Journal of Agricultural Science and Technology (2025) Vol. 27(6): 1299-1319

Investigating Agricultural Ecosystem Functions and Services in Northern Iran

Sareh Hosseini[1*], and Fahimeh Karimpour[2]

ABSTRACT

Agricultural ecosystem provides various functions and services for humans. Therefore, investigating their role and importance in agricultural land programming and management is one of the research goals. In this research, we used Common International Classification of Ecosystem Services (CICES) for identification of the Agricultural Ecosystem Functions and Services (AEFS). Also, Multi-Criteria Decision-Making (MCDM) models were used for weighting and prioritizing of the AEFS like Stepwise Weight Assessment Ratio Analysis (SWARA) for calculating their weight, and Simple Additive Weighting (SAW), Additive Ratio Assessment (ARAS), and Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) for prioritizing them. The research data was extracted using field survey, random sampling, and completing the Delphi questionnaire of 40 agricultural experts in the north of Iran. Also, the R^2 coefficient was used to compare the AEFS prioritization models. The results of SWARA technique showed that provisioning, regulation, and cultural functions with weights of 0.0298, 0.0286 and 0.0250 had the highest weight, respectively. Also, the results indicated that the SAW model with the R^2= 0.90 was chosen as the appropriate prioritization model. Provisioning, regulation, and cultural functions with marginal weights of 0.6319, 0.5448, and 0.5092 were ranked the first to third priority, respectively. Also, food supply, employment, genetic material supply, and educational and research services were important positive services of the agricultural ecosystem compared to the other services. It is suggested that more appropriate programming and more research be done by relevant organizations for the sustainable management of agricultural ecosystems in northern Iran.

Keywords: Agricultural Ecosystem Functions and Services, Common International Classification of Ecosystem Services, Weighting assessment.

INTRODUCTION

A set of ecosystem services that human life depends on them is provided by agriculture (Heinze *et al.*, 2022). Also, due to the increasing growth of the world population, there is more pressure on agricultural prospects to receive different services (Azaiez *et al*., 2020). Based on this, a series of factors such as climate, geology, ecology, as well as management methods, technology and skills affect the provision of landscapes ecosystem services. In fact, agriculture ecosystems are both a recipient and a provider of services. Therefore, the sustainability of agricultural ecosystems requires their ability to simultaneously provide services in a balance between the provision and consumption of services. However, the main management approach is based on the preservation of the services for the use of future generations, and the balance between services compared with other agricultural ecosystems (Altieri, 2018). Therefore, agricultural ecosystem managers

[1] Department of Forest Science and Engineering, Faculty of Natural Resources, University of Guilan, Sowmeh Sara, Islamic Republic of Iran.
[2] Department of Irrigation and Drainage, Faculty of Agricultural Engineering, Sari University of Agricultural Sciences and Natural Resources, Islamic Republic of Iran.
*Corresponding author; e-mail: S.Hosseini@Guilan.ac.ir

are trying to integrate ecosystem services in agricultural ecosystem policies and management by using a set of methods including evaluation of dependencies and effects of ecosystem services, valuation of ecosystem services, scenario creation and other interventions that can become the main basis for resolving conflicts and establishing a compromise between development and nature, and guaranteeing the stability of both (Xu and Peng 2022). Therefore, access to quantitative and qualitative information about the positive services of the agricultural ecosystem is of particular importance to achieve sustainable agriculture (Jia *et al*., 2021).

Among the diverse ecosystems, the agricultural ecosystem with different functions and services have direct and indirect roles in the economic and human livelihoods (FAO, 2018), whose maintenance should be the main goal of human activities. Therefore, five classifications including the study of Costanza *et al*., 1998, De Groot *et al*. (2012), Millennium Ecosystem Classification (MEA, 2005), The Economics of Ecosystems and Biodiversity (TEEB) (2010), and Common International Classification of Ecosystem Services (CICES) (2018) emphasized the classification of ecosystem services (Haines-Young and Potschin 2013). CICES (2018) is the latest classification of ecosystem functions and their services that was developed by the European Environment Agency (EEA) with the aim of providing a standard for the systematic nomenclature, description, and classification of ecosystem services. This classification includes three main groups of provision, regulating, and cultural functions (EEA, 2016).

Based on CICES classification, provisioning services are products and energy outputs obtained from goods and products. The regulating services include all the ways in which ecosystems can manage the environment where people live or depend on in some way, and benefit from them in terms of their health or safety. Finally, the cultural services category refers to all the non-material aspects of an ecosystem that contribute to or are important for humans' mental or intellectual wellbeing. Cultural services are intangible benefits that contribute to human development and culture, including the functioning of local, national, and international cultural ecosystems. It is included dissemination of knowledge and ideas, and interaction with nature (music, art, architecture) creativity emerges from dialogue, and entertainment (CICES, 2018).

These functions and services are not free and have hidden economic value. If these services are considered free, the agricultural ecosystem will be destroyed (Dick *et al*., 2018). Various pressures arising as economic purposes have caused their decline and destruction, and we are witnessing their destruction in everywhere in the world. For this reason, the identification of the Agricultural Ecosystem Functions and Services (AEFS) has become very important. Obviously, this issue requires the participation of stakeholders and finding out about their preferences for positive services of the agricultural ecosystem, especially the Agricultural Ecosystem of Northern Iran (AENI) (Dumont *et al.*., 2019). So far, different models have been proposed for ranking and valuation functions and services, but few studies have been done about defining them. Some of the most important ones are mentioned here.

Jia *et al*. (2021) surveyed agricultural ecosystem services in arid and semi-arid regions of western China based on the equivalent factor method. The study results showed that the factor evaluation method is an accounting tool for the evaluation of ecosystem services. Also, 9 agricultural ecosystem services were analyzed in this evaluation. The findings showed that the agricultural environmental services value in Gansu Province increased from 2008 to 2017. Also, ecological services are the most important agricultural ecosystem services in arid and semi-arid areas. Sun *et al*. (2021) assessed agricultural services in North China and predicted their changes under different land use scenarios. The results indicated that agricultural ecosystem services play an important role in the economic and social conditions of the society. Also, Wang *et al*. (2022) assessed the ecological value of China's conventional agricultural ecosystem services in the framework of Energy-Based Life-Cycle Assessment. The findings showed that the importance of agricultural ecosystem provisioning services ecosystem is much higher than the production services provided by them. In this regard, Heinze *et al*. (2022) investigated farm diversity and its ecosystem services in different land use scenarios of southeastern Mexico. The results indicated that farms provide different services, and provisioning services are more important compared to other services and should be considered in different management methods.

A review of the previous sources showed that despite the existence of research related to the AEFS evaluation with different approaches, no study has been done about the identification, weighting, and prioritization of AEFS. Therefore, this has been tried according to the followings:

a. The importance of the AENI and highlighting its values to the society.

b. The tensions resulting from the change of agricultural land use in the north of Iran.

c. The possibility of the agricultural lands' drought of northern Iran due to the lack of water resources and the phenomenon of climate change in recent years.

d. The important role of agricultural ecosystem services in the comprehensive management of water resources.

Also, the three main provisioning, regulating, and cultural services and the AENI based on the CICES are identified and prioritized for their optimal management.

MATERIALS AND METHODS

Study Area

The agricultural ecosystem has an important role in Iran's economy. The Iranian agricultural land area is 16.5 million hectares, of which 14.7 million hectares are under field crops and the rest are gardens. Crops production in the Northern Iran was about 8417436 tons in 2017-2018, which was almost a ninth of the countries (Figure 1).

To carry out this research, the three provinces of Mazandaran, Guilan and Golestan were selected. Currently, the cultivated area of agricultural lands in Mazandaran is 476 thousand ha with an annual production of more than 3.574 million tons. Important characteristics of

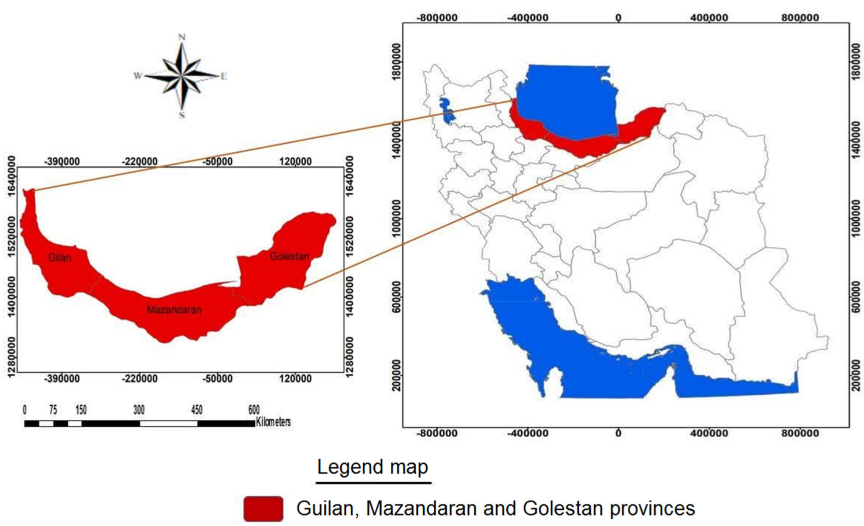

Figure 1. The location of the case study.

Mazandaran is the high cultivation coefficient (1.4) compared to the total of Iran (0.7). It has made Mazandaran as the largest producer of rice in Iran, and it has many capacities in increasing the quality and quantity in this regard. Also, it has caused the annual cultivated land of this province to more than 600000 ha. Notably, there are more than 45 types of cultivated crops in Mazandaran, of which the most important ones are rice, wheat, barley, soy bean, rapeseed, corn, fodder plants, vegetables and summer vegetables. Each of these products provide many services to the society. Also, the area of arable land of Golestan Province is 850000 ha, of which the agricultural land area is 710000 ha (250,000 ha of irrigated land and 460,000 ha of dry land). Also, the products of the agricultural ecosystem are very diverse, and some of the products are of special value and importance on a national scale in Guilan Province. Therefore, agriculture in Guilan has both nutritional and commercial value for its producers. The agricultural ecosystem is about 30% of Guilan area. The proportion of irrigated and dry lands in this province is 82% and 18%, respectively (https://maj.ir/).

Methodology of the Study

In this research, in order to weigh and prioritize the AEFS in northern Iran, firstly, the AEFS were identified and compiled based on the most CICES. Then, the research data was extracted in the form of field survey, random sampling, and by completing the Delphi questionnaire and face-to-face interviews with 40 experts of agricultural ecosystem management. Then, the question was asked which of the positive AEFS in northern Iran were more important for the optimal and sustainable management of agricultural ecosystem? Based on the answers, one of the five degrees of importance of the Likert scale were selected: Unimportant= 1, Little importance= 2, Important= 3, Great importance= 4, and Very important= 5 (Hosseini *et al*.., 2021). Also, if there were new services, they were added to the questionnaire. Finally, among the 40 questionnaires gathered, 10 questionnaires were removed due to the incompleteness of the information, and the data of 30 questionnaires were used to analyze the information (Table 1).

In order to check the reliability of the Delphi questionnaire, Cronbach's alpha coefficient of reliability technique was used (Mengual-Andrés *et al*., 2016). According to the value of this coefficient (α= 0.91), the reliability of the questionnaire was confirmed.

In this study, to weigh and prioritize each of AEFS, we used the Multi-Criteria Decision-Making (MCDM) models such as the Stepwise Weight Assessment Ratio Analysis (SWARA) in order to calculate the weight of AEFS (Debnath *et al*., 2023),we used the Simple Additive Model (SAW) (Hosseini *et al*.., 2021), the Additive Ratio Assessment (ARAS) (Ben Amor *et al*.., 2022), and Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) and to prioritize functions and services (Ramón-Canul *et al*., 2021). Finally, the curve slope (R^2) was used for comparing and choosing the suitable models for prioritizing the AEFS in the northern Iran (Figure 2).

Spss16 software was used to process and statistically analyze the questionnaire data such as calculating the questionnaire

Table 1. Delphi members to identify the positive functions and services of the northern Iran agricultural ecosystem.

Row	Delphi members	Education	Number
1	Faculty members of agricultural universities in Iran	Ph.D	15
2	Ministry of Agricultural Jihad of Iran	MSc, Ph.D	10
3	Land Affairs Organization of Iran	BC, MSc	5

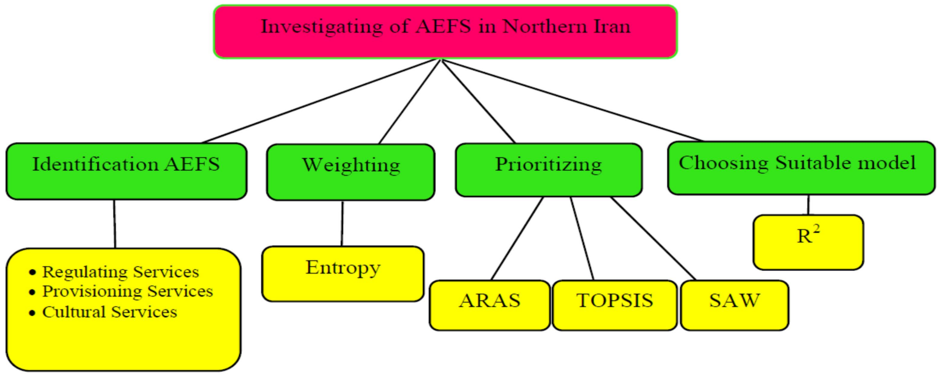

Figure 2. Methodology steps for investigating the agricultural ecosystem functions and services in northern Iran.

reliability with Cronbach's alpha test. Also, Excel software was used for weighting and prioritization models analysis.

Step-Wise Weight Assessment Ratio Analysis (SWARA)

The most important advantages of the SWARA method is its ability to evaluate the accuracy of experts' opinions about weight criteria, simple implementation, and no need for high volume of comparisons (Ayan *et al*, 2023). The steps to implement this method are as follows:

• First Step: Sorting Criteria (Services)

At first, the criteria are written based on their importance. The most important criteria are placed in higher categories and less important criteria in lower categories (Debnath *et al*., 2023).

• Second Step: Determining the Relative Importance of Each Criterion (S_j)

In this step, the relative importance of each criterion was compared with the previous criteria. This value represented using S_j.

• The Third Step: Calculating the Coefficient K_j

The coefficient K_j is a service of the relative importance of each criterion that is calculated using Equation (1):

$$K_j = S_j + 1 \quad (1)$$

• Fourth Step: Calculating the Initial Weight of Each Services

The initial weight (recalculated weight) of criteria (Q_j) is calculated with Equation (2). In this regard, it should be noted that the weight of the first criterion (the most important criterion) is considered equal to one (Majeed and Breesam, 2021; Zolfani and Saparauskas, 2013).

$$Q_j = x_j - 1 / K_j \quad (2)$$

• Step Five: Calculate the Final Normal Weight

In the last step, the final weight of the evaluation criteria is calculated by Equation (3). Normalization is done by simple linear method (Yücenur *et al*., 2021).

$$W_j = Q_j / \sum_k^n Q_j \quad (3)$$

Additive Ratio Assessment Method (ARAS)

The ARAS method was proposed by Zavadsakas *et al.* (2010). This method is one of the best MCDM models to choose the best option. The best option is to have the greatest distance from negative factors and the least distance from the positive factors (Ben Amor *et al*., 2022). The implementation section of this method is as follows:

Formation of the Decision Matrix

The first step in this technique is to create a decision matrix. A decision matrix is a matrix for evaluating a number of options based on a number of criteria. That is, a matrix in which each option is scored based on a number of criteria. The decision matrix is denoted by x and each term is denoted by x_{ij} (Equation 4) (Fan *et al*., 2021).

$$X = \begin{bmatrix} x_{11} & x_{12} & x_{1n} \\ x_{21} & x_{22} & x_{2n} \\ x_{m1} & x_{m2} & x_{mn} \end{bmatrix} \quad (4)$$

Creation of Normal Decision Matrix

Normalization or descaling is the second step in solving all MCDM models (Equation 5) (Prayogo *et al*., 2019).

$$N = \begin{bmatrix} n_{11} & n_{12} & n_{1n} \\ n_{21} & n_{22} & n_{2n} \\ n_{m1} & n_{m2} & n_{mn} \end{bmatrix} \quad (5)$$

Formation the Normal Weighted Decision Matrix

In the third step of the ARAS technique, the created normal decision matrix should be weighted. For this purpose, each criterion weight is multiplied in all the regions under the same criterion. The criteria weight should be determined in advance (Equation 6). The SWARA technique is usually used for this purpose (Jaukovic Jocic *et al*., 2020).

$$V = \begin{bmatrix} v_{11} & v_{12} & v_{1n} \\ v_{21} & v_{22} & v_{2n} \\ v_{m1} & v_{m2} & v_{mn} \end{bmatrix} \quad (6)$$

Calculate the Utility of Each Option

The desirability of each option is calculated by the desirability service in the fourth step of the ARAS technique. The best option is the one that has greater utility. Finally, the degree of desirability must be calculated. The total desirability of each option is represented by S_i that it calculated with Equation (7):

$$S_i = \sum V_{ij} \quad (7)$$

The degree of desirability of the option (K_i) is calculated based on the comparison with an optimal value (S_o) using Equation (8). The optimal value can be obtained based on the opinion of experts or the best weighted matrix values (Hosseini *et al*.., 2025)

$$K_i = {S_i}/{S_o} \quad (8)$$

Simple Additive Weighing (SAW)

In order to use the SAW model for prioritizing AEFS, first, the completed decision matrix was scaled using the linear scaling method. Then, weight is calculated by the SWARA technique multiplying in the unscaled matrix. In this method, taking into account the AEFS weight is calculated by the SWARA technique. The score of each Service (S_i) is calculated by the weighted average of their values in all services based on Equation (9) (Hosseini *et al*.., 2021).

$$S_i = \sum_j n_{ij}.w_j \quad (9)$$

Where, W_j is Weight of each service and n_{ij} is score of each service.

Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS)

In this method, m options are evaluated by n indicators and the options are ranked based on their similarity to the ideal solution (Ramón-Canul *et al*.., 2021). The technique basis is based on the concept that the selected option should have the smallest distance with the positive ideal solution and the largest distance with the negative ideal solution. The steps of this method are as follows (Zavadskas and Turskis, 2010):

First Step: Converting the Existing Decision-Making Matrix into a Matrix (Unscaled) Using Equation (10):

$$n_{ij} = \frac{r_{ij}}{\sqrt{\sum_{i=1}^{m} r_{ij}^2}} \quad (10)$$

Where, n_{ij}: normalized matrix, and r_{ij}: score of each criterion.

The Second Step: Creating the Weight Matrix Assuming the Vector Was Input to the Algorithm Equation (11):

$$W= \{ W_1, W_2, \ldots\ldots W_n \} \quad (11)$$

Where, W is Weight of each criterion.

So that ND is a matrix in which the criteria scores are dimensionless and comparable,

and $W_{n\times n}$ is a diagonal matrix in which only the main diagonal elements will be non-zero Equation (12).

$$V = ND \,.W_{n*n} = \begin{bmatrix} v_{11} & v_{12} & v_{1n} \\ v_{21} & v_{22} & v_{2n} \\ v_{m1} & v_{m2} & v_{mn} \end{bmatrix}$$

(12)

Where, V is weight matrix (dimensionless).

The Third Step: Specifying the Positive Ideal Solution (A^+) and the Negative Ideal Solution (A^-) Based on Equation (13):

$A^+ = \{(max\ V_{ij} \mid j \in J), (min\ V_{ij} \mid j \in J') \mid i = 1, 2... m\} = \{V_1^+, V_2^+, ..., V_j^-, ..., V_n^+\}$

$A^- = \{(min\ vi\, j \mid j \in J), (max\ V_{ij} \mid j \in J') \mid i = 1, 2, ..., m\} = \{V_1^-, V_2^-, ..., V_j^-, ..., V_n^-\}$

(13)

$J = \{j = 1, 2... n \mid j \in \text{benefit}\}$, $J' = \{j = 1, 2... n \mid j \text{ Cost}\}$

Step 4: Calculate the Distance between the i_{th} Option and Ideals (di) Using the Euclidean Method Based on Equation (14):

$d_{i+}\ \sum_{j=1}^{n} = (V_{ij} - V_j^+)^2\}^{0.5}$; i= 1, 2…m

$d_{i-}\ \sum_{j=1}^{n} = (V_{ij} - V_j^+)^2\}^{0.5}$; i= 1, 2… (14)

The Fifth Step: Calculating the Relative Proximity of A_i to the Ideal Solution (cl_{i+}) Using Equation (15):

$cl_{i+} = \frac{d_{i-}}{(d_{i+} + d_{i\_})}$; $0 \leq cl_{i+} \leq 1$; i= 1, 2…m (15)

The Sixth Step: Ranking the Options Based on cli+ Descending.

RESULTS

The research results include two parts of identifying and determining the AEFS in northern Iran using the Delphi method and prioritizing them with MCDM models. The findings of each part are presented separately below:

Identifying the AEFS of the Northern Iran

In this research, the AEFS of northern Iran identified using CICES (Table 1). Then, the questionnaire containing them was distributed among the members of the Delphi group (experts in the field of agricultural ecosystem management with at least 15 years of experience) in order to score based on the Likert scale. In our research, 30 people formed a Delphi group and expressed their opinions regarding the identification of positive AEFS at each stage (Table 1).

At the end of the first stage of the Delphi method, using the opinions of experts and some specialist expert in this field (Delphi method designer and analyst team), the positive AEFS of northern Iran were modified, integrated, and adjusted. Then, three functions and 23 services were determined for the agricultural ecosystem in northern Iran (Table 2).

In this research, in order to investigate the reliability of the questionnaire questions, the Cronbach's Alpha coefficient was used. Cronbach's alpha coefficient obtained was $\alpha = 0.97$, which was confirmed.

Weighing and Prioritizing the AEFS in Northern Iran

After collecting and analyzing the questionnaires, in order to determine the weight of the AEFS, SAW, ARAS, and TOPSIS method, the SWARA technique was used for AEFS priority. The finding models are presented below.

Determining the Weight of the AEFS of

Table 2. The Agricultural Ecosystem Functions and Services (AEFS) of northern Iran.

Functions	Services	Description
Regulating services	Local and regional climate regulation	The plants of the agricultural ecosystem can create a more addictive microclimate by creating shade and lowering the temperature.
	Improve air quality	Carbon storage by plants causes reduction of greenhouse gas and consequently improves air quality.
	Hydrological cycle and groundwater maintenance (including regulation of surface water flow; groundwater recharge; basin drainage)	In the agricultural ecosystem, the high rate of water infiltration causes the regulation of surface flows and maintaining the flow of underground water.
	Regulating water quality (Water purification)	The vegetation of the agricultural ecosystem causes its filtration by breaking down and removing nutrients and other water pollutants.
	Pollination and seed dispersal	Wind causes seeds to disperse by moving plants in the agricultural ecosystem.
	Pest and disease control (Biological pest control)	Some agricultural plants help to regulate and control the abundance of pathogens.
	Smell reduction, noise reduction, visual screening	Vegetation reduces noise pollution in addition to creating visual appeal and creating a pleasant smell, agricultural.
	Natural hazard regulation	Agricultural vegetation prevents soil erosion and landslides and prevents floods by absorbing rain.
	Soil erosion control	Vegetation increases resistance to erosion; It also prevents soil erosion by keeping sediments.
	Soil formation	Agricultural vegetation facilitates soil formation by depositing organic matter.
	Regulating soil moisture and maintaining soil fertility	Agricultural vegetation regulates soil moisture and maintains soil fertility.
	Ecosystem connectivity	The agricultural ecosystem provides the migration paths of plants and animals to other ecosystems and provides ecosystem connectivity.
	Nutrient cycle	The living organisms in the agricultural ecosystem play an important role in the decomposition of plant and animal organic matter and the cycle of carbon, oxygen, nitrogen, etc. elements.
	Role in food webs and prey/predator relationships	Agricultural ecosystem connects several food chains. It also causes communication between different species (such as coexistence, competition and hunting and hunter).
	Providing and maintaining habitats (Biodiversity)	The agricultural ecosystem provides suitable habitats for the life, reproduction of all kinds of plant and animal species, invertebrates and vertebrates.
	Primary production	The consumption of carbon dioxide by plants in the process of photosynthesis causes the production of organic substances, which in addition to plant growth, also produces oxygen.

Table 2 continued

Functions	Services	Description
Regulating services	Local and regional climate regulation	The plants of the agricultural ecosystem can create a more addictive microclimate by creating shade and lowering the temperature.
	Improve air quality	Carbon storage by plants causes reduction of greenhouse gas and consequently improves air quality.
	Hydrological cycle and groundwater maintenance (including regulation of surface water flow; groundwater recharge; basin drainage)	In the agricultural ecosystem, the high rate of water infiltration causes the regulation of surface flows and maintaining the flow of underground water.
	Regulating water quality (water purification)	The vegetation of the agricultural ecosystem causes its filtration by breaking down and removing nutrients and other water pollutants.
	Pollination and seed dispersal	Wind causes seeds to disperse by moving plants in the agricultural ecosystem.
	Pest and disease control (biological pest control)	Some agricultural plants help to regulate and control the abundance of pathogens.
	Smell reduction, noise reduction, visual screening	Vegetation reduces noise pollution in addition to creating visual appeal and creating a pleasant smell, agricultural.
	Natural hazard regulation	Agricultural vegetation prevents soil erosion and landslides and prevents floods by absorbing rain.
	Soil erosion control	Vegetation increases resistance to erosion; It also prevents soil erosion by keeping sediments.
	Soil formation	Agricultural vegetation facilitates soil formation by depositing organic matter.
	Regulating soil moisture and maintaining soil fertility	Agricultural vegetation regulates soil moisture and maintains soil fertility.
	Ecosystem connectivity	The agricultural ecosystem provides the migration paths of plants and animals to other ecosystems and provides ecosystem connectivity.
	Nutrient cycle	The living organisms in the agricultural ecosystem play an important role in the decomposition of plant and animal organic matter and the cycle of carbon, oxygen, nitrogen, etc. elements.
	Role in food webs and prey/predator relationships	Agricultural ecosystem connects several food chains. It also causes communication between different species (such as coexistence, competition and hunting and hunter).
	Providing and maintaining habitats (Biodiversity)	The agricultural ecosystem provides suitable habitats for the life, reproduction of all kinds of plant and animal species, invertebrates and vertebrates.
	Primary production	The consumption of carbon dioxide by plants in the process of photosynthesis causes the production of organic substances, which in addition to plant growth, also produces oxygen.

Table 2 continued

Table 2 continued

Functions	Services	Description
Provisioning services	Water supply	Water supply systems are very important for the proper functioning of communities. It can be achieved with various engineering projects such as wells or reservoirs.
	Food supply	Commercial and subsistence production of food and crops
	Energy production (Renewable)	Production of fuel energy
	Fiber, fuel, fodder	Providing renewable and extractable raw materials for fuel and fiber, including plant stumps, shrubs and fodder and wood (fuel wood); providing fiber from plants (water hyacinth, straw, etc.); Charcoal production from the processing of many plants.
	Biological materials (Biotics)	The use of agricultural plants as building materials, the production of various secretions such as gum, resin, handicrafts, etc.
	Providing genetic materials, natural medicines and biochemistry (Biochemical)	Including the extraction of genetic material from plants in the agricultural ecosystem for biomass production, biochemical, industrial and pharmaceutical processes (such as drugs, fermentation, detoxification), breeding programs (examination of genes for resistance to plant pathogens)
	Creating a green belt (Protective walls)	The agricultural ecosystem with diverse vegetation plays a very important role in beauty and reducing the amount of air pollution and preventing floods and soil erosion, etc.
	Carbon sequestration	The agricultural ecosystem with diverse vegetation reduces the concentration of carbon dioxide in the atmosphere.
	Fauna and Flora habitat and shelter	The agricultural ecosystem is home to some small rodents that feed on invasive and non-native plants.
Cultural services	Spiritual, religious and therapeutic services	Agricultural ecosystem has spiritual and religious value in many religions, some plant species have spiritual importance.
	Recreation and ecotourism	The agricultural ecosystem provides opportunities for recreational activities such as hiking, hunting, observing plant and animal species, recreational camps, nature watching, etc.
	Cultural heritage values and sense of place	The agricultural ecosystem represents the culture and civilization of many years of indigenous communities located around it.
	Conservation values	Endangered native species are preserved in the agricultural ecosystem and its margins.
	Aesthetic, inspiring culture, art and design	The existence of spectacular landscapes is one of the aesthetic aspects of the agricultural ecosystem.
	Health and Mental Well-being	Reducing stress by spending time near the agricultural ecosystem, enjoying recreational activities such as group camps in the vicinity of the agricultural ecosystem.
	Education and Research	Agroecosystem can be used to develop many research and education (educational ecosystem services mean formal and informal educational opportunities created by access to particular ecosystems such as providing condition for education and research about ecosystem services such as biotechnology research, thesis research, toxicology research on the ecosystem services and etc).
	Existence values	People feel pleasure and satisfaction from the plant and animal species in and around it.
	Employment (Creating job)	The agricultural ecosystem directly by creating employment in field of agricultural products, crops, livestock, fish, and aquaculture and indirectly by attracting investments and businesses that support tourism and eco-tourism to help contributes to the economy of the region
	Meetings and social relations	Agricultural ecosystem connects people, places and other forms of life and causes social interaction. Also, agricultural ecosystem is a suitable place for holding ceremonies.

Table 3. Calculating the AEFS weight in northern Iran using the SWARA technique.

Functions	Services	W_j
Regulating services	Local and regional climate regulation	0.0305
	Improve air quality	0.0309
	Hydrological cycle and groundwater maintenance	0.0306
	Regulating water quality (Water purification)	0.0279
	Pollination and seed dispersal	0.0311
	Pest and disease control (Biological pest control)	0.0252
	Smell reduction, noise reduction, visual screening	0.0267
	Natural hazard regulations	0.0270
	Soil erosion control	0.0319
	Soil formation	0.0286
	Regulating soil moisture and maintaining soil fertility	0.0267
	Ecosystem connectivity	0.0248
	Nutrient cycle	0.0275
	Role in food webs and prey/predator relationships	0.0288
	Providing and maintaining habitats (Biodiversity)	0.0290
	Primary production	0.0301
Provisioning services	water supply	0.0163
	food supply	0.0397
	Energy production (Renewable)	0.0304
	Fiber, fuel, fodder	0.0290
	Biological materials (Biotics)	0.0238
	Providing genetic materials, natural medicines and biochemistry (Biochemical)	0.0367
	Creating a green belt (Protective walls)	0.0338
	Carbon sequestration	0.0346
	Fauna and Flora habitat and shelter	0.0239
Cultural services	Spiritual, religious and therapeutic services	0.0154
	Recreation and ecotourism	0.0221
	Cultural heritage values and sense of place	0.0236
	Conservation values	0.0236
	Aesthetic, inspiring culture, art and design	0.0323
	Health and mental well-being	0.0161
	Education and research	0.0365
	Existence values	0.0260
	Employment	0.0384
	Meetings and social relations	0.0257
	Security	0.0148

Northern Iran with the SWARA Technique the results of AEFS weighting are indicated in Table 3. The weighing findings showed that the food supply, employment, supply of genetic materials, and educational and research services have the highest weight, respectively.

According to the results of Table 4, the provisioning function has the highest weight among other functions of the agricultural ecosystem in northern Iran (Table 4).

Determining the Priority of the AEFS in Northern Iran

The results obtained from the implementation of ARAS, TOPSIS and SAW models to determine the priority of the AEFS are presented in Tables 5 and 6.

The final weight of the agricultural ecosystem functions with ARAS, TOPSIS and SAW models is indicated in Table 7.

Table 4. Calculating the weight of agricultural ecosystem functions in northern Iran, using the SWARA.

Function	W_j	Rank
Provisioning	0.0298	1
Regulating	0.0286	2
Cultural	0.0250	3

Table 5. Final weights of the AEFS in northern Iran.

Code	**Services**	**Models**		
	Regulating services	**ARAS**	**SAW**	**TOPSIS**
A_1	Local and regional climate regulation	0.7679	0.6091	0.5422
A_2	Improve air quality	0.7782	0.7252	0.5114
A_3	Hydrological cycle and groundwater maintenance	0.7713	0.6179	0.5493
A_4	Regulating water quality (Water purification)	0.7048	0.5198	0.5000
A_5	Pollination and seed dispersal	0.7850	0.6772	0.5449
A_6	Pest and disease control (Biological pest control)	0.6365	0.4392	0.4661
A_7	Smell reduction, noise reduction, visual screening	0.6724	0.4586	0.4551
A_8	Natural hazard regulations	0.6809	0.4590	0.4661
A_9	Soil erosion control	0.8055	0.6226	0.4551
A_{10}	Soil formation	0.7201	0.5369	0.5061
A_{11}	Regulating soil moisture and maintaining soil fertility	0.6741	0.4705	0.4696
A_{12}	Ecosystem connectivity	0.6246	0.3864	0.3965
A_{13}	Nutrient cycle	0.6945	0.5013	0.4878
A_{14}	Role in food webs and prey/predator relationships	0.7270	0.5593	0.5228
A_{15}	Providing and maintaining habitats (Biodiversity)	0.7304	0.5561	0.5174
A_{16}	Primary production	0.7594	0.5782	0.5199
	Provisioning services	**ARAS**	**SAW**	**TOPSIS**
B_1	Water supply	0.4113	0.2487	0.3754
B_2	Food supply	1.0000	1.1024	0.6667
B_3	Energy production (Renewable)	0.7662	0.6138	0.5469
B_4	Fiber, fuel, fodder	0.7304	0.5503	0.5124
B_5	Biological materials (Biotics)	0.6007	0.3764	0.4120
B_7	Providing genetic materials, natural medicines and biochemistry (Biochemical)	0.9249	0.8950	0.7509
B_8	Creating a green belt (Protective walls)	0.8515	0.7227	0.4871
B_9	Carbon sequestration	0.8737	0.7623	0.5135
B_{10}	Fauna and Flora habitat and shelter	0.6024	0.4157	0.4690
	Cultural services	**ARAS**	**SAW**	**TOPSIS**
C_1	Spiritual, religious and therapeutic services	0.3891	0.2314	0.3696
C_2	Recreation and ecotourism	0.5580	0.4149	0.4815
C_3	Cultural heritage values and sense of place	0.0141	0.4369	0.4706
C_4	Conservation values	0.0141	0.3826	0.4313
C_5	Aesthetic, inspiring culture, art and design	0.0263	0.6772	0.4255
C_6	Health and mental well-being	0.0065	0.2376	0.3512
C_7	Education and research	0.0337	0.8917	0.4824
C_8	Existence values	0.0170	0.4522	0.4645
C_9	Employment	0.0371	1.0207	0.5796
C_{10}	Meetings and social relations	0.0167	0.6456	0.6772
C_{11}	Security	0.0055	0.2102	0.3392

Table 6. Prioritization of agricultural ecosystem services in northern Iran.

ARAS	SAW	TOPSIS
B_2	B_2	B_7
B_7	C_9	C_{10}
B_9	B_7	B_2
B_8	C_7	C_9
A_9	B_9	A_3
A_5	A_2	B_3
A_2	B_8	A_5
A_3	C_5	A_1
A_1	A_5	A_{14}
B_3	C_{10}	A_{16}
A_{16}	A_9	A_{15}
A_{15}	A_3	B_9
B_4	B_3	B_4
A_{14}	A_1	A_2
A_{10}	A_{16}	A_{10}
A_4	A_{14}	A_4
A_{13}	A_{15}	A_{13}
A_8	B_4	B_8
A_{11}	A_{10}	C_7
A_7	A_4	C_2
A_6	A_{13}	C_3
A_{12}	A_{11}	A_{11}
B_{10}	A_8	B_{10}
B_5	A_7	A_8
C_2	C_8	A_6
B_1	A_6	C_8
C_1	C_3	A_7
C_9	B_{10}	A_9
C_7	C_2	C_4
C_5	A_{12}	C_5
C_8	C_4	B_5
C_{10}	B_5	A_{12}
C_4	B_1	B_1
C_3	C_6	C_1
C_6	C_1	C_6
C_{11}	C_{11}	C_{11}

Table 7. The final weight and priority of the agricultural ecosystem functions in northern Iran.

Functions	Final weight			Priorities		
	TOPSIS	SAW	ARAS	TOPSIS	SAW	ARAS
Provisioning	0.5260	0.6319	0.7512	1	1	1
Regulating	0.4944	0.5448	0.7208	2	2	2
Cultural	0.4611	0.5092	0.1016	3	3	3

The finding showed that the provisioning functions have gained more weight among other functions at the three models (Table 7).

Statistical Analysis of Selecting the Appropriate Model for Prioritizing the AEFS in Northern Iran.

In order to compare the models for prioritizing the AEFS in northern Iran, the curve slope (R^2) of the factor weight was used in the three models (Figure 3). The slope curve of the relative proximity of the weights in the SAW model is a descending exponential function with an explanatory degree of 0.90, which indicates the obvious difference between the AEFS in northern Iran.

The R^2 in the SAW model is higher and

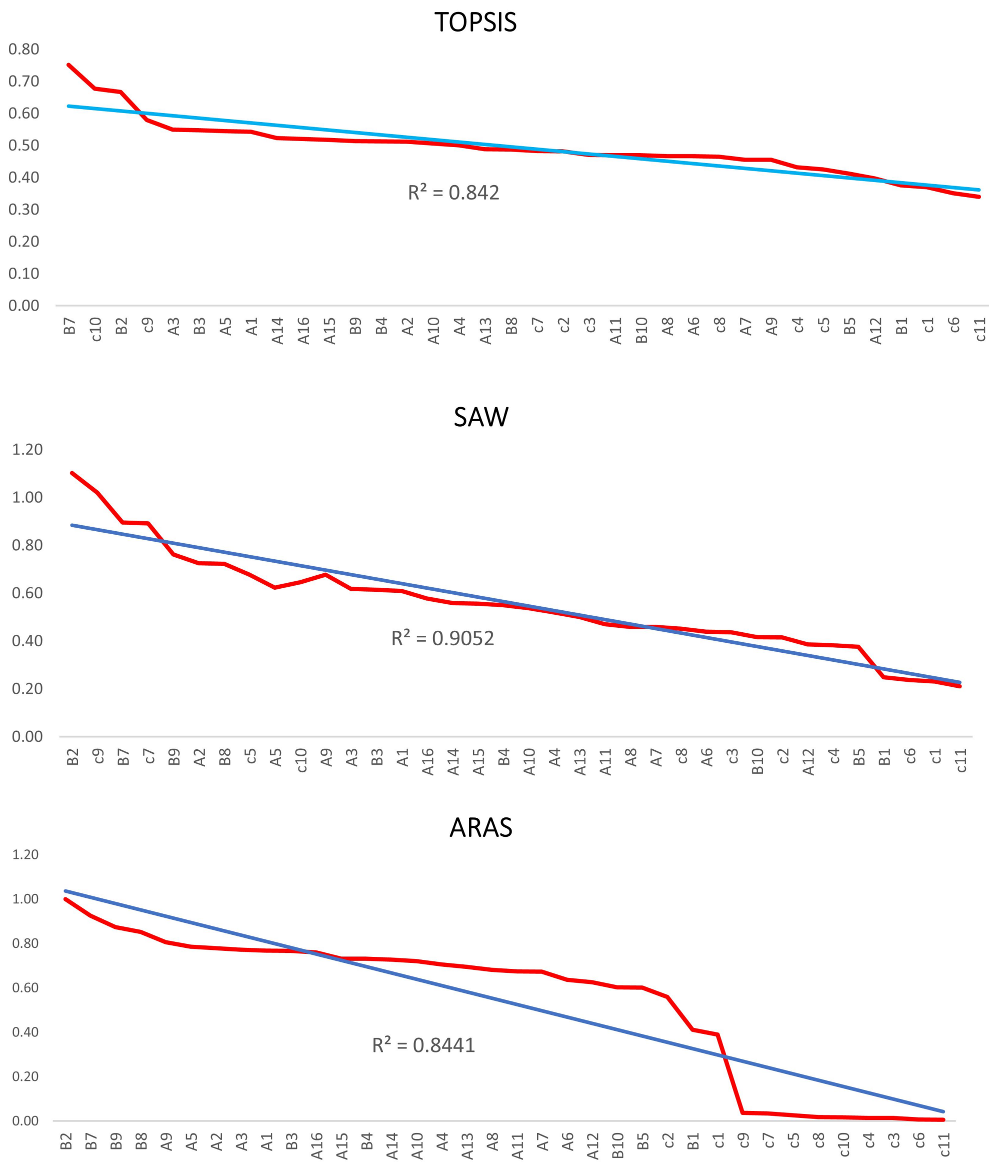

Figure 3. Curve slope (R^2) in ARAS, TOPSIS and SAW models.

closer to one than the other models. Based on the findings and the consensus of some experts, the result prioritization of the AEFS in northern Iran in the SAW model is closer to reality. Therefore, the SAW model is suggested as a suitable model for prioritizing the AEFS in northern Iran.

-Prioritizing the AEFS in Northern Iran Based on Suitable Model (SAW Model)

Based on the results of the best model for prioritizing the AEFS in northern Iran (SAW model), provisioning, regulating and cultural functions are, respectively, the most important functions of the agricultural ecosystem in that area (Figure 4).

The findings of prioritizing agricultural ecosystem services in northern Iran with the SAW model are presented in Figures 5, 6, and 7. The results indicated that food supply, employment, air quality improvement services of provisioning, and cultural regulating functions had, respectively, the first priority compared to other agricultural ecosystem services in the north of Iran.

DISCUSSION

Although the primary goal of agriculture is

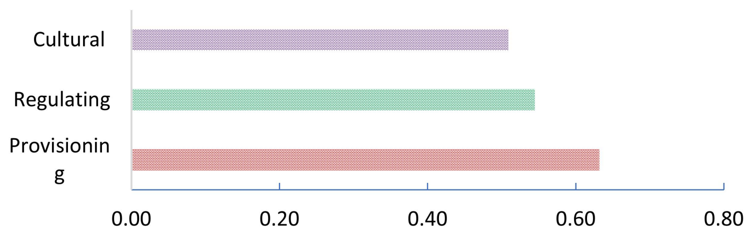

Figure 4. The priority of the functions of agricultural ecosystem in northern Iran with SAW model.

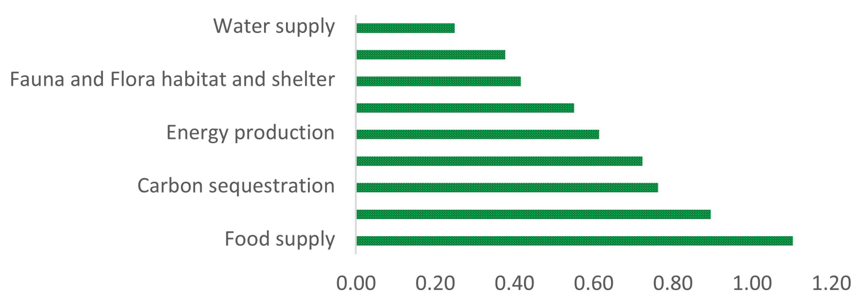

Figure 5. The priority of the provisioning services.

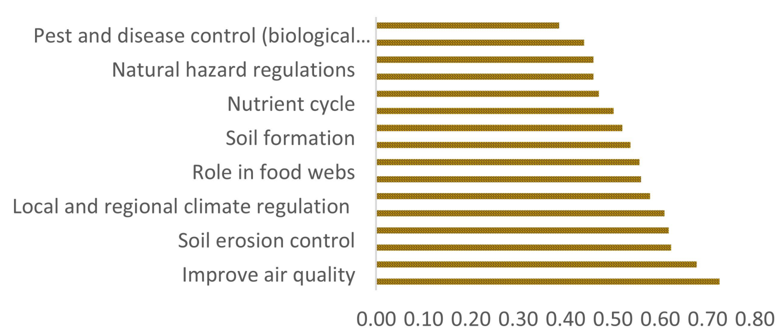

Figure 6. The priority of regulating services.

to produce food, the importance of agriculture is beyond the production of crops (Swinton *et al.*., 2015). And a set of ecosystem services that human life depends on is provided by agriculture (Rabbinge and Bindraban, 2012). The knowledge and skills of farmers in managing agro ecosystems can play an essential role in improving the balance between ecosystem services. Based on this, the management approach of each agro ecosystem is very important, so that sustainable agro ecosystems are involved with ecosystem services. However, the management approach plays a fundamental role in any agroecosystem, and in sustainable agroecosystems, management focuses on maintaining ecosystem services for the benefit of future generations (Altieri, 2018).

The AEFS prioritization results in northern Iran using MCDM models indicated that the provisioning and regulating functions have the first priority among all the prioritization models. In other words, provisioning and regulating functions are the most important functions of the agricultural ecosystem in northern Iran. According to the agricultural experts' opinions in northern Iran, the higher priority of the provisioning function is due to the fact that the agricultural ecosystem in northern Iran was one of the richest ecosystems in terms of providing food, genetic material, carbon sequestration, creating a green belt, etc., each of which has

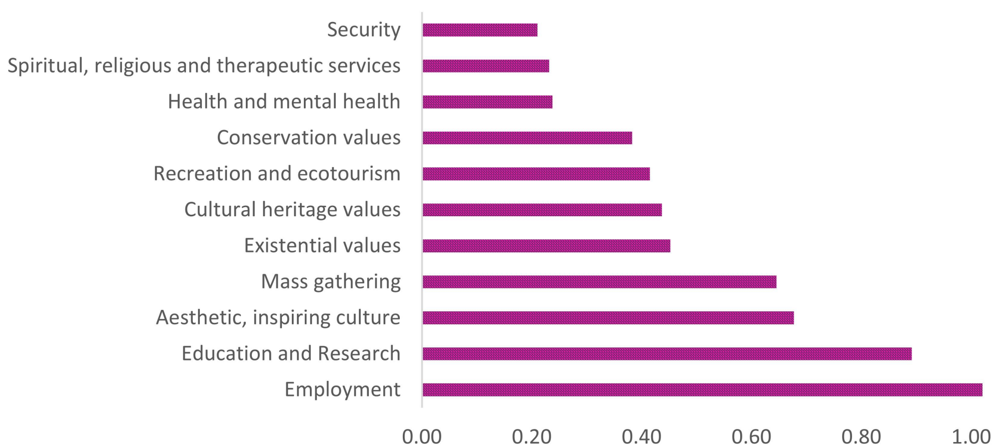

Figure 7. The priority of cultural services.

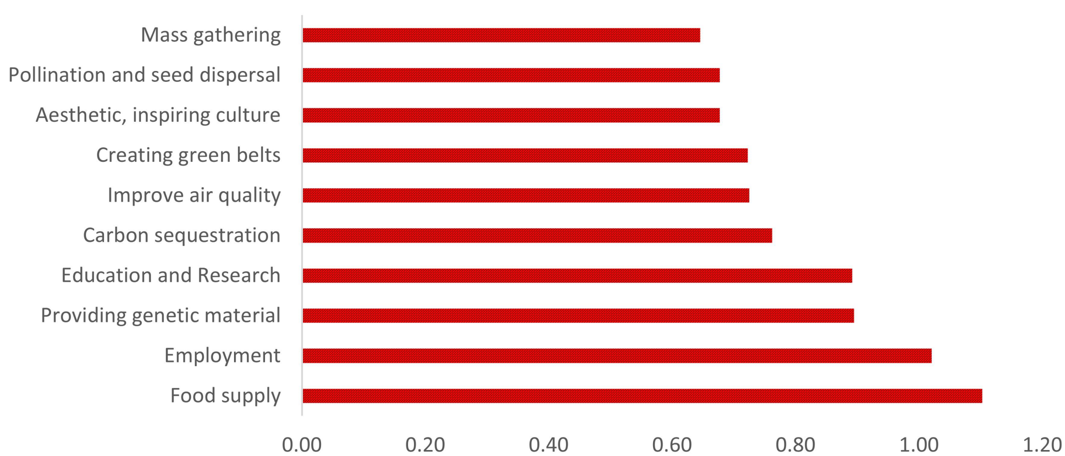

Figure 8. The most important agricultural ecosystem services in northern Iran.

many benefits for the local communities (Figure 8). The result is in accordance with the findings of Jia *et al*. (2021) and Heinze *et al*. (2022). Also, De Groot *et al*. (2012) stated regulating services include maintaining essential ecological processes and environmental protection systems. The study results showed that the agricultural ecosystem regulating services such as air quality improvement, pollination and seed dispersal, and soil erosion control have the highest priorities compared to the other services in that area.

Cultural services provide opportunities for spiritual, aesthetic, educational and scientific enrichment. In this regard, the results obtained from the prioritization of agricultural ecosystem services in the north of Iran indicated that the services of creating employment, education and research are the most important agricultural ecosystem cultural services. In other words, the agricultural ecosystem of northern Iran has created many employment, educational and research opportunities for various academic researchers. Also, the presence of beautiful landscapes on the edge of the agricultural ecosystem of northern Iran has provided a suitable potential for tourism and ecotourism. The improvement of recreational conditions and tourism facilities provided tourism income for investment in this area, which is one of the reasons for getting higher priority of employment creation services from the point of view of communities on the edge of the agricultural ecosystem. These results confirm Sohrabi's *et al*. (2021) in Iran and Assandri's *et al*. (2018) in Trentino, Italy. The findings showed that the cultural function was one of the most important functions of the agricultural ecosystem.

Unfortunately, the lack of information and insufficient recognition of the positive services of the agricultural ecosystem in northern Iran has caused increase in the amount of damage to the ecosystem and decrease in its habitat desirability. Meanwhile, most of the economic researches published in developing countries are focused on the direct benefits of the agricultural ecosystem. The lack of proper understanding of these functions and the services produced by them is considered a serious danger for the society. Therefore, it is suggested to inform the communities about the importance of the positive services of the agricultural ecosystem in northern Iran in order to protect them.

As seen, the current research has been done at a relatively limited level. Therefore, it is necessary to pay attention to the agricultural ecosystem services in a large area. In addition to the opinions of experts, the opinions of native and non-native communities should be considered in determining priority. Because knowing, classifying, and prioritizing the services will be the guidance for policy making, management, and how to use the agricultural ecosystem (De Groot *et al*., 2010). Also, it is necessary for future researchers to pay more attention to the role and importance of the functions and services and to survey the environmental behaviors of people in relation to the northern areas in Iran AEFS. Because the concept of agricultural ecosystem services, including all social, economic, and ecological dimensions, is a suitable framework for integration in the planning and management of these areas.

ACKNOWLEDGEMENTS

The present study was done at Sari Agricultural Sciences and Natural Resources University (SANRU). We thank and appreciate the cooperation of experts and specialists in the field of agricultural ecosystem management at the SANRU and Agricultural Jihad Organization in Iran for cooperation in this research.

REFERENCES

1. Majeed, R. A. and Breesam, H. K. 2021. Application of SWARA Technique to Find Criteria Weights for Selecting Landfill Site in Baghdad Governorate. *IOP Conf. Ser.:*

Mater. Sci. Eng., **1090(1):** 012045.
2. Altieri, M. A. 2018. *Agroecology: The Science of Sustainable Agriculture.* 2nd Edition, Westview Press, Boulder, CO, USA, (October 13, 1995).
3. Ben Amor, W. D., Martinez Lopez, L. and Frikha, H. M. 2022. A Multigranular Linguistic Additive Ratio Assessment Model in Group Decision Making. World Academy of Science, Engineering and Technology. *Int. J. Comput. Sci. Eng.,* **16(8):** 357-362.
4. Assandri, G., Bogliani, G., Pedrini, P. and Brambilla, M. 2018. Beautiful Agricultural Landscapes Promote Cultural Ecosystem Services and Biodiversity Conservation. *Agriculture*, **256**: 200-210.
5. Ayan, B., Abacıoğlu, S. and Basilio, M. P. A. 2023. Comprehensive Review of the Novel Weighting Methods for Multi-Criteria Decision-Making. *Information,* **14(5):** 1-28.
6. Azaiez, N., Alleoua, A., Baazaoui, N. and Qhtani, N. 2020. Assessment of Soil Loss in the Mirabah Basin: An Overview of the Potential of Agricultural Terraces as Ancestral Practices (Saudi Arabia). *Open J. Soil Sci.,* **10**: 159–180.
7. Bishop, J. T. 1999. *Valuing Forests: A Review of Method and Application in Developing Countries*. International Institute for Environment and Development (IIED), WC1 ODD, London, UK, PP. 53-67.
8. Chen, T. –C. and Yu, S. –Y. 2022. Study on the Risk Level of Food Production Enterprise Based on TOPSIS Method. *Food Sci. Technol. (Campinas),* **42**: 1-6
9. Czúcz, B., I., Arany, M., Potschin-Young, K., Bereczki, M., Kertész, M. and Haines-Young, R. 2018. Where Concepts Meet the Real World: A Systematic Review of Ecosystem Service Indicators and Their Classification Using CICES. *Ecosyst. Serv.,* **29:** 145-157.
10. CICES., 2018. Common International Classification of Ecosystem Services (CICES). https://cices.eu/.
11. Costanza, R., d'Arge, R., de Groot, R., Farber, S., Grasso, M., Hannon, B., Limburg, K., Naeem, Sh., O'Neill, R., Paruelo J., Raskin R., Sutton P. and Belt M., 1998. The Value of the World's Ecosystem Services and Natural Capital. *Ecol. Econ.,* **25**: 67-72.
12. De Groot, R. S., Alkemade, R., Braat, L., Hein, L. and Willemen, L., 2010. Challenges in Integrating the Concept of Ecosystem Services and Values in Landscape Planning, Management and Decision Making. *Ecol. Complex.,* **7:** 260–272.
13. De Groot, R., Brander, L. and Ploeg, S., 2012. Estimates of the Value of Ecosystems and Their Services in Monetary Units. *Ecosyst. Serv.,* **1**: 50–61.
14. Debnath, B., Baria, M., Haqa, M., Pachecob, J. and Khan. M., 2023. An Integrated Stepwise Weight Assessment Ratio Analysis and Weighted Aggregated Sum Product Assessment Framework for Sustainable Supplier Selection in the Healthcare Supply Chains. *Supply Chain Analytics,* **1:** 1-11
15. Dick, J., Turkelboom, F. and Woods, H., Iniesta-Arandia, I., Primmer, E., Saarela, S. R., Bezák, P., Mederly, P., Leone, M., Verheyden, W., Kelemen, E., Hauck, J., Andrews, C., Antunes, P., Aszalós, R., Baró, F., Barton, D. N., Berry, P., Bugter, R., Carvalho, L., Czúcz, B., Dunford, R., Garcia Blanco, G., Geamănă, N., Giucă, R., Grizzetti, B., Izakovičová, Z., Kertész, M., Kopperoinen, L., Langemeyer, J., Montenegro Lapola, D., Liquete, C., Luque, S., Martínez Pastur, G., Martin-Lopez, B., Mukhopadhyay, R., Niemela, J., Odee, D., Luis Peri, P., Pinho, P., Patrício-Roberto, G. B., Preda, E., Priess, J., Röckmann, C., Santos, R., Silaghi, D., Smith, R., Vădineanu, A., van der Wal, J. T., Arany, I., Badea, O., Bela, G., Boros, E., Bucur, M., Blumentrath, S., Calvache, M., Carmen, E., Clemente, P., Fernandes, J., Ferraz, D., Fongar, C., García-Llorente, M., Gómez-Baggethun, E., Gundersen, V., Haavardsholm, O., Kalóczkai, Á., Khalalwe, T., Kiss, G., Köhler, B., Lazányi, O., Lellei-Kovács, E., Lichungu, R., Lindhjem, H., Magare, C., Mustajoki, J., Ndege, C., Nowell, M., Girona, S. N., Ochieng, J., Often, A., Palomo, I., Pataki, G., Reinvang, R., Rusch, G., Saarikoski, H., Smith, A., Massoni, E. S., Stange, E., Traaholt, N. V., Vári, Á., Verweij, P., Vikström, S., Yli-Pelkonen, V. and Zulian, G. 2018. Stakeholders' Perspectives on the Operationalisation of the Ecosystem Service Concept: Results from 27 Case Studies. *Ecosyst. Serv.,* **29(Part C):** 552–

565.
16. Dumont, B., Ryschawy, J., Duru, M., Benoit, M., Chatellier V., Delaby L., Donnars, C., Dupraz, P., Lemauviel-Lavenant, S. Méda B., Vollet D. and Sabatier, R. 2019. Associations among Goods, Impacts and Ecosystem Services Provided by Livestock Farming. *Animal*, **13(8):** \1773-1784.
17. EEA. 2016. *Climate Change, Impacts and Vulnerability in Europe 2016*. European Environment Agency.
18. FAO. 2018. *Incentives for Ecosystem Services: Supporting the Transition to Sustainable Food Systems*. Food and Agriculture Organization, PP. 1-6.
19. Fan, J., Han, D. and Wu, M. 2023. Picture Fuzzy Additive Ratio Assessment Method (ARAS) and VIseKriterijumska Optimizes I Kompromisno Resenje (VIKOR) Method for Multi-Attribute Decision Problem and Their Application. *Complex. Intell. Syst.,* **9**: 5345–5357.
20. Haines-Young, R. and Potschin, M. 2013. *Common International Classification of Ecosystem Services (CICES), Version 4.3*. Report to the European Environment Agency. (download: www.cices.eu)
21. Heinze, A., Bongers, F., Ramírez Marcial, N., García Barrios, L. E. and Kuyper T. W. 2022. Farm Diversity and Fine Scales Matter in the Assessment of Ecosystem Services and Land Use Scenarios. *Agric. Syst.,* **196:** 1-15.
22. Hosseini, S., Amirnejad, H. and Azadi, H. 2025. Impacts of Hyrcanian Forest Ecosystem Loss: The Case of Northern Iran. *Environ. Dev. Sustain.,* **27:** 14397–14418.
23. Hosseini, S., Oladi, J. and Amirnejad, H. 2021. The Evaluation of Environmental, Economic and Social Services of National Parks. *Environ. Sci. Dev.,* **23**: 9052-9075.
24. Jaukovic Jocic, K., Jocic, G., Karabasevic, D., Popovic, G., Stanujkic, D., Zavadskas, E. K. and Thanh Nguyen, P. 2020. A Novel Integrated PIPRECIA-Interval-Valued Triangular Fuzzy ARAS Model: E-Learning Course Selection. *Symmetry (Basel),* **12(6):** 1-14.
25. Jia, Y., Liu, Y. and Zhang, S. 2021. Evaluation of Agricultural Ecosystem Service Value in Arid and Semiarid Regions of Northwest China Based on the Equivalent Factor Method. *Environ. Process.,* **8:** 713–727.
26. MEA (Millennium Ecosystem Assessment). 2005. *Ecosystems and Human Well-Being: Synthesis*. Island Press, World Resources Institute, Washington DC, 155 PP.
27. Mengual-Andrés, S., Roig-Vila, R. and Mira, J. B. 2016. Delphi Study for the Design and Validation of a Questionnaire about Digital Competences in Higher Education. *Int. J. Educ. Technol. High. Educ.,* **13(12)**: 1-12.
28. Prayogo, M. A., Suseno, J. E., Nugraheni, D. M. K., 2019. Selecting Palm Oil Cultivation Land Using ARAS Method. *In International Seminar on Research of Information Technology and Intelligent Systems (ISRITI),* **PP**. 358-362.
29. Rabbinge, R. and Bindraban P. S. 2012. Making More Food Available: Promoting Sustainable Agricultural Production. *J. Integr. Agric.,* **11**: 1–8.
30. Ramón-Canul, L., Margarito-Carrizal, D., Limón-Rivera R., Morales-Carrrera, U. A., Rodríguez-Buenfil, I. M., Ramírez-Sucre, M. O., Cabal-Prieto, A., Herrera-Corredor, J A. and de Jesús Ramírez-Rivera, E. 2021. Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) Method for the Generation of External Preference Mapping Using Rapid Sonometric Techniques. *J. Sci. Food Agric.,* **101(8):** 3298-3307.
31. Schmidt, M., Weißhuhn, P., Augustin, J., Funk, R., Häfner, K., König, H., Loft, L., Merz, C., Meyer, C., Piorr, A., Reutter, M., Stachow, U., Stein-Bachinger, K. and Matzdorf, B. 2017. Evaluation of the Ecosystem Services Approach in Agricultural Literature. *One Ecosyst.,* **2**: 1-17.
32. Sohrabi, S., Veisi, H. and Khoshbakht, K. 2021. A Comparative Analysis of Ecosystem Services Valuation in Alternative Agricultural Systems (Case of Dezful County, Khuzestan Province). Environ. Res., **11(22):** 45-56.
33. Sun, Q., Qi, W. and Yu, X. 2021. Impacts of Land Use Change on Ecosystem Services in the Intensive Agricultural Area of North China Based on Multi-Scenario Analysis. *Alex. Eng. J.,* **60(1):** 1703–1716.
34. Swinton, S. M., Jolejole-Foreman, C. B., Lupi, F., Ma, S., Zhang, W. and Chen, H. 2015. Economic Value of Ecosystem Services from Agriculture. The Ecology of

Agricultural Landscapes: Long-Term Research on the Path to Sustainability. Oxford University Press, New York, New York, USA.
35. TEEB. 2010.The Economics of Ecosystems and Biodiversity. 84 p.
36. Wang, Y., Liu, G., Cai, Y., Giannetti, B., Agostinho, F., Almeida, C. M. V. B. and Casazza, M. 2022. The Ecological Value of Typical Agricultural Products: An Emergy-Based Life-Cycle Assessment Framework. *Front. Environ. Sci.,* **10**: 1-20
37. Yücenur, G. N. and Ipekçi, A. 2021. SWARA/WASPAS Methods for a Marine Current Energy Plant Location Selection Problem. *Renew. Energy,* **163**: 1287–1298
38. Zavadskas, E. and Turskis, Z., 2010. A New Additive Ratio Assessment (ARAS) Method in Multicriteria Decision-Making, *Technol. Econ. Dev. Econ.,* **16(2):** 159-172.
39. Zolfani S. and Saparauskas J. 2013. New Application of SWARA Method in Prioritizing Sustainability Assessment Indicators of Energy System. *INZ EKON.,* **24(5):** 408-414.
40. Xu, Z. and Peng, J. 2022. Ecosystem Services-Based Decision-Making: A Bridge from Science to Practice. *Environ. Sci. Policy,* **135**: PP. 6-15.

بررسی کارکردها و خدمات اکوسیستم کشاورزی در شمال ایران

سارە حسینی، و فهیمه کریمپور

چکیده

اکوسیستم کشاورزی کارکردها و خدمات مختلفی را برای انسان فراهم می‌کند. لذا بررسی نقش و اهمیت آنها در برنامه‌ریزی و مدیریت اراضی کشاورزی یکی از اهداف تحقیق می‌باشد. برای شناسایی کارکردها و کالاها و خدمات اکوسیستم کشاورزی از طبقه‌بندی مشترک بین‌المللی خدمات اکوسیستمی (CICES) استفاده گردید. همچنین جهت وزن‌دهی و اولویت‌بندي کارکردها و خدمات اکوسیستم کشاورزی از تکنیک های تصمیم‌گیری چند معیاره شامل تحلیل نسبت ارزیابی وزن‌دهی تدریجی (SWARA) به منظور محاسبه وزن کارکردها و خدمات، و مدل‌های مجموع ساده وزین (SAW)، ارزیابی نسبت جمعی (ARAS) و تکنیک ترجیحات بر اساس مشابهت به راه حل ایده‌آل (TOPSIS) برای اولویت‌بندی آنها استفاده شده است. در این مطالعه داده‌هاي پژوهش به صورت پیمایش میدانی، نمونه‌گیری تصادفی و با تکمیل پرسشنامه دلفی توسط ۴۰ نفر از خبرگان کشاورزی در شمال ایران استخراج گردید تا نمایان شود کدامیک از کارکردها و خدمات مثبت اکوسیستم کشاورزی دارای اهمیت بیشتری در مدیریت بهینه آن می‌باشند. همچنین برای مقایسه مدل‌های اولویت‌بندی از ضریب R^2 استفاده شد. یافته‌هاي تکنیک SWARA نشان داد که کارکردهای تامینی، تنظیمی و فرهنگی به ترتیب با کسب وزن‌های ۰/۰۲۹۸، ۰/۰۲۸٦ و ۰/۰۲۵۰ بیشترین وزن را به خود اختصاص داده اند. همچنین نتایج نشان داد که مدل SAWبا کسب $R^2=$ ۰/۹۰ به عنوان مدل مناسب انتخاب گردید. طبق نتایج اولویت‌بندی این مدل، کارکردهای تامینی، تنظیمی و فرهنگی با وزن‌های ۰/٦٣١٩، ۰/٥٤٤٨ و ۰/۰٥۰۹۲ به ترتیب در اولویت اول تا

سوم جهت مدیریت بهینه اکوسیستم کشاورزی شمال ایران قرار گرفتند. همچنین در میان خدمات اکوسیستمی، خدمات تامین غذا، اشتغال، تأمین مواد ژنتیکی و خدمات آموزشی و پژوهشی جزء خدمات مهم و مثبت اکوسیستم کشاورزی شمال ایران نسبت به سایر خدمات می‌باشند. لذا پیشنهاد می‌شود برنامه‌ریزی و تحقیقات مناسب توسط سازمان‌های ذیربط جهت مدیریت پایدار اکوسیستم‌های کشاورزی صورت پذیرد.

واژگان کلیدی: کارکردها و خدمات اکوسیستم کشاورزی، طبقه‌بندی مشترک بین‌المللی خدمات اکوسیستم، ارزیابی وزنی.