A New Smart Approach for Best Location Determination Based on Internet of Things

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Abstract. Finding the best location among several alternatives require more effort, time, and devices in the usual cases, especially if these locations in another city or governorate. This study pursuit using a smart approach to select the best new primary school site with an accurate result in a short time and low cost. The presented approach utilizes a smartphone as an internet of things (IoT) device that has an internal Global Positioning System (GPS) unit to collect and send the location (GPS coordinates) via Google maps application to urban planners (decision-makers) to give their opinion in each site sent to them after making a spatial analysis for these site using the Arc GIS program to assess every advised site with each criterion. Then, the fuzzy TOPSIS method aggregates urban planners’ opinions to determine the more suitable site for a new primary school. The Fuzzy TOPSIS method was implemented using python code to reduce the time required for manual computation. All the Fuzzy TOPSIS steps executed time does not exceed 1 minute, and it just needs to enter the number of (criteria, decision-makers, and alternative sites). The importance weight of the criteria for each decision-maker and the ratings of alternative sites by the decision-makers’ chosen criteria. So with this smart approach, with a few hours, we can find a more fitting new site, although it took more than a week in the normal way.

Keywords. Smart approach, Internet of things, GPS, Fuzzy TOPSIS.

1. Introduction

Any new site selection required a complete survey for these sites and neighbor areas to decide from urban planners that need a long time to collect this geographic information. The interactions of the Internet of Things and the big information analytics are significantly wedged by location data and successively greatly impact location privacy [1]. IoT has become part of our daily lives, being recruited to deal with a wide variety of real-life issues and problems. An important parameter becomes the location of things. In order to understand native environmental conditions for the creation of facilities, the exact position of physical world measurement (IoT) is highly important [2][3]. It has become possible and easy to share our location (longitude and latitude) using the Google Maps application available in smartphones that contain GPS units that provide information about the location [4]. Therefore, the process will be inexpensive compared to special GPS units, which are expensive but highly accurate [5][6]. This is a beneficial technique because it helps decision-makers provide their opinions without visiting these sites and surveyed it at a low cost [7]. According to the planning requirements, we concentrated on deciding a new primary school’s suitable location from several alternatives in this study. The choice of the best location for primary schools is a decision-
making challenge that needs many essential criteria to be taken into account, which are roads, population, existing primary schools, hospitals or health centers, industrial and towers of electricity, to provide a solution. If the complexity of the problem structure increases, taking precise and efficient decisions is not simple. The Fuzzy TOPSIS (Technique for Order Performance by Similarity to Ideal Solution) approach is also recommended because it is one of the methods of multi-criteria decision-making (MCDM) and is easy to implement. Fuzzy TOPSIS requires many computations so we will use python code to implement it [8]. Because the site of the schools is very important, it is shown that there are a lot of studies associated with it. Zubaidah Bukhari et al., 2010 delves into a site choice method to establish a systematic international school carried out by a GIS and multi-criteria assessment model. Using a spatial analysis model, a collection of criteria were used to design many possible sites [9]. Alhaji Hussaini et al., 2018 conducted research to locate the physical site for any school using GIS technology integrated with the Analytical Hierarchy Process (AHP), a multi-criteria evaluation (MCE) tool for finding an appropriate location for any new school. Also, a weighted overlay process, an ArcGIS tool, was used to combine all the criteria found, and the results showed that there are suitable and economically viable areas to add new schools [10]. (Khalid Ahmed Ali, 2018)The research goal of designing a primary school site selection model using Geographic Information Systems (GIS) has been combined with a new methodology. Geographic Information Systems and a multi-criteria assessment model (MCEM) have been carried out. Various parameters were used to indicate many likely primary school locations using a spatial analysis [11] parameters to indicate many likely primary school locations using spatial analysis.

2. Methodology
There are three main stages for this study, as shown in Figure.1. First, collecting GPS geographic locations of suggested sites of primary school using smartphones as an Internet of thing Device. Second, the spatial analysis using the Euclidean distance tool in Arc GIS program and then Reclassified Distances gives the decision-maker the distances between the suggested sites and each criterion for rating each site. Finally, using Fuzzy TOPSIS python code to ranking suggested sites.

![Figure 1. Main stages for the study.](image)

2.1. The first stage: collect GPS location
Collect GPS geographic locations using the Google Maps application available in smartphones as IoT devices containing GPS units to send the location (longitude and latitude) to decision-makers. Six alternative locations are suggested for establishing new primary school sites, as shown in Figure 2. The alternative locations are presented in Table 1. GPS is one of the essential smartphone information. The location is discovered using the trilateration theory. The coordinates are computed by distance are measured from three or more satellites [3]. The smartphone could be used at the sensing / auto-tracking layer level as an automatic sensing and sensing system and at the application layer level as a back-end system where different users who access different applications could obtain the services required [12].
### Table 1. GPS locations coordinates of the alternatives sites

| Alternative site | Longitude (N) | Latitude (E) |
|------------------|--------------|--------------|
| Site 1           | 32.040674    | 44.378671    |
| Site 2           | 32.033047    | 44.393952    |
| Site 3           | 32.026868    | 44.395477    |
| Site 4           | 32.021505    | 44.403049    |
| Site 5           | 32.039604    | 44.410979    |
| Site 6           | 32.033417    | 44.386858    |

#### Figure 2. The corresponding locations of the alternative sites.

#### 2.2. The second stage: spatial analysis

Spatial analysis by using the Euclidean distance tool in Arc GIS and then reclassified these distances. Arc GIS is a Geographic Information System (GIS) developed by the Environmental Systems Research Institute (Esri) for working with maps and geographic information. It is used for the production and use of maps, the collection of geographical data, the study of mapped data, the sharing and exploration of geographical information, the use of maps and geographical information in a variety of applications, and the management of geographical information in a database [13]. Many distance mapping tools are provided by ArcGIS Spatial Analyst to measure straight line (Euclidean) distance and distance calculated in terms of other variables such as slope, current road, and land use. The calculation of the mapping distance can provide additional information for the user to make decisions. The Euclidean distance output raster includes the measured distance from the individual cell to the closest’s origin. Euclidean distance is calculated in the raster projection units such as meters or feet and is obtained from center to cell center. The Euclidean Distance tool is also used as a stand-alone tool used to produce a map of suitability when data is required showing the distance from a particular object [10][14]. And then reclassified these distances to enable the decision-makers to give their opinions to the suggested sites with each criterion [15], based on the below the criteria:

- **Roads**
  
The primary school site must be far away from the main roads by more than 10m. Figure 3a shows the range of distance begins from 50m.
• **Population**
  The primary school site must be closer to the residential areas with a higher population under 14 years old, and the distance from the residential area to the new site must not exceed 500m. Figure 3b shows the range of distance begins from 200m.

• **Existing primary schools**
  The suggested site must get far away from them. Figure 3c shows the range of distance begins from 200m.

• **Hospital or Health center**
  The primary school site must be nearby the health center or hospital. Figure 3d shows the range of distance begin from 200m

• **Industrial**
  The primary school site must be far away from industrial sites. Figure 3e shows the range of distance begin from 200m

• **Tower of electricity**
  The primary school site must be far away from the electricity towers by more than 25m. Figure 3f shows the range of distance begins from 25m.

Figure 3. Show the range of distance.
2.3. The third stage: Fuzzy TOPSIS method

Use Fuzzy TOPSIS is a Multi-Criteria Decision-Making approach developed to remove the fuzziness arising from the human judgment in decision-making processes. Fuzzy set theory has several definitions, such as misty, vague, undefined, etc. In 1965 Zadeh applied Fuzzy theory to the literature [16]. Any set theory can be inadequate when making decisions with linguistic variables. Hwang and Yoon first developed the TOPSIS technique in 1981 [17]. It is the most common option ranking method based on the criteria and the decision maker’s opinions. TOPSIS method’s basic concept is to evaluate the alternatives from best to worst. The best solution among the alternatives is the nearest to the positive ideal solution at the same time as the farthest negative solution [18].

The primary procedure of the Fuzzy TOPSIS method process,[17],[18],[19][20],[21],[22] are explained in the following steps:

Step 1: Establishing a committee of decision-makers.

In this study, a committee composed of two urban planners (decision-makers D1, D2) was established to give opinions about each site based on all required criteria.

Step 2: Selection of collection of alternatives

Six alternatives sites were assumed site 1, site 2, site 3, site 4, site 5, and site 6, as explained previously.

Step 3: Selection of evaluation criteria

Six criteria have been established to select a new primary school site, as described previously, which are roads, population, existing schools, hospitals or health centers, industrial, and the tower of electricity.

Step 4: Selection of fuzzy linguistic variables and membership function

Linguistic variables mean ratings such as poor, good, very good, etc., in case of alternatives and low, high, very high, etc., in case of the criteria. Triangular fuzzy number (TFN). TFN will be in the form A = (α1, α2, α3) the membership functions shown as in Equation (1) and Figure 4:

\[ \mu_A(x) = \begin{cases} 0, & x < \alpha_1 \\ \frac{x-\alpha_1}{\alpha_2-\alpha_1}, & \alpha_1 \leq x \leq \alpha_2 \\ \frac{\alpha_3-x}{\alpha_3-\alpha_2}, & \alpha_2 \leq x \leq \alpha_3 \\ 1, & x > \alpha_3 \end{cases} \]  

(1)

Figure 4. Triangular Fuzzy number.

The linguistic variables used to evaluate the criterion weights, the significance levels of the alternatives, and the corresponding fuzzy numbers are shown in Table 2.

| **Table 2.** Linguistic variables for the criteria and Linguistic variables for the ratings. |
|---------------------------------|---------------------------------|
| Linguistic variables for the importance weight of each criterion | Linguistic variables for the ratings of each alternative |
| Very low (VL) | (0, 0, 0.1) | Very poor (VP) | (0, 0, 1) |
| Low (L) | (0, 0.1, 0.3) | Poor (P) | (0, 1, 3) |
| Medium low (ML) | (0.1, 0.3, 0.5) | Medium poor (MP) | (1, 3, 5) |
| Medium (M) | (0.3, 0.5, 0.7) | Fair (F) | (3, 5, 7) |
| Medium high (MH) | (0.5, 0.7, 0.9) | Medium good (MG) | (5, 7, 9) |
| High (H) | (0.7, 0.9, 1.0) | Good (G) | (7, 9, 10) |
| Very high (VH) | (0.9, 1.0, 1.0) | Very good (VG) | (9, 10, 10) |
Step 5: Evaluating the fuzzy weights of criteria

Decision-makers evaluate the importance weights of the parameters, as shown in Table 3, after selecting acceptable linguistic variables and choosing the alternative site ratings for each criterion based on the outcome of the second stage. The rating of six alternatives by two decision-makers for the six criteria is presented in Table 4.

Table 3. Importance weights of criteria for each decision-maker.

| Criteria                 | Decision-makers |
|-------------------------|-----------------|
|                         | D1   | D2   |
| Roads                   | VH   | H    |
| Population              | VH   | VH   |
| Existing schools        | H    | VH   |
| Hospital or Health center | MH  | H    |
| Industrial              | M    | MH   |
| Tower of electricity    | MH   | M    |

Table 4. Ratings of alternatives by decision-makers under selected criteria.

| Criteria                  | Candidate sites | Decision Makers |
|---------------------------|-----------------|-----------------|
|                           | Site 1 | Site 2 | Site 3 | Site 4 | Site 5 | Site 6 | Site 1 | Site 2 | Site 3 | Site 4 | Site 5 | Site 6 | Site 1 | Site 2 | Site 3 | Site 4 | Site 5 | Site 6 | Site 1 | Site 2 | Site 3 | Site 4 | Site 5 | Site 6 |
| Roads                     | VG    | MP    | P      | G      | VG    | F      | MG    | VP    | P      | MG    | G      | F      | MG    | G      | F      | MG    | G      | F      | VG    | VG    | G      | VG    | VG    | VG    |
| Population                | VG    | VP    | F      | G      | VG    | F      | MG    | G     | MG    | G     | G      | G      | G     | G      | F      | MG    | G      | MP    | VG    | VG    | VG    | VG    | VG    |
| Existing schools          | VG    | VG    | P      | MP    | VP    | F      | MG    | G     | MP    | VP    | F      | MG    | G     | G      | F      | MG    | G      | P      | VG    | VG    | VG    | VG    | VG    |
| Hospital or Health center | VG    | VG    | VG    | VG    | VG    | VG    | VG    | VG    | VG    | VG    | VG    | VG    | VG    | VG    | VG    | VG    | VG    | VG    | VG    | VG    | VG    | VG    | VG    |
| Industrial                | VG    | VG    | G      | G      | G      | G      | G      | G      | G      | G      | G      | G      | G      | G      | G      | G      | G      | G      | G      | G      | G      | G      | G      |
| Tower of electricity      | VG    | VG    | VG    | VG    | VG    | VG    | VG    | VG    | VG    | VG    | VG    | VG    | VG    | VG    | VG    | VG    | VG    | VG    | VG    | VG    | VG    | VG    | VG    | VG    |
Also, the rating of alternatives and criterion weights are collated at this step by using Equations (2) and (3) for fuzzy triangular numbers, respectively:

\[
\bar{x}_{ij} = \frac{1}{k} [\bar{x}^1_{ij} (+) \bar{x}^2_{ij} (+) ... (+) \bar{x}^k_{ij} ] \\
\bar{w}_j = \frac{1}{k} [\bar{w}^1_j (+) \bar{w}^2_j (+) ... (+) \bar{w}^k_j ]
\]

(2) (3)

Where the rating and the importance weight of the decision-maker are \( \bar{x}_{ij} \) and \( \bar{w}_j \), respectively. The outcome of this move is shown in Table 5.

| Criteria weights |
|------------------|
| Roads            | (0.8, 0.95, 1) |
| Population       | (0.9, 1, 1)    |
| Existing schools | (0.8, 0.95, 1) |
| Hospital or Health center | (0.6, 0.8, 0.95) |
| Industrial       | (0.4, 0.6, 0.8) |
| Tower of electricity | (0.4, 0.6, 0.8) |

Step 6: Construct the fuzzy decision matrix

This step involves constructing the fuzzy decision matrix for ranking alternatives (\( \bar{D} \)). The fuzzy decision matrix is constructed as below:

\[
\bar{D} = \begin{bmatrix}
\bar{x}_{11} & \bar{x}_{12} & ... & \bar{x}_{1n} \\
\bar{x}_{21} & \bar{x}_{22} & ... & \bar{x}_{2n} \\
\vdots & \vdots & \ddots & \vdots \\
\bar{x}_{m1} & \bar{x}_{m2} & ... & \bar{x}_{mn}
\end{bmatrix}
\]

Where \( \bar{x}_{ij}, j = 1, 2, ..., m \) are linguistic variables. Fuzzy triangular numbers describe these linguistic variables, \( \bar{x}_{ij} = (a_{ij}, b_{ij}, c_{ij}) \). The results of this step are shown in Table 6.

| Alternatives | Roads       | Population | Existing schools | Hospital or Health center | Industrial | Tower of electricity |
|--------------|-------------|------------|------------------|---------------------------|------------|----------------------|
| Site1        | (9, 10, 10) | (9, 10, 10)| (9, 10, 10)      | (2, 4, 6)                 | (8, 9.5, 10)| (9, 10, 10)         |
| Site2        | (0.5, 1.5, 3)| (9, 10, 10)| (0.5, 2, 4)      | (2, 4, 6)                 | (0, 0.5, 2) | (8, 9.5, 10)        |
| Site3        | (0.0, 0.5, 0.2)| (6, 8, 9.5)| (0.0, 0.5, 0.2) | (0.5, 2, 4)              | (9, 10, 10) | (9, 10, 10)         |
| Site4        | (8, 9.5, 10)| (0, 0.5, 0.2)| (0.5, 2, 4)   | (9, 10, 10)              | (9, 10, 10) | (8, 9.5, 10)        |
| Site5        | (9, 10, 10) | (8, 9.5, 10)| (2, 4, 6)       | (6, 8, 9.5)              | (4, 6, 8)  | (9, 10, 10)         |
| Site6        | (9, 10, 10) | (4, 6, 8)  | (8, 9.5, 10)    | (9, 10, 10)              | (8, 9.5, 10)| (9, 10, 10)         |

Step 7: Normalized fuzzy decision matrix

To transform the different criteria scales into comparable scales, construct the normalized fuzzy decision matrix of the alternative ratings in (\( \bar{D} \)) using linear scale transformation. Equations (4) and (5) are used to achieve the normalized fuzzy decision matrix. The outcome of this step is shown in Table 7.

\[
\bar{r}_{ij} = \left( \begin{array}{c}
\frac{a_{ij}}{c_{ij}} \\
\frac{b_{ij}}{c_{ij}} \\
\frac{c_{ij}}{c_{ij}}
\end{array} \right) \quad c_{ij} = \max_i c_{ij} \\
\bar{r}_{ij} = \left( \begin{array}{c}
\frac{a_{ij}}{b_{ij}} \\
\frac{b_{ij}}{b_{ij}} \\
\frac{a_{ij}}{a_{ij}}
\end{array} \right) \quad a_{ij} = \min_i a_{ij}
\]

(4) (5)
Table 7. Fuzzy normalize decision matrix.

| Alternatives | Roads            | Population      | Existing schools | Hospital or Health center | Industrial | Tower of electricity |
|--------------|------------------|-----------------|------------------|---------------------------|------------|----------------------|
| Site1        | (0.9,1,1)        | (0.9,1,1)       | (0.9,1,1)        | (0.2,0,4,0.6)             | (0.8,0.95,1) | (0.9,1,1)            |
| Site2        | (0.05,0.15,0.3)  | (0.9,1,1)       | (0.9,0.2,0.4)    | (0.2,0,4,0.6)             | (0.05,0.2)  | (0.8,0.95,1)         |
| Site3        | (0.0,0.05,0.2)   | (0.6,0.8,0.95)  | (0.0,0.05,0.2)   | (0.05,0.2,0.4)            | (0.9,1,1)   | (0.9,1,1)            |
| Site4        | (0.8,0.95,1)     | (0.0,0.05,0.2)  | (0.05,0.2,0.4)   | (0.9,1,1)                 | (0.8,0.95,1) |                    |
| Site5        | (0.9,1,1)        | (0.8,0.95,1)    | (0.2,0,4,0.6)    | (0.6,0.8,0.95)            | (0.4,0.6,0.8) | (0.9,1,1)            |
| Site6        | (0.9,1,1)        | (0.4,0.6,0.8)   | (0.8,0.95,1)     | (0.9,1,1)                 | (0.8,0.95,1) | (0.9,1,1)            |

Step 8: Calculate the weighted normalized fuzzy decision matrix

Calculate the weighted normalized decision matrix, \( \tilde{v}_{ij} \) by multiplying the weight of the criteria, \( \tilde{w}_j \) by the elements \( \tilde{r}_{ij} \) of the normalized fuzzy decision matrix, as shown in Equation (6). The results of this step are shown in Table 8.

\[
\tilde{v}_{ij} = \tilde{r}_{ij} \times \tilde{w}_j
\]  

Table 8. Weighted Fuzzy normalize decision matrix.

| Alternatives | Roads            | Population      | Existing schools | Hospital or Health center | Industrial | Tower of electricity |
|--------------|------------------|-----------------|------------------|---------------------------|------------|----------------------|
| Site1        | (0.72,0.95,1)    | (0.81,1,1)      | (0.72,0.95,1)    | (0.12,0.32,0.57)           | (0.32,0.57,0.8) | (0.36,0.6,0.8)      |
| Site2        | (0.04,0.142,0.3) | (0.81,1,1)      | (0.04,0.19,0.4)  | (0.12,0.32,0.57)           | (0,0.03,0.16)   | (0.32,0.57,0.8)     |
| Site3        | (0,0.048,0.2)    | (0.54,0.8,0.95) | (0.0048,0.2)     | (0.03,0.16,0.38)           | (0.36,0.6,0.8)  | (0.36,0.6,0.8)      |
| Site4        | (0.64,0.902,1)   | (0.81,1,1)      | (0.64,0.902,1)   | (0.0,0.04,0.19)            | (0.36,0.6,0.8)  | (0.36,0.6,0.8)      |
| Site5        | (0.64,0.902,1)   | (0.18,0.4,0.6)  | (0.48,0.76,0.95) | (0.24,0.48,0.76)           | (0.36,0.6,0.8)  | (0.36,0.6,0.8)      |
| Site6        | (0.32,0.57,0.8)  | (0.36,0.6,0.8)  | (0.64,0.902,1)   | (0.54,0.8,0.95)            | (0.32,0.57,0.8) | (0.36,0.6,0.8)      |

Step 9: Determine the fuzzy positive ideal solution (A*) and the fuzzy negative ideal solution (A~)

As shown below, using the values on the weighted normalized fuzzy decision matrix, the results of this step are shown in Table 9.

\[
A^* = (v_1^*, v_2^*, \ldots, v_n^*)
\]

\[
A^- = (v_1^-, v_2^-, \ldots, v_n^-)
\]

Where;

\[
v_j^* = (1,1,1), v_j^- = (0,0,0), j=1,2,\ldots,n
\]

Step 10: Calculating the distance of each alternative from A* and A~

The distances of each location alternative from A* and A~ can be calculated, as shown in Equation (7) and (8).

\[
D_i^+ = \sum_{j=1}^{n} d(\tilde{v}_{ij}, v_j^+) , \quad i=1, 2 \ldots, m, \quad j=1, 2 \ldots, n
\]

\[
D_i^- = \sum_{j=1}^{n} d(\tilde{v}_{ij}, v_j^-) , \quad i=1, 2 \ldots, m, \quad j=1, 2 \ldots, n
\]

Where d is the distance measurement between two fuzzy numbers. Chen uses the vertex method to calculate the distance between two triangular fuzzy numbers \( \tilde{m} = (m_1, m_2, m_3) \) and \( \tilde{n} = (n_1, n_2, n_3) \) as shown in equation (9).

\[
d(\tilde{m}, \tilde{n}) = \left[ \frac{1}{3} \left( (m_1 - n_1)^2 + (m_2 - n_2)^2 + (m_3 - n_3)^2 \right) \right]^{\frac{1}{2}}
\]
Step 11: Calculating the closeness coefficient of each alternative and ranking the alternatives based on their closeness coefficient

In order to decide the ranking order of each alternative, the closeness coefficient \( CC_i \) of each alternative location is determined, as shown in Equation (10). The results of this step are shown in Table 9.

\[
CC_i = \frac{D_i^+}{D_i^+ + D_i^-}, \quad i=1,2,...,m
\]  

(10)

Table 9. Final result.

| Alternatives | \( A^* \) | \( A^- \) | Closeness Coefficient(\( CC_i \)) | Final ranking |
|--------------|----------|----------|----------------------------------|---------------|
| Site1        | 2.05595214 | 4.33136059 | 0.678                           | 1             |
| Site2        | 3.86578209 | 2.46482144 | 0.389                           | 6             |
| Site3        | 3.85793881 | 2.48532062 | 0.392                           | 5             |
| Site4        | 2.36901854 | 4.00199276 | 0.628                           | 3             |
| Site5        | 2.62875106 | 3.80945371 | 0.592                           | 4             |
| Site6        | 2.36528438 | 4.06292228 | 0.632                           | 2             |

All these steps are implemented using python code; Figure 5 shows the final result.

3. Results

As seen in Table 9 and Figure 5, calculations were obtained according to the fuzzy TOPSIS method implemented with python code. The closeness coefficient value means the higher the value, the more suitable, and the lower the value, the less suitable. Closeness coefficients of alternatives are defined in descending order \( CC1 > CC6 > CC4 > CC5 > CC3 > CC2 \), it is seen that the order is site1, site 6, site 4, site 5, site 3, site 2 for best new primary school site from alternatives are evaluated according to criteria and decision-makers opinions.

4. Conclusions

This study aims to find the best new primary school site using a smart approach. Our setting is based on a smartphone, which is considered an IoT device to collect and send these sites due to the ease of use and availability. The proposed method applied the spatial analysis using the Euclidean distance
tool in the Arc GIS program to analyze these sites according to criteria and then reclassified it to help the decision-makers giving accurate options without needing to visit these sites. The best new primary school site as we explained must be far away from main roads, existing schools, industrial area, and the towers of electricity, another hand the new site must be in a residential area with a higher population under 14 years old, and it must closer to hospital or health centers. All the criteria and opinions of decision-makers for each site are combined using the Fuzzy TOPSIS method. The fuzzy TOPSIS method determines the preferred site that is suitable for a new primary school. The proposed method was implemented via python code.

This research has three main advantages: (1) the proposed framework is to reduce the time and effort required for field survey (2) the uncertainty that stems from different opinions is modeled by fuzzy TOPSIS method (3) using fuzzy TOPSIS python code reduce the time required for manual computation.

Abbreviations

| Acronym | Full Form |
|---------|-----------|
| IoT | Internet of Things |
| GPS | Global Positioning System |
| TOPSIS | Technique for Order Performance by Similarity to Ideal Solution |
| GIS | Geographic information system |
| MCDM | Multi Criteria Decision Making |
| AHP | Analytical Hierarchy Process |
| MCE | Multi Criteria Evaluation |
| MCEM | Multi Criteria Evaluation Model |
| TFN | Triangular Fuzzy Number |

5. References

[1] R P Minch 2015 *Location Privacy in the Era of the Internet of Things and Big Data Analytics* (Proc. Annu. Hawaii Int. Conf. Syst. Sci.) vol 2015-March pp 1521–1530

[2] A Kamilaris and F O Ostermann 2018 *Geospatial Analysis and the Internet of Things* (ISPRS Int. J. Geo-Information) vol 7 no 7 pp 1–22

[3] W Kassab and K A Darabkh 2020 *A–Z Survey of Internet of Things: Architectures, Protocols, Applications, Recent Advances, Future Directions and Recommendations* (J. Netw. Comput. Appl.) vol 163

[4] P Battin and S D Markande 2017 *Location Based Reminder Android Application Using Google Maps API* (Int. Conf. Autom. Control Dyn. Optim. Tech. ICACDOT) pp 649–652

[5] I Senanayake, C Jayawardena and S Udara Jayakodi 2018 *Accuracy of Smartphone Location Services for Geo-tagged Data Collection: A Field Study Disaggregating satellite soil moisture products View project* (https://www.researchgate.net/publication/328420822

[6] K Merry and P Bettinger 2019 *Smartphone GPS Accuracy Study In An Urban Environment* (PLoS One) vol 14 no 7

[7] M M A Hashem 2018 *An IoT Based Approach for Very Low Cost Real Time Vehicle Tracking System*

[8] J Papathanasiou and N Ploskas 2018 *Multiple Criteria Decision Aid: Methods, Examples and Python Implementations*

[9] N Ahmad, Z Bukhari, A R Mahmud, A Rashid and M Shariff *Developing Policy for School Development Using Spatial Multi-Criteria Decision Analysis* (Developing Policy For School Development Using Spatial Multi-Criteria Decision Analysis)

[10] A Hussaini, S Amerudin, K T K Wee and S I Musa 2018 *Integration of GIS and Multicriterieria Evaluation for International School Site Selection* (Proc.-39th Asian Conf. Remote Sens. Remote Sens. Enabling Prosper. ACRS) vol 1 pp 39–48
[11] K A Ali 2018 Multi-Criteria Decision Analysis for Primary School Site Selection in Al-Mahaweel district Using GIS Technique (J. Univ. Kerbala) vol 16 no 1
[12] S. Adiloğlu et al Smartphone: The Ultimate IoT and IoE Device (Intech) vol i no tourism p 13
[13] ESRI ArcGIS 2020 (Wikipedia : https://en.wikipedia.org/wiki/ArcGIS.)
[14] C R Maurer, R Qi, V Raghavan and S Member 2003 Short Papers vol 25 no 2 pp 265–270
[15] Y R Nassif 2018 GIS and Multi Criteria Decision Analysis for Landfill Site Selection in Karbala Governorate
[16] H H Demir 2019 Evaluation of Service Quality of Airway Companies Giving Domestic Services in Turkey With Fuzzy Set Approach (Int. J. Electron. Mech. Mechatronics Eng.) vol 2 no 3 pp 233–239
[17] T Wang and H Lee 2009 Expert Systems with Applications Developing a Fuzzy TOPSIS Approach Based on Subjective Weights and Objective Weights (Expert Syst. Appl.) vol 36 no 5 pp 8980–8985
[18] B Daneshvar Rouyendegh, A Yıldızması and Ü Z B Arikan 2018 Using Intuitionistic Fuzzy TOPSIS in Site Selection of Wind Power Plants in Turkey (Adv. Fuzzy Syst.) vol no Mcdm
[19] V G Venkatesh, V Vijeesher and A Moosa 2015 Supplier Selection In Blood Bags Manufacturing Industry Using TOPSIS Model vol 24 no 4
[20] E N Madi, J M Garibaldi and C Wagner 2016 A Comparison Between Two Types Of Fuzzy Topsis Method (Proc.-2015 IEEE Int. Conf. Syst. Man, Cybern. SMC) pp 291–297
[21] S Belbag, M Deveci and A S Uludag 2013 Comparison Of Two Fuzzy Multi Criteria Decision Methods For Potential Airport Location Selection (ICORES 2013 - Proc. 2nd Int. Conf. Oper. Res. Enterp. Syst.) no 1059 pp 270–276
[22] V S ARIKAN KARGI 2016 Bir Tekstil Firmasında Bulanık TOPSIS Yöntemiyle Tedarikçi Seçimi (Yönetim ve Ekon. Celal Bayar Üniversitesi İktisadi ve İdari Bilim. Fakültesi Derg) pp 791–791

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