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Risk Assessment at Workplace in Underground Lead and Zinc Mine with Application of Fuzzy Topsis Method

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Abstract

Underground mining is considered one of the most dangerous industries, because serious injuries or accidents often occur at the workplace. In recent years, fuzzy multiple criteria decision-making has found increasing application in job risk assessment, taking into account a number of influential parameters. This paper uses fuzzy TOPSIS method for workplace risk assessment in an underground lead and zinc mine, where the results are be compared with the number of injuries and accidents that have occurred in individual workplaces to assess its accuracy. Accurate workplace risk assessment in underground mines is very important so that appropriate safety measures can be taken in a timely manner to avoid injuries and deaths at work.

Keywords

Risk assessment, workplace, underground mine, fuzzy multi-criteria decision-making, fuzzy TOPSIS

1. Introduction

Underground mining is considered one of the most hazard prone industries worldwide if one considers occupational accidents linked to death and injury risks [1]. World consumption of minerals has increased to such an extent in modern times that more minerals were used in the 20th century than ever used throughout the previous centuries. Practically, we are now a society that depends on automobiles, trains, telephones, television, computers, fertilizers, heavy machinery, industrial minerals for building construction, electricity production based on coal-fired power plants, nuclear plants. However, during all these times of mineral resources utilization, the mining industry and related activities have had negative environmental impacts associated with natural disasters and human life loss [2]. Mining is an industry without which it is impossible to live in the modern world, so it is necessary to take appropriate measures to prevent accidents and catastrophes. The most important step in preventing accidents and disasters is workplace risk assessment.

Risk is defined as the combination of the severity of the harm and the occurrence probability of this harm [3, 4]. Risk assessment includes identifying and evaluating all possible risks, reducing them and documenting the results. There are many methods of risk assessment [5], which are classified into two main groups as qualitative and quantitative [6, 7]. Multi-criteria decision-making base methods are used as quantitative risk assessment methods.

In multi-criteria decision-making methods, it is often a difficult evaluation for decision makers to give a precise rating to an alternative with respect to the criteria. Giving the relative importance of criteria using fuzzy numbers instead of crisp numbers is one of the advantages of fuzzy multi-criteria decision-making methods [3]. Over the years, numerous fuzzy multi-criteria decision making (FMCDM) methods have been proposed in the literature, which are different in areas such as the type of questions asked, theoretical background, and type of obtained results. A number of methods have been designed for a particular problem, hence inapplicable to other problems. Recently, a number of FMCDM methods have been introduced to choose the best compromise options. The FMCDM approaches have been developed not only by the motivation received from various real-life problems that require the consideration of multiple criteria, but also by the desire of practitioners for enhancing decision-making techniques through recent developments occurred in computer technology, scientific computing, and mathematical optimization [8].

This paper uses the fuzzy TOPSIS method for workplace risk assessment in underground lead and zinc mines, that is metallic mineral raw materials. The aim of the paper is to accurately assess the risks at the workplace in order to take appropriate safety measures so as to avoid serious injuries and accidents at work. The second section of this paper presents a literary research of the application of fuzzy multi-criteria decision-making methods in risk assessment in mining. The third section of this paper presents a case study, where the Fuzzy TOPSIS method is used to assess the risk of workplaces in an underground mine for lead and zinc ore mining. The fourth section presents a brief conclusion from the research conducted in this paper.

2. Literature review

Underground mining of mineral resources is one of the most risky activities and therefore has a very large impact on risk assessment in the workplace. Accurate workplace risk assessment depends on many parameters that need to be considered. To this end, fuzzy multi-criteria decision-making methods are widely used to solve these tasks. Fuzzy AHP is the most widely applied multi-criteria decision-making methodology, which combines fuzzy logic with AHP. Numerous studies have been conducted to assess workplace risk using fuzzy multi-criteria decision-making methods.

Marhavilas and Koulouriotis in 2008 [9], explained two new quantitative risk assessment techniques called proportional technique and decision matrix technique and presented an application of these techniques on an aluminium extrusion industry in Greece, using real accident data. Lang and Fu-Bao in 2010 [10], determined influential factors that lead to the spontaneous combustion of coal seams and proposed a framework including a holistic scoring method and an AHP for evaluating the hazard of spontaneous combustion, and was used in Chinese coal mines. Badri et al. in 2013 [11], developed the integration of a novel concept called hazard concentration and AHP, where the all hazards and associated risks in gold mines throughout Quebec, Canada were dealt with. Mahdevari et al. in 2014 [12], proposed a FTOPSIS based approach to assess the risks associated with human health in order to manage control measures and support decision- making in underground coal mines in Iran. They identified and ranked 86 hazards under the categories of geo-mechanical, geochemical, electrical, mechanical, chemical, environmental, personal, social, cultural, and managerial risks. After applying the FTOPSIS model, 12 groups with different risks were obtained. Verma and Chaudhri in 2014 [13], proposed the integration of Fuzzy Reasoning approach (FRA) and Fuzzy Analytic Hierarchy Process (FAHP) for risk assessment in mining industry. Gul and Guneri in 2016 [3], proposed a hybrid fuzzy MCDM method that avoids shortcomings of a crisp risk score calculation and decreases the inconsistency in decision making. It is the study in OHS risk assessment of aluminum industry in Turkey that uses FAHP-fuzzy TOPSIS hybrid approach. Javadi et al. in 2017 [14], used Fuzzy Bayesian Network Model for roof fall risk analysis in underground coal mines. Samantra et al. in 2017 [15], used an unique hierarchical structure on various occupational health hazards including physical, chemical, biological, ergonomic, and psychosocial hazards, and associated adverse consequences in relation to an underground coal mine was presented using fuzzy aggregation rules. In order to evaluate risks, three important measuring parameters were considered as a consequence of exposure, period of exposure, and probability of exposure. Health hazards were categorized into different risk levels and potential control measures were suggested. Gul and Ak in 2018 [16], used the proposed approach PFAHP-FTOPSIS to provide importance weights to the risk parameters of a 5 x 5 risk matrix method by using interval-valued Pythagorean fuzzy linguistic scale in a pairwise-comparison manner for risk assessment in the mining industry, that is, in underground copper and zinc mines. Oz et al. in 2018 [17], performed risk assessment for clearing and grading process of a natural gas pipeline project: An extended TOPSIS model with Pythagorean fuzzy sets for prioritizing hazards. Bakhtavar and Yousefi in 2018 [18], performs assessment of workplace accident risks in underground collieries by integrating a multi-goal cause-and-effect analysis method with MCDM sensitivity analysis. Shi et al. in 2018 [19], performs assessment of gas and dust explosion in coal mines by means of fuzzy fault tree analysis. Gul et al. in 2019 [20], used a fuzzy-based model for risk assessment of routes in oil transportation using the fuzzy analytical hierarchy process. Gul et al. in 2019 [1], applied a new OHS risk assessment approach based on PFVIKOR for the assessment of occupational risks in an underground copper and zinc mine. Utilizing Pythagorean fuzzy sets, they appropriately managed the ambiguity and unpredictability of the OHS expert realization during the risk assessment process. Huang et al. in 2019 [21], used key factors identification and risk assessment for the stability of deep surrounding rock in coal roadway. Dong et al. in 2020 [22], used safety risk assessment at a Pb-Zn Mine based on Fuzzy-Grey correlation analysis. Petrovic et al. in 2020 [23], used fuzzy model for risk assessment of machinery failures in the mining.

The TOPSIS method was firstly proposed by Hwang et al. in 1981 [24]. The basic concept of this method is that the chosen alternative should have the shortest distance from the positive ideal solution (PIS) and the farthest distance from negative ideal solution (NIS). PIS minimizes the cost criteria and maximizes the benefit criteria, whereas the NIS minimizes the benefit criteria and maximizes the cost criteria. In the TOPSIS method, decision makers judgments are represented with crisp values. According to the problems associated with determining the precise preference rating to an alternative for the criteria under consideration, decision makers are keen on using fuzzy numbers instead of precise numbers. For this reason, the fuzzy TOPSIS method is appropriate for solving real world problems under a fuzzy environment [25, 26, 27, 28, 29, 30]. The TOPSIS and fuzzy TOPSIS methods have been extensively applied to engineering and management fields over the last two decades as well as there have been plenty of studies related with the TOPSIS method in the literature [31, 32, 33, 34, 35, 36]. The fuzzy theory is one of the modern techniques which can deal with the impreciseness of input data and domain knowledge by giving quick, simple and often sufficiently good approximations of the desired solutions.

3. Case study

This study uses the fuzzy TOPSIS method to assess the risk at workplaces in an underground lead-zinc mine. It is of great importance to accurately assess the risk at work in an underground lead and zinc mine, in order to take all necessary measures in a timely manner to eliminate the risks and dangers of injuries at work, occupational diseases and related diseases at work and establish a management system for health and safety at work.

Workplace risk assessment consists of an analysis of the frequency of workers' injuries, the severity of injuries, the identification of hazards and injuries in the workplace.

The identification of hazards and damage to the investigated works is determined on the basis of:

- multi-year monitoring (supervision) of work at workplaces,
- interviews with several employees who are employed in these workplaces, filling out questionnaires about the dangers and harms associated with these workplaces,
- consultations with mining engineers who are directly involved in the process of mining the lead-zinc ore,
- consultations with mining engineers in charge of safety and health at work in underground lead-zinc mining,
- consultations with workplace risk assessment experts,
- detailed analysis of recorded severe bodily injuries and serious bodily injuries with fatal consequences at the mentioned workplaces.

3.1. Alternatives

Workplace risk assessment in the underground lead and zinc mine is performed at all workplaces that are directly involved in the process of underground lead-zinc mining. This paper assesses the risk in sixteen workplaces that are actually alternatives (Table 1) and aims to determine which workplaces have the highest risk.

Table 1. Alternatives for risk assessment at workplaces

Symbol	Alternatives
A_1	A mining engineer at the mine
A_2	Operator with drilling machine at the mine
A_3	Operator with loading machine at the mine
A_4	Operator with mining truck at the mine
A_5	Operator with locomotive at the mine
A_6	Blaster
A_7	Support miner at the mine
A_8	Miner for preparing horizontal mining works
A_9	Miner for making oblique and vertical mining works
A_{10}	Stope miner
A_{11}	Miner for deep exploratory drilling
A_{12}	Miner for road maintenance at the mine
A_{13}	Miner in charge of ventilation
A_{14}	Miner in charge of technical water and drainage
A_{15}	Electrician at the mine
A_{16}	Worker for maintenance of mechanization at the mine

3.2. Criteria

Workplace risk assessment is performed by detailed investigation of hazards and damage at workplaces, based on multi-year monitoring (supervision) of the work process [37]. Hazards and damages that occur in the workplace are in fact the criteria according to which the risk assessment in the workplace was performed, i.e. according to which alternatives were compared and depending on which the results of the research were produced. In this paper, 38 criteria are taken into account (Table 2). Each criterion has a different weight, i.e. the impact on alternative solutions. In this paper, the weights of the criteria are adopted by voting, i.e. in consultation with a group of 10 experts in the field of professional risk assessment in the underground exploitation of metallic mineral raw materials, in order to minimize subjectivity in optimization, and then these values were turned into equivalent fuzzy values. The goal that the criteria aim at is minimum, i.e. the least danger or damage in the workplace. Criteria can be quantitative (they can be measured or calculated) or qualitative (they cannot be measured and defined by descriptive results, so in order for them to be used for calculation, they need to be converted into numerical values).

Table 2. Criteria for risk assessment at workplaces

Symbol	Criteria	Weights of criteria
C_1	Insufficient safety due to rotating or moving parts	Low
C_2	Free movement of parts or materials that can cause injuries to employees	Medium
C_3	Internal transport and movement of work machines or vehicles, as well as the transfer of work equipment	Medium
C_4	Use of hazardous work tools that may produce an explosion or fire	Medium
C_5	Impossibility or limitations of timely removal from the workplace, exposure to closure, mechanical shock, overlap, etc.	Low
C_6	Dangerous surfaces (floors and all types of treads, surfaces with which the employee	High

	comes into contact and which have sharp edges, spikes, rough surfaces, protruding parts, etc.)	
C_7	Work at height or depth, in accordance with safety and health regulations	Medium
C_8	Work indoors, restricted or in a hazardous area (between two or more fixed parts, between moving parts or vehicles, working indoors, in low light and low ventilated area, etc.)	High
C_9	Possibility of slipping or tripping (wet or slippery surfaces)	Low
C_{10}	Physical instability in the workplace	Medium
C_{11}	Possible consequences or disturbances due to mandatory use of personal protective equipment or means for working	Very Low
C_{12}	Impacts due to work process performance using inappropriate or unadapted methods	High
C_{13}	Danger of direct contact with parts of electrical installations and equipment under voltage	Low
C_{14}	Danger of indirect contact with parts of electrical installations and equipment under voltage	Low
C_{15}	Danger of thermal effects of electrical equipment and installations (overheating, fire, explosion, electric arc or sparks, etc.)	Very Low
C_{16}	Danger of harmful effects of electrostatic charge	Very Low
C_{17}	Handling flammable solids, liquids and gases	Medium
C_{18}	Explosives handling	High
C_{19}	Possibility of creating explosive mixtures	Low
C_{20}	Possibility of generating electrostatic electricity as a condition of ignition and explosion	Very Low
C_{21}	Traffic explosions	Very Low
C_{22}	Contact with hot or cold medium	Very Low
C_{23}	Chemical hazard due to the presence of dust, liquids, gases, smoke, easily corrosive substances, reactive / non-volatile substances, chemical leaks (inhalation, suffocation, ingestion, penetration into the body through the skin, burns, poisoning, etc.)	Very High
C_{24}	Physical hazard due to the presence of noise and mechanical vibrations	High
C_{25}	Biological hazard due to exposure to infectious agents, microorganisms, allergens and the like	Very Low
C_{26}	Adverse effects of microclimate (high or low temperature, humidity and air speed)	High
C_{27}	Inadequate - insufficient lighting	Medium
C_{28}	Harmful effects of radiation (thermal, ionizing or non-ionizing, laser, ultrasound)	Very Low
C_{29}	Hazards arising from the use of hazardous substances in the manufacture, transport, packaging, storage or destruction	Medium
C_{30}	Adverse climatic effects (outdoor work)	Medium
C_{31}	Work in conditions of increased or decreased atmospheric pressure	Very Low
C_{32}	Work near water or underwater	Very Low
C_{33}	Hazard due to exertion or physical stresses (manual load transfer, pushing or pulling a load, prolonged increased physical activity, climbing and lowering, etc.)	Medium
C_{34}	Hazard due to non-physiological body position (longer standing, sitting, kneeling, squatting, etc.)	Medium
C_{35}	Efforts for various tasks that cause psychological stress (stress, monotony, etc.)	Medium
C_{36}	Responsibility for receiving and transmitting information, use of appropriate knowledge and skills, responsibility for rules of conduct, rapid changes in work procedures, work intensity, spatial conditioning in the workplace, conflict situations, working with clients, working with money, insufficient motivation to work, responsibility in management, the need for decision making and the like	High

C_{37}	Work longer than full time (overtime), shift work, night work, emergency preparedness, etc.	High
C_{38}	Hazard caused by other persons (violence in the working counters, security work, work of auditors, inspections, police, health workers, etc.)	Very Low

Workplace dangers can be divided into 5 main groups which are then divided into several subgroups [37]. The main groups are given below:
- Mechanical dangers caused by the use of work equipment (this group includes criteria C_1 to C_5);
- Dangers that arise in connection with the characteristics of the workplace (this group includes criteria C_6 to C_{12});
- Dangers arising from the use of electricity (this group includes criteria C_{13} to C_{16});
- Fire and explosion dangers (this group includes criteria C_{17} to C_{21});
- Thermal dangers (this group includes a criterion C_{22})

Hazards that occur in the workplace can be divided into 4 main groups which are then divided into several subgroups [37]. The main groups are given below:
- Hazards arising or occuring during the work process, which can be chemical, physical and biological hazards (this group includes criteria C_{23} to C_{32});
- Hazards arising from psychological and psycho-physiological efforts (this group includes criteria C_{33} to C_{36});
- Hazards associated with the work organization (this group includes criterion C_{37});
- Other hazards that occur in the workplaces (this group includes criterion C_{38})

3.3. Numerical example

For risk assessment at workplace among sixteen proposed alternatives, the fuzzy TOPSIS method involves ten steps [25, 28, 29, 30, 33, 38, 39]:
Step 1. Identify the evaluation criteria and alternatives.
Step 2. Choose the appropriate linguistic variable.
Triangular fuzzy numbers can be used to represent linguistic variables, which can be used for the importance weight of the criteria (Table 3) and the evaluation of alternatives with respect to each criterion (Table 4).

Table 3. Linguistic variable for the importance weight of criteria

Linguistic variables	Fuzzy triangular
Very Low (VL)	(0.1, 0.1, 0.3)
Low (L)	(0.1, 0.3, 0.5)
Medium (M)	(0.3, 0.5, 0.7)
High (H)	(0.5, 0.7, 0.9)
Very High (VH)	(0.7, 0.9, 0.9)

Table 4. Linguistic variable for the alternatives rating

Linguistic variables	Fuzzy triangular
Very Poor (VP)	(1, 1, 3)
Poor (P)	(1, 3, 5)
Fair (F)	(3, 5, 7)
Good (G)	(5, 7, 9)
Very Good (VG)	(7, 9, 9)

Step 3. Construct the fuzzy decision matrix.
Step 4. Establish criteria weighted matrix.
Step 5. Normalize the fuzzy decision matrix.
Step 6. Compute the weighted normalized fuzzy decision matrix.
Step 7. Compute the Fuzzy Positive Ideal Solution (FPIS) and Fuzzy Negative Ideal Solution (FNIS).
Step 8. Compute the distance from each alternative to the FPIS and to the FNIS.
Step 9. Compute the closeness coefficient of each alternative.
Step 10. Rank the alternatives.

In the first step of the fuzzy TOPSIS analysis, the three decision makers use the linguistic variables (Table 3 and Table 4) to evaluate the relative importance or weights of criteria and the ratings of alternatives for various attributes, but there may be more decision makers. Final results on the outcome of decision makers' views are presented in the fuzzy decision matrixs (Table 5) and normalized fuzzy decision matrixs (Table 6). The fuzzy decision matrix and normalized fuzzy decision matrix for decision makers 2 and 3 are not shown in the interest of the number of pages of the paper.
Then, combined normalized fuzzy decision matrix is produced (Table 7). Then, the combined normalized fuzzy decision matrix is normalized, the corresponding matrix is presented in Table 8. Next, weighted normalized fuzzy decision matrix is calculated and the result is given in Table 9.
Then, FPIS and FNIS are calculated and the result is given in Table 10. After determining the distance of each alternative from the FPIS and FNIS, the results are presented in Table 11 and Table 12. Next, closeness coefficient of each alternative is calculated and the result is given in Table 13. The result also shows the ranking of alternatives.

Table 5. Fuzzy decision matrix (Decision Maker – 1)

Criterion	Alternative															
	A_1	A_2	A_3	A_4	A_5	A_6	A_7	A_8	A_9	A_{10}	A_{11}	A_{12}	A_{13}	A_{14}	A_{15}	A_{16}
C_1	VG	G	G	G	G	VG	G	G	G	G	G	G	G	VG	VG	G
C_2	G	F	P	G	G	F	VP	P	VP	VP	G	G	G	G	G	G
C_3	VG	G	G	G	G	F	F	G	G	G	VG	F	G	G	G	F
C_4	VG	G	G	G	G	P	G	G	G	F	G	G	VG	VG	G	F
C_5	VG	F	F	G	G	F	P	F	P	P	G	G	G	G	G	F
C_6	G	P	VP	F	G	VP	VP	P	P	VP	G	F	G	G	G	G
C_7	G	P	P	G	G	VP	P	G	P	VP	G	G	G	G	G	F
C_8	F	P	P	P	P	P	P	P	VP	VP	F	P	P	P	P	P
C_9	F	F	F	F	F	P	P	F	P	P	F	F	F	F	F	F
C_{10}	F	P	P	F	F	P	VP	F	P	VP	F	F	F	F	F	F
C_{11}	VG	VG	VG	VG	VG	VG	G	VG	G	G	VG	VG	VG	VG	VG	VG
C_{12}	F	P	P	F	F	VP	VP	P	VP	VP	F	F	P	F	P	P
C_{13}	VG	G	VG	VG	F	G	G	G	G	G	G	G	F	F	P	F
C_{14}	G	G	G	G	P	F	F	F	F	G	F	F	P	P	VP	P
C_{15}	VG	G	G	G	P	G	G	G	G	G	F	G	F	F	P	P
C_{16}	VG	G	G	G	F	G	G	G	G	G	F	G	F	F	F	G
C_{17}	VG	G	G	G	G	G	F	G	G	G	G	G	G	G	G	P
C_{18}	VG	VG	VG	VG	VG	VP	G	F	F	F	VG	VG	VG	VG	VG	VG

C_{19}	VG	G	VG	VG	VG	F	G	G	G	G	VG	VG	VG	VG	VG	G
C_{20}	VG	G	VG	VG	G	G	VG	G	G	G	G	G	F	F	F	F
C_{21}	VG	VG	VG	VG	G	G	VG	VG	VG	VG	VG	VG	VG	VG	VG	VG
C_{22}	VG	F	F	F	F	G	G	G	G	G	F	F	F	F	F	F
C_{23}	G	G	VP	F	G	G	G	F	F	F	G	F	G	G	G	F
C_{24}	G	VP	VP	VP	F	G	F	F	F	F	P	VP	F	F	G	F
C_{25}	VG	VG	G	VG	VG	VG	VG	VG	G	VG	VG	VG	VG	VG	VG	G
C_{26}	G	VP	VP	F	F	P	P	P	VP	VP	F	F	P	P	G	F
C_{27}	F	P	F	F	F	G	G	G	G	G	P	F	F	F	P	P
C_{28}	VG	VG	VG	VG	VG	VG	VG	VG	VG	VG	VG	VG	VG	VG	G	VG
C_{29}	VG	VG	VG	VG	VG	G	VG	VG	VG	VG	VG	VG	VG	VG	VG	VG
C_{30}	VG	F	F	VG	VG	F	G	F	F	F	VG	VG	G	G	VG	VG
C_{31}	VG	F	F	G	G	F	P	F	F	F	G	G	G	G	G	G
C_{32}	VG	G	G	G	G	G	G	G	G	G	G	G	G	F	G	G
C_{33}	VG	G	G	G	G	P	VP	F	F	F	G	G	G	G	G	F
C_{34}	G	G	F	F	F	P	VP	P	P	P	F	G	F	F	F	F
C_{35}	G	F	P	F	F	F	P	F	P	P	F	G	G	G	G	G
C_{36}	VP	P	VP	F	F	P	VP	F	F	P	F	F	F	F	F	F
C_{37}	VP	VP	VP	VP	VP	VP	VP	VP	VP	VP	VP	P	P	P	VP	VP
C_{38}	G	P	P	F	F	P	P	P	P	P	F	F	F	F	F	F

Table 6. Normalized fuzzy decision matrix (Decision Maker – 1)

Criteria	Alternatives															
	A_1	A_2	A_3	A_4	A_5	A_6	A_7	A_8	A_9	A_{10}	A_{11}	A_{12}	A_{13}	A_{14}	A_{15}	A_{16}
C_1	(7,9,9)	(5,7,9)	(5,7,9)	(5,7,9)	(5,7,9)	(7,9,9)	(5,7,9)	(5,7,9)	(5,7,9)	(5,7,9)	(5,7,9)	(5,7,9)	(5,7,9)	(7,9,9)	(7,9,9)	(5,7,9)
C_2	(5,7,9)	(3,5,7)	(1,3,5)	(5,7,9)	(5,7,9)	(3,5,7)	(1,1,3)	(1,3,5)	(1,1,3)	(1,1,3)	(5,7,9)	(5,7,9)	(5,7,9)	(5,7,9)	(5,7,9)	(5,7,9)
C_3	(7,9,9)	(5,7,9)	(5,7,9)	(5,7,9)	(5,7,9)	(3,5,7)	(3,5,7)	(5,7,9)	(5,7,9)	(5,7,9)	(7,9,9)	(3,5,7)	(5,7,9)	(5,7,9)	(5,7,9)	(3,5,7)
C_4	(7,9,9)	(5,7,9)	(5,7,9)	(5,7,9)	(5,7,9)	(1,3,5)	(5,7,9)	(5,7,9)	(5,7,9)	(3,5,7)	(5,7,9)	(5,7,9)	(7,9,9)	(7,9,9)	(5,7,9)	(3,5,7)
C_5	(7,9,9)	(3,5,7)	(3,5,7)	(5,7,9)	(5,7,9)	(3,5,7)	(1,3,5)	(3,5,7)	(1,3,5)	(1,3,5)	(5,7,9)	(5,7,9)	(5,7,9)	(5,7,9)	(5,7,9)	(3,5,7)
C_6	(5,7,9)	(1,3,5)	(1,1,3)	(3,5,7)	(5,7,9)	(1,1,3)	(1,1,3)	(1,3,5)	(1,3,5)	(1,1,3)	(5,7,9)	(3,5,7)	(5,7,9)	(5,7,9)	(5,7,9)	(5,7,9)
C_7	(5,7,9)	(1,3,5)	(1,3,5)	(5,7,9)	(5,7,9)	(1,1,3)	(1,3,5)	(5,7,9)	(1,3,5)	(1,1,3)	(5,7,9)	(5,7,9)	(5,7,9)	(5,7,9)	(5,7,9)	(3,5,7)
C_8	(3,5,7)	(1,3,5)	(1,3,5)	(1,3,5)	(1,3,5)	(1,3,5)	(1,3,5)	(1,3,5)	(1,1,3)	(1,1,3)	(3,5,7)	(1,3,5)	(1,3,5)	(1,3,5)	(1,3,5)	(1,3,5)
C_9	(3,5,7)	(3,5,7)	(3,5,7)	(3,5,7)	(3,5,7)	(1,3,5)	(1,3,5)	(3,5,7)	(1,3,5)	(1,3,5)	(3,5,7)	(3,5,7)	(3,5,7)	(3,5,7)	(3,5,7)	(3,5,7)
C_{10}	(3,5,7)	(1,3,5)	(1,3,5)	(3,5,7)	(3,5,7)	(1,3,5)	(1,1,3)	(3,5,7)	(1,3,5)	(1,1,3)	(3,5,7)	(3,5,7)	(3,5,7)	(3,5,7)	(3,5,7)	(3,5,7)
C_{11}	(7,9,9)	(7,9,9)	(7,9,9)	(7,9,9)	(7,9,9)	(7,9,9)	(5,7,9)	(7,9,9)	(5,7,9)	(5,7,9)	(7,9,9)	(7,9,9)	(7,9,9)	(7,9,9)	(7,9,9)	(7,9,9)
C_{12}	(3,5,7)	(1,3,5)	(1,3,5)	(3,5,7)	(3,5,7)	(1,1,3)	(1,1,3)	(1,3,5)	(1,1,3)	(1,1,3)	(3,5,7)	(3,5,7)	(1,3,5)	(3,5,7)	(1,3,5)	(1,3,5)
C_{13}	(7,9,9)	(5,7,9)	(7,9,9)	(7,9,9)	(3,5,7)	(5,7,9)	(5,7,9)	(5,7,9)	(5,7,9)	(5,7,9)	(5,7,9)	(5,7,9)	(3,5,7)	(3,5,7)	(1,3,5)	(3,5,7)
C_{14}	(5,7,9)	(5,7,9)	(5,7,9)	(5,7,9)	(1,3,5)	(3,5,7)	(3,5,7)	(3,5,7)	(3,5,7)	(5,7,9)	(3,5,7)	(3,5,7)	(1,3,5)	(1,3,5)	(1,1,3)	(1,3,5)
C_{15}	(7,9,9)	(5,7,9)	(5,7,9)	(5,7,9)	(1,3,5)	(5,7,9)	(5,7,9)	(5,7,9)	(5,7,9)	(5,7,9)	(3,5,7)	(5,7,9)	(3,5,7)	(3,5,7)	(1,3,5)	(1,3,5)
C_{16}	(7,9,9)	(5,7,9)	(5,7,9)	(5,7,9)	(3,5,7)	(5,7,9)	(5,7,9)	(5,7,9)	(5,7,9)	(5,7,9)	(3,5,7)	(5,7,9)	(3,5,7)	(3,5,7)	(3,5,7)	(5,7,9)
C_{17}	(7,9,9)	(5,7,9)	(5,7,9)	(5,7,9)	(5,7,9)	(5,7,9)	(3,5,7)	(5,7,9)	(5,7,9)	(5,7,9)	(5,7,9)	(5,7,9)	(5,7,9)	(5,7,9)	(5,7,9)	(1,3,5)
C_{18}	(7,9,9)	(7,9,9)	(7,9,9)	(7,9,9)	(7,9,9)	(1,1,3)	(5,7,9)	(3,5,7)	(3,5,7)	(3,5,7)	(7,9,9)	(7,9,9)	(7,9,9)	(7,9,9)	(7,9,9)	(7,9,9)
C_{19}	(7,9,9)	(5,7,9)	(7,9,9)	(7,9,9)	(7,9,9)	(3,5,7)	(5,7,9)	(5,7,9)	(5,7,9)	(5,7,9)	(7,9,9)	(7,9,9)	(7,9,9)	(7,9,9)	(7,9,9)	(5,7,9)
C_{20}	(7,9,9)	(5,7,9)	(7,9,9)	(7,9,9)	(5,7,9)	(5,7,9)	(7,9,9)	(5,7,9)	(5,7,9)	(5,7,9)	(5,7,9)	(5,7,9)	(3,5,7)	(3,5,7)	(3,5,7)	(3,5,7)
C_{21}	(7,9,9)	(7,9,9)	(7,9,9)	(7,9,9)	(5,7,9)	(5,7,9)	(7,9,9)	(7,9,9)	(7,9,9)	(7,9,9)	(7,9,9)	(7,9,9)	(7,9,9)	(7,9,9)	(7,9,9)	(7,9,9)
C_{22}	(7,9,9)	(3,5,7)	(3,5,7)	(3,5,7)	(3,5,7)	(5,7,9)	(5,7,9)	(5,7,9)	(5,7,9)	(5,7,9)	(3,5,7)	(3,5,7)	(3,5,7)	(3,5,7)	(3,5,7)	(3,5,7)
C_{23}	(5,7,9)	(5,7,9)	(1,1,3)	(3,5,7)	(5,7,9)	(5,7,9)	(5,7,9)	(3,5,7)	(3,5,7)	(3,5,7)	(5,7,9)	(3,5,7)	(5,7,9)	(5,7,9)	(5,7,9)	(3,5,7)
C_{24}	(5,7,9)	(1,1,3)	(1,1,3)	(1,1,3)	(3,5,7)	(5,7,9)	(3,5,7)	(3,5,7)	(3,5,7)	(3,5,7)	(1,3,5)	(1,1,3)	(3,5,7)	(3,5,7)	(5,7,9)	(3,5,7)
C_{25}	(7,9,9)	(7,9,9)	(5,7,9)	(7,9,9)	(7,9,9)	(7,9,9)	(7,9,9)	(7,9,9)	(5,7,9)	(7,9,9)	(7,9,9)	(7,9,9)	(7,9,9)	(7,9,9)	(7,9,9)	(5,7,9)
C_{26}	(5,7,9)	(1,1,3)	(1,1,3)	(3,5,7)	(3,5,7)	(1,3,5)	(1,3,5)	(1,3,5)	(1,1,3)	(1,1,3)	(3,5,7)	(3,5,7)	(1,3,5)	(1,3,5)	(5,7,9)	(3,5,7)
C_{27}	(3,5,7)	(1,3,5)	(3,5,7)	(3,5,7)	(3,5,7)	(5,7,9)	(5,7,9)	(5,7,9)	(5,7,9)	(5,7,9)	(1,3,5)	(3,5,7)	(3,5,7)	(3,5,7)	(1,3,5)	(1,3,5)
C_{28}	(7,9,9)	(7,9,9)	(7,9,9)	(7,9,9)	(7,9,9)	(7,9,9)	(7,9,9)	(7,9,9)	(7,9,9)	(7,9,9)	(7,9,9)	(7,9,9)	(7,9,9)	(7,9,9)	(5,7,9)	(7,9,9)
C_{29}	(7,9,9)	(7,9,9)	(7,9,9)	(7,9,9)	(7,9,9)	(5,7,9)	(7,9,9)	(7,9,9)	(7,9,9)	(7,9,9)	(7,9,9)	(7,9,9)	(7,9,9)	(7,9,9)	(7,9,9)	(7,9,9)
C_{30}	(7,9,9)	(3,5,7)	(3,5,7)	(7,9,9)	(7,9,9)	(3,5,7)	(5,7,9)	(3,5,7)	(3,5,7)	(3,5,7)	(7,9,9)	(7,9,9)	(5,7,9)	(5,7,9)	(7,9,9)	(7,9,9)

C_{31}	(7,9,9)	(3,5,7)	(3,5,7)	(5,7,9)	(5,7,9)	(3,5,7)	(1,3,5)	(3,5,7)	(3,5,7)	(3,5,7)	(5,7,9)	(5,7,9)	(5,7,9)	(5,7,9)	(5,7,9)	(5,7,9)
C_{32}	(7,9,9)	(5,7,9)	(5,7,9)	(5,7,9)	(5,7,9)	(5,7,9)	(5,7,9)	(5,7,9)	(5,7,9)	(5,7,9)	(5,7,9)	(5,7,9)	(5,7,9)	(3,5,7)	(5,7,9)	(5,7,9)
C_{33}	(7,9,9)	(5,7,9)	(5,7,9)	(5,7,9)	(5,7,9)	(1,3,5)	(1,1,3)	(3,5,7)	(3,5,7)	(3,5,7)	(5,7,9)	(5,7,9)	(5,7,9)	(5,7,9)	(5,7,9)	(3,5,7)
C_{34}	(5,7,9)	(5,7,9)	(3,5,7)	(3,5,7)	(3,5,7)	(1,3,5)	(1,1,3)	(1,3,5)	(1,3,5)	(1,3,5)	(3,5,7)	(5,7,9)	(3,5,7)	(3,5,7)	(3,5,7)	(3,5,7)
C_{35}	(5,7,9)	(3,5,7)	(1,3,5)	(3,5,7)	(3,5,7)	(3,5,7)	(1,3,5)	(3,5,7)	(1,3,5)	(1,3,5)	(3,5,7)	(5,7,9)	(5,7,9)	(5,7,9)	(5,7,9)	(5,7,9)
C_{36}	(1,1,3)	(1,3,5)	(1,1,3)	(3,5,7)	(3,5,7)	(1,3,5)	(1,1,3)	(3,5,7)	(3,5,7)	(1,3,5)	(3,5,7)	(3,5,7)	(3,5,7)	(3,5,7)	(3,5,7)	(3,5,7)
C_{37}	(1,1,3)	(1,1,3)	(1,1,3)	(1,1,3)	(1,1,3)	(1,1,3)	(1,1,3)	(1,1,3)	(1,1,3)	(1,1,3)	(1,1,3)	(1,3,5)	(1,3,5)	(1,3,5)	(1,1,3)	(1,1,3)
C_{38}	(5,7,9)	(1,3,5)	(1,3,5)	(3,5,7)	(3,5,7)	(1,3,5)	(1,3,5)	(1,3,5)	(1,3,5)	(1,3,5)	(3,5,7)	(3,5,7)	(3,5,7)	(3,5,7)	(3,5,7)	(3,5,7)

Table 7. Combined normalized fuzzy decision matrix (Decision makers – 1, 2 and 3)

Criterion	Alternative															
	A_1	A_2	A_3	A_4	A_5	A_6	A_7	A_8	A_9	A_{10}	A_{11}	A_{12}	A_{13}	A_{14}	A_{15}	A_{16}
C_1	(7.0,9.0,9.0)	(3.0,5.7,9.0)	(3.0,5.7,9.0)	(3.0,5.7,9.0)	(3.0,5.7,9.0)	(5.0,8.3,9.0)	(3.0,5.7,9.0)	(3.0,5.7,9.0)	(3.0,5.7,9.0)	(3.0,5.7,9.0)	(3.0,5.7,9.0)	(3.0,5.7,9.0)	(3.0,6.3,9.0)	(5.0,7.7,9.0)	(7.0,9.0,9.0)	(5.0,7.0,9.0)
C_2	(5.0,7.0,9.0)	(1.0,4.3,7.0)	(1.0,3.7,7.0)	(5.0,7.0,9.0)	(5.0,7.0,9.0)	(3.0,5.0,7.0)	(1.0,1.7,5.0)	(1.0,3.0,5.0)	(1.0,1.7,5.0)	(1.0,1.7,5.0)	(5.0,7.0,9.0)	(5.0,7.0,9.0)	(5.0,7.0,9.0)	(5.0,7.0,9.0)	(5.0,7.0,9.0)	(5.0,7.0,9.0)
C_3	(5.0,8.3,9.0)	(1.0,5.0,9.0)	(1.0,5.0,9.0)	(1.0,5.0,9.0)	(1.0,5.0,9.0)	(3.0,5.0,7.0)	(1.0,3.7,7.0)	(3.0,5.7,9.0)	(3.0,5.7,9.0)	(3.0,5.7,9.0)	(5.0,8.3,9.0)	(3.0,5.0,7.0)	(3.0,6.3,9.0)	(3.0,6.3,9.0)	(5.0,7.0,9.0)	(3.0,5.0,7.0)
C_4	(7.0,9.0,9.0)	(5.0,7.0,9.0)	(5.0,7.0,9.0)	(5.0,7.0,9.0)	(5.0,7.0,9.0)	(1.0,1.7,5.0)	(3.0,6.3,9.0)	(3.0,5.7,9.0)	(3.0,5.7,9.0)	(3.0,5.0,7.0)	(5.0,7.0,9.0)	(5.0,7.0,9.0)	(7.0,9.0,9.0)	(7.0,9.0,9.0)	(5.0,7.0,9.0)	(3.0,6.3,9.0)
C_5	(5.0,7.7,9.0)	(1.0,3.0,7.0)	(1.0,3.0,7.0)	(3.0,5.7,9.0)	(3.0,5.7,9.0)	(1.0,3.0,7.0)	(1.0,1.7,5.0)	(1.0,3.7,7.0)	(1.0,1.7,5.0)	(1.0,1.7,5.0)	(3.0,5.7,9.0)	(3.0,5.7,9.0)	(3.0,6.3,9.0)	(3.0,6.3,9.0)	(3.0,6.3,9.0)	(1.0,5.0,9.0)
C_6	(3.0,6.3,9.0)	(1.0,1.7,5.0)	(1.0,1.0,3.0)	(1.0,4.3,7.0)	(3.0,5.7,9.0)	(1.0,1.0,3.0)	(1.0,1.0,3.0)	(1.0,2.3,5.0)	(1.0,2.3,5.0)	(1.0,1.0,3.0)	(1.0,5.7,9.0)	(1.0,4.3,7.0)	(3.0,6.3,9.0)	(3.0,6.3,9.0)	(3.0,6.3,9.0)	(3.0,6.3,9.0)
C_7	(3.0,6.3,9.0)	(1.0,1.7,5.0)	(1.0,1.7,5.0)	(3.0,6.3,9.0)	(3.0,6.3,9.0)	(1.0,1.0,3.0)	(1.0,2.3,5.0)	(1.0,5.0,9.0)	(1.0,1.7,5.0)	(1.0,1.0,3.0)	(3.0,6.3,9.0)	(3.0,6.3,9.0)	(3.0,6.3,9.0)	(3.0,6.3,9.0)	(3.0,6.3,9.0)	(3.0,5.7,9.0)
C_8	(3.0,5.0,7.0)	(1.0,1.7,5.0)	(1.0,1.7,5.0)	(1.0,3.0,5.0)	(1.0,3.0,5.0)	(1.0,1.7,5.0)	(1.0,1.7,5.0)	(1.0,2.3,5.0)	(1.0,1.0,3,0)	(1.0,1.0,3.0)	(1.0,3.7,7.0)	(1.0,3.0,5.0)	(1.0,3.0,5.0)	(1.0,3.0,5.0)	(1.0,3.0,5.0)	(1.0,3.0,5.0)
C_9	(3.0,5.7,9.0)	(1.0,4.3,7.0)	(1.0,4.3,7.0)	(3.0,5.0,7.0)	(3.0,5.0,7.0)	(1.0,2.3,5.0)	(1.0,2.3,5.0)	(3.0,5.0,7.0)	(1.0,2.3,5.0)	(1.0,2.3,5.0)	(3.0,5.0,7.0)	(3.0,5.0,7.0)	(3.0,5.0,7.0)	(3.0,5.0,7.0)	(3.0,5.0,7.0)	(3.0,5.0,7.0)
C_{10}	(3.0,5.0,7.0)	(1.0,1.7,5.0)	(1.0,1.7,5.0)	(3.0,5.0,7.0)	(3.0,5.0,7.0)	(1.0,2.3,5.0)	(1.0,1.0,3.0)	(1.0,3.7,7.0)	(1.0,1.7,5.0)	(1.0,1.0,3.0)	(3.0,5.0,7.0)	(3.0,5.0,7.0)	(3.0,5.0,7.0)	(3.0,5.0,7.0)	(3.0,5.0,7.0)	(3.0,5.0,7.0)
C_{11}	(7.0,9.0,9.0)	(5.0,8.3,9.0)	(5.0,8.3,9.0)	(7.0,9.0,9.0)	(7.0,9.0,9.0)	(5.0,8.3,9.0)	(5.0,7.0,9.0)	(7.0,9.0,9.0)	(5.0,7.0,9.0)	(5.0,7.0,9.0)	(7.0,9.0,9.0)	(7.0,9.0,9.0)	(7.0,9.0,9.0)	(7.0,9.0,9.0)	(7.0,9.0,9.0)	(7.0,9.0,9.0)
C_{12}	(1.0,3.7,7.0)	(1.0,2.3,5.0)	(1.0,2.3,5.0)	(3.0,5.0,7.0)	(3.0,5.0,7.0)	(1.0,1.7,5.0)	(1.0,1.7,5.0)	(1.0,2.3,5.0)	(1.0,1.7,5.0)	(1.0,1.7,5.0)	(3.0,5.0,7.0)	(3.0,5.0,7.0)	(1.0,2.3,5.0)	(1.0,3.7,7.0)	(1.0,2.3,5.0)	(1.0,2.3,5.0)
C_{13}	(7.0,9.0,9.0)	(5.0,7.0,9.0)	(7.0,9.0,9.0)	(7.0,9.0,9.0)	(1.0,4.3,7.0)	(3.0,6.3,9.0)	(5.0,7.0,9.0)	(5.0,7.0,9.0)	(5.0,7.0,9.0)	(5.0,7.0,9.0)	(5.0,7.0,9.0)	(5.0,7.7,9.0)	(3.0,5.0,7.0)	(3.0,5.0,7.0)	(1.0,3.0,5.0)	(3.0,5.0,7.0)
C_{14}	(5.0,7.0,9.0)	(5.0,7.0,9.0)	(5.0,7.0,9.0)	(5.0,7.0,9.0)	(1.0,3.7,7.0)	(3.0,5.0,7.0)	(3.0,5.0,7.0)	(3.0,5.0,7.0)	(3.0,5.0,7.0)	(3.0,6.3,9.0)	(3.0,5.0,7.0)	(3.0,6.3,9.0)	(1.0,4.3,7.0)	(1.0,4.3,7.0)	(1.0,2.3,5.0)	(1.0,4.3,7.0)
C_{15}	(5.0,8.3,9.0)	(3.0,6.3,9.0)	(3.0,6.3,9.0)	(3.0,6.3,9.0)	(1.0,3.7,7.0)	(3.0,6.3,9.0)	(3.0,5.7,9.0)	(3.0,5.7,9.0)	(3.0,5.7,9.0)	(3.0,6.3,9.0)	(3.0,5.0,7.0)	(3.0,6.3,9.0)	(3.0,5.0,7.0)	(3.0,5.0,7.0)	(1.0,3.7,7.0)	(1.0,3.7,7.0)
C_{16}	(5.0,8.3,9.0)	(5.0,7.0,9.0)	(5.0,7.7,9.0)	(5.0,7.7,9.0)	(3.0,5.0,7.0)	(3.0,5.7,9.0)	(5.0,7.0,9.0)	(3.0,6.3,9.0)	(3.0,6.3,9.0)	(3.0,6.3,9.0)	(3.0,5.0,7.0)	(5.0,7.7,9.0)	(3.0,5.0,7.0)	(3.0,5.0,7.0)	(3.0,5.0,7.0)	(3.0,6.3,9.0)
C_{17}	(7.0,9.0,9.0)	(5.0,7.0,9.0)	(5.0,7.0,9.0)	(5.0,7.0,9.0)	(5.0,7.7,9.0)	(5.0,7.0,9.0)	(3.0,5.7,9.0)	(5.0,7.0,9.0)	(5.0,7.0,9.0)	(5.0,7.0,9.0)	(5.0,7.0,9.0)	(5.0,7.0,9.0)	(5.0,7.0,9.0)	(5.0,7.0,9.0)	(5.0,7.0,9.0)	(1.0,3.7,7.0)
C_{18}	(7.0,9.0,9.0)	(5.0,8.3,9.0)	(7.0,9.0,9.0)	(7.0,9.0,9.0)	(7.0,9.0,9.0)	(1.0,1.0,3.0)	(5.0,7.7,9.0)	(1.0,4.3,7.0)	(1.0,4.3,7.0)	(1.0,4.3,7.0)	(7.0,9.0,9.0)	(7.0,9.0,9.0)	(7.0,9.0,9.0)	(7.0,9.0,9.0)	(7.0,9.0,9.0)	(7.0,9.0,9.0)
C_{19}	(7.0,9.0,9.0)	(5.0,7.7,9.0)	(5.0,8.3,9.0)	(7.0,9.0,9.0)	(7.0,9.0,9.0)	(3.0,5.0,7.0)	(5.0,7.0,9.0)	(3.0,6.3,9.0)	(3.0,6.3,9.0)	(3.0,6.3,9.0)	(7.0,9.0,9.0)	(7.0,9.0,9.0)	(7.0,9.0,9.0)	(7.0,9.0,9.0)	(7.0,9.0,9.0)	(5.0,7.7,9.0)
C_{20}	(7.0,9.0,9.0)	(5.0,7.0,9.0)	(7.0,9.0,9.0)	(7.0,9.0,9.0)	(5.0,7.0,9.0)	(5.0,7.0,9.0)	(7.0,9.0,9.0)	(5.0,7.0,9.0)	(5.0,7.0,9.0)	(5.0,7.0,9.0)	(5.0,7.0,9.0)	(5.0,8.3,9.0)	(3.0,5.7,9.0)	(3.0,5.0,7.0)	(3.0,5.0,7.0)	(3.0,5.0,7.0)
C_{21}	(7.0,9.0,9.0)	(7.0,9.0,9.0)	(7.0,9.0,9.0)	(7.0,9.0,9.0)	(5.0,8.3,9.0)	(3.0,5.7,9.0)	(7.0,9.0,9.0)	(5.0,7.7,9.0)	(5.0,7.7,9.0)	(5.0,8.3,9.0)	(7.0,9.0,9.0)	(7.0,9.0,9.0)	(7.0,9.0,9.0)	(7.0,9.0,9.0)	(7.0,9.0,9.0)	(7.0,9.0,9.0)
C_{22}	(5.0,8.3,9.0)	(1.0,4.3,7.0)	(1.0,3.7,7.0)	(1.0,4.3,7.0)	(3.0,5.0,7.0)	(5.0,7.0,9.0)	(3.0,5.7,9.0)	(3.0,5.7,9.0)	(3.0,5.7,9.0)	(5.0,7.0,9.0)	(1.0,4.3,7.0)	(1.0,4.3,7.0)	(3.0,5.0,7.0)	(3.0,5.0,7.0)	(3.0,5.0,7.0)	(3.0,5.0,7.0)
C_{23}	(5.0,7.0,9.0)	(3.0,5.7,9.0)	(1.0,1.0,3.0)	(1.0,4.3,7.0)	(5.0,7.0,9.0)	(3.0,6.3,9.0)	(3.0,6.3,9.0)	(1.0,4.3,7.0)	(1.0,3.7,7.0)	(1.0,4.3,7.0)	(3.0,6.3,9.0)	(1.0,4.3,7.0)	(3.0,6.3,9.0)	(5.0,7.0,9.0)	(5.0,7.0,9.0)	(3.0,5.7,9.0)
C_{24}	(5.0,7.0,9.0)	(1.0,1.0,3.0)	(1.0,1.0,3.0)	(1.0,1.0,3.0)	(3.0,5.0,7.0)	(3.0,6.3,9.0)	(3.0,5.0,7.0)	(3.0,5.0,7.0)	(3.0,5.0,7.0)	(3.0,5.0,7.0)	(1.0,3.0,5.0)	(1.0,1.0,3.0)	(1.0,4.3,7.0)	(3.0,5.0,7.0)	(5.0,7.0,9.0)	(3.0,5.0,7.0)
C_{25}	(7.0,9.0,9.0)	(5.0,8.3,9.0)	(5.0,7.7,9.0)	(7.0,9.0,9.0)	(7.0,9.0,9.0)	(7.0,9.0,9.0)	(7.0,9.0,9.0)	(7.0,9.0,9.0)	(5.0,7.7,9.0)	(7.0,9.0,9.0)	(7.0,9.0,9.0)	(7.0,9.0,9.0)	(7.0,9.0,9.0)	(7.0,9.0,9.0)	(7.0,9.0,9.0)	(5.0,8.3,9.0)
C_{26}	(5.0,7.0,9.0)	(1.0,1.7,5.0)	(1.0,1.0,3.0)	(1.0,4.3,7.0)	(1.0,3.7,7.0)	(1.0,3.0,5.0)	(1.0,3.0,5.0)	(1.0,3.0,5.0)	(1.0,1.0,3.0)	(1.0,1.0,3.0)	(3.0,5.0,7.0)	(3.0,5.0,7.0)	(1.0,3.0,5.0)	(1.0,3.0,5.0)	(5.0,7.0,9.0)	(3.0,5.0,7.0)
C_{27}	(3.0,5.7,9.0)	(1.0,3.7,7.0)	(3.0,5.7,9.0)	(1.0,4.3,7.0)	(1.0,4.3,7.0)	(3.0,6.3,9.0)	(3.0,6.3,9.0)	(3.0,6.3,9.0)	(3.0,6.3,9.0)	(3.0,6.3,9.0)	(1.0,4.3,9.0)	(1.0,4.3,7.0)	(3.0,5.7,9.0)	(3.0,5.7,9.0)	(1.0,3.7,7.0)	(1.0,3.7,7.0)
C_{28}	(7.0,9.0,9.0)	(7.0,9.0,9.0)	(7.0,9.0,9.0)	(7.0,9.0,9.0)	(7.0,9.0,9.0)	(7.0,9.0,9.0)	(7.0,9.0,9.0)	(7.0,9.0,9.0)	(7.0,9.0,9.0)	(7.0,9.0,9.0)	(7.0,9.0,9.0)	(7.0,9.0,9.0)	(7.0,9.0,9.0)	(7.0,9.0,9.0)	(5.0,7.0,9.0)	(7.0,9.0,9.0)
C_{29}	(7.0,9.0,9.0)	(7.0,9.0,9.0)	(7.0,9.0,9.0)	(7.0,9.0,9.0)	(7.0,9.0,9.0)	(5.0,7.0,9.0)	(7.0,9.0,9.0)	(7.0,9.0,9.0)	(7.0,9.0,9.0)	(7.0,9.0,9.0)	(7.0,9.0,9.0)	(7.0,9.0,9.0)	(7.0,9.0,9.0)	(7.0,9.0,9.0)	(7.0,9.0,9.0)	(7.0,9.0,9.0)
C_{30}	(7.0,9.0,9.0)	(3.0,5.0,7.0)	(3.0,5.0,7.0)	(7.0,9.0,9.0)	(7.0,9.0,9.0)	(3.0,5.0,7.0)	(3.0,5.7,9.0)	(3.0,5.7,9.0)	(3.0,5.0,7.0)	(3.0,5.0,7.0)	(7.0,9.0,9.0)	(7.0,9.0,9.0)	(5.0,7.0,9.0)	(5.0,7.0,9.0)	(7.0,9.0,9.0)	(7.0,9.0,9.0)
C_{31}	(5.0,8.3,9.0)	(3.0,5.0,7.0)	(3.0,5.0,7.0)	(5.0,7.0,9.0)	(5.0,7.0,9.0)	(3.0,5.0,7.0)	(1.0,3.7,7.0)	(3.0,5.0,7.0)	(3.0,5.0,7.0)	(3.0,5.0,7.0)	(5.0,7.0,9.0)	(5.0,7.0,9.0)	(3.0,6.3,9.0)	(5.0,7.0,9.0)	(5.0,7.0,9.0)	(5.0,7.0,9.0)
C_{32}	(5.0,8.3,9.0)	(5.0,7.0,9.0)	(5.0,7.0,9.0)	(5.0,7.0,9.0)	(5.0,7.0,9.0)	(5.0,7.0,9.0)	(5.0,7.0,9.0)	(5.0,7.0,9.0)	(5.0,7.0,9.0)	(5.0,7.0,9.0)	(5.0,7.0,9.0)	(5.0,7.0,9.0)	(5.0,7.0,9.0)	(3.0,5.0,7.0)	(5.0,7.0,9.0)	(5.0,7.0,9.0)
C_{33}	(5.0,8.3,9.0)	(3.0,6.3,9.0)	(3.0,6.3,9.0)	(5.0,7.7,9.0)	(5.0,7.0,9.0)	(1.0,2.3,5.0)	(1.0,1.0,3.0)	(3.0,5.0,7.0)	(1.0,4.3,7.0)	(1.0,4.3,7.0)	(3.0,6.3,9.0)	(3.0,7.0,9.0)	(5.0,7.0,9.0)	(5.0,7.0,9.0)	(5.0,7.0,9.0)	(3.0,5.7,9.0)
C_{34}	(3.0,6.3,9.0)	(3.0,5.7,9.0)	(1.0,3.7,7.0)	(1.0,3.7,7.0)	(1.0,3.7,7.0)	(1.0,2.3,5.0)	(1.0,1.0,3.0)	(1.0,3.0,5.0)	(1.0,3.0,5.0)	(1.0,3.0,5.0)	(1.0,4.3,7.0)	(1.0,5.0,9.0)	(3.0,5.0,7.0)	(3.0,5.0,7.0)	(3.0,5.0,7.0)	(3.0,5.0,7.0)
C_{35}	(3.0,6.3,9.0)	(1.0,3.7,7.0)	(1.0,2.3,5.0)	(1.0,4.3,7.0)	(1.0,4.3,7.0)	(1.0,3.7,7.0)	(1.0,2.3,5.0)	(1.0,4.3,7.0)	(1.0,2.3,5.0)	(1.0,2.3,5.0)	(1.0,4.3,7.0)	(1.0,5.0,9.0)	(3.0,5.7,9.0)	(3.0,5.7,9.0)	(5.0,7.0,9.0)	(5.0,7.0,9.0)
C_{36}	(1.0,1.0,3.0)	(1.0,2.3,5.0)	(1.0,1.0,3.0)	(3.0,5.0,7.0)	(3.0,5.0,7.0)	(1.0,1.7,5.0)	(1.0,1.0,3.0)	(1.0,3.7,7.0)	(1.0,2.3,7.0)	(1.0,1.7,5.0)	(3.0,5.0,7.0)	(3.0,5.0,7.0)	(1.0,4.3,7.0)	(3.0,5.0,7.0)	(1.0,4.3,7.0)	(1.0,4.3,7.0)
C_{37}	(1.0,1.0,3.0)	(1.0,1.0,3.0)	(1.0,1.0,3.0)	(1.0,1.0,3.0)	(1.0,1.0,3.0)	(1.0,1.0,3.0)	(1.0,1.0,3.0)	(1.0,1.0,3.0)	(1.0,1.0,3.0)	(1.0,1.0,3.0)	(1.0,1.0,3.0)	(1.0,3.0,5.0)	(1.0,3.0,5.0)	(1.0,1.7,5.0)	(1.0,1.0,3.0)	(1.0,1.0,3.0)
C_{38}	(5.0,7.0,9.0)	(1.0,3.0,5.0)	(1.0,3.0,5.0)	(3.0,5.0,7.0)	(3.0,5.0,7.0)	(1.0,3.0,5.0)	(1.0,3.0,5.0)	(1.0,3.0,5.0)	(1.0,3.0,5.0)	(1.0,3.0,5.0)	(3.0,5.0,7.0)	(1.0,4.3,7.0)	(3.0,5.0,7.0)	(3.0,5.0,7.0)	(3.0,5.0,7.0)	(3.0,5.0,7.0)

Table 8. Normalized fuzzy decision matrix

Criterion	Alternative																Weight
	A_1	A_2	A_3	A_4	A_5	A_6	A_7	A_8	A_9	A_{10}	A_{11}	A_{12}	A_{13}	A_{14}	A_{15}	A_{16}	W
C_1	(0.3,0.3,0.4)	(0.3,0.5,1.0)	(0.3,0.5,1.0)	(0.3,0.5,1.0)	(0.3,0.5,1.0)	(0.3,0.4,0.6)	(0.3,0.5,1.0)	(0.3,0.5,1.0)	(0.3,0.5,1.0)	(0.3,0.5,1.0)	(0.3,0.5,1.0)	(0.3,0.5,1.0)	(0.3,0.5,1.0)	(0.3,0.4,0.6)	(0.3,0.3,0.4)	(0.3,0.4,0.6)	(0.1,0.3,0.5)
C_2	(0.1,0.1,0.2)	(0.1,0.2,1.0)	(0.1,0.3,1.0)	(0.1,0.1,0.2)	(0.1,0.1,0.2)	(0.1,0.2,0.3)	(0.2,0.6,1.0)	(0.2,0.3,1.0)	(0.2,0.6,1.0)	(0.2,0.6,1.0)	(0.1,0.1,0.2)	(0.1,0.1,0.2)	(0.1,0.1,0.2)	(0.1,0.1,0.2)	(0.1,0.1,0.2)	(0.1,0.1,0.2)	(0.3,0.5,0.7)
C_3	(0.1,0.1,0.2)	(0.1,0.2,1.0)	(0.1,0.2,1.0)	(0.1,0.2,1.0)	(0.1,0.2,1.0)	(0.1,0.2,0.3)	(0.1,0.3,1.0)	(0.1,0.2,0.3)	(0.1,0.2,0.3)	(0.1,0.2,0.3)	(0.1,0.1,0.2)	(0.1,0.2,0.3)	(0.1,0.2,0.3)	(0.1,0.2,0.3)	(0.1,0.1,0.2)	(0.1,0.2,0.3)	(0.3,0.5,0.7)
C_4	(0.1,0.1,0.1)	(0.1,0.1,0.2)	(0.1,0.1,0.2)	(0.1,0.1,0.2)	(0.1,0.1,0.2)	(0.2,0.6,1.0)	(0.1,0.2,0.3)	(0.1,0.2,0.3)	(0.1,0.2,0.3)	(0.1,0.2,0.3)	(0.1,0.1,0.2)	(0.1,0.1,0.2)	(0.1,0.1,0.1)	(0.1,0.1,0.1)	(0.1,0.1,0.2)	(0.1,0.2,0.3)	(0.3,0.5,0.7)
C_5	(0.1,0.1,0.2)	(0.1,0.3,1.0)	(0.1,0.3,1.0)	(0.1,0.2,0.3)	(0.1,0.2,0.3)	(0.1,0.3,1.0)	(0.2,0.6,1.0)	(0.1,0.3,1.0)	(0.2,0.6,1.0)	(0.2,0.6,1.0)	(0.1,0.2,0.3)	(0.1,0.2,0.3)	(0.1,0.2,0.3)	(0.1,0.2,0.3)	(0.1,0.2,0.3)	(0.1,0.2,1.0)	(0.1,0.3,0.5)
C_6	(0.1,0.2,0.3)	(0.2,0.6,1.0)	(0.3,1.0,1.0)	(0.1,0.2,1.0)	(0.1,0.2,0.3)	(0.3,1.0,1.0)	(0.3,1.0,1.0)	(0.2,0.4,1.0)	(0.2,0.4,1.0)	(0.3,1.0,1.0)	(0.1,0.2,1.0)	(0.1,0.2,1.0)	(0.1,0.2,0.3)	(0.1,0.2,0.3)	(0.1,0.2,0.3)	(0.1,0.2,0.3)	(0.5,0.7,0.9)
C_7	(0.1,0.2,0.3)	(0.2,0.6,1.0)	(0.2,0.6,1.0)	(0.1,0.2,0.3)	(0.1,0.2,0.3)	(0.3,1.0,1.0)	(0.2,0.4,1.0)	(0.1,0.2,1.0)	(0.2,0.6,1.0)	(0.3,1.0,1.0)	(0.1,0.2,0.3)	(0.1,0.2,0.3)	(0.1,0.2,0.3)	(0.1,0.2,0.3)	(0.1,0.2,0.3)	(0.1,0.2,0.3)	(0.3,0.5,0.7)
C_8	(0.1,0.2,0.3)	(0.2,0.6,1.0)	(0.2,0.6,1.0)	(0.2,0.3,1.0)	(0.2,0.3,1.0)	(0.2,0.6,1.0)	(0.2,0.6,1.0)	(0.2,0.4,1.0)	(0.3,1.0,1.0)	(0.3,1.0,1.0)	(0.1,0.3,1.0)	(0.2,0.3,1.0)	(0.2,0.3,1.0)	(0.2,0.3,1.0)	(0.2,0.3,1.0)	(0.2,0.3,1.0)	(0.5,0.7,0.9)
C_9	(0.1,0.2,0.3)	(0.1,0.2,1.0)	(0.1,0.2,1.0)	(0.1,0.2,0.3)	(0.1,0.2,0.3)	(0.2,0.4,1.0)	(0.2,0.4,1.0)	(0.1,0.2,0.3)	(0.2,0.4,1.0)	(0.2,0.4,1.0)	(0.1,0.2,0.3)	(0.1,0.2,0.3)	(0.1,0.2,0.3)	(0.1,0.2,0.3)	(0.1,0.2,0.3)	(0.1,0.2,0.3)	(0.1,0.3,0.5)

C_{10}	(0.1,0.2,0.3)	(0.2,0.6,1.0)	(0.2,0.6,1.0)	(0.1,0.2,0.3)	(0.1,0.2,0.3)	(0.2,0.4,1.0)	(0.3,1.01.0)	(0.1,0.3,1.0)	(0.2,0.6,1.0)	(0.3,1.0,1.0)	(0.1,0.2,0.3)	(0.1,0.2,0.3)	(0.1,0.2,0.3)	(0.1,0.2,0.3)	(0.1,0.2,0.3)	(0.1,0.2,0.3)	(0.3,0.5,0.7)
C_{11}	(0.6,0.6,0.7)	(0.6,0.6,1.0)	(0.6,0.6,1.0)	(0.6,0.6,0.7)	(0.6,0.6,0.7)	(0.6,0.6,1.0)	(0.6,0.7,1.0)	(0.6,0.6,0.7)	(0.6,0.7,1.0)	(0.6,0.7,1.0)	(0.6,0.6,0.7)	(0.6,0.6,0.7)	(0.6,0.6,0.7)	(0.6,0.6,0.7)	(0.6,0.6,0.7)	(0.6,0.6,0.7)	(0.1,0.1,0.3)
C_{12}	(0.1,0.3,1.0)	(0.2,0.4,1.0)	(0.2,0.4,1.0)	(0.1,0.2,0.3)	(0.1,0.2,0.3)	(0.2,0.6,1.0)	(0.2,0.6,1.0)	(0.2,0.4,1.0)	(0.2,0.6,1.0)	(0.2,0.6,1.0)	(0.1,0.2,0.3)	(0.1,0.2,0.3)	(0.2,0.4,1.0)	(0.1,0.3,1.0)	(0.2,0.4,1.0)	(0.2,0.4,1.0)	(0.5,0.7,0.9)
C_{13}	(0.1,0.1,0.1)	(0.1,0.1,0.2)	(0.1,0.1,0.1)	(0.1,0.1,0.1)	(0.1,0.2,1.0)	(0.1,0.2,0.3)	(0.1,0.1,0.2)	(0.1,0.1,0.2)	(0.1,0.1,0.2)	(0.1,0.1,0.2)	(0.1,0.1,0.2)	(0.1,0.1,0.2)	(0.1,0.2,0.3)	(0.1,0.2,0.3)	(0.2,0.3,1.0)	(0.1,0.2,0.3)	(0.1,0.3,0.5)
C_{14}	(0.1,0.1,0.2)	(0.1,0.1,0.2)	(0.1,0.1,0.2)	(0.1,0.1,0.2)	(0.1,0.3,1.0)	(0.1,0.2,0.3)	(0.1,0.2,0.3)	(0.1,0.2,0.3)	(0.1,0.2,0.3)	(0.1,0.2,0.3)	(0.1,0.2,0.3)	(0.1,0.2,0.3)	(0.1,0.2,1.0)	(0.1,0.2,1.0)	(0.2,0.4,1.0)	(0.1,0.2,1.0)	(0.1,0.3,0.5)
C_{15}	(0.1,0.1,0.2)	(0.1,0.2,0.3)	(0.1,0.2,0.3)	(0.1,0.2,0.3)	(0.1,0.3,1.0)	(0.1,0.2,0.3)	(0.1,0.2,0.3)	(0.1,0.2,0.3)	(0.1,0.2,0.3)	(0.1,0.2,0.3)	(0.1,0.2,0.3)	(0.1,0.2,0.3)	(0.1,0.2,0.3)	(0.1,0.2,0.3)	(0.1,0.3,1.0)	(0.1,0.3,1.0)	(0.1,0.1,0.3)
C_{16}	(0.3,0.4,0.6)	(0.3,0.4,0.6)	(0.3,0.4,0.6)	(0.3,0.4,0.6)	(0.4,0.6,1.0)	(0.3,0.5,1.0)	(0.3,0.4,0.6)	(0.3,0.5,1.0)	(0.3,0.5,1.0)	(0.3,0.5,1.0)	(0.4,0.6,1.0)	(0.3,0.4,0.6)	(0.4,0.6,1.0)	(0.4,0.6,1.0)	(0.4,0.6,1.0)	(0.3,0.5,1.0)	(0.1,0.1,0.3)
C_{17}	(0.1,0.1,0.1)	(0.1,0.1,0.2)	(0.1,0.1,0.2)	(0.1,0.1,0.2)	(0.1,0.1,0.2)	(0.1,0.1,0.2)	(0.1,0.2,0.3)	(0.1,0.1,0.2)	(0.1,0.1,0.2)	(0.1,0.1,0.2)	(0.1,0.1,0.2)	(0.1,0.1,0.2)	(0.1,0.1,0.2)	(0.1,0.1,0.2)	(0.1,0.1,0.2)	(0.1,0.3,1.0)	(0.3,0.5,0.7)
C_{18}	(0.1,0.1,0.1,)	(0.1,0.1,0.2)	(0.1,0.1,0.1)	(0.1,0.1,0.1)	(0.1,0.1,0.1)	(0.3,1.0,1.0)	(0.1,0.1,0.2)	(0.1,0.2,1.0)	(0.1,0.2,1.0)	(0.1,0.2,1.0)	(0.1,0.1,0.1)	(0.1,0.1,0.1)	(0.1,0.1,0.1)	(0.1,0.1,0.1)	(0.1,0.1,0.1)	(0.1,0.1,0.1)	(0.5,0.7,0.9)
C_{19}	(0.3,0.3,0.4)	(0.3,0.4,0.6)	(0.3,0.4,0.6)	(0.3,0.3,0.4)	(0.3,0.3,0.4)	(0.4,0.6,1.0)	(0.3,0.4,0.6)	(0.3,0.5,1.0)	(0.3,0.5,1.0)	(0.3,0.5,1.0)	(0.3,0.3,0.4)	(0.3,0.3,0.4)	(0.3,0.3,0.4)	(0.3,0.3,0.4)	(0.3,0.3,0.4)	(0.3,0.4,0.6)	(0.1,0.3,0.5)
C_{20}	(0.3,0.3,0.4)	(0.3,0.4,0.6)	(0.3,0.3,0.4)	(0.3,0.3,0.4)	(0.3,0.4,0.6)	(0.3,0.4,0.6)	(0.3,0.3,0.4)	(0.3,0.4,0.6)	(0.3,0.4,0.6)	(0.3,0.4,0.6)	(0.3,0.4,0.6)	(0.3,0.4,0.6)	(0.3,0.5,1.0)	(0.4,0.6,1.0)	(0.4,0.6,1.0)	(0.4,0.6,1.0)	(0.1,0.1,0.3)
C_{21}	(0.3,0.3,0.4)	(0.3,0.3,0.4)	(0.3,0.3,0.4)	(0.3,0.3,0.4)	(0.3,0.4,0.6)	(0.3,0.5,1.0)	(0.3,0.3,0.4)	(0.3,0.4,0.6)	(0.3,0.4,0.6)	(0.3,0.4,0.6)	(0.3,0.3,0.4)	(0.3,0.3,0.4)	(0.3,0.3,0.4)	(0.3,0.3,0.4)	(0.3,0.3,0.4)	(0.3,0.3,0.4)	(0.1,0.1,0.3)
C_{22}	(0.1,0.1,0.2)	(0.1,0.2,1.0)	(0.1,0.3,1.0)	(0.1,0.2,1.0)	(0.1,0.2,0.3)	(0.1,0.1,0.2)	(0.1,0.2,0.3)	(0.1,0.2,0.3)	(0.1,0.2,0.3)	(0.1,0.1,0.2)	(0.1,0.2,1.0)	(0.1,0.2,1.0)	(0.1,0.2,0.3)	(0.1,0.2,0.3)	(0.1,0.2,0.3)	(0.1,0.2,0.3)	(0.1,0.1,0.3)
C_{23}	(0.1,0.1,0.2)	(0.1,0.2,0.3)	(0.3,1.0,1.0)	(0.1,0.2,1.0)	(0.1,0.1,0.2)	(0.1,0.2,0.3)	(0.1,0.2,0.3)	(0.1,0.2,1.0)	(0.1,0.3,1.0)	(0.1,0.2,1.0)	(0.1,0.2,0.3)	(0.1,0.2,1.0)	(0.1,0.2,0.3)	(0.1,0.1,0.2)	(0.1,0.1,0.2)	(0.1,0.2,0.3)	(0.7,0.9,0.9)
C_{24}	(0.1,0.1,0.2)	(0.3,1.0,1.0)	(0.3,1.0,1.0)	(0.3,1.0,1.0)	(0.1,0.2,0.3)	(0.1,0.2,0.3)	(0.1,0.2,0.3)	(0.1,0.2,0.3)	(0.1,0.2,0.3)	(0.1,0.2,0.3)	(0.2,0.3,1.0)	(0.3,1.0,1.0)	(0.1,0.2,1.0)	(0.1,0.2,0.3)	(0.1,0.1,0.2)	(0.1,0.2,0.3)	(0.5,0.7,0.9)
C_{25}	(0.6,0.6,0.7)	(0.6,0.6,1.0)	(0.6,0.6,1.0)	(0.6,0.6,0.7)	(0.6,0.6,0.7)	(0.6,0.6,0.7)	(0.6,0.6,0.7)	(0.6,0.6,0.7)	(0.6,0.6,1.0)	(0.6,0.6,0.7)	(0.6,0.6,0.7)	(0.6,0.6,0.7)	(0.6,0.6,0.7)	(0.6,0.6,0.7)	(0.6,0.6,0.7)	(0.6,0.6,1.0)	(0.1,0.1,0.3)
C_{26}	(0.1,0.1,0.2)	(0.2,0.6,1.0)	(0.3,1.0,1.0)	(0.1,0.2,1.0)	(0.1,0.3,1.0)	(0.2,0.3,1.0)	(0.2,0.3,1.0)	(0.2,0.3,1.0)	(0.3,1.0,1.0)	(0.3,1.0,1.0)	(0.1,0.2,0.3)	(0.1,0.2,0.3)	(0.2,0.3,1.0)	(0.2,0.3,1.0)	(0.1,0.1,0.2)	(0.1,0.2,0.3)	(0.5,0.7,0.9)
C_{27}	(0.1,0.2,0.3)	(0.1,0.3,1.0)	(0.1,0.2,0.3)	(0.1,0.2,1.0)	(0.1,0.2,1.0)	(0.1,0.2,0.3)	(0.1,0.2,0.3)	(0.1,0.2,0.3)	(0.1,0.2,0.3)	(0.1,0.2,0.3)	(0.1,0.2,1.0)	(0.1,0.2,1.0)	(0.1,0.2,0.3)	(0.1,0.2,0.3)	(0.1,0.3,1.0)	(0.1,0.3,1.0)	(0.3,0.5,0.7)
C_{28}	(0.6,0.6,0.7)	(0.6,0.6,0.7)	(0.6,0.6,0.7)	(0.6,0.6,0.7)	(0.6,0.6,0.7)	(0.6,0.6,0.7)	(0.6,0.6,0.7)	(0.6,0.6,0.7)	(0.6,0.6,0.7)	(0.6,0.6,0.7)	(0.6,0.6,0.7)	(0.6,0.6,0.7)	(0.6,0.6,0.7)	(0.6,0.6,0.7)	(0.6,0.7,1.0)	(0.6,0.6,0.7)	(0.1,0.1,0.3)
C_{29}	(0.6,0.6,0.7)	(0.6,0.6,0.7)	(0.6,0.6,0.7)	(0.6,0.6,0.7)	(0.6,0.6,0.7)	(0.6,0.7,1.0)	(0.6,0.6,0.7)	(0.6,0.6,0.7)	(0.6,0.6,0.7)	(0.6,0.6,0.7)	(0.6,0.6,0.7)	(0.6,0.6,0.7)	(0.6,0.6,0.7)	(0.6,0.6,0.7)	(0.6,0.6,0.7)	(0.6,0.6,0.7)	(0.3,0.5,0.7)
C_{30}	(0.3,.3,0.4)	(0.4,0.6,1.0)	(0.4,0.6,1.0)	(0.3,0.3,0.4)	(0.3,0.3,0.4)	(0.4,0.6,1.0)	(0.3,0.5,1.0)	(0.3,0.5,1.0)	(0.4,0.6,1.0)	(0.4,0.6,1.0)	(0.3,0.3,0.4)	(0.3,0.3,0.4)	(0.3,0.4,0.6)	(0.3,0.4,0.6)	(0.3,0.3,0.4)	(0.3,0.3,0.4)	(0.3,0.5,0.7)
C_{31}	(0.1,0.1,0.2)	(0.1,0.2,0.3)	(0.1,0.2,0.3)	(0.1,0.1,0.2)	(0.1,0.1,0.2)	(0.1,0.2,0.3)	(0.1,0.3,1.0)	(0.1,0.2,0.3)	(0.1,0.2,0.3)	(0.1,0.2,0.3)	(0.1,0.1,0.2)	(0.1,0.1,0.2)	(0.1,0.2,0.3)	(0.1,0.1,0.2)	(0.1,0.1,0.2)	(0.1,0.1,0.2)	(0.1,0.1,0.3)
C_{32}	(0.3,0.4,0.6)	(0.3,0.4,0.6)	(0.3,0.4,0.6)	(0.3,0.4,0.6)	(0.3,0.4,0.6)	(0.3,0.4,0.6)	(0.3,0.4,0.6)	(0.3,0.4,0.6)	(0.3,0.4,0.6)	(0.3,0.4,0.6)	(0.3,0.4,0.6)	(0.3,0.4,0.6)	(0.3,0.4,0.6)	(0.4,0.6,1.0)	(0.3,0.4,0.6)	(0.3,0.4,0.6)	(0.1,0.1,0.3)
C_{33}	(0.1,0.1,0.2)	(0.1,0.2,0.3)	(0.1,0.2,0.3)	(0.1,0.1,0.2)	(0.1,0.1,0.2)	(0.2,0.4,1.0)	(0.3,1.0,1.0)	(0.1,0.2,0.3)	(0.1,0.2,1.0)	(0.1,0.2,1.0)	(0.1,0.2,0.3)	(0.1,0.1,0.3)	(0.1,0.1,0.2)	(0.1,0.1,0.2)	(0.1,0.1,0.2)	(0.1,0.2,0.3)	(0.3,0.5,0.7)
C_{34}	(0.1,0.2,0.3)	(0.1,0.2,0.3)	(0.1,0.3,1.0)	(0.1,0.3,1.0)	(0.1,0.3,1.0)	(0.2,0.4,1.0)	(0.3,1.0,1.0)	(0.2,0.3,1.0)	(0.2,0.3,1.0)	(0.2,0.3,1.0)	(0.1,0.2,1.0)	(0.1,0.2,1.0)	(0.1,0.2,0.3)	(0.1,0.2,0.3)	(0.1,0.2,0.3)	(0.1,0.2,0.3)	(0.3,0.5,0.7)
C_{35}	(0.1,0.2,0.3)	(0.1,0.3,1.0)	(0.2,0.4,1.0)	(0.1,0.2,1.0)	(0.1,0.2,1.0)	(0.1,0.3,1.0)	(0.2,0.4,1.0)	(0.1,0.2,1.0)	(0.2,0.4,1.0)	(0.2,0.4,1.0)	(0.1,0.2,1.0)	(0.1,0.2,1.0)	(0.1,0.2,0.3)	(0.1,0.2,0.3)	(0.1,0.1,0.2)	(0.1,0.1,0.2)	(0.3,0.5,0.7)
C_{36}	(0.3,1.0,1.0)	(0.2,0.4,1.0)	(0.3,1.0,1.0)	(0.1,0.2,0.3)	(0.1,0.2,0.3)	(0.2,0.6,1.0)	(0.3,1.0,1.0)	(0.1,0.3,1.0)	(0.1,0.4,1.0)	(0.2,0.6,1.0)	(0.1,0.2,0.3)	(0.1,0.2,0.3)	(0.1,0.2,1.0)	(0.1,0.2,0.3)	(0.1,0.2,1.0)	(0.1,0.2,1.0)	(0.5,0.7,0.9)
C_{37}	(0.3,1.0,1.0)	(0.3,1.0,1.0)	(0.3,1.0,1.0)	(0.3,1.0,1.0)	(0.3,1.0,1.0)	(0.3,1.0,1.0)	(0.3,1.0,1.0)	(0.3,1.0,1.0)	(0.3,1.0,1.0)	(0.3,1.0,1.0)	(0.3,1.0,1.0)	(0.2,0.3,1.0)	(0.2,0.3,1.0)	(0.2,0.6,1.0)	(0.3,1.0,1.0)	(0.3,1.0,1.0)	(0.5,0.7,0.9)
C_{38}	(0.1,0.1,0.2)	(0.2,0.3,1.0)	(0.2,0.3,1.0)	(0.1,0.2,0.3)	(0.1,0.2,0.3)	(0.2,0.3,1.0)	(0.2,0.3,1.0)	(0.2,0.3,1.0)	(0.2,0.3,1.0)	(0.2,0.3,1.0)	(0.1,0.2,0.3)	(0.1,0.2,1.0)	(0.1,0.2,0.3)	(0.1,0.2,0.3)	(0.1,0.2,0.3)	(0.1,0.2,0.3)	(0.1,0.1,0.3)

Table 9. Weighted normalized fuzzy decision matrix

Criterion	Alternative															
	A_1	A_2	A_3	A_4	A_5	A_6	A_7	A_8	A_9	A_{10}	A_{11}	A_{12}	A_{13}	A_{14}	A_{15}	A_{16}
C_1	(0.03,0.10,0.21)	(0.03,0.16,0.50)	(0.03,0.16,0.50)	(0.03,0.16,0.50)	(0.03,0.16,0.50)	(0.03,0.11,0.30)	(0.03,0.16,0.50)	(0.03,0.16,0.50)	(0.03,0.16,0.50)	(0.03,0.16,0.50)	(0.03,0.16,0.50)	(0.03,0.16,0.50)	(0.03,0.14,0.50)	0.03,0.12,0.30)	(0.03,0.10,0.21)	(0.03,0.13,0.30)
C_2	(0.03,0.07,0.14)	(0.04,0.12,0.70)	(0.04,0.14,0.70)	(0.03,0.07,0.14)	(0.03,0.07,0.14)	(0.04,0.10,0.23)	(0.06,0.30,0.70)	(0.06,0.17,0.70)	(0.06,0.30,0.70)	(0.06,0.30,0.70)	(0.03,0.07,0.14)	(0.03,0.07,0.14)	(0.03,0.07,0.14)	0.03,0.07,0.14)	(0.03,0.07,0.14)	(0.03,0.07,0.14)
C_3	(0.03,0.06,0.14)	(0.03,0.10,0.70)	(0.03,0.10,0.70)	(0.03,0.10,0.70)	(0.03,0.10,0.70)	(0.04,0.10,0.23)	(0.04,0.14,0.70)	(0.03,0.09,0.23)	(0.03,0.09,0.23)	(0.03,0.09,0.23)	(0.03,0.06,0.14)	(0.04,0.10,0.23)	(0.03,0.08,0.23)	0.03,0.08,0.23)	(0.03,0.07,0.14)	(0.04,0.10,0.23)
C_4	(0.03,0.06,0.10)	(0.03,0.07,0.14)	(0.03,0.07,0.14)	(0.03,0.07,0.14)	(0.03,0.07,0.14)	(0.06,0.30,0.70)	(0.03,0.08,0.23)	(0.03,0.09,0.23)	(0.03,0.09,0.23)	(0.04,0.10,0.23)	(0.03,0.07,0.14)	(0.03,0.07,0.14)	(0.03,0.06,0.10)	0.03,0.06,0.10)	(0.03,0.07,0.14)	(0.03,0.08,0.23)
C_5	(0.01,0.04,0.10)	(0.01,0.10,0.50)	(0.01,0.10,0.50)	(0.01,0.05,0.17)	(0.01,0.05,0.17)	(0.01,0.10,0.50)	(0.02,0.18,0.50)	(0.01,0.08,0.50)	(0.02,0.18,0.50)	(0.02,0.18,0.50)	(0.01,0.05,0.17)	(0.01,0.05,0.17)	(0.01,0.05,0.17)	0.01,0.05,0.17)	(0.01,0.05,0.17)	(0.01,0.06,0.50)
C_6	(0.06,0.11,0.30)	(0.10,0.42,0.90)	(0.17,0.70,0.90)	(0.07,0.16,0.90)	(0,06.0,12,0.30)	(0.17,0.70,0.90)	(0.17,0.70,0.90)	(0.10,0.30,0.90)	(0.10,0.30,0.90)	(0.17,0.70,0.90)	(0.06,0.12,0.90)	(0.07,0.16,0.90)	(0.06,0.11,0.30)	0.06,0.11,0.30)	(0.06,0.11,0.30)	(0.06,0.11,0.30)
C_7	(0.03,0.08,0.23)	(0.06,0.30,0.70)	(0.06,0.30,0.70)	(0.03,0.08,0.23)	(0.03,0.08,0.23)	(0.10,0.50,0.70)	(0.06,0.21,0.70)	(0.03,0.10,0.70)	(0.06,0.30,0.70)	(0.10,0.50,0.70)	(0.03,0.08,0.23)	(0.03,0.08,0.23)	(0.03,0.08,0.23)	0.03,0.08,0.23)	(0.03,0.08,0.23)	(0.03,0.09,0.23)
C_8	(0.07,0.14,0.30)	(0.10,0.42,0.90)	(0.10,0.42,0.90)	(0.10,0.23,0.90)	(0.10,0.23,0.90)	(0.10,0.42,0.90)	(0.10,0.42,0.90)	(0.10,0.30,0.90)	(0.17,0.70,0.90)	(0.17,0.70,0.90)	(0.07,0.19,0.90)	(0.10,0.23,0.90)	(0.10,0.23,0.90)	0.10,0.23,0.90)	(0.10,0.23,0.90)	(0.10,0.23,0.90)
C_9	(0.01,0.05,0.	(0.01,0.07,0.	(0.01,0.07,0.	(0.01,0.06,0.	(0.01,0.06,0.	(0.02,0.13,0.	(0.02,0.13,0.	(0.01,0.06,0.	(0.02,0.13,0.	(0.02,0.13,0.	(0.01,0.06,0.	(0.01,0.06,0.	(0.01,0.06,0.	0.01,0.06,0.	(0.01,0.06,0.	(0.01,0.06,0.

	17)	50)	50)	17)	17)	50)	50)	17)	50)	50)	17)	17)	17)	17)	17)	17)
C_{10}	(0.04,0.10,0.23)	(0.06,0.30,0.70)	(0.06,0.30,0.70)	(0.04,0.10,0.23)	(0.04,0.10,0.23)	(0.06,0.21,0.70)	(0.10,0.50,0.70)	(0.04,0.14,0.70)	(0.06,0.30,0.70)	(0.10,0.50,0.70)	(0.04,0.10,0.23)	(0.04,0.10,0.23)	(0.04,0.10,0.23)	(0.04,0.10,0.23)	(0.04,0.10,0.23)	(0.04,0.10,0.23)
C_{11}	(0.06,0.06,0.21)	(0.06,0.06,0.30)	(0.06,0.06,0.30)	(0.06,0.06,0.21)	(0.06,0.06,0.21)	(0.06,0.06,0.30)	(0.06,0.07,0.30)	(0.06,0.06,0.21)	(0.06,0.07,0.30)	(0.06,0.07,0.30)	(0.06,0.06,0.21)	(0.06,0.06,0.21)	(0.06,0.06,0.21)	(0.06,0.06,0.21)	(0.06,0.06,0.21)	(0.06,0.06,0.21)
C_{12}	(0.07,0.19,0.90)	(0.10,0.30,0.90)	(0.10,0.30,0.90)	(0.07,0.14,0.30)	(0.07,0.14,0.30)	(0.10,0.42,0.90)	(0.10,0.42,0.90)	(0.10,0.30,0.90)	(0.10,0.42,0.90)	(0.10,0.42,0.90)	(0.07,0.14,0.30)	(0.07,0.14,0.30)	(0.10,0.30,0.90)	(0.07,0.19,0.90)	(0.10,0.30,0.90)	(0.10,0.30,0.90)
C_{13}	(0.01,0.03,0.07)	(0.01,0.04,0.10)	(0.01,0.03,0.07)	(0.01,0.03,0.07)	(0.01,0.07,0.50)	(0.01,0.05,0.17)	(0.01,0.04,0.10)	(0.01,0.04,0.10)	(0.01,0.04,0.10)	(0.01,0.04,0.10)	(0.01,0.04,0.10)	(0.01,0.04,0.10)	(0.01,0.06,0.17)	(0.01,0.06,0.17)	(0.02,0.10,0.50)	(0.01,0.06,0.17)
C_{14}	(0.01,0.04,0.10)	(0.01,0.04,0.10)	(0.01,0.04,0.10)	(0.01,0.04,0.10)	(0.01,0.08,0.50)	(0.01,0.06,0.17)	(0.01,0.06,0.17)	(0.01,0.06,0.17)	(0.01,0.06,0.17)	(0.01,0.05,0.17)	(0.01,0.06,0.17)	(0.01,0.05,0.17)	(0.01,0.07,0.50)	(0.01,0.07,0.50)	(0.02,0.13,0.50)	(0.01,0.07,0.50)
C_{15}	(0.01,0.01,0.06)	(0.01,0.02,0.10)	(0.01,0.02,0.10)	(0.01,0.02,0.10)	(0.01,0.03,0.30)	(0.01,0.02,0.10	(0.01,0.02,0.10)	(0.01,0.02,0.10)	(0.01,0.02,0.10)	(0.01,0.02,0.10)	(0.01,0.02,0.10)	(0.01,0.02,0.10)	(0.01,0.02,0.10)	(0.01,0.02,0.10)	(0.01,0.03,0.30)	(0.01,0.03,0.30)
C_{16}	(0.03,0.04,0.18)	(0.03,0.04,0.18)	(0.03,0.04,0.18)	(0.03,0.04,0.18)	(0.04,0.06,0.30)	(0.03,0.05,0.30)	(0.03,0.04,0.18)	(0.03,0.05,0.30)	(0.03,0.05,0.30)	(0.03,0.05,0.30)	(0.04,0.06,0.30)	(0.03,0.04,0.18)	(0.04,0.06,0.30)	(0.04,0.06,0.30)	(0.04,0.06,0.30)	(0.03,0.05,0.30)
C_{17}	(0.03,0.06,0.10)	(0.03,0.07,0.14)	(0.03,0.07,0.14)	(0.03,0.07,0.14)	(0.03,0.07,0.14)	(0.03,0.07,0.14)	(0.03,0.09,0.23)	(0.03,0.07,0.14)	(0.03,0.07,0.14)	(0.03,0.07,0.14)	(0.03,0.07,0.14)	(0.03,0.07,0.14)	(0.03,0.07,0.14)	(0.03,0.07,0.14)	(0.03,0.07,0.14)	(0.04,0.14,0.70)
C_{18}	(0.06,0.08,0.13)	(0.06,0.08,0.18)	(0.06,0.08,0.13)	(0.06,0.08,0.13)	(0.06,0.08,0.13)	(0.17,0.70,0.90)	(0.06,0.09,0.18)	(0.07,0.16,0.90)	(0.07,0.16,0.90)	(0.07,0.16,0.90)	(0.06,0.08,0.13)	(0.06,0.08,0.13)	(0.06,0.08,0.13)	(0.06,0.08,0.13)	(0.06,0.08,0.13)	(0.06,0.08,0.13)
C_{19}	(0.03,0.10,0.21)	(0.03,0.12,0.30)	(0.03,0.11,0.30)	(0.03,0.10,0.21)	(0.03,0.10,0.21)	(0.04,0.18,0.50)	(0.03,0.13,0.30)	(0.03,0.14,0.50)	(0.03,0.14,0.50)	(0.03,0.14,0.50)	(0.03,0.10,0.21)	(0.03,0.10,0.21)	(0.03,0.10,0.21)	(0.03,0.10,0.21)	(0.03,0.10,0.21)	(0.03,0.12,0.30)
C_{20}	(0.03,0.03,0.13)	(0.03,0.04,0.18)	(0.03,0.03,0.13)	(0.03,0.03,0.13)	(0.03,0.04,0.18)	(0.03,0.04,0.18)	(0.03,0.03,0.13)	(0.03,0.04,0.18)	(0.03,0.04,0.18)	(0.03,0.04,0.18)	(0.03,0.04,0.18)	(0.03,0.04,0.18)	(0.03,0.05,0.30)	(0.04,0.06,0.30)	(0.04,0.06,0.30)	(0.04,0.06,0.30)
C_{21}	(0.03,0.03,0.13)	(0.03,0.03,0.13)	(0.03,0.03,0.13)	(0.03,0.03,0.13)	(0.03,0.04,0.18)	(0.03,0.05,0.30)	(0.03,0.03,0.13)	(0.03,0.04,0.18)	(0.03,0.04,0.18)	(0.03,0.04,0.18)	(0.03,0.03,0.13)	(0.03,0.03,0.13)	(0.03,0.03,0.13)	(0.03,0.03,0.13)	(0.03,0.03,0.13)	(0.03,0.03,0.13)
C_{22}	(0.01,0.01,0.06)	(0.01,0.02,0.30)	(0.01,0.03,0.30)	(0.01,0.02,0.30)	(0.01,0.02,0.10)	(0.01,0.01,0.06)	(0.01,0.02,0.10)	(0.01,0.02,0.10)	(0.01,0.02,0.10)	(0.01,0.01,0.06)	(0.01,0.02,0.30)	(0.01,0.02,0.30)	(0.01,0.02,0.10)	(0.01,0.02,0.10)	(0.01,0.02,0.10)	(0.01,0.02,0.10)
C_{23}	(0.08,0.13,0.18)	(0.08,0.16,0.30)	(0.23,0.90,0.90)	(0.10,0.21,0.90)	(0.08,0.13,0.18)	(0.08,0.14,0.30)	(0.08,0.14,0.30)	(0.10,0.21,0.90)	(0.10,0.25,0.90)	(0.10,0.21,0.90)	(0.08,0.14,0.30)	(0.10,0.21,0.90)	(0.08,0.14,0.30)	(0.08,0.13,0.18)	(0.08,0.13,0.18)	(0.08,0.16,0.30)
C_{24}	(0.06,0.10,0.18)	(0.17,0.70,0.90)	(0.17,0.70,0.90)	(0.17,0.70,0.90)	(0.07,0.14,0.30)	(0.06,0.11,0.30)	(0.07,0.14,0.30)	(0.07,0.14,0.30)	(0.07,0.14,0.30)	(0.07,0.14,0.30)	(0.10,0.23,0.90)	(0.17,0.70,0.90)	(0.07,0.16,0.90)	(0.07,0.14,0.30)	(0.06,0.10,0.18)	(0.07,0.14,0.30)
C_{25}	(0.06,0.06,0.21)	(0.06,0.06,0.30)	(0.06,0.07,0.30)	(0.06,0.06,0.21)	(0.06,0.06,0.21)	(0.06,0.06,0.21)	(0.06,0.06,0.21)	(0.06,0.06,0.21)	(0.06,0.07,0.30)	(0.06,0.06,0.21)	(0.06,0.06,0.21)	(0.06,0.06,0.21)	(0.06,0.06,0.21)	(0.06,0.06,0.21)	(0.06,0.06,0.21)	(0.06,0.06,0.30)
C_{26}	(0.06,0.10,0.18)	(0.10,0.42,0.90)	(0.17,0.70,0.90)	(0.07,0.16,0.90)	(0.07,0.19,0.90)	(0.10,0.23,0.90)	(0.1,0.023,0.90)	(0.10,0.23,0.90)	(0.17,0.70,0.90)	(0.17,0.70,0.90)	(0.07,0.14,0.30)	(0.07,0.14,0.30)	(0.10,0.23,0.90)	(0.10,0.23,0.90)	(0.06,0.10,0.18)	(0.07,0.14,0.30)
C_{27}	(0.03,0.09,0.23)	(0.04,0.14,0.70)	(0.03,0.09,0.23)	(0.04,0.12,0.70)	0.04,0.12,070)	(0.03,0.08,0.23)	(0.03,0.08,0.23)	(0.03,0.08,0.23)	(0.03,0.08,0.23)	(0.03,0.08,0.23)	(0.03,0.12,0.70)	(0.04,0.12,0.70)	(0.03,0.09,0.23)	(0.03,0.09,0.23)	(0.04,0.14,0.70)	(0.04,0.14,0.70)
C_{28}	(0.06,0.06,0.21)	(0.06,0.06,0.21)	(0.06,0.06,0.21)	(0.06,0.06,0.21)	(0.06,0.06,0.21)	(0.06,0.06,0.21)	(0.06,0.06,0.21)	(0.06,0.06,0.21)	(0.06,0.06,0.21)	(0.06,0.06,0.21)	(0.06,0.06,0.21)	(0.06,0.06,0.21)	(0.06,0.06,0.21)	(0.06,0.06,0.21)	(0.06,0.07,0.30)	(0.06,0.06,0.21)
C_{29}	(0.17,0.28,0.50)	(0.17,0.28,0.50)	(0.17,0.28,0.50)	(0.17,0.28,0.50)	(0.17,0.28,0.50)	(0.17,0.36,0.70)	(0.17,0.28,0.50)	(0.17,0.28,0.50)	(0.17,0.28,0.50)	(0.17,0.28,0.50)	(0.17,0.28,0.50)	(0.17,0.28,0.50)	(0.17,0.28,0.50)	(0.17,0.28,0.50)	(0.17,0.28,0.50)	(0.17,0.28,0.50)
C_{30}	(0.10,0.17,0.30)	(0.13,0.30,0.70)	(0.13,0.30,0.70)	(0.10,0.17,0.30)	(0.1,00.17,0.30)	(0.13,0.30,0.70)	(0.10,0.26,0.70)	(0.10,0.26,0.70)	(0.13,0.30,0.70)	(0.13,0.30,0.70)	(0.10,0.17,0.30)	(0.10,0.17,0.30)	(0.10,0.21,0.42)	(0.10,0.21,0.42)	(0.10,0.17,0.30)	(0.10,0.17,0.30)
C_{31}	(0.01,0.01,0.06)	(0.01,0.02,0.10)	(0.01,0.02,0.10)	(0.01,0.01,0.06)	(0.01,0.01,0.06)	(0.01,0.02,0.10)	(0.01,0.03,0.30)	(0.01,0.02,0.10)	(0.01,0.02,0.10)	(0.01,0.02,0.10)	(0.01,0.01,0.06)	(0.01,0.01,0.06)	(0.01,0.02,0.10)	(0.01,0.01,0.06)	(0.01,0.01,0.06)	(0.01,0.01,0.06)
C_{32}	(0.03,0.04,0.18)	(0.03,0.04,0.18)	(0.03,0.04,0.18)	(0.03,0.04,0.18)	(0.03,0.04,0.18)	(0.03,0.04,0.18)	(0.03,0.04,0.18)	(0.03,0.04,0.18)	(0.03,0.04,0.18)	(0.03,0.04,0.18)	(0.03,0.04,0.18)	(0.03,0.04,0.18)	(0.03,0.04,0.18)	(0.04,0.06,0.30)	(0.03,0.04,0.18)	(0.03,0.04,0.18)
C_{33}	(0.03,0.06,0.14)	(0.03,0.08,0.23)	(0.03,0.08,0.23)	(0.03,0.07,0.14)	(0.03,0.07,0.14)	(0.06,0.21,0.70)	(0.10,0.50,0.70)	(0.04,0.10,0.23)	(0.04,0.12,0.70)	(0.04,0.12,0.70)	(0.03,0.08,0.23)	(0.03,0.07,0.23)	(0.03,0.07,0.14)	(0.03,0.07,0.14)	(0.03,0.07,0.14)	(0.03,0.09,0.23)
C_{34}	(0.03,0.08,0.23)	(0.03,0.09,0.23)	(0.04,0.14,0.70)	(0.04,0.14,0.70)	(0.04,0.14,0.70)	(0.06,0.21,0.70)	(0.10,0.50,0.70)	(0.06,0.17,0.70)	(0.06,0.17,0.70)	(0.06,0.17,0.70)	(0.04,0.12,0.70)	(0.03,0.10,0.70)	(0.04,0.10,0.23)	(0.04,0.10,0.23)	(0.04,0.10,0.23)	(0.04,0.10,0.23)
C_{35}	(0.03,0.08,0.23)	(0.04,0.14,0.70)	(0.06,0.21,0.70)	(0.04,0.12,0.70)	(0.04,0.12,0.70)	(0.04,0.14,0.70)	(0.06,0.21,0.70)	(0.04,0.12,0.70)	(0.06,0.21,0.70)	(0.06,0.21,0.70)	(0.04,0.12,0.70)	(0.03,0.10,0.70)	(0.03,0.09,0.23)	(0.03,0.09,0.23)	(0.03,0.07,0.14)	(0.03,0.07,0.14)
C_{36}	(0.17,0.70,0.90)	(0.10,0.30,0.90)	(0.17,0.70,0.90)	(0.07,0.14,0.30)	(0.07,0.14,0.30)	(0.10,0.42,0.90)	(0.17,0.70,0.90)	(0.07,0.19,0.90)	(0.07,0.30,0.90)	(0.10,0.42,0.90)	(0.07,0.14,0.30)	(0.07,0.14,0.30)	(0.07,0.16,0.90)	(0.07,0.14,0.30)	(0.07,0.16,0.90)	(0.07,0.16,0.90)
C_{37}	(0.17,0.70,0.90)	(0.17,0.70,0.90)	(0.17,0.70,0.90)	(0.17,0.70,0.90)	(0.17,0.70,0.90)	(0.17,0.70,0.90)	(0.17,0.70,0.90)	(0.17,0.70,0.90)	(0.17,0.70,0.90)	(0.17,0.70,0.90)	(0.17,0.70,0.90)	(0.10,0.23,0.90)	(0.10,0.23,0.90)	(0.10,0.42,0.90)	(0.17,0.70,0.90)	(0.17,0.70,0.90)
C_{38}	(0.01,0.01,0.06)	(0.02,0.03,0.30)	(0.02,0.03,0.30)	(0.01,0.02,0.10)	(0.01,0.02,0.10)	(0.02,0.03,0.30)	(0.02,0.03,0.30)	(0.02,0.03,0.30)	(0.02,0.03,0.30)	(0.02,0.03,0.30)	(0.01,0.02,0.10)	(0.01,0.02,0.30)	(0.01,0.02,0.10)	(0.01,0.02,0.10)	(0.01,0.02,0.10)	(0.01,0.02,0.10)

Table 10. Fuzzy positive ideal solution (FPIS) and fuzzy negative ideal solution (FNIS)

Criteria	FPIS	FNIS
C_1	(0.03,0.16,0.50)	(0.03,0.10,0.21)
C_2	(0.06,0.30,0.70)	(0.03,0.07,0.14)
C_3	(0.04,0.14,0.70)	(0.03,0.06,0.14)
C_4	(0.60,0.30,0.70)	(0.03,0.06,0.10)
C_5	(0.02,0.18,0.50)	(0.01,0.04,0.10)
C_6	(0.17,0.70,0.90)	(0.06,0.11,0.30)
C_7	(0.10,0.50,0.70)	(0.03,0.08,0.23)
C_8	(0.17,0.70,0.90)	(0.07,0.14,0.30)
C_9	(0.02,0.13,0.50)	(0.01,0.05,0.17)

C_{10}	(0.10,0.50,0.70)	(0.04,0.10,0.23)
C_{11}	(0.06,0.07,0.30)	(0.06,0.06,0.21)
C_{12}	(0.10,0.42,0.90)	(0.07,0.14,0.30)
C_{13}	(0.02,0.10,0.50)	(0.01,0.03,0.07)
C_{14}	(0.02,0.13,0.50)	(0.01,0.04,0.10)
C_{15}	(0.01,0.03,0.30)	(0.01,0.01,0.06)
C_{16}	(0.04,0.06,0.30)	(0.03,0.04,0.18)
C_{17}	(0.04,0.14,0.70)	(0.03,0.06,0.10)
C_{18}	(0.17,0.70,0.90)	(0.06,0.08,0.13)
C_{19}	(0.04,0.18,0.50)	(0.03,0.10,0.21)
C_{20}	(0.04,0.06,0.30)	(0.03,0.03,0.13)
C_{21}	(0.03,0.05,0.30)	(0.03,0.03,0.13)
C_{22}	(0.01,0.03,0.30)	(0.01,0.01,0.06)
C_{23}	(0.23,0.90,0.90)	(0.08,0.13,0.18)
C_{24}	(0.17,0.70,0.90)	(0.06,0.10,0.18)
C_{25}	(0.06,0.07,0.30)	(0.06,0.06,0.21)
C_{26}	(0.17,0.70,0.90)	(0.06,0.10,0.18)
C_{27}	(0.04,0.14,0.70)	(0.03,0.08,0.23)
C_{28}	(0.06,0.07,0.30)	(0.06,0.06,0.21)
C_{29}	(0.17,0.36,0.70)	(0.17,0.28,0.50)
C_{30}	(0.13,0.30,0.70)	(0.10,0.17,0.30)
C_{31}	(0.01,0.03,0.30)	(0.01,0.01,0.06)
C_{32}	(0.04,0.06,0.30)	(0.03,0.04,0.18)
C_{33}	(0.10,0.50,0.70)	(0.03,0.06,0.14)
C_{34}	(0.10,0.50,0.70)	(0.03,0.08,0.23)
C_{35}	(0.06,0.21,0.70)	(0.03,0.07,0.14)
C_{36}	(0.17,0.70,0.90)	(0.07,0.14,0.30)
C_{37}	(0.17,0.70,0.90)	(0.10,0.23,0.90)
C_{38}	(0.02,0.03,0.30)	(0.01,0.01,0.06)

Table 11. Distance of each alternative from the FPIS

Criterion	Alternative															
	A_1	A_2	A_3	A_4	A_5	A_6	A_7	A_8	A_9	A_{10}	A_{11}	A_{12}	A_{13}	A_{14}	A_{15}	A_{16}
C_1	0.17	0.00	0.00	0.00	0.00	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.12	0.17	0.12
C_2	0.35	0.11	0.09	0.35	0.35	0.29	0.00	0.08	0.00	0.00	0.35	0.35	0.35	0.35	0.35	0.35
C_3	0.33	0.02	0.02	0.02	0.02	0.27	0.00	0.27	0.27	0.27	0.33	0.27	0.27	0.27	0.33	0.27
C_4	0.37	0.35	0.35	0.35	0.35	0.00	0.30	0.30	0.30	0.29	0.35	0.35	0.37	0.37	0.35	0.30
C_5	0.24	0.05	0.05	0.21	0.21	0.05	0.00	0.06	0.00	0.00	0.21	0.21	0.21	0.21	0.21	0.07
C_6	0.49	0.17	0.00	0.32	0.48	0.00	0.00	0.23	0.23	0.00	0.34	0.32	0.49	0.49	0.49	0.49
C_7	0.36	0.12	0.12	0.36	0.36	0.00	0.17	0.23	0.12	0.00	0.36	0.36	0.36	0.36	0.36	0.36
C_8	0.48	0.17	0.17	0.27	0.27	0.17	0.17	0.23	0.00	0.00	0.30	0.27	0.27	0.27	0.27	0.27
C_9	0.20	0.03	0.03	0.20	0.20	0.00	0.00	0.20	0.00	0.00	0.20	0.20	0.20	0.20	0.20	0.20
C_{10}	0.36	0.12	0.12	0.36	0.36	0.17	0.00	0.21	0.12	0.00	0.36	0.36	0.36	0.36	0.36	0.36
C_{11}	0.05	0.01	0.01	0.05	0.05	0.01	0.00	0.05	0.00	0.00	0.05	0.05	0.05	0.05	0.05	0.05
C_{12}	0.13	0.07	0.07	0.38	0.38	0.00	0.00	0.07	0.00	0.00	0.38	0.38	0.07	0.13	0.07	0.07
C_{13}	0.25	0.23	0.25	0.25	0.02	0.19	0.23	0.23	0.23	0.23	0.23	0.23	0.19	0.19	0.00	0.19
C_{14}	0.24	0.24	0.24	0.24	0.03	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.03	0.03	0.00	0.03
C_{15}	0.14	0.12	0.12	0.12	0.00	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.00	0.00
C_{16}	0.07	0.07	0.07	0.07	0.00	0.01	0.07	0.01	0.01	0.01	0.00	0.07	0.00	0.00	0.00	0.01
C_{17}	0.35	0.33	0.33	0.33	0.33	0.33	0.27	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.00
C_{18}	0.58	0.55	0.58	0.58	0.58	0.00	0.55	0.32	0.32	0.32	0.58	0.58	0.58	0.58	0.58	0.58
C_{19}	0.17	0.12	0.12	0.17	0.17	0.00	0.12	0.02	0.02	0.02	0.17	0.17	0.17	0.17	0.17	0.12

C_{20}	0.10	0.07	0.10	0.10	0.07	0.07	0.10	0.07	0.07	0.07	0.07	0.07	0.01	0.00	0.00	0.00
C_{21}	0.10	0.10	0.10	0.10	0.07	0.00	0.10	0.07	0.07	0.07	0.10	0.10	0.10	0.10	0.10	0.10
C_{22}	0.14	0.00	0.00	0.00	0.12	0.14	0.12	0.12	0.12	0.14	0.00	0.00	0.12	0.12	0.12	0.12
C_{23}	0.62	0.56	0.00	0.41	0.62	0.57	0.57	0.41	0.39	0.41	0.57	0.41	0.57	0.62	0.62	0.56
C_{24}	0.54	0.00	0.00	0.00	0.48	0.49	0.48	0.48	0.48	0.48	0.27	0.00	0.32	0.48	0.54	0.48
C_{25}	0.05	0.00	0.00	0.05	0.05	0.05	0.05	0.05	0.00	0.05	0.05	0.05	0.05	0.05	0.05	0.00
C_{26}	0.54	0.17	0.00	0.32	0.30	0.27	0.27	0.27	0.00	0.00	0.48	0.48	0.27	0.27	0.54	0.48
C_{27}	0.27	0.00	0.27	0.01	0.01	0.27	0.27	0.27	0.27	0.27	0.01	0.01	0.27	0.27	0.00	0.00
C_{28}	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.00	0.05
C_{29}	0.12	0.12	0.12	0.12	0.12	0.00	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
C_{30}	0.24	0.00	0.00	0.24	0.24	0.00	0.03	0.03	0.00	0.00	0.24	0.24	0.17	0.17	0.24	0.24
C_{31}	0.14	0.12	0.12	0.14	0.14	0.12	0.00	0.12	0.12	0.12	0.14	0.14	0.12	0.14	0.14	0.14
C_{32}	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.00	0.07	0.07
C_{33}	0.41	0.36	0.36	0.41	0.41	0.17	0.00	0.36	0.22	0.22	0.36	0.37	0.41	0.41	0.41	0.36
C_{34}	0.36	0.36	0.21	0.21	0.21	0.17	0.00	0.19	0.19	0.19	0.22	0.23	0.36	0.36	0.36	0.36
C_{35}	0.28	0.05	0.00	0.06	0.06	0.05	0.00	0.06	0.00	0.00	0.06	0.07	0.28	0.28	0.33	0.33
C_{36}	0.00	0.23	0.00	0.48	0.48	0.17	0.00	0.30	0.24	0.17	0.48	0.48	0.32	0.48	0.32	0.32
C_{37}	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.27	0.27	0.17	0.00	0.00
C_{38}	0.14	0.00	0.00	0.12	0.12	0.00	0.00	0.00	0.00	0.00	0.12	0.01	0.12	0.12	0.12	0.12

Table 12. Distance of each alternative from the FNIS

Criterion	Alternative															
	A_1	A_2	A_3	A_4	A_5	A_6	A_7	A_8	A_9	A_{10}	A_{11}	A_{12}	A_{13}	A_{14}	A_{15}	A_{16}
C_1	0.00	0.17	0.17	0.17	0.17	0.05	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.05	0.00	0.05
C_2	0.00	0.32	0.33	0.00	0.00	0.06	0.35	0.33	0.35	0.35	0.00	0.00	0.00	0.00	0.00	0.00
C_3	0.00	0.32	0.32	0.32	0.32	0.06	0.33	0.06	0.06	0.06	0.00	0.06	0.05	0.05	0.01	0.06
C_4	0.00	0.02	0.02	0.02	0.02	0.37	0.08	0.08	0.08	0.08	0.02	0.02	0.00	0.00	0.02	0.08
C_5	0.00	0.23	0.23	0.04	0.04	0.23	0.24	0.23	0.24	0.24	0.04	0.04	0.04	0.04	0.04	0.23
C_6	0.00	0.39	0.49	0.35	0.01	0.49	0.49	0.36	0.36	0.49	0.35	0.35	0.00	0.00	0.00	0.00
C_7	0.00	0.30	0.30	0.00	0.00	0.36	0.28	0.27	0.30	0.36	0.00	0.00	0.00	0.00	0.00	0.01
C_8	0.00	0.38	0.38	0.35	0.35	0.38	0.38	0.36	0.48	0.48	0.35	0.35	0.35	0.35	0.35	0.35
C_9	0.00	0.19	0.19	0.00	0.00	0.20	0.20	0.00	0.20	0.20	0.00	0.00	0.00	0.00	0.00	0.00
C_{10}	0.00	0.29	0.29	0.00	0.00	0.28	0.36	0.27	0.29	0.36	0.00	0.00	0.00	0.00	0.00	0.00
C_{11}	0.00	0.05	0.05	0.00	0.00	0.05	0.05	0.00	0.05	0.05	0.00	0.00	0.00	0.00	0.00	0.00
C_{12}	0.35	0.36	0.36	0.00	0.00	0.38	0.38	0.36	0.38	0.38	0.00	0.00	0.36	0.35	0.36	0.36
C_{13}	0.00	0.02	0.00	0.00	0.25	0.06	0.02	0.02	0.02	0.02	0.02	0.02	0.06	0.06	0.25	0.06
C_{14}	0.00	0.00	0.00	0.00	0.23	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.23	0.23	0.24	0.23
C_{15}	0.00	0.02	0.02	0.02	0.14	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.14	0.14
C_{16}	0.00	0.00	0.00	0.00	0.07	0.07	0.00	0.07	0.07	0.07	0.07	0.00	0.07	0.07	0.07	0.07
C_{17}	0.00	0.02	0.02	0.02	0.02	0.02	0.08	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.35
C_{18}	0.00	0.03	0.00	0.00	0.00	0.58	0.03	0.45	0.45	0.45	0.00	0.00	0.00	0.00	0.00	0.00
C_{19}	0.00	0.05	0.05	0.00	0.00	0.17	0.05	0.17	0.17	0.17	0.00	0.00	0.00	0.00	0.00	0.05
C_{20}	0.00	0.03	0.00	0.00	0.03	0.03	0.00	0.03	0.03	0.03	0.03	0.03	0.10	0.10	0.10	0.10
C_{21}	0.00	0.00	0.00	0.00	0.03	0.10	0.00	0.03	0.03	0.03	0.00	0.00	0.00	0.00	0.00	0.00
C_{22}	0.00	0.14	0.14	0.14	0.02	0.00	0.02	0.02	0.02	0.00	0.14	0.14	0.02	0.02	0.02	0.02
C_{23}	0.00	0.07	0.62	0.42	0.00	0.07	0.07	0.42	0.42	0.42	0.07	0.42	0.07	0.00	0.00	0.07
C_{24}	0.00	0.54	0.54	0.54	0.07	0.07	0.07	0.07	0.07	0.07	0.42	0.54	0.42	0.07	0.00	0.07
C_{25}	0.00	0.05	0.05	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.05
C_{26}	0.00	0.46	0.54	0.42	0.42	0.42	0.42	0.42	0.54	0.54	0.07	0.07	0.42	0.42	0.00	0.07
C_{27}	0.01	0.27	0.01	0.27	0.27	0.00	0.00	0.00	0.00	0.00	0.27	0.27	0.01	0.01	0.27	0.27
C_{28}	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00
C_{29}	0.00	0.00	0.00	0.00	0.00	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C_{30}	0.00	0.24	0.24	0.00	0.00	0.24	0.24	0.24	0.24	0.24	0.00	0.00	0.07	0.07	0.00	0.00
C_{31}	0.00	0.02	0.02	0.00	0.00	0.02	0.14	0.02	0.02	0.02	0.00	0.00	0.02	0.00	0.00	0.00
C_{32}	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.00
C_{33}	0.00	0.05	0.05	0.00	0.01	0.34	0.41	0.06	0.32	0.32	0.05	0.05	0.01	0.01	0.01	0.06
C_{34}	0.00	0.01	0.27	0.27	0.27	0.28	0.36	0.27	0.27	0.27	0.27	0.27	0.01	0.01	0.01	0.01
C_{35}	0.05	0.33	0.33	0.32	0.32	0.33	0.33	0.32	0.33	0.33	0.32	0.32	0.05	0.05	0.00	0.00
C_{36}	0.48	0.36	0.48	0.00	0.00	0.38	0.48	0.35	0.36	0.38	0.00	0.00	0.35	0.00	0.35	0.35

C_{37}	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.00	0.00	0.11	0.27	0.27
C_{38}	0.00	0.14	0.14	0.02	0.02	0.14	0.14	0.14	0.14	0.14	0.02	0.14	0.02	0.02	0.02	0.02

Table 13. Closeness coefficient (CC) of each alternative and ranking of alternatives

Alternative	Closeness coefficient	Rank
A_1	0.11	13
A_2	0.54	3
A_3	0.62	1
A_4	0.35	5
A_5	0.30	7
A_6	0.59	2
A_7	0.59	2
A_8	0.49	4
A_9	0.59	2
A_{10}	0.62	1
A_{11}	0.27	9
A_{12}	0.29	8
A_{13}	0.26	10
A_{14}	0.20	12
A_{15}	0.24	11
A_{16}	0.31	6

The ranking of alternatives is done according to the closeness coefficient (CC) and is presented in Table 13. It can be concluded that alternatives "A_3" and "A_{10}" have the highest values, i.e. "Operator with loading machines" and "Stope miner" workplaces are associated with the highest risks (Figure 1). Alternatives "A_6", "A_7" and "A_9" are second in the rank, followed by alternative "A_2", and last ranked alternative is A_1.

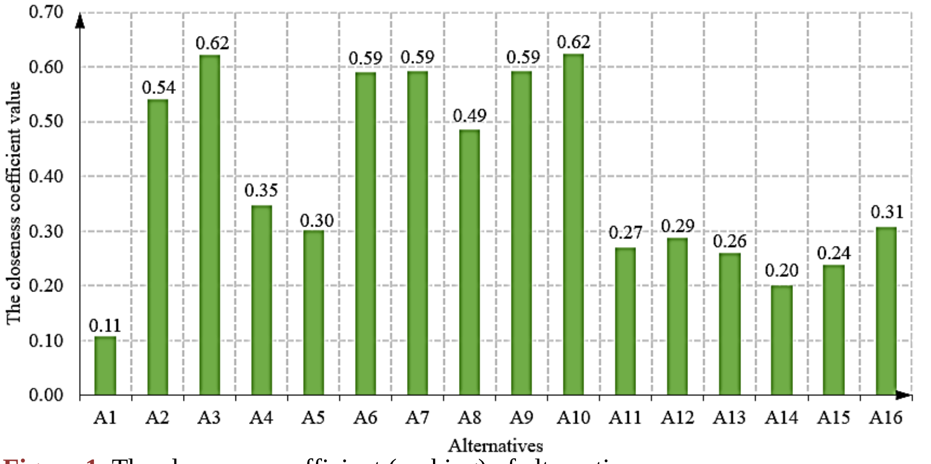

Figure 1. The closeness coefficient (ranking) of alternatives

In general, it can be said that all workplaces in underground mines are high risk workplaces. According to the results obtained by the fuzzy TOPSIS method, the risk at workplaces in underground lead and zinc mines can be divided into two groups:
- High risk workplaces, CC<0.40, (A_4, A_{16}, A_5, A_{12}, A_{11}, A_{13}, A_{15}, A_{14}, A_1);

- Workplaces with very high risk, CC>0.40, (A_3, A_{10}, A_6, A_7, A_9, A_2, A_8).

In order to confirm the reliability of the obtained values for workplace risk assessment using the fuzzy TOPSIS method, an analysis of severe bodily injuries and fatal injuries in three underground lead and zinc mines in the Republic of Macedonia (Sasa Mine, Zletovo Mine and Toranica Mine) for the period from 1992 until 2010 [40, 41] is presented (Table 14).

Table 14. Review of the participation of injuries at work according to the types of activities in which they occurred (1992-2010)

No	Activities in which the injury occurred	Number of serious injuries	Number of serious bodily injuries with fatal consequences	Total
1.	Crumbling rocks in drift and stope	20	19	39
2.	Deblocking ore pass - leakage	1	4	5
3.	Transport by locomotives in mine	6	5	11
4.	Drilling and blasting works and misfired explosives	9	2	11
5.	Surface transport by vehicles	0	1	1
6.	Electric shock	1	1	2
7.	Fall from height	3	3	6
8.	Underground transport with diesel machines	4	1	5
9.	Auxiliary works and others	3	1	4
10.	Total	47	37	84

According to the analysis of activities in which severe bodily injuries and fatal injuries occurred, it can be concluded that the largest number of accidents occurred during the crumbling of rocks in the drift and stope. This confirms the reliability of risk assessment in the workplace, i.e. "Operator with loading machine" and "Stope miner" workplaces have the highest risk, because most accidents happen due to crumbling rocks in the drift and stope.

4. Conclusion

There are several methods for assessing workplace risk, such as KINNEY, BG, IGA, AHP and other methods. In this paper, the fuzzy TOPSIS method was used, which examined 16 workplaces (alternatives) and 38 criteria according to which the workplaces risk assessment was performed.

The application of the fuzzy TOPSIS method for risk assessment in the workplace gives satisfactory results. In that way, precise identification of risks, ranking of workplaces according to risk, as well as the possibility of implementing a plan with measures for control of assessed risks and their elimination can be performed. Numerous decision makers can be involved in risk assessment using this method, taking into account the experience of all of them and obtaining the most optimal risk assessment for the workplace.

Out of the conducted risk assessment at the workplaces, it was concluded that the "Operator with loading machine" and "Stope miner" workplaces have the highest risk, and most accidents occurred due to crumbling on the rocks in the drift and stope. Taking into account the aforementioned, it can be concluded that the application of Fuzzy TOPSIS method provides an accurate workplace risk assessment in underground mines and can be used to verify the results obtained by applying other methods.

The analysis of data obtained by assessing the risk of workplaces in the underground lead and zinc mine, as well as the identified hazards and recorded injuries at work, gave a clear picture of the hazards and damages that require more attention and appropriate measures to eliminate them.

Workplace hazards related to workplace instability, chemical hazards and microclimatic factors must be thoroughly investigated in order to implement appropriate hazard elimination measures as quickly and efficiently as possible.

Conflicts of Interest

There is no conflict of interest.

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