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GIS-Based Multi-Criteria Decision Analysis for Site Selection of Surface Water Desalination Plants in Basrah, Iraq

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Abstract

The Basrah Governorate in southern Iraq faces a serious water deficit despite its surface water supplies and economic growth. However, no drastic measures have been proposed to address the problem. The goal of this study is to identify the ideal location for surface water desalination facilities in the Basrah Governorate. The best location for surface water desalination is determined by a number of variables, each of which has a distinct impact. Nine factors were selected based on the local conditions in the study location and the available data. Terrain-related parameters (distance to the road, distance to the network, distance to the river, LULC, slope, elevation, soil, geology, and rainfall) were among the factors used. The professional opinions and previous literature were used to calculate the weights of these elements. There are five zones with appropriate levels ranging from very low to very high, according to the weight sum technique. The low to very low zones occupied 7,636 km², followed by the moderate zones (4,772.5 km²) and then the high to very high zones (6,681.5 km²). This was demonstrated by the methodical application of the weight overlay and weight sum techniques in GIS. According to the weight overlay technique, the low to very low zones cover 20% the moderate zones encompass 60% (11,454 km^2), and the high to very high zones cover 20% (3,818 km^2). Experts and decision-makers can benefit from this study as it saves time and effort and serves as a scientific guide for selecting the best location in the Basrah Governorate. Based on the spatial distribution and the results of the applied techniques, the Shatt al-Arab area was identified as the best place to establish massive surface water desalination plants, followed by the Al-Faw area and the Khor Al-Zubair Canal.

Keywords: *Shatt al-Arab; Weight Sum; Al-Faw; Basrah; Desalination.*

1. Introduction

The scarcity of water resources in arid Arab countries such as Iraq is a source of concern for water resource planners. Iraq has relied on the Tigris and Euphrates rivers for centuries to provide about 95% of its water needs. Water consumption has increased dramatically due to the global population growth. Drinking water has become a major problem facing most countries worldwide, particularly in Iraq. The study area is situated in the far south of Iraq, specifically in Basrah Governorate, and encompasses the Arabian Gulf region. Basrah Governorate is known for its low annual rainfall. Given the climatic conditions that the country is experiencing in general and Basrah in particular, the need to produce potable water at a low capacity for areas with high population density is critical. The country is now categorized as having low freshwater resources, which will impact the country's economic support as well as the decline of its industry and agriculture (Alatta et al., 2022). The Al-Faw District and Shatt al-Arab are affected by saltwater intrusion due to water scarcity and disruptions to the Karun River, which increases salt concentrations and impacts soils and living organisms (Abdul-Hameed et al., 2021).

There is evidence that the shortage of fresh water and the rise in salinity have led to a decline in the agricultural sector in southern Iraq, specifically in Basrah Governorate. A study conducted by Schnepf et al. (2004) highlights that the per capita share of freshwater has decreased by 60% or more over the past two decades. The need for more urgent freshwater resource strategies will necessitate desalination choices from all available resources as interest in using natural surface water resources, such as the Arabian Gulf and Shatt al-Arab, grows. One of these solutions may be desalination where plants can produce fresh water (Gokçek & Gokçek, 2016). This process involves removing salt from seawater to produce fresh water suitable for human use (Younos et al., 2005). It can offer a significant solution for the country and lessen the strain on new natural resources (Al-Ansari et al., 2023). It also explained that desalination meets the increasing demand for water in southern Iraq, especially in coastal areas with easy access to seawater. Soon, Desalination plants will play a significant role in supplying vast amounts of potable water for drinking, as well as other applications such as irrigation, industry, and agriculture. Desalination facilities must utilize clean energy, as it helps protect the environment from pollutants over time.

The current study aims to find the best location for desalinating surface water, using nine factors (distance to river, distance to network, distance to the road, LULC, slope, elevation, soil, geology, and rainfall). By applying the weight overlay and weight sum techniques, the appropriate location

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for desalinating surface water in southern Iraq can be found. This study saves decision-makers and planners considerable time and effort in identifying the optimal location for surface water desalination plants. The results will help determine the investment priorities of desalination options.

2. Study area

Basrah is one of the cities in the south of Iraq and is located at longitude (30°0′0″-31°0′0″)N and latitude (47°0′0″ - 48°0′0″)E (Figure 1); it shows the most important geological units in the study area. Iran borders it on the east and the Arabian Gulf on the south. The area is roughly 19090 square kilometers. Given that it is the gateway to Iraq and that most of the ports are located inside this governorate, its location is crucial. The Shatt al-Arab River, a notable geographical feature that supports enormous agricultural activity and provides vital water resources, is formed by the confluence of the Tigris and Euphrates rivers (Al-Ansari, 2018).

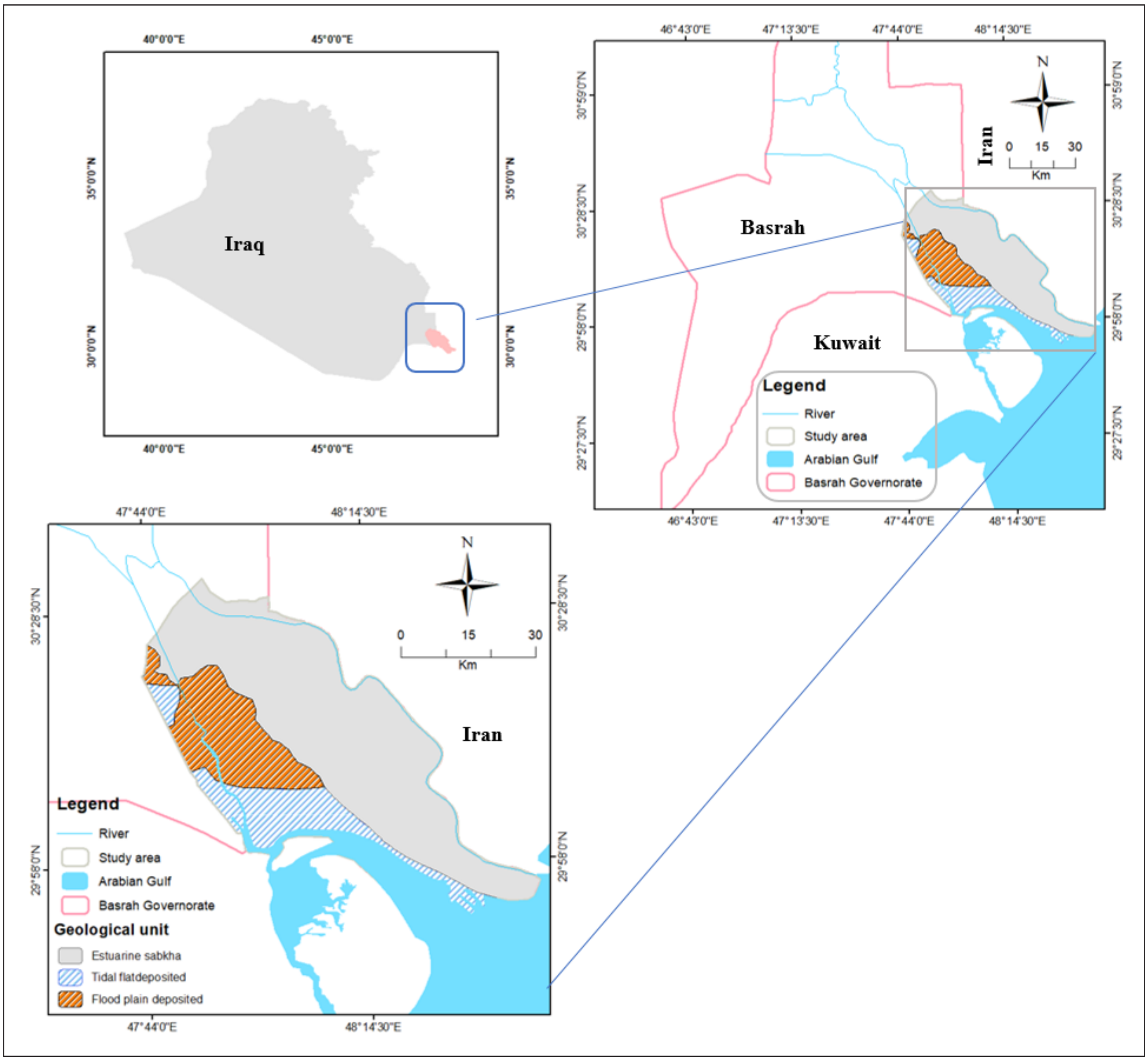

Figure 1. Location of the study area with the geological ' 'unit's map.

3. Methodology

3.1 GIS workflow for the best desalination site

In order to identify the location of surface water desalination, this study comprises five steps (Figure 2) , first, choosing the appropriate factors that have effects at different levels within the availability of data and existing literature, and these factors include (distance to the river - distance to roads - rainfall - distance to power lines - slope - elevation - LULC - geology - soil) (Figure 3) second, unifying the data into point format and with a fixed accuracy (30 x 30 m) so that the analysis is easier and faster, third, the hierarchical calculator was used to help calculate the weights of the influential factors that were applied in the techniques, fourth, applying each of the methods (Weight sum- Weight overlay) to classify the best solution based on the weighted factors, as these algorithms were used with the least error, fifth and finally, the appropriate areas for establishing surface water desalination plants were obtained by drawing maps that represent the best locations where surface water desalination plants can be based in the future and very large areas, and these areas were divided into (suitable, very suitable, moderate, low, very low).

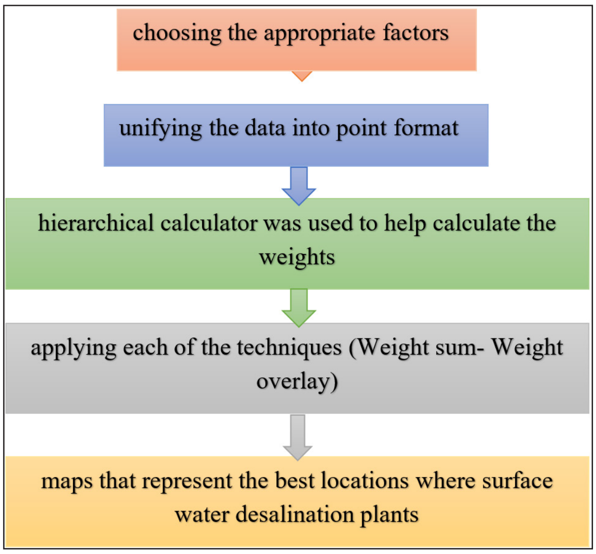

Figure 2. Flow chart of the desalination plant site in the study area.

3.2 Making Spatial Factor Maps for the Analysis of Desalination Site Suitability

Nine factors thatare thought to have a basic and varied impact on the study's goal were used. These factors included (distance to the river - distance to roads - rainfall - distance to electrical energy - slope - elevation -LULC- geology- and soil) (Figure 3). Each factor is important in choosing the best location to establish a water desalination plant, and these nine maps were collected in the database using the ArcMap program (10.4) after they were matched with spatial accuracy. An Excel file was also prepared to compile all the information about the nine factors affecting the selection of the best location for establishing a water desalination plant, so that the second phase could be implemented. The selection of factors that otherwise influence the choice of the appropriate location for establishing a water desalination plant depends on the availability of data and local conditions. Nine influencing factors were selected for the study area based on data availability and literature review. All of these parameters were prepared from an SRTM (Shuttle Radar Topography Mission) -type digital elevation model (DEM) with a spatial resolution of 1 arcsecond (~30 x 30 m cell size). Eight DEM tiles were downloaded from the official website of the United States Geological Survey (https://earthexplorer.usgs.gov/) and pre-processed to generate topographic factors (Al-Abadi, 2018). Except for the map (LULC) that was downloaded from a site (https://livingatlas.arcgis.com/landcoverexplorer/) where its spatial resolution represents (10 x 10 m) and was converted to a resolution (30 x 30 m) to match the accuracy of other maps between the period (2017-2021).

3.2.1 LULC map

Due to the substantial environmental, infrastructural, economic, and regulatory implications, land use and land cover are important considerations when selecting a location for a desalination plant. Additionally, they are essential in avoiding conflicts and assessing the general fitness of a property. It is crucial to understand land usage in order to assess environmental effects and choose the best water sources for desalination. Coastal regions with suitable land cover are frequently considered the best places for these facilities (Shahabi et al., 2015). Desalination facilities can be more easily integrated into current systems if current land use patterns indicate the presence of necessary infrastructure, such as roads and electrical networks (Mahi, 2001). Sentinel-2 images, artificial intelligence, and a sizable training dataset with billions of human-labeled image pixels are used to generate these worldwide LULC maps. As seen in Figure 3 A, the 2021 LULC map was used for this investigation. To match other thematic layers created in this work, the original map was first reprojected to WGS 1984 (zone 38) and then resampled to a resolution of 30 m. The five classifications identified were water, shrub, bare, developed area, and green cover (including trees, flooded vegetation, and crops). For water, constructed area, shrub, barren, and green cover, these classes make up 20% (549 km^2), 3% (79 km^2), 16% (442 km^2), 59% (1652 km^2), and 3% (71 km^2) of the total area, respectively. A desalination plant might be built on bare land, which makes up almost three-quarters of the whole area. The large amount of available land suggests that the area is favourable for such development.

3.2.2 Topographic map

Elevation and slope are essential factors when siting desalination plants as they significantly impact infrastructure, cost, and environmental issues (Mohamed et al., 2020). Higher elevations require more energy to pump seawater uphill and distribute desalinated water downwards, which has an impact on construction and operating costs (Slocum et al., 2016). Plants should be placed at slightly higher altitudes to reduce the risk of floods, which can destroy infrastructure and interfere with operations in lower elevations, particularly those close to the coast. The ideal height strikes a balance between cost-effective water transportation and accessibility to the seawater source; intermediate altitudes are usually favoured to save pumping expenses while avoiding flood-prone areas. Slope affects the stability and viability of construction; gentle slopes are favoured since they require less land alteration and offer a secure base for large machinery (Tsiourtis et al., 2009). The elevation in the study area ranges from 0 to 90 m, as shown in Figure 3B). The average of the slope is 2.17 ± 2.34 degrees, with a range of 0 to 30 degrees (Figure 3C). The majority of the research region is categorized as flat because its slope is less than five degrees. This feature, together with other elements, makes the location favourable for the installation of desalination plants because of its appropriate slope.

3.2.3 Soil map

Placing desalination plants requires careful consideration of the soil type since it can impact stability, construction feasibility, and environmental impact (Radwan et al., 2022). When building desalination plants, stable soil types are favoured because they limit erosion and runoff concerns during construction and long-term operation, and they offer a firm base for large machinery (Sepehr et al., 2017).

The US Department of Agriculture (USDA) developed the most well-known standard for defining these sizes. Based on the Food and Agriculture Organization's (FAO) global digital soil map (https://www.fao.org/soils-portal/data-hub/soil-maps-and-databases/faounesco-soil-map-of-the-world/

en/), this categorization method identifies silty loam, clay loam, and loam as the three primary textural classifications found in this study area. Silty loam, clay loam, and loam textures comprise 50%, 35%, and 15% of the total area, respectively (Table 1), making them the preferred choice for desalination plant infrastructure (Figure 3D).

Table 1. Types of soil and their coverage rate

Soil Type	Coverage (Km², %)
Silty Loam	50% (1304 Km²)
Clay Loam	35% (911 km²)
Loam	15% (410 km²)

3.2.4 Service map

Maps from the Basrah Governorate Municipality's Department of Urban and Urban Planning were used to determine the distances of roads and transmission power lines. Vectors were used to make these maps. We created raster maps of these variables using the ArcMap 10.4 Euclidean distance tool (Figures 3E-G). The Rainfall Measurement Mission's official website (https://power.larc.nasa.gov/data-access) provided daily rainfall data for 18 grid sites that covered the research area from 2010 to 2022. Next, the IDW interpolation method, found in the Geostatistical Extension for ArcGIS 10.4 Programming, was used to interpolate the table data. This method of random interpolation automates the most challenging parts of creating a high-quality model. (Figure 3H) displays the research area's annual rainfall map. Annual precipitation rises from the southwest to the northeast. Rainfall, in general, helps increase the amount of water available in the region, whether surface or groundwater. Therefore, the rain factor is important in the water desalination process, as it depends primarily on the water as a primary source. It is re-desalinated through desalination plants and becomes suitable for human use.

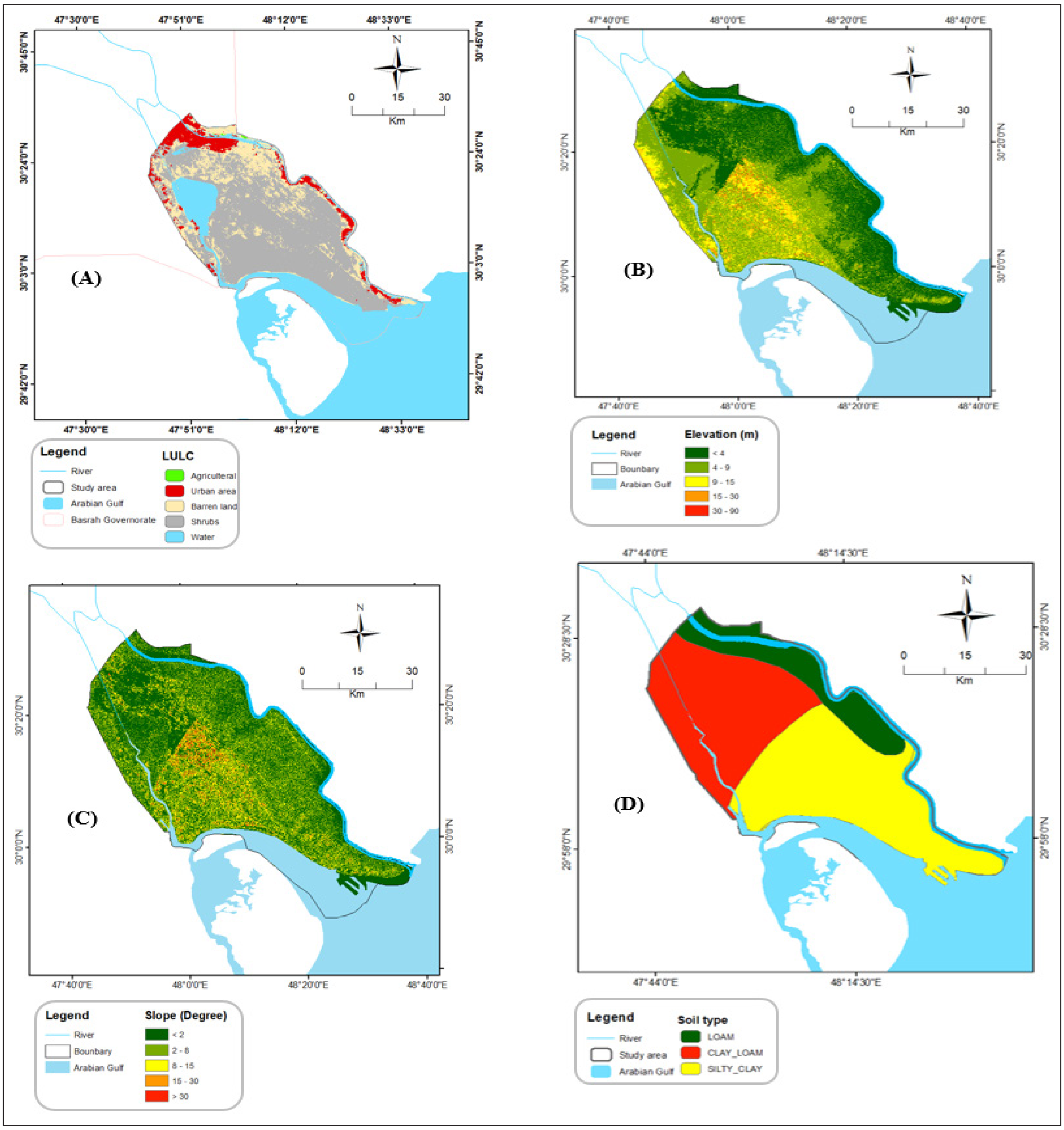

Figure 3. Factors used in determining the location of a surface water desalination plant. (a) LULC, (b) elevation (m a.s.l), (c) slope (degree), (d) soil type.……

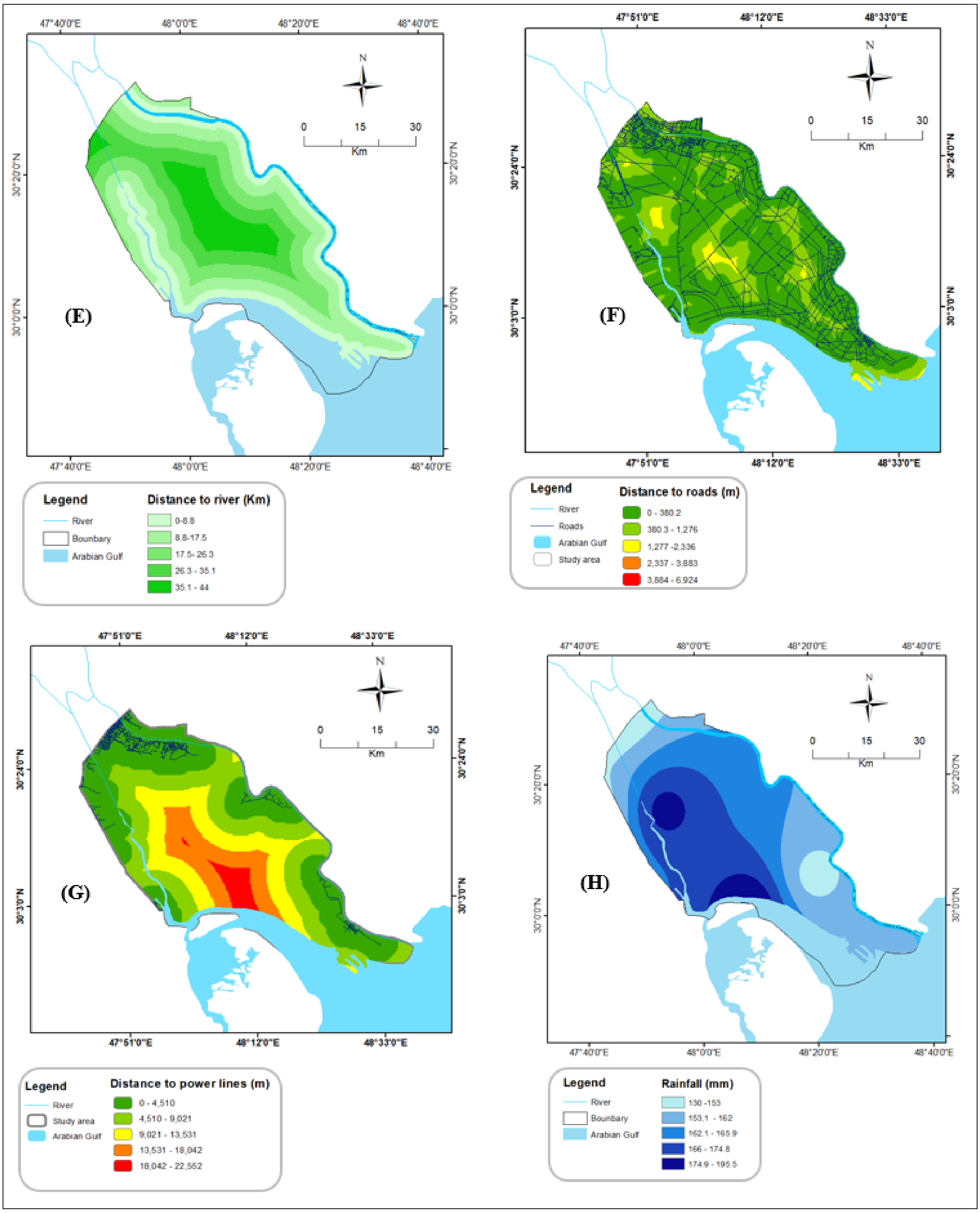

Figure 3. (E) distance to the river (Km), (F) distance to the road (m), (G) distance to the power line (m), and (H) Rainfall (mm).

3.3 Multi-Criteria Decision Analysis (MCDA)

Multi-criteria decision Analysis (MCDA) is a paradigm for decision-making that assesses and ranks many alternatives according to diverse criteria (Hwang et al., 1981). Two well-known MCDA approaches—Weight Sum and Weight Overlay methods—are examined in this work. Fields, including resource allocation, urban planning, and environmental management, extensively utilize these strategies. The techniques of Weight Sum and Weight Overlay have been applied in several fields. In environmental management, for instance, Weight Overlay is used to determine appropriate sites for conservation areas, whereas Weight Sum is utilized in project management to assess project proposals (Odu, 2019). Multi-criteria decision analysis (MCDA) methodologies, such as Weight Sum and Weight Overlay procedures, offer essential instruments for decision-makers. By considering multiple criteria, these methods help ensure that decisions are well-informed and balanced. The integration of geographical, environmental, social, and economic elements can effectively employ environmental risk and threat analysis in the process of choosing the best locations for surface water desalination facilities in Basrah. Some important factors could be elevation, soil, geology, slope, rainfall, distance to the road, LULC, distance to the river, distance to the power line, and so on.

The study assessed locations for desalination facilities using the weight overlay and weight sum approaches. The weighted sum approach ranks sites by summing the weighted scores after assigning weights to different criteria based on their importance. In contrast, the weight overlay approach imposes multiple criteria maps, each with a weight according to its importance. The final results were based on the weights assigned to the criteria, affecting the selection of the best desalination site, with the distance to the river having the most important weight (17%). Soil and geology factors were the least influential (3%). The weights of these factors were determined using the online AHP calculator (Table 2), based on the views of experts and previous scientific studies from around the world (Dweiri et al., 2018), (Gokçek & Gokçek, 2016).

Table 2. Weights of the factors weight sum technique.

Factors	Weight %
Rainfall	19
Distance to the river	17
Distance to the network	17
Elevation	15
Distance to the road	13
Slope	10
LULC	4
Geology	3
Soil	3

3.4 Weight sum & Weight overlay Methods

The Weighted Sum Method (WSM) and the Weighted Overlay Method (WOM) are two well-liked Multi-Criteria Decision Analysis (MCDA) techniques for spatial decision-making, especially in Geographic Information System (GIS)-based site selection studies (Figure 4). These techniques help combine several elements to determine the best sites for a given objective, such as the placement of desalination plants. These two techniques are used to create a map that identifies the best location for establishing a surface water desalination plant in Basrah Governorate, southern Iraqand add several raster data that were relied upon within the study, and thus multiply these raster data, each by its specified weight. All maps were 30*30 meters in size, allowing for easy handling that minimize errors. Moreover, add them together. Generate a file of random points for the study area, where each contains geographic coordinates (X, Y). Approximately 500 points were used to cover the entire region. Then, add all the original point data before modifying it using the (Extract Multi value) command. Then, get a table containing all the data. The table is converted to Jupiter. To obtain the code for calculating the weights, each factor has a corresponding weight that influences the selection of a suitable location for establishing a water desalination plant. Each method has its own code, which assigns different weights based on the available data.

A method of weighted sum by entering a group of point data with the same extent and spatial resolution. Determine weights for raster data. Weight represents the importance of data in the final output. For example, if one wants to know the best location, the highest weight is given to the most critical data (distance to the river and distance to the network) (Figure 3), Table 2. The weights are then summed. The weights of the factors affecting the appropriate location for establishing water desalination must be 100%, Table 2, after which all factor maps are added, the weight of each map is added through the (weight overlay) command.

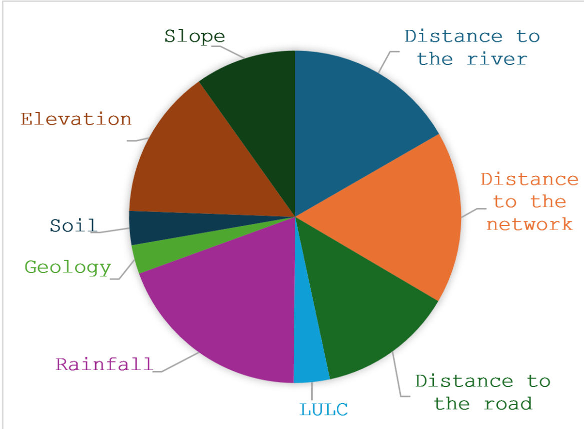

Figure 4. Weight of factors by using the Weight overlay technique.
Weights of the factors. (Malczewski, 1999)

Effat and El-Zeiny (2017) explained the method of the rank sum and applied multi-criteria decision analysis (MCDA). Surface water desalination was assigned the priority, starting with the priority rank rainfall, second priority rank distance to a river, distance to the power line, elevation, distance to road, slope, LULC, soil, and finally, priority rank geology. The AHP online calculator was used to calculate the weights of the factors affecting the selection of the most suitable site for the construction of a surface water desalination plant. Table 1 shows the weights of factors.

WSM is a simple MCDA method that weighs each criterion according to its relative importance. The weighted values of all the requirements are then added up to determine the final appropriateness score for each alternative (Malczewski, 1999). It uses the following equation (1):

$$s = \sum_{i=1}^{n} wi * xi \quad (1)$$

Where: S = final suitability score, wi = weight of criterion i, and xi = normalized value of criterion i.

This technique integrates characteristics such as elevation, soil type, distance to the power line, and distance to the river, among others. It is especially helpful for ranking possible locations for desalination facilities in Basrah (Saaty, 1980). WOM can provide a suitability map by analyzing geographical characteristics such as slope, distance to power lines, distance to river, and LULC, which will help decision-makers choose the best sites for the Basrah desalination project (Jankowski & Nyerges, 2001). WSM and WOM both offer methodical frameworks for assessing various site selection factors. WOM is more useful for mapping and visualization in GIS-based investigations as it is spatially explicit, whereas WSM is more algebraic and utilized for ranking alternatives (Malczewski, 2004). Using these techniques to select a location for Basrah's desalination plant ensuresa data-driven, open, and effective decision-making process.

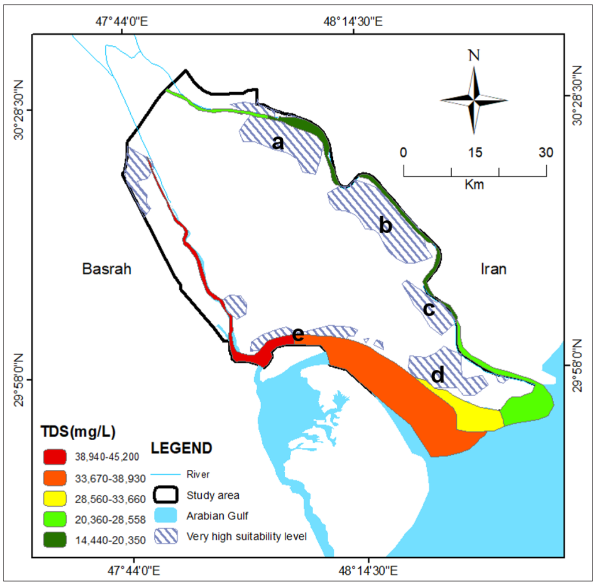

Figure 5. TDS map in (mg/l) with suitable locations for surface water desalination plants.

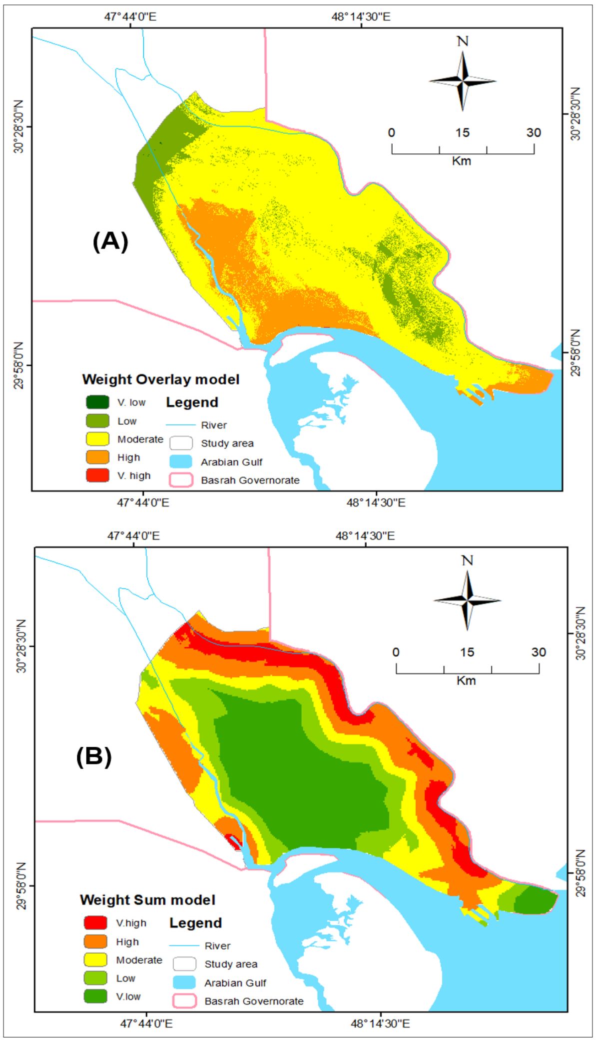

Figure 6. (a) Weight overlay model, (b) Weight sum model.

4. Results and Discussion

Using the online AHP calculator, the study extracted factor weights, assessed their significance through expert comments and literature reviews, produced a pairwise comparison matrix, and verified their consistency. A consistent decision-making process was indicated by the consistency ratio of 0.04 (< 0.1). Rainfall (0.192), distance to the river (0.167), elevation (0.145), distance to roads (0.131), slope (0.098), LULC (0.035), soil (0.033), and geology (0.028) were prioritised in the weight distribution, Table 2, Figure 4. For the factor weights specific to the technique (Weight sum), rainfall was ranked first with a weight of 19%, followed by distance to rivers (17%), distance to power lines (17%), elevation (15%), distance to roads (13%), slope (10%), LULC (4%), geology (3%), and soil (3%). This consistency ensures that each category reflects a comparable subset of the dataset (Longley et al., 2005). In the weight sum technique, the low to very low areas cover approximately 7636 km² (45%), medium areas cover 4772.5 km² (20%), and high to very high areas cover 6681 km² (35%). This area is represented along the banks of the Shatt al-Arab and parts of Khor al-Zubair. In the weight overlay technique, the ratio of low to very low areas is 20% (3818 km²), medium (60%) 11,454 km², and finally, high to very high areas occupy a ratio of 20% (3818 km²)· which includes both the Al-Faw and Khor Al-Zubair areas. As for the spatial distribution, there were three main and significant areas considered as the best-selected sites for establishing surface water desalination plants in them and on huge areas, and these areas were identified by the techniques mentioned previously, where the (Weight overlay) technique showed that the best site is the Al-Faw area north of the Arabian Gulf and the Khor Al-Zubair area. In contrast, the other technique represented by (Weight sum) shows that the best site for establishing surface water desalination plants in the future is along the banks of the Shatt Al-Arab and also the Khor Al-Zubair Canal. Low levels of pollutants and turbidity in high-quality source water reduce the need for intensive pre-treatment, which in turn lowers energy and operating expenses (Ghaffour et al., 2013). High-quality water can mitigate the ecological impact of brine discharge, protecting marine life. The Shatt Al-Arab River's discharge rate fluctuates due to seasonal changes and upstream water management (Al-Asadi et al., 2020). Dam construction and water diversions in Iran and Turkey have reduced river flow, causing pollution and salinity issues. Contaminants include heavy metals, nitrogen, phosphorus, and oil spills.

Increased salinity in Khora Al-Zubair is a result of a combination of irrigation runoff, seawater intrusion, and other nearby sources of pollution. Construction in the area is somewhat complicated by the clayey loam soil. High compressibility and poor stability are characteristics of clayey soils that can compromise the foundation and structural soundness of a desalination plant. There are several ways to stabilize these soils, however. According to research, the addition of materials such as fly ash, cement, and lime can enhance the geotechnical characteristics of clayey soils (Sendilvadivelu et al., 2023). Low-salinity locations reduce membrane wear and tear, extending the life of desalination equipment and minimising maintenance expenses (Lattemann et al., 2008).

Additionally, lower salinity levels reduce osmotic pressure, which uses less energy during desalination and improves energy efficiency. They are especially significant (Elimelech et al., 2011). Furthermore, the viability of hybrid desalination systems, which can alternate between various technologies according to salinity levels, can maximise operational efficiency and energy consumption (Younos et al., 2005). A monitoring program is necessary to obtain historical water quality data and spatial mapping of salinity levels and other chemical variables because seasonal changes, upstream water management, and tides have a significant impact on the water quality of the water bodies in the study area (Shatt Al-Arab River Al-Fawd, and Khor Al-Zubair e) (Figure 5). TDS levels were mapped for this investigation using the total dissolved solids (TDS) in mg/L from 10 sample locations gathered between April 1 and April 2, 2024. The three best locations will be prioritised using this mapping (Fig. 5). The range of the TDS value is (14,440 – 45,200) mg/l. In the weight overlay technique, the best sites considered suitable for establishing surface water desalination plants in the future are located on the Al-Faw side, represented by regions (d) and (e) Khor Al-Zubair (Figure 6a). In terms of soil texture, the study area is composed of silty loam, clayey loam, and Loma, which constitute 50% (1,304 km²), 35% (911 km²), and 16% (410 km²) of the total area, respectively. Of these three types, silt is generally considered the optimal choice for constructing the infrastructure of a desalination plant (Figure 3D).

The results indicated a suitable site for establishing a surface water desalination plant in Basrah Governorate, specifically in the south of Basrah, particularly in the Al-FAW region, as well as in Khor Al-Zubair and along the Shatt Al-Arab. The maps of the (weight overlay and weight overlay) techniques were divided into five categories (V. high, High, Moderate, Low, and V. low). The high ery very high areas best represent suitable locations for setting up desalination plants. According to the weight sum technique, the low to very low zones occupied 7636 km^2 (40%), the moderate zones 4772.5 km^2 (25%), and the high to very high zones 6681.5 km^2 (35%). The result of the weight overlay technique shows that the moderate zones encompass 60% (11,454 km²), the high to very high zones cover 20% (3,818 km²), and the low to very low zones cover 20% (3,818 km²). Using hydrological techniques models with GIS considers the key factors involved in selecting alternatives, e.g., desalinated water, feed water source, desalination technology, plant locations, and capabilities. As for the Weight sum technique, the most suitable location for establishing surface water desalination plants in Basrah Governorate is along the banks of the Shatt Al-Arab, specifically north of the Shatt Al-Arab (a, b), southeast of the Shatt Al-Arab (c), and the part adjacent to the Khor Al-Zubair channels (d), (Figure 6 b). The percentages of dissolved solids (TDS) values are considered the dividing line when choosing the appropriate location. Comparing these values with the suitable locations that appeared within a high to very high range in the two techniques (Weight overlay- Weight sum) is compared within the values of the total dissolved solids (Fig. 5), where it was found that the lowest percentage of dissolved solids is along the banks of the Shatt Al-Arab (14440.93-20350.90) mg/l, which proves the validity of the results of the appropriate areas that were suggested within the Weight sum model. As for the Weight overlay model, the lowest percentage of TDS is on the side of the region Al-Faw, North of the Arabian Gulf, and this proves (20350.91-28558.45) mg/l, the validity of the results of the areas suitable for establishing a surface water desalination project within the results of the first technology. Where the techniques (Weight overlay- Weight sum), Figure 6 showed that the indicated sites, which represent area (a-b-c) affiliated to the banks of the Shatt al-Arab and area (d) affiliated to Al-Faw, and finally area (e) Khor Al-Zubair and Basrah Governorate, are ideal for future projects in Iraq, particularly Basrah. These areas lack large-scale projects and serve the public interest by providing substantial water quantities for human use. This study saves agencies time and effort.

5. Conclusion

Comparing two primary methods for identifying the best site for a surface water desalination plant and mapping the site appropriateness for prospective future desalination plants in the Basrah Governorate were the two primary components of the study. This work was accomplished by integrating GIS, MCE, and spatial AHP. Basrah Governorate in southern Iraq was chosen as a case study due to its strategic location on the Arabian Gulf; moreover, Iraq's primary water resources are limited, comprising non-renewable groundwater from deep wells, some renewable aquifers, and seawater. Decision-makers can manage current desalination plants and plan for future ones with the aid of the work outcomes. Other studies may find the technique employed in this paper useful. The optimal locations for developing water desalination plants are the north-south Shatt Al-Arab (a-b-c), the FAW area (d), and Khor Al-Zubair (e), according to the results of hydrological techniques. In the modeling map, these places correspond to the V. high and High classes.

The best locations in the Basrah Governorate for a water desalination project were selected using weighted sum and weighted overlay techniques. In addition, the research area's lithology, rainfall, land cover, and land use, as well as proximity to major roads, electricity transmission lines, and urban centers, were taken into account, along with the land surface's height and slope. Land use, as well as proximity to major roads, electricity transmission lines, and urban centers, were taken into account, along with the land surface's height and slope. In the study area, regions (a) and (b) are considered the most suitable in terms of establishing a surface water desalination project due to the low salinity and the water fluctuations of the Shatt al-Arab drainage, which affects the salt tongue coming from the Arabian Gulf. As for the second region, Al-Faw (c), it is considered one of the most suitable sites chosen due to the abundance of land ideal for establishing large projects, such as the seawater desalination project, as most of it is a salt marsh, in addition to its lower salinity compared to the Arabian Gulf. Finally, the Khor Al-Zubair region (d), despite the pollution of the water source of this region with chemical and oil pollutants, is close to the Al-Zubair region, meaning that it is easy to treat this water and transport it for use for many purposes (domestic and industrial).

Therefore, it is believed that this study is essential for both decision-makers and implementers. When choosing the ideal location for a surface water desalination plant, several methods are crucial. Government organizations will save a significant amount of time and effort by identifying suitable locations for the construction of a large-scale water desalination plant in the Basrah Governorate.

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