Comparison between Saaty’s approach and Alonso and Lamata's approach in site selection process

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Abstract. This paper illustrates comparisons between Saaty’s Approach and Alonso and Lamata's Approach to deploying a set of indicators/criteria for prioritizing and selecting practice to Irrigation Project with the application of remote sensing techniques. Inaccuracy in checking the consistency of the site process leads to poor selection of irrigation projects location. Where the loss of appropriate plan and mistake in the choice of the most reasonable site for the irrigation project is one of the deficiencies that resulted in shortcoming in the building of the irrigation projects and this may prompt the fall of the farming. Data are gathered through expert's questionnaires, group discussions, interviews and literature review. Based on all pre-mentioned tools, indicators /criteria were derived for use in the selection process evaluation. This paper paved the way for further research on the topic of accuracy in adopting consistency approaches that give the best results.

Keywords: Spatial model, Saaty’s Approach, irrigation projects.

1. Introduction

In this paper, it is argued that surveying various experts on the topic of decision making affects the result of suitable sites. As a result of this, the accuracy will be different from one case to another for the same problem. The role of remote sensing in site selection has received increased attention across a number of disciplines in recent years. Unacceptable administration leads to the poor performance of irrigation projects. Thus, the lack of proper design and inaccuracy in the selection of the most suitable site for the irrigation project and hydraulic structures built on this network, operation, and maintenance is one of the shortcomings that leads to weakness in the performance of the irrigation system and this may lead to the collapse of the agricultural reality of the country. Some studies suggest that irrigation development, including agricultural reformulation in terms of the policy, technology, and management practices could contribute to greater food security and increased overall economic growth (Worqlul et al., 2018). In this study, it was the highlight of accuracy in the selection of the most appropriate site for the establishment of the irrigation project, which is considered one of the most important factors determining project failure or success! It can be said that steps selecting the best site of the establishment of the project are the foundation stones, which it is not an easy step. The designers must be using the decision-making process for the selection of the most suitable site according to strict procedures and logical decision. There is an urgent need to compare the consistency accuracy caused by surveying various experts to obtain scores of indicators. These needs empower the basic Decision-Making identified with arranging, positioning or choosing the most appropriate option in issues (Corrente et al. 2012). One of the greatest points of interest of the AHP approach is that it encourages users to dismember a mind-boggling issue into its constituent parts in a way that is increasingly oversimplified (De Felice et al. 2013). This examination, along these lines, utilizes a GIS-based Multi-Criteria Evaluation (MCE) strategy to distinguish the spatial conveyance of the land that is
conceivably appropriate for shallow groundwater irrigation under both current and future climate conditions. This method recognizes the conceivably reasonable land by considering various indicators influencing the suitability of a specific land for irrigation. These indicators are weighted to decide their relative effect on the process. Afterward, they consolidated to build up a solitary ordered yield. MCE has been connected to arrive at appropriate investigation for irrigation projects (Assefa et al. 2018). The site must be optimally selected meaning it must be friendly with the environment and close to the agricultural area. Selecting the best site for an irrigation project is not an easy task. The analysis must consider socio-economic, demographic and physical criteria and the reality of the study area, as well as the plans of Governments and previous experience in this complicated task.

The main objectives of the current study are:

- To specify criteria to enable us to select suitable sites for an irrigation project.
- To compare between Saaty’s Approach and Alonso and Lamata’s Approach in the Site selection process
- Finally, a selection of irrigation project was carried out.

The study area is located in Thi Qar governorate, especially in between Al-Nasiriyah City and Alshatrah City. Figure 1 represents boundaries of the study area which is rich in different agricultural crops.

![Study area](image)

**Figure 1.** Study area.

2. Methods and materials

2.1. Datasets

Recent trends in remote sensing and geomatics have led to a proliferation of studies that integrate AHP with spatial data through GIS. The Spatial Data were ASTER Global Digital Elevation Model (GDEM), Landuse/Landover Dataset: Dataset display roads networks, Villages and Landcover of the study area in shapefile and GeoTIFF format. Water body and soil type: Dataset display water bodies, rivers and soil types in the study area (Source: Ministry of Municipalities of the Regional Government of Thi Qar Governorate) and Satellite Imagery: QuickBird and LandSat. Questionnaires were gathered
through experts surveying for specifying scores of indicators/criteria. The indicators were selected according to Questionnaire, group discussions, interviews and literature review.

2.2. Selected indicators
Indicators were specified through expert's questionnaires, group discussions, interviews and literature review. In this study, the use of geomatics for the selection of the most appropriate site for the irrigation and drainage networks site for control structures, is according to the following indicators:

1) First Indicator (I1): Topography of study area specifically, a bumpy or inclining area can be a test. Dribble irrigation functions admirably if the laterals can be kept running along topographic lines. Systems run times may be changed in accordance with averting spillover. Voyagers and focus turn systems are as a rule impossible on bumpy and seriously inclining area (Worqlul et al 2019).

2) Second Indicator (I2): The slant of waterway area is viewed as the principal wellspring of Feeder water for irrigation venture.

3) Third Indicator (I3): villages and urban areas should be near the project (You et al., 2011).

4) Fourth Indicator (I4): Proximity to agricultural areas that need to be irrigated. Where these zones are considered as the fundamental target of any irrigation venture.

5) Fifth Indicator (I5): Soil type: The kind of soil in a territory can influence the sort irrigation strategy utilized as well as irrigation run times. Sandy soils normally require water at a high rate to keep dampness in the root zone. More tightly, clay can hold dampness longer than sandy soils; however, they may require water at a lower rate to anticipate spillover (Worqlul, et al 2019, Kim and van 2009).

There are other indicators related to selecting location like financial issue, political view of central and local Government, main road network and pattern of villages distribution, and mining factors and industry but paper did not take it because they are not spatial criteria and on the other hand was the purpose of paper is comparing two different spatial models

2.3. Model building
The model of suitability areas was generalized using a model builder in ArcGIS10.5. It was built based on weighted linear combination (Malczewski 2000, Al-Hameedawi 2014, 2018, Khatwani,& Kar 2016), in which the weight of the relative importance found to each criterion and a total score, V (xi), is then conducted for each criterion by multiplying the weight found by the scale value for that criteria. The final suitability maps were produced by combining various datasets with indicators through the model.

2.4. Consistency checking
i. Using Saaty
Based on AHP process the following formula was used

\[
M.E = \frac{L_{\text{max}}}{E}
\]  

M is the comparison matrix of size n×n, for n criteria also called the priority matrix.
E is the Eigenvector of size n×1, also called the priority vector.
Lmax is the Eigenvalue

\[
CR = \frac{CI}{RI} \leq 0.1
\] 

Values for RI according to Saaty & Vargas, 1991.
The consistency index CI can be straightforwardly figured from the matrix with

\[
CI = (L_{\text{max}} - n) / (n - 1)
\] 

Saaty and Vargas (1991) suggest a modification of the preference matrix if the consistency proportion CR surpasses an estimation of 0.1.

ii. Using Alonso and Lamata's Method for Checking consistency
We have recently observed Saaty's way to deal with deciding if a given matrix falls inside our resiliencies for inconsistency. This approach is extremely included and makes a few strides subsequent to figuring the estimation of $L_{\text{max}}$ for the matrix being referred to. There is a simpler path, created by Alonso and Lamata (2006) that permits us to promptly endless supply of $L_{\text{max}}$ whether a matrix falls inside the standards. To start, we first compute the average estimation of $L_{\text{max}}$ for a large number of $n \times n$ matrices. We will allude to this value as $\lambda_{\text{max}}$. By finding $L_{\text{max}}$ for the matrices of each size $n$, Alonso and Lamata could plot these qualities against the measure of the matrix and locate a least-square line to display the relationship. The curve that fits the data best is linear, with condition

$$\lambda_{\text{max}} (n) = 2.7699n - 4.3513$$

(4)

We do the accompanying estimations to demonstrate the most extreme worthy estimation of $L_{\text{max}}$ in the event that we need our CR to be under 0.1. To start with, we realize that we can represent the RI for a matrix of size $n$ by

$$RI = \lambda_{\text{max}} - \frac{n}{n-1}$$

(5)

Accordingly, consolidating this outcome with our equation 3 we see that

$$\lambda_{\text{max}} < 1.17699n - 0.43513$$

(6)

Utilizing this equation, we can decide the most extreme allowable $L_{\text{max}}$ for a $n \times n$ network by essentially computing $1.17699n - 0.43513$. On the off chance that our $L_{\text{max}}$ is not as much as this esteem, then our matrix will even now be inside the reasonable inconsistency. Besides, we can take after these same calculations to decide the permissible $L_{\text{max}}$ for different inconsistency.

### 3. Results and discussion

3.1. Testing consistency

i. Using Saaty's approach

The consistency list of a haphazardly delivered corresponding reciprocal matrix is known as the random index (RI). The normal RI values for matrices of orders 1–15 have been created for example, size of 100 (Brent et al. 2007). The last proportion that must be computed is the CR (Consistency Ratio). If the CR is under 0.1, the judgments are reliable and the determined weights can be utilized. Formula (2 and 3) for computing CR is basic (Deng 1999). Nine specialists or experts partook in giving scores, and just four of their reactions were dismissed because of conflicting correlations where CR is more than 0.1 (Tables 1 and 2).

ii. Using Alonso and Lamata's approach

Utilizing Formula 4, we will calculate $\lambda_{\text{max}}$ then we utilize this value to compute RI: $RI = \lambda_{\text{max}} - \frac{n}{n-1}$. An Afterward we figured $1.17699n - 0.43513$. In this paper, we have compared CR values using Saaty’s Approach and Alonso and Lamata's Approach, respectively. Alonso and Lamata's Approach utilizes a consistency list which is less complex and more adaptable than Saaty's ($L_{\text{max}}$) and an exceptionally straightforward paradigm for tolerating or dismissing networks on the other hand, Saaty's Approach was more precise and rigorous as expressed underneath. Alonso and Lamata's Approach thinks about the matrix level of consistency to the consistency level of the rest of the matrices (random matrices) of a similar measurement.

### Table 1. Normalized priority matrix (Saaty's approach) according to experts.

| Experts | I1     | I2     | I3     | I4     | I5     | Sum I | Saaty's Cr |
|---------|--------|--------|--------|--------|--------|-------|------------|
| E1      | 0.2228 | 0.4095 | 0.208  | 0.1145 | 0.07087| 1     | 0.08       |
| E2      | 0.228959| 0.29788| 0.2096 | 0.116  | 0.16901| 1     | 0.081      |
| E3      | 0.121156| 0.1305 | 0.242  | 0.1001 | 0.4031 | 1     | 0.078      |
3.2. Land use suitability
The process of choosing the suitable areas must take into consideration that the most important thing is the non-agricultural areas were excluded from the comparison process. This was done through extracting process to include only the agricultural areas. Layers were reclassified so that the derived datasets had to be combined to enable us in creating the suitability map that would identify the potential sites for the irrigation project (Al-Hameedawi et al. 2018). Nevertheless, it was not feasible to combine them in their existing form; they had to be unified at the same scale measurement. To combine the datasets, they first had to be set to a standard measurement scale. What stands out in this figure 2 is the use of expert’s score according to Saaty’s approach. Hence, these results confirm the association between the influences of different approaches regarding consistency on selected sites.

3.3. Major findings
Some evidence suggests that the accuracy of remote sensing technology has an important role to play, although further work required confirming these findings. Site (1) covers arable areas of 4.89603(km²) but there are no intersection regions (headwork) with the river, and the nearest city from this site is about 15 km. While, Site (2) covers an arable area of 89.948 km², and includes the intersection regions with an area of 0.593 km², and the nearest city from this site is about 12 km. Site (3) covers an arable area of 123.781 km², and includes the intersection regions (headwork) with an area of 1.892 km², and the nearest city from this site is about 9 km. On the other hand Site (4) covers an arable area of 105.632 km² and includes the intersection regions (headwork) with an area of 1.619 km² and the nearest city from this site is about 6 km. Site (5) covers an arable area of 13.92 km² and includes the intersection regions with an area of 0.466 km², and the nearest city from this site is about 3 km. Looking at Figure 4, it is apparent that Alonso and Lamata’s approach reported significantly more susceptibility than Saaty’s approach regarding consistency checking of scores obtained by surveying. As can be seen from the analysis of results of that site 3 is the best because it covers a larger area from the intersection regions with section River, also covers the largest agricultural area and the site of the an appropriate distance from the nearest city boundaries of the study area and then followed by the site 4 and then the site 2 and then site 5. Finally, site 1 will be excluded because of the lack of the intersection regions of with the river which is an important condition of the establishment of the project irrigation because the river is source feeder water for the project site 1, site 2 .....etc.. Please note that these were extracted by spatial model according to indicators (importance, hierarchy).

Table 2. Normalized priority matrix (Alonso and Lamata’s approach) according to experts.

| Experts | Indicators | Alonso and Lamata's Cr | Geo-Mean of weights |
|---------|------------|------------------------|---------------------|
| E1      | 0.038822   | 0.054087               | 0.209815            |
| E2      | 0.01923    | 0.507724               | 0.260336            |
| E3      | 0.257164   | 0.442214               | 0.219346            |
| E4      | 0.02195    | 0.57667                | 0.0865              |
| E5      | 0.27427    | 0.29566                | 0.0862              |

**Table 2.** Normalized priority matrix (Alonso and Lamata's approach) according to experts.
Figure 2. Suitable sites for irrigation project (Satay’s approach).
Figure 3. Suitable sites for irrigation project (Alonso and Lamata’s approach).

Figure 4. Comparison between consistency approaches.

4. Conclusions
The most obvious finding emerging from this paper is that Alonso and Lamata’s approach reported significantly more susceptibility than Saaty’s approach regarding consistency checking. The proper choice of an irrigation project site is ‘a strategic step that can develop economic growth and increase agricultural production’; a significant step in agricultural progress. Decision making requires a lot of efforts including time-consuming and experience for the purpose of obtaining accurate and productive work. Further work needs to be done to establish the capability of such papers which will improve the overall accuracy through using the benefits of various technologies. The developed model can be applied to different irrigation site choice. Therefore, further applications and suggestions are highly recommended.

References
[1] Alonso J and Lamata M 2006 Int. J. of Uncer., Fuzz. and Know. -Based on Sys. Vol. 14 No. 4 pp 445–459
[2] AL-Hameedawi 2018. Inter. J. of Civil Eng. and Tech.Volume 9, Issue 11, November 2018 pp 1333–1351
[3] Al-Hameedawi A, Salih M Mohammed, Razzak H and Hassan M 2018 MAT. Web of Conf. 162, 03018
[4] Assefa T, Jha M, Reyes M, Srinivasan R and Worqlul A 2018 Wat. 10 p 495
[5] Worqlul A W et al. 2019 Com. Elec. Agric. 157 pp 110–125
[6] Corrente S, Greco S, Slowin` ski R 2012, Dec. Support Syst. 53 (3) (2012) pp 660–674
[7] De Felice F, Petrillo A 2013 Int. J. Simul. Process Model. 8 (1) (2013) pp 6–16
[8] Worqlul A.W. et al.2018 Sustain.10 pp 1–23
[9] You L. et al. 2011 Food Pol. 36 pp 770–782
[10] Kim Y, van Zyl JJ 2009 IEEE Trans. Geosci. Remote Sens. 47 pp 2519–2527
[11] Saaty 1977 J of Math. Psy. 15 pp 234-281