Applications of Fuzzy Soft Sets to the Flood Alarm Model in Northern Thailand

Kanwara Waraha, Duangroetai Bakham and Peerapong Suebsan

Abstract—**This paper concentrates on studying the application of fuzzy soft sets and the construction of an algorithm to identify a better approach flood alarm prediction model that applies to eight selected provinces sites in Northern Thailand. Finally, an example is provided to show which of the methods can be successfully used to predict potential flood in the future.**

Index Terms—**fuzzy soft sets, flood alarm prediction.**

I. Introduction

THE solutions to a myriad of real-life problems in the economics, engineering, medical science, environment and many other fields are numerous and complicated. These problems are often solved using classical methods, but the uncertainties are usually present when dealing with these problems. There are various theories such as the theory of fuzzy sets [1], the theory of rough sets [2] and theory of vague sets [3] which can be considered as mathematical methods for dealing with uncertainties. Accordingly, in 1999, Molodtsov [4] introduced the first concept of soft set theory as a new mathematical tool to be used in solving such problems. He discussed how soft set theory is free from the parameterization inadequacy condition of fuzzy set theory, rough set theory, probability theorem etc. Maji *et al.* [5], [6] presented soft subsets, equality of two soft sets and supported these claims with examples. The discussion also took place for an application of soft sets in decision-making problems.

In 2001, Maji *et al.* [7] extended the soft sets to fuzzy soft sets. The concept of the fuzzy soft set was introduced while defining the intersection and union of fuzzy soft set over a universe. In 2007, Roy and Maji [8] presented an application of fuzzy soft sets in decision-making problems. They used the comparison table from the resultant fuzzy soft set in decision-making problems. Following, Kalayathankal and Singh [9] used a fuzzy soft set to produce some results and developed an algorithm followed by simulated flood alarms at five key locations in Kerala, India. The theory of fuzzy set is a valuable mathematical tool when it comes to dealing with uncertainty. However, it is also a rather new notion when it comes to applying it to abstract algebraic structures. In 2017, Julath and Siripitukdet [10] examined some characterizations of fuzzy bi-ideals and fuzzy quasi-ideals of semigroups. In 2020, Yairayong [11] debated on combining the theories of hesitant fuzzy sets on semigroups and also establishing a new framework for hesitant fuzzy sets on semigroups.

Due to the fact that rainfall is being the predominant element in most hydrological systems. Reliable rainfall is essential for the study of ecology, meteorology, geomorphology and various disaster management. Since the occurrence and distribution of rainfall in the region are affected by a number of independent factors, reliable forecasts become a complex task. A particularly challenging task for water management and flood management is to create reliable rainfall forecasts. Precise predictions of the spatial and spatial distribution of rainfall are useful in the area of flood warning systems. In order to have a fast response time for a quarantine, an early warning system with adequate lead times is essential.

The flood warning system is a non-structural measure for flood mitigation. Many of these parameters are responsible for flood-related disasters and a fast-response flood warning system is needed to achieve effective flood mitigation measures. When it comes to important atmospheric parameters affecting flooding, they are rainfall, wind speed, wind direction, relative humidity, and surface pressure. Rivers and topography are two geographic parameters that directly affect rainfall and water distribution.

This paper concentrates on the study of fuzzy soft sets theory and construction of an effective algorithm approach for flood alarm prediction which is applied to selected sites across eight provinces of Northern Thailand. Lastly, the examples are provided which show that the method can be successfully used to predict potential floods in the future.

II. Preliminaries

Decision-related thought processes include complex streaming possibilities where individuals choose or discard information available from a variety of sources. In doing so, individuals are led by the meaningful analysis of the available data, and making the best choice is a result of several obvious effective decisions. The information is provided based on certain criteria and the threshold values are not an explicit but fuzzy set. However, in real life situations, information provided to a person becomes blurry, vague, and often ambiguous. Clear examples of atmospheric conditions such as high surface temperatures, downpours, soft winds and high humidity. Due to the existence of a wide range of uncertainties, it is impossible to make accurate predictions based on classical models requiring exact and clear information.

Presented below are the basic definitions and results that will be utilized in this study.

Definition 1 [4] Let U be an initial universe set and let E be a set of parameters. Let $P(U)$ denotes the power set of

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U and let $\emptyset \neq A \subseteq E$. A pair $(\widehat{F}, A)$ is called a **soft set** over U, where $\widehat{F}$ is a mapping given by $\widehat{F} : A \to P(U)$.
Definition 2 [1] Let X be a nonempty set. A function f from X to the unit interval $[0, 1]$ is called a **fuzzy set** on X.
Definition 3 [7] Let E be a set of parameters and let $\emptyset \neq A \subseteq E$. A pair (F, A) is called a **fuzzy soft set** over U, where F is a mapping given by $F : A \to \text{Fuz}(U)$ and $\text{Fuz}(U)$ is the set of all fuzzy sets on U.

The following is an example of the fuzzy soft sets over an initial universe set.
Example 1. Let $U = \{c_1, c_2, c_3, c_4, c_5\}$ be a set of five cars under consideration. Let $E = \{e_1\{\text{beautiful}\}, e_2\{\text{modern}\}, e_3\{\text{sport}\}, e_4\{\text{deluxe}\}, e_5\{\text{expensive}\}\}$ be a set of parameters and $A = \{e_1, e_3, e_5\}$. Let (F, A) be a fuzzy soft set over U, where $F(e_1) = \{c_1/0.6, c_2/0.9, c_3/0.1, c_4/0.5, c_5/0.4\}$,
$F(e_3) = \{c_1/0.7, c_2/0.5, c_3/0.1, c_4/0.4, c_5/0.3\}$,
$F(e_5) = \{c_1/0.1, c_2/0.1, c_3/0.6, c_4/0.2, c_5/0.2\}$.
Then (F, A) is a fuzzy soft set over U representing the "attractiveness of the cars" which Mr. X is going to buy. The fuzzy soft set (F, A) can be written as Table I as follows,

TABLE I
THE TABULAR FORM OF THE FUZZY SOFT SET (F, A)

U	e_1	e_3	e_5
c_1	0.6	0.7	0.1
c_2	0.9	0.5	0.1
c_3	0.1	0.1	0.6
c_4	0.5	0.4	0.2
c_5	0.4	0.3	0.2

Now, presenting some operations of the fuzzy soft sets over an initial universe set.
Definition 4. [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) for all $p \in A$,$F(p)$ is a fuzzy subset of $G(p)$, that is $F(p) \leq G(p)$ for all $p \in A$.
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 $(F, A)\tilde{\supset}(G, B)$.
Definition 5. [7] If (F, A) and (G, B) are 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 $H(\alpha, \beta) = F(\alpha)\tilde{\cap}G(\beta)$ for all $\alpha \in A$ and for all $\beta \in B$, where $\tilde{\cap}$ is the operation "fuzzy intersection" of two fuzzy sets. This is $F(\alpha)\tilde{\cap}G(\beta) = \min\{F(\alpha), G(\beta)\}$ for all $\alpha \in A$ and for all $\beta \in B$.
Definition 6. [7] If (F, A) and (G, B) are two fuzzy soft sets then "(F, A) OR (G, B)" is a fuzzy soft set denoted by $(F, A) \vee (G, B)$ and is defined by $(F, A) \vee (G, B) = (H, A \times B)$, where $H(\alpha, \beta) = F(\alpha)\tilde{\cup}G(\beta)$ for all $\alpha \in A$ and for all $\beta \in B$, where $\tilde{\cup}$ is the operation "fuzzy union" of two fuzzy sets. This is $F(\alpha)\tilde{\cup}G(\beta) = \max\{F(\alpha), G(\beta)\}$ for all $\alpha \in A$ and for all $\beta \in B$.

At this stage, it is important to review the methodology that was used in decision-making problems briefly.

It is primarily focused on the Analytic Hierarchy Process (AHP), which was first proposed in 1980 by Saaty [12]. AHP is a structure used in dealing with complex decisions, which, since its first introduction, has been extensively studied and refined. It can also be used to determine the leverage of a particular decision maker in an environment where a decision must be agreed collectively by a group. In more detail, when it comes to the use of AHP, it involves the table of "Saatay Rating Scale," which is as follows:

TABLE II
THE TABLE OF SAATY RATING SCALE

Intensity importance	1
Definition	Equal importance
Explanation	Two factor contribute equally to the objective
Intensity importance	3
Definition	Somewhat more important
Explanation	Experience and judgement slightly favour one over the other
Intensity importance	5
Definition	Much more important
Explanation	Experience and judgement strongly favour one over the other
Intensity importance	7
Definition	Very much more important
Explanation	Experience and judgement very strongly favour one over the other. Its importance is demonstrated in practice
Intensity importance	9
Definition	Absolutely more important
Explanation	The evidence favouring one over other is of the highest possible validity
Intensity importance	$2, 4, 6, 8$
Definition	Intermediate values
Explanation	When compromise is needed

Let $E = \{e_1, e_2, ..., e_n\}$ be a set of parameters. Then, according to the table of Saaty's 1-9 scale relative parameter d_E is defined as follows,

TABLE III
THE TABLE OF SAATY RATING SCALE

E	e_1	e_2	$\cdots$	e_n
e_1	1	$d_E(e_1, e_2)$	$\cdots$	$d_E(e_1, e_n)$
e_2	$d_E(e_2, e_1)$	1	$\cdots$	$d_E(e_2, e_n)$
$\vdots$	$\vdots$	$\vdots$	$\ddots$	$\vdots$
e_n	$d_E(e_n, e_1)$	$d_E(e_n, e_2)$	$\cdots$	1

For example, if e_1 is somewhat more important by e_2 then we can write $d_E(e_1, e_2) = 3$ and $d_E(e_2, e_1) = \dfrac{1}{3}$ from the Table II.

In 2007, Roy and Maji [8] used the comparison table approach in decision-making problems. Let $U = \{o_1, o_2, ..., o_n\}$ be an object set and let $E = \{e_1, e_2, ..., e_k\}$ be a set of parameters.

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

Obviously, $0 \leq c_{ij} \leq k$, and $c_{ii} = k$, for all i, j where, k is the number of all parameters 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.

Roy and Maji [8] used the comparison table in the algorithm as follows:

Algorithm

Step 1. Input $(F, A), (G, B)$ and (H, C).
Step 2. Input the set P (parameter set).
Step 3. Compute (S, P) from $(F, A), (G, B)$ and (H, C).
Step 4. Compute the comparison table of (S, P) and compute row sum and column sum of o_i for all i.
Step 5. Compute the score value of o_i for all i.
Step 6. The decision is S_k if $S_k = \max_i S_i$.
Step 7. We choose only o_k if k has more than one value.
They computed (S, P) by "AND" or "OR" operations.

The next section, we revised the algorithm of Roy and Maji [8] approach to flood alarm prediction.

III. Main Results

Reliable prediction of flooding cannot be achieved based on the information available in conventional analytical methods. To do so, it is imperative to turn to fuzzy soft sets and develop simple but effective models (algorithms) that can be designed to provide reliable results in predicting the possibility of flooding. The inputs need to be a basic parameter (variable with real value) associated with a deluge in which a fuzzy membership grade is assigned to the parameter. The model should process fuzzy soft sets generated from the data it collects and identifies the locations most vulnerable to flooding. (The position showing the highest or lowest score value).

With the assumption that $U = \{L_1, L_2, ..., L_i\}, i \in \{1, 2, ..., m\}$ is the location set and $P = \{P_1, P_2, ..., P_j\}, j \in \{1, 2, ..., n\}$ is the parameter set, the general multiple attribute decision-making method of the basic fuzzy soft set was built, the specific content is as follows:

First of all, the decision attribute usually has different dimensions, orders of magnitude and attribute category (efficiency attribute and cost type attribute). There is, unfortunately, 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 standardize the decision attribute values. Efficiency type attribute refers to the attribute of the attribute value, the larger the better, cost attribute refers to the attribute of attribute value the smaller the better.

Using different formulas for the standardization of the two types of attributes: Cost type attribute index according to the following formula:

$$r_{ij} = \frac{\max\{a_{ij}\} - \{a_{ij}\}}{\max\{a_{ij}, \} - \min\{a_{ij}\}},$$

$i = 1, 2, \ldots, m;\ j = 1, 2, \ldots, n.$
Efficiency attribute index was calculated by the following formula:

$$r_{ij} = \frac{\{a_{ij}\} - \min\{a_{ij}\}}{\max\{a_{ij}\} - \min\{a_{ij}\}},$$

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

The decision-making information matrix $V = [a_{ij}]_{m\times n}$ form original data was converted into standardized matrix $D = [r_{ij}]_{m\times n}$, further according to the decision matrix $D = [r_{ij}]_{m\times n}$ build basic fuzzy soft set (F, E). Based on domain objects, the mapping F of basic fuzzy soft set (F, E) is presented in Table IV as follows,

TABLE IV
The tabular form of the basic fuzzy soft set (F, E)

U	P_1	P_2	P_3	...	P_j
L_1	r_{11}	r_{12}	r_{13}	...	r_{1j}
$L2$	r_{21}	r_{22}	r_{23}	...	r_{2j}
L_3	r_{31}	r_{32}	r_{33}	...	r_{3j}
...	...	...	...	...	...
L_i	r_{i1}	r_{i2}	r_{i3}	...	r_{ij}

Now, the first model of fuzzy soft sets can be constructed to approach flood alarm prediction.

Algorithm I

Step 1. Selection of a required number of places (m).
Step 2. Selection of a required number of parameters (n).
Step 3. Computation of the average of basic data.
Step 4. Computation as follows

$$r_{ij} = \frac{\max\{a_{ij}\} - \{a_{ij}\}}{\max\{a_{ij}, \} - \min\{a_{ij}\}},$$

$i = 1, 2, \ldots, m;\ j = 1, 2, \ldots, n.$
Step 5. Construction of a fuzzy soft set (F, P) and tabulation.
Step 6. Utilizing the "Saaty's"1-9 scale to compute the weight of each criterion.
Step 7. Multiplication of each of the parameters by the weight of criteria for each decision-maker.
Step 8. Construction of the comparison table.
Step 9. Computation of the row sum and column sum of o_i for all i.
Step 10. Computation of the score value of o_i for all i.
Step 11. The decision in S_k if $S_k = \min_i S_i$.
Step 12. Computation of the consistency test and the consistency ratio. The consistency test : $CI = \dfrac{S_i - m}{m - 1}$, where m is the number of locations and the consistency ratio : $CR = \dfrac{CI}{RI}$, where RI is the random indices corresponding to the number of locations.

TABLE V
The tabular form of the random indices IR

m	1	2	3	4	5	6	7	8
RI	0	0	0.58	0.90	1.12	1.24	1.32	1.41

Step 13. The consistency ratio is acceptable if it does not exceed 0.10.
Now, it is important to present a practical example of using the above algorithm.

Example 2. The areas selected for the study were Chiang Rai, Phayao, Chiang Mai, Lampang, Lamphun, Phrae, Nan and Mae Hong Son provinces in Northern Thailand (see fig 1).

Step 1. When it comes to the selection of the required number of places (m). Let $U = \{L_1, L_2, L_3, L_4, L_5, L_6, L_7, L_8\}$ represent eight selected locations in Chiang Rai, Phayao, Chiang Mai, Lampang, Lamphun, Phrae, Nan and Mae Hong Son provinces in Northern Thailand, respectively (see fig 1).
Step 2. Next, the selection of the required number of parameters (n). Let $P = \{P_1, P_2, P_3\}$ by the following parameters: average temperature, wind speed and rainfall.
Step 3. Computation of the average of basic data (see Table VI).

Fig. 1. The map of Northern Thailand [13]

TABLE VI
THE TABULAR FORM OF BASIC DATA [14]

U	Temperature($^\circ c$)	Wind speed (km/hr.)	Rainfall
L_1	23.29	16.0816129	1879.4387
L_2	23.61	9.38709677	1453.6516
L_3	25.15	15.4248387	975.43548
L_4	25.29	10.8822581	1168.071
L_5	25.01	15.4248387	1115.5161
L_6	25.76	15.0648387	1051.4323
L_7	24.93	8.19129032	1113.6258
L_8	23.83	12.9129032	1118.9387

Step 4. Computation

$$r_{ij} = \frac{\max\{a_{ij}\} - \{a_{ij}\}}{\max\{a_{ij}\} - \min\{a_{ij}\}},$$

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

Step 5. The construction of a fuzzy soft set (F, P) and tabulation (see Table VII).

TABLE VII
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. The evaluation table for each criterion according to decision makers are constructed via wise comparison using the Saaty's 1-9 scale (see Table VIII) as follows;

We define $c_{ij} = \sum_{j=1}^{n} d_{ij}$ where $d_{ij} = d_P(e_i, e_j)$ and define $a_{ij} = \frac{d_{ij}}{c_i}$. The weight is denoted by $W(P_i)$ and is defined by $W(P_i) = \frac{1}{|P|}\sum_{i=1}^{n} a_{ij}$ where $\frac{1}{|P|}$ is the number of parameter

TABLE VIII
THE TABLE OF SAATY RATING SCALE

P	P_1	P_2	P_3
P_1	1	$\frac{1}{3}$	$\frac{1}{7}$
P_2	3	1	$\frac{1}{5}$
P_3	7	5	1
$c_i = \sum_{j=1}^{n} d_{ij}$	11	$\frac{19}{3}$	$\frac{47}{35}$

and $\sum_i W(P_i) = 1$. The weights of each criterion are obtained as (see Table IX).

TABLE IX
THE TABLE OF THE WEIGHTS

P	P_1	P_2	P_3	$W(P_i)$
P_1	0.051	0.053	0.108	0.08
P_2	0.273	0.158	0.149	0.19
P_3	0.683	0.785	0.745	0.73

Step 7. Multiplication of each of the parameters in Table VI by the weight of criteria for each decision-maker as follows;

TABLE X
THE TABULAR FORM OF FUZZY SOFT SETS BY MULTIPLY THE WEIGHT

U	P_1	P_2	P_3
L_1	0.08	0.00	0.00
L_2	0.95	0.16	0.34
L_3	0.02	0.01	0.73
L_4	0.01	0.13	0.58
L_5	0.02	0.01	0.62
L_6	0.00	0.02	0.67
L_7	0.03	0.19	0.62
L_8	0.06	0.08	0.61

The predictions are based on the actual flood rate data that has been collected. It is important to mention that the parameters that are examined and analyzed are easily suspectable to changes by both temporal and topographical conditions. For example, the prediction's accuracy can be negatively impacted by the combined effect of critical parameters through minute variations. Moreover, the increase in the number of parameters requires laborious computation work to reflect changes in the comparison table.

Step 8. Construction of the comparison table (see Table XI).

Step 9. Computation of the row sum and column sum of o_i for all i (see Table XII).

Step 10. Computation of the score value of o_i for all i (see Table XII).

Step 11. From the above Table XII, it is clear that the minimum score is -9, which was scored by L_1 hence by the decision the most flood-prone location is L_1.

Step 12. Computation of the consistency test and the consistency ratio. Thus $CI = \frac{-9-8}{8-1} = \frac{-17}{7} = -2.43$ and $CR = \frac{CI}{RI} = \frac{-2.43}{1.41} = -1.72$.

Step 13. The consistency ratio is acceptable if it does not

TABLE XI
THE TABULAR FORM OF THE COMPARISON TABLE

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

TABLE XII
THE TABULAR FORM OF ROW SUM AND COLUMN SUM

U	Row sum	Column sum	Score value
L_1	9	18	-9
L_2	17	10	7
L_3	15	14	1
L_4	11	16	-5
L_5	13	17	-4
L_6	12	15	-3
L_7	19	9	10
L_8	15	12	3

exceed 0.10. Based on this information the choice is being made to choose the location L_1 (Chiang Rai) as the first province to be alerted with the second alert warning issued to L_4 (Lamphun) province.
Now, the second model of fuzzy soft sets can be constructed to approach flood alarm prediction.

Algorithm II

Step 1. Selection of a required number of places (m).
Step 2. Selection of a required number of parameters (n).
Step 3. Computation of the average of basic data.
Step 4. Computation as follows

$$r_{ij} = \frac{\{a_{ij}\} - \min\{a_{ij}\}}{\max\{a_{ij},\} - \min\{a_{ij}\}},$$

$i = 1, 2, \ldots, m;\ j = 1, 2, \ldots, n.$
Step 5. Construction of a fuzzy soft set (F, P) and tabulation.
Step 6. Utilizing the "Saaty's"1-9 scale to compute the weight of each criterion.
Step 7. Multiplication of each of the parameters by the weight of criteria for each decision-maker.
Step 8. Construction of the comparison table.
Step 9. Computation of the row sum and column sum of o_i for all i.
Step 10. Computation of the score value of o_i for all i.
Step 11. The decision in S_k if $S_k = \max_i S_i$.
Step 12. Computation of the consistency test and the consistency ratio. The consistency test : $CI = \dfrac{S_i - m}{m-1}$, where m is the number of locations and the consistency ratio : $CR = \dfrac{CI}{RI}$, where RI is the random indices corresponding to the number of locations (See Table V).
Step 13. The consistency ratio is acceptable if it does not exceed 0.10.
Now, it is important to present a practical example of using the above algorithm.
Example 3. The areas selected for the study were Chiang Rai, Phayao, Chiang Mai, Lampang, Lamphun, Phrae, Nan and Mae Hong Son provinces in Northern Thailand.
Step 1. When it comes to the selection of the required number of places (m). Let $U = \{L_1, L_2, L_3, L_4, L_5, L_6, L_7, L_8\}$ represent eight selected locations in Chiang Rai, Phayao, Chiang Mai, Lampang, Lamphun, Phrae, Nan and Mae Hong Son provinces in Northern Thailand, respectively (see fig 1).
Step 2. Next, the selection of the required number of parameters (n). Let $P = \{P_1, P_2, P_3\}$ by the following parameters: average temperature, wind speed and rainfall.
Step 3. Computation of the average of basic data (see Table V).
Step 4. Computation

$$r_{ij} = \frac{\{a_{ij}\} - \max\{a_{ij}\}}{\max\{a_{ij}\} - \min\{a_{ij}\}},$$

$i = 1, 2, \ldots, m;\ j = 1, 2, \ldots, n$ (see Table XIII).
Step 5. The construction of a fuzzy soft set (F, P) and tabulation (see Table XIII).

TABLE XIII
THE TABULAR FORM OF FUZZY SOFT SETS

U	P_1	P_2	P_3
L_1	0.00	1.00	1.00
L_2	0.13	0.15	0.53
L_3	0.75	0.92	0.00
L_4	0.81	0.34	0.21
L_5	0.69	0.92	0.15
L_6	1.00	0.87	0.08
L_7	0.66	0.00	0.15
L_8	0.22	0.60	0.16

Step 6. The evaluation table for each criterion according to decision makers are constructed via wise comparison using the Saaty's 1-9 scale (see Table VIII). The weights of each criterion are obtained as $W(P_1) = 0.08, W(P_2) = 0.19$ and $W(P_3) = 0.73$ (see Table IX).
Step 7. Multiplication of each of the parameters in Table XIII by the weight of criteria for each decision-maker as follows;

TABLE XIV
THE TABULAR FORM OF FUZZY SOFT SETS BY MULTIPLY THE WEIGHT

U	P_1	P_2	P_3
L_1	0.00	0.19	0.73
L_2	0.01	0.03	0.39
L_3	0.06	0.17	0.00
L_4	0.06	0.06	0.15
L_5	0.05	0.17	0.11
L_6	0.08	0.16	0.06
L_7	0.05	0.00	0.11
L_8	0.02	0.11	0.12

Step 8. Construction of the comparison table (see Table XV).
Step 9. Computation of the row sum and column sum of o_i for all i (see Table XVI).
Step 10. Computation of the score value of o_i for all i (see Table XVI).
Step 11. From the above Table XVI, it is clear that the maximum score is 7, which was scored by L_1 hence by the decision the most flood-prone location is L_1.

TABLE XV
THE TABULAR FORM OF THE COMPARISON TABLE

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

TABLE XVI
THE TABULAR FORM OF ROW SUM AND COLUMN SUM

U	Row sum	Column sum	Score value
L_1	17	10	7
L_2	11	16	-5
L_3	15	14	1
L_4	16	12	4
L_5	16	14	2
L_6	15	12	3
L_7	10	19	-9
L_8	12	15	-3

Step 12. Computation of the consistency test and the consistency ratio. Thus $CI = \frac{7-8}{8-1} = \frac{-1}{7} = -0.14$ and $CR = \frac{CI}{RI} = \frac{-0.14}{1.41} = -0.10$.

Step 13. The consistency ratio is acceptable if it does not exceed 0.10. Based on this information the choice is being made to choose the location L_1 (Chiang Rai) as the first province to be alerted with the second alert warning issued to L_4 (Lamphun) province.

IV. Conclusion

In this paper, a different approach to the flood alarm prediction process using algorithms of fuzzy soft sets was applied to selected sites in eight provinces across Northern Thailand and demonstrated in detail. Finally, practical examples were presented in detail which shows that the methods used in this paper can be used to successfully predict potential floods in the future.

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