Fuzzy Logic Based Risk Analysis Using Risk Matrix

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***Abstract*—** Since the World War I, industrial risk anatomize has been applied with success to many power, nuclear, petroleum, and chemical sites. Along our daily life, we are all reveal to situation when we automatically counter act of risk diminish or risk control. Risk analysis is a process of identifying and quantifying of risk resulting from a specific event or scenario. Risk anatomize is concerned with determining those factors which are especially dangerous and determining the likelihood of unacceptable risk. The issue under this study is the application of Fuzzy Logic to develop a Fuzzy Model to enhance the risk analysis process which is dealing with uncertainties that arise in each phase of the risk analysis process. Risk management applications are complex, multi-criteria and concern with uncertainties.

The assessment of the social risk is a major issue for the responsible risk management and the sustainable regional development Department of Horticulture and Agriculture Chhattisgarh. The paper presents a fuzzy logic model for social risk estimation from natural hazards in the Raigarh Chhattisgarh region, based on the available information sources and the expert knowledge. The risk analysis problem is defined as a multi criteria task that evaluates several input variables (indicators for natural hazards and social assailable). A hierarchical fuzzy logic system with five inputs and one output is designed in the Mat lab software environment using Fuzzy Logic Toolbox and Simulink. The simulation investigations are done for six villages in Raigarh Chhattisgarh. This fuzzy system is part of the Web Integrated Information System for risk management of natural disasters which will be developed.

Keywords*—*Fuzzy Logic, Risk Assessment, Risk Management, Fuzzy Inference System (FIS), MATLAB®.

I. INTRODUCTION

Along our day-to-day life, we are all exposed to situation when we automatically of risk reduction or risk control.

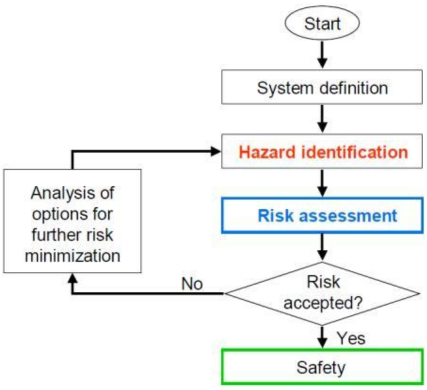


Figure 1: Continuous Process For Risk Assessment [3]

Managing risk -by nature- is about:

- Insurance coverage
- Complying with constitutional requirements
- Establishing an Emergency Response Plan
- Relying on personal experience by making sure you don't make the same mistake twice.
- Relying on personal experience to determine appropriate controls

II. WHY WE NEED RISK ASSESSMENT

Above approaches are missing the principle of ensuring identification of all risk, allocation of appropriate resources, and selection of best controls. This was the origin of "Risk Assessment" or "Risk Management" which is inherently an objective determination of the most cost effective way of ensuring that risk levels are acceptable and therefore controls are appropriate.

This process of risk assessment is about risk quantification and determining appropriate controls.

Quantification is the step by which we measure how large and important each risk is, relative to each other. This allows us to prioritize risks for attention and appropriately allocate resources between the risks to manage them. Determining appropriate controls for each risk involves a process which considers what would be an acceptable level of risk and which controls would most cost effectively reduce risk.

Risk assessment matrix is a tool to conduct subjective risk assessment. The bases for risk matrix are the definition of risk as a combination of severity of the consequences occurring in a certain accident scenario and its frequency.

Although the conventional Risk Matrix provides a standard tool for treating the relationship between the severity of consequences and the likelihood (probability) in assessing process risks, it has a disadvantage of uncertainties.

III. WORKING OF RISK QUANTIFICATION

Risk level = Consequence x Likelihood. So in order to estimate the risk level of a particular scenario we need to estimate the consequences of that scenario and the likelihood of that particular consequence occurring. Two approaches are available for estimating risk. [2]

A. Single point on the curve estimations

The first approach is called "Single Point Estimation". In this approach, we only estimate one point on the risk profile curve and use this as an estimation of the area under the curve.

- Subjective assessment of how big or important risks are.
- Subjective assessment of acceptable risk levels and effective controls.

For example considering the Risk of burning down a $1M building, following are the risk variables. Consequences of burning the building = $1M, Likelihood of $1M consequence (likelihood of fire per year) = 0.5% /y. Therefore Risk = C x L = $1M x 0.005/y = $5,000/y. As a matter of fact, most risks are not a point but are actually a curve on a Consequences Vs Likelihood graph or a risk profile.

B. Curve Estimations

The second approach is called “Multiple point estimations”. This is about estimating multiple points on the curve to approximate the curve and then estimate the area under the approximate curve.

If we consider the same example estimating the Risk of burning down a $1M building, then to quantify the risk of fire to a $1M building, we would have to quantify the likelihood of a fire doing $1K damage to the building, $10K damage to the building, $1M damage to the building and every possible consequence in between. If we developed this profile it might look something like below.

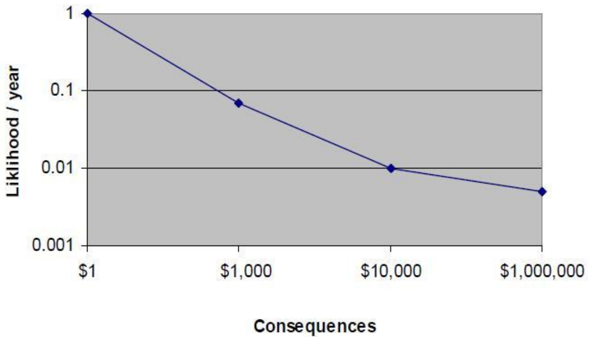


Figure 2: Risk Approximation Curve

The risk level is actually represented by the area under the curve. This leaves us with a bit of a problem because not only is the curve a much more time consuming to estimate than a point but it is also much harder to estimate the area under the curve than the simple C x L calculation for a point.

In practice, single point estimations are normally accurate enough for most risks except for some very large risks or risks with expensive potential controls. In any case, it is a good idea to start with a single point risk quantification to filter the large risks from the smaller ones. You can then use more sophisticated methods on the larger risks if warranted.

C. Increasing Quantification Accuracy

The most accurate single point method is the use of a number and unit to estimate consequences ($) and a number and unit to estimate likelihood (likelihood per year). The estimates are then placed in the equation C x L = R. The unit for risk then becomes $/y. Refer to Single Point Risk Estimation Example above.

Because we are using one point to approximate the area under the risk profile curve, the point with the highest risk value should be used – ie. the highest product of consequence and likelihood value. For example, should we pick the point with a $1M consequence or the point with a $10K consequence to approximate the risk profile. It may take a bit of practice to develop an intuition as to which point will have the highest risk level but if you are in doubt and the risk is important enough (remember the value proposition) estimate other points on the curve to determine which has the highest risk value.

IV. BASIC QUANTIFICATION METHOD ERRORS

A. Estimating the Likelihood of a Lesser Consequence

A common reason for over estimation of risk levels is estimating the likelihood of a scenario before estimating the consequences of a scenario. This often causes over estimation because you may not be estimating the likelihood of a lesser consequence.

For example the likelihood of a fire (a minor fire) in the building maybe 20% per year, while the likelihood of a fire which destroys the building maybe 1% per year. If we used the likelihood of a fire (20%) in our calculations rather than the likelihood of fire burning down the building (1%) we would be over estimating the fire risk level by a factor of 20. Only use the likelihood of incurring the consequences you have previously estimated.

B. Measuring Inherent Risk

Inherent risk is defined as the risk level without controls in place. In the past trying to quantify Inherent Risk was a popular method of conducting risk assessments but it is now much less popular as people have come to understand the fault of this method.

The Inherent Risk method is faulty for a number of reasons including:

- The purpose of a Risk Assessment is to help allocating resources based on the needs of the actual business environment. If we artificially remove controls, we are not measuring the actual environment. We are measuring an artificial one, which then doesn’t resemble the actual one.
- The past proponents of this method argued that because controls could fail, the inherent risk gave a better picture of what would happen if controls failed. But again this is not the real world. If you are quantifying the current (actual) risk level correctly the estimation of the likelihood of incurring a particular consequence should take into account the probability of controls failing.
- In practice it was difficult to decide which controls to remove because each risk has a large number of tangible, less tangible, direct and indirect controls.

C. Not Including all Areas of Impact

Make sure all the consequences of a possible event are included in the estimation of the consequences. If you leave any consequences out you will understate the consequences and the risk level.

V. THE RISK QUANTIFICATION MATRIX

The risk quantification matrix is a very popular risk quantification tool. The matrix can be reasonably accurate or very inaccurate depending on how the matrix is designed. Some potential matrix errors include:

A. Qualitative matrix

These matrixes measure consequences and likelihood in terms of words only, without defining the words with units. Measuring consequences and likelihood in terms of words is highly subjective.

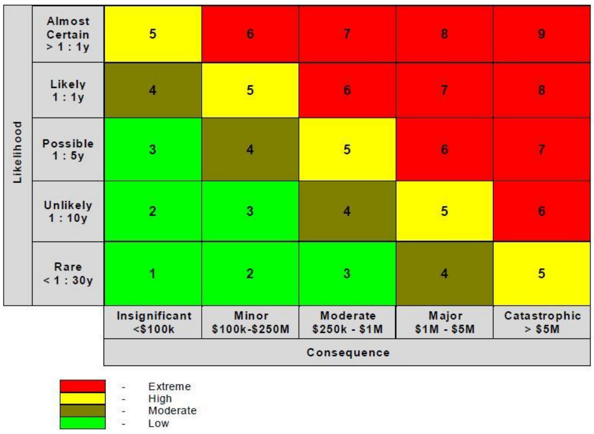
B. Scaling errors

These errors are introduced if the matrix has uneven or inconsistent consequences and likelihood scales. The errors are also introduced if the risks are positioned on the boundaries of the consequence and likelihood scales.

C. Scaling band width approximations

These inaccuracies are due to the band width of the consequence and likelihood categories. For example, Moderate

= $250k to $1M. This band width means that risks, which maybe orders of magnitude different in size, are given the same risk ranking. Accordingly, it is possible that a $50K per year risk ($1M x 1/20y) and a $50 per year risk ($250k x 1/5,000y) are both called a level 3 risk.



Risk Quantification has a number of inaccuracies and uncertainties, like the estimation of the likelihood of an event occurring.

VI. BASIC DEFINITIONS

All safety standards exist to reduce risk, which is inherent wherever manufacturing or processing occurs.

A. Value Proposition

If we are to cost effectively manage risk, than we can't spend large amounts of time quantifying every risk. On the other hand we have to quantify risks accurately enough to appropriately allocate resources between them and help us make decisions on which controls cost effectively reduce the risks to acceptable levels. [2]

This brings up the term "Value Proposition" as that the sophistication of any risk assessment must be proportionate to the size of risk, cost of controls or the value which could be gained from conducting the risk assessment.

B. Tolerable Risk

There is a point where risk becomes unacceptable or "intolerably high". Where there is –equally- a point where the risk is accepted as negligible. The area of the tolerable risk is bounded between these two points. [5]

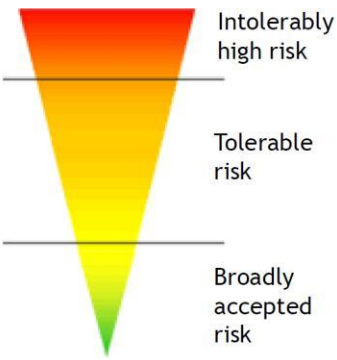


Figure 3: Example Matrix With Scaling And Band Width Approximation Errors

Because of these problems, using the matrix for large or important risk should consider that the matrix should not be a Qualitative Matrix and it should be designed to reduce scaling error.

VII. FUZZY LOGIC

Fuzzy logic is a set of mathematical principles for knowledge representation based on degrees of membership. It deals with degrees of membership and degrees of truth. It reflects how people think and attempts to model our sense of words, our decision making and our common sense. [6]

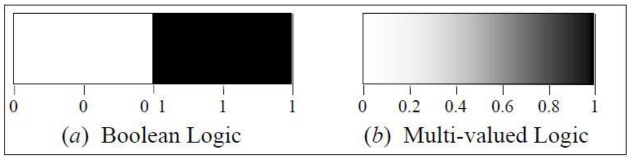


Figure 5: Boolean Logic Versus Multi-Valued Logic

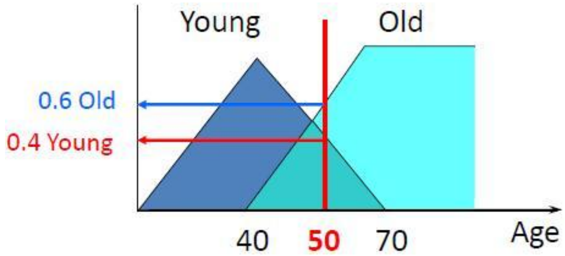


Figure 6: Fuzzy Age-Classification Scheme

The basic structure of a fuzzy inference system consists of three conceptual components: a rule base, which contains a selection of fuzzy rules; a database which defines the membership function used in the fuzzy rules; and a reasoning mechanism which performs the inference procedure upon the rules and given facts to derive a reasonable output or conclusion.

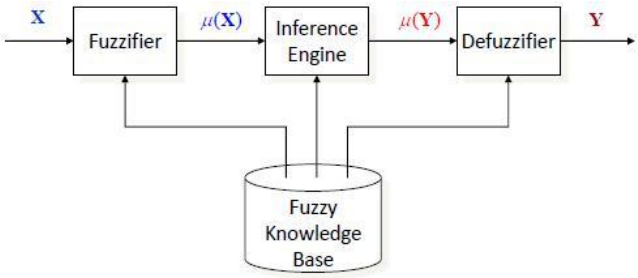


Figure 7: Basic Structure Of Fuzzy Systems

VIII. FUZZY RISK MATRIX

In the light of the work presented in the Fuzzy Risk Graph Model for Determining Safety Integrity Level presented by R. Nait [4] for the application of fuzzy logic to conventional risk graph, the scope of work under this work is to apply fuzzy logic to conventional risk matrix in order to get benefit of the fuzzy logic potential to overcome uncertainties and imprecision to solve problems where there are no sharp boundaries and precise values for the risk matrix parameters (severity of the consequences, and its frequency).

Consequency (Severity) / Probability (Likelihood)		Catastrophic I	Critical II	Marginal III	Negligible IV
Frequent	A	HIGH	HIGH	SERIOUS	MEDIUM
Probable	B	HIGH	HIGH	SERIOUS	MEDIUM
Occasional	C	HIGH	SERIOUS	MEDIUM	LOW
Remote	D	SERIOUS	MEDIUM	MEDIUM	LOW
Improbable	E	MEDIUM	MEDIUM	MEDIUM	LOW

Figure 8: Typical Standard Risk Graph Model

For applying fuzzy, a category shall be selected for each variable in order to establish the fuzzy sets which are characterized by a membership function with varying values in the interval [0, 1]. The typical standard risk matrix shown in figure VIII is used in this work.

The layout of this risk matrix layout is presented in MIL-STD-882D and categories of the severity and levels of probability are presented as follows:

Table 1: Suggested Mishap Severity Categories

Description	Category	Environmental, Safety, and Health Result Criteria
Catastrophic	I	Could result in death, permanent total disability, loss exceeding $1M, or irreversible severe environmental damage that violates law or regulation.
Critical	II	Could result in permanent partial disability, injuries or occupational illness that may result in hospitalization of at least three personnel, loss exceeding $200K but less than $1M, or reversible environmental damage causing a violation of law or regulation.
Marginal	III	Could result in injury or occupational illness resulting in one or more lost work days(s), loss exceeding $10K but less than $200K, or mitigatible environmental damage without violation of law or regulation where restoration activities can be accomplished.
Negligible	IV	Could result in injury or illness not resulting in a lost work day, loss exceeding $2K but less than $10K, or minimal environmental damage not violating law or regulation.

Table 2: Suggested Mishap Probability Levels

Description*	Level	Specific Individual Item	Fleet or Inventory**
Frequent	A	Likely to occur often in the life of an item, with a probability of occurrence greater than 10^{-1} in that life.	Continuously experienced.
Probable	B	Will occur several times in the life of an item, with a probability of occurrence less than 10^{-1} but greater than 10^{-2} in that life.	Will occur frequently.
Occasional	C	Likely to occur some time in the life of an item, with a probability of occurrence less than 10^{-2} but greater than 10^{-3} in that life.	Will occur several times.
Remote	D	Unlikely but possible to occur in the life of an item, with a probability of occurrence less than 10^{-3} but greater than 10^{-6} in that life.	Unlikely, but can reasonably be expected to occur.
Improbable	E	So unlikely, it can be assumed occurrence may not be experienced, with a probability of occurrence less than 10^{-6} in that life.	Unlikely to occur, but possible.

For the purpose of this work, equally distributed ranges have been assigned to each risk level as shown in table 3:

Table 3: Case Study Risk Levels

	FROM	TO
L	0	25
M	25	50
S	50	75
H	75	100

In this research the Gaussian type of membership function was selected as the most natural and popular choice for these systems. Figure IX presents the fuzzy sets and its membership function for each variable used in the fuzzy risk assessment matrix.

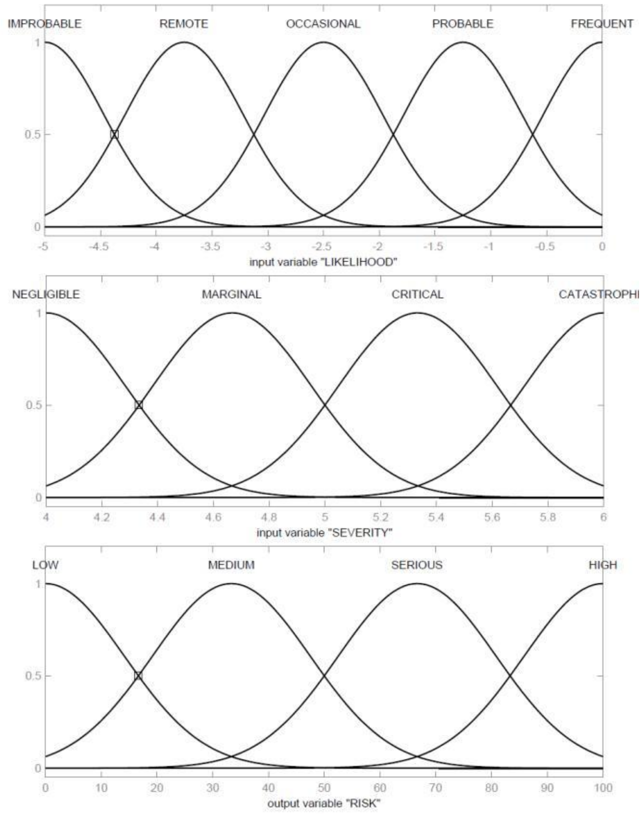


Figure 9: Risk Matrix Membership Functions

Because the likelihood values are logarithmically spaced, the likelihood is presented over logarithmic scale and a LOG function has been applied as shown in figure IX. Matlab was used to apply fuzzy logic to develop a fuzzy risk matrix.

Mamdani method was selected against sugeno method due to the reason that Mamdani is widely accepted for capturing expert knowledge and it allows us to describe the expertise in more intuitive, more human-like manner. On the other hand, Sugeno method is computationally efficient and works well with optimization and adaptive techniques, which makes it very attractive in control problems, particularly for dynamic nonlinear systems.

All possible combinations of crisp input patterns have been used for all of the risk graph parameters using the five Defuzzification methods (Centroid, Bisector, MOM, LOM, and SOM). Each crisp input was tested over three values within its range as simulated in figure X.

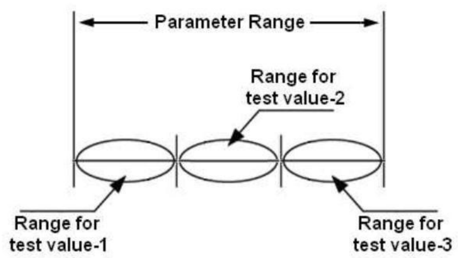


Figure 10: Fuzzy Risk Graph Model Testing

Results of the test combinations are summarized in figure XI below.

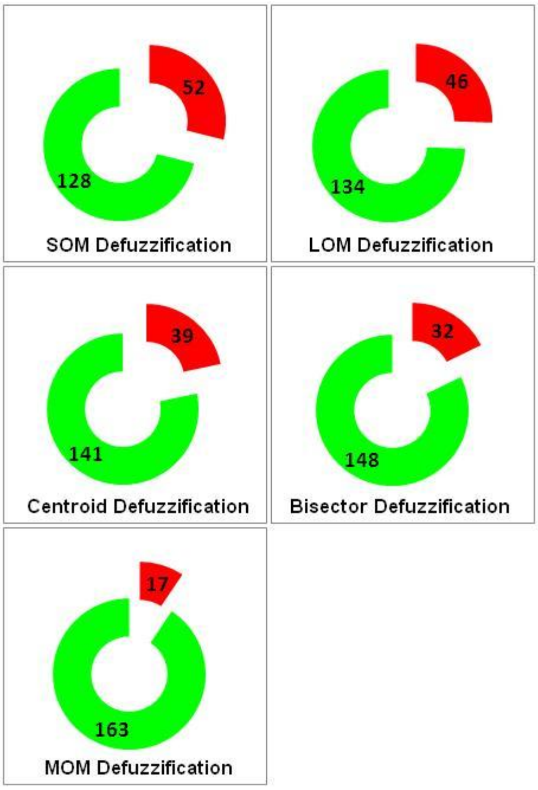


Figure 11: Defuzzification Methods' Test For Safety Fuzzy Risk Graph

III. FUZZY LOGIC FOR SOCIAL RISK ASSESSMENT

The fuzzy logic model is designed as a hierarchical structure with several inputs and one output. The number of inputs corresponds to the linguistic variables (indicators), which described the environmental risk and social vulnerability. The output represents a social risk assessment from natural disasters. Among the qualitative approaches, the Fuzzy Logic technique is based on subjective judgments about the relative importance of the predictive variables and their various states

In this study, five indicators for the social risk assessment for the SW Bulgaria region are defined using the expert knowledge, statistical data and published thematic maps for the seismic, and flood hazards [7]-[10],[19], [20]. The indicators of the fuzzy logic model are input variables of the designed fuzzy system. The fuzzy system inputs are defined as follow:

- Input 1 "Highest temperature";
- Input 2 "Tide";
- Input 3 "Seismic Endangerment";
- Input 4 "Population Massiveness";
- Input 5 "Socio Economical status".

The proposed fuzzy logic model is designed as a three-level hierarchical fuzzy system with previously defined five inputs.

The first level includes one fuzzy logic subsystem. The second level includes two fuzzy logic subsystems. The third level includes only one subsystem. The each fuzzy subsystem has two inputs. The fuzzy logic system output gives the social risk assessment of the natural hazards in studied region of SW Bulgaria. A scheme of the three-level hierarchical fuzzy system is presented on Fig. 2.

The inputs of the first fuzzy logic subsystem are the Input 1 "Highest temperature" and the Input 2 "Tide", and the linguistic output variable is defined as Intermediate variable 1 "Metrological risk".

The inputs of the second fuzzy logic subsystem are Intermediate variable 1 "Metrological risk" and the Input 3 "Seismic Endangerment", and the linguistic output variable is defined as Intermediate variable 2 "Environmental risk".

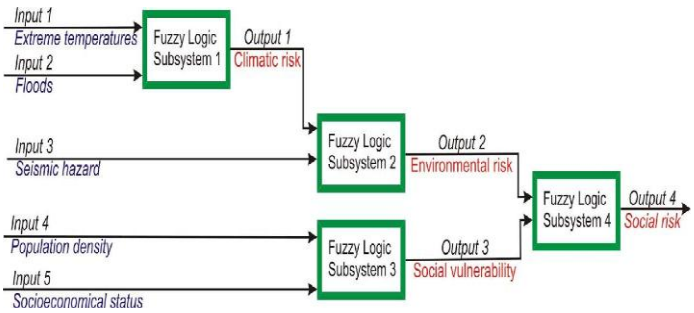
The inputs of the third fuzzy logic subsystem are the Input 4 "Population Massiveness" and the Input 5 "Socio-economical status", and the linguistic output variable is defined as Intermediate variable 3 "Social vulnerability".

The inputs of the fourth fuzzy logic subsystem are the Intermediate variable 2 "Environmental risk" and the Intermediate variable 3 "Social Susceptibility ". The output of the fuzzy subsystem is output of the whole fuzzy system.

The system output variable gives the complex assessment of the social risk from natural hazards relevant to the studied region. The value of the complex assessment is a criterion for final decision making about the degree of social risk for the considered six areas. The higher value corresponds to the higher risk degree.

Inherently qualitative features of the indicators are rather than quantitative values, which are usually represented by linguistic variables. Information and decision are closely linked and different methods exist to make a decision on the basis of imperfect information. Expertise is always required to define the types of possible phenomena, to assess the environmental hazard, social vulnerability and risk levels and to propose prevention measures. Expert judgments depend on quality and uncertainty of the available information that may result from measures, historical analysis, subjective testimonies, possibly conflicting, and assessments done by the experts themselves.

In fuzzy logic system the input linguistic variables (five indicators and three intermediate variables) are represent. by three fuzzy membership functions: "Low", "Middle", and "High". The input variables are assessed in the interval [0, 10] using trapezoid membership functions (Fig. 3). Subsystems are built in the Mamdani type fuzzy inference system [21]. The inference surfaces in 3D for the fuzzy logic subsystems are given on Fig by three fuzzy membership functions: "Low", "Middle", and "High". The input variables are assessed in the interval [0, 10] using trapezoid membership functions (Fig. 3).



The fuzzy logic system output (complex risk assessment) is described by five fuzzy membership functions: "Very low", "Low", "Middle", "High", and "Very high". The social risk from natural disasters is assessed in the interval [0, 100] using triangular membership functions. The input and output membership functions are shown in Fig. 4.

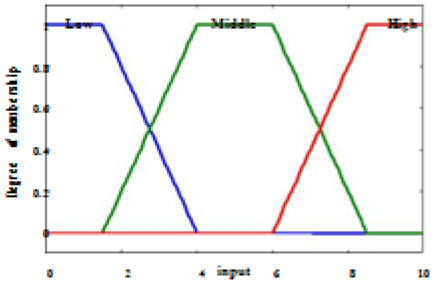


Figure 3: Membership functions of the input variables.

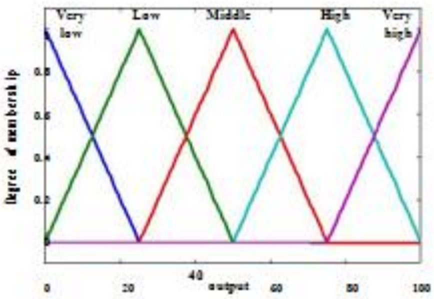


Figure 4: Membership functions of the fuzzy system output.

The inference rules in the fuzzy logic system are defined through "IF - THEN"-clause. Rule numbers of the knowledge base per each of the fuzzy logic subsystems are 9. Some of the inference rules are defined as follow:

IF "Extreme temperature" is "Middle" and "Tide" is "Low" THEN "Climatic risk" is "Middle";
IF "Extreme temperature" is "High" and "Tides" is "Middle" THEN "Climatic risk" is "High";
IF "Climatic risk" is "Middle" and "Seismic Endangerment" is "Low" THEN "Environmental risk" is "Low";
IF "Climatic risk" is "High" and "Seismic hazard" is"Middle" THEN "Environmental risk" is "Middle";
IF "Population density" is "Low" and "Socio-economical status" is "Middle" THEN "Social vulnerability" is "Low";
IF "Population density" is "Middle" and "Socio-economical status" is "High" THEN "Social vulnerability" is "Middle";
IF "Environmental risk" is "Low" and "Social vulnerability" is "Low" THEN "social risk from natural disasters" is "Very low";
IF "Population density" is "Middle" and "Socio-economical status" is "High" THEN "Social vulnerability" is "Middle";
IF "Environmental risk" is "Low" and "Social vulnerability" is "Low" THEN "social risk from natural disasters" is "Very low";
IF "Environmental risk" is "High" and "Social vulnerability" is "Low" THEN "social risk from natural disasters" is "Middle";
IF "Environmental risk" is "High" and "Social vulnerability" is "High" THEN "social risk from natural disasters" is "Very High".

The fuzzy logic hierarchical system is designed in Mat lab environment using Fuzzy Logic Toolbox. The fuzzy subsystems are built in the Mamdani type fuzzy inference system [21]. The inference surfaces in 3D for the fuzzy logic subsystems are given on Fig. 5.

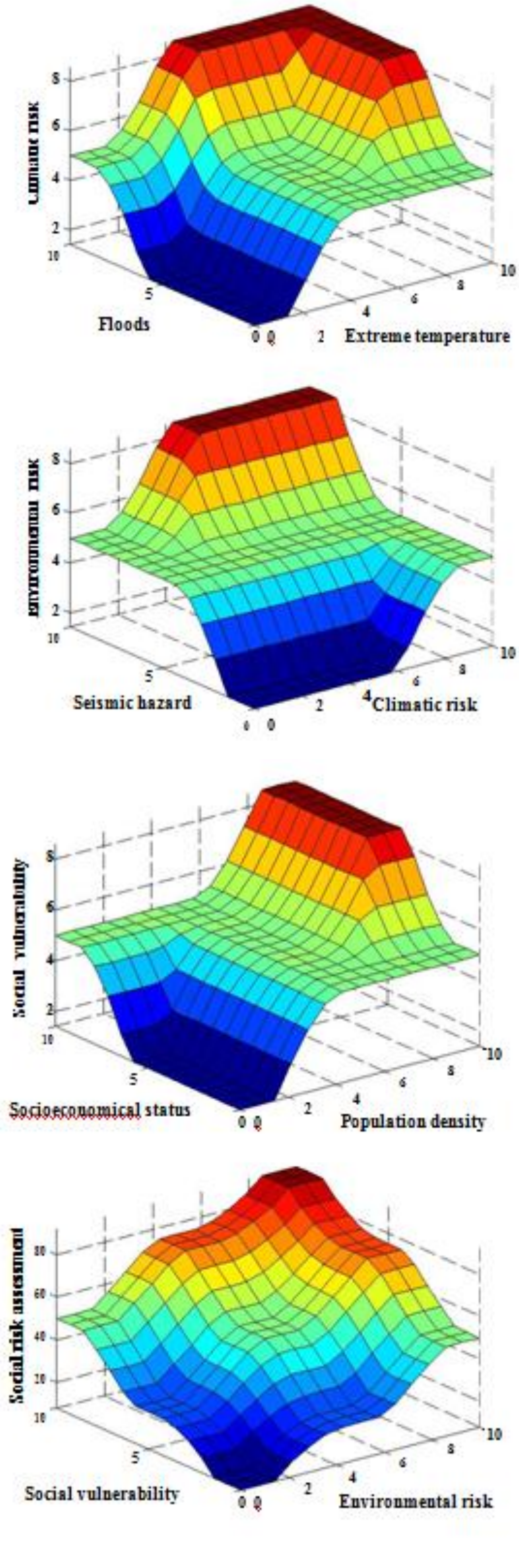


Fig. 5.Surfaces of the fuzzy logic subsystems

IV. APPLICATION OF FUZZY LOGIC MODEL FOR THE SW BULGARIA REGION

The designed fuzzy logic model is used to assess the natural risk of areas in the Raigarh region. are exposed to the several types of the natural hazards. The values of the all input variables are chosen to be relative each to other for the six areas in the interval [0, 10]. Input data indicators for the six local areas and the obtained results are presented in Table 1. Risk-based prioritization incorporates the scientific decision making aspects, such as Vulnerability estimation (value of indicator), and potential damage value, such tolerance to the consequence of failure. The definition of risks zones is based on the extrapolation of historical information known on particular natural events using morphology based analysis.

Table I: Input Data And Simulation Results

Criterion	Saria	sarangarh	Sambalpur	Sonepur	Pharsia	Sihawa
Input 1 Highest temperature	1.2	2.3	6.3	7.2	10.3	10.3
Input 2 Tide	2.4	8.3	10	6.4	1.3	3.4
Climatic risk	*1.4*	*5.4*	*8.6*	*5.9*	*4.8*	*6.7*
Input 3 Seismic Endangerment	6.4	8.3	10.2	7.3	3.4	1.4
Environmental risk	*4.9*	*7.5*	*8.5*	*6.1*	*4.1*	*2.8*
Input 4 Population Massiveness	10.4	3.3	1.5	1.3	5.5	7.3
Input 5 Socio economical status	9.4	3.3	3.4	3.4	6.2	6.4

The results show the Sambalpur area has the highest value of the climatic risk according to the defined input indicators. The areas ordered by the decreasing degree of this risk are, Sihawa, Sarangarh, Sonepur and Pharsia respectively. The climatic risk is lowest for the Saria area.

The combination of climatic risk with seismic hazards changes the risk degree of some areas. The environmental risk again is higher for Sambalpur area, but the Sihawa area has a lower risk value comparing to the Pharsia area.

The social vulnerability is significantly higher for the Sambalpur area due to its population density as the district center. Sonepur and Pharsia have a similar vulnerability, following by Sarangarh, as the lower equal values are obtained for Sambalpur and Sonepur.

Sambalpur area has the highest level of the social risk according to the considered natural hazards and social vulnerability. The rest areas are ordered by risk degree as follow: Sarangarh, Sonepur, Saria, Pharsia, and Sihawa. The social risk assessment is almost two times lower for Sambalpur and Sihawa comparing to the area of sambalpur despite of the relatively higher climatic risk for Sarangarh and higher environmental risk for Sambalpur areas. The stakeholders have to take the relevant management decisions using the obtained social risk assessment for the six local areas to mitigate the potential dangerous consequences.

CONCLUSIONS

A fuzzy logic model for social risk assessment from the natural hazards in the six regions of the Raigarh is proposed. This model is based on the models described in [14]-[16] and it is expanded with additional input linguistic parameters, related to the social vulnerability. The social risk of the studied areas is assessed using available map, hydro-meteorological and seismic hazards information, and expert knowledge. The fuzzy logic model is designed as a hierarchical system with five inputs and one output in Matlab

Software environment using Fuzzy logic Toolbox and Simulink. The simulation investigations are done for six geographic areas in Raigarh. The social risk assessment results can support the stakeholders to take more informed decisions for the sustainable regional development of SW Bulgaria.

Risk management applications are complex, multi-criteria and concern with uncertainties. The fuzzy logic is able to represent the complex risk parameters from real world situations and rules are used to represent knowledge. The risk factors are grouped based on their roles in the decision-making system [1]. The work presented in this report can be concluded like 1. Use of Fuzzy logic has ability to solve the problem better manner when it is selected over risk matrix. 2. For the implementation of fuzzy risk matrix Mamdani FIS is selected and also for knowledge representation from expert. It provides facility to represent knowledge in more familiar manner i.e. very similar to human communication. Flood in Mahanadi (Raigarh, Chhattisgarh) is due to heavy rainfall in region during monsoon period i.e. June to September. Flood risk assessment for this area has done by collecting long term rainfall data provided by Department of Horticulture and Agriculture of Chhattisgarh government. Long term data (1992 to 2014) is used for prediction of rainfall in upcoming years by use of first order Markov- Chain Model is used. Risk assessment prepared in this report has considered two input parameter i.e. 'rainfall level' as first consequence and 'probability of occurring' is another and one output parameter 'flood risk'. Although there are many other parameters are not considered like rainfall intensity, slope, soil type, vegetation cover due to lack of data availability. The rainfall data may also have some uncertainty due to instrumental or human error. The fuzzy logic model is quite capable of handling uncertainty in data. Fuzzy logic model is most suitable approach when we don't have reliable and enough data to apply quantitative statistical method, because it uses both quantitative and qualitative data. We can provide some numerical value also can express our knowledge or experience to problem in the form of fuzzy rule (if premises then conclusions). The model prepared produced very fast output and also reduces the computational power required as compares to statistical methods.

The designed fuzzy system is a part of the Web integrated information system for risk management of natural disasters which will be developed [22]. Full-value usage of the useful information from different sources for effective social risk management requires establishing an integrated information system that addresses complex geological, geo-technical and other issues. Such system combines different methods and tools [23]. The system will be most effective if it is implemented in a web-based GIS environment, thus it might serve as a unified platform for interdisciplinary research of the impact of natural disasters. Major goal of this system is to support the effective management of the decision making process regarding risk prevention and risk mitigation for given areas. Stakeholders on different administrative level could use this Web integrated information system for an efficient risk management. A consolidation of knowledge integrating programs for fostering innovation and new strategic approaches, and timely coordination across infrastructures is a crucial factor for social risk reduction from environmental hazards.

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