Environmental Adaptation of Construction Barriers under Intuitionistic Fuzzy Theory

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Abstract: The project of construction barriers removal is a comprehensive planning task and it demands a suitable support for identification, and priority ranking of facilities necessary for barriers removal. This paper proposes a multicriteria Intuitionistic Fuzzy (IF) ELECTRE model to support decision makers in the process of managing of removal project of construction barriers for physically disabled in high schools. IF ELECTRE approach is used to deal with complex problems, where decision-makers have ambiguities and dualities in evaluation of considered solution. Hereby 17 high schools are defined and seven criteria are determined by decision-makers. These criteria are further used for the alternatives assessments. Each DM is also evaluated by linguistic and numerical values, assigning them this way an importance according to their background and the years of experience. The Intuitionistic Fuzzy Weighted Average (IFWA) operator is calculated to achieve aggregated alternatives evaluations. Furthermore, concordance and discordance sets and indexes are calculated to obtain dominance matrix and final ranking of schools for the construction barriers removal. The model is validated on high schools in the city of Split. Using IF theory, the given problematic can be operated more effectively by diminishing the inaccuracy of available information.

Keywords: construction barriers; ELECTRE; Intuitionistic Fuzzy Theory; multicriteria decision-making; physically disabled

1 INTRODUCTION

Identifying constriction barriers in the physical world demands taking into account the positioning of necessary ramps, elevators, lifts, adjustment of sanitary elements, etc. To eliminate the construction barriers as much as possible, designers, spatial planners, architects, transportation planners, construction contractors, and many others must have a crucial role in such projects. Before construction even begins, the process requires an effective cooperation between spatial planners, architects, contractors and end-user. Such a cooperation results in constructing the facilities that serve to the public, and are economically practicable, and enables creative design [1]. Managing this type of projects is a complex and poorly structured task, because it includes various aspects which seek a holistic approach. To deal with this problems, systematic and sustainable decision procedures are needed in management activities. Also, there is a significant lack of approaches that deal with this type of problem under the multicriterial decision making (MCDM) environment. According to Kassab et al. [2], MCDM is a decision analysis tool that is beneficial for the assessment and comparison of the alternatives by multiple criteria, and then ranking of these alternatives from most to least preferred. However, multiple-party problems containing various conflicting criteria, various different solutions and multiple decision makers with different opinions and attitudes are more comprehensive and involve a series of actions by participants, and eventually end in failing with decision or indecision.

Therefore, in this paper, a MCDM model is proposed. More particularly presented research refers to construction barriers in public education facilities such are high schools (HS) in urban and suburban areas. The approach is designed to be used at a local governmental level. The aim of the research is to resolve the multicriterial problem dealing with the removal of construction barriers in school facilities by provision of a unique multicriterial model, which stands as a tool for planners dealing with this issue. MCDM is used for solving various complex problems with multiple criteria, solutions and decision-makers to give a support in finding the most appropriate alternative. Although, the problem of construction barriers removal is multicriterial, it is not sufficient to use classical MCDM method due to the uncertain information and duality in decision maker’s evaluations.

Nowadays, classical MCDM methods are not efficient when dealing with uncertain and vagueness data in decision-making process. Zadeh [3] proposed Fuzzy Set Theory, which was lately integrated in MCDM methods. This tool is very effective when it comes to uncertain data. Since classical Fuzzy Set Theory is shown to be hard for decision makers to quantify opinions between zero and one, an Intuitionistic Fuzzy Theory (IFT), developed by Atanassov [4, 5], has shown to be more applicable. The Intuitionistic Fuzzy Sets (IFS) are characterized by three degrees: membership, non-membership, and hesitancy. In recent years, the IFS has been applied in many fields such as decision-making problems, pattern recognition, health and medical diagnostic, supplier selection, personnel selection, selection of the facility location, and evaluation of renewable energy.

Atanassov, Pasi, and Yager [6] proposed an intuitionistic fuzzy interpretation of multi-stakeholders and MCDM. Each decision maker evaluated the alternatives according to each defined criterion: their evaluations are described as numeric values under the intuitionistic IFT. Hong and Choi [7] developed new functions to measure the degree of accuracy of membership of each alternative evaluate by criteria which are presented as uncertain values. Hung and Yang [8] in their study gave an approach for measuring distance between IFSs which is based on the Hausdorff distance. A new method for solving MCDM problem under IFT is presented by Liu and Wang [9] They firstly defined an evaluation function which served to measure the degrees of satisfaction and nonsatisfaction of alternatives. After that, the concept of intuitionistic fuzzy operators is described. Szmidt and Kacprzyk [10], in their study have has determined solutions in group decision using IFS, while in [11] they extended the idea of a fuzzy logic to a state when individual opinions are introduced as IF preference relations. Wang [12] proposed a decision approach under ambiguity information to service
The high schools in the city of Split, Croatia. In this paper, the model of IF ELECTRE is proposed with IF Theory to gain more accurate and precise results. Furthermore, IFT can be used to gather images with construction barriers. Hammel et al. [36] made an exploratory study to investigate how the physically disabled struggle with access barriers, and to define strategies to increase access to needed services. Kayes et al. [41] adopted a qualitative research on physical barriers as an interference for physical activity for people with multiple sclerosis. Yuker et al. [42] gave a comprehensive source of information pertinent to the education of physically disabled, with an accent on the construction of facility barriers. Leigh Hill [43] examined the level of physical accessibility for students with disabling conditions in universities across Canada, while Klinger [44] examined the evidence of the physical accessibility of schools for students with mobility impairments and provided an overview of the barriers and facilitators. Burton et al. [45] presented findings from a project that examined the environmental, and institutional barriers faced by disabled people. Martin Ginis et al. [46] made a review of published studies of factors related to leisure-time physical activity among people with physical disabilities.

None of the mentioned studies dealt with the construction barriers removal as a multicriterial problem and none has developed any type of model to solve vagueness and duality in the observed problems.

2 METHODOLOGY

Atanassov [4] developed the IFS theory to deal with uncertainty. In this section, a review of some necessary concepts related to intuitionistic fuzzy sets is given.

Definition 1: Let $X$ be a finite set, and let $A \subseteq X$ be a fixed set [5]. Where $X$ can be described as:

$$X = \{a, \mu_a(a), \nu_a(a) \, | \, a \in A\}$$

(1)
Where
$$\mu_x(a); \mu_x(a) \in [0, 1] , S \rightarrow [0, 1]$$
$$v_x(a); v_x(a) \in [0, 1] , S \rightarrow [0, 1]$$

Membership and non-membership functions can be explained as:

$$0 \leq \mu_x(a) + v_x(a) \leq 1 \ \forall s \in S, R \rightarrow [0, 1]$$

**Definition 2:** The hesitation degree of IFS is $$\pi_x(a)$$ and can be described as:

$$\pi_x(a) = 1 - \mu_x(a) - v_x(a)$$

where $$\pi_x(a)$$ is degree of uncertainty of x to A.

Let Z and Y be IFSs of the set A, then multiplication operators are [4]:

$$Z \ast Y = \left\{ \mu_{(a)}(a), v_{(a)}(a) - v_{(a)}(a) \cdot v_{(a)}(a) \right\}$$

In this section, an IF ELECTRE approach is presented to the project management of construction barriers removal in HS objects. In proposed algorithm, the judgments provided by different decision makers are given as well as the quantitative and the qualitative data [32, 33]. Three groups of experts are asked to compare each alternative by each criterion. The algorithm is described in an eight-step, and presented in Fig. 1.

**Algorithm:**

Step1. Criteria weight determination by pairwise comparisons using 1-9 scale developed by Saaty [47].

Step2. DMs importance calculation using Boran et al. [48] expression:

$$\lambda_i = \frac{\mu_i + \pi_i \left( \frac{\mu_j}{\mu_i + v_j} \right)}{\sum_{i=1}^{k} \left( \mu_i + \pi_i \left( \frac{\mu_j}{\mu_i + v_j} \right) \right)}$$

where $$\lambda_i \in [0, 1]$$ and $$\sum_{i=1}^{k} \lambda_i = 1$$.

Step3. Calculation of aggregated intuitionistic fuzzy decision matrix using DMs’ importance as the base to equation of IFWA operator [49]. Each DM’s opinion is merged into single opinion.

Let $$P_{ij} = (p_{ij}^{(1)}, p_{ij}^{(2)}, \ldots, p_{ij}^{(k)})$$ be the IF decision matrix of each DM. $$\lambda = \{\lambda_1, \lambda_2, \ldots, \lambda_k\}$$ is the importance of the DM.

$$P = (p_{ij}^{*})_{m \times n}$$

Where

$$p_{ij} = \text{IFWA}_{\lambda} \left( p_{ij}^{(1)}, p_{ij}^{(2)}, \ldots, p_{ij}^{(k)} \right) = \lambda_1 p_{ij}^{(1)} + \lambda_2 p_{ij}^{(2)} + \ldots + \lambda_k p_{ij}^{(k)}$$

$$= \left[ 1 - \prod_{i=1}^{k} \left( 1 - \mu_{ij}^{(i)} \right)^{\pi_i} \right] \cdot \prod_{i=1}^{k} \left( 1 - \mu_{ij}^{(i)} \right)^{\pi_i} \prod_{i=1}^{k} \left( 1 - \mu_{ij}^{(i)} \right)^{\pi_i}$$

Hereby, decision problem is described as:

$$P_{ij} = \left[ p_{i1} \ p_{i2} \ \ldots \ p_{in} \right]$$

$$P_{ij} = \left[ p_{j1} \ p_{j2} \ \ldots \ p_{jn} \right]$$

$$P = \left[ p_{m1} \ p_{m2} \ \ldots \ p_{mn} \right]$$

$$P_{ij} = (\mu_{ij}, \nu_{ij}, \pi_{ij})$$ ($$i = 1, 2, \ldots, m; j = 1, 2, \ldots, n$$) is an element of aggregated intuitionistic fuzzy decision matrix.

Step4. Calculation of the concordance and discordance sets where $$C_{zy}$$ shows the degree of confidence in the pairwise comparison of the z and y alternatives ($$X_z \rightarrow X_y, x, y = 1, 2, \ldots, m; z \neq y$$). The concordance set $$C^{(1)}_{zy}$$ of $$Z_k$$ and $$Y_l$$ is composed of all criteria for which $$Z_k$$ is preferred to $$Y_l$$. The concordance set is defined as:

$$C^{(1)}_{zy} = \left\{ (\mu_{zl} \geq \mu_{ly}, v_{zl} < v_{ly}, \pi_{zl} < \pi_{ly}) \right\}$$

The midrange concordance set is defined as:

$$C^{(2)}_{zy} = \left\{ (\mu_{zl} \geq \mu_{ly}, v_{zl} < v_{ly}, \pi_{zl} \geq \pi_{ly}) \right\}$$

The weak concordance set is defined as
The discordance set is composed of all criteria for which $Z_k$ is not preferred to $Y_l$. The degree of disagreement in $(X_z \rightarrow X_t)$ is constructed as follows:

$$D_{zy}^{(1)} = \left\{ \| \mu_{z2} < \mu_{t2}, \nu_{z2} \geq \nu_{t2}, \pi_{z2} > \pi_{t2} \right\}$$

(12)

The midrange discordance set is defined as follows:

$$D_{zy}^{(2)} = \left\{ \| \mu_{z2} < \mu_{t2}, \nu_{z2} \geq \nu_{t2}, \pi_{z2} < \pi_{t2} \right\}$$

(13)

The weak discordance set is defined as follows:

$$D_{zy}^{(3)} = \left\{ \| \mu_{z2} < \mu_{t2}, \nu_{z2} < \nu_{t2} \right\}$$

(14)

Step5. Determination of the concordance index $C_{zy}$ and the discordance index $D_{zy}$ for the proposed model using IFS is defined as follows:

$$C_{zy} = w_c^{(1)} \sum_{i=1}^{2} w_i + w_c^{(2)} \sum_{i=2}^{2} w_i + w_c^{(3)} \sum_{i=2}^{2} w_i$$

(15)

The concordance index is equal to the sum of the weights of criteria that are contained in the concordance sets, where $w_c^{(1)}$, $w_c^{(2)}$, and $w_c^{(3)}$ are the weights of the concordance, midrange concordance, and weak concordance sets, respectively. The assessments of a $Z_k$ are worse than assessments of a competing $Y_l$. Hereby, the discordance index is defined as follows:

$$D_{zy} = \frac{\max_{j=1}^{n} W_D \times d(x_{il}, x_{ij})}{\max_{j=1}^{n} d(x_{il}, x_{ij})}$$

(16)

Where $W_D$ is equal to $w_D^{(1)}$, $w_D^{(2)}$ or $w_D^{(3)}$. These sets integrate the weight of discordance, midrange discordance, and weak discordance sets, respectively. The distance between $X_{il}$ and $X_{ij}$ is shown as:

$$d(x_{il}, x_{ij}) = \sqrt{\frac{1}{2n} \sum_{j=1}^{n} \left( (\mu_{il} - \mu_{lj})^2 + (\nu_{il} - \nu_{lj})^2 + (\pi_{il} - \pi_{lj})^2 \right)}$$

(17)

Where $d(x_{il}, x_{ij})$ is Euclidian distance between $X_{il}$ and $X_{ij}$.

Step6. In the concordance dominance matrix calculation process, the chosen alternative has the shortest distance from the positive ideal solution. Hence, the concordance dominance matrix $K$ can be defined as:

$$K_{ij} = (C_{zy})^* - (C_{zy})_{ij}$$

(18)

where $(C_{zy})^*$ is the maximum value of $(C_{zy})_{ij}$, and $C_{zy} \geq C$, where $C = \sum_{z=1}^{m} \sum_{x=1}^{x} \sum_{y=1}^{y} \sum_{z=2}^{z} C_{zy}$, which refers to the separation of each alternative from the positive ideal solution. A higher value of $K_{ij}$ indicates that $Z_k$ is less favorable than $Y_l$.

In the discordance dominance matrix calculation, the chosen alternative has the longest distance from the negative ideal solution. Hence, the discordance dominance matrix $L$ is defined as follows:

$$L_{ij} = (D_{zy})^* - (D_{zy})_{ij}$$

(19)

where $(D_{zy})^*$ is the minimum value of $(D_{zy})_{ij}$, and $D_{zy} \geq D$, where $D = \sum_{z=1}^{m} \sum_{x=1}^{x} \sum_{y=1}^{y} \sum_{z=2}^{z} D_{zy}$, which refers to the separation of each alternative from the negative ideal solution. A higher value of $L_{ij}$ indicates that $Z_k$ is preferred to $Y_l$.

Step7. To determine aggregate dominance matrix, the distance of each alternative to both positive and negative ideal alternatives should be calculated to determine the ranking. Hence, the aggregate dominance matrix $R$ is defined as follows:

$$R_{ij} = \begin{bmatrix}
- & r_{i1} & \cdots & r_{im} \\
r_{21} & - & \cdots & r_{2m} \\
\vdots & \vdots & \ddots & \vdots \\
r_{(m-1)m} & \cdots & - & r_{(m-1)m} \\
r_{m1} & r_{m2} & \cdots & r_{m(m-1)}
\end{bmatrix}$$

(20)

Where $r_{ij} = \frac{l_{ij}}{k_{kl} + l_{kl}}$, and $l_{ij}$ and $k_{kl}$ are defined in (18) and (19), respectively. $r_{ij}$ refers to the relative closeness to the ideal alternative, with a range from 0 to 1. Higher the value of $r_{ij}$, closer is the alternative $X_k$ to the positive ideal and more distant form the negative ideal solution then the alternative $X_l$. Hence, it is better solution.

Step8. In final ranking of the alternatives, determination of matrix $T$ is needed. $T_{ij}$ is the final value of assessment, and is defined as follows:

$$T_{kl} = \frac{1}{m-1} \sum_{i=1, i \neq k}^{m} r_{ki}$$

(21)

Alternatives are ranked according to $T_{ij}$. The best alternative $X^*$, which is the one with the shortest distance to the positive ideal point and the longest distance from the negative ideal point, and is defined as:

$$X^* = \max(T_{ij})$$

(22)
Where $X^*$ is the best alternative.

### 3 RESULTS AND DISCUSSION

In this section, the proposed model is applied on the HS facilities. There are 17 HSs in the City of Split that need construction barriers removal for the physically disabled. These construction barriers are mostly related to the external access of school buildings and other facilities. Furthermore, the existence of a ramp and elevator outside and inside schools and school facilities is missing. Also, an appropriate front door width, and the existence of access to sanitary facilities that are adapted to people with disabilities are crucial to embed. The Department of Construction and Urban Planning is continuously taking measures to adapt facilities for disabled students, urgently fulfilling the needs of schools [50]. In Tab. 1, a list of HSs necessary for construction barriers removal are presented.

| HS   | High School name                        |
|------|----------------------------------------|
| HS1  | II. Grammar School                     |
| HS2  | IV. Grammar School                     |
| HS3  | V. Grammar School                      |
| HS4  | Science-technical sch.                 |
| HS5  | Construction-geodetic sch.             |
| HS6  | Electrotechnic sch.                    |
| HS7  | Industrial sch.                        |
| HS8  | Trade sch.                             |
| HS9  | Technic sch.                           |
| HS10 | Touristic-hospitality sch.             |
| HS11 | Art sch.                               |
| HS12 | Design, graphics and sustainable constr. sch. |
| HS13 | Trade-technic sch.                     |
| HS14 | Commercial-trade sch.                 |
| HS15 | Maritime sch.                          |
| HS16 | Music sch. Jospip Hatze                |
| HS17 | Technical-traffic sch.                 |

Furthermore, to support final decision-makers in managing the projects of removal of constrain barriers in HSs, which is a problematic with a high uncertainty and duality, all HSs must be evaluate by certain number of criteria. Decision-makers, three in this case, define these criteria. A list of criteria is given in Tab. 2, and only the crucial one are presented to avoid extensive calculations and data presentation.

| Criterion | Criterion name                        |
|-----------|---------------------------------------|
| C1        | Number of construction barriers       |
| C2        | External access to school’s facilities |
| C3        | Ramp or elevator inside school’s facilities |
| C4        | Adjusted door width                   |
| C5        | Adjusted sanitary access in the building |
| C6        | Cost of project documentation         |
| C7        | Amount of investment                  |

After the relevant criteria are defined, the comparison of all criteria is done using 1-9 number scale defined by Saaty [47]. Each decision-maker (DM) made a comparison. The 1-9 scale is given in Tab. 3, while calculated criteria weights by each DM and aggregated weight are presented in Tab. 4.

| Importance | Definition                        |
|------------|-----------------------------------|
| 1          | Same significance                  |
| 3          | Average significance of one over another |
| 5          | Powerful significance of one over another |
| 7          | Very powerful significance of one over another |
| 9          | Extreme significance of one over another |
| 2, 4, 6, 8 | Intermediate values               |

The linguistic expressions of DM’s importance with IF numbers are given in Tab. 5. Each DM is evaluated according to his/her background and years of experience. Using Eq. (6) the importance for each DM is calculated, and presented in Tab. 6 with linguistic and numerical value.

| Importance | IFNs                             |
|------------|----------------------------------|
| Very Important (VI) | (0.8, 0.1, 0.1) |
| Important (I)      | (0.6, 0.3, 0.1)   |
| Medium (M)         | (0.5, 0.5, 0.0)   |
| Bad (B)            | (0.3, 0.6, 0.1)   |
| Very Bad (VB)      | (0.1, 0.8, 0.1)   |

Furthermore, the linguistic expressions for the alternatives assessments are given in Tab. 7 with appurtenant IF numbers, and are further used to evaluate each HS by each criterion. The alternatives assessments are calculated by IFWA operator, defined in Eq. (7). The membership, non-membership and hesitation degree are determined as common values of all DMs’ opinions that were included in the evaluation process. The aggregated IF decision matrix is presented in Tab. 8.

| Linguistic expression | IFNs                             |
|-----------------------|----------------------------------|
| Very Good (VG)        | (0.9, 0.05, 0.05)                |
| Good (G)              | (0.7, 0.2, 0.1)                  |
| Medium (M)            | (0.5, 0.5, 0.0)                  |
| Bad (B)               | (0.2, 0.7, 0.1)                  |
| Very Bad (VB)         | (0.05, 0.9, 0.05)                |
Applying step 4, and using aggregated IF values of HS evaluations, the concordance sets are defined. The concordance set, applying (9), is defined as follows:

$$c_{xy}^1 = \begin{cases} 
1 & - & - & 1 & 1 & 1 & 1 & 1 & - & - & - & - & - & - & - & - & - & - & - \\
1 & - & 1 & 1 & 1 & 1 & - & - & - & - & - & - & - & - & - & - & - & - & - \\
6,7 & - & - & - & - & 6,7 & - & - & - & - & - & - & - & - & - & - & - & - & - \\
1 & - & 1 & 1 & 1 & 1 & - & - & - & - & - & - & - & - & - & - & - & - & - \\
- & - & - & - & - & - & - & - & - & - & - & - & - & - & - & - & - & - & - & - \\
6,7 & - & - & - & - & 6,7 & - & - & - & - & - & - & - & - & - & - & - & - & - & - \\
1.3,4 & - & - & 1.3,4 & 1.3,13,4,13,3,13,4 & 1,3,13,4 & 3 & 1.3 & 13,4 & 1.3 & 13,4 & 1.3 & - & - & 6,7 & - & - \\
- & - & - & - & - & - & - & - & - & - & - & - & - & - & - & - & - & - & - & - \\
1.4 & - & - & 1.4 & 1.4 & 1.4 & 1.4 & - & - & - & - & - & - & - & - & - & - & - & - & - \\
6,7 & - & - & - & - & 6,7 & - & - & - & - & - & - & - & - & - & - & - & - & - & - \\
6,7 & - & - & - & - & 6,7 & - & - & - & - & - & - & - & - & - & - & - & - & - & - \\
- & - & - & - & - & - & - & - & - & - & - & - & - & - & - & - & - & - & - & - \\
6,7 & - & - & - & - & 6,7 & - & - & - & - & - & - & - & - & - & - & - & - & - & - \\
6,7 & - & - & - & - & 6,7 & - & - & - & - & - & - & - & - & - & - & - & - & - & - \\
- & - & - & - & - & - & - & - & - & - & - & - & - & - & - & - & - & - & - & - \\
\end{cases}$$

Then, the midrange concordance set, applying (10), is:

$$c_{xy}^2 = \begin{cases} 
- & 5.6,7 & 5.6,7 & 1.2,5 & 6,7 & 5 & 1.2,5 & 1.2,5 & 5.6,7 & 1.2,5 & 1.2,5 & 1.2,5 & 1.2,5 & 1.2,5 & 1.2,5 & 1.2,5 & 1.2,5 & 1.2,5 & 1.2,5 \\
3,4 & 5 & 5 & 2,3,4,5 & 3 & 3 & 2,3,4,5 & 2,3,4,5 & 3 & 2,3,4,5 & 2,3,4,5 & 3 & 2,3,4,5 & 2,3,4,5 & 3 & 2,3,4,5 & 2,3,4,5 & 3 & 2,3,4,5 & 2,3,4,5 \\
3,4 & 5.6,7 & 5 & 2,3,4,5 & 3 & 3,5 & 2,3,4,5 & 2,3,4,5 & 3 & 2,3,4,5 & 2,3,4,5 & 3 & 2,3,4,5 & 2,3,4,5 & 3 & 2,3,4,5 & 2,3,4,5 & 3 & 2,3,4,5 & 2,3,4,5 \\
6 & 6,7,6 & 2 & 6,7 & 5 & 2,5 & 6,7 & 2,5 & - & - & 6,7 & - & - & 6,7 & - & - & 6,7 & - & - & 6,7 & - & - \\
- & 6,7 & 6,7 & - & - & - & - & - & - & - & - & - & - & - & - & - & - & - & - & - & - & - & - \\
4 & 5.6,7 & 5 & 2,4,5 & - & - & 5 & 2,4,5 & 2,5 & 4,5 & 2,4,5 & 4,5 & 4 & 2,3,5 & 2,3,4,5 & 2,3,4,5 & 2,3,4,5 & 2,3,4,5 \\
4 & 6,7,6 & 1.2,4 & 6,7 & - & - & 1.2,4 & 1.2 & - & - & - & - & - & - & - & - & - & - & - & - & - & - & - & - \\
- & - & - & - & - & - & - & - & - & - & - & - & - & - & - & - & - & - & - & - & - & - & - \\
4 & 6,7,6 & 6,7 & - & - & 6,7,6 & 6,7 & - & - & - & - & - & - & - & - & - & - & - & - & - & - & - & - \\
- & - & - & - & - & - & - & - & - & - & - & - & - & - & - & - & - & - & - & - & - & - & - \\
4 & 6,7,6 & 6,7 & - & - & 6,7 & 6,7 & - & - & - & - & - & - & - & - & - & - & - & - & - & - & - & - \\
4 & 6,7,6 & 6,7 & - & - & 6,7 & 6,7 & - & - & - & - & - & - & - & - & - & - & - & - & - & - & - & - \\
- & - & - & - & - & - & - & - & - & - & - & - & - & - & - & - & - & - & - & - & - & - & - \\
4 & 6,7,6 & 6,7 & - & - & 6,7 & 6,7 & - & - & - & - & - & - & - & - & - & - & - & - & - & - & - & - \\
4 & 6,7,6 & 6,7 & - & - & 6,7 & 6,7 & - & - & - & - & - & - & - & - & - & - & - & - & - & - & - & - \\
- & - & - & - & - & - & - & - & - & - & - & - & - & - & - & - & - & - & - & - & - & - & - \\
4 & 6,7,6 & 6,7 & - & - & 6,7 & 6,7 & - & - & - & - & - & - & - & - & - & - & - & - & - & - & - & - \\
4 & 6,7,6 & 6,7 & - & - & 6,7 & 6,7 & - & - & - & - & - & - & - & - & - & - & - & - & - & - & - & - \\
- & - & - & - & - & - & - & - & - & - & - & - & - & - & - & - & - & - & - & - & - & - & - \\
4 & 6,7,6 & 6,7 & - & - & 6,7 & 6,7 & - & - & - & - & - & - & - & - & - & - & - & - & - & - & - & - \\
4 & 6,7,6 & 6,7 & - & - & 6,7 & 6,7 & - & - & - & - & - & - & - & - & - & - & - & - & - & - & - & -
And the weak concordance set, applying (11), is defined as:

\[
\mathcal{D}_{xy}^{1} = \begin{cases} 
- & 5 \\
1 & - \\
2 & - \\
3 & - \\
4 & - \\
5 & - \\
6 & - \\
7 & - \\
\end{cases}
\]

The discordance set is determined using (12), and given as follows:

\[
\mathcal{D}_{xy}^{2} = \begin{cases} 
- & 6,7 \\
1 & - \\
2 & - \\
3 & - \\
4 & - \\
5 & - \\
6 & - \\
7 & - \\
\end{cases}
\]

The midrange discordance set, applying (13), is:

\[
\mathcal{D}_{xy}^{3} = \begin{cases} 
7 & - \\
6,7 & - \\
5 & - \\
4 & - \\
3 & - \\
2 & - \\
1 & - \\
\end{cases}
\]

The weak discordance set is defined by (14), and is presented as: \( \mathcal{D}_{xy}^{3} = \{ - \} \).

The concordance and discordance dominance matrices \( K \) and \( L \) are calculated applying step 6, then the aggregate dominance matrix \( R \) defined by (20) is calculated and presented as follows:

For the final ranking calculation (21) is used, to determine matrix \( T \). According to \( T \), alternatives are ranked where the best alternative is the one that has the shortest distance from the positive ideal point and the longest distance from the negative ideal point.

The values of \( T \) are determined as follows: \( T_1 = 0.86; T_2 = 0.69; T_3 = 0.93 \); \( T_4 = 0.55; T_5 = 0.60; T_6 = 0.86; T_7 = 0.51; T_8 = 0.63; T_9 = 0.91; T_{10} = 0.67; T_{11} = 0.65 \).

Hence, the final ranking of HS according to the necessary for the construction barriers removal is achieved as: HS9 > HS15 > HS12 > HS1 > HS3 > HS5 > HS6 > HS2 > HS16 > HS17 > HS14 > HS8 > HS11 > HS7 > HS10 > HS4 > HS13. According to final ranking Technic school has the highest priority for the construction barriers removal, and Trade-technic school the last priority. HS9 has the most construction barriers, all four of them while HS13 has only one. This way, the proposed model is shown to be applicable and useful in dealing with this type of civil engineering.
problematics.

\[
R_{gy} = \begin{cases} 
- & 1 & 1 & 0.48 & 0.35 & 0.50 & 1 & 1 & 1 & 1 & 1 & 1 & 0.36 & 1 & 1 \\
1 & - & 0.54 & 0.54 & 1 & 1 & 0.54 & 0.41 & 0.48 & 0.54 & 0.41 & 1 & 0.54 & 1 & 1 & 0.54 & 0.41 \\
1 & 0.29 & - & 1 & 0.34 & 1 & 1 & 1 & 0.48 & 1 & 1 & 0.50 & 1 & 1 & 1 & 1 & 1 \\
0.28 & 1 & 1 & - & 1 & 0 & 0.22 & 0.50 & 1 & 0.22 & 0.37 & 1 & 0.24 & 0.50 & 0.54 & 0.48 & 0.35 \\
1 & 0.31 & 0.50 & 1 & - & 1 & 1 & 1 & 0.29 & 1 & 1 & 0.48 & 1 & 1 & 1 & 1 & 1 \\
0.49 & 0.39 & 0.39 & 1 & 1 & - & 1 & 1 & 1 & 0.34 & 1 & 1 & 0.49 & 1 & 1 & 1 & 1 & 1 \\
0.54 & 1 & 0.52 & 1 & 1 & - & 0.50 & 0.41 & 0.48 & 0.50 & 0.37 & 0.48 & 0.51 & 0.29 & 0.37 & 0.50 \\
0.54 & 1 & 0.52 & 1 & 1 & - & 0.50 & 0.41 & 0.48 & 0.50 & 0.37 & 0.48 & 0.51 & 0.29 & 0.37 & 0.50 \\
0.29 & 1 & 1 & 0.48 & 1 & 0.28 & 0.36 & - & 1 & 0.38 & 0.50 & 0.37 & 0.48 & 0.50 & 1 & 0.48 & 0.48 \\
0.54 & - & 0.54 & - & - & - & - & - & - & - & - & - & - & - & - & - & - & - \\
0.28 & 1 & 1 & 0.48 & 0.41 & 0.28 & 0.48 & 0.48 & 1 & 0.36 & - & 1 & 0.51 & 0.39 & 1 & 0.37 & 0.51 \\
0.34 & 0.52 & 1 & 0.49 & 1 & 1 & 0.36 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\
0.32 & 0.36 & 0.38 & 0.50 & 0.38 & 1 & 0.50 & 0.50 & 1 & 0.50 & 0.51 & 0.39 & - & 0.50 & 0.29 & 0.48 & 0.50 \\
0.50 & 1 & 0.37 & 0.51 & 1 & 1 & 0.51 & 0.51 & 0.41 & 0.55 & 0.52 & 1 & 0.49 & - & 0.29 & 0.48 & 0.51 \\
0.50 & 1 & 1 & 1 & 1 & 1 & 0.50 & 1 & 0.50 & 1 & 0.50 & 1 & 0.50 & 1 & 0.50 & 1 & 0.50 \\
0.29 & 1 & 1 & 0.48 & 1 & 0.29 & 0.48 & 0.48 & 1 & 0.48 & 0.50 & 0.34 & 0.48 & 0.50 & 1 & 0.35 & - & - \\
\end{cases}
\]

4 CONCLUSION

The IF ELECTRE method is provided for solving multicriterial problem with IFS information. The IFS data are used instead of single values in the evaluation process of the ELECTRE method. With these data, different sets of concordance and discordance are classified to fit a real life decision. IF ELECTRE algorithm is proposed to support final decision makers in managing the project of removal of construction barriers in HSs. There were 17 HSs defined for evaluation by seven criteria. Three DMs are included in the process according to their background and the years of experience to lower a partiality in the decision-making process. Hereby, proposed model uses determined concordance and discordance sets to construct concordance and discordance matrices. Defining these matrices, an aggregated matrix is calculated and the final ranking of HSs is achieved. Technic school is rank with the highest priority for the removal of construction barriers, and the least necessary is the Trade-technic school. These school are ranked according to the number and complexity of barriers that need to be remove. Only the crucial criteria are included in the assessment process, to lower the comprehensives of the calculations and results. Since the problem is multicriterial with large amount of uncertain data, therefore the proposed IF ELECTRE is an effective approach because fuzzy theory can precisely resolve the natural duality associated with the DM’s definition of uncertain data. Furthermore, the approach enables DMs to select the best alternative by determine the shortest distance form positive ideal solution and negative ideal solution. The IF ELECTRE hereby, is used to define the HS that is the most necessary for the construction barriers removal and then by the final ranking of all HSs, defined the plan for the removal projects. For distance measure calculation of discordance index, the Euclidian distance is used. This approach gives more systematic description of the decision process, and it removes the ambiguity and vagueness in collected data. It has the ability to solve other complex problems with the high degree of uncertainty and hesitation. For the future study, more criteria described by interval valued IF information will be defined to achieve a detailed evaluation of alternatives, integrating users’ opinions.

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