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SELECTION OF GREEN PACKAGING SUPPLIERS UNDER INTUITIONISTIC FUZZY ENVIRONMENT: CASE STUDY OF AGRO-FOOD COMPANY

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Abstract

The main goal of the performed research is scientific-based selection of supplier of "green" packaging (environmentally friendly) that is adequate for the long-term partnership with the observed enterprise ("Farm Land") active within the agro-food sector. Accomplishment of defined research objective required establishment of research model that involves ten criteria, based on which was analyzed the properness of each of ten potential packaging suppliers. According to existing model, there was developed the research methodology based on the Intuitionistic Fuzzy Set (IFS), due to inclusion of the uncertainty in decision-making process while considering the best possible option for the enterprise. To determine the importance of used criteria, the DiWeC (Direct Weight Calculation) method was used, while the derived results show that the focus during the selection of "green" packaging suppliers has been turned on their products, i.e. mentioned products must be biodegradable, produced from ecological materials, certified and of high quality. Meanwhile, towards the selection of optimal supplier, the CORASO (COMpromise Ranking from Alternative SOlutions) method was used. Performed research shown that in line to analyzed values of preselected criteria, the supplier S3 could serve as the best possible solution for long-term business cooperation. Validity of gained research results was also confirmed by the application of sensitivity analysis. The contribution of performed research is multiple. It primarily supports development of existing MCDM methodology, through testing and designing the new approaches. Then it offers ecological aspect, corresponding to reduction of overall environmental pollution, while it also affects advancement of business activity of observed enterprise.

Key words**:** *suppliers, "green" (ecological) packaging, agri-food industry, intuitionistic fuzzy approach, waste management, decrease in environmental pollution*

INTRODUCTION

Sustainability is one of the key factors in contemporary unstable global business environment [10; 71; 78]. No matter to economy sector, by applying the principle of sustainability, enterprises differentiate themselves towards rapidly growing competition [44]. Nowadays, sustainability has been becoming the widely recognized factor of competitiveness. In practice, the most often it does not imply the fulfillment of all three components of sustainability, emphasizing the economy above all [8; 55]. In recent times, business of the companies from the agri-food sector is affected by the changes emerged due to the increasing demands of final consumers, as well as certain environmental concerns by various groups and activists [21; 66]. By the life logic, food has prefix of ecology before economy, as it is considered as existential factor for humans greatly affecting the health status [38; 42]. Agricultural producers and companies from mentioned sector do not have just to be concerned about environmental impact of the production process, further products logistic and distribution, or product's quality and expected health status [56; 61; 73], but also about how to reduce or even eliminate the pollution caused by food packaging [14; 37, 54]. Due to that in practice are more and more available eco-friendly packaging (use of bio-composite materials characterized by high renewability and biodegradability), which has

negligible or no impact on the environment, i.e. which leaves a shallow environmental footprint [49; 51]. This represents "green" packaging, that tends to be the standard in upcoming future in agri-food sector [47], as administratively driven production and marketing policies for the enterprises are more turned to their social and environmental responsibility [7]. As was previously mentioned, such packaging is made from biodegradable materials, or materials that could be easily recycled, meanwhile fully preserving the food products quality and safety, freshness, chemical and biological composition, texture, etc. [28, 79]. Agri-food enterprises usually do not produce the packaging for their products, while they are procuring it from adequate suppliers [4]. So, the suppliers (producer or distributor of packaging materials) are generally the key factor in supporting enterprises to acquire „green" packaging and implement sustainable practices [46], while adequate selection of "green" packaging supplier represents significant activity that contributes enterprise strivings to reduce its impact on pollution of immediate or wider environment.

Presently, consumers are asking from agri-food enterprises that their products are safe for health [39], while used packaging does not harm the environment [20]. Established trends show that enterprise who uses „green" packaging can improve its market reputation, or even develop, in some extent recognizable brand [67]. Mainly, this is more important for new enterprises that are entering certain market, as they have to fight for the initial market share. Except the agri-food sector, "green" packaging could be used in any sector that practices circular economy, as it affects waste reduction [33; 52]. Briefly, circular economy could be considered as economic mechanism turned to preserving long-distance economic indicators, but under highly optimized use of nonrenewable natural resource and strict reduction or elimination of emerged waste in economic activities (continuity and completity in recycling and reusing). It is part of human strivings to protect available environmental potential and capacity, while fulfilling social needs [72].

Besides environmental impact, the most often, packaging has some additional functions, mainly it protects the product from damaging and external influences, while as a part of marketing strategy it attracts consumers to buy certain products, or it initiates the value-added creation [53; 64]. Therefore, the packaging must be developed or involved in enterprise in cooperation with proper supplier towards the fully achievement of all previously set enterprise's goals. Therefore, developing the long-term cooperation with certain supplier, due to buying „green" packaging, or at the end realizing the enterprise sustainability strategy has been the primary scientific motivation for performing following research.

During the establishment of long-term cooperation with supplier, primarily there has to be determined which supplier can support in the best way achieving the enterprise's goals. This research uses the multi-criteria analysis method, and in order to select some of the alternatives, we must first determine the necessary criteria [5; 45]. The selection concerns suppliers of packaging materials to an agricultural and food company. Selected supplier that is the most suitable solution for enterprise (it satisfies the preset criteria in the best way) will sign the long-term cooperation contract. Preset selection criteria have to represent all things that enterprise expects from suppliers to fit in (facilitators in goals achieving). Traditional MCDM approach has not consider the uncertainty and insecurity in supplier selection. Due to that Intuitionistic Fuzzy Approach (IFS) will be used in performed research. Approach allows the use of subjective evaluations in the form of linguistic terms in order to make a correct decision. Besides, the application of IFS enables enterprise to handle the market changes occurred in dynamic business environment.

In performed research has been involved the enterprise "Farm land" that is active in agri-food sector. As case study, chosen enterprise will serve to show how to select the adequate supplier of „green" packaging applying the intuitionistic fuzzy approach (IFS). So, the main paper goal is to select, using the key criteria analysis and IFS, the best fitting supplier who will enter the long-term partnership with the enterprise "Farm Land" that will enable development of sustainable business. Research goal complexity requires determining of specific goals, as are:

- Identifying available „green" packaging suppliers, as well as key selection criteria;

- Applying IFS due to determination of the weights of key criteria, while further ranking of available suppliers;
- Recommending steps for development of similar research in future.

There is multiple scientific-practical contribution of performed research. Firstly, the development of the methodological framework for the selection of proper supplier involves adjustment of the criteria to enterprise needs. Secondly, theoretical contribution of research could be seen in IFS development appropriate to used methods. Thirdly, the practical contribution of the research assumes the provision of guidelines for enterprises towards selection of "green" packaging suppliers. Fourth, research will serve as the base for development of new approaches for selection of suppliers in further research. Fifth, derived research results will support agri-food enterprises to develop sustainable practices within the supply chain as well as in the entire business.

Literature review

Process of literature review will be focused on few segments, such are: the impact of packaging on environment and human behaving, selection of packaging suppliers, or the use of MCDM methods in selecting adequate packaging and packaging suppliers.

There are several researches that observe the impact of packaging for food products on environment. Some of them have been made retrospection of impacts of packaging on environment in case of online sale [20; 23; 36], while others were turned to investigation in use of nanocellulose as alternative to synthetic packaging films [1; 13; 30], or use of different sensors in packaging due to monitoring the quality of food products, while supporting the recycling processes [17; 63; 85]. More specific, some researches were investigated the use of hydrogels as a valuable sensor in packaging the food products [12; 70; 83]. Some researches have been observed how ecological („green") packaging affects the consumers due to food products purchasing [27; 53; 57], while some of them were focused to impacts of plastic used in food packaging in order to develop strategic approaches to mitigate negative characteristics of plastic on environment [16; 34; 50]. So previous initiate researches considering the issues of plastic packaging for food products from the side of consumers and level of consumers involvement in plastic packaging recycling [82], or systematization of knowledge related to problems occurred in plastic packaging recycling in food sector [22], and difficulties occurred in running sustainable business due to use of plastic packaging for food products [74]. There were also performed certain literature reviews related to „greening" of packaging due to decrease in its impact on environment [41; 69; 80]. In line to previously mentioned scientific references there could be underlined that packaging generally has very strong impact on environment, while its decreasing requires deep awareness and large efforts form overall society.

Otherwise, there were certain research based on MCDM methods use related to supplying of packaging, such is research focused on packaging suppliers for shoe box when was applied DEMATEL (Decision-Making Trial and Evaluation Laboratory), ANP (Analytic Network Process), and WZOGP (Weighted Zero-One Goal Programming) methods [26], or drawing attention to the fact that implementation of QMS (quality management system) and selection of suppliers for packaging and raw materials in meat processing could be key factor affecting the quality and safety of final products [32]. In other research there was selected the packaging suppliers (on the example of the sector of beverage in Pakistan) underlying the implementation of Industry 4.0 concept, when were used FUCOM (Full Consistency Method), MULTIMOORA (Multi-objective Optimization Based on Ratio Analysis with the Full Multiplicative Form) and ODT (Ordinal Dominance Theory), [3], while other research summarized all MCDM methods generally used for supplier selection under industry 4.0 concept [65]. Some research was linked to packaging suppliers and their impact on cutting of packaging costs. For that purpose, targeted programing and ANP and DEMATEL methods have been used [25]. Through other research was made global selection of packaging suppliers required for food packaging due to strivings for reduction of costs occurred in functioning of supply chain [40]. In previous works, certain methods were used to select an adequate sustainable supplier. [81] [84] [9] Some of them were also applicable in the food

industry. On that occasion, they used their fuzzy variant. [2] [24] [29].

Based on made literature review, there can be noticed just few researches focused on selection of „green" packaging suppliers using the MCDM, so this research tried to fill some research gaps. Before all, performed research covers research gap on „green" packaging supplier selection based on MCDM methods, as just very few researches have been done in recent period towards this topic. Secondly, performed research is providing methodological guidelines regarding the preselected criteria that could be used in subsequent research. Third, by the development of intuitionistic fuzzy approach, there will be used some relatively new methods that have not been previously used in this form, expecting their contribution to the development of applied approach in practice. Fourthly, performed research will be also connected with certain postulates of the circular economy, while it will describe one more way how the selection of packaging suppliers can contribute to the improvement of environmental protection activities.

MATERIALS AND METHODS

During the beginning of 80' of the XX century, in order to include uncertainty and insecurity in decision-making processes and procedures, there was developed Intuitionistic Fuzzy Set (IFS) by the Atanassov [6]. Up to current time procedure is tested and widely used in many sectors of economy [15; 18; 19; 43; 75].

Contrary to classic fuzzy theory, where each element of the set has a membership function $(\mu_A(x))$ IFS considers both degree of membership $(\mu_A(x))$ and non-membership $(v_A(x))$ of the set of elements *A*, as well as degree of uncertainty $(\pi_A(x))$. According to that, IFS of set *A* is defined as:

$$A = \{(x, \mu_A(x), v_A(x)) \mathrm{I}\ x \in X\} \quad (1)$$

While the degree of uncertainty $(\pi_A(x))$ is defined as:

$$\pi_A(x) = 1 - \mu_A(x) - v_A(x) \quad (2)$$

IFS is applied when there is uncertainty, subjectivity and insecurity in the available data set which underlies the decision-making process [68]. On the example of selection of „green" packaging supplier, it is very difficult to assess the qualitative criteria, so there is always a certain level of uncertainty within the evaluation. Besides, mentioned evaluations are purely subjective, while there is uncertainty in decision making. Therefore, IFS approach was chosen for performed research. Basic operations with IFS are defined by Atanassov [6], including:

$$A \cap B = \{x, \min(\mu_A(x), \mu_B(x)), \max(v_A(x), v_B(x), \mathrm{I}\ x \in A\} \quad (3)$$

$$A \cup B = \{x, \max(\mu_A(x), \mu_B(x)), \min(v_A(x), v_B(x), \mathrm{I}\ x \in A\} \quad (4)$$

$$A.B = \{x, \mu_A(x).\mu_B(x), v_A(x) + v_B(x) - v_A(x).v_B(x), \mathrm{I}\ x \in A\} \quad (5)$$

$$A + B = \{x, \mu_A(x) + \mu_B(x) - \mu_A(x).\mu_B(x), v_A(x).v_B(x), \mathrm{I}\ x \in A\} \quad (6)$$

$$A - B = \{x, \min(\mu_A(x), \mu_B(x)), \max(\mu_B(x), v_A(x), \mathrm{I}\ x \in A\} \quad (7)$$

For evaluating the importance of preset criteria, while to select adequate suppliers according to these criteria, the same linguistic terms were used (Table 1).

Table 1. Linguistic terms for assessing the criteria importance and supplier's selection

Ling. terms	Abbreviation	IFNs
Extr.-good	E G	[1.00, 0.00]
Very very- good	V V G	[0.85, 0.10]
Very -good	V G	[0.80, 0.15]
Good	G	[0.70, 0.20]
Med.- good	M G	[0.60, 0.30]
Fair	F	[0.50, 0.40]
Med.- bad	M B	[0.40, 0.50]
Bad	B	[0.25, 0.60]
Very- bad	V B	[0.10, 0.75]
Very very -bad	V V B	[0.10, 0.90]

Source: [31].

In order to enable applying of the IFS in decision-making process, firstly the Intuitionistic Fuzzy Numbers (IFN) have to be transformed into ordinary numbers, while some classical methods will be then applied. The steps for IFN transforming are [31]:

Step 1. Determining the importance of decision maker (DM)
Step 2. Evaluation of DMs with grades presented in Table 1.
Step 3. Forming the aggregate decision matrix for IFN. Mentioned matrix is defined as
$\check{R} = \left[\check{A}_{m\alpha}\right]_{nxk}$
Step 4. Determining IFN positive ideal solution (τ^{+}) and negative ideal solution (τ^{-})
Step 5. Determining the measure of distance, by defining the positive (δ_m^{+}) and negative distance (δ_m^{-})

$$\delta_m^{+} = \sqrt{\left(\mu_{\check{A}_m} - \tau^{+}\right)^2 + \left(v_{\check{A}_m} - \tau^{+}\right)^2 + \left(\pi_{\check{A}_m} - \tau^{+}\right)^2} \quad (8)$$

$$\delta_m^{-} = \sqrt{\left(\mu_{\check{A}_m} - \tau^{-}\right)^2 + \left(v_{\check{A}_m} - \tau^{-}\right)^2 + \left(\pi_{\check{A}_m} - \tau^{-}\right)^2} \quad (9)$$

Step 6. Calculating the Closeness Coefficient (CC)

$$CC_m = \frac{\delta_m^{-}}{\delta_m^{+} + \delta_m^{-}} \quad (10)$$

Step 7. Forming the decision-making matrix, as a last step in IFS transformation in ordinary crisp numbers.
First step in any MCDM analysis is determining the weight of criteria. In this research for weights determining has been used DiWeC (Direct Weight Calculation) method. This method was used in several researches, but it has been named, while defining of all method steps was done by Puška and associates [59]. Method belongs to the group of simplest methods for subjective determining of criteria weights. It follows normalization of aggregate criteria evaluation. Steps of method applying are:
Step 1. Evaluation of criteria importance by the DM
Step 2. Appliance of the IFN transformation into the crisp numbers and forming the decision matrix
Step 3. Aggregating the grades per criteria, i.e. summing the all grades for certain criteria

$$v_j = \sum_{j=1}^{n} x_j \quad (11)$$

Step 4. Calculating the weights of criteria

$$w_j = \frac{v_j}{\sum_{j=1}^{n} v_j} \quad (12)$$

After determining the weights of individual criteria, there has to rank the suppliers according to previously given ratings by the DM. In practice, there are many methods that can be used for ranking the suppliers. In this research, the CORASO (COMpromise Ranking from Alternative SOlutions) method was chosen. This is a newly developed MCDM method that ranks the available alternatives due to solution alternatives, which represent the maximal and minimal values of alternatives for individual criteria. The CORASO method was used in order to propagate its application in practice, as in some of previous research of Puška et al. [58] there was demonstrated that method could give similar results to other alternative ranking methods. The steps of the method are:
Step 1. Evaluation of alternatives by selected criteria
Step 2. Appliance of IFN transformation into the crisp numbers and forming the decision matrix
Step 3. Normalization of decision matrix

$$n_{ij} = \frac{x_{ij}}{\max x_j}; \text{ for benefit criteria} \quad (13)$$

$$n_{ij} = \frac{\min x_j}{x_{ij}}; \text{ for cost criteria} \quad (14)$$

Step 4. Determining the alternative solutions
Step 5. Weighting

$$v_j = w_j \cdot n_{ij} \quad (15)$$

Step 6. Forming the aggregate values

$$S_j = \sum_{i=1}^{n} \tilde{v}_j \quad (16)$$

Step 7. Deviation form alternative solutions

$$R_j = \frac{S_j}{S_{j\,max\,AS}} \quad (17)$$

$$R'_j = \frac{S_{min\,AS}}{S_j} \quad (18)$$

Step 8. Results defining for CORASO method

$$Q_i = \frac{R_j - R'_j}{R_j + R'_j} \quad (19)$$

Case study "Farm Land" enterprise

The enterprise "Farm land" is one of the newly established but promising legal entities engaged in agri-food production at national level, located in the Brcko District, Bosnia and Herzegovina. Striving to establish a recognizable brand on the market, enterprise have been decided to use “green” (environmentally friendly) packaging, while distancing itself from the competition. For procuring “green” packaging there are identified ten possible suppliers on the market, from whom the enterprise could purchase needed input. As it wants to improve its business, enterprise is decided to identify which of these ten suppliers

would be the most suitable for establishing a long-term cooperation. Therefore, selected supplier has to meet certain criteria. Initially, enterprise has selected five decision makers (DM), i.e. its employees who will evaluate the importance of predefined criteria, and then preselected suppliers. These DMs are selected according to their experience, as all of them had to have at least ten years of experience in agri-food production, specifically in relations with suppliers.

The criteria selected by experts, or decision-makers, at one of the previous meetings were of an economic and environmental nature. In order to make evaluation procedure easier, there was decision to select just ten criteria. Each of the DMs proposed certain criteria, while in total there was collected 23 criteria. Explaining the importance of each criteria by DMs, list with criteria was gradually shortening (by joint DMs decision), until finally list of ten criteria were selected, as they fit the best preset business goals of the "Farm land" enterprise (Table 2).

Table 2. Criteria for selection of "green" packaging supplier

Id	Criteria	Description	Reference
C1	Packaging quality	Complying the quality standards in terms of basic functions of packaging	[32; 53; 80]
C2	Packaging price	Value paid for packaging as ratio between the packaging costs and value	[22; 32; 53; 82]
C3	Delivery date	Supplier's capability to deliver the products on time and in volume that overlaps with enterprise need	[3; 32; 83]
C4	Reputation	Current supplier's reputation	[3; 82]
C5	Innovativeness	Possibility of supplier to adjust the requests and offer innovated packaging	[3; 80]
C6	Ecological certificate	Possession of ecological certificates and their usability in practice	[3; 32]
C7	Waste management	Practices oriented to decrease in volume of waste during the common business activity, or reuse policies	[22; 53; 80; 82]
C8	Bio-degradability	Capability of packaging material to decompose in nature without negative environmental impact	[22; 53; 80]
C9	Ecological material	Use of environmentally friendly materials that do not leave, or leave so shallow environmental footprint	[3; 20; 80]
C10	Recycling the packaging	Possibility to easily recycle the packaging material if it is not bio-degradable	[20; 22; 53; 80; 82]

Source: Developed by authors.

After defining the criteria that will serve for reconsideration of available suppliers of „green" packaging, DMs have been evaluated the importance of each criteria, while evaluated the preselected suppliers according to predefined criteria. In order to facilitate the selection process, there was used the same value scale to determine the criteria importance and to evaluate suppliers. Besides, construction of used linguistic terms, Table 1 has allowed DMs not to think about criterion's types, what additionally made their work easier. Based on the preselected criteria and suppliers, there was created the adequate questionnaire, while distributed to all DMs. After completing the questionnaire, gained datasets were prepared for further MCDM analysis. Further suitability of available suppliers for long-term contracting was done by the use of IFS, where the DiWeC method was applied to determine the importance (weight) of predefined selection criteria, while CORASO method was performed to rank the available suppliers that meet initially set criteria.

In order to confirm the derived research results, or to determine which criterion causes the largest effects on process of adequate supplier selection, a sensitivity analysis was additionally performed, i.e. there was determined the impact of certain criteria on the final ranking of suppliers.

RESULTS AND DISCUSSIONS

Research results

Determining which of available suppliers have and offer the most suitable characteristics in line to enterprise's needs, or to determine which supplier is the best option for long-term cooperation with the enterprise "Farm Land", initially there has to be determined the importance (weight) of each individual criterion used in supplier's assessment. Mentioned requires expert evaluation of preselected criteria by linguistic terms (Table 3).

Table 3. Importance of criteria according to DM's evaluation

No.	Criteria	DM1	DM2	DM3	DM4	DM5
C1	Packaging quality	VVG	VVG	EG	VVG	EG
C2	Packaging price	VG	VG	VG	G	G
C3	Delivery date	G	G	VVG	MG	VG
C4	Reputation	VVG	MG	VG	VVG	G
C5	Innovativeness	VG	F	G	VG	MG
C6	Ecological certificate	EG	VVG	EG	EG	VVG
C7	Waste management	VVG	VG	VVG	VVG	VG
C8	Bio-degradability	EG	EG	VVG	EG	VVG
C9	Ecological material	EG	VVG	EG	EG	VVG
C10	Recycling the packaging	VVG	VG	VG	VVG	VG

Source: Developed by authors.

Later, it is transformed into the IFS, while degree of uncertainty will be determined. For example, the linguistic term VVG (very very good), as the most represented, will be transformed into [0.85, 0.10], while based on this, the degree of uncertainty has been calculated as: 1 - 0.85 - 0.10 = 0.05. In same way there will be transformed other values, but with the use of membership functions (Table 1).

The next step in this simplified methodology is to determine the average values for all IFS parameters (Table 4).

Table 4. Calculations by DiWeC method

no.	μ	N	Π	δ+	δ-	CW	W
C1	0.910	0.060	0.030	0.112	1.309	0.921	0.108
C2	0.760	0.170	0.070	0.302	1.128	0.789	0.093
C3	0.730	0.190	0.080	0.340	1.093	0.763	0.090
C4	0.760	0.170	0.070	0.302	1.128	0.789	0.093
C5	0.680	0.240	0.080	0.408	1.023	0.715	0.084
C6	0.940	0.040	0.020	0.075	1.344	0.947	0.111
C7	0.830	0.120	0.050	0.214	1.211	0.850	0.100
C8	0.940	0.040	0.020	0.075	1.344	0.947	0.111
C9	0.940	0.040	0.020	0.075	1.344	0.947	0.111
C10	0.820	0.130	0.050	0.228	1.197	0.840	0.099
					sum	8.508	

Source: Developed by authors.

On the example of criterion C1 – Packaging quality, it looks as:

$\bar{\mu}_1 = \frac{0.85+0.85+1+0.85+1}{5} = 0.910; \bar{v}_1 = \frac{0.10+0.10+0.00+0.10+0.00}{5} = 0.060;$

$\bar{\pi}_1 = \frac{0.05+0.05+0.00+0.05+0.00}{5} = 0.030$

In same manner there will be calculated the average value for other criteria. Then, the measures of distance are determined as they are required for calculating the positive and negative distances. For example, for criterion C1, it looks like as:

$\delta_1^+ = \sqrt{(0.910-1)^2 + (0.060-0)^2 + (0.030-0)^2} = 0.112$

$\delta_1^- = \sqrt{(0.910-0)^2 + (0.060-1)^2 + (0.030-0)^2} = 1.309$

At the end, there was calculated the Closeness Coefficient under previously defined procedure:

$CC_1 = \frac{1.309}{0.112 + 1.309} = 0.921$

Then, using derived coefficient the value of weights was determined, i.e. each individual coefficient was divided by the sum of all coefficients. On example of criterion C1, calculating process could be presented as:

$w_1 = \frac{0.921}{8.508} = 0.108$

According to DM's evaluations, it is obvious that three criteria had been marked with the same importance: C6 - Ecological certificate, C8 – Biodegradability, and C9 - Ecological material. Frankly, importance of these criteria was somehow expected, since in focus was selection for supplier of green packaging. Mentioned criteria are followed by C1 – Packaging quality, what was also expected.

After determining the importance of criteria, in next step, there was done the ranking of preselected suppliers. As in case of determination of criteria importance, initially was done the evaluation of alternatives by the use of preset criteria and linguistic terms (Table 5.).

Table 5. Evaluation of suppliers by DMs

DM1	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
Supplier 1 (S1)	VG	MG	G	VG	G	VVG	VG	VVG	VVG	VG
Supplier 2 (S2)	VVG	F	MG	VVG	VG	VG	G	VG	VG	G
Supplier 3 (S3)	EG	G	VG	EG	VVG	EG	VVG	EG	EG	VVG
Supplier 4 (S4)	G	G	MG	G	MG	G	G	G	G	G
Supplier 5 (S5)	MG	VG	G	MG	MG	MG	MG	MG	MG	MG
Supplier 6 (S6)	VG	MG	G	VG	G	VG	G	VG	VG	G
Supplier 7 (S7)	VVG	MG	VG	VVG	VG	VVG	VG	VVG	VVG	VG
Supplier 8 (S8)	G	G	MG	G	MG	MG	MG	G	G	MG
Supplier 9 (S9)	VVG	G	VG	VVG	VG	VVG	VG	VVG	VVG	VG
Supplier 10 (S10)	VG	MG	G	VG	G	VG	G	VG	VG	G
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
DM5	**C1**	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**C8**	**C9**	**C10**
Supplier 1 (S1)	VG	MG	G	VG	G	VVG	VG	VVG	VVG	VG
Supplier 2 (S2)	VVG	F	MG	VVG	VG	VG	G	VG	VG	G
Supplier 3 (S3)	EG	G	VG	EG	VVG	EG	VVG	EG	EG	VVG
Supplier 4 (S4)	G	G	MG	G	MG	G	G	G	G	G
Supplier 5 (S5)	MG	VG	G	MG	MG	MG	MG	MG	MG	MG
Supplier 6 (S6)	VG	MG	G	VG	VG	VG	G	VG	VG	G
Supplier 7 (S7)	VVG	MG	VG	VVG	VG	VVG	VG	VVG	VVG	VG
Supplier 8 (S8)	G	G	MG	G	MG	MG	MG	G	G	MG
Supplier 9 (S9)	VVG	G	VG	VVG	VG	VVG	VG	VVG	VVG	VG
Supplier 10 (S10)	VG	MG	G	VG	G	VG	G	VG	VG	G

Source: Developed by authors.

The further procedure is similar to this active in the DiWeC method, except that a Closeness Coefficient is calculated for each criterion. Using this procedure, a summarized decision matrix is formed (Table 6).

Table 6. Aggregate decision-making table

no.	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
Supplier 1 (S1)	0.772	0.645	0.703	0.821	0.741	0.869	0.821	0.850	0.850	0.789
Supplier 2 (S2)	0.840	0.549	0.645	0.850	0.789	0.821	0.741	0.789	0.789	0.703
Supplier 3 (S3)	0.921	0.741	0.821	0.947	0.869	1.000	0.869	0.947	0.947	0.869
Supplier 4 (S4)	0.684	0.741	0.645	0.741	0.645	0.741	0.703	0.703	0.703	0.703
Supplier 5 (S5)	0.607	0.821	0.741	0.645	0.645	0.645	0.645	0.645	0.645	0.645
Supplier 6 (S6)	0.772	0.645	0.741	0.789	0.772	0.789	0.741	0.805	0.798	0.703
Supplier 7 (S7)	0.840	0.645	0.821	0.850	0.821	0.869	0.821	0.850	0.850	0.821
Supplier 8 (S8)	0.684	0.741	0.645	0.741	0.645	0.645	0.645	0.703	0.703	0.645
Supplier 9 (S9)	0.840	0.741	0.821	0.850	0.821	0.869	0.821	0.850	0.850	0.821
Supplier 10 (S10)	0.772	0.645	0.741	0.789	0.741	0.789	0.741	0.789	0.789	0.703

Source: Developed by authors.

Later, based on that steps of the CORASO method are performed.

The mechanism of the CORASO method will be explained at the example of the first supplier (S1) and for the first criterion (C1).

First step is normalization, where at each criterion individual values are divided with maximal value in observed criterion.

$$n_{11} = \frac{0.772}{0.921} = 0.839$$

Further, alternative solutions have been determined.

There has be underlined that the maximum alternative solution is actually the maximal value of alternative for each criterion, while the minimum alternative solution is the minimal value of alternative for each criterion.

Then the weighting process has been done, when the normalized values are multiplied by the weights.

$v_1 = 0.108 \cdot 0.839 = 0.091$

In next step, the aggregate values are calculated, or for each alternative is determined the aggregate value (S_j), while the same is done for alternative solutions too (Table 7).

Then the level of deviation from alternative solutions are calculated, as well as the final values of the CORASO method are determined (Table 7).

$$R_1 = \frac{0.8729}{1.0000} = 0.8729;$$

$$R'_1 = \frac{0.7003}{0.8729} = 0.8023;$$

$$Q_1 = \frac{0.8729 - 0.8023}{0.8729 + 0.8023} = 0.0421$$

Table 7. Results gained by CORASO method

No.	S_j	R_j	R'_j	Q_i	Rank
Supplier 1 (S1)	0,8729	0,8729	0,8023	0,0421	4
Supplier 2 (S2)	0,8324	0,8324	0,8413	-0,0054	6
Supplier 3 (S3)	0,9909	0,9909	0,7067	0,1674	1
Supplier 4 (S4)	0,7776	0,7776	0,9006	-0,0733	8
Supplier 5 (S5)	0,7415	0,7415	0,9445	-0,1204	10
Supplier 6 (S6)	0,8376	0,8376	0,8361	0,0009	5
Supplier 7 (S7)	0,9080	0,9080	0,7713	0,0814	3
Supplier 8 (S8)	0,7539	0,7539	0,9290	-0,1041	9
Supplier 9 (S9)	0,9188	0,9188	0,7622	0,0931	2
Supplier 10 (S10)	0,8315	0,8315	0,8422	-0,0064	7
MAX AS	1.0000				
MIN AS	0.7003				

Source: Developed by authors.

Derived results are shown that the supplier S3 has the best indicators, followed by suppliers S9, and S7. Supplier S5 has the worst indicators based on DMs evaluation. So, the supplier S3 is the most suitable for the long-term contracting, while it could affect further business improvements of the „Farm land" enterprise.

Validation of gained research results and determining the impact intensity of certain criteria on ranking of suppliers is performed by sensitivity analysis. So, analysis aims to determine how much the change in criteria weights affects the ranking of available alternatives. Sensitivity analysis could be done in several ways [77]. In this research are applied two different methods of sensitivity analysis. The first one uses the weights obtained by the Simple Weight Calculation (SiWeC) method as was tested in some previous research [58]. Establishment of the scenarios for this analysis considers that individual criterion is reduced by 90% while other criteria are increased by 10%, keeping the overall sum of criteria weights approximately around one. So, the first scenario is formed as the weight of criterion C1 is reduced by 90%, while the other criteria (C2-C10) are increased by 10%. Then, the other scenarios are created in a similar way, with the weight being changed for the next criterion C2, C3, ... C10.

The second sensitivity analysis is performed independently of the gained weights for the observed criteria. Within this analysis there are created special scenarios when one of the criteria is favored, while the other criteria are given less importance. So, for example, to one of the criteria is given a weight of 0.28, while the other criteria are weighted with 0.08. In such a way, there are formed in total 10 scenarios, since there are 10 criteria in performed research.

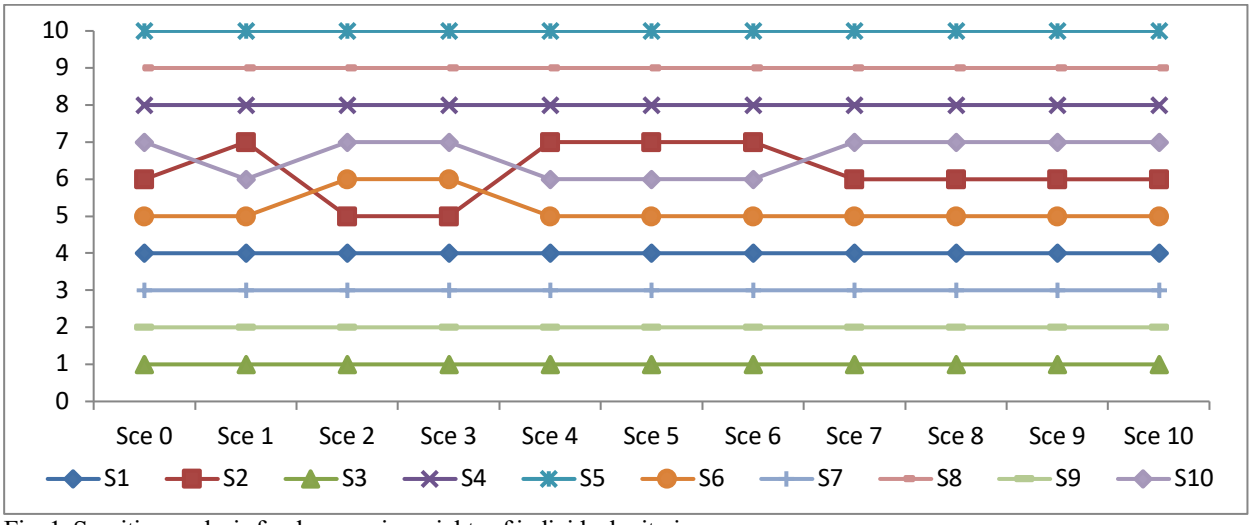

Fig. 1. Sensitive analysis for decrease in weights of individual criteria
Source: Developed by authors.

The results derived from the first sensitivity analysis (Figure 1) show that the ranking order of the first four suppliers has been remained the same, as well as for the three worst ranked

suppliers. Meanwhile, for suppliers ranked from fifth to seventh place, there came to change in ranking. Mentioned is caused by the fact that those three suppliers had similar ratings, so small change in weight of criteria could affect their final ranking. If supplier S6 is observed, it has changed its ranking order in two scenarios (Scenarios 2. and 3.). That was caused as supplier S6 had better values for criteria C2 and C3 compared to supplier S2. Due to decrease in importance of these two criteria, supplier S2 had a better ranking order than supplier S6. In the same way could be explained other changes in supplier's ranking.

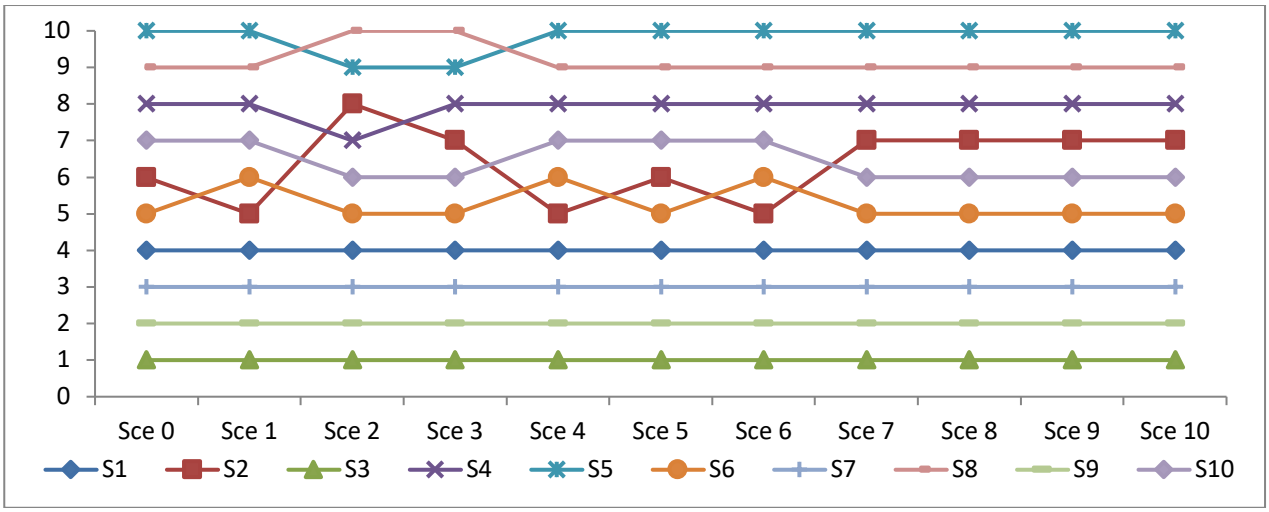

Fig. 2. Sensitive analysis for giving larger importance to individual criteria
Source: Developed by authors.

By observing both images, it can be seen that the ranking order of these three suppliers, that changed the places in the first analysis, is actually inverted. A supplier that in certain scenario was better in the first analysis found itself worse in the second analysis. Of course, in second analysis comes to minor deviations, as the initial weight of criteria was not used.

Such a ranking was somehow expected, as in the first analysis the individual value of weight of certain criterion decreased, while in the second analysis the value of same criterion has increased. If there comes that certain supplier is better in the second analysis, that means it had better values for certain criterion compared to another supplier.

Performed sensitive analysis are shown that previously established supplier's ranking remains the same, confirming the derived results and conclusion that the supplier S3 sounds as the best alternative for long-term contracting.

Discussions

For business venture of any enterprise suppliers have huge importance [48]. In practice, there are not too many enterprises that succeed to complete its overall business process. For this reason, they have to purchase certain inputs from suppliers, whether it is raw material, services, semi-finished products, packaging material, etc. [76]. At agri-food products, especially at agricultural products, the product itself does not pollute or leave so shallow footprint in environment, while the packaging of mentioned products usually has negative effects on environment [3; 11]. According to mentioned, enterprise "Farm Land" strives to acquire environmentally acceptable packaging in order to distance itself from competition. Besides, in this way it tries to improve its brand, providing more value to consumers than they expect [35].

Research was performed with the goal to select proper green packaging supplier that will serve as long-term cooperator of the enterprise "Farm Land". Process was supported by adequately developed methodology, while criteria selection for supplier assessment had strong environmental tone. Research considers 10 predefined criteria for observing economic and environmental dimensions of potential suppliers. So basically, there was done selection of green supplier [62], that delivers green packaging. So, research additionally underlines environmental importance that food packaging should be generally green,

without impact on environment and human health. By research was once again touched the global problem of plastic waste or packaging that is non-degradable and not recyclable [22; 86].

Selecting the most optimal supplier of „green" packaging, as potential long-term partner of the enterprise "Farm Land", requires defining five DMs who will assessed the preset selection criteria and preselected suppliers. The IFS approach was used for determining the criteria importance and ranking the suppliers. The reason why this approach was used, while not the usual fuzzy approach, is the fact that DMs are not always in position to have all necessary information required for decision making. Therefore, there always exists certain level of uncertainty in decision making process. So, unlike classic fuzzy sets, IFS insert this uncertainty into IFN, while enabling proper decision.

Results derived from this approach applying (including DiWeC method) have been showed that, according to DMs opinion, the most important criteria are ecological certificates (environmental friendliness of packaging), biodegradability, use of ecological materials and quality of packaging. In line with mentioned, the focus in process of selecting suppliers was on their products. Of course, besides aspect of "greening", there should be also required the basic function of packaging, its ability to preserve the agri-food products. To other assessed criteria were given a lower importance, for example the weight of innovation criteria is for 25% less than the weights of the most important criteria. During the ranking of suppliers by the CORASO method, derived results have been showed that supplier S3 has the most desired characteristics. According to the performed sensitivity analysis, i.e. changing the weights of observed criteria, there are concluded that DMs generally agreed with the assessed criteria for the top four suppliers, as their ranking order does not change due to changes in the weight of the criteria. So, validation shows correctness of gained results in previously selected supplier for the „Farm Land" enterprise. Establishing of long-term cooperation between the legal entities could be the win-win situation for both of them.

Results of performed sensitivity analysis have been verified the previously gained results by CORASO method. Wherever was small difference between the observed suppliers after appliance of CORASO method, there were later come to change in ranking during the sensitivity analysis. Besides, results under CORASO method could theoretically range from minus one (-1) to man (1). If gained results are closer to one, they show greater dominance of certain alternative over others, or if gained results are closer to minus one, they show how much worse are the results of certain alternative than others. In this way derived results from CORASO method could be used, due to examine what alternative and for how much is better than other alternatives.

Research implications

Performed research indicated significant implications on theoretical and practical development of the "green" packaging issue. Initially, research requested development of relevant methodological frameworks used for selecting potential suppliers. Preselected criteria have strong environmental focus, i.e. its considered ecological dimension of packaging, as packaging have much expressed impact on environmental cleanness than agri-food products. So, from supplier is expected to boost the environmental aspect of enterprise business sustainability. Further, research implication is in applying and testing certain elements of IFS methodology. By purpose, although specific, methodological approach was simplified, striving to enable wider application of used methods in practice. Efforts have been directed in inclusion of uncertainty and insecurity in decision-making process, while to make their transformation into some classic approach that uses crisp values. In this way, decision-making activity is facilitated even for those DMs who have no deep prior knowledge about used MCDM approach. By applying the CORASO method, there are given certain indications for further development of this method, i.e. mentioned method is newer method and so far, it has been used just in fuzzy and crisp form. Using this method at IFS strongly contributes to its further theoretical and practical development. One of the most important research implications is tendency to apply sustainability concept in certain agri-food enterprise in its overall cycle of business. In this process supplier has crucial role as enterprise is buying several inputs from him, including packaging. Avoiding the economic trap, „garbage in - garbage out",

what could endanger the sustainability even survival of enterprise, mutual correspondence has to be based on trust. So, (un)consciously supplier supports building and keeping the business sustainability at enterprise.

Limitations and further research steps

Research has certain limitations that have to be exceeded in upcoming period. Limitations are mostly turned to the appliance of criteria for supplier's selection. Previously was mentioned that initially 23 criteria were identified that could be used in selection of adequate supplier. But, it is so hard to identify and use unified all criteria with potential impact in certain research.

Therefore, in future research, as many criteria and as many experts as possible should be involved in research in form of preliminary activities. After grouping of all criteria by their specificities, while determining which of them affect the most the process of suppliers' selection, there will be done final selection of criteria that will be used in research. This process could also facilitate performing of some future research on same or similar issue. Besides, research limitation could be number of DMs (respondents), due to the fact that enterprise „Farm Land" belongs to the group of legal entities with a several employees involved in decision making process. Option could have been involvement of external experts, but in the end, by the economic logic, they cannot be the part of final decision, as it has to be made by enterprise management. The use of IFS can be also characterized as research limit, as there are several other approaches appropriate for decision-making. Therefore, in future research, available approaches could be compared, with development of certain guidelines for presenting available approach, while suggesting to which situation they fit the best.

CONCLUSIONS

Performed research was oriented to examining suppliers of "green" packaging, as a part of enterprise (Farm Land) strivings to impact the reduction in its environmental footprint. Enterprise is trying to build a competitive brand. Enterprise marketing logic was to offer recognizable products by applying "green" (environmentally friendly) packaging. Therefore, it requires long term cooperation with reliable local supplier of "green" packaging. Selection of adequate supplier was based on combination of preselected economic and environmental criteria. Besides, IFS approach was applied, trying to incorporate uncertainty in decision making. Derived results (based on DiWeC and CORASO methods) have directed the research focus and final decision to final product (quality and environmental suitability of packaging). Opposing the preselected criteria and characteristics of available suppliers, as the best possible solution for the enterprise is underlined the supplier S3, expecting that after the establishment of mutual long-term cooperation, supplier would affect improvement of overall enterprise business sustainability.

Performed research gained following contributions:

- Establishment of methodological framework for selection of „green" packaging supplier.
- Use of "green" packaging at enterprise "Farm land" will support establishment of recognizable enterprise's brand, while to decrease the negative impact on environment.
- Supplier of „green" packaging will contribute to decrease of negative impact on environment in enterprise „Farm land".
- Simplified IFS approach was presented in order to promote its more frequent use in practice.
- There are established certain guidelines how could be improved ecological sustainability of the enterprise by adequate supplier selection and green packaging use.

Briefly, used methodology and criteria have been demonstrated one simple and flexible way for green packaging supplier selection, that has to be further developed in upcoming research.

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