APPLICATION OF FUZZY SOFT SETS TO FLOOD ALARM MODEL

KANWARA WARAHA
DUANGROETAI BAKHAM

An Independent Study Submitted in Partial Fulfillment of the Requirements for the degree of Bachelor of Science Program in Mathematics

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Advisor and Dean of School of Science have considered the independent study entitled "Application of fuzzy soft sets to flood alarm model" submitted in partial fulfillment of the requirements for the degree of Bachelor of Science Program in Mathematics is hereby approved

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ชื่อเรื่อง การประยุกต์ใช้เซตอ่อนวิภัชนัยสำหรับแบบจำลองการเตือนภัยน้ำท่วม

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บทคัดย่อ

ในงานวิจัยนี้คณะผู้วิจัยได้ศึกษาเซตอ่อนวิภัชนัยและสร้างขั้นตอนวิธีสำหรับการเตือนภัยน้ำท่วม ที่ถูกนำไปใช้กับแปดจังหวัด ทางภาคเหนือของไทยสุดท้ายคณะผู้วิจัยได้ยกตัวอย่าง ซึ่งแสดงว่าวิธีการนี้สามารถคาดการณ์น้ำท่วมที่อาจจะเกิดขึ้นในอนาคต

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ABSTRACT

In this work, we study fuzzy soft sets and construct an algorithm approach to flood alarm prediction applied to eight provinces selected sites of the North of Thailand. Finally, we give an example which shows that the method can be successfully to predict potential flood in the future.

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CHAPTER I
Introduction

The real life problems in environment, engineering, economics, medical science and many other fields are numerous and complicated. These problems are solved by the classical methods but the uncertainties are present in these problems. There are theories such as theory of fuzzy sets [19] theory of rough sets [13] and theory of vague sets [4] which these can be considered as mathematical methods for dealing with uncertainties. Accordingly, in 1999, Molodtsov [10] introducted the first concept of soft set theory as a new mathematical tool to solove such problems. He discussed how soft set theory is free from the parameterization inadequacy condition of rough set theory, fuzzy set theory, probability theorem etc. Maji et al. [8, 9] presented soft subset, equality of two soft sets and supported examples. They discussed an application of soft sets in decision making problems.

In 2001, Maji et al. [7] extended the soft sets to fuzzy soft sets. They introducted the concept of fuzzy soft set and defined the union and intersection of fuzzy soft set over common universe. The fuzzy soft set theory has been developed by many researchers in decision making problems. In 2007, Roy and Maji [14] presented an application of fuzzy soft sets in decisionn making problems. They used comparison table from resultant fuzzy soft set in decision making problems. Next, Kalayathankal and Singh used fuzzy soft sets establish some results on them and develop an algorithm followed by simulation for flood warning in five important locations in the state of Kerala, India. Moreover, the past decade has witnessed a few applications of fuzzy soft sets approach to flood prediction studies [3, 5, 12, 15, 16, 17, 18]. In 2015, Congliang et al. used fuzzy soft sets in the application of the asphalt pavement maintenance sorting.

We inspired and motivated from papers above. In Chapter II, we give some basic Definition of fuzzy soft sets. In Chapter III, we study algorithm approach to flood alarm prediction applied by simulation for flood warning in eight locations in the North of Thailand. Moreover, we use microsoft excel to comput the result of examples. Fanally, we show the conclusion of this work in Chapter IV.

CHAPTER II
Preliminaries

2.1 Basic Results on Fuzzy Soft Sets

In this section, we present the basic definitions and results that will be used.

Definition 2.1.1. [10] Let U be an initial universe set and E be a set of parameter (real-valued variables). Let $P(U)$ denotes the power set of U and $\emptyset \neq A \subseteq E$. A pair (F, A) is called a *soft set over* U, where F is a mapping given by $F : A \to P(U)$.

Example 2.1.2. [9] Let $U = \{h_1, h_2, h_3, h_4, h_5, h_6\}$ be the set of six houses and $E = \{e_1, e_2, e_3, e_4, e_5\}$ be the set of parameters : where

e_1 stands for the parameter "expensive" ,

e_2 stands for the parameter "beautiful" ,

e_3 stands for the parameter "wooden" ,

e_4 stands for the parameter "cheap",

e_5 stands for the parameter "in the green surroundings" .

Figure 2.1.1: The houses

Suppose that $F : E \to P(U)$ where

$$
\begin{aligned}
F(e_1) &= \{h_2, h_4\},\\
F(e_2) &= \{h_1, h_3\},\\
F(e_3) &= \{h_3, h_4, h_5\},\\
F(e_4) &= \{h_1, h_3, h_5\},\\
F(e_5) &= \{h_1\}.
\end{aligned}
$$

The soft set (F, E) is a parametrized family $\{F(e_i), i = 1, 2, 3, 4, 5\}$ of subsets of the set U and gives us a collection of approximate descriptions of an object. Consider the mapping F which is " houses (.)" where dot (.) is to be filled up by a parameter $e \in E$. Therefore, $F(e_1)$ means "houses (expensive)" whose functional-value is the set h_2, h_4. Thus,we can view the soft set (F, E) as a collection of approximations as below: (F, E) ={expensive houses $=\{h_2, h_4\}$, beautiful houses $=\{h_1, h_3\}$, wooden houses $= \{h_3, h_4, h_5\}$, cheap houses $=\{h_1, h_3, h_5\}$, in the green surroundings $=\{h_1\}$}.

Definition 2.1.3. [7] Let U be an initial universe set and E be a set of parameter (real-valued variables) and $\emptyset \neq A \subseteq E$. Let $Fuz(U)$ denote the set of all fuzzy sets of U where a function f from U into unit interval $[0, 1]$ is a *fuzzy set* on U.

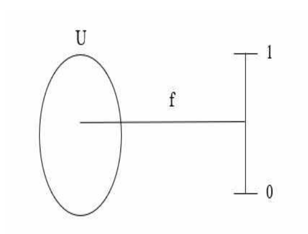

Figure 2.1.2: Fuzzy sets on U

A pair (F, A) is called a *fuzzy soft set over* U, where F is a mapping given by $F : A \to Fuz(U)$

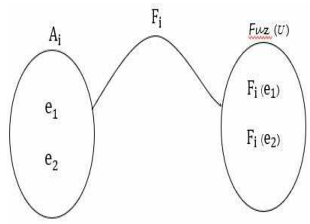

Figure 2.1.3: Fuzzy soft sets over U

Example 2.1.4. Let $U = \{h_1, h_2, h_3, h_4, h_5\}$ be the set of five houses and let $A = \{\text{blackish, reddish, green}\}$ be the set of parameters. Then (F, A) is a fuzzy soft set over U representing the attractiveness of the houses which Mr. X is going to buy where

$$F(\text{blackish}) = \{h_1/.4, h_2/.6, h_3/.5, h_4/.8, h_5/1\},$$
$$F(\text{reddish}) = \{h_1/1, h_2/.5, h_3/.5, h_4/1, h_5/.7\},$$
$$F(\text{green}) = \{h_1/.5, h_2/.6, h_3/.8, h_4/.8, h_5/.7\}.$$

Definition 2.1.5. [7] For two fuzzy soft sets (F, A) and (G, B) over a common universe $U, (F, A)$ is a *fuzzy soft subset* of (G, B) if
(i) $A \subseteq B$, and
(ii) $\forall \varepsilon \in A$,$F(\varepsilon)$ is a fuzzy subset of $G(\varepsilon)$, that is $F(\varepsilon) \leq G(\varepsilon) \;\; \forall \varepsilon \in A$.

We write $(F, A)\tilde{\subset}(G, B)$. (F, A) is said to be a fuzzy soft super set of (G, B), if (G, B) is a *fuzzy soft subset* of (F, A). We denote it by $(F, A)\tilde{\supset}(G, B)$.

Example 2.1.6. Consider *two fuzzy soft sets* (F, A) and (G, B) over the same universal set $U = \{h_1, h_2, h_3, h_4, h_5\}$. Here U represents the set of houses,

$A = \{\text{blackish, reddish, green}\}$ and $B = \{\text{blackish, reddish, green, large}\}$, and

$$F(\text{blackish}) = \{h_1/.4, h_2/.6, h_3/.5, h_4/.8, h_5/1\},$$
$$F(\text{reddish}) = \{h_1/1, h_2/.5, h_3/.5, h_4/1, h_5/.7\},$$
$$F(\text{green}) = \{h_1/.5, h_2/.6, h_3/.8, h_4/.8, h_5/.7\},$$
$$G(\text{blackish}) = \{h_1/.4, h_2/.7, h_3/.6, h_4/.9, h_5/1\},$$
$$G(\text{reddish}) = \{h_1/1, h_2/.6, h_3/.5, h_4/1, h_5/1\},$$
$$G(\text{green}) = \{h_1/.6, h_2/.6, h_3/.9, h_4/.8, h_5/1\},$$
$$G(\text{large}) = \{h_1/.4, h_2/.6, h_3/.5, h_4/.8, h_5/1\}.$$

Clearly,$(F, A)\tilde{\subset}(G, B)$.

Definition 2.1.7. [8] If (F, A) and (G, B) be two fuzzy soft sets then "(F, A) AND (G, B)" is a fuzzy soft set denoted by $(F, A) \wedge (G, B)$ and is defined by
$(F, A) \wedge (G, B) = (H, A \times B)$, where $H(\alpha, \beta) = F(\alpha)\tilde{\cap}G(\beta), \forall\alpha \in A$ and $\forall\beta \in B$, where $\tilde{\cap}$ is the operation "fuzzy intersection" of two fuzzy sets.
This is $F(\alpha)\tilde{\cap}G(\beta) = min\{F(\alpha), G(\beta)\}$ $\forall\alpha \in A$ and $\forall\beta \in B$.

2.2 Algorithm

In 2007, Roy and Maji [14] construct a comparison table used to in an algorithm in decision making problems.

Comparison table is a square table in which the number of rows and number of columns are equal, rows and columns both are labelled by the object names $o_1, o_2, o_3, ..., o_n$ of the universe, and the entries are $c_{ij}, i, j = 1, 2, ..., n$, given by c_{ij} = the number of parameters for which the membership value of oi exceeds or equal to the membership value of o_j .

Clearly, $0 \leq c_{ij} \leq k$, and $c_{ii} = k$ $\forall i, j$ where, k is the number of parameters present in a fuzzy soft set Thus, c_{ij} indicates a numerical measure, which is an integer number and o_i dominates o_j in c_{ij} number of parameters out of k parameters. The row sum of an object o_i is denoted by r_i and is calculated by using the formula,

$$r_i = \sum_{j=1}^{n} c_{ij}. \tag{2.2.1}$$

Clearly, r_i indicates the total number of parameters in which o_i dominates all the members of U. Likewise, the column sum of an object o_j is denoted by t_j and may be computed as

$$t_j = \sum_{i=1}^{n} c_{ij}. \tag{2.2.2}$$

The integer t_j indicates the total number of parameters in which o_j is dominated by all the members of U. The score of an object o_i is S_i may be given as $S_i = r_i - t_i$. The problem here is to choose an object from the set of given objects with respect to a set of choice parameters P. We now present an algorithm for identification of an object, based on multiobservers input data characterised by colour, size and surface texture features.

Algorithm[14]

1.Input the fuzzy soft sets $(F, A), (G, B)$ and (H, C).

2.Input the parameter set P as observed by the observer.

3.Compute the corresponding resultant fuzzy soft set (S, P) from the fuzzy soft sets $(F, A), (G, B), (H, C)$ and place it in tabular form.

4. Construct the Comparison table of the fuzzy soft set (S, P) and compute r_i and t_i for o_i, $\forall i$.

5.Compute the score of $o_i, \forall i$.

6.The decision is S_k if, $S_k = \max_i S_i$.

7.If k has more than one value then any one of o_k may be chosen.

In 2015, Congliang et al.[1] used different formulas standardized the two types of attributes. First of all, the decision attribute usually have different dimensions, orders of magnitude and attribute category (efficiency attribute and cost type attribute). There is no unified metrics between different decision attribute, in order to eliminate the influence on the result of decisions of dimension, orders of magnitude, category, must to standardized the decision attribute values. Efficiency type attribute refers to the attribute of attribute value the larger the better, cost attribute refers to the attribute of attribute value the smaller the better. Using different formulas standardized the two types of attributes: Efficiency attribute index was calculated by the following formula:

$$r_{ij} = \frac{\{a_{ij}, i = 1, ..., m, j = 1, ..., n\} - \min\{a_{ij}, i = 1, ..., m, j = 1, ..., n\}}{\max\{a_{ij}, i = 1, ..., m, j = 1, ..., n\} - \min\{a_{ij}, i = 1, ..., m, j = 1, ...n\}} \quad \text{or}$$

$$r_{ij} = \frac{\max\{a_{ij}, i = 1, ..., m, j = 1, ..., n\} - \{a_{ij}, i = 1, ..., m, j = 1, ..., n\}}{\max\{a_{ij}, i = 1, ..., m, j = 1, ..., n\} - \min\{a_{ij}, i = 1, ..., m, j = 1, ...n\}}$$

$i = 1, 2, \ldots, m;\ j = 1, 2, \ldots, n.$

CHAPTER III
Main Results

3.1 Model Construction

In this secsion, we can struct the model approach to flood alarm prediction.

Definition 3.1.1. (Estimation bank) It is a table in which the number of rows and columns are equal. Both are labeled by location variables. Entries e_{ij} = the number of parameters for which the membership value of L_i exceeds or equals the membership value of L_j.

Remark 3.1.2. $0 \leq e_{ij} \leq n$, where n is the number of parameters.

Remark 3.1.3. Each main diagonal element of an estimation bank is always equal to the constant n, where n is the number of parameters of the system.

Definition 3.1.4. (Impact indicator). The row sum of L_i's determine total cumulative impact on each location L_i's

$$I_{ri} = \sum_{j=1}^{n} e_{ij}. \tag{3.1.1}$$

Definition 3.1.5. (Divider factor). The sum of each column in estimation bank tracks the prediction procedure. The divide factor

$$D_j = \sum_{i=1}^{n} e_{ij}. \tag{3.1.2}$$

Definition 3.1.6. (Discrimination factor). The discrimination factor discriminates flood probable location. Discrimination factor *(DF)* is defined as

$$DF_i = I_{ri} - D_i. \tag{3.1.3}$$

Algorithm

1.Selection of a desired number of locasions (m).

2.Selection of a desired number of parameters (n).

3.Compute the average of basic data.

4.Compute

$$r_{ij} = \frac{\{a_{ij}, i = 1, ..., m, j = 1, ..., n\} - \min\{a_{ij}, i = 1, ..., m, j = 1, ..., n\}}{\max\{a_{ij}, i = 1, ..., m, j = 1, ..., n\} - \min\{a_{ij}, i = 1, ..., m, j = 1, ...n\}} \quad \text{or}$$

$$r_{ij} = \frac{\max\{a_{ij}, i = 1, ..., m, j = 1, ..., n\} - \{a_{ij}, i = 1, ..., m, j = 1, ..., n\}}{\max\{a_{ij}, i = 1, ..., m, j = 1, ..., n\} - \min\{a_{ij}, i = 1, ..., m, j = 1, ...n\}}$$

$i = 1, 2, \ldots, m;\ j = 1, 2, \ldots, n.$

5.Construction of a fuzzy soft set (F, P) and tabulation.

6.Construction of estimation bank.

7.Calculation of impact indicator and divider factor.

8.Estimation of discrimination factors.

9.Construction of I_r and DF optimization table.

10.Identification of flood prone location from I_r and DF optimization table.

Discrimination algorithm is computed using data composed of nine pertinent parameters related to flood occurrence and relevant conclusions are drawn.

3.2 Application

Example 3.2.1. [5]The area selected for the study the five selected locations in Kerala: Trivandrum, Alappuzha, Cochin AP, Palakkad and Kozhikode are denoted by $L_1, L_2, L_3, L_4,$ and L_5. The parameter set $P = \{P_1, P_2, P_3, P_4, P_5, P_6, P_7\}$ respectively denotes wind speed, wind direction, relative humidity, surface pressure, river contribution, topography, and rainfall amount.

Step 1. Selection of a desired number of locations (m).

Step 2. Selection of a desired number of parameters (n).

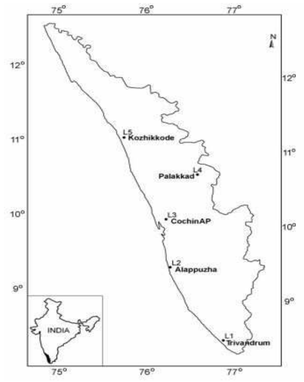

Figure 3.2.1: The state of Kerala, India map

Step 3. Construction of a fuzzy soft set (F, P) and tabulation.

$$\text{The fuzzy soft set } (F,P) = \{F(P_i) \mid P_i \in P\} \text{ where}$$

$$F(P_1) = \{L_1/0.7, L_2/0.6, L_3/0.6, L_4/0.9, L_5/0.5\},$$

$$F(P_2) = \{L_1/0.7, L_2/0.8, L_3/0.9, L_4/0.6, L_5/0.9\},$$

$$F(P_3) = \{L_1/0.8, L_2/0.8, L_3/1.0, L_4/0.7, L_5/0.8\},$$

$$F(P_4) = \{L_1/0.9, L_2/0.9, L_3/1.0, L_4/0.8, L_5/0.9\},$$

$$F(P_5) = \{L_1/1.0, L_2/0.5, L_3/1.0, L_4/0.5, L_5/0.5\},$$

$$F(P_6) = \{L_1/0.5, L_2/1.0, L_3/1.0, L_4/0.5, L_5/0.5\},$$

$$F(P_7) = \{L_1/0.5, L_2/0.6, L_3/1.0, L_4/0.4, L_5/0.9\}.$$

Table 3.2.1: Fuzzy soft set from collected data

U	P_1	P_2	P_3	P_4	P_5	P_6	P_7
L_1	0.7	0.7	0.8	0.9	1.0	0.5	0.5
L_2	0.6	0.8	0.8	0.9	0.5	1.0	0.6
L_3	0.6	0.9	1.0	1.0	1.0	1.0	1.0
L_4	0.9	0.6	0.7	0.8	0.5	0.5	0.4
L_5	0.5	0.9	0.8	0.9	0.5	0.5	0.9

Step 4. Construction of estimation bank.

Table 3.2.2: Estimation bank.

U	L_1	L_2	L_3	L_4	L_5
L_1	7	4	2	6	5
L_2	5	7	2	6	5
L_3	6	7	7	6	7
L_4	2	2	1	7	3
L_5	5	5	1	6	7

Step 5. Calculation of impact indicator and divider factor (see the Table 3.2.3).

Step 6. Estimation of discrimination factors (see the Table 3.2.3).

Step 7. Construction of I_r and DF optimization table (see the Table 3.2.3).

Step 8. Identification of flood prone location from I_r and DF optimization table (see the Table 3.2.3).

Table 3.2.3: Optimization table.

U	Impact indicator	Divider factor	Discrimination factor
L_1	24	25	-1
L_2	25	25	0
L_3	33	13	20
L_4	15	31	-16
L_5	24	27	-3

Impact of parameters affects the location. If ID ratio is less than unity the location will not be affected by such changes. If ID ratio is unity, the location is minimally affected by the changes in the parameters. We call that location a Red spot. This is because any fluctuation in the estimation bank input critically affects the result. In such cases instead of constructing a fuzzy soft set for a given set of values, we take a sequence of values for each parameter which forms a real sequence. If it converges, the corresponding parameter shows consistency. Otherwise the parameter is significant in determining the nature of uncertainty of the prediction. If the convergent criterion for all input values are satisfied, this estimation bank gives us reliable results.

Example 3.2.2. The area selected for the study is Chiang Rai, Phayao, Chiang Mai, Lampang, Lamphun, Phrae , Nan and Mae Hong Son provinces.

Figure 3.2.2: The Northen map

Step 1. Selection of a desired number of locations (m).
Let $U = \{L_1, L_2, L_3, L_4, L_5, L_6, L_7, L_8\}$ be the eight selected locations in Chiang Rai, Phayao, Chiang Mai, Lampang, Lamphun, Phrae, Nan and Mae Hong Son provinces.
Step 2. Selection of a desired number of parameters (n).
Let $P = \{P_1, P_2, P_3\}$ be the parameters are average temperature, wind speed and rainfall.
Step 3. Compute the average of basic data.

Table 3.2.4: The tabular form of basic data [2]

U	Temperature	Wind speed	Rainfall
Chiang Rai	23.29	16.0816129	1879.4387
Phayao	23.61	9.38709677	1453.6516
Chiang Mai	25.15	15.4248387	975.43548
Lampang	25.29	10.8822581	1168.071
Lamphun	25.01	15.4248387	1115.5161
Phrae	25.76	15.0648387	1051.4323
Nan	24.93	8.19129032	1113.6258
Mae Hong Son	23.83	12.9129032	1118.9387

Step 4. Compute

$$r_{ij} = \frac{\{a_{ij}, i = 1, ..., m, j = 1, ..., n\} - \min\{a_{ij}, i = 1, ..., m, j = 1, ..., n\}}{\max\{a_{ij}, i = 1, ..., m, j = 1, ..., n\} - \min\{a_{ij}, i = 1, ..., m, j = 1, ...n\}} \quad \text{or}$$

$$r_{ij} = \frac{\max\{a_{ij}, i = 1, ..., m, j = 1, ..., n\} - \{a_{ij}, i = 1, ..., m, j = 1, ..., n\}}{\max\{a_{ij}, i = 1, ..., m, j = 1, ..., n\} - \min\{a_{ij}, i = 1, ..., m, j = 1, ...n\}}$$

$i = 1, 2, \ldots, m;\ j = 1, 2, \ldots, n.$ (see Table 3.2.5).

Step 5. Construction of a fuzzy soft set (F, P) and tabulation.

Table 3.2.5: The tabular form of fuzzy soft sets

U	P_1	P_2	P_3
L_1	1.00	0.00	0.00
L_2	0.87	0.85	0.47
L_3	0.25	0.08	1.00
L_4	0.19	0.66	0.79
L_5	0.31	0.08	0.85
L_6	0.00	0.13	0.92
L_7	0.34	1.00	0.85
L_8	0.78	0.40	0.84

Step 6. Construction of estimation bank (see Table 3.2.6).

Table 3.2.6: The tabular form of estimation bank

U	L_1	L_2	L_3	L_4	L_5	L_6	L_7	L_8
L_1	3	1	1	1	1	1	1	1
L_2	2	3	2	2	2	2	1	2
L_3	2	1	3	2	1	2	1	1
L_4	2	1	1	3	1	2	0	1
L_5	2	1	2	2	3	1	0	1
L_6	2	1	1	1	2	3	1	1
L_7	2	2	2	3	3	2	3	2
L_8	2	1	2	2	2	2	1	3

Step 7. Calculation of impact indicator and divider factor (see Table 3.2.7).

Step 8. Estimation of discrimination factors (see Table 3.2.7).

Table 3.2.7: The tabular form of indicator and divider factor

U	Impact Indicator	Divider Factor	Discrimination Factor
L_1	10	17	-7
L_2	16	11	5
L_3	13	14	-1
L_4	11	16	-5
L_5	12	15	-3
L_6	12	15	-3
L_7	19	8	11
L_8	15	12	3

Step 9. Construction of I_r and DF optimization table.

From the above Discrimination factor Table 3.2.4, it is clear that the minimun score is -7, scored by L_1 and the decision is most flood prone location is L_1.

Step 10. Identification of flood prone location from I_r and DF optimization table.

So, we will choose the location L_1 (Chiang Rai) is the first province that we will be in the second warning, L_4 (Lamphun) province and the third is L_5 (Phrae) and L_6 (Nan) respectively.

CHAPTER IV
Conclusions

In this work, we studied fuzzy soft sets and constructed the algorithm approach of flood alarm prediction as follows :

Algorithm

1.Selection of a desired number of locations (m).

2.Selection of a desired number of parameters (n).

3.Compute the average of basic data.

4.Compute

$$r_{ij} = \frac{\{a_{ij}, i = 1, ..., m, j = 1, ..., n\} - \min\{a_{ij}, i = 1, ..., m, j = 1, ..., n\}}{\max\{a_{ij}, i = 1, ..., m, j = 1, ..., n\} - \min\{a_{ij}, i = 1, ..., m, j = 1, ...n\}} \quad \text{or}$$

$$r_{ij} = \frac{\max\{a_{ij}, i = 1, ..., m, j = 1, ..., n\} - \{a_{ij}, i = 1, ..., m, j = 1, ..., n\}}{\max\{a_{ij}, i = 1, ..., m, j = 1, ..., n\} - \min\{a_{ij}, i = 1, ..., m, j = 1, ...n\}}$$

$i = 1, 2, \ldots, m;\ j = 1, 2, \ldots, n.$

5.Construction of a fuzzy soft set (F, P) and tabulation.

6.Construction of estimation bank.

7.Calculation of impact indicator and divider factor.

8.Estimation of discrimination factors.

9.Construction of I_r and DF optimization table.

10.Identification of flood prone location from I_r and DF optimization table.

The example which shows that method can be successfully to predict potential flood in the future.

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