# Hierarchical Risk Management Model with Gained Fuzzy Parameters

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***Abstract**: Risk management as a decision making challenge is basically a complex structure with non-crisp input factors. Based on the strength of those attributes it is a reasonable way for fast and human-like decision to group the factors, and to use the fuzzy approach in the risk management modelling. The additional advantage of this model-structure is the possibility to gain the different factor-group's impact in the system. As an example, the paper presents a possible crisis monitoring application.*

***Keywords**: risk management; hierarchical fuzzy decision making system*

## 1 Introduction

Risk management modeling as a complex, multi-parametrical problem is one of the main research fields in the world today, from the micro-communities, families to the macro society structures and global phenomena of nature monitoring. Statistical methods-based reasoning models in crisis situations need long-time experiments and enough reliable data elaborated by experts. Additionally, they are time- and computing-demanding. The problems to be solved are full of uncertainties, and complexity of the systems increases the runtime factor of the decision process. Considering all those conditions fuzzy set theory helps manage complexity and uncertainties, and represents the inputs and outputs of the model in an emphatic form. The relationship between risk factors, risks and their consequences are represented in different forms, but in [1] a well-structured solution, suitable for the fuzzy approach is given. A risk management system can be built up as a hierarchical system of the risk factors (inputs), risk management actions (decision making system) and direction or directions for the next level of risk situation solving algorithm. A possible preliminary system construction of the risk management principle can be given based on this structured risk factor classification and on the fact, that some risk factor groups, risk factors or management actions have a weighted role in the system operation. The system parameters are represented with the fuzzy sets, and the grouped risk factors' values give intermediate result [2]. Considering some system input parameters, which determine the risk factors' role in the decision making system, intermediate results can be weighted and forwarded to the next level of the reasoning process [3].

# 2 Hierarchical Structured Risk Management Systems

The steps of the risk management model constructions are:, following the systematic approach, the steps of the problem solving are as listed: the risk factor identification, the qualitative or quantitative description of their effects on the environment, the development of response actions to these risks, and if possible, and trying to increase the effects of them [1].

Based on those ideas a risk management system can be built up as a hierarchical system of the risk factors (inputs), risk management actions (decision making system) and direction or directions for the next level of risk situation solving algorithm. Actually, those directions are risk factors for the action on the next level of the risk management process. To realise this risk factors in a complex system are grouped to the risk relevant events or decision step. The goal is to determinate the necessary actions to increase the negative effects. Actions or decision steps are described by the 'if … then' type rules. With the output those components frame one unit in the hole risk management system, where the items are usually attached on the principle of the time-scheduling, significance or other criteria (Figure 1). Input Risk Factors (RF) grouped and assigned to the current action are described by the Fuzzy Risk Measure Sets (FRMS) such as 'low', 'normal', 'high', and can include the fuzziness of their membership functions too. This fuzziness can be represented by type 2 fuzzy sets.

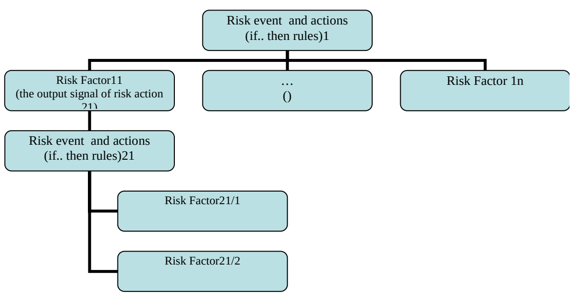


Figure 1

The hierarchical risk management construction

## 2.1 Fuzzy Rule-based Realization

Soft computing and especially the fuzzy-based risk management and risk level calculation method is close to the human mind and it is one of the reasons why the actors from a wide range of scientific fields applied fuzzy approximate reasoning. This methodology is able to manage the complex, multi-parametrical, multi-criteria problems and the uncertainty and the vagueness of conditions. The fuzzy set representation of system parameters' properties and fuzzy-based techniques helps to incorporate inherent imprecision, uncertainties and subjectivity of available data. The systems can be managed not only by experts, but by everyone, including the micro-communities to the macro society structures [7]. The numerical modelling of the system behaviour and the real-time decision making are further difficulties solvable with soft computing methodologies. Furthermore, the complexity of the systems increases the runtime factor, and the system parameter representation is usually not user-friendly in traditionally applied models. There are also well-known numerical methods and operation research models to give acceptable results for some finite dimensional problems, but without management of the uncertainties. Considering all those conditions fuzzy set theory helps to enable manage complexity and uncertainties and to give visualization of the system parameters, moreover represents the inputs and outputs in qualitative linguistic form. The models for solving are usually knowledge based models, where the linguistically communicated modelling of the mental processes is needed, and the objective and subjective knowledge (definitional, causal, statistical, and heuristic knowledge) is included in the decision process as the rule data base.

## 2.2 Example

Crisis or disaster event monitoring provides basic information for many decisions in today’s social life. The disaster recovery strategies of the country, the financial investments plans of investors, or the level of the tourism activities all depend on different groups of disaster or crisis factors.

The disaster can be defined as an unforeseen event that causes great damage, destruction and human suffering, evolved from a natural or man-made event that negatively affects life, property, livelihood or industry. A disaster is the start of a crisis, and often results in permanent changes to human societies, ecosystems and environment.

Based on the experts’ observations [4], [5], the risk factors, which prejudice disaster situation can be classified as follows:

- natural disasters;

- man-made disasters (unintended events or willful events).

Natural disasters arise without direct human involvement, but may often occur, because of human actions prior, during or after the disaster itself (for example, a hurricane may cause flooding by rain or by a storm surge).

The natural disasters also can be grouped primarily based on the root cause:

- hydro-meteorological disasters: floods, storms, and droughts;

- geophysical disasters: earthquakes, tsunamis and volcanic eruptions;

- biological disasters: epidemics and insect infestations;

or they can be structured hierarchically, based on sequential supervention.

The example, presented in this paper, is constructed based on the first principle, with fuzzified inputs and hierarchically constructed rule base system (Figure 2). The risk or disaster factors, as the inputs of one subsystem of the global fuzzy decision making system, give outputs for the next level of decision, where the main natural disaster classes result the total impact of this risk category.

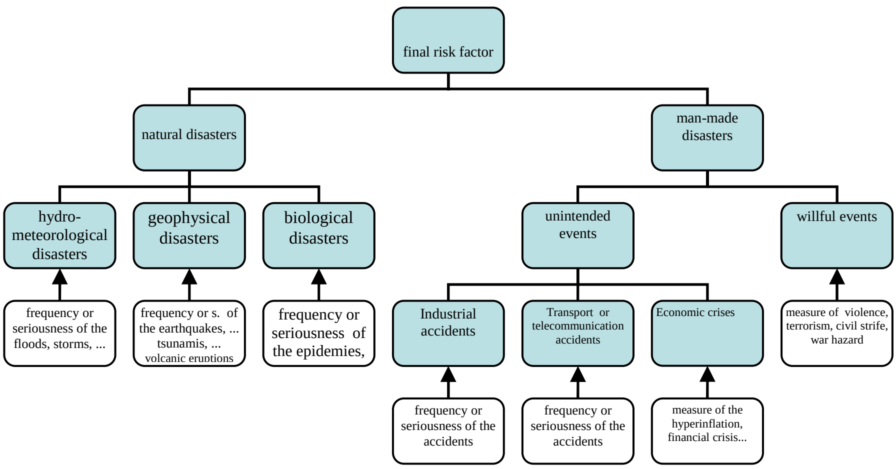


Figure 2

Hierarchically constructed rule base system

This approach allows additional possibilities to handle the set of risk factors.

It is easy to add one factor to a factors-subset; the complexity of the rule base system has been changed only in the affected subsystem.

In different seasons, environmental situations etc., some of the risk groups are more important for the global conclusion than others, so they can be achieved with a importance factor (number from the [0,1]).

The man-made disasters have an element of human intent or negligence. However, some of those events can also occur as the result of a natural disaster. The man-made factors and disasters can be structured in a similar way, as the natural risks, events. One of the possible classifications of the basic man-made risk factors or disaster events (applied in our example) is as follows:

1. unintended events:

   - Industrial accidents (chemical spills, collapses of industrial infrastructures);

   - Transport or telecommunication accidents (by air, rail, road or water means of transport);

   - Economic crises (growth collapse, hyperinflation, and financial crisis);

2. willful events (violence, terrorism, civil strife, riots, and war).

The effects of man-made disasters as the inputs in the decision making process are represented with their relative frequency, and the premises of the related fuzzy rules are very often represented with the membership functions: never, rarely, frequently, etc.

The final conclusion based on both disasters' as risk factors' groups is shown in Figure 3. More details about the example and simulation results can be seen in [6].

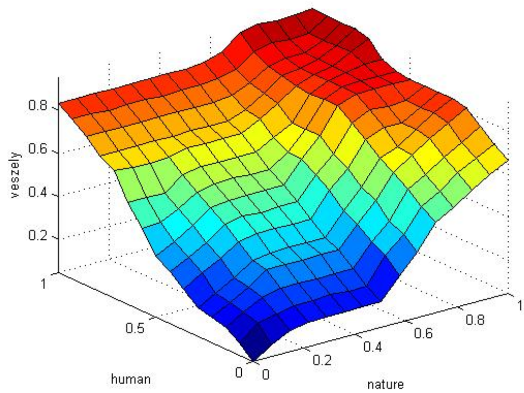


Figure 3
The final conclusion based on both disasters' as risk factors' groups

## Conclusions

Disaster event monitoring as one of the steps of risk and crisis management is very complex system with uncertain input parameters. Fuzzified inputs, fuzzy rule base, constructed using objective and subjective definitional, causal, statistical, and heuristic knowledge is able to present the problem in a user-friend form. The complexity of the system can be managed by the hierarchical structured reasoning model, with thematically grouped, and if it is necessary, gained risk factor structure.

## Acknowledgement

The support of the Óbuda University and Vojvodina Academy of Science and Art (project title: Mathematical Models for Decision Making under Uncertain Conditions and Their Applications ) is kindly announced.

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