Available online at www.jrors.ir

Journal Of Radar and Optical Remote Sensing

JRORS 1 (2020) 7–20

Investigation and Selection of Optimal and Suitable Locations for Arsenal Camouflage using Remote Sensing Studies (Case Study: Iran)

Mehdi Mohamadpour[a*], Davod Majidi[b]

[a] *Department of GIS & RS, Yazd Branch, Islamic Azad University, Yazd, Iran*
[b] *University of Complex Preparation and Passive Defense, Malek Ashtar University of Technology*

Received 12 January 2020; revised 14 March 2020; accepted 25 March 2020

Abstract

Identifying suitable and optimal areas for camouflage of arsenals is very important. The purpose of this study is to investigate and select the optimal and suitable places for camouflage of arsenals in the country using AHP model and mathematical analysis in ARC GIS environment. Locating is a process through which the best place for an activity can be determined based on the conditions and according to the available resources and facilities. Accordingly, in this study, first the effective factors in locating the ammunition slot are examined and the map of each of the effective factors in locating the arsenal such as slope map, slope direction map, Altitude map, Access road map, Distance from big cities map, Distance from medium cities map, Distance from small towns Map, Distance from villages map, Distance from faults map and distance from water level map were prepared in ARC GIS environment and the importance coefficients of criteria and sub-criteria were obtained using Analytic Hierarchy Process (AHP) and Expert Choice software. Then, these coefficients were applied in the layers related to each parameter through a linear weight combination and suitable places for selecting the arsenal were identified with a range of values.

***Keywords**:* Arsenal, Positioning System, Analytical Hierarchy Process (AHP), Geographic Information System (GIS), Iran

[*] *Corresponding autho*r. Tel: +98-*9374351520*.
Email address: mohamadpour.1520@gmail.com.

1. Introduction

When it comes to find optimal location, there are always fundamental issues for locating. The most important of these issues can be posed in the form of a series of questions, and most of the theories presented in the field of location have been formulated by economists to link the location factor to the main body of economic activity. The spatial dimension of economic activities and spatial relations has also attracted the attention of many geographers, and as a result of the cooperation and participation of these two groups (economists and geographers) and the combination of their ideas, the ground for the formation of Rules for locating and determining the optimal location is prepared. According to studies, Spatial Decision Support Systems (SDSS) along with Geographic Information Systems (GIS) can be of great help in locating vital and important sites and centers. This is because GIS solves complex geographic analysis problems. By providing this tool, the user is able to make appropriate decisions based on existing problems and plan the site, which includes analysis and selection with a systematic perspective (Sahami, 2007). Locating is a process through which the best location for an activity can be determined based on the conditions set and according to the available resources and facilities. Location is the simultaneous analysis of spatial information and descriptive data in order to find one or more spatial positions with descriptive features desired by the user. In other words, finding a suitable place for a defence center, special facilities, industrial area, etc. in such a way that various parameters such as the shape of the area, distance from main roads, distance from population centers, etc. with different weights effects finding this place is called locating (Sahami, 2007). Numerous studies have been done by researchers on location finding. However, due to the military nature of the subject, no articles are available for locating and examining arsenals. Accordingly, among the studies that have been done in the field of locating are: Shojae et al. (2011) in a study investigated optimally locate crisis management support bases using GIS in District 6 of Tehran. The results of their work by introducing four operations of addition, multiplication, phase sharing and phase community were introduced as options as a desirable location, among which, the northeastern part of the intersection of Kurdistan Highway and Shahid Gomnam was suggested as a superior option (Shojae, Tolani and Ziyaeiyan, 2011). Rajabi et al. (2011) in a case study of Isfahan province studied locating hydropower plants with a passive defense approach and using TOPSIS in the context of GIS software system. The output maps indicated that according to the TOPSIS model, the northeastern regions of Isfahan province have better conditions for the construction of new hydropower plants. This was confirmed by the inclusion of passive defence factors in the model, but the area of suitable areas decreased by 27.3% (Rajabi et al. 2011). Givehchi et al. (2013) applied multi-criteria decision-making models in locating temporary housing after the earthquake in District 6 of Shiraz. Using TOPSIS model and Excel software, places suitable for temporary accommodation were ranked according to priority. The results showed that the criteria of distance from the river, land area and distance from the passages are more important among other criteria. Also, the best places for temporary accommodation operations are parks and barren lands in this urban area (Givechi and Atar, 2012). In this study, the aim is to find optimal locations for camouflage of arsenals using GIS and hierarchical analysis process, which examines the effective components in locating arsenals using GIS technique and The AHP model, is discussed and suitable locations for selecting arsenals are presented in the form of raster maps.

1.1 Geographical Location of Iran

Iran is located in the northern hemisphere, between 25 - 40 degrees north latitude and between 44 - 63.5 degrees east longitude, which indicates that Iran is in the temperate zone.

On the other hand, Iran is in southwest Asia and connects the three continents of Asia, Europe and Africa, and the economic, cultural, political and military events that take place on these continents will also have an impact on Iran (Figure 1).

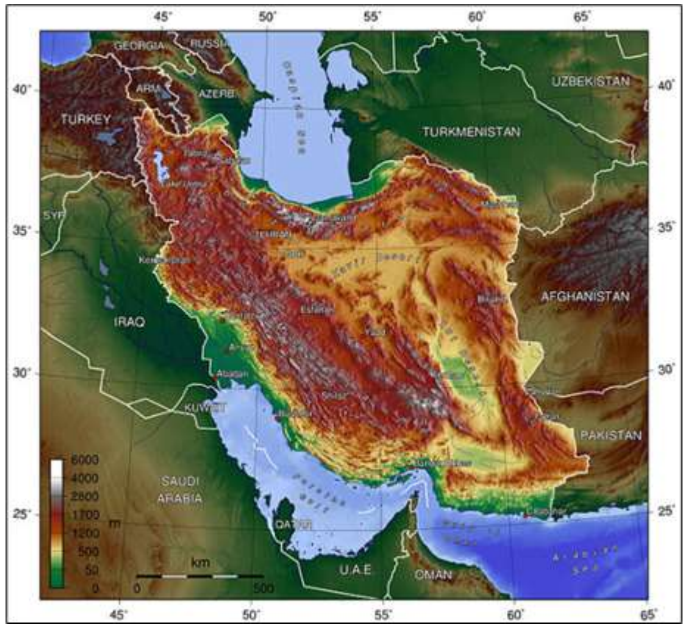

Figure 1. Geographical location of the study area

2. Materials and Methods

In this project, 12 layers (factors) of information have been used and each layer has been digitized in GIS environment and a raster network has been produced where each pixel contains only one value. Here all the influential factors of standard, weighting and dimension were combined (Figure 2). In this paper, digital ground elevation model (DEM) map, for preparing slope map, slope direction map, elevation floor map And data related to Iran communication network, data related to urban and rural centres map, data Surface water hydrological networks, boundary data, geological data (faults), temperature data were used and in addition to the above maps, Distance map of urban centres in three groups of large cities (population over 100 thousand people), medium cities (population between 50 to 100 thousand people), small cities (population less than 50 thousand people) were extracted using Google Earth software . To create and complete databases, digitize and edit maps, georeferencing the maps, determine coordinate system and image system, using functions and privacy maps of each layer, to apply weights It was used to overlay weighted layers.

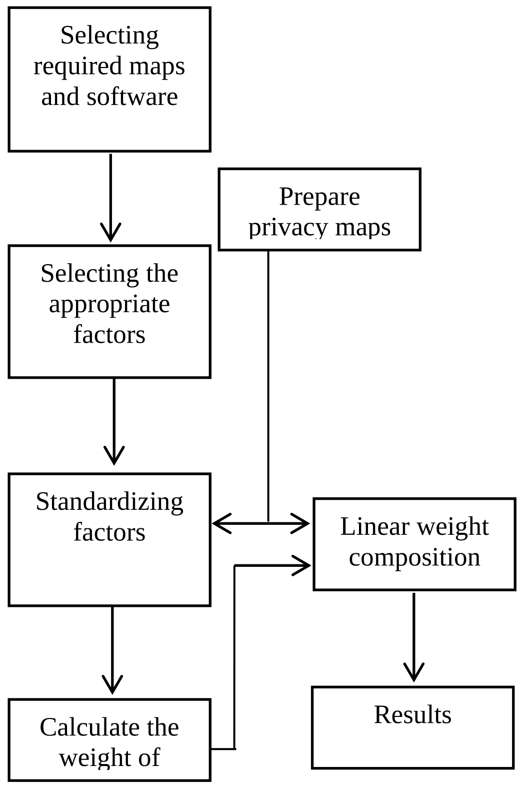

Figure 2. Arsenal location algorithm

2.1 Evaluation of Parameters or Factors (Criteria and Sub-Criteria)

Arsenal location parameters in this study include four main groups which are: social, economic, security-political and climatic factors. The main parameters are divided into sub-parameters according to Table 1.

Table 1. Evaluation of effective parameters in locating arsenal

	Criteria	Sub-criteria
Evaluation of effective parameters in locating arsenal	Social	Cities with a population of less than 50,000
		Cities with a population of 50 to 100 thousand people
		Cities with a population of over 100,000
		Villages
	Economic	Slope
		slope direction
		Height
	Security-Political	Border strips
		Communication routes
		Faults
	Climate	Waters; Temperature

2.2 Preparation of Privacy Maps

Privacy map is a raster map which its pixel value is the spatial distance from the center of the pixels to the target (Sanjeri, 2012). In this stage, a privacy map is produced for the effective factors in locating the arsenal.

Urban Space Map:

Urban areas are very sensitive areas, which should be considered for security reasons and the potential dangers of ammunition. In this study, cities in three groups of large cities (population over 100 thousand people), medium cities (population between 50 to 100 thousand people), small cities (population less than 50 thousand people) were surveyed and the area from 0 to 20 km, 20 Up to 25 km, 25 to 30 km and above 30 km for small towns and 0 to 30 km, 30 to 35 km, 35 to 40 km and above 40 km for medium cities and 0 to 40 km, 40 to 45 km, 45 to 50 km and over 50 km were considered for large cities based on the knowledge and experience of experts.

Village Privacy Map:

Due to the fact that villages have a smaller population than cities, but for security reasons, the area for villages was 0 to 10 km, 10 to 12 km, 12 to 15 km and above 15 km.

Fault Area Map:

It should be noted that the selection sites of the arsenal should not be located on the fault line and seismic areas, because the presence of faults is considered as a factor that increases the higher seismic potential. The fault can also reduce the integrity of the bedrock, which protects the arsenal site and its facilities. For the fault, 0 to 10 km, 10 to 12 km, 12 to 15 km and above 15 km were considered.

Slope Map, Slope Direction and Elevation Classes:

Other effective parameters in the study and selection of optimal and suitable places for camouflage of arsenal are slope maps, slope orientation and elevation floor maps. Each map was prepared in GIS environment based on DEM (Digital Elevation Model). Then the slope map of the region was classified into four classes: 0 to 10%, 10 to 20%, 20 to 30% and above 30%. For a slope orientation map that shows the different effects of sunlight in different directions and the amount of earth illumination at different slopes, there are four classes: 1- flat and south, 2- north, northwest, northeast 3- West and East, 4- Southeast and Southwest were considered. And the map of height classes was prepared in four classes: 0 to 800 meters, 800 to 2500 meters, 2500 to 4000 meters and above 4000 meters.

Road Privacy Map:

The roadmap is one of the important parameters in choosing the optimal and suitable places for camouflage of the arsenal. Because of economic issues, the distance between the arsenal and the access roads should not be much longer. In general, for convenience, reduction of transportation time and cost, the location of the slum should be as close as possible to the existing roads. Accordingly, the road map in four classes 0 to 5 km, 5 to 20 km, 20 to 40 km and over 40 km is prepared.

Water Privacy Map:

Due to the diffusion of moisture from the surface water surface and the sensitivity of ammunition to water and moisture and the presence of moist and humid air around surface water, it is necessary to consider a suitable distance for selecting an ammunition slot from the water surface. In this project, 0 to 2 km, 2 to 4 km, 4 to 6 km and above 6 km were considered for water.

Border Map:

Iran shares land borders with Pakistan, Afghanistan, Turkmenistan, the Republic of Azerbaijan, Armenia, Turkey and Iraq. In order to increase the security of the arsenal against the border countries, areas of 0 to 100 km, 100 to 110 km, 110 to 120 km and above 120 km were considered. (Figures 3 to 14) show the privacy map of each factors influencing the location.

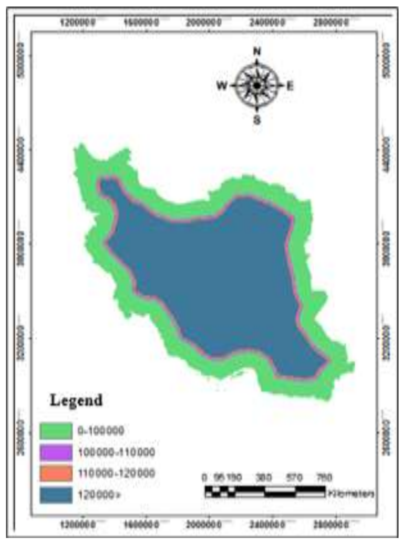

Figure 3. Border strip privacy map

Temperature Map:

The importance of the temperature parameter is very important in choosing the location of the arsenal, because most ammunition reacts quickly to heat and the probability of explosion in areas with higher temperatures is very high. The lower the temperature, the higher the value.

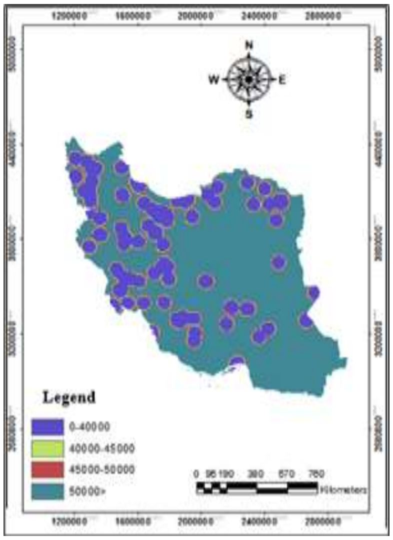

Figure 4. Map of the privacy of large cities

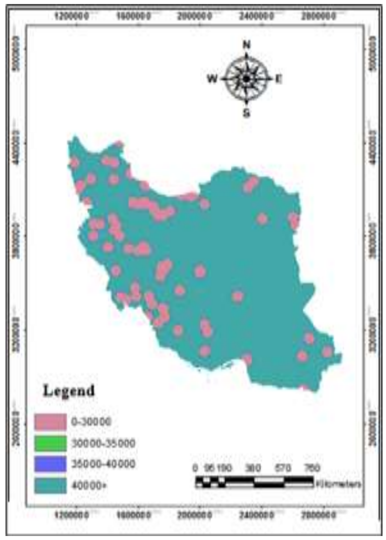

Figure 5. Medium city privacy map

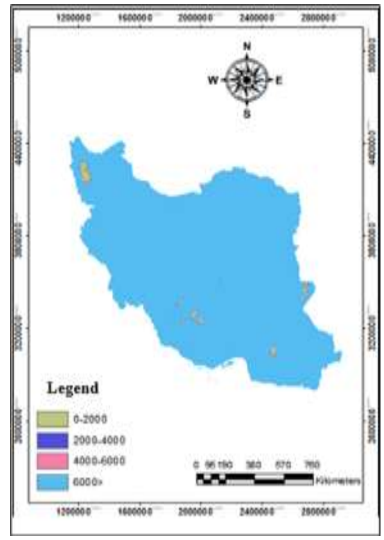

Figure 6. Water privacy map

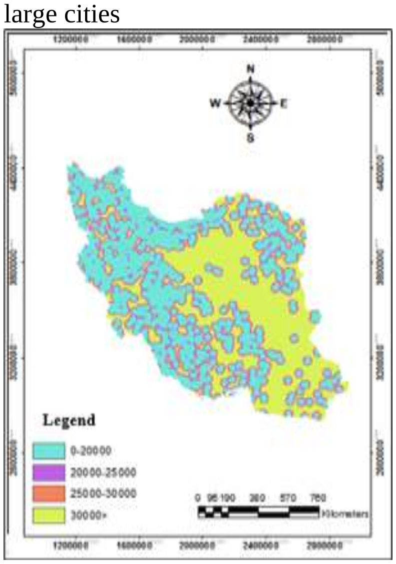

Figure 7. Small town privacy map

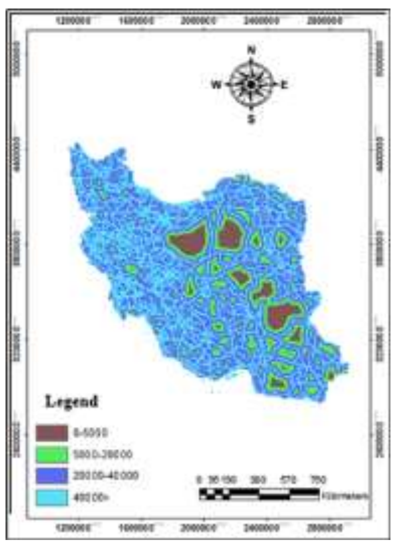

Figure 8. Road area map

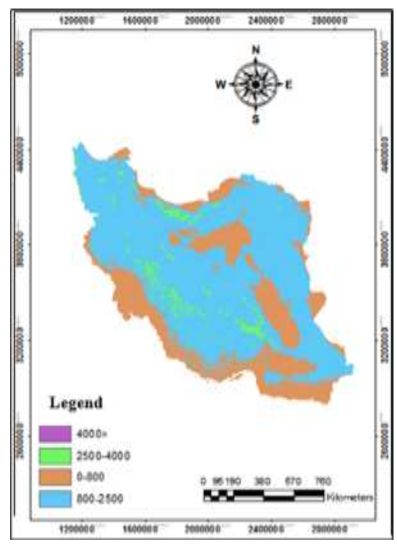

Figure 9. Map of elevated floors

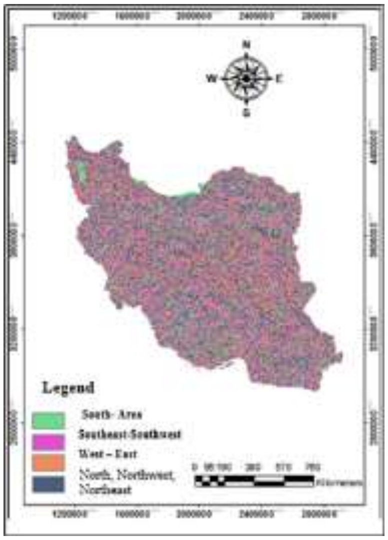

Figure 10. Slope direction map

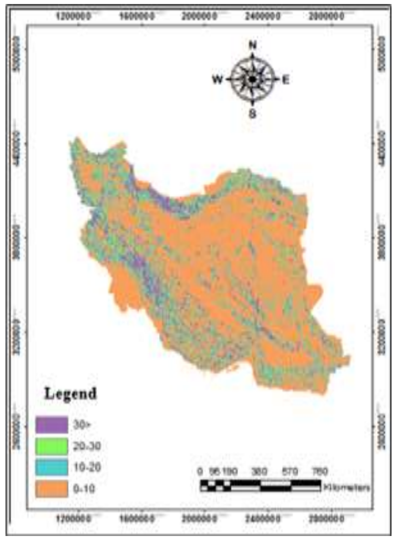

Figure 11. Slope map

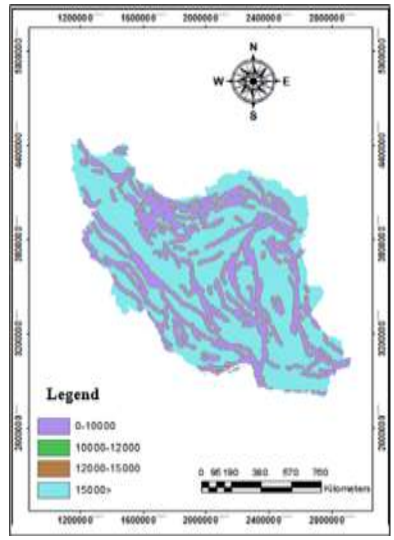

Figure 12. Fault area map

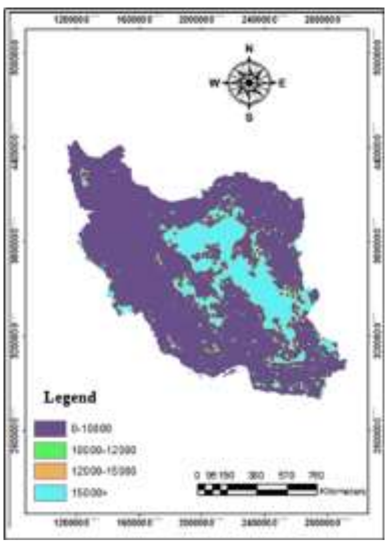

Figure 13. Village privacy map

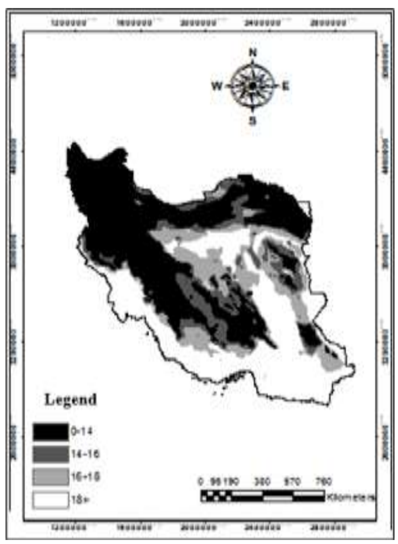

Figure 14. Temperature map

2.3 Factors Standardizing

In the location process, the first step is to ensure that the sizes are standard. In the measurement of all factors, because most rasters still retain the pixel values of the original map, they must be standardized to a single scale (Dai, Lee and Zhang, 2006). In this study, values between 1 and 7 are marked for easy analysis. Marking values to a certain value is such that there is a threshold for each factor to be decided. Table 2 shows the class boundaries and standardized values for each factor.

Table 2. Standardized values

Criteria	Value			
	1	3	5	7
Border strip (km)	0-100	100-110	110-120	>120
Large cities (km)	0-40	40-45	45-50	>50
Medium towns (km)	0-30	30-35	35-40	>40
Small towns (km)	0-20	20-25	25-30	>30
Waters (km)	0-2	2-4	4-6	>6
Roads	>40	20-40	5-20	0-5
Height floors (m)	>4000	2500-4000	0-800	800-2500
Slope direction	South and flat	South-East and South-West	West and East	North, Northwest and North-East
Slope (%)	>30	20-30	10-20	0-10
Fault (km)	0-10	10-12	12-15	>15
Villages (km)	0-10	10-12	12-15	>15
Temperature degrees (Celsius)	>18	16-18	14-16	0-14

2.4 Calculate the Weight of Factors

The primary issue in any assessment is to determine the weights separately for each factor. Here the hierarchical analysis process, which is a theory for economic and socio-political issues, is a convenient way to obtain the weights of each factor.

AHP is a multi-criteria decision-making approach that uses a binary comparison method to achieve the appropriate weight between different approaches (Carver, 2007; Banai, 2005; Bantayan and Bishop, 2009). To apply this approach, we must break down a complex problem into its component factors and classify these factors hierarchically to each of the numerical values according to the relative importance of each factor, and these factors. We put them together to determine which one takes precedence over the other (Saaty, 2008). Table 3 shows the significance values for binary comparisons.

Table 3. Significance values for binary comparisons

Definition	Significance
Equal importance	1
Equal to moderate importance	2
Medium importance	3
Medium to strong importance	4
Strong importance	5
Strong to very strong importance	6
Very strong importance	7
Very strong to extremely strong importance	8
Extremely strong importance	9

After constructing the binary comparison matrix, it is time to calculate the weight of the factors, which includes the following steps: a) Sum of the values of each column of the binary comparison matrix A: Calculate the average of the components in each row of the normalized matrix, i.e. divide the sum of the normalized scores for each row by the number of criteria. These means represent an estimate of the relative weight of the comparable criteria (Sener, 2004). After the weight of the factors, the ratio of the agreement is estimated. This step includes the following operations: A: Determining the total weight vector by multiplying the weight of the first criterion in the first column of the main binary comparison matrix the third column of the main matrix etc. Finally, aggregating these values in rows. B: Determining the agreement vector by dividing the total weight vector by the previously defined standard weights. After calculating the agreement vector, it is necessary to calculate the values of the two expressions Landa (λ) and the agreement index (CI). The value of λ is simply equal to the average of the values of the agreement vector. The calculation of the agreement index (CI) is based on the fact that Landa is always greater than or equal to the number of criteria under consideration, and $\lambda = n$ if the binary comparison matrix of a matrix is consistent. Therefore, λ - n can be considered as a criterion of the degree of compatibility (agreement), which is normalized as Equation (1):

Equation 1 = CI= λ – n/n -1

The term (CI), which is referred to as the agreement index (incompatibility index), is considered a criterion for deviating from the agreement. The value of the agreement index is calculated for matrices with different dimensions and with completely random values, and it is called the random matrix incompatibility index, the values of which you see in Table 4.

Table 4. Incompatibility index for stochastic matrices (Source: Saaty, 2006)

n	1	2	3	4	5	6	7	8	9	10
IIR	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49

For each matrix, the result of dividing the incompatibility index by the incompatibility index of the random matrix is a suitable criterion for judging the incompatibility, which we call the incompatibility rate. If this number is less than 0.1, the consistency of the decision is acceptable; otherwise, the judgments should be reconsidered (Sahami, 2007).

Therefore (CR) the agreement ratio (incompatibility rate) can be calculated through Equation 2.

Equation 2= CR=CI/IIR

The agreement ratio (CR), as mentioned, is designed to show that if the CR <0.1, the acceptable level of agreement in binary comparisons; But if CR≥0 / 1, it indicates inconsistent judgments. In such cases, the original values of the binary comparison matrix should be revised (Salari, 2012). In this study, binary comparison of criteria, calculation of weights and agreement ratio in Expert Choice software was performed automatically, which shows Figure 15 of the final weight of the obtained criteria.

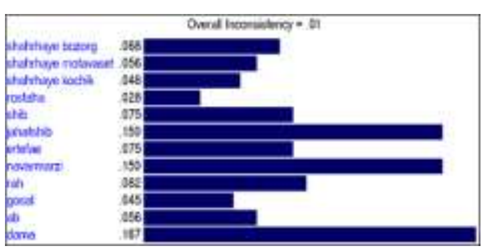

Figure 15. Final weight of Effective criteria for location

2.5 Linear Weight Composition

In this method, the standard points of the factors are multiplied by the weight of the factors, the product of the multiplications is added as a vector and the sum of the points of each pixel is obtained. The method of linear composition of the given weight can be shown as Equation (3) (Fataei and Alsheikh, 2009).

Equation 3= $S = \sum W_i X_i$

Where S: utility and Wi: weight of factor i and Xi: standard score of factor i. In this study, the calculated final weights are transferred to GIS and the weighted linear combination is applied to the factors and a suitable location map is created with a range of values (Figure 16).

3. Results

In this study, according to the nature of the research, the method of multi-spatial evaluation was used to combine a set of criteria and each of the factors were combined with their own weight and a desirability map was obtained (Figure 16). In the next step, in order to carefully study, the map of suitable, medium, weak and unsuitable places obtained from the previous method was prepared in two classes of suitable and unsuitable places. (Figure 17) and using the Query function, Sites were prepared that have the maximum characteristics considered for the criteria among the appropriate areas. In this study, about 20 sites were considered as suitable areas for arsenal selection (Figure 18) and characteristics of each site are shown in Tables 5 and 6.

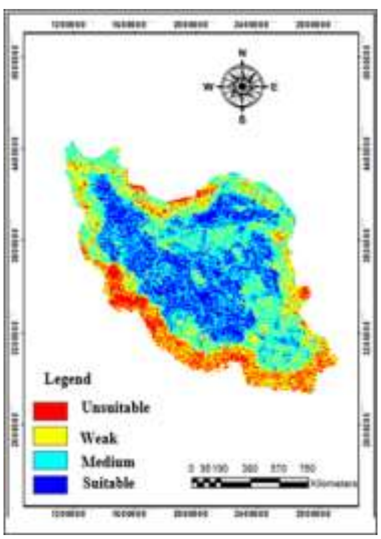

Figure 16. General location map

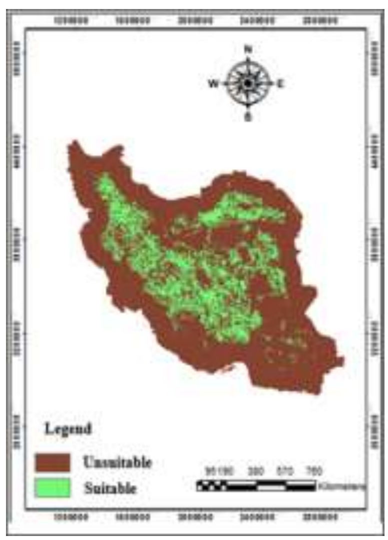

Figure 17. Location map of suitable and unsuitable areas

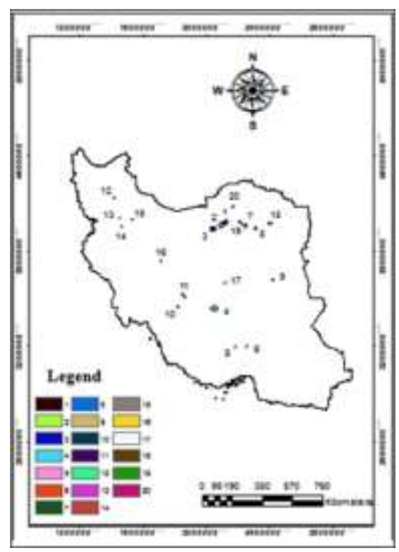

Figure 18. Map of sites located by the Query method

Table 5. Features of sites located 1 to 10

Factors to be evaluated	Site No.1	Site No.2	Site No.3	Site No.4	Site No.5	Site No.6	Site No.7	Site No.8	Site No.9	Site No.10
Distance from border strip (km)	180	175	153	472	202	184	257	268	212	229
Temperature (C)	0-14	0-14	0-14	0-14	0-14	0-14	0-14	0-14	14-16	0-14
Distance from road (km)	1	1	1	4	1	1	1	1	1	1
Distance from big cities (km)	62	75	94	93	70	113	103	81	79	66
Distance from medium cities (km)	91	71	68	176	127	199	167	103	266	55
Distance from small towns (km)	52	84	58	50	59	42	65	51	44	35
Distance from villages (km)	19	12	12	28	5	4	10	7	15	3
Distance from fault (km)	31	28	38	26	68	58	47	18	60	9
Slope (percentage)	0-10	0-10	0-10	0-20	0-10	0-10	0-10	0-10	0-10	0-10
Height floors (meters)	800-2500	800-2500	800-2500	800-2500	800-2500	800-2500	800-2500	800-2500	800-2500	800-2500
Distance from water (km)	463	458	441	103	187	255	471	465	295	88

Table 6. Features of sites located 11 to 20

Factors to be evaluated	Site No.11	Site No.12	Site No.13	Site No.14	Site No.15	Site No.16	Site No.17	Site No.18	Site No.19	Site No.20
Distance from border strip (km)	295	154	144	180	191	348	651	191	247	139
Temperature (C)	0-14	0-14	0-14	0-14	0-14	0-14	0-14	0-14	14-16	0-14
Distance from road (km)	1	1	1	1	1	1	1	1	1	1
Distance from big cities (km)	66	105	92	97	87	63	111	55	123	73
Distance from medium cities (km)	68	47	96	49	48	62	119	68	166	150
Distance from small towns (km)	41	33	31	28	24	32	99	34	55	37
Distance from villages (km)	5	3	4	3	2	6	5	10	25	12
Distance from fault (km)	19	26	52	105	38	20	7	23	45	15

Slope (percentage)	0-10	0-20	0-10	0-10	0-10	0-10	0-10	0-10	0-10	0-10
Height floors (meters)	800-2500	800-2500	800-2500	800-2500	800-2500	800-2500	800-2500	800-2500	0-2500	800-2500
Distance from water (km)	142	132	238	282	295	391	88	531	460	553

4. Discussions and Results

Numerous studies have been done by researchers on location. However, no articles are available for locating and examining arsenals due to the military nature of the subject.

The results of this evaluation can help designers in choosing the optimal and suitable places for arsenal camouflage. GIS is able to provide a utility map for locating arsenal in large and small areas. The best advantage of this method is that it is easy, affordable and low cost. Land-based environmental assessment and mapping usually requires a lot of time, effort, and requires a lot of effort to manage and process spatial data. GIS software can be used to store, analyze and display all required data and allows layers of spatial data to be analyzed with complex precision when analyzing complex location issues. The results of the GIS study show the location of the arsenal in the whole area of the country. The results obtained depend on various factors such as the input data of the weighting method used, etc., as explained in (Van der Merwe, 2010). The modeling results are sensitive to the weights used and changing these weights on different factors will have a significant effect on the result.

References

Banai, R. (2005). A new method for site suitability analysis: an analytic hierarchy process. *Environmental Management, 6*, 693-785.

Bantayan, N. C., & Bishop, I. D. (2009). Linking objective and subjective modeling for landuse decision-making. *Landscape and Urban Planning, 43*, 35-48.

Carver, S. (2007). Integrating multi-criteria evaluation with geographical information systems. *International Journal of Geographical Information systems, 5*, 321-339.

Dai, F. C., Lee, C. F., & Zhang, X. H. (2006). GIS-based geo-environmental evaluation for urban land-use. *Engineering Geology, 61*, 257-271.

Fataei, E., & Alsheikh, A. (2009). Locating solid waste landfills using GIS and AHP. *Environmental Science, 6*, 145-158.

Givechi, S., & Atar, M. A. (2012). Application of multi-criteria decision models place and finding temporary accommodation after the earthquake (Case study: Shiraz). *Journal of Disaster Management*.

Godsipour, S. H. (2006). *Analytical Hierarchy Process*. Amirkabir University publication.

Rajabi, M. R., Golmehr, E., Majidi, D., & Rastgar, A. M. (2011). Topsis-Based Model for Hydropower Dam Site-Selection in Isfahan Province. *The Scientific Journal of Passive Defence Science and Technology, 4*, 315-324.

Saaty, T. L. (2008). A scaling method for priorities in hierarchical structures. *Journal of Mathematical psychology, 15*, 234-281.

Saaty, T. (2006). *The Analytic Hierarchy Process*. McGraw university: New York.

Salari, M. (2012). *Locate suitable areas for municipal solid waste landfills using GIS*. Master's thesis, Chamran University.

Sahami, H. (2007). *Preparation and positioning*. Malek Ashtar University Publications.

Sanjeri, S. (2012). *Practical Guide to Arc GIS 10*. Abed Publications.

Sener, B. (2004). *Landfill site selection by using geographic information system*. M.Sc. Thesis.

Shojae, M., Tolani, S., & Ziyaeiyan, P. (2011). Optimum positioning of base support crisis management using GIS (Case Study of Tehran). *Journal of Urban and Regional Studies and Research*, *10*, 41-60.

Van der Merwe, J. H. (2010). GIS-aided land evaluation and decision-making for regulating urban expansion: a South African case study. *GeoJournal*, *43*, 135-151.