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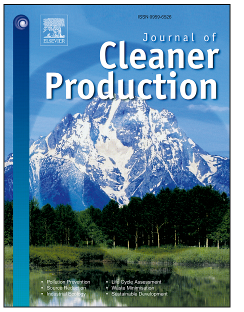

Determination of the Best Strategies for Development of Organic Farming: A SWOT – Fuzzy Analytic Network Process Approach

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Title:

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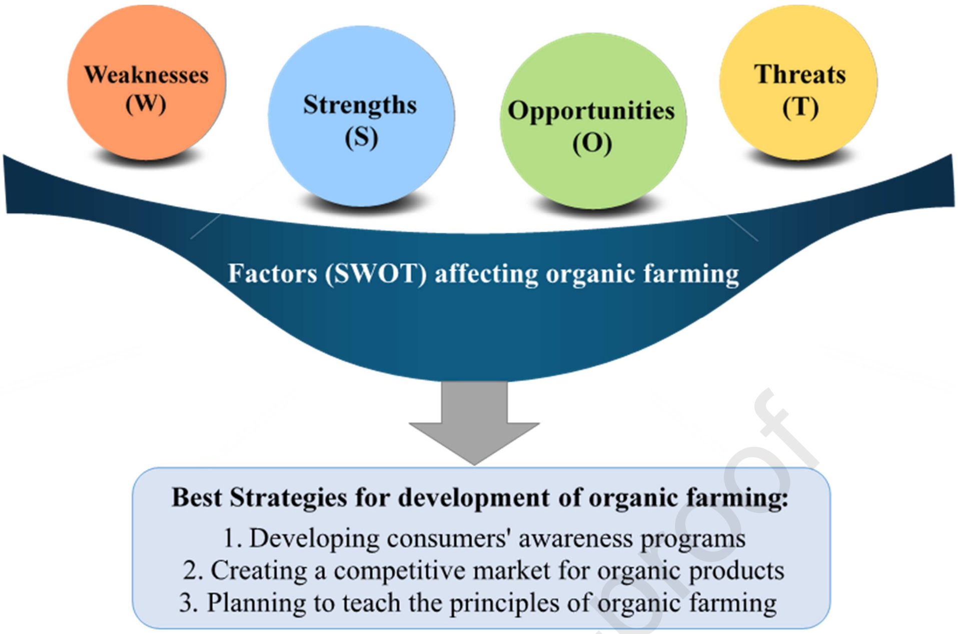
Weaknesses
(W)
Strengths
(S)
Opportunities
(O)
Threats
(T)
Factors (SWOT) affecting organic farming
Best Strategies for development of organic farming:
1. Developing consumers' awareness programs
2. Creating a competitive market for organic products
3. Planning to teach the principles of organic farming

Determination of the Best Strategies for Development of Organic Farming: A SWOT – Fuzzy Analytic Network Process Approach

Abstract

Organic farming pursues sustainable agricultural development and improves the sustainability of food systems. Hence, policy makers and researchers around the world tried to develop it focusing on some factors and large areas. However, organic farmlands have been recently decreasing in some countries. The goal of this study is to determine the best strategies for development of organic farming based on comprehensive factors affecting organic farming, considering the interdependence among them under the uncertainty in the decision-making environment with a focus on Iran's Khorasan Razavi province, a country suffering from a decrease in organic farmland. In this study, Strengths, Weaknesses, Opportunities, and Threats (SWOT) analysis, fuzzy theory, and Analytic Network Process (ANP) method were utilized. Based on interview with 20 organic farming experts and the SWOT analysis, 28 factors affecting organic farming were identified and nine possible strategies for organic farming development were defined. The results of fuzzy and ANP methods indicated that developing consumers' awareness programs is the best strategy with the priority of 0.276, followed by creating a competitive market for organic products, and planning to teach the principles of organic farming with the priority of 0.262 and 0.230, respectively. The findings provide guidelines for decision makers involved in organic farming development.

Keywords: Consumers' awareness programs, Development, Fuzzy Analytic Network Process, Organic farming, Strategy, SWOT Analysis.

1. Introduction

One of the most important challenges of human society is meeting the food demand of the world's growing population (Davis et al., 2016), which is predicted to increase to 9.7 billion in 2050 from current 7.7 billion (United Nations Report, 2019). Although feeding such a population involves an increase in agricultural production, many restrictions exist in the use of natural resources, energy, and farmlands (Bayramov, 2018). Modern farming has reduced resource constraints and increased agricultural productivity through the Green Revolution and the application of chemical inputs, machinery, irrigation systems, and genetic engineering (Tsvetkov et al., 2018). Nevertheless, the use of chemical inputs like pesticides, chemical fertilizers, and heavy metals has created serious environmental and health problems (Udeigwe et al., 2015).

For example, soil degradation (Liu and Xie, 2018), contamination of surface and groundwater (Zhang et al., 2018), as well as reduction in crop yields (Rahman and Zhang, 2018) and greenhouse gas emissions (Shakoor et al., 2018) are some of the adverse effects of chemical inputs. In addition, environmental pollution (Cai et al., 2018), dangerous human and animal diseases (Nicolopoulou-Stamati et al., 2016), and reduced biodiversity (Wintermantel et al., 2018) have resulted from the use of the chemical inputs.

Organic farming is well known as a feasible solution for modern farming crisis. Organic farming is defined as a production system that promotes human, plant, animal, and soil health, sustains ecological systems and biodiversity, ensures fairness regarding the environment and life opportunities, and preserves the health of future generations and the environment, which refer to IFOAM's four principles of Health, Ecology, Fairness, and Care (IFOAM, 2016). The use of synthetic or chemical fertilizers and pesticides in organic farming is prohibited, relying instead on bio-fertilizers, natural pathogen, and pest control (Fess and

Benedito, 2018). Thus, organic farming pursues sustainable agricultural development in the long run (Smith and Lampkin, 2019) and contributes to improving the sustainability of food systems (Muller et al., 2017).

Organic farming has had a significant development around the world in recent years. As the surveys by Research Institute of Organic Agriculture (FiBL) and IFOAM in 2019 show, organic farming is practiced in 181 countries on 69.8 million hectares of farmland, which constitutes almost 1.4% of the world farmland. Many countries have experienced an increase in organic farmland. For example, organic farmland increased by 32% and 12% in China and Argentina, respectively, in 2017 compared with 2016. However, it decreased in some countries like Iran, Kazakhstan, and Ukraine. Furthermore, no change has been observed in the growth rate of organic farmland in some other countries including the U.S., Japan, and Mexico in recent years (Willer and Lernoud, 2019).

Although the growth rate of organic farmland in these countries is negative or zero, consumers' tendency for organic products has increased. Consumers' knowledge of the health, taste, quality and environmental friendliness of organic products (Bryla, 2016) and their concerns about food quality (Rahmati Ghofrani et al., 2017) has made them more inclined towards buying these products (Jarczok-Guzy, 2018). This in turn, has created a potential market for organic products in those countries (Bondar, 2016). In fact, the global interest in organic foods has increased the global sales of organic food from $15 billion to $97 billion in the last two decades. Furthermore, many countries in North America and Europe, and some countries in Asia, Latin America and Africa are expanding their share of the global organic market (Willer and Lernoud, 2019). Hence, the development of organic farming contributes to sustainable agricultural development, helps meet domestic consumers' demand for organic products, and increases the share in the global market for organic products.

Even though several supportive policies such as legislative, financial, communication, and action plans have been implemented in Europe to develop organic farming, the development of organic farming has not ever been ideal (Brzezina et al., 2017). Also, in most developing countries, government support for organic farming is negligible and no significant operational policies and programs have been implemented in this regard. Hence, it is important to identify and determine the best strategies for organic farming development based on comprehensive factors affecting organic farming.

Few studies have identified the strategies for organic farming development and suggested various strategies such as implementation of innovative technologies (Ferreira et al., 2020), local government guidance (Qiao et al., 2019), support for implementation of scientific research (Tsvetkov et al., 2018), government support and subsidies (Adams Inkoom, 2017), and management of organic farming constraints and modification of regulatory standards (Brzezina et al., 2017). Other studies pointed to green marketing (Aceleanu, 2016), establishment of institutions for providing services such as organic certification (Adebiyi, 2014), and financial and trade policies (KhezriNejhad Gharaei and Bakhshoudeh, 2014). A summary of previous studies related to organic farming development is shown in Table 1.

Table 1

Literature on organic farming development strategies

Author(s)	Study region	Method used	Factor(s)	Results
Ferreira et al. (2020)	Lis Valley (Portugal)	Interviews with farmers	Constraining organic farming	Results suggest ways such as rural development policies, stimulation of young farmers, modernization of irrigation, supporting land restructuring, implementation of innovative technologies, and facilitation of market access.

Qiao et al. (2019)	Wanzai County	Interviews with stakeholders of organic farming	Factors driving organic farming	Results emphasize the role of local government as a guide in organic farming development.
Tsvetkov et al. (2018)	World	Review of various aspects of plant organic farming	Challenges and opportunities of organic farming	Results show the necessity of support for implementation of scientific research and improvement of the cooperation between all stakeholders at the national and international level.
Paull (2017)	India, Fiji, Kiribati, Bhutan, Dominican Republic,	Review of research papers	Success on the cooperation of commerce, government, and community	Results suggest four strategies including 'one crop at a time', 'one state at a time', 'one island at a time, and 'one country at a time'.
Adams Inkoom (2017)	United States	Descriptive statistics and multiple linear regression	Factors driving and inhibiting organic farming	Results show that subsidies and government support are essential for most small-scale farmers to cultivate organic agricultural products
Brzezina et al. (2017)	Europe	Three system archetypes	Challenges of organic farming	Results offer the management of organic farming constraints and modification of regulatory standards.
De Cock et al. (2016)	Flanders (Belgium)	Discourse analytical approach	Factors limiting organic production	Results indicate that the stakeholders of agricultural, political and food market should accept non-competitive discourses to support the organic farming development
Aceleanu (2016)	Romania	statistical methods and regression equations	Marketing factors	Results show green marketing strategy based on marketing factors to stimulate production of organic products.
Adebiyi (2014)	Uganda	Reviewing the literature	Success factors of organic farming	Results recommend establishment of institutions for providing services such as organic certification and marketing, developing organic standards, and organic research.
KhezriNejhad Gharaei and Bakhshoudeh, (2014)	Iran	SWOT-ANP	General factors	Results suggest four strategies including financial and trade policies, developing motives for investments, creating responsive foundation for research, and promotional programs.
Rozman et al. (2013)	Slovenia	System dynamics model	Some factors affecting organic farming	Results propose subsidies and activities improving organic farming to create motivation for organic farming development.

The previous studies have been based on different quantitative and qualitative methods such as mathematical programming, regression equations, and scientific reports. However, these methods have not considered all the factors affecting organic farming, like local history of organic farming, suitable soil, pests and plant diseases. In addition, the interdependence between these factors and the uncertainty of the real world and the decision-makers' judgments have not received any attention in those studies. Moreover, strategies need to be specifically determined for each geographic area based on the different climatic conditions. In this study, these gaps in determining the strategies for organic farming development are addressed by a hybrid SWOT-multi-criteria decision-making (MCDM) method. Only one study conducted in the organic farming area has used SWOT and ANP methods. It identified general factors influencing the transition of conventional farming into organic farming and offered four strategies including financial and trade policies, developing motives for investments, creating responsive foundation for research, and promotional programs in Iran (KhezriNejhad Gharaei and Bakhshoudeh, 2014).

These hybrid methods have been recently utilized in other fields. For example, the hybrid SWOT-AHP has been used in cross-border electricity trade (Haque et al., 2020) and SWOT-Fuzzy AHP in determining the best renewable energy resources to generate electricity (Wang et al., 2020) and in methanol vehicle development (Li et al., 2020). SWOT-QSPM has been applied to sustainable ecotourism development (Mallick et al., 2020) and SWOT-AHP-Fuzzy TOPSIS has been utilized for energy cooperation (Papapostolou et al., 2020) and sustainable energy planning (Solangi et al., 2019). SWOT-Fuzzy Logic-grey relational method has been used in ceramic and tile industries development (Karimi et al., 2019) and SWOT-Fuzzy Goal Programing in CNG Industry development (Khan, 2018). SWOT-AHP-TOWS has been applied for biogas sector development (Gottfried et al., 2018) and SWOT-ANP-Fuzzy TOPSIS for energy development (Ervural et al., 2018). SWOT-PROMETHEE/GAIA-GDSS has been utilized in prioritizing the goals of a university (Zivkovic et al., 2017) and finally SWOT-Fuzzy ELECTRE has been used in selecting private sectors in partnership projects (Shakeri et al., 2015).

The present study, considering the above mentioned gaps in the organic farming studies, aims to identify comprehensive factors affecting organic farming, define strategies for organic farming development, prioritize the strategies and determine the best ones. To do so, among hybrid methods, a combination of SWOT analysis, fuzzy theory, and ANP method is utilized due to it's consistent with the objectives of the study. SWOT analysis involves strengths, weaknesses, opportunities, threats, and all factors affecting organic farming. ANP approach is a powerful method to prioritize the strategies and determine the best ones based on the interdependence between the effective factors. Finally, fuzzy set theory was applied to effectively overcome the ambiguities in the real world. Therefore, the current study contributes to the literature in four aspects. First, it determines strategies with regard to strengths, weaknesses, opportunities, threats, and comprehensive factors affecting organic farming. Second, the interdependence between the factors is considered. Third, the uncertainty of real-world and decision-makers' opinions are addressed. Finally, unlike most previous studies that defined strategies at the country level, this study focuses on one province, i.e. the Khorasan Razavi province of Iran because of the difference in climatic conditions in different regions both in Iran and in other countries. The rest of current study is organized as follows. The status of organic farming in Iran is described in Section 2. The hybrid method is explained in Section 3. The results and discussion are presented in Section 4, and the conclusion is summarized in Section 5.

2. Organic farming in Iran

Iran plays an important role in global agriculture market and ranks first to third in the global export of saffron, pistachio, and raisins, respectively (FAO, 2020; UNIDO, 2014). The existence of different types of climate and the widespread farming in Iran, has made it possible to cultivate organic agricultural products in the country (Majnoun Hosseini, 2019). Organic farming has attracted the attention of Iranian academia and researchers since 1990s.

Different institutions such as the Iranian Organic Association and the Iranian Scientific Society of Agro-ecology (ISSA) have been established to support organic farming (Ardakani and Shafighi, 2017). In 2008, the standard no. 11000 was assigned as a national standard for organic products by the Institute of Standards and Industrial Research of Iran (ISIRI), which specifies the requirements for production, processing, certification, labeling and marketing of organic products. In addition, the development of organic farming was considered in environmental policies and the Law on the Sixth Five-Year Economic, Cultural, and Social Development Plan in Iran (Kledal et al., 2012).

Organic farming has declined from 12156 hectares in 2013 to 11916 hectares in 2017 in Iran, which constitutes less than 0.04 percent of total farmland (Willer and Lernoud, 2019). Khorasan Razavi, as one of the largest provinces of Iran, has cultivated over 2000 hectares of organic farmland. It ranks first, both nationally and globally, for the production of saffron and is a major producer of pistachio and raisins as well (Khorasan Razavi Agricultural Jihad Organization, 2014). However, a limited part of the province's organic farmland is allocated to the cultivation of the above-mentioned products. At the same time, organic products are increasingly more demanded (Amirnejad and Tonakbar, 2015) because of domestic consumers' awareness of their quality (Haghjou et al., 2013) as well as concerns about the environment (Rahmati Ghofrani et al., 2017). Although more than 95% of Iran's organic products are exported (Kledal et al., 2012), the province's share of organic products in the global market is negligible.

3. Methodology

In the present study, a hybrid SWOT-fuzzy ANP method was used to identify factors affecting organic farming and define and prioritize alternative strategies for its development. Based on this method, SWOT analysis was applied to identify SWOT factors (the strengths, weaknesses, opportunities, and threats) and sub-factors affecting organic farming through questionnaires were filled by twenty organic farming experts from academia and agricultural jihad organization in Khorasan Razavi province, Iran (see Appendices B and C). According to these factors and sub-factors, possible strategies were defined for the development of organic farming. Then, the SWOT factors and sub-factors were prioritized, using fuzzy ANP, with regard to the ambiguity and uncertainty of the real world and the decision-makers' judgments. Finally, the best strategies were identified based on the results of the fuzzy ANP approach using supervision software. The research methodology is illustrated in Fig. 1.

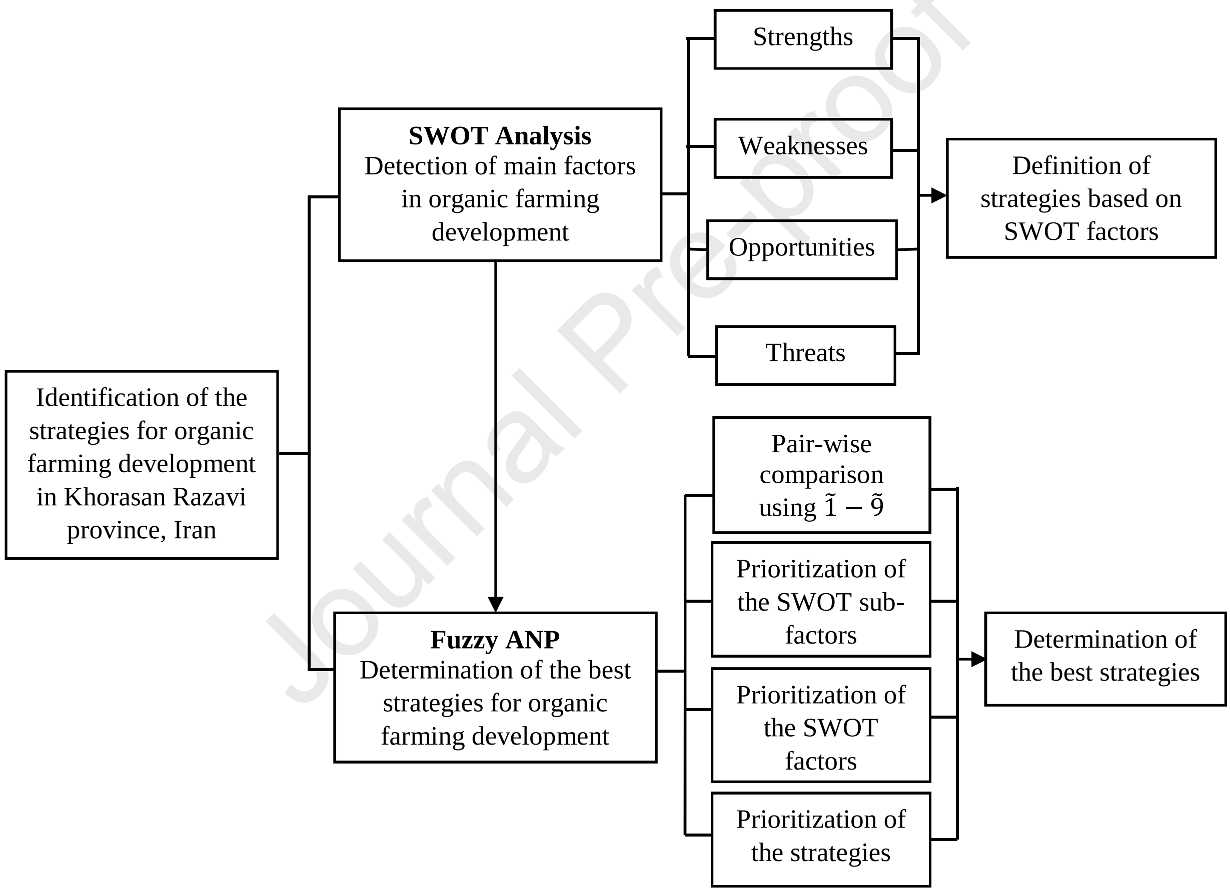

Fig. 1 The SWOT-Fuzzy ANP framework in the study

3. 1. SWOT analysis

SWOT analysis is a method widely used in strategy development, strategic planning, and decision making (Wang et al., 2020). It involves comprehensive factors influencing specific objective (ArshadiKhamseh and Fazayeli, 2013) such as agricultural development (Mansour et al., 2019) and sustainable agriculture (Emami et al., 2018). The SWOT stands for 'strengths', 'weakness', 'opportunities' and 'threats' (Gurel and Tat, 2017). The Strengths and Weaknesses are known as internal factors and Opportunities and Threats are external (Arsić et al., 2017). In the other words, Strengths and Weaknesses factors are identified through assessing the internal system environment, while Opportunities and Threats factors are recognized through evaluating the external system environment (Khan, 2018). Therefore, SWOT analysis provides a list of Strengths, Weaknesses, Opportunities, and Threats associated with the internal and external environment affecting the system. The internal factors are combined with the external ones (Christodoulou and Cullinane, 2019) in a framework named SWOT matrix to formulate four types of strategies as represented in Fig. 2

Internal / **External**	**Strengths (S)** 1. 2. . (Strengths List) . .	**Weaknesses (W)** 1. 2. . (Weaknesses List) . .
Opportunities (O) 1. 2. . (Opportunities List) . .	**SO** Strategies (Employing strengths to make use of opportunities)	**WO** Strategies (Minimizing weaknesses through exploiting opportunities)
Threats (T) 1. 2. . (Threats List) . .	**ST** Strategies (Using strengths to prevent the effect of threats)	**WT** Strategies (Decreasing the impact of weaknesses and environmental threats)

Fig. 2 The structure of SWOT matrix

Based on Fig. 2, when internal and external factors are combined, SO, WO, ST, and WT strategies are formed. SO strategies are adopted when strengths are employed to make use of opportunities. WO strategies are obtained when weaknesses are minimized through exploiting opportunities. ST strategies are extracted from using strengths to prevent the effect of threats. The decrease in the effect of weaknesses and environmental threats leads to the formation of WT strategies (Kazemi et al., 2018). In general, the SWOT matrix can be formed in six stages: 1) detection of main internal factors, 2) detection of main external factors, 3) combination of internal strengths with external opportunities and definition of SO strategies, 4) combination of internal weaknesses with external opportunities and definition of WO strategies, 5) combination of internal strengths with external threats and definition of ST strategies, and 6) combination of internal weaknesses with external threats and definition of WT strategies (Genc et al., 2018).

3. 2. Fuzzy ANP Method

Since SWOT analysis is a qualitative method, it can't rank the SWOT factors and sub-factors and prioritize the strategies. Hence, it should be combined with quantitative methods such as multi-criteria decision-making (MCDM). MCDM can incorporates the decision-making alternatives into several qualitative and quantitative factors and leads to an optimal solution (Kolios et al., 2016). MCDM method includes a wide range of approaches which can be grouped into the following three general categories (Tscheikner-Gratl et al., 2017):

- Value measurement approach: in this approach, the weight of each factor is determined by the pairwise comparison of factors and then, a score is assigned for each alternative, which reflexes its priority (e.g., Analytic Network Process (ANP), Analytic Hierarchy Process (AHP)).
- Goal, aspiration and reference level approach: the distance between alternatives and specific solutions is measured and the alternatives closest to the ideal solution (e.g., TOPSIS) are specified.
- Outranking approach: this approach creates a preferential relationship among the alternatives and determines the most dominant ones (e.g., ELECTRE, PROMETHEE).

None of the above approaches is so comprehensive to be applied to any kind of problem (Ishizaka and Nemery, 2013). As a rule, MCDA method should be selected in commensurate with the objectives of the decision problem (Guarini, 2018). The approaches in the first group, especially ANP and AHP, are consistent with the objectives of this study. ANP is the developed form of AHP introduced by Saaty (2001). It can significantly simplify the decision-making processes in which factors have complex relationships. It further allows the evaluation of all relationships through adding interdependencies and feedbacks to the decision system (Avakh Darestani, Hojjat Shamami, 2019). By a non-linear and network structure, this method overcomes the limitation of hierarchy in AHP (Zaim et al., 2014), so it can solve the real world's problems in a multi-level network. In this method, the goal of the problem is placed at the top of the multi-level network and the lower levels are composed of factors related to each other and to the higher levels (Liu et al., 2018). SWOT analysis with dependent SWOT factors is structured as a network system. Therefore, ANP is an effective tool to evaluate the interactions, dependencies, and feedbacks of the factors, sub-factors, and alternative strategies.

ANP method relies on the pairwise comparisons using the 1–9 scales of Saaty (1980). These comparisons rarely happen in a definitive environment. Since human judgments are usually unclear and vague, certain numbers cannot be assigned to human perception (Balaman, 2019). Probability, fuzzy, and grey theories are used to deal with these ambiguous situations (Tsai et al., 2017). The theories are three distinct paradigms because they address the problem of uncertainty quantification from different aspect (Javanmardi and liu, 2019). Characteristics of each of the above theories are shown in Table 2. The uncertainty of multi-criteria decision-making and the vagueness of human's judgment are known as epistemic uncertainty (Wicaksono et al., 2020). In other words, epistemic uncertainty is related to decision-making processes, linguistic variables, and data based on beliefs that come from the inadequate knowledge, misunderstanding of the process, and imperfect information and data (Basu, 2017). This kind of uncertainty is also recognized as reducible uncertainty because it can be reduced by new information and data (Sanchez et al., 2019). Fuzzy theory can be effectively applied to investigate epistemic uncertainty. This theory differs from grey theory which investigates small sample uncertainty. It is also different from probability theory which is employed to address large sample uncertainty (Tsai et al., 2017). According to Table 2, fuzzy theory is based on the fuzzy set, membership function, and boundary data; probability theory relies on cantor sets, probability distribution, and abundant data and grey theory is supported by gray set, information coverage, and few data.

Table 2

Characteristics of probability theory, fuzzy theory, and grey theory

Characteristics	Probability theory	Fuzzy theory	Grey theory
Context	Large sample uncertainty	Epistemic uncertainty	Small sample uncertainty
Basis	Probability distribution	Membership function	Information coverage
Method	Statistics	Boundary values	Generation
Requirement	Generic distribution required	Functions	Optional distributions allowed
Data feature	Abundant data	Boundary data	Few data
Basic set	Cantor sets	Fuzzy sets	Gray set
Objective	Statistical laws	Cognitive expression	Laws of real world
Required information	Unlimited information	Experience information	At least information

Source: Tsai et al. (2017).

Zadeh (1965) suggested fuzzy theory for the first time to solve the judgments' uncertainties. This theory describes fuzzy features through defining a membership function in which each member takes a membership degree in the range of zero to one (Guo and Wong, 2013). There are many fuzzy functions which represent unclear data. The triangular fuzzy function was employed here because it could present particular linguistic variables and provide easy interpretations (Thaker and Nagori, 2018). A triangular fuzzy number (TFN) is shown by (l, m, u) for the smallest (l), medium (m) and largest (u) possible values and their function ($\mu(x)$) is defined as follows (Meng and Chen, 2016):

$$\mu(x) = \begin{cases} 0, & x < l \\ \dfrac{x-1}{m-1} & l \le x \le m \\ \dfrac{u-x}{u-m} & m \le x \le u \\ 0 & x > u \end{cases} \quad (1)$$

To fuzzify the judgments made by the expert team, a pairwise comparison matrix was formed based on the triangular fuzzy number in Table 3. This matrix is represented in Eqs (2) (Tsai et al., 2020):

$$\tilde{A} = [\widetilde{a_{ij}}] = \begin{bmatrix} (a_{11}^L & a_{11}^m & a_{11}^u) & (a_{12}^L & a_{12}^m & a_{12}^u) & \dots & (a_{1i}^L & a_{1i}^m & a_{1i}^u) \\ (a_{21}^L & a_{21}^m & a_{21}^u) & (a_{22}^L & a_{22}^m & a_{22}^u) & \dots & (a_{2i}^L & a_{2i}^m & a_{2i}^u) \\ \vdots & \vdots & \ddots & \vdots \\ (a_{j1}^L & a_{j1}^m & a_{j1}^u) & (a_{j2}^L & a_{j2}^m & a_{j2}^u) & \dots & (a_{ij}^L & a_{ij}^m & a_{ij}^u) \end{bmatrix} \quad (2)$$

$$\widetilde{a_{ij}} = \begin{cases} (1 \quad 1 \quad 1) & if \ \ i = j \\ (a_{ij}^L \quad a_{ij}^m \quad a_{ij}^u) & if \ \ j > i \\ (\dfrac{1}{a_{ij}^u} \quad \dfrac{1}{a_{ij}^m} \quad \dfrac{1}{a_{ij}^u}) & if \ \ j < i \end{cases}$$

Where, $\tilde{A}$ is the fuzzy pairwise comparison matrix and $\tilde{a}_{ij}$ which is shown by $(a_{ij}^L \quad a_{ij}^m \quad a_{ij}^u)$ indicates the comparison of m with n. To calculate the fuzzy priorities of SWOT factors and strategies $(\widetilde{W_p})$, the logarithmic least square approach (Khanmohammadi et al., 2019) was used as follows (Sevkli et al., 2012):

$$\widetilde{W_p} = (W_p^L \quad W_p^m \quad W_p^u), \qquad p = 1, 2, \dots, n \quad (3)$$

So that:

$$W_p^s = \frac{\left(\prod_{j=1}^{n} a_{ij}^s\right)^{1/n}}{\sum_{p=1}^{n}\left(\prod_{j=1}^{n} a_{pj}^m\right)^{1/n}}, \qquad S\epsilon\{l, m, u\} \quad (4)$$

Table 3

Definition of triangular fuzzy number (TFN) for linguistic scale

Fuzzy number	Linguistic scale	Triangular fuzzy scale
$\tilde{1}$	Equal preference	(1, 1, 1)
$\tilde{2}$	Equal to moderate preference	(1, 3/2, 3/2)
$\tilde{3}$	Moderate preference	(1, 2, 2)

$\tilde{4}$	Moderate to strong preference	(3, 7/2, 4)
$\tilde{5}$	Strong preference	(3, 4, 9/2)
$\tilde{6}$	Strong to very strong preference	(3, 9/2, 5)
$\tilde{7}$	Very strong preference	(5, 11/2, 6)
$\tilde{8}$	Very strong to extreme preference	(5, 6, 7)
$\tilde{9}$	Extreme preference	(5, 7, 9)

Source: Sevkli et al. (2012).

3.3. The SWOT-Fuzzy ANP Method

Fuzzy ANP method relying on SWOT analysis includes nine steps (Sevkli et al., 2012). In general, SWOT factors, sub-factors and strategies are first identified. Then, the priority of SWOT factors is determined in both status when they are dependent on each other or not. Finally, the defined strategies are prioritized and the best of them are identified. Therefore, the steps can be expressed as follows:

Step 1: Detection of SWOT factors, sub-factors based on literature review and interviews with the expert team, and definition of the alternative strategies based on sub-factors.

Step 2: Transformation of the problem into a hierarchical structure by using ANP analysis.

Step 3: Prioritization of the SWOT factors using the $\tilde{1} - \tilde{9}$ scales, assuming the independence between the SWOT factors (calculation of $\widetilde{W_1}$).

Step 4: Determination of the dependence between the SWOT factors through investigating the effect of each factor on other factors using the $\tilde{1} - \tilde{9}$ scale (calculation of $\widetilde{W_2}$).

Step 5: Prioritization of the SWOT factors based on the weights of SWOT factors defined in steps 2, 4 (calculation of $\widetilde{W}_{factors} = \widetilde{W_1} \times \widetilde{W_2}$).

Step 6: Recognition of the local priorities of SWOT sub-factors using the $\tilde{1} - \tilde{9}$ scale, (calculation of $\widetilde{W}_{sub-factors}$).

Step 7: Determination of the global priorities of SWOT sub-factors based on the priority of SWOT factors and the local priorities of the SWOT sub-factors (calculation of $\widetilde{W}_{sub-factors\,(global)} = \widetilde{W}_{factors} \times \widetilde{W}_{sub-factors\,(local)}$).

Step 8: Prioritization of defined strategies related to each SWOT sub-factors and composition the matrix $\widetilde{W}_4$.

Step 9: Determination of the total fuzzy priorities of all the defined strategies and their transformation into exact ones as the following formula (Khanmohammadi et al., 2019):

$$W_p = \frac{1}{4}(W_p^L + 2W_p^m + W_p^u), \qquad p = 1, 2, \dots, n \qquad (5)$$

4. Results and Discussion

4.1. SWOT Analysis Results

As the first step in the current study, the SWOT factors and sub-factors including 6 strengths, 7 weaknesses, 6 opportunities and 7 threats were identified based on literature review and interview with experts' team (see Table 4). Then, based on these sub-factors, nine possible strategies were determined for organic farming development in Khorasan Razavi province, Iran.

Two SO strategies were proposed based on the strengths and the specified opportunity factors. The strategy SO1, i.e. the completion of the value chain of organic products, was suggested to take advantage of the opportunities O3 and O4 by using the strength S5. By applying the strengths S1, S2, S4, and S6 to benefit from the opportunities O1, O4, and O6, the strategy SO2, encouraging communities to invest in organic projects, was defined. To minimize the weaknesses W1 and W2 using the opportunity O1, the strategy WO1 that is financial support to farmers in the transition period, was offered. The strategy WO2, i.e.

planning to teach the principles of organic farming, was proposed to optimize the use of the opportunities O2 and O6 through overcoming the weaknesses W3 and W6.

The strategy ST1, i.e. facilitating access to organic inputs, was suggested based on the benefits of the strengths S1, S4, S5, and S6 to avoid the threat T3. Facilitating farmers' access to insurance for the cultivation of organic producers, that is the strategy ST2, was offered with the aim of minimizing the influence of the threat T5 and maximizing the strength S3. The strategy ST3, removing legal and political barriers to exporting organic products, was proposed with the use of the advantages of the strengths S4 and S5 to reduce the threat T2. Creating a competitive market for organic products, the strategy WT1, was suggested to eliminate the impact of the threats T4 and T1 and the weakness W7. The strategy WT2, developing consumers' awareness programs, was the last strategy which was defined to remove the threats T1, T6, and T7 and the weakness W7.

Table 4

SWOT Matrix for the development of organic farming

Internal Factors / **External Factors**	**Strengths (S)**	**Weaknesses (W)**
	• **S1** - Suitable soil and lands • **S2** - History of organic farming in the province • **S3** - Improving human health • **S4** - The profitability of organic farming • **S5** - Production of high quality and safe food • **S6** - Favorable climate	• **W1** - Lack of access to financial facilities for organic farming • **W2** - The financial loss of transition period • **W3** - Low level of farmers' literacy • **W4** - Low yield per hectare • **W5** - Weak farmers' interaction with promoters • **W6** - Lack of farmers' knowledge about the principles of organic farming • **W7** - The limited supply of organic products in specialized stores
Opportunities (O) • **O1** - Possibility to attract private sector capital • **O2** - Developing incentives for farmers by promoting and supporting organic farming • **O3** - Demand for organic	**SO Strategies** • **SO1** - Completion of the value chain of organic products • **SO2** - Encouraging communities to invest in organic projects	**WO strategies** • **WO1** - Financial support to farmers in the transition period • **WO2** - Planning to teach the principles of organic farming

products • **O4** -Improvement of foreign trade • **O5** - Reduction in environmental degradation • **O6** - Applying and executing scientific achievements		
Threats (T) • **T1** - The emergence of fake organic products • **T2** - Legal barriers to exporting organic products • **T3** - Lack of access to organic resources and inputs • **T4** - Lack of pricing mechanism for organic products • **T5** - The existence of pests and plant diseases • **T6** - Low level of consumers' awareness about organic products • **T7** - The weakness of educational and promotional planning	**ST Strategies** • **ST1** - Facilitating access to organic inputs • **ST2** - Facilitating farmers' access to insurance for the cultivation of organic producers • **ST3** - Removing legal and political barriers to exporting organic products	**WT Strategies** • **WT1** - Creating a competitive market for organic products • **WT2** -Developing consumers' awareness programs

Source: Research findings.

4.2. The Results of SWOT-Fuzzy ANP Method

Based on SWOT analysis, nine feasible strategies were determined for the development of organic farming. ANP method combined with fuzzy theory was applied to prioritize these strategies and determine the best ones considering the uncertainty of decision-makers' judgment and the real world. As a result, the problem was transformed into a four-level hierarchical structure presented in Fig. 3. In the first level, the objective of determining the best strategy was located. SWOT factors, including strengths, weaknesses, opportunities, and threats were presented in the second level. In the third level, the SWOT sub-factors containing six strength sub-factors, seven weakness sub-factors, six opportunity sub-factors, and seven threat sub-factors were placed. The nine strategies defined in the present study were in the last level of the ANP model.

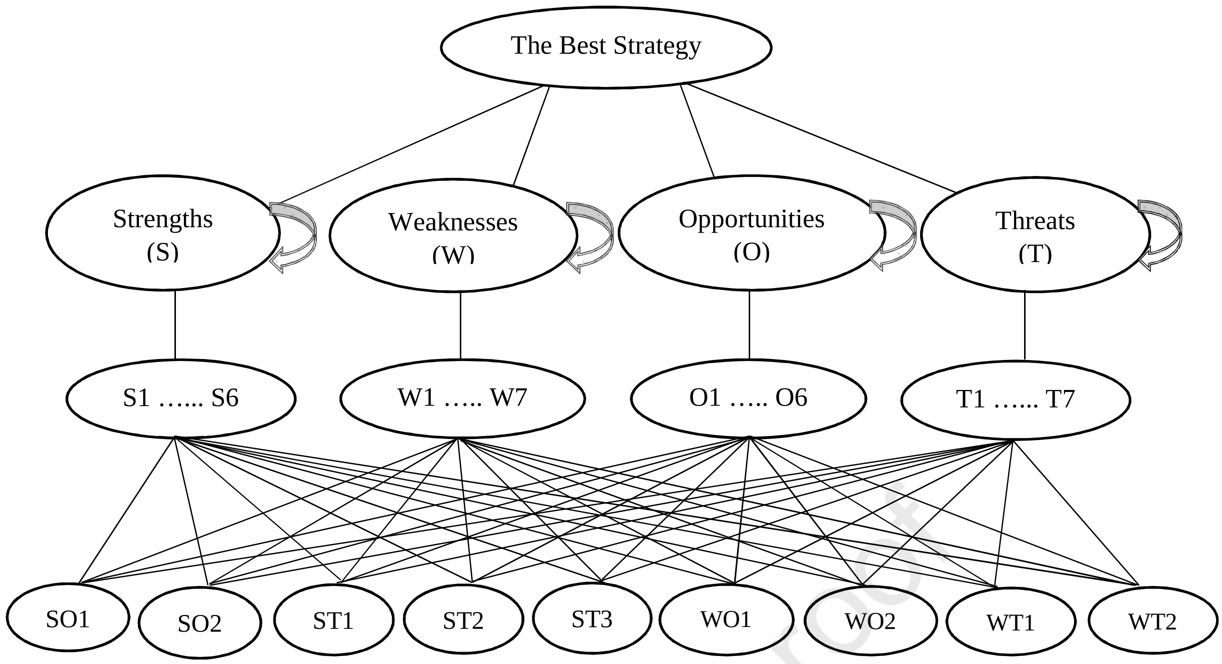

Fig. 3 The Fuzzy ANP model to select the best strategy

In the third step, SWOT factors (i.e. strengths, weaknesses, opportunities, and threats) were compared two by two in regard with the objective of the ANP model, assuming independence between the SWOT factors. Pairwise comparisons were conducted by the expert team and defined by a triangular fuzzy number and $\tilde{1}-\tilde{9}$ scale, as represented in Table 4. The inconsistency rate in the last row of the table indicates the lack of inconsistency in the responses of the experts' team. $\widetilde{W}_1$ matrix was obtained from Table 5 as follows:

$$\widetilde{W}_1 = \begin{bmatrix} \text{Strength} \\ \text{Weaknesses} \\ \text{Opportunities} \\ \text{Threats} \end{bmatrix} = \begin{bmatrix} (0.185 & 0.158 & 0.152 \\ (0.245 & 0.239 & 0.237) \\ (0.323 & 0.363 & 0.372) \\ (0.245 & 0.239 & 0.237) \end{bmatrix}$$

Table 5

Pairwise comparison matrix of SWOT factors, assuming the independence between them

SWOT factors	Strength	Weaknesses	Opportunities	Threats	Importance weights of SWOT factors
Strength	(1,1,1)	(1,1,1)	(1/3, 2/7, 1/4)	(1, 2/3, 2/3)	(0.185, 0.158, 0.152)
Weaknesses		(1,1,1)	(1,1,1)	(1,1,1)	(0.245, 0.239, 0.237)
Opportunities			(1,1,1)	(1, 3/2, 3/2)	(0.323, 0.363, 0.372)

Threats	(1,1,1)	(0.245, 0.239, 0.237)
IR= 0.06		

Source: Research findings.

In the fourth step, the dependence among SWOT factors was specified through investigating the impact of each factor on other factors by pairwise comparisons (as shown in Fig. 4) and the scores from the comparison were fuzzified. Tables 6-9 indicate the dependence matrices of SWOT factors, in each of which one factor is controlled. For example, to determine the dependence among weaknesses, opportunities, and threats, the strengths were controlled as shown in Table 6. The fuzzy importance weights of factors are displayed in the last column of the tables. As seen in Tables 6-9, no inconsistency is observed in the responses provided by the expert team.

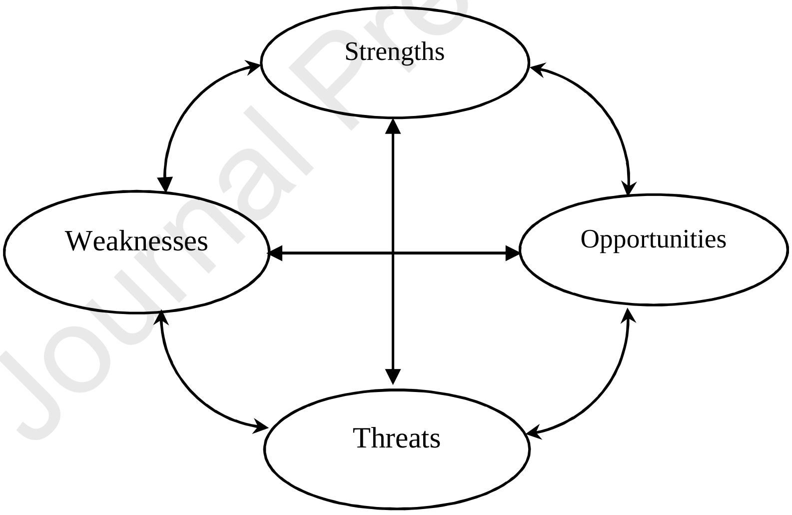

Fig. 4 Dependence among the SWOT factors

Table 6

The dependence among the SWOT factors while the strengths are controlled

Strengths	Weaknesses	Opportunities	Threats	Importance weights
Weaknesses	(1,1,1)	(1, 3/2, 3/2)	(1,2,2)	(0.333, 0.453, 0.453)
Opportunities		(1,1,1)	(1,2,2)	(0.333, 0.347, 0.347)
Threats			(1,1,1)	(0.333, 0.199, 0.199)
IR= 0.09				

Source: Research findings.

Table 7

The dependence among the SWOT factors while the weaknesses are controlled

Weaknesses	Strengths	Opportunities	Threats	Importance weights
Strengths	(1,1,1)	(1, 3/2, 3/2)	(1,2,2)	(0.333, 0.453, 0.453)
Opportunities		(1,1,1)	(1,2,2)	(0.333, 0.347, 0.347)
Threats			(1,1,1)	(0.333, 0.199, 0.199)
IR= 0.05				

Source: Research findings.

Table 8

The dependence among the SWOT factors while opportunities are controlled

Opportunities	Strengths	Weaknesses	Threats	Importance weights
Strengths	(1,1,1)	(1,2,2)	(1,2,2)	(0.333, 0.492, 0.492)
Weaknesses		(1,1,1)	(1,2,2)	(0.333, 0.311, 0.311)
Threats			(1,1,1)	(0.333, 0.197, 0.197)
IR= 0.09				

Source: Research findings.

Table 9

The dependence among the SWOT factors while the threats are controlled

Threats	Strengths	Weaknesses	Opportunities	Importance weights
Strengths	(1,1,1)	(3, 7/2, 4)	(1,2,2)	(0.459, 0.567, 0.584)
Weaknesses		(1,1,1)	(1,3/2,3/2)	(0.221, 0.226, 0.212)
Opportunities			(1,1,1)	(0.319, 0.207, 0.204)
IR= 0.09				

Source: Research findings.

According to the computed fuzzy importance weights in Tables 6-9, the dependence matrix of the SWOT factors ($\widetilde{W}_2$) was made as follows:

$$\widetilde{W}_2 = \begin{bmatrix} (1 & 1 & 1) & (0.333 & 0.453 & 0.453) & (0.333 & 0.492 & 0.492) & (0.459 & 0.567 & 0.584) \\ (0.333 & 0.453 & 0.453) & (1 & 1 & 1) & (0.333 & 0.311 & 0.311) & (0.221 & 0.226 & 0.212) \\ (0.333 & 0.347 & 0.347) & (0.333 & 0.347 & 0.347) & (1 & 1 & 1) & (0.319 & 0.207 & 0.204) \\ (0.333 & 0.199 & 0.199) & (0.333 & 0.199 & 0.199) & (0.333 & 0.197 & 0.197) & (1 & 1 & 1) \end{bmatrix}$$

In the fifth step, the matrix related to the prioritization of SWOT factors using the weights of SWOT factors defined in steps 3, 4 i.e. $\widetilde{W}_2, \widetilde{W}_1$ was obtained as follows:

$$\widetilde{W}_{factors} = \widetilde{W}_2 * \widetilde{W}_1 = \begin{bmatrix} (0.488 & 0.581 & 0.581) \\ (0.469 & 0.545 & 0.473) \\ (0.545 & 0.209 & 0.556) \\ (0.497 & 0.048 & 0.389) \end{bmatrix}$$

As the above matrix indicates, strengths has the highest priority among the SWOT factors.

In the sixth step, the local priorities of SWOT sub-factors were determined by pairwise comparison. In the seventh step, the global priorities of SWOT sub-factors ($\widetilde{W}_{sub-factors(global)}$) were calculated through multiplying $\widetilde{W}_{factors}$, obtained in the fifth step by the priorities of SWOT sub-factors defined in the sixth step as presented in Table 10. Conversion of these fuzzy values into exact values presented in the last column of Table 10 shows that the highest priorities among SWOT sub-factors belongs to sub-factors S4, i.e. profitability of organic farming (0.129), followed by O4, i.e., improvement of foreign trade (0.125) and then S5 that is, production of high quality and safe food (0.105). In many countries, premiums are usually paid for organic production (Fanasch and Frick, 2019), which often results in higher profitability of organic farming. The profitability and the global movement towards organic products lead to an increase in organic farming and facilitate organic product trading in international markets (Karthikeyan et al., 2019). Furthermore, advantages of organic farming for food safety have been discussed in Jones et al. (2019) study.

Table 10

The priority of factors and sub-factors of the SWOT matrix

SWOT factors	Priority of the factors	SWOT sub-factors	Local priority of the sub-factors	Global priority of the sub-factors	Exact global priority of the sub-factors
Strengths (S)	(0.488, 0.581, 0.581)	S1	(0.166, 0.139, 0.139)	(0.809, 0.081, 0.081)	0.081
		S2	(0.166, 0.191, 0.191)	(0.081, 0.111, 0.111)	0.104
		S3	(0.138, 0.094, 0.092)	(0.067, 0.055, 0.053)	0.057
		S4	(0.199, 0.241, 0.245)	(0.097, 0.139, 0.143)	0.129
		S5	(0.166, 0.195, 0.195)	(0.081, 0.113, 0.113)	0.105
		S6	(0.166, 0.139, 0.139)	(0.081, 0.081, 0.081)	0.081
Weakness (W)	(0.469, 0.545, 0.473)	W1	(0.142, 0.125, 0.125)	(0.067, 0.068, 0.059)	0.065
		W2	(0.142, 0.148, 0.148)	(0.067, 0.081, 0.070)	0.075
		W3	(0.121, 0.111, 0.108)	(0.057, 0.060, 0.051)	0.057
		W4	(0.142, 0.127, 0.127)	(0.067, 0.069, 0.059)	0.066
		W5	(0.142, 0.132, 0.132)	(0.067, 0.072, 0.062)	0.068
		W6	(0.142, 0.148, 0.148)	(0.067, 0.081, 0.070)	0.075
		W7	(0.166, 0.208, 0.211)	(0.078, 0.113, 0.100)	0.101
Opportunities (O)	(0.545, 0.209, 0.556)	O1	(0.106, 0.130, 0.119)	(0.058, 0.076, 066/0)	0.069
		O2	(0.128, 0.197, 0.183)	(0.069, 0.114, 0.102)	0.100
		O3	(0.128, 0.206, 0.192)	(0.069, 0.119, 0.107)	0.104
		O4	(0.153, 0.254, 0.242)	(0.083, 0.148, 0.135)	0.128
		O5	(0.128, 0.172, 0.160)	(0.069, 0.099, 0.089)	0.089
		O6	(0.128, 0.040, 0.104)	(0.069, 0.023, 0.058)	0.043
Threats (T)	(0.497, 0.048, 0.389)	T1	(0.143, 0.168, 0.168)	(0.071, 0.008, 066/0)	0.038
		T2	(0.143, 0.134, 0.134)	(0.071, 0.006, 0.052)	0.034
		T3	(0.143, 0.126, 0.126)	(0.071, 0.006, 0.049)	0.033
		T4	(0.143, 0.168, 0.168)	(0.071, 0.008, 066/0)	0.038
		T5	(0.143, 0.126, 0.126)	(0.071, 0.006, 0.049)	0.033
		T6	(0.143, 0.126, 0.126)	(0.071, 0.006, 0.049)	0.033
		T7	(0.143, 0.150, 0.150)	(0.071, 0.007, 0.058)	0.036

407 Source: Research findings.

In the eighth step, the fuzzy priorities of the nine defined strategies were determined in relation to each SWOT sub-factors and the matrix ($\widetilde{W}_4$) reported in Table 11 in the Appendix was formed.

In the final step, the total fuzzy priorities of the nine defined strategies were determined and next, transformed into exact priorities as follows:

$$\widetilde{W}_{alternative} = \begin{bmatrix} SO1 \\ SO2 \\ ST1 \\ ST2 \\ ST3 \\ WO1 \\ WO2 \\ WT1 \\ WT2 \end{bmatrix} = \widetilde{W}_4 * \widetilde{W}_{sub-factors(global)} = \begin{bmatrix} (0.186 & 0.123 & 0.139) \\ (0.189 & 0.143 & 0.156) \\ (0.204 & 0.161 & 0.189) \\ (0.208 & 0.168 & 0.195) \\ (0.209 & 0.197 & 0.224) \\ (0.207 & 0.198 & 0.222) \\ (0.223 & 0.219 & 0.258) \\ (0.222 & 0.264 & 0.299) \\ (0.225 & 0.282 & 0.316) \end{bmatrix} = \begin{bmatrix} 0.143 \\ 0.158 \\ 0.179 \\ 0.185 \\ 0.207 \\ 0.206 \\ 0.230 \\ 0.262 \\ 0.276 \end{bmatrix}$$

The results of SWOT-fuzzy ANP demonstrates that strategy WT2, i.e., developing consumers' awareness programs, is the best strategy with a priority of 0.276. In fact, the life and success of any product depend on the consumers' awareness (Muhammad et al., 2015). That is, a rise in the consumers' awareness of the benefits of organic products can increase the demand for these products (Mkhize and Ellise, 2020), and consequently, develop organic farming. Therefore, as supported by Aceleanu (2016), provision of consumers' awareness programs can have a significant impact on the development of organic farming.

Creating a competitive market for organic products (WT1) is placed in the second level of priority. Although the global market for organic products has grown, their market is so limited in Khorasan Razavi province (Iran) and the organic products are only available in 13 specialized stores in this province (Iranian Organic Association, 2020). The lack of access to these stores due to their small number, the inconsistent prices of products and the emergence of counterfeit organic products indicate the necessity of establishing competitive market for organic products. Attention to the market in the organic farming development has also been emphasized in Ferreira et al. (2020) and Adebiyi (2014) studies. The third level of priority belongs to planning to teach the principles of organic farming (WO2). Farmers' knowledge and education significantly affect the adoption of sustainable agricultural practices and facilitate its implementation (Mishra et al, 2018). Therefore, in order to develop organic farming, it is necessary to improve the knowledge of farmers in the field of organic farming.

To validate the approach used, the SWOT analysis combined with other value measurement approaches such as ANP, AHP, and fuzzy AHP (FAHP) was analyzed. The priorities obtained for the strategies are shown in Table 12. In all three methods, like fuzzy ANP (FANP) analysis, the WT2 and WT1 are detected to be the best strategies and SO1 is found to be of the least priority. However, WO2, WO1, and ST3 strategies were differently ranked by three methods. It is clear that the difference is caused by the dependence between factors and consideration of the fuzzy environment.

Table 12

The priority of strategies with ANP, AHP, and FAHP

Strategy	Whole Priority				Ranking			
	ANP	FANP	AHP	FAHP	ANP	FANP	AHP	FAHP
SO1	0.107	0.143	0.055	0.068	9	9	9	9
SO2	0.125	0.158	0.065	0.073	8	8	8	8
ST1	0.154	0.179	0.081	0.086	7	7	7	7
ST2	0.163	0.185	0.090	0.091	6	6	6	6
ST3	0.209	0.207	0.120	0.010	5	4	4	4
WO1	0.210	0.206	0.133	0.011	4	5	3	3
WO2	0.245	0.230	0.113	0.099	3	3	5	5
WT1	0.319	0.262	0.167	0.123	2	2	2	2
WT2	0.340	0.276	0.176	0.126	1	1	1	1

Source: Research findings.

4.3. Generalizing the study method and results

The SWOT analysis involves comprehensive factors that affect organic farming. Some of these factors, like favorable climate, suitable soil and lands, and local history of organic farming, are different in various regions. This causes the variation of SWOT factors and sub-factors in different regions and accordingly, leads to different results and strategies. Therefore, the study method can be developed in other areas after redefining these factors in accordance with those areas' characteristics. This means that only the first of the nine steps (as descripted in Section 4.3) needs to be adjusted to the new area, while the other steps remain intact regardless of the factors identified in the SWOT analysis. In any case, if the SWOT analysis is applied to a different region, factors similar to those defined for this study, even the best strategies, may be valid for that region.

5. Conclusions

Organic farming as one of the most promising ways to reduce the negative effects of modern farming has concerned academia, policymakers, producers, and consumers. So that, several support policies and academic studies have been conducted on this subject in recent years. Although organic farming is increasing in many countries, it has had a reverse trend in some countries. This study was able to determine the best strategies for the development of organic farming and filled the gap in the previous studies in four ways. First, it identified strengths, weaknesses, opportunities, threats, and comprehensive factors affecting organic farming. Second, the interdependence between the factors was considered. Third, the uncertainty of real-world and decision-makers' opinions were addressed. Finally, it focused on Iran as a country suffering from the decrease in organic farmland, with special focus on Khorasan Razavi province. To that, a combination of SWOT analysis, fuzzy theory, and ANP method was applied with introducing several new procedural factors for the development of the organic farming.

SWOT analysis was used as an effective method to identify the factors (strengths, weakness, opportunities and threats) affecting organic farming and define organic farming development strategies. In a survey participated by 20 agricultural experts, 13 internal factors including 6 strengths and 7 weaknesses and 13 external factors including 6 opportunities and 7 threats were identified, relating to the case study. Among the strengths and opportunities, the profitability of organic farming (S4) and the improvement of foreign trade (O4) are the most important factors which drive organic farming development. Despite the strengths and opportunities, weaknesses and threats decrease organic farming in Khorasan Razavi province. The limited supply of organic products in specialized stores (W7) and the emergence of fake organic products (T1) are the most important weakness and threat recognized, respectively.

Through combining strengths, weakness, opportunities and threats, nine strategies were identified for organic farming development. Since SWOT analysis could not rank the SWOT factors and prioritize the obtained strategies, it was integrated with ANP method. In ANP, the weight of each factor was specified and a score was assigned to each alternative. This approach was based on pairwise comparisons, considering the interdependence between them. To overcome the ambiguities in the linguistic evaluation process, fuzzy set theory was applied.

The results of this hybrid method showed that WT2, WT1, and WO2 are the best strategies for development of organic farming, respectively. This means that developing consumers' awareness programs, creating a competitive market for organic products, and planning to teach the principles of organic farming are the main drivers of organic farming development in the studied case. Other value measurement methods, i.e., ANP, AHP, and FAHP also confirmed these findings. Therefore, it is important to develop educational and awareness programs for both consumers and farmers. In addition, creating a competitive market for organic products removes sales barriers and builds consumer confidence in these products.

The method utilized in this study allows to consider objectively, by combining both qualitative and quantitative approaches, the factors affecting organic farming in one province of Iran. This means that the method can be used in any other factors framework and regions. In regions with similar characteristics to the studied region, the best strategies obtained can be applied. To use the study method for other areas, the SWOT factors and sub-factors should be redefined in accordance with the new areas' characteristics.

Due to limitations in article space, it was impossible to employ the method for all areas to combine the SWOT analysis with the other MCDM approaches to rank strategies. Therefore, future studies are recommended to be conducted to investigate the other areas and methods.

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Appendix A

Table 11

	S1	S2	S3	S4	S5	S6	W1	W2	W3	W4	W5	W6	W7	O1	O2	O3	O4	O5	O6	T1	T2	T3	T4	T5	T6	T7
B-Value																										
SO1	0.097	0.111	0.098	0.070	0.111	0.109	0.097	0.081	0.097	0.111	0.098	0.097	0.097	0.111	0.111	0.111	0.098	0.098	0.111	0.097	0.096	0.098	0.098	0.086	0.098	0.098
SO2	0.097	0.111	0.098	0.074	0.111	0.109	0.110	0.097	0.097	0.111	0.098	0.097	0.097	0.111	0.098	0.111	0.111	0.111	0.111	0.097	0.096	0.098	0.098	0.098	0.098	0.098
ST1	0.110	0.111	0.125	0.095	0.111	0.139	0.097	0.097	0.097	0.111	0.111	0.097	0.097	0.111	0.111	0.111	0.111	0.111	0.111	0.097	0.085	0.141	0.111	0.110	0.111	0.111
ST2	0.097	0.111	0.110	0.107	0.098	0.096	0.158	0.110	0.110	0.111	0.111	0.109	0.110	0.111	0.111	0.111	0.111	0.111	0.111	0.097	0.109	0.111	0.111	0.141	0.111	0.111
ST3	0.110	0.111	0.098	0.121	0.111	0.096	0.097	0.124	0.110	0.111	0.111	0.097	0.110	0.111	0.111	0.111	0.125	0.111	0.111	0.097	0.157	0.111	0.111	0.110	0.111	0.111
WO1	0.092	0.111	0.110	0.107	0.111	0.109	0.124	0.110	0.110	0.111	0.141	0.109	0.110	0.111	0.111	0.111	0.111	0.111	0.111	0.109	0.096	0.111	0.111	0.110	0.111	0.111
WO2	0.131	0.111	0.110	0.107	0.125	0.123	0.097	0.110	0.159	0.111	0.111	0.178	0.110	0.111	0.111	0.111	0.111	0.111	0.111	0.140	0.096	0.111	0.111	0.125	0.141	0.141
WT1	0.110	0.111	0.110	0.164	0.111	0.109	0.110	0.124	0.110	0.111	0.111	0.109	0.159	0.111	0.125	0.111	0.111	0.111	0.111	0.109	0.139	0.111	0.141	0.110	0.111	0.111
WT2	0.158	0.111	0.141	0.155	0.111	0.109	0.110	0.148	0.110	0.111	0.111	0.109	0.110	0.111	0.111	0.111	0.111	0.125	0.111	0.158	0.123	0.111	0.111	0.110	0.111	0.111
M-Value																										
SO1	066/0	0.072	0.073	0.053	0.113	0.065	0.060	0.070	0.059	0.083	0.065	0.062	0.073	0.081	0.072	0.068	0.061	0.061	0.085	0.088	0.074	0.062	0.065	066/0	0.071	0.073
SO2	0.073	0.084	0.104	0.045	0.093	0.125	0.079	0.061	0.079	0.073	0.056	0.076	0.064	0.127	0.078	0.095	0.091	0.091	0.104	0.059	0.061	066/0	0.063	0.065	0.065	0.065
ST1	0.110	0.110	0.094	0.090	0.084	0.147	0.104	0.071	0.075	0.095	0.080	0.083	0.069	0.079	0.074	0.098	0.088	0.097	0.083	0.078	0.064	0.180	0.107	0.146	0.103	0.106
ST2	0.072	0.108	0.086	0.081	0.079	0.087	0.156	0.085	0.096	0.107	0.124	0.118	0.093	066/0	0.120	0.090	0.088	0.086	0.091	0.074	0.090	0.086	0.119	0.182	0.131	0.101
ST3	0.095	0.107	0.068	0.129	0.080	0.062	0.101	0.159	0.076	0.112	0.125	0.071	0.112	0.128	0.111	0.129	0.163	0.127	0.099	066/0	0.200	0.117	0.144	0.099	0.097	0.085
WO1	0.084	0.119	0.099	0.121	0.093	0.097	0.147	0.112	0.116	0.125	0.198	0.116	0.133	0.101	0.132	0.090	0.088	0.092	0.117	0.107	0.090	0.098	0.106	0.103	0.111	0.135
WO2	0.148	0.104	0.157	0.070	0.157	0.140	0.074	0.085	0.231	0.107	0.088	0.233	0.083	0.141	0.097	0.138	0.124	0.130	0.161	0.167	0.104	0.123	0.089	0.138	0.189	0.192
WT1	0.156	0.134	0.136	0.209	0.128	0.137	0.139	0.147	0.130	0.140	0.127	0.118	0.225	0.137	0.166	0.146	0.135	0.144	0.130	0.137	0.157	0.143	0.173	0.107	0.131	0.132
WT2	0.198	0.163	0.183	0.201	0.174	0.141	0.141	0.211	0.139	0.157	0.137	0.123	0.146	0.139	0.149	0.146	0.162	0.171	0.130	0.225	0.160	0.125	0.135	0.093	0.101	0.111
T-Value																										
SO1	0.064	0.072	0.072	0.051	0.113	0.064	0.059	0.068	0.058	0.083	0.064	0.061	0.072	0.081	0.072	0.068	0.060	0.060	0.085	0.086	0.073	0.061	0.063	0.064	0.070	0.072
SO2	0.071	0.084	0.102	0.043	0.093	0.125	0.079	0.059	0.077	0.073	0.055	0.074	0.063	0.127	0.077	0.095	0.091	0.091	0.104	0.058	0.059	0.065	0.062	0.064	0.064	0.064
ST1	0.109	0.110	0.095	0.088	0.084	0.150	0.102	0.069	0.074	0.095	0.080	0.081	0.068	0.079	0.074	0.098	0.088	0.097	0.083	0.076	0.061	0.185	0.107	0.145	0.102	0.105
ST2	0.070	0.108	0.086	0.080	0.077	0.085	0.162	0.084	0.095	0.107	0.123	0.117	0.093	066/0	0.120	0.090	0.088	0.086	0.091	0.072	0.090	0.086	0.119	0.187	0.131	0.101
ST3	0.094	0.107	0.067	0.129	0.080	0.061	0.099	0.161	0.075	0.112	0.125	0.070	0.112	0.128	0.111	0.129	0.165	0.127	0.099	0.064	0.207	0.117	0.143	0.098	0.097	0.085
WO1	0.083	0.119	0.099	0.120	0.093	0.096	0.148	0.111	0.115	0.125	0.203	0.115	0.132	0.101	0.132	0.090	0.088	0.092	0.117	0.106	0.088	0.097	0.105	0.103	0.111	0.134
WO2	0.148	0.104	0.157	0.069	0.159	0.141	0.073	0.084	0.239	0.107	0.088	0.244	0.083	0.141	0.097	0.138	0.123	0.130	0.161	0.170	0.101	0.123	0.089	0.140	0.194	0.196
WT1	0.155	0.134	0.136	0.214	0.128	0.137	0.138	0.148	0.129	0.140	0.126	0.117	0.234	0.137	0.168	0.146	0.135	0.144	0.130	0.136	0.160	0.142	0.177	0.106	0.131	0.132
WT2	0.205	0.163	0.187	0.207	0.174	0.141	0.141	0.215	0.138	0.157	0.136	0.122	0.145	0.139	0.149	0.146	0.162	0.173	0.130	0.232	0.161	0.124	0.134	0.093	0.101	0.110

The fuzzy matrix W4

Appendix B

Questionnaire 1

Dear expert, the questionnaire that is in front of you is related to conduct a research in the field of organic farming development. Please help to complete it. Thank you in advance for your cooperation in answering the questions.

What are the strengths of organic farming in Khorasan Razavi province? Please prioritize them.

strengths of organic farming	degree of importance
1. …………………………………………………………………	……
2. …………………………………………………………………	……
3. …………………………………………………………………	……
4. …………………………………………………………………	……
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1. What are the weaknesses of organic farming in Khorasan Razavi province? Please prioritize them.

weaknesses of organic farming	degree of importance
1. …………………………………………………………………	……
2. …………………………………………………………………	……
3. …………………………………………………………………	……
4. …………………………………………………………………	……
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2. What are the opportunities of organic farming in Khorasan Razavi Province? Please prioritize them.

opportunities of organic farming	degree of importance
1. …………………………………………………………………	……
2. …………………………………………………………………	……
3. …………………………………………………………………	……
4. …………………………………………………………………	……
.	
.	
.	

3. What are the threats for organic farming in Khorasan Razavi province? Please prioritize them.

threats of organic farming	degree of importance
1. …………………………………………………………………	……
2. …………………………………………………………………	……
3. …………………………………………………………………	……
4. …………………………………………………………………	……

. . .	……

Appendix C

Questionnaire 2

Dear expert, the questionnaire that is in front of you is related to a research in the field of organic farming development. Thank you in advance for your cooperation in answering the questions.

Note: The preference will be indicated by numbers 1 to 9, which will be measured in pairs. In this method, the number 1 means that the two elements have the same preference and the number 9 have the most preferred. Thus, compare the two elements and choose the best one. For example, if the right element is three times more preferable than the left element, you must select the number 3 on the right, and vice versa.

Table 1. The fundamental scale for pairwise comparisons

Intensity of preference	Definition	Explanation
1	Equal preference	Two elements have equal preference.
2	Weak preference	Preference between equal and moderate
3	Moderate preference	Judgment slightly prefers one element.
4	Moderate to strong preference	Preference between moderate and strong
5	Strong preference	An element is strongly preferred.
6	Strong to very strong preference	Preference between strong and very strong
7	Very strong preference	An element is very strongly preferred.
8	Very strong to extreme preference	Preference between very strong and extreme
9	Extreme preference	An element is extremely preferred.

❖ Please answer Questions 1 to 19, considering the strengths, weaknesses, opportunities and threats of organic farming in Table 2 and organic farming development strategies in Table 3.

Table 2. Strengths, Weaknesses, Opportunities, and Threats (SWOT Factors) of Organic Farming

SWOT Factors	Description
Strengths (S)	• The profitability of organic farming • Producing quality and safe food • Improving human health • History of organic farming in the province • Suitable soil and lands • Favorable climate • Improving human health • History of organic farming in the province
Weaknesses (W)	• Lack of access to financial facilities for organic farming • The financial loss of transition period • Low level of farmers' literacy • Low yield per hectare • Weak farmers' interaction with promoters • Lack of farmers' knowledge about the principles of organic farming • The limited supply of organic products in specialized stores
Opportunities (O)	• Possibility to attract private sector capital • Developing incentives for farmers by promoting and supporting organic farming • Demand for organic products • Improvement of foreign trade • Reduction in environmental degradation • Applying and executing scientific achievements
Threats (T)	• The emergence of fake organic products • Legal barriers to exporting organic products • Lack of access to organic resources and inputs • Lack of pricing mechanism for organic products • The existence of pests and plant diseases • Low level of consumers' awareness about organic products • The weakness of educational and promotional planning

Table 3. Strategies for organic farming development

Strategies	Description
SO strategies	• Completing the value chain of organic products (SO1) • Encouraging communities to invest in organic projects (SO2)
WO strategies	• Financial support to farmers in the transition period (WO1) • Planning to teach the principles of organic farming (WO2)
ST strategies	• Facilitating access to organic inputs (ST1) • Facilitating farmers' access to insurance for the cultivation of organic producers (ST2) • Removing legal and political barriers to exporting organic products (ST3)
WT strategies	• Creating a competitive market for organic products (WT1) • Developing consumers' awareness programs (WT2)

1. Compare the relative importance of Strengths, Weaknesses, Opportunities, and Threats.

SWOT factors Preference																		
Strengths	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Weaknesses
Strengths	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Opportunities
Strengths	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Threats
Weaknesses	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Opportunities
Weaknesses	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Threats
Opportunities	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Threats

2. Compare the relative importance of Strengths.

Strengths Preference																		
The profitability of organic farming	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Producing quality and safe food
The profitability of organic farming	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Improving human health
The profitability of organic farming	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	History of organic farming in the province
The profitability of organic farming	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Suitable soil and lands
The profitability of organic farming	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Favorable climate
Producing quality and safe food	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Improving human health
Producing quality and safe food	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	History of organic farming in the province
Producing quality and safe food	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Suitable soil and lands
Producing quality and safe food	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Favorable climate
Improving human health	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	History of organic farming in the province
Improving human health	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Suitable soil and lands
Improving human health	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Favorable climate

History of organic farming in the province	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Suitable soil and lands
History of organic farming in the province	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Favorable climate
Suitable soil and lands	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Favorable climate

3. Compare the relative importance of Weaknesses.

Weaknesses Preference																		
Lack of access to financial facilities for organic farming	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	The financial loss of transition period
Lack of access to financial facilities for organic farming	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Low level of farmers' literacy
Lack of access to financial facilities for organic farming	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Low yield per hectare
Lack of access to financial facilities for organic farming	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Weak farmers' interaction with promoters
Lack of access to financial facilities for organic farming	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Lack of farmers' knowledge about the principles of organic farming
Lack of access to financial facilities for organic farming	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	The limited supply of organic products in specialized stores
The financial loss of transition period	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Low level of farmers' literacy
The financial loss of transition period	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Low yield per hectare
The financial loss of transition period	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Weak farmers' interaction with promoters
The financial loss of transition period	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Lack of farmers' knowledge about the principles of organic farming
The financial loss of transition period	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	The limited supply of organic

																		products in specialized stores
Low level of farmers' literacy	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Low yield per hectare
Low level of farmers' literacy	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Weak farmers' interaction with promoters
Low level of farmers' literacy	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Lack of farmers' knowledge about the principles of organic farming
Low level of farmers' literacy	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	The limited supply of organic products in specialized stores
Low yield per hectare	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Weak farmers' interaction with promoters
Low yield per hectare	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Lack of farmers' knowledge about the principles of organic farming
Low yield per hectare	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	The limited supply of organic products in specialized stores
Weak farmers' interaction with promoters	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Lack of farmers' knowledge about the principles of organic farming
Weak farmers' interaction with promoters	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	The limited supply of organic products in specialized stores
Lack of farmers' knowledge about the principles of organic farming	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	The limited supply of organic products in specialized stores

4. Compare the relative importance of Opportunities.

Opportunities Preference																		
Possibility to attract private sector capital	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Developing incentives for farmers by promoting and supporting organic

																		farming
Possibility to attract private sector capital	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Demand for organic products
Possibility to attract private sector capital	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Improvement of foreign trade
Possibility to attract private sector capital	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Reduction in environmental degradation
Possibility to attract private sector capital	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Applying and executing scientific achievements
Developing incentives for farmers by promoting and supporting organic farming	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Demand for organic products
Developing incentives for farmers by promoting and supporting organic farming	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Improvement of foreign trade
Developing incentives for farmers by promoting and supporting organic farming	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Reduction in environmental degradation
Developing incentives for farmers by promoting and supporting organic farming	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Applying and executing scientific achievements
Demand for organic products	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Improvement of foreign trade
Demand for organic products	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Reduction in environmental degradation
Demand for organic products	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Applying and executing scientific achievements
Improvement of foreign trade	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Reduction in environmental degradation
Improvement of foreign trade	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Applying and executing scientific

																		achievements
Reduction in environmental degradation	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Applying and executing scientific achievements

5. Compare the relative importance of Threats.

Threats Preference																		
The emergence of fake organic products	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Legal barriers to exporting organic products
The emergence of fake organic products	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Lack of access to organic resources and inputs
The emergence of fake organic products	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Lack of pricing mechanism for organic products
The emergence of fake organic products	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	The existence of pests and plant diseases
The emergence of fake organic products	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Low level of consumers' awareness about organic products
The emergence of fake organic products	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	The weakness of educational and promotional planning
Legal barriers to exporting organic products	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Lack of access to organic resources and inputs
Legal barriers to exporting organic products	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Lack of pricing mechanism for organic products
Legal barriers to exporting organic products	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	The existence of pests and plant diseases
Legal barriers to exporting organic products	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Low level of consumers' awareness about organic products
Legal barriers to exporting organic products	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	The weakness of educational and promotional

																		planning
Lack of access to organic resources and inputs	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Lack of pricing mechanism for organic products
Lack of access to organic resources and inputs	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	The existence of pests and plant diseases
Lack of access to organic resources and inputs	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Low level of consumers' awareness about organic products
Lack of access to organic resources and inputs	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	The weakness of educational and promotional planning
Lack of pricing mechanism for organic products	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	The existence of pests and plant diseases
Lack of pricing mechanism for organic products	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Low level of consumers' awareness about organic products
Lack of pricing mechanism for organic products	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	The weakness of educational and promotional planning
The existence of pests and plant diseases	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Low level of consumers' awareness about organic products
The existence of pests and plant diseases	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	The weakness of educational and promotional planning
Low level of consumers' awareness about organic products	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	The weakness of educational and promotional planning

6. Assuming each of the following strengths, compare the relative importance of strategies as a number between 1 and 9.

Strengths	SO strategy to WO	SO strategy to ST	SO strategy to WT	ST strategy to WO	ST strategy to WT	WO strategy to WT

Suitable soil and lands						
History of organic farming in the province						
Improving human health						
The profitability of organic farming						
Producing quality and safe food						
Favorable climate						

7. Assuming each of the following weaknesses, compare the relative importance of strategies as a number between 1 and 9.

Weaknesses	SO strategy to WO	SO strategy to ST	SO strategy to WT	ST strategy to WO	ST strategy to WT	WO strategy to WT
Lack of access to financial facilities for organic farming						
The financial loss of transition period						
Low level of farmers' literacy						
Low yield per hectare						
Weak farmers' interaction with promoters						
Lack of farmers' knowledge about the principles of organic farming						
The limited supply of organic products in specialized stores						

8. Assuming each of the following opportunities, compare the relative importance of strategies as a number between 1 and 9.

Opportunities	SO strategy to WO	SO strategy to ST	SO strategy to WT	ST strategy to WO	ST strategy to WT	WO strategy to WT
Possibility to attract						

private sector capital						
Developing incentives for farmers by promoting and supporting organic farming						
Demand for organic products						
Improvement of foreign trade						
Reduction in environmental degradation						
Applying and executing scientific achievements						

9. Assuming each of the following threats, compare the relative importance of strategies as a number between 1 and 9.

Threats	SO strategy to WO	SO strategy to ST	SO strategy to WT	ST strategy to WO	ST strategy to WT	WO strategy to WT
The emergence of fake organic products						
Legal barriers to exporting organic products						
Lack of access to organic resources and inputs						
Lack of pricing mechanism for organic products						
The existence of pests and plant diseases						
Low level of consumers' awareness about organic products						
The weakness of educational and promotional planning						

10. Assuming each of the following SWOT factors, compare the relative importance of Strengths, Weaknesses, Opportunities, and Threats as a number between 1 and 9.

SWOT Factors	Strengths to Weaknesses	Strengths to Opportunities	Strengths to Threats	Weaknesses to Opportunities	Weaknesses to Threats	Opportunities to Threats
Strengths						
Weaknesses						
Opportunities						
Threats						

Highlights

- A hybrid SWOT- Fuzzy Analytic Network Process is applied to find the best strategies for organic farming development in a given region.
- The method considers holistic factors affecting organic farming and their interaction.
- The method considers uncertainty in decision-makers' judgments.
- The method considers the agronomic and climatic peculiarities of the studied region.
- Developing consumers' awareness programs is the best strategy for organic farming development.

Declaration of interests

☒ The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

☐The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: