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Food security assessment in rural areas: evidence from Iran

Atefeh Ahmadi Dehrashid[1] , Masoud Bijani[2*] , Naser Valizadeh[3] , Hossein Ahmadi Dehrashid[4] ,
Bahram Nasrollahizadeh[5] and Akbar Mohammadi[6]

Abstract

Background: Food security is considered a pivotal factor for the sustainable development of communities and focus on this issue in rural areas. More specifically, it is of paramount importance in developing countries. Accordingly, this descriptive-analytical study aimed to evaluate the status of food security in rural areas of Iran. The main originality of the present study is to assess the strategic future-oriented vision for food security in addition to the evaluation of the current status of the studied area.

Methodology: Data were collected using the standard questionnaire of U.S. Department of Agriculture (USDA) and a researcher-made close-ended questionnaire. The validity and reliability of the research instrument were confirmed by a panel of specialists and Cronbach's alpha coefficients, respectively. In addition, data analysis was performed using $SPSS_{24}$ (to analyze the descriptive statistics) and Fuzzy Technique for Order Preference by Similarity to Ideal Situation (FTOPSIS).

Results: According to the results, 80% of the villagers suffered from food insecurity (25% in low food insecurity situation, 42% in moderate food insecurity situation, and 13% in severe food insecurity situation). Evaluation of the factors affecting food insecurity demonstrated that economic (standardized weight of 0.566), stability (standardized weight of 0.559), and availability (standardized weight of 0.558) were the most important components affecting food insecurity. Moreover, in a systemic approach, the growth of migration from rural to urban areas, pressure on water and soil resources, and the occurrence of environmental hazards are of the most significant consequences of food insecurity. In addition, due to the excessive use of underground water for cucurbits, which is the dominant cultivation pattern in this region, the groundwater level has dropped sharply in some villages farther from the city which can be alarming for exacerbating food insecurity in the near future.

Conclusion: Since the low-income level of villagers, lack of job diversity, and lack of access to adequate food are the main reasons for food insecurity, in this respect, it is suggested that more attention be paid to the development of occupations and job diversity in these regions by decision-makers and policy-makers.

Keywords: Food security, Food insecurity, Rural people, Consequences, Fuzzy TOPSIS (FTOPSIS)

Background

Without a doubt, the safety of societies depends on "food security". This concept has various interpretations in different countries, which makes it more complicated and extensive [1]. The term food security was first introduced at the World Food Summit in 1974. The meeting focused on the fact that food security is a mutual responsibility

*Correspondence: mbijani@modares.ac.ir
[2] Department of Agricultural Extension and Education, College of Agriculture, Tarbiat Modares University (TMU), 1497713111 Tehran, Iran
Full list of author information is available at the end of the article

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of all nations and its achievement requires international cooperation and serious measures [2].

In fact, food and safety are necessary for political stability and creating peace among people [1]. Scientifically, food security is defined as a planned method designed to solve food and nutrition problems in the framework of codified programs and development management [3, 4]. Accordingly, food security is a factor for national growth and development which its fulfillment requires practical strategies to reduce or eliminate barriers to the realization of global food security [5, 6]. Given the increased productivity and efficiency of agricultural crops in the world [7], especially over the last half-century, the need for food has increased dramatically due to the increasing growth of the world's population. In this regard, researchers have found no direct relationship between food production and food security [8].

The necessity of food security establishment has been extensively emphasized in Iran through the 5-year economic, social, and cultural development programs and national plan of action for nutrition and food security (2012–2020). The Constitution of the Islamic Republic of Iran, in Principles 3, 29, and 43, emphasizes the need to meet the basic needs of different groups of society, alleviate poverty, and eliminate any kind of deprivation in the field of nutrition, and individual and social welfare. The 20-year Development Agenda also pays special attention to improving the food security situation. The most important executive policies of food supply based on The 20-year Development Agenda and The Constitution of the Islamic Republic of Iran include: (1) sustainable agriculture, food security, and rural development, (2) increasing production, improving productivity, and development of a comprehensive pest control system, (3) management of water resources and increasing efficiency of agricultural water consumption, (4) management of soil and prevention of its erosion, self-sufficiency of basic products, and achieving a dominant pattern of suitable food, and (5) developing a training, research, and extension system in the field of agricultural production process from farm to forest [9].

In this regard, policies and measures such as the formation of the High Council for Health and Food Safety, the development and implementation of necessary training programs to promote the nutrition culture and literacy of the society, providing basic food items and ensuring a proper market, mandatory and optional enrichment of main and complementary foods, healthy food and safe in the supply, and the standard of food chain have been considered. Despite carrying out the mentioned plans and related policy-makings, there have been challenges to the realization of food security in Iran, especially in rural areas. This is more observed in the western regions

of Iran and the villages in this part of the country, which is mostly due to their geographical location (being on the borders) and their distance from the effects of development in the Core Periphery System (CPS). Moreover, the economy and food security of this region are more vulnerable; since most of the human settlements are located on Zagros Mountains and their domain. In general, due to the mountainous nature of the region and the lack of fertile lands, the agricultural sector of this region has not grown sufficiently. Therefore, most people of the region focus on horticulture and animal husbandry. However, it is worth noting that the relative prosperity in agriculture can be seen in limited plains of this region [10]. In addition, villages in this part of the country have low population due to being mountainous and located on a borders. Given the fact that agriculture is seasonal in this region, population movements (migration) are extremely high in these areas in the second half of the year (autumn and winter), which results in reduced social capital and rural economic prosperity, weakened agricultural sector, and a threat to food security in western regions of Iran [11].

In this respect, villages of Dehgolan Township in Kurdistan Province (west of Iran) were selected as the study area. In addition to the above-mentioned challenges, issues, such as improper methods of resource utilization, low level of knowledge in rural households, increasing decline in water resources' quality and quantity, increased inequality among rural families, environmental pollution, increased toxins, contamination of water and soil resources, and decreased soil fertility, have prevented sustainable food security. Meanwhile, maintaining and enhancing environmental, social, and economic grounds are crucial to achieve sustainable food security [12]. Therefore, the present study was performed to assess the food security situation of the study area with a comprehensive or systematic view. Its aim was also to identify the negative consequences for lack of food security and focus on the current situation of the study population using identifying the effective factors in sustainable food security. As such, the novelty of the present study, compared to other studies carried out at the international level, is to assess the strategic future-oriented vision for food security in addition to the evaluation of the current status of the studied area. In other words, the present study was one of the first applied research in this field. Moreover, primary assessments demonstrated a lack of research on the evaluation of food security in these regions. Meanwhile, assessing food security in these areas can greatly contribute to understanding the current status of food security, recognizing vulnerable individuals/groups in terms of food security, developing appropriate policies to improve food security, and implementing effective interventions in this area. With this background in

mind, the present study aimed to evaluate food security in rural areas of western Iran. In the process of achieving this goal, an attempt was made to answer the following questions:

1. What are the elements and dimensions of food security in the study area?;
2. Which of the elements and dimensions of food security have the highest priority in the study area?;
3. What are the consequences of food insecurity in the study area?; and
4. Which of the consequences of food insecurity is more important in the study area?

Food security issues and the role of food security assessment in food security

The global food security situation and outlook remain delicately imbalanced amid surplus food production and the prevalence of hunger, due to the complex interplay of social, economic, and ecological factors that mediate food security outcomes at various human and institutional scales [13–15]. A growing population and rising incomes with the resultant nutritional transition of millions more people entering into the middle class are some of the unprecedented challenges that mankind has never handled before [16]. Food production outpaced food demand over the past 50 years due to expansion in crop area and irrigation, as well as supportive policy and institutional interventions that led to the fast and sustained growth in agricultural productivity and improved food security in many parts of the world [17, 18]. However, future predictions point to a slow-down in agricultural productivity and a food-gap mainly in areas across Africa and Asia which are having ongoing food security issues. The problem of food insecurity is expected to worsen due to, among others, rapid population growth and other emerging challenges such as climate change and rising demand for biofuels. To tackle this problems, some research priorities have been provided by international organizations. According to the researchers [19–21], food security assessment in the rural areas is one of the most significant research priorities which can have a great role in measuring the level of food security, identifying high-risk areas in terms of food security, and taking required measure to tackle food insecurity. Therefore, present study has an interwoven relationship with food security and its results can be very insightful in interventions aiming at reducing food insecurity.

Theoretical framework

The intellectual origins of food security, as one of the most important components of global security, date back to the food crisis of the early 1970s. At the World Food Conference in 1975, the United Nations defined food security as the adequate supply of basic foodstuffs worldwide and at all times; in a way that increases or stabilizes consumption and compensates for fluctuations in production and prices. In 1983, FAO introduced a broader concept of food security, stating that everyone has physical and economic access to essential food at all times. This definition included three basic components: food availability, access, and utility [22, 23]. Later, another dimension called "stability" was added to food security. Therefore, the definitions of food security now consist of four main dimensions. Food availability is basically physical availability through national food stocks and commercial food imports, farming, community gardens and harvesting (own production and storage), purchasing (the market) or bartering, etc. [21, 24]. Financial and physical access to food refers to the equal distribution of the available food using existing structures and resources. Food utilization refers to the extent to which households are maximizing the consumption of sufficient nutrition and energy. The fourth dimension of food security or food stability refers to consistent food security over time [25]. Evaluation of the trend of agricultural production along with the trend of world population growth over the last 50 years shows that agricultural production has increased in proportion to the population due to increased cultivated area [26, 27]. However, access of people of different countries to the food has decreased, which has led to hidden hunger and food insecurity in a large scale [6, 28–31].

Today, 13% of the population of developing countries are dealing with food insecurity [32, 33]. In other words, about 98% of those who face malnutrition and food insecurity in the world are living in developing countries [18, 30]. Since a considerable part of these people live in rural regions, improving the food security of rural households is of great importance [34–36]. Today, rural areas are facing food insecurity due to various reasons, including rapid growth in the population, low productivity in agriculture, lack of sustainable policies related to food security, macroeconomic instability, and sharp fluctuations in agricultural prices [37–39]. The great importance of food security in rural areas has made it a core issue in global decision-makings. In addition, this notion is recognized as a fundamental challenge for national policies and public concerns [17, 40, 41]. Therefore, ensuring villagers' food security, which is a pre-requisite for national security, is one of the main responsibilities of government in all countries [42].

Notably, rural food security is realized by taking the novel aspects of sustainable development (e.g., social, economic, environmental, institutional, structural, and

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technological dimensions) into account. In this context, a number of factors affecting rural food security, such as agricultural production policies, food distribution system, natural resources, nutrition and consumption pattern, occupational status and income distribution, business policy, and nutrition culture should be considered [43]. There is a scarcity of research on food security at the level of villages in Iran. Meanwhile, those conducted at the international level have solely focused on specific aspects of food security. Some of these studies are pointed out below.

Some researchers [see 44, 45] believe that economic and income factors play a key and determining role in food security and the potential ability of the household in meeting their needs. In addition, cultural and social issues significantly influence the effective management of the family budget and choosing the right food at the right price. Moreover, the production of agricultural products has decreased due to the growth of urban population and decrease of the rural population (especially in developing countries), which has made access to food more difficult for the growing urban, and even rural populations. Furthermore, there is a higher demand for food supply with an increase in relative population density, which is the ratio of population to the area of a region in terms of people per km^2. Increasing demands for food has caused more challenges in the area of the food supply. Other researchers [see 46, 47] in the field of diet have analyzed food security in some countries (including India, the Philippine, and Mozambique) using a linear regression method. In the end, the mentioned scholars confirmed the presence of a relationship between food diversity with food security and access to calories and food at the individual and household levels. In a study, Ojeleye [48] evaluated the indicators of food security of farming households in Nigeria. According to the results, about one-third of rural farmer families (the average size of their family farm was 2.05 hectares), dealt with food insecurity. In another research, Patel et al. [19] evaluated the interplay between household food security and wellbeing among small-scale farmers in the context of rapid agrarian change in India. The research focused on the analysis of food security with three approaches of "food availability", "livelihood", and "food governance". By analyzing the food security status of farmer households in arid regions of Sudan, Abdalla et al. [49] reported that 82% of the participants faced food security problems. In a qualitative research, Norhasmah et al. [50] evaluated the coping strategies of female household heads in conditions of food insecurity in the Salangar and Similan region of Nigeria, and concluded that each strategy showed a different level of severity.

In a study, Belay Bedeke [51] evaluated the factors affecting the status of food security in Kersa district, east Hararghe Ethiopia, and found a negative association between food security and factors such as the size of the family and gender of the head of the household (women). In addition, Zhai [52] explored the concept of food security in China based on the framework of structure, system, and resources. The results of employing the system theory revealed that food realization in China must be based on specific national conditions, optimal resource allocation, and structural optimization. Regmi and Meade [53] assessed food security stimuli based on demand in the society and determined how consumers' preferences change in this context. By estimating price and income elasticities in several countries, they concluded that consumers in low-income countries allocate a major part of their income to the food. In a study entitled "*factors affecting food security in rural families in Punjab, India*", Bashir et al. [54] marked that while the national food security level of the region is on par with the level of food security at the international level, 26% of families experience food insecurity at the household level. Furthermore, they indicated that monthly income, household livestock assets, and family size had a positive effects on the food security of villagers. Assessing agricultural productivity and food insecurity in Brazil, Costa et al. [55] observed a significant relationship between the level of education of household heads and the presence of people under 18 years with farmers' productivity and food insecurity. van Meijl et al. [56] evaluated the modeling of the future of world food security and concluded that the concept is affected by two factors of inequality and sustainability. In the end, these scholars presented some practical scenarios for evaluating complex and multidimensional food security conditions. Furthermore, Cooper et al. [57] claimed that food security indicators have been defined differently over time in different countries. According to this research, food security was assessed based on governments' economic policies and global issues in the past, but today, other components such as health and welfare have received more attention in this field. Figure 1 is presented as the theoretical framework of the research to assess variables affecting the realization of food security, including economic, social, structural-spatial, stability, availability and achievement factors, and consequences of food insecurity at economic, social, environmental, and physical dimensions in rural areas.

Material and methods
Research design
This study was an applied, qualitative, non-experimental, and descriptive-analytical research in terms of its orientation, the nature of the issue, extent and degree of
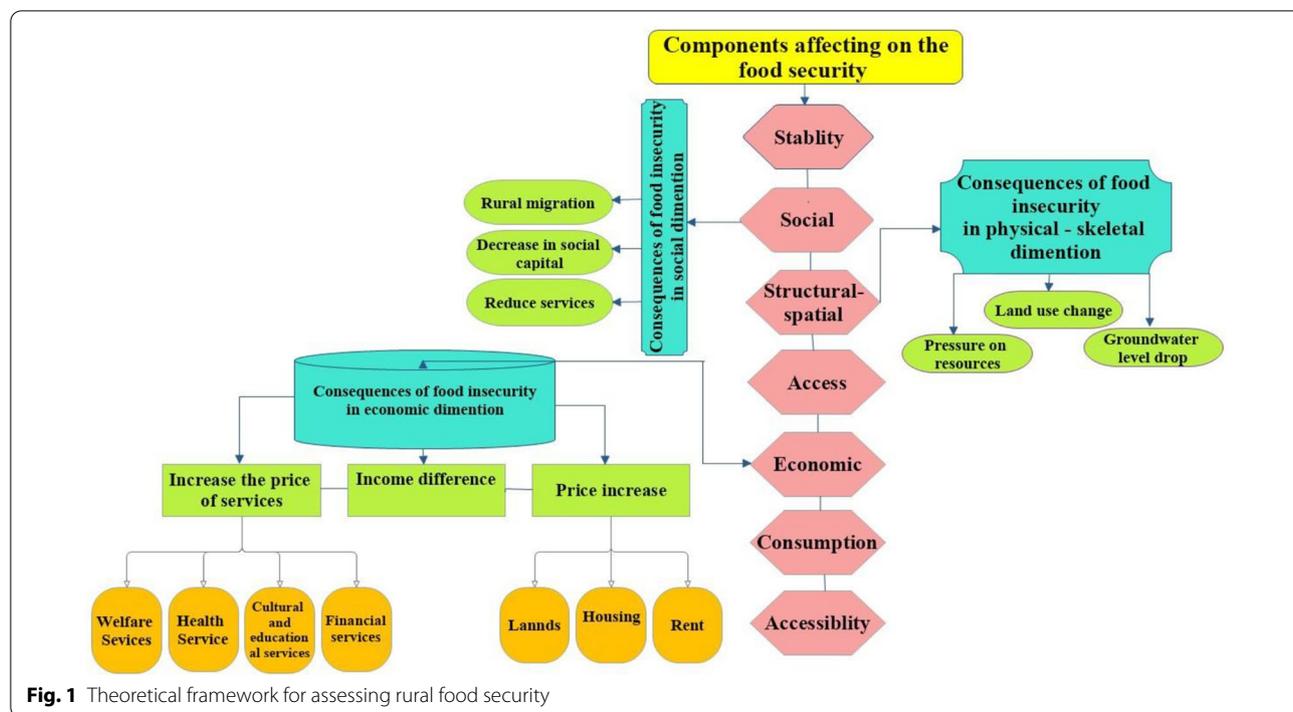
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Fig. 1 Theoretical framework for assessing rural food security

control over variables, and methodology, respectively. The study was conducted using multi-criteria decision analysis methods and survey techniques.

Study area
The research setting was five administrative divisions of Homeh, North Eylagh, South Eylagh, Sis, and Ghoru-chaie) in Dehgolan county of Kurdistan Province, Iran (Fig. 2).

Statistical population and sampling method
In total, 60 individuals were selected from the councils and village administers of the mentioned villages by a multi-staged stratified sampling method. For this purpose, the study area was first divided into 104 villages based on national geographical divisions. Then, according to the information of the Statistics Center of Iran, these villages were classified into four strata (Homeh, North Eylagh, South Eylagh, Sis, and Ghoruchaie). In the next stage, 30 villages were randomly selected according to the number of available villages in each category. Given that each of the selected villages had two village administrators, the total population was estimated to be 60. Finally, all 60 village administrators were selected as a sample using the census method. The subjects were selected from these people, since they were reliable and key informants who are constantly informed of villages' challenges and problems. In addition, due to their key responsibilities in rural governance, they can play an

effective role in problem defining in a rural community. As community representatives in the local governance process, they were also aware of programs and policies to improve food security and were able to provide reliable information.

The instrument of data collection and survey
The instrument for data collection included the standard questionnaire of the U.S. Department of Agriculture (USDA) and a researcher-made close-ended questionnaire. The face and content validities of the researcher-made questionnaire were confirmed by a panel of thematic specialists in Kharazmi and Tarbiat Modares universities. The panel members included researchers and specialists who had carried out extensive research on food security and its measurement and assessment. First, we searched international and Farsi journals to find works published on food security/assessment of food security by Iranian researchers to ensure their acquaintance with the issue and expertise for assessing the questionnaire. Following the meticulous assessment of the documents, the most related works were selected, and then, a number of researchers and authors, whose works were mostly related to the present research, were selected as the members of the specialist panel. Following that, the initial version of the designed questionnaire was provided to them in person/electronically, and after receiving the opinions and feedbacks of the panel members regarding the questionnaire's face and content validities,
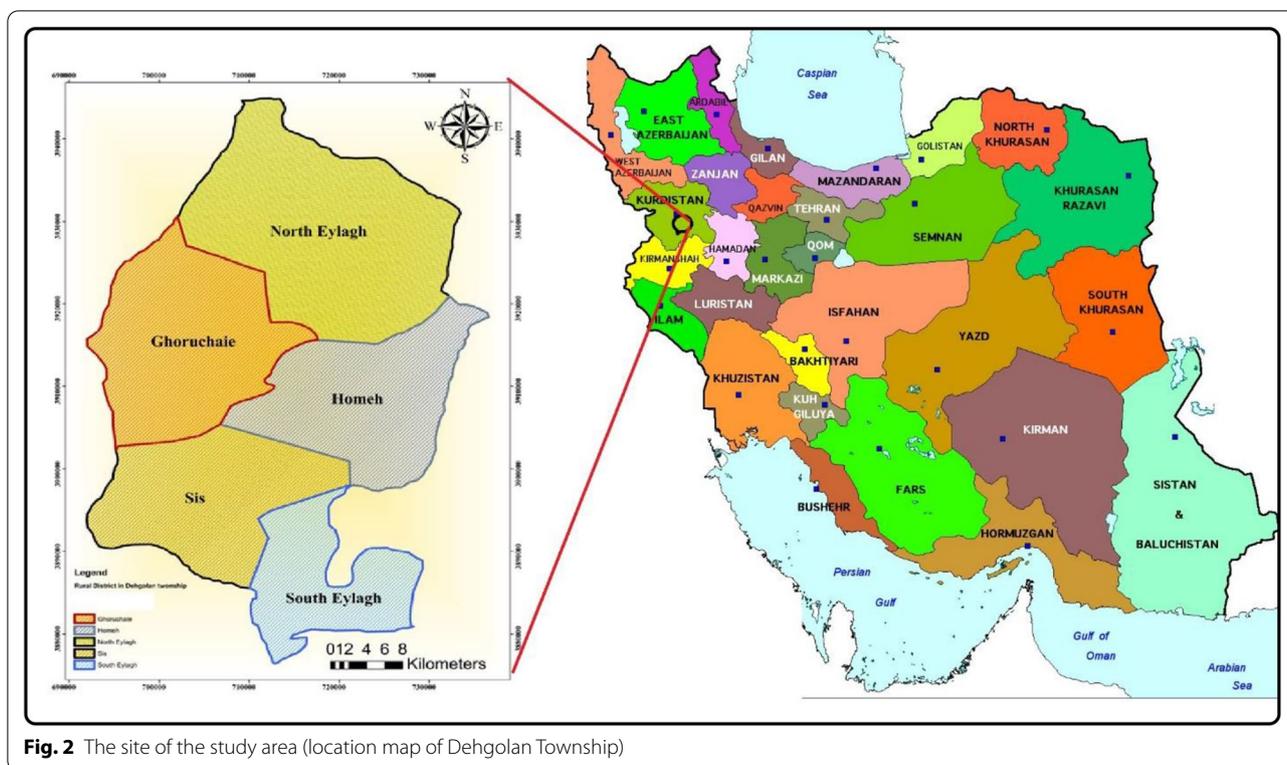
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Fig. 2 The site of the study area (location map of Dehgolan Township)

the research team conducted two meetings to achieve a consensus in this regard. Therefore, the instrument was prepared for the pilot and reliability analysis steps after corrections made in the tool based on the specialists' opinions.

The pilot study had several important achievements and results; the first result was that some variables had Cronbach's alpha values less than 0.7. However, the alpha values reached an acceptable level with the removal of some items. The second result was related to the difficulties of some of the participants in understanding specific concepts and terms used in the questionnaire. To solve this problem, we simplified the writing structure of the items to be more comprehensible. The third result was related to the significant contribution of the pilot study to estimation of the required time and costs for the research. Moreover, the Cronbach's alpha reliability scores of the items used to evaluate food security in Dehgolan Township villages were at an acceptable level (0.92). We also used the standard USDA questionnaire to evaluate food security within the area under study [58, 59]. It is notable that some of the indicators expressed in the questionnaire were localized based on the demographic characteristics of the Iranian rural community, and some other indicators were developed according to the knowledge of the target community. In addition, a researcher-made questionnaire was exploited to evaluate

the consequences of food security. This instrument was able to measure the severity of food insecurity and family hunger. This instrument divided the studies' community into four groups/categories (with food security, with food insecurity without hunger, with food insecurity with moderate hunger, and with food insecurity with severe hunger) (Table 1).

Due to the time constraints and the extensiveness of the statistical population, council members and village administers who had complete knowledge of their village were requested to score the rural status of their residence based on Table 1.

In the end, the food security status of the villages was determined based on descriptive statistics. Data analysis was performed using SPSS and FTOPSIS (which is one of the latest and most accurate analytical methods in studies with the nature of measuring multiple judgments in different societies). This technique increases the accuracy of analysis and facilitates the assessment of relations when the variance between the data in the studied samples is very low and the relationships between the variables are ambiguous and have degree of uncertainty. Moreover, it puts the effects level of indicators in the range between zero and one and a fraction of one leading to its high accuracy. This integrated method is able to mathematically formulate several vague concepts and variables as is the case in the

Table 1 Typology of food security/insecurity

Types of food security	Code	Number of positive responses	
		Families with children under 18 years old (total score: 18)	**Families without children under 18 years (Total score: 10)**
Food security[a]	0	0–2	0–2
Food insecurity without hunger[b]	1	3–7	3–5
Food insecurity with moderate hunger[c]	2	8–12	6–8
Food insecurity with severe hunger[d]	3	13–18	9–10

[a] Households that show little evidence of food insecurity or have not experienced food insecurity during the year

[b] Households who are concerned about the inadequacy of food and manage the current situation by reducing the quality of food or reducing the amount of food consumption

[c] Households in which food consumption is significantly reduced for adults, so that adults often experience hunger

[d] Households in which in addition to reduction of adults' food intake, the children's food intake significantly affected, so that children also have painful and frequent experiences of hunger Source: (Nord 2009; Ramesh 2010)

real world and lay the foundation for reasoning, inferring, controlling, and decision-making in uncertainty conditions.

Therefore, due to the fact that multiple variables with different nature were studied in present research, the application of this method was useful owing to its high accuracy. The variables studied in this study (e.g., components affecting the realization of food security and the consequences of food insecurity) were identified based on the previous research studies and field visits (Tables 2 and 3). As presented below, items and questions were designed for each variable in the form of a five-point Likert type scale, which was provided to the research population to use the results in achieving the study's objective.

In this study, the FTOPSIS method was applied to identify the most important components and prioritize variables to achieve the research objectives based on the designed questionnaires. In fact, a generalization of the TOPSIS method in management science led to expressing the predictions made by elites and specialists in the form of definite numbers for the first time. The theory is able to express many inaccurate phases and concepts into mathematical language and lay the ground for reasoning, inference, control, and decision-making in conditions of uncertainty. The theory is a specific fuzzy set known as $\tilde{A} = x \in R/\mu_{\tilde{A}}(x)$, where x accepts actual values of the member of R series, and its membership function is presented as $\mu_{\tilde{A}}(x)$. The most commonly used fuzzy numbers are triangular and trapezoidal fuzzy numbers. However, triangular fuzzy numbers are more commonly used due to simpler calculations. Therefore, the mentioned type of numbers was applied in the current research. A triangular fuzzy number A is

defined as Formula 1 with the membership function of linear fractions µA:

$$\mu_x(x) = \begin{cases} (x - a^l)/(a^m - a^l), & a^l \le x < a^m \\ 1, & x = a^m \\ (a^r - x)/(a^r - a^m), & a^m < x \le a^r \\ 0, & \text{otherwise} \end{cases}, \quad (1)$$

which can be shown in the form of (a^l, a^m, a^r) triangular fuzzy number. Figure 3 shows the membership function.

If $A = (a^l, a^m, a^r)$ and $B = (b^l, b^m, b^r)$ are two triangular fuzzy numbers, $d(A, B)$ distance function is defined as Formula 2:

$$d(A, B) = \sqrt{\frac{1}{3}\left[(a^l - b^l)^2 + (a^m - b^m)^2 + (a^r - b^r)^2\right]}. \quad (2)$$

In this model, the $(\widetilde{a}_{ij})$ fuzzy numbers were estimated after receiving the opinions of specialists in the first stage. The mentioned numbers were defined in the form of four equations based on selecting the triangular fuzzy numbers in the research model:

$$a_{ij} = (\alpha_{ij}, \beta_{ij}, \gamma_{ij}) \quad (3)$$

$$\alpha_{ij} = \text{Min}(\beta_{ijk}), k = 1, \dots, n \quad (4)$$

$$\delta_{ij} = \left(\prod_{k=1}^{n} \beta_{ijk}\right)^{1/3} \quad (5)$$

$$\gamma_{ij} = \text{Max}(\beta_{ijk}), k = 1, \dots, n. \quad (6)$$

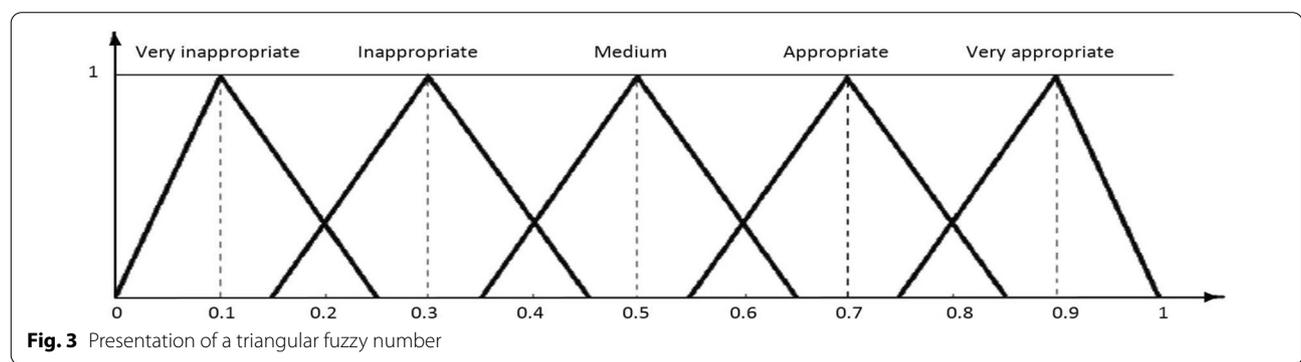In the mentioned equations, β_{ij} shows the relative importance of parameter I to parameter j from the perspective of specialist k, γ_{ij} is the upper limit of specialists' opinions, and α_{ij} is the lower limit of specialists' opinions

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Table 2 Components and indicators affecting the realization of food security

Components	Variables	ID code	Sources
Economic	Housing quality	E1	Sarlio-Lahteenkorva and Lahelma [44]; Studdert et al. [41]; Bedeke [60]
	Housing ownership	E2	
	Arable land area	E3	
	The amount of savings	E4	
	Number of small and large livestock	E5	
	The amount of income earned from the agricultural sector	E6	
	Job variety of household	E7	
	Benefiting from banking facilities	E8	
Social	Age of household head	E9	Nord [58]; Sugie [62] Coleman-Jensen [63]; Cox and Wallace [64]
	Literacy level	E10	
	Dependency burden (the number of individuals to support in the family)	E11	
	Size of family	E12	
	Number of children	E13	
Structural-spatial	Number of visits to the city	E14	Browne et al. [65]
	The extent of urban–rural relations	E15	
	Investment of urban people in villages	E16	
	Going to the city for employment	E17	
	Selling products to urban intermediaries	E18	
	Going to the city to receive general services (educational, health, cultural, and welfare)	E19	
	The number of visits to buy food in the city	E20	
	Selling manufactured products without intermediaries and directly to the city	E21	
Access	Unavailability of food needed by the household	E22	Lima [66]; Food Security Network [67]
	Lack of availability of various foods	E23	
	Insufficient food supply centers	E24	
	Appropriate quantity and quality of food available in village retail stores	E25	
	Access to organic food and non-transgenic products	E26	
	Access to appropriate technologies for food production	E27	
	The high cost of access to food	E28	
Accessibility	Insufficient income to buy food	E29	Audsley et al. [69]; WRAP [70]; Schmidinger and Stehfest [71]
	Insufficient income to diversify the diet	E30	
	Lack of government cooperation in easy access to food throughout the year for the lower economic classes of the village	E31	
	Lack of access to food without suffering psychological damage	E32	
	Lack of sense of social justice in access to food among the people	E33	
Consumption	Awareness of the quality of food consumed	E34	Sim et al. (2006); Edwards-Jones et al. [73]
	Low food waste	E35	
	Awareness of proper diet of family members	E36	
	Lack of proper diet for the family during the week	E37	
	Lack of proper nutrition for children during the week	E38	
Stability	Instability in household food consumption throughout the year	E39	Sim et al. (2006); Edwards-Jones et al. [73]
	Instability in the consumption of various foods throughout the year	E40	
	Lack of stable income for food consumption throughout the year	E41	

Table 3 Consequences of food insecurity in the villages of Dehgolan Township

Components	Variables	ID code
Physical-skeletal	Agricultural land use changes	C1
	Horticultural land use changes	C2
	The weakening of the agricultural sector and the prosperity of service activities in the village	C3
Economic	Expansion of land and stock exchange transactions	C4
	Increases in land, housing, and rental prices	C5
	Increasing the price of services	C6
	Increased inflation and rental income	C7
	Increasing income gap between rural and urban areas	C8
Social-cultural	Expansion of rural–urban migrations	C9
	Reduction of social capital in rural areas	C10
	Reduction of participatory and group activities in the village	C11
	Satisfaction with the quality of educational, social and cultural services	C12
	Satisfaction with the quality of health services	C13
	Satisfaction with the quality of the living environment and welfare services	C14
	Satisfaction with the quality of facilities and infrastructure	C15
	Satisfaction with the quality and quantity of services of rural financial institutions	C16
Environmental	Sustainability of water resources (improper operation, irrigation at inappropriate times	C17
	Sustainability of soil and air resources (limited use of pesticides and chemical fertilizers, burning of crop residues)	C18
	Disruption of the natural ecosystem (burning of trees, hunting of birds, non-compliance with the number of livestock and pastures, pressure on natural resources and loss of ecological potential of resources)	C19
	Declining groundwater resources	C20
	Drying of rivers, springs, and wells due to over-exploitation	C21
	Drilling unlicensed wells	C22
	Pressure on water resources and the occurrence of hazards (ground subsidence, landslides, erosion, etc.)	C23

Fig. 3 Presentation of a triangular fuzzy number

for research variables. In these equations, δ_{ij} is the geometric mean of experts' opinion. Evidently, the fuzzy components are defined in a way that they are in the form of $\gamma_{ij} \leq \delta_{ij} \leq \alpha_{ij}$. Moreover, the values of the components

or fuzzy numbers for the valuation of specialists to the research indicators presented in Table 4.

After quantifying the indicators according to Table 4, the required matrix of indicators was constructed, similar to the following matrix:

Table 4 Linguistic variables to assess the importance of indicators

The importance of indicators	Fuzzy number
Very insignificant	(0, 0, 0.1)
Nonsignificant	(0, 0.1, 0.3)
Somewhat insignificant	(0.1, 0.3, 0.5)
Indifferent	(0.3, 0.5, 0.7)
Somewhat important	(0.5, 0.7, 0.9)
Important	(0.7, 0.9, 1)
Very important	(0.9, 1, 1)

Source: (Ataie 2012)

$$G = \left[G_{ij}\right]_{m*n} = \begin{array}{c} \\ A_1 \\ A_2 \\ \vdots \\ \vdots \\ A_m \end{array} \begin{array}{c} C_1 \quad C_2 \quad \ldots \quad C_n \\ \left[\begin{array}{cccc} G_{11} & G_{12} & \ldots & G_{1n} \\ G_{21} & G_{22} & \ldots & G_{2n} \\ \vdots & \vdots & \cdots & \vdots \\ \vdots & \vdots & \cdots & \vdots \\ G_{m1} & G_{m2} & \ldots & G_{mn} \end{array}\right]. \end{array}$$

Here, A_1, A_2, ..., A_m are possible options that should be assessed by the specialists. In addition, C_n C_1, C_2, ..., C_n are criteria considered relative to the options. G_{ij} is the rank of A_i option against C_j and W_j criteria of C_j weight. In the process of evaluating these weights, the degree of importance of the criteria provided by experts (in this study, council members) is indicated by fuzzy numbers.

It is assumed that $b_{ij}(e)$ shows the value of representative index j in course e, where $i=1,2,...,m$, $i=1,2,...,m$, and $e=1,2,...,t$. G_{ij} is defined according to the concept of triangular fuzzy numbers:

$$G_{ij} = \left(g_{ij}^l, g_{ij}^m, g_{ij}^r\right), \tag{7}$$

where:

$$g_{ij}^l = \min\left\{b_{ij}(e)|e = 1, 2, ..., t\right\}$$

$$g_{ij}^m = \frac{1}{t}\sum_{e=1}^{t} b_{ij}(e) \tag{8}$$

$$g_{ij}^r = \max\left\{b_{ij}(e)|e = 1, 2, ..., t\right\}.$$

Therefore, $[G_{i1}, G_{i2}, ..., G_{in}]$ shows the performance rankings of option A_i on criteria n.

Next, using the MAX and MIN operators, the positive ideal (A^+) and negative ideal (A^-) solutions for the set of options are identified:

$$A^- = \left[G_1^-, G_2^-, \ldots, G_n^-\right]$$

Table 5 Food security status in Dehgolan Township

Types of food security	Frequency	Percent
Food security	12	20
Food insecurity without hunger	15	25
Food insecurity with moderate hunger	25	42
Food insecurity with severe hunger	8	13
Total	60	100

$$A^+ = \left[G_1^+, G_2^+, \ldots, G_n^+\right].$$

In the equations above, G_n^- and G_n^+, which are triangular fuzzy numbers in the form of Formula 9, form the lowest and highest values of g_{ij}^l, g_{ij}^m, and g_{ij}^r for the nth option. Furthermore, d_{ij} and d_{ij}^+ show the distance of G_{ij} from G_j^- and G_j^+, which is estimated using the formula below:

$$d_{ij}^- = d\left(G_{ij}, G_j^-\right) = \sqrt{\frac{1}{3}\left[\left(g_{ij}^l - g_j^{l-}\right)^2 + \left(g_{ij}^m - g_j^{m-}\right)^2 + \left(g_{ij}^r - g_j^{r-}\right)^2\right]}$$

$$(i = 1, 2, ..., m), (j = 1, 2, ..., n)$$

$$d_{ij}^+ = d\left(G_{ij}, G_j^{l+}\right) = \sqrt{\frac{1}{3}\left[\left(g_{ij}^l - g_j^{l+}\right)^2 + \left(g_{ij}^m - g_j^{m+}\right)^2 + \left(g_{ij}^r - g_j^{r+}\right)^2\right]}$$

$$(i = 1, 2, ..., m), (j = 1, 2, ..., n). \tag{9}$$

Fuzzy numbers are used to determine the coefficient of the importance of different decision criteria. In this way, $W_{jk} = (w_{jk}^l, w_{jk}^m, w_{jk}^r)$ is a triangular fuzzy number that expresses the linguistic weights expressed by specialist E_k about C_j criterion in the form of fuzzy ($k=1,2, ..., p$ and $j=1,2,..., n$).
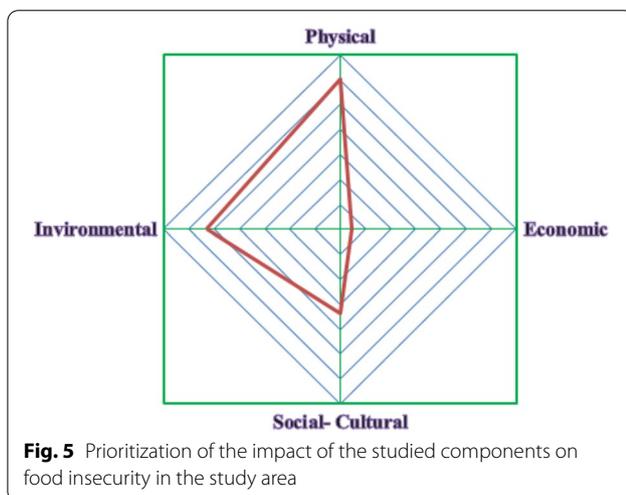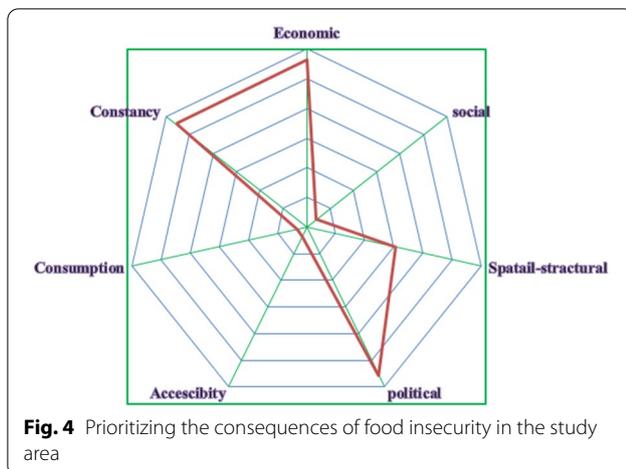
W_j is considered the mean weight of C_j criteria, estimated using the equation below:

Symbols $\otimes, \oplus$ and $\otimes, \oplus$ show the fuzzy multiplication and addition. Ultimately, the proximity coefficient of A_i option shown as A_i^* is estimated using the equation below.

Results and discussion

Evaluation of food security status showed that 20% of villagers in the studied area had food security, whereas 25, 42, and 13% had food insecurity without hunger, food insecurity with moderate hunger, and food insecurity with severe hunger, respectively (Table 5). Given the fact that a large part of the studies community had food insecurity, it is crucial to recognize the most important indicators and components that lead to the formation of food insecurity.

In this study, we used a multi-criteria decision analysis method to more efficiently recognize the most important variables that had the most powerful impact on food insecurity. According to the results,

Fig. 4 Prioritizing the consequences of food insecurity in the study area

Fig. 5 Prioritization of the impact of the studied components on food insecurity in the study area

the economic (standardized weight of 0.566), stability (standardized weight of 0.559) and availability (standardized weight of 0.558) were the most important components affecting food insecurity (Figs. 4 and 5). In addition, the factors with the highest influence on the phenomenon were as follows: in the economic component, indexes E6 (the amount of income earned from the agricultural sector), E4 (the amount of savings), and E3 (arable land area) had the most impact. In the social component, the indexes E9 (age of household heads), E10 (level of education), and E12 (size of family) had the greatest importance, whereas in structural-spatial component, indexes E19 (visit the city to provide public services (educational, health, cultural, and welfare), E17 (visit the city for employment purposes), and E20 (the number of visits to buy food in the city) obtained the greatest weight (importance). In the availability component, indexes E23 (lack of availability

of various foods), E28 (high cost of access to food), and E22 (lack of access to food required by households) were the most important indicators, while in the availability component, indexes E33 (lack of sense of social justice in access to food among the people), E29 (insufficient income to buy food), and E32 (lack of access to food without suffering psychological damage) were of paramount importance. In the consumption component, the indexes E38 (lack of proper diet for children during the week), E37 (lack of proper diet for the family during the week), and E36 (awareness of proper diet of family members) were the most significant indicators, whereas, in the stability component, indexes E41 (lack of stable income for food consumption throughout the year), E40 (instability in the consumption of various foods throughout the year), and E39 (instability in household food consumption throughout the year) had the most powerful impact (Table 6). Our findings are in line with the results obtained by others [11, 44, 55, 57]. Therefore, food insecurity will occur in areas where there are instabilities from socio-cultural, availability, and economic aspects.

According to the results of the study, food insecurity had consequences in the studied area, the most important of which are in the physical (weight of 0.603) and environmental (weight of 0.532) dimensions. In the former, indexes of C3 (weakening of the agricultural sector and prosperity of service activities in the village), C2 (horticultural land use changes), and C3 (agricultural land use changes) obtained the greatest weights. In the economic dimension, the indexes of C8 (increased income gap between rural and urban areas), C6 (increased cost of services), and C5 (increasing the cost of lands, houses, and rents) were the most important indicators, whereas, in the socio-cultural dimension, the indexes of C11 (reduction of participatory and group activities in the village), C9 (decreased social capital in villages), and C10 (expanding rural and urban migration) were the most significant (important) indicators. In the environmental dimension, the indexes of C20 (declining groundwater resources), C22 (drilling unlicensed wells), C23 (pressure on water sources and occurrence of ground subsidence, landslides, and erosions), and C21 (drying of rivers, springs, and wells due to over-exploitation) had the most effect (Table 7 and Fig. 6).

The images below show some of the human pressures caused by human mismanagement and the damage to the environment in the study area. Some issues such as excessive use of groundwater resources and consequences such as ground subsidence (Fig. 7), landslides (Fig. 8), and evacuation of villages (Fig. 9) were closely related to food security in the studied region.

Table 6 Components and indicators affecting the realization of food security in study area

Components	ID code	D^+	D^-	A^*	Rank in effectiveness	The final weight of the component	Prioritization of influential components
Economic	E1	0.2025	0.0961	0.492	5	0.566	**1**
	E2	0.2025	0.0961	0.494	4		
	E3	0.0324	0.3364	0.612	3		
	E4	0	0.5776	0.694	2		
	E5	0	0.5776	0.494	4		
	E6	0	0.5776	0.757	1		
	E7	0	0.5776	0.757	1		
	E8	0.2025	0.0961	0.230	6		
Social	E9	0.2025	0.0961	0.704	1	0.042	**7**
	E10	0	0.5776	0.600	2		
	E11	0	0.5776	0.283	4		
	E12	0.2025	0.0961	0.419	3		
	E13	0.2025	0.0961	0.230	5		
Structural-spatial	E14	0.2025	0.0961	0.492	5	0.306	**4**
	E15	0.2025	0.0961	0.494	4		
	E16	0.0324	0.3364	0.286	6		
	E17	0	0.5776	0.683	2		
	E18	0	0.5776	0.494	4		
	E19	0	0.5776	0.704	1		
	E20	0.0081	0.4489	0.653	3		
	E21	0.2025	0.0961	0.230	7		
Access	E22	0	0.5776	0.672	3	0.558	**3**
	E23	0	0.5776	0.757	1		
	E24	0.0324	0.3364	0.612	4		
	E25	0.2025	0.0961	0.389	6		
	E26	0.2025	0.0961	0.389	6		
	E27	0.0081	0.4489	0.396	5		
	E28	0	0.5776	0.694	2		
Accessibility	E29	0.2025	0.0961	0.442	2	0.036	**6**
	E30	0.2025	0.0961	0.230	5		
	E31	0	0.5776	0.283	4		
	E32	0.2025	0.0961	0.419	3		
	E33	0.2025	0.0961	0.547	1		
Consumption	E34	0.2025	0.0961	0.230	4	0.032	**5**
	E35	0.2025	0.0961	0.230	4		
	E36	0	0.5776	0.283	3		
	E37	0.2025	0.0961	0.419	2		
	E38	0.2025	0.0961	0.522	1		
Stability	E39	0	0.5776	0.547	3	0.559	**2**
	E40	0.2025	0.0961	0.565	2		
	E41	0.2025	0.0961	0.567	1		

Conclusion

Today, having an acceptable level of food security in the societies is one of the most important pillars of rural development policies and planning. Food insecurity in rural communities shows improper planning and policy-making in the development of local communities and the need for revision of policies. In addition, food insecurity in rural communities can lead to various consequences in their environment, distancing them from the main goals. As a developing country which its

Table 7 Consequences of food insecurity in the study area

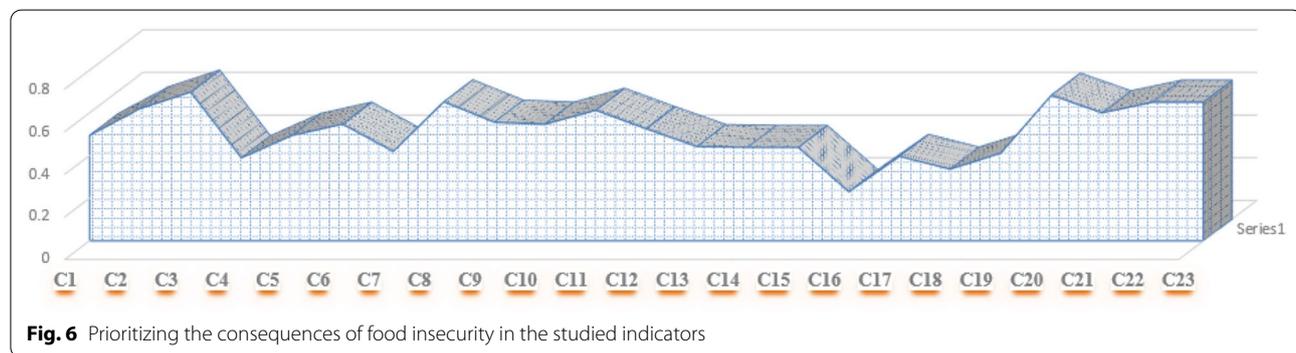| Components	ID code	D^+	D^-	A^*	Rank in effectiveness	The final weight of the component	Prioritization of influential components
Physical-skeletal	C1	0	0.5776	0.494	3	0.603	**1**
	C2	0.2025	0.0961	0.620	2		
	C3	0	0.5776	0.697	1		
Economic	C4	0.2025	0.0961	0.389	4	0.047	**4**
	C5	0.2025	0.0961	0.494	3		
	C6	0	0.5776	0.547	2		
	C7	0.2025	0.0961	0.419	4		
	C8	0	0.5776	0.652	1		
Social-cultural	C9	0.2025	0.0961	0.556	2	0.335	**3**
	C10	0.2025	0.0961	0.547	3		
	C11	0.0324	0.3364	0.612	1		
	C12	0	0.5776	0.525	4		
	C13	0	0.5776	0.442	5		
	C14	0.0081	0.4489	0.438	6		
	C15	0.0081	0.4489	0.438	6		
	C16	0.2025	0.0961	0.230	7		
Environmental	C17	0.2025	0.0961	0.396	5	0.532	**2**
	C18	0	0.5776	0.336	6		
	C19	0.0324	0.3364	0.411	4		
	C20	0	0.5776	0.683	1		
	C21	0	0.5776	0.600	3		
	C22	0.0081	0.4489	0.650	2		
	C23	0.0081	0.4489	0.650	2		

Fig. 6 Prioritizing the consequences of food insecurity in the studied indicators

economy is mainly based on oil exports, Iran has not been focused on the agriculture and this sector has been overlooked in policy-makings and decision-makings [12]. This doubles the necessity of developing operational solutions and plans to solve the problem and recognize the factors affecting food insecurity and its consequences, considering that 26% of the country's population lives in rural areas and their livelihood and food security depend on the agricultural sector.

According to the results of the present study, 20% of families had food security, whereas 25%, 42%, and 13% had food insecurity without hunger, food insecurity with moderate hunger, and food insecurity with severe hunger, respectively. Therefore, it could be concluded that the majority of individuals had food insecurity. These findings are congruent with the results obtained by other researchers [15, 18, 72, 74, 75]. The study of the factors affecting the occurrence of insecurity showed that

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Fig. 7 Ground subsidence phenomenon (eastern plains of Kurdistan, Dehgolan, and Qorveh), 2019

Fig. 8 Landslide phenomenon (Dehrshid village), 2019

Fig. 9 Village evacuation phenomenon (Karimabad village of Dehgolan Township), 2020

economic, stability, and availability components were the most important components of food insecurity in the villages under study, respectively. Low-income level of villagers, lack of job diversity, and lack of access to adequate food for families and children are the main reasons for food insecurity. In this respect, it is suggested that more attention be paid to the development of occupations and job diversity in these regions by decision-makers and policy-makers. Overall, not only diversifying the income-generating activities of rural residents can increase the income level of villagers (which was the most important cause of food insecurity), but also it can guarantee their access to food with acceptable quality and quantity. Given the high level of food insecurity in villages in the western part of Iran, we assessed the consequences of this issue, as well. According to the results, changing the use of agricultural lands and the weakening of the agricultural sector in the studied area were the most important consequences of food insecurity in the villages of Dehgolan.

It is notable that the change of agricultural land use has occurred in most villages of this area; due to the high potential of access to the city of Dehgolan, these villages are often considered as a center for attracting the poor population who have migrated from the city and other surrounding villages due to food insecurity. As the population in these villages increases, so does the demand for housing, land and infrastructure, and service facilities. An increase in demand for the mentioned items leads to increased land prices for villagers. In this situation, farmers whose interest in agricultural land has exceeded the commodity price of land, sell the land, and/or change its use. As a result, the share of agricultural land in the villages is declining and they have become dormitories around the cities. As such, the agricultural sectors of the villages have been weakened to the benefit of the service sector. Accordingly, it is suggested that subsidies be provided to farmers by the government and the mechanisms be strengthened to purchase farmers' products at reasonable prices. This will maintain the comparative advantage of agriculture over its change of use/sale. Not only this will strengthen the agricultural sector, but also it increases farmers' interest and desire for agricultural development and production of essential agricultural/food products, which will decrease food insecurity. This result is in line with the results of Debebe and Zekarias [61, 76, 77]. Therefore, the establishment of farmer-centered organizations and associations to bargain for marketing, pricing of agricultural products, and the supply of agricultural inputs can also be useful and effective. At present, in the agricultural sector of Iran, there is no market analysis and farmers suffer a lot of losses without knowing the market situation and the volume of crops and the high risk of crop prices at harvest. Therefore, improving the pricing system of products, removing intermediaries from pricing system, expanding the social security system, better targeting of subsidies, reforming, and correct targeting of agricultural loans to villagers can be considered as some of the most important policy implications of this study for decision-makers and policy-makers in the food and rural development sector of Iran.

In addition, due to the excessive use of underground water for cucurbits, which is the dominant cultivation pattern in this region, the groundwater level has dropped sharply in some villages farther from the city. For instance, Dehrashid village has experienced a 50-m decline in underground water sources in the past few decades, which has led to environmental hazards such as ground subsidence in some villages (Fig. 9). The long-term consequence of this crisis is the evacuation of villages and decreased young and efficient (active) social capital in the agricultural sector. In this regard, one of the best ways to prevent the intensification of such negative consequences is to carry out technological and social interventions in the field of developing optimal irrigation methods in the study area. Moreover, given that the wastewaters of many cities around the study area are released in nature, it is recommended that plans be designed by the government to guide urban wastewaters toward groundwater aquifers that are being destroyed in the region. Not only this action will prevent the excessive decline in underground water resources, but also it can contribute to the continuation of agriculture and the production of food products, which is one of the main pillars of food security in the region. Another consequence of food insecurity is pressure on water and soil resources. In addition, the geographical conditions of this region are mostly mountainous, and limited water and soil resources, especially the droughts of recent decades in Iran, have put additional pressure on natural resources. Along with these limitations, most rural households, on average, have between 35 hectares of arable land. In these circumstances, people excessively use the natural resources needed in the agricultural sector to access food resources and provide a livelihood for themselves and their families. This has led to the excessive exploitation of water sources in rivers, fountains, and wells. A major part of surface water resources in these areas (rivers and fountains) have been dried and well water sources have faced a drop in groundwater levels, the representation of which can be observed in the occurrence of ground subsidence and landslides, which have occurred in some parts of the region (Figs. 7 and 8). Therefore, it can be understood that although the villagers and farmers of the study area overuse water and soil resources only to meet their food and livelihood needs, but in the long run, this can intensify their food insecurity. Therefore, it is necessary to improve the efficiency of agricultural activities. In addition, the application of adaptation strategies to water scarcity must be prioritized by regional decision-makers and policy-makers in agricultural and rural development policies. Strategies for adapting to soil and water problems and ensuring long-term food security include encouraging the use of water-resistant crops and planting crops that consume less water. Planning to implement these strategies can both lead to agricultural development and provide long-term food security [78]. Agricultural extension practitioners and rural development facilitators can be the most important executive arms of decision-makers and policy-makers in this field.

In addition to the mentioned factors, the geographical conditions and the seasonal agricultural system in this area have resulted in the migration of active and educated young people from the villages to the cities and even to the neighboring country (Iraq). It is notable that most of these people take on informal service jobs in the destination country due to the lack of income. In addition, food insecurity in rural areas will be transferred to urban regions, which doubles the necessity of planning and policy-making to solve this issue considering the structural–functional continuity of urban and rural areas. Similar to any other study, there were some limitations to the present study. One of the major drawbacks of the current research was a lack of accurate statistics and information in some cases. In addition, although there is much theoretical literature on the factors affecting food security, less work has been done on the consequences of food insecurity in rural areas. This issue, despite the limitations of the literature review, provided an opportunity for further reflection to explore this issue, especially in Iran. Another limitation is related to the methodological approached and results of present study. This study was based on a cross-sectional survey of village administrators, and thus, results' analysis was fulfilled mainly by quantitative methods. Therefore, it is recommended that further studies be carried out using mixed methods (qualitative and quantitative) to yield more reliable and wider results. It should also be mentioned that there was no reference valued for food security in Iran. Therefore, the comparison of our results with the standard and acceptable values was not possible. However, future researchers can fill this gap using some comprehensive meta-analysis-based studies. Since, such studies can set the ground for defining reference values for the food security in different dimensions.

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Ethical approval and consent to participate

Prior to starting the work, the study design was fully explained to respondents to obtain consent. No false promise such as remuneration and or per diem, food, and financial aids was given. Information was collected after securing consent from study participant. Data obtained from each study participant were kept confidential, and all peoples who participated in the study were acknowledged. The consent form has been read to me, and voluntarily, I agree to participate in this study.

Consent for publication

Not applicable, because there are no data contained within our manuscript from which participants may be identified.

Competing interests

The authors declare that they have no competing interests.

Author details

[1] Department of Geomorphology, Faculty of Natural Resources, Lecture in University of Kurdistan , 6617715175 Sanandaj, Iran. [2] Department of Agricultural Extension and Education, College of Agriculture, Tarbiat Modares University (TMU), 1497713111 Tehran, Iran. [3] Department of Agricultural Extension and Education, School of Agriculture, Shiraz University, 7144165186 Shiraz, Iran. [4] Department of Human Geography, Faculty of Geography, University of Tehran, 1417853933 Tehran, Iran. [5] Department of Climatology, Faculty of Natural Resources, University of Kurdistan , Sanandaj 6617715175, Iran. [6] Department of Development and Planning, Planning and Budget Organization, Sanandaj 6617713155, Iran.

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