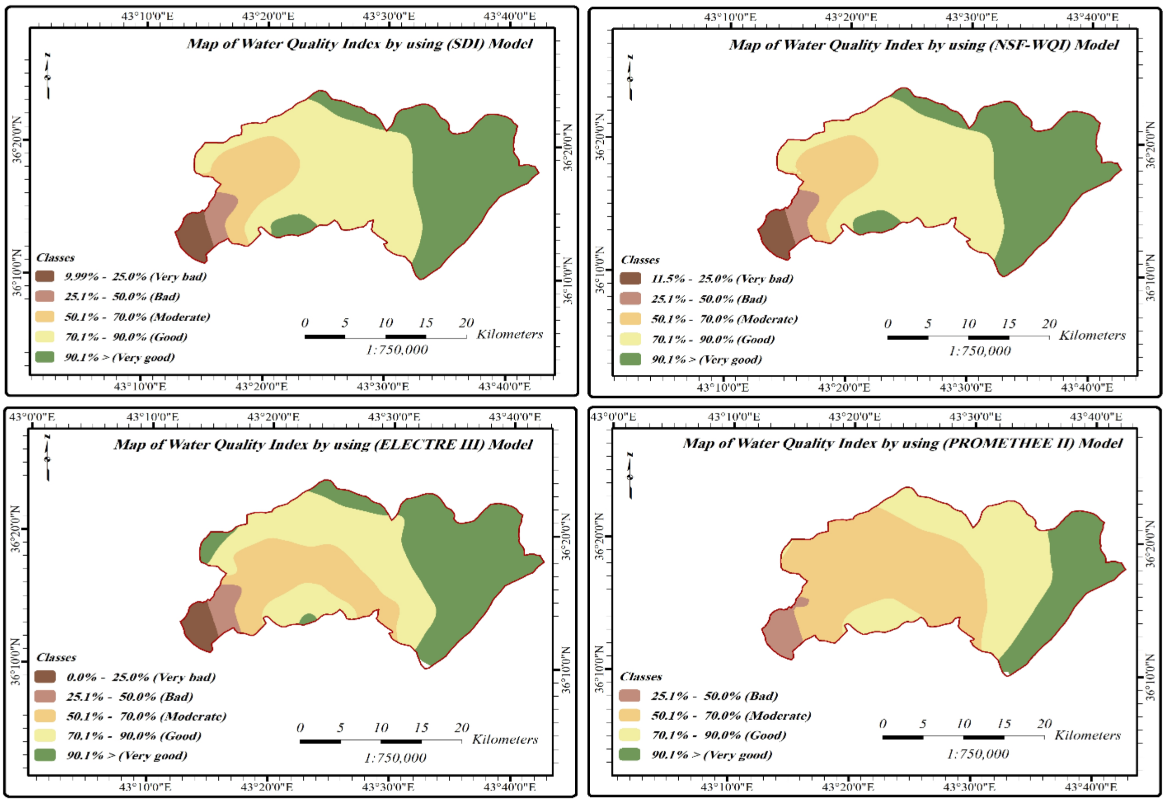

Figure 5. Classes of suitably areas according to the four methods for livestock

Results of The Validation

Tables (4, 5, and 6) listed the results of validation between the used method. The results of the similarity coefficient SC with regard to the suitability of using water for drinking purposes listed in table (5). It was showed that the SDI method achieved the highest degree of similarity among other methods, as it reached 0.929 in the SDI, followed by the ELECTREE III method, where the SC reached 0.769, and the last one, as it has 0.664.

From the observation of Table (6), which shows the results of SC for irrigation purpose, the results showed that the SDI method achieved the highest degree of similarity with the standard method NSF, as the SC reached (0.994), followed by the result of the PROMTHEE method, which reached (0.802). Finally, the result of the ELECTREE III method, SC, reached the lowest degree 0.629.

Table (7) shows the results of SC for livestock purposes. It was noted that the SDI method achieved the highest degree of similarity with the results of the standard method NSF since the SC listed value was greater than 0.997. The ELECTREE III method achieved lowrer value of similarity with the results than the standard method NSF (0.778). Finally PROMTHEE had the lowest degree of similarity which had only (0.438).

Table 5. Similarity coefficient SC results for drinking purpose

The Model	The intersect between two areas $(\mathbf{CA}-\mathbf{SA})$ (km²)	The sum of the two areas (STA) (km²)	Similarity Coefficient (SC)
NSF-SDI	625.497	672.673	0.929
NSF_ ELECTRE III	517.904	672.673	0.769
NSF_PROMTHEE	446.732	672.673	0.664

Table 6. Similarity coefficient SC results for irrigation purpose

The Model	The intersect between two areas $(CA-SA)$ (km²)	The sum of the two areas (STA) (km²)	(SC)
NSF-SDI	635.214	672.673	0.994
NSF_ELECTREE	423.438	672.673	0.629
NSF_PROMTHEE	539.772	672.673	0.802

Table 7. Similarity coefficient SC results for livestock purpose

The Model	The intersect between two areas $(CA-SA)$ (km²)	The sum of the two areas (STA) (km²)	(SC)
NSF-SDI	657.270	672.673	0.997
NSF_ELECTREE	523.971	672.673	0.778
NSF_PROMTHEE	295.163	672.673	0.438

CONCLUSION

The use MCDM in water quality assessment is considered one of the modern and wide sprite methods because it gives results closer to reality, especially after the issuance of multiple programs that facilitate finding results quickly and accurately. The multiplicity of these methods has become necessary to make comparisons between them in order to choose the best and most appropriate. Therefore, four main methods were chosen to be used to find the extent of convergence between them. Similarity coefficient was used to validate the results, which indicated that there is a significant convergence between the results of both the SDI and NSF methods for all uses, while the results of the ELECTREE III method did not indicate a clear similarity with the standard method for the purpose of livestock. The PROMTHEE method came last in terms of the mean score (SC). The results proved the effectiveness of the SDI method in classifying WQ for all purposes, and therefore the study recommends methods since it has provides flexibility, unity, and ease of application.

It was found from the maps that the eastern regions of the study area are of GWQ and suitable for all purposes, and that WQ begins to deteriorate as we move to the western regions. The final map shows that the eastern regions of the study area are considered to be of high quality for two reasons: The first is that they are located within geological formations, as they are located within the Anjana Formation. The second reason is the presence of the Khazir River in the eastern region, which gives the groundwater a reasonable purity as a result of the infiltration of the Khazir River water into it, while the quality of the groundwater begins to deteriorate the further west we go due to the Al-Fatha formation, which is characterized by containing a high percentage of sulfates and salinity.

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DATA AVAILABILITY STATEMENT

The authors confirm that the data that supports the findings of this study are available within the article. Raw data that support the finding of this study are available from the corresponding author, upon reasonable request.

CONFLICT OF INTEREST

The author declares that there is no conflict of interest with any individual, institution, or organization in the preparation, evaluation, or publication of this study.

USE OF AI FOR WRITING ASSISTANCE

Not declared.

ETHICS

There are no ethical issues with the publication of this manuscript.

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