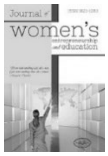
DOI: 10.28934/jwee25.12.pp26-39
JEL: M51

ORIGINAL SCIENTIFIC PAPER

Empowering Women in Agribusiness: A Fuzzy VIKOR Approach to Personnel Selection



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A B S T R A C T

This study addresses the challenges of personnel selection in modern management, particularly focusing on women's roles in agribusiness - a critical sector for economic stability and sustainability. The research method used in the paper was multi-criteria decision-making, or fuzzy logic, in selecting the most suitable candidate as one of the basic goals of work. In these cases, it is necessary to apply fuzzy decision-making logic, which would reduce the existing uncertainty in the selection process. Research shows that including women in the agricultural sector can significantly enhance productivity and innovation, key for maintaining market competitiveness. Also, the application of the Fuzzy VIKOR method identified Candidate 5 as the optimal choice, demonstrating the method's effectiveness in multi-criteria decision-making. The importance of the research is the existence of a good basis for further research on this topic in other areas, as

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well as in the further development of multi-criteria decision-making methods that are used for these purposes.

KEYWORDS: *unemployment, staff selection, agribusiness, Fuzzy VIKOR method*

Introduction

Staff selection in modern management represents a significant challenge, especially regarding women in agribusiness, a sector that is crucial for economic stability and sustainability. Given the global trends emphasizing gender equality and women's empowerment, this topic is becoming increasingly important. Agribusiness, which encompasses all aspects of food production, processing, and distribution, often faces biases and stereotypes that can undermine women's capabilities. Empowering women in this industry is not just a matter of justice but also an economic necessity. Research shows that including women in the agricultural sector can significantly improve productivity and innovation, which are essential for maintaining competitiveness in the market.

However, traditional staff selection methods often rely on subjective assessments and simple quantitative criteria, highlighting the need for innovative approaches that consider the complexity and dynamism of the labor market. One such approach is the fuzzy VIKOR method, which facilitates decision-making under uncertainty by taking multiple criteria into account, such as work experience, education, communication skills, etc. This method can help employers better evaluate candidates and make informed decisions, thereby increasing the chances of success for women in a sector that often favors traditional gender roles.

The initial and main hypothesis of the research is that the research selection process is a complex process that involves the application and inclusion of multiple criteria with the aim of obtaining a rational decision. As a sub-hypothesis in the paper, the question of the role of women in agribusiness, or rather their competence, which is completely equal to men, is imposed, although practice sometimes denies this. For this purpose, it is necessary to use modern methods of multi-criteria decision-making, namely its fuzzy logic due to possible uncertainties and indecision in the decision-maker. The importance of this is especially evident in agribusiness, as a complex business area that includes multiple influencing factors.

Literature Review

As Jovanović (2021) notes, in today's dynamic business environment, there is a constant struggle for survival in the market. Accordingly, the digitalization of organizational units continuously drives the assessment and innovation of existing business models (Perić et al., 2021). The current labor market situation is largely characterized by the employment of efficient personnel. Human resources are an asset in modern business conditions, as they play a crucial role in forming knowledge, education, training, skills, and expertise for work in companies (Aziz et al., 2019). Employees' skills develop over time, respond to the demands of the environment, represent components of behavior structured into coherent models, and, ultimately, cognitive requirements decrease as skills increase (Jovičić et al., 2018). The search for employees with developed awareness of responsibility and self-motivation poses a challenge and an imperative for any serious organization (Dragić et al., 2024). Every employee is a unique individual, and each company is an individual entity (Pavlović et al., 2024). Many authors have studied the phenomenon of unemployment and the factors that influence it (Kovačević et al., 2015; Radović Marković et al., 2019; Cvijanović et al., 2019; Nikitović, Vujičić, 2021; Radović Marković et al., 2021). Tsareva (2021) considers employees to be a unique competitive resource and a source of profit for every organization. Konderman Ilić (2021) states that in modern business conditions, human resources are the most valuable asset that enables the achievement and maintenance of an organization's competitive advantage. Certain skills of employees are crucial for the company's ultimate success and can be considered as competitive advantages. Therefore, they are highlighted during the recruitment process (Rabrenović et al., 2024). Personnel selection presents a significant challenge in modern management, especially in sectors like agribusiness, where gender equality and women's empowerment are particularly important. In recent years, research has focused on the application of innovative methods in the selection process to better meet the complex demands of the labor market. Studies by domestic and foreign authors increasingly apply multi-criteria decision-making methods, especially in the field of agribusiness (Puška et al., 2024; Nedeljković, 2022; Stević, 2019; Puška et al., 2022; Puška et al., 2021; Puška et al., 2023; Joshi et al., 2020; Rahman Muhammad, 2024). Numerous studies have explored the use of MCDM methods in personnel selection. In their study, Alguliyev et al. (2015) propose the application of a multi-criteria model (VIKOR) for evaluating personnel. Additionally, Liu et al. (2015) combine this model to facilitate the selection of appropriate staff, while Ersoy (2017) suggests an algorithm based on fuzzy logic for the VIKOR method. Similarly, in decision-making regarding staff selection, Chen and Wang (2009) use the fuzzy VIKOR method.

Methodology

This research specifically uses the fuzzy VIKOR method for selecting existing candidates. First, a matrix was created with seven criteria and five alternative candidates. The criteria include interview preparedness, work experience, education, interpersonal skills, communication skills, computer proficiency, and foreign language knowledge. Each criterion was assigned to an equal weight of 0.143, reflecting their equal significance.

Subsequently, positive and negative ideal values were calculated for each criterion, allowing for the normalization of the decision matrix. Based on the normalized values, fuzzy numbers S, R, and Q were calculated, representing the group benefit and individual performance of the candidates. The Fuzzy VIKOR method enables the determination of a compromise solution through the analysis of the obtained values. The results of the research are presented below through the steps of the applied research method.

Research Results

The results of the research will be presented through the defined steps of the applied method. The first step is the formation of the initial decision matrix, where seven criteria were used to evaluate five alternatives, or candidates, in the present study. The names of the criteria with the assigned weight coefficients are provided in the following Table 1. The criteria selected were the personal skills of each candidate, and the same weight value was assigned to each criterion.

Table 1: Used Criteria

	Name	Type	Weight
1	Interview preparedness	+	(0.143,0.143,0.143)
2	Work experience	+	(0.143,0.143,0.143)
3	Education	+	(0.143,0.143,0.143)
4	Interpersonal skills	+	(0.143,0.143,0.143)
5	Communication skills	+	(0.143,0.143,0.143)
6	Computer skills	+	(0.143,0.143,0.143)
7	Knowledge of foreign languages	+	(0.143,0.143,0.143)

Source: Authors

The linguistic scale used for the purposes of this research is provided in the following Table 2.

Table 2: Fuzzy Scale

Code	Linguistic terms	L	M	U
1	Very low	0	0	1
2	Low	0	1	3
3	Medium low	1	3	5
4	Medium	3	5	7
5	Medium high	5	7	9
6	High	7	9	10
7	Very high	9	10	10

Source: Puška et al. (2024)

The results obtained using the previous scale and the initial decision matrix are presented in the following Table 3. The results are ratings in the form of arithmetic means, based on the evaluations of all the experts who participated in the research.

Table 3: Decision matrix

	Interview preparedness	**Work experience**	**Education**	**Interpersonal skills**	**Communi-cation skills**	**Computer skills**	**Knowledge of foreign languages**
Candidate 1	(1.800, 3.800, 5.800)	(2.200, 4.200, 6.200)	(3.400, 5.400, 7.200)	(3.200, 5.000, 7.000)	(3.400, 5.400, 7.400)	(3.800, 5.800, 7.800)	(3.400, 5.400, 7.400)
Candidate 2	(2.200, 4.200, 6.200)	(3.000, 5.000, 7.000)	(2.600, 4.200, 6.200)	(3.200, 5.000, 6.800)	(2.200, 3.800, 5.800)	(2.400, 4.200, 6.200)	(2.800, 4.600, 6.600)
Candidate 3	(1.600, 3.400, 5.400)	(2.400, 4.200, 6.200)	(4.400, 6.200, 7.800)	(3.000, 4.600, 6.400)	(2.800, 4.600, 6.600)	(3.000, 5.000, 7.000)	(2.600, 4.600, 6.600)
Candidate 4	(2.600, 4.600, 6.600)	(2.600, 4.600, 6.600)	(5.000, 7.000, 8.600)	(4.200, 6.2000, 8.000)	(3.800, 5.800, 7.800)	(2.600, 4.600, 6.600)	(2.200, 4.2000, 6.200)
Candidate 5	(2.800, 4.600, 6.600)	(3.800, 5.800, 7.800)	(5.400, 7.200, 8.600)	(4.200, 6.200, 8.200)	(3.400, 5.400, 7.400)	(4.200, 6.200, 8.200)	(4.200, 6.200, 8.000)

Source: Authors

The second step involves determining the positive ideal and negative ideal solutions, which were obtained as follows:

$$\tilde{f}_j^* = \underset{i}{Max}\, \tilde{f}_{ij} \qquad i=1, 2, \ldots, n$$

$$\tilde{f}_j^\circ = \underset{i}{Min}\, \tilde{f}_{ij} \qquad i=1, 2, \ldots, n$$

$$\tilde{f}_j^* = \underset{i}{Min}\, \tilde{f}_{ij} \qquad i=1, 2, \ldots, n$$

$$\tilde{f}_j^\circ = \underset{i}{Max}\, \tilde{f}_{ij} \qquad i=1, 2, \ldots, n$$

The following Table 4 shows the results of the previous expressions, i.e., the positive ideal and negative ideal solutions in this case.

Table 4: Positive and negative ideal solutions of the criteria

	Positive ideal	**Negative ideal**
Interview preparedness	(2.800,4.600,6.600)	(1.600,3.400,5.400)
Work experience	(3.800,5.800,7.800)	(2.200,4.200,6.200)
Education	(5.400,7.200,8.600)	(2.600,4.200,6.200)
Interpersonal skills	(4.200,6.200,8.200)	(3.000,4.600,6.400)
Communication skills	(3.800,5.800,7.800)	(2.200,3.800,5.800)
Computer skills	(4.200,6.200,8.200)	(2.400,4.200,6.200)
Knowledge of foreign languages	(4.200,6.200,8.000)	(2.200,4.200,6.200)

Source: Authors

The third step is the calculation of the normalized decision matrix based on the previous positive and negative ideal solutions. These are obtained using the following expressions:

$\tilde{d}_{ij} = (\tilde{f}_j^* \ominus \tilde{f}_{ij})/(r_j^* - l_j^\circ)$ Positive ideal solution

$\tilde{d}_{ij} = (\tilde{f}_{ij} \ominus \tilde{f}_j^*)/(r_j^\circ - l_j^*)$ Negative ideal solution

Where is

$\tilde{f}_j^* = (l_j^*, m_j^*, r_j^*)$

$\tilde{f}_j^\circ = (l_j^\circ, m_j^\circ, r_j^\circ)$

The values of the normalized decision matrix are presented in the following Table 5.

Table 5: The normalized decision matrix

	Interview preparedness	Work experience	Education	Interpersonal skills	Communication skills	Computer skills	Knowledge of foreign languages
Candidate 1	(-0.600, 0.160, 0.960)	(-0.429, 0.286, 1.000)	(-0.300, 0.300, 0.867)	(-0.538, 0.231, 0.962)	(-0.643, 0.071, 0.786)	(-0.621, 0.069, 0.759)	(-0.552, 0.138, 0.793)
Candidate 2	(-0.680, 0.080, 0.880)	(-0.571, 0.143, 0.857)	(-0.133, 0.500, 1.000)	(-0.500, 0.231, 0.962)	(-0.357, 0.357, 1.000)	(-0.345, 0.345, 1.000)	(-0.414, 0.276, 0.897)
Candidate 3	(-0.520 ,0.240, 1.000)	(-0.429, 0.286, 0.964)	(-0.400, 0.167, 0.700)	(-0.423, 0.308, 1.000)	(-0.500, 0.214, 0.893)	(-0.483, 0.207, 0.897)	(-0.414, 0.276, 0.931)
Candidate 4	(-0.760, 0.000, 0.800)	(-0.500, 0.214, 0.929)	(-0.533, 0.033, 0.600)	(-0.731, 0.000, 0.769)	(-0.714, 0.000, 0.714)	(-0.414, 0.276, 0.966)	(-0.345, 0.345, 1.000)
Candidate 5	(-0.760, 0.000, 0.760)	(-0.714, 0.000, 0.714)	(-0.533, 0.000, 0.533)	(-0.769, 0.000, 0.769)	(-0.643, 0.071, 0.786)	(-0.690, 0.000, 0.690)	(-0.655, 0.000, 0.655)

Source: Authors

Step four involves transforming the normalized matrix into a weighted normalized decision matrix then the values $\tilde{S}_i$and $\tilde{R}_i$ can be calculated as follows:

If $\tilde{R}_{\mathrm{i}} = (R_i^l, R_i^m, R_i^r)$ and $\tilde{s}_{\mathrm{i}} = (s_i^l, s_i^m, s_i^r)$

$$\tilde{S}_i = \sum_{\mathrm{j=1}}^{\mathrm{J}} (\widetilde{w}_j \otimes \tilde{d}_{ij})$$

$$\tilde{R}_i = \max_j (\widetilde{w}_j \otimes \tilde{d}_{ij})$$

Step five calculates the value (Q) based on the following expressions:

If $\tilde{Q}_{\mathrm{i}} = (Q_i^l, Q_i^m, Q_i^r)$

$$\widetilde{\mathrm{Q}}_{\mathrm{i}} = v \frac{(\tilde{s}_i \ominus \tilde{s}^*)}{s^{\circ r} - s^{*l}} \oplus (1 - v) \frac{(\tilde{R}_i \ominus \tilde{R}^*)}{R^{\circ r} - R^{*l}}$$

Where is

$$\tilde{s}^* = \min_i \tilde{s}_i$$

$$s^{\circ r} = \max_i \ s_i^r$$

$$\tilde{R}^* = \min_i \tilde{R}_i$$

$$R^{\circ r} = \max_i \ R_i^r$$

The variable *v* representing the maximum group utility is equal to 0.5 in this study.

The fuzzy numbers S, R and Q can be transformed into crisp numbers using the following formula.

If $\tilde{A} = (\mathrm{l}, \mathrm{m}, \mathrm{r})$ ($\tilde{A}$ is expreseed as a fuzzy number)

$$Crisp(\tilde{A}) = \frac{2m+l+r}{4}$$

The following Table 6 shows the fuzzy values S, R, and Q.

Table 6: Values S, R, and Q

	Fuzzy R	Fuzzy S	Fuzzy Q
A1	(0.043,0.043,0.143-)	(0.527,0.179,0.876-)	(0.732,0.127,0.979-)
A 2	(0.019,0.072,0.143-)	(0.429,0.276,0.943-)	(0.648,0.222,1.000-)
A 3	(0.057,0.044,0.143-)	(0.453,0.243,0.913-)	(0.742,0.149,0.991-)
A 4	(0.049,0.049,0.143-)	(0.572,0.124,0.826-)	(0.761,0.124,0.964-)
A 5	(0.076,0.010,0.112-)	(0.681,0.010,0.702-)	(0.856,0.000,0.856-)

Source: Authors

Table 7 below shows the crisp values S, R and Q and Ranking the alternatives based on R, S and Q.

Table 7: The crisp values S, R, Q and alternatives ranking

	Crisp value of R	Rank in R	Crisp value of S	Rank in S	Crisp value of Q	Rank in Q
A 1	0.046	3	0.177	3	0.125	3
A 2	0.067	5	0.267	5	0.199	5
A 3	0.043	2	0.236	4	0.136	4
A 4	0.048	4	0.126	2	0.113	2
A 5	0.014	1	0.01	1	0	1

Source: Authors

Step six involves proposing a compromise solution, where the decision is made based on the values of R, S, and Q in the final descending order of ranking. In this case, there are two conditions under which a set of compromise solutions can be proposed. The conditions and proposed solutions are provided below:

Condition 1. Acceptable advantage: $Q(A^{(2)}) - Q(A^{(1)}) \geq 1/(m-1)$ where $A^{(1)}$ is the alternative with first position and $A^{(2)}$is the alternative with second position in the ranking list by Q. m is number of alternatives.

Condition 2. Acceptable stability in decision making: The alternative $A^{(1)}$ must also be the best ranked by S or/and R.

If one of the previous conditions is not met, a set of compromise solutions is proposed as follows:

Solution 1. Alternatives $A^{(1)}, A^{(2)}, \ldots, A^{(M)}$ if Condition 1 is not satisfied; Alternative $A^{(M)}$ is determined by $Q(A^{(M)}) - Q(A^{(1)}) < 1/(m-1)$ for maximum M (the positions of these alternatives are ‘‘in closeness’’).

Solution 2. Alterntives $A^{(1)}$ and $A^{(2)}$ if only condition 2 is not satisfied.

Solution 3. Alteratives with the minimum Q value will be selected as the best Alternative if both conditions are satisfied.

Table 8: Provides an overview of the aforementioned

Table 8: Result of the conditions survey

Condition 1	Non acceptance
Condition 2	-
Selected solution	Solution 1

Source: Authors

The final alternatives are the candidates in the following order: Candidate 5, Candidate 4, Candidate 1, Candidate 3, Candidate 2.

Conclusion

Agribusiness is a complex activity whose development is influenced by many criteria. Human resources are of particular importance. For this reason, their proper selection is an important aspect of management in this economic area. The results of the research show that the fuzzy VIKOR method is an effective tool for the selection of women in agribusiness, enabling a systematic approach to decision-making. By analysing the candidates, the best candidates were identified based on defined criteria. Candidate 5 was declared the best according to the criteria R, S, and Q, while the other candidates also demonstrated good performance. This approach can serve as a model for future research and applications in the agribusiness sector, providing support for gender equality and women's empowerment. Further studies could focus on expanding the criteria and including other relevant factors that influence success in this sector.

Acknowledgments

Paper is a part of research financed by the MSTDI RS, agreed in decision no. 451-03-66/2024-03/200009 from 5 February 2024.

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Article history: Received: October 31st, 2024

Accepted: March 3rd, 2025

First Online: March 5th, 2025