

1 **Investigating of agricultural ecosystem functions and services in Northern**
2 **Iran**

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4 **Abstract**

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

26 **Key words:** AEFS, Agroecological maintenance, CICES, Final function, Prioritization,
27 Weighting assessment.
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31 INTRODUCTION

32 A set of ecosystem services that human life depends on them is provided by agriculture
33 (Heinze et al, 2022); Also, due to the increasing growth of the world population, there is
34 more pressure on agricultural prospects to receive different services (Azaiez et al., 2020).
35 Based on it, a series of factors such as climate, geology, ecology, as well as management
36 methods, technology and skills affect the provision of landscapes ecosystem services. In fact,
37 agriculture ecosystems are both a recipient and a provider of services. Therefore, the
38 sustainability of agricultural ecosystems requires their ability to simultaneously provide
39 services in a balance between the provision and consumption of services. However, the main
40 management approach is based on the preservation of the services for the use of future
41 generations, that the balance between services compared whit other agricultural ecosystems
42 (Altieri, 2018). Therefore, agricultural ecosystem managers are trying to integrate ecosystem
43 services in agricultural ecosystem policies and management by using a set of methods
44 including evaluation of dependencies and effects of ecosystem services, valuation of
45 ecosystem services, scenario creation and other interventions which can become the main
46 basis for resolving conflicts and establishing a compromise between development and nature
47 and guaranteeing the stability of both (Peng et al., 2019). Therefore, access quantitative and
48 qualitative information about the positive services of the agricultural ecosystem is of
49 particular importance to achieve sustainable agriculture (Jia et al., 2021).

50 Among the diverse ecosystems, the agricultural ecosystem with different functions and
51 services have directly and indirectly role in the economic and human livelihoods (FAO
52 2018), whose maintenance of them should be the main goal of human activities. Therefore,
53 five classifications include the study of Castanza et al. (1997); De Groot et al. (2012);
54 Millennium Ecosystem Classification (MEA 2005); The Economics of Ecosystems and
55 Biodiversity (TEEB) (2010); and Common International Classification of Ecosystem
56 Services (CICES) (2018) is emphasized for the classification of ecosystem services (Heinz
57 Jung and Putshin 2018). CICES (2018) is the latest classification of ecosystem functions and
58 their services that was developed by the European Environment Agency (EEA) with the aim
59 of providing a standard for the systematic nomenclature, description and classification of
60 ecosystem services. This classification includes three main groups of provision, regulating
61 and cultural functions (European Environment Agency 2016).

62 Based on CICES classification, provisioning services are products and energy outputs
63 obtained from goods and products. The regulating services include all the ways in which

64 ecosystems can manage the environment in which people live or depend in some way and
65 benefit from them in terms of their health or safety, for example. Finally, the cultural services
66 category refers to all the non-material aspects of an ecosystem that contribute to or are
67 important for humans' mental or intellectual wellbeing. Cultural services are intangible
68 benefits that contribute to human development and culture, including the functioning of local,
69 national, and international cultural ecosystems. Dissemination of knowledge and ideas; and
70 interaction with nature (music, art, architecture). Creativity emerges from dialogue and
71 entertainment (CICES, 2018).

72 These functions and services are not free and have hidden economic value. If these
73 services are considered free, the agricultural ecosystem will be destroyed (Dick et al., 2018).
74 Currently stated various pressures arising as economic purposes have caused their decline and
75 destruction, and we are witnessing their destruction in every aria of the world. For this
76 reason, the identification of the agricultural ecosystem functions and services (AEFS) has
77 become very important. Obviously, this issue requires the participation of stakeholders and
78 finding out about their preferences for positive services of the agricultural ecosystem,
79 especially the Agricultural Ecosystem of Northern Iran (AENI) (Dumont et al., 2019). So far,
80 different models have been done for ranking and valuation functions and services, but few
81 studies have been done about defining them. Some of the most important ones are mentioned
82 here:

83 Jia et al. (2021) surveyed agricultural ecosystem services in arid and semi-arid regions of
84 western China based on the equivalent factor method. The study results showed that the
85 factor evaluation method is an accounting tool for the evaluation of ecosystem services. Also,
86 9 agricultural ecosystem services analyzed in this evaluation. The findings showed that the
87 agricultural environmental services value in Gansu province increased from 2008 to 2017.
88 Also, ecological services are the most important agricultural ecosystem services in arid and
89 semi-arid areas. Sun et al. (2021) assessed agricultural service's North China and predicted
90 their changes under different land use scenarios. The results indicated that agricultural
91 ecosystem services play an important role in the economic and social conditions of society.
92 Also, Wang et al. (2022) assessed the ecological value of China's conventional agricultural
93 ecosystem services in the framework of Energy-Based Life-Cycle Assessment. The findings
94 showed that the importance of agricultural ecosystem provisioning services ecosystem is
95 much higher than the production services provided by them. In this regard, Heinze et al.
96 (2022) investigated farm diversity and its ecosystem services in different land use scenarios

97 of southeastern Mexico. The results indicated that farms provide different services, which
98 provisioning services are more important compared to other services and should be
99 considered in different management methods.

100 A review of the previous sources showed that despite the existence of research related to
101 the AEFS evaluation with different approaches, no study has been done about the
102 identification, weighting and prioritization of AEFS. Therefore, it has been tried according to
103 a) The importance of the AENI and highlighting its values to the society, b) The tensions
104 resulting from the change of agricultural land use in the north of Iran, c) The possibility of the
105 agricultural lands drought of northern Iran due to the lack of water resources and the
106 phenomenon of climate change in recent years and d) the important role of agricultural
107 ecosystem services in the comprehensive management of water resources. Also, the three
108 main provisioning, regulating and cultural services and the AENI based on the CICES are
109 identified and prioritized for their optimal management.

110

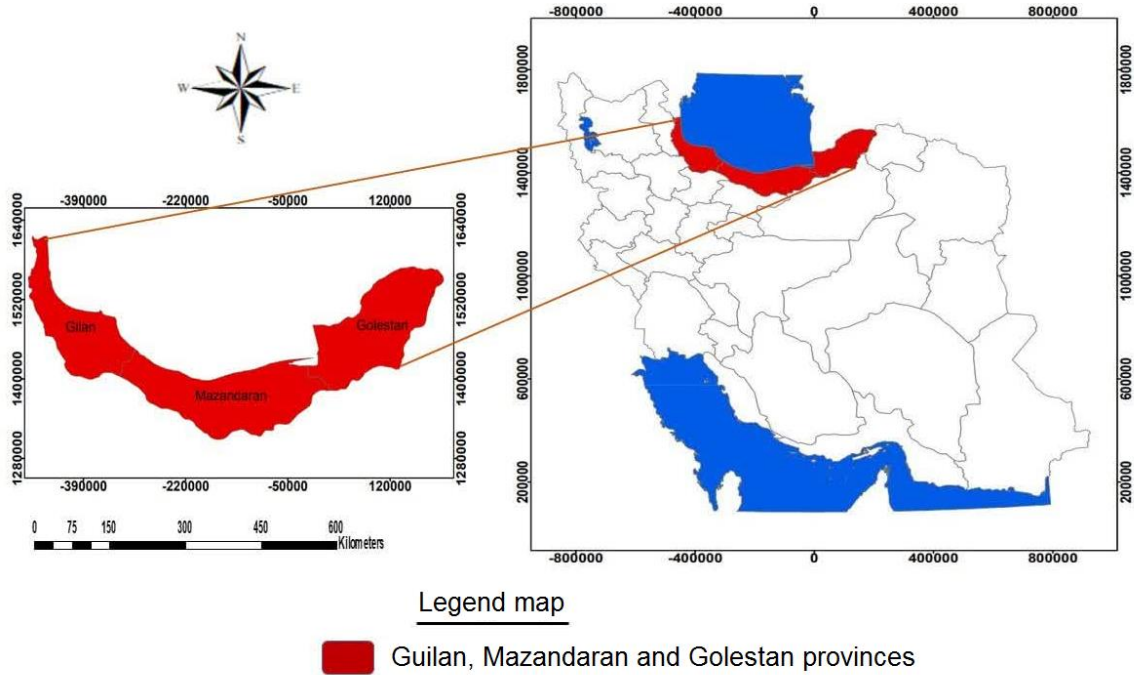
111 MATERIALS AND METHODS

112 A) Study Area

113 The agricultural ecosystem has an important role in Iran country's economy. The Iran's
114 agricultural land area is 16.5 million ha, of which 14.7 million ha are agricultural lands and
115 the rest are gardens lands. The crops production in the Northern Iran was about 8417436 tons
116 in 2017-2018 which was almost a ninth of the country's total crops.

117 To carry out this research, the three provinces of Mazandaran, Guilan and Golestan has
118 been selected. Currently, the cultivated area of agricultural lands in Mazandaran province was
119 476 thousand ha with an annual production of more than three million and 574 thousand tons.
120 Important characteristics of Mazandaran province is the high cultivation coefficient (1.4)
121 compared to the cultivation coefficient total of Iran (0.7). It has made Mazandaran province
122 to the largest producer of rice in the Iran, and it has many capacities in increasing the quality
123 and quantity in this regard. Also, it has caused the annual cultivated land of this province
124 increase to more than 600 thousand ha. On the other wise, there are more than 45 types of
125 cultivated crops in Mazandaran which the most important of them are rice, wheat, barley,
126 soy, rapeseed, corn, fodder plants, vegetables and summer vegetables. Each of these products
127 provide many services to the society. Also, the area of arable land of Golestan province is
128 850 thousand ha which the agricultural land area is 710 thousand ha (250 thousand ha of
129 irrigated land and 460 thousand ha of dry land). Also, the products of the agricultural

130 ecosystem are very diverse, and some of its products are of special value and importance on a
 131 national scale in Guilan province. Therefore, agriculture in Guilan province has both
 132 nutritional and commercial value for its producers. The agricultural ecosystem is about 30%
 133 of the Guilan province area. The proportion of irrigated and dry lands in this province is 82%
 134 and 18% respectively (<https://maj.ir/>).



135
 136 **Figure. 1.** The location of the case study.

137 **b) Methodology**

138 In this research, in order to weighting and prioritize of the AEFS in northern Iran, firstly;
 139 the AEFS were identified and compiled based on the most the CICES. Then the research data
 140 was extracted in the form of field survey, random sampling and by completing the Delphi
 141 questionnaire and face-to-face interviews with 40 experts of agricultural ecosystem
 142 management. Also, information about AEFS in northern Iran write in a Delphi questionnaire
 143 in order to familiarize the respondents with AEFS in northern Iran. Then this question asked
 144 which of the positive AEFS in northern Iran have more important role in the optimal and
 145 sustainable management of the agricultural ecosystem? After express your answers based on
 146 one of the five degrees of importance of the Likert scale conations; unimportant=1, little
 147 important=2, important=3, great important=4 and very important= 5 (Hosseini et al., 2021).
 148 Also, if there are new services, they add them to the questionnaire. Finally; among the 40
 149 questionnaires gathered, 10 questionnaires were removed due to the incompleteness of the
 150 information, and the data of 30 questionnaires were used to analyze the information (Table
 151 1).

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

155 In this study, for weighting and prioritizing each of AEFS used the Multi-Criteria
156 Decision-Making (MCDM) models such as the Step wise Weight Assessment Ratio Analysis
157 (SWARA) in order to calculate the weighting of AEFS (Debnath et al., 2023); the Simple
158 Additive Model (SAW) (Hosseini et al., 2021); the Additive Ratio Assessment (ARAS)
159 (Amor et al., 2022) and Technique for Order of Preference by Similarity to Ideal Solution
160 (TOPSIS) has been used to prioritize functions and services (Ramón-Canul et al., 2021).
161 Finally, the curve slope (R^2) used for comparing and choosing the suitable models for
162 prioritizing the AEFS in the northern Iran.

163 Spss16 software used to process and statistically analyze the questionnaire data such as
164 calculating the questionnaire reliability with Cronbach's alpha test. Also, Excel software used
165 to implement the weighting and prioritization models analysis.

166

167 - **Step-Wise Weight Assessment Ratio Analysis (SWARA)**

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

172 • **First step: Sorting criteria (Services)**

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

176 • **Second step: determining the relative importance of each criterion (S_j)**

177 In this step, the relative importance of each criterion compared to the previous criteria.
178 This value represented using S_j .

179 • **The third step: calculating the coefficient K_j**

180 The coefficient K_j , it is a service of the relative importance of each criterion that is
181 calculated using Eq 1:

$$182 \quad K_j = S_j + 1 \quad (1)$$

183 • **Fourth step: calculate the initial weight of each services**

184 The initial weight (recalculated weight) of criteria (Q_j) is calculated with Eq 2. In this

185 regard, it should be noted that the weight of the first criterion (the most important criterion) is
186 considered equal to one (Ali Majeeda and Breesam, 2021; Zolfani and Saparauskas, 2013).

$$187 \quad Q_j = x_j - 1 / K_j \quad (2)$$

188 **•Step five: Calculate the final normal weight**

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

$$191 \quad W_j = Q_j / \sum_k^n Q_j \quad (3)$$

192 - **Additive Ratio Assessment method (ARAS)**

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

197 **• Formation of the decision matrix**

198 The first step in this technique is to create a decision matrix. A decision matrix is a
199 matrix for evaluating a number of options based on a number of criteria. That is, a matrix
200 in which each option is scored based on a number of criteria. The decision matrix is
201 denoted by x and each term is denoted by x_{ij} (Eq 3) (Fan et al., 2021).

$$202 \quad X = \begin{bmatrix} x_{11} & x_{12} & x_{1n} \\ x_{21} & x_{22} & x_{2n} \\ x_{m1} & x_{m2} & x_{mn} \end{bmatrix} \quad (4)$$

203 **• Creation of normal decision matrix**

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

$$206 \quad N = \begin{bmatrix} n_{11} & n_{12} & n_{1n} \\ n_{21} & n_{22} & n_{2n} \\ n_{m1} & n_{m2} & n_{mn} \end{bmatrix} \quad (5)$$

207 **• Formation the normal weighted decision matrix**

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

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

212

213 • **Calculate the utility of each option**

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

$$218 \quad S_i = \sum V_{ij} \quad (7)$$

219 The degree of desirability of the option (K_i) is calculated based on the comparison with an
 220 optimal value (S_o) using Eq 8. The optimal value can be obtained based on the opinion of
 221 experts or the best weighted matrix values (Hosseini et al., 2024)

$$222 \quad K_i = S_i / S_o \quad (8)$$

223 - **Simple Additive Weighting (SAW)**

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

$$229 \quad S_i = \sum_j n_{ij} \cdot w_j \quad (9)$$

230 w_j is weight of each service and n_{ij} is score of each service (Eq 9).

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

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

237 • **First step: Converting the existing decision-making matrix into a matrix (unscaled)**
 238 **using Eq (10):**

$$239 \quad n_{ij} = \frac{r_{ij}}{\sqrt{\sum_{i=1}^m r_{ij}^2}} \quad (10)$$

240 n_{ij} : normalized matrix r_{ij} : score of each criterion

241 • **The second step: Creating the weight matrix assuming the vector was input to the**
 242 **algorithm (Eq 11):**

$$243 \quad W = \{ W_1, W_2, \dots, W_n \} \quad (11)$$

244 W is weight of each criterion.

245 S_0 that ND is a matrix in which the criteria scores are dimensionless and comparable, and
 246 $W_{n \times n}$ is a diagonal matrix in which only the main diagonal elements will be non-zero (Eq 12).

$$247 \quad V = ND \cdot W_{n \times n} = \begin{bmatrix} v_{11} & v_{12} & v_{1n} \\ v_{21} & v_{22} & v_{2n} \\ v_{m1} & v_{m2} & v_{mn} \end{bmatrix} \quad (12)$$

248 V is weight matrix (dimensionless).

249 • **The third step: Specifying the positive ideal solution (A^+) and the negative ideal**
 250 **solution (A^-) based on Eq 13:**

$$251 \quad A^+ = \{ (\max V_{ij} / j \in J), (\min V_{ij} / j \in J') \mid i = 1, 2, \dots, m \} = \{ V_1^+, V_2^+, \dots, V_j^+, \dots, V_n^+ \}$$

$$252 \quad A^- = \{ (\min v_{ij} / j \in J), (\max V_{ij} / j \in J') \mid i = 1, 2, \dots, m \} = \{ V_1^-, V_2^-, \dots, V_j^-, \dots, V_n^- \} \quad (13)$$

$$253 \quad J = \{ j = 1, 2, \dots, n \mid j \in \text{benefit} \} \quad J' = \{ j = 1, 2, \dots, n \mid j \in \text{Cost} \}$$

254 • **Step 4: Calculate the distance between the i th option and ideals (d_i) using the**
 255 **Euclidean method based on Eq 14:**

$$256 \quad d_{i+} = \{ \sum_{j=1}^n (V_{ij} - V_j^+)^2 \}^{0.5} ; i = 1, 2, \dots, m \quad (14)$$

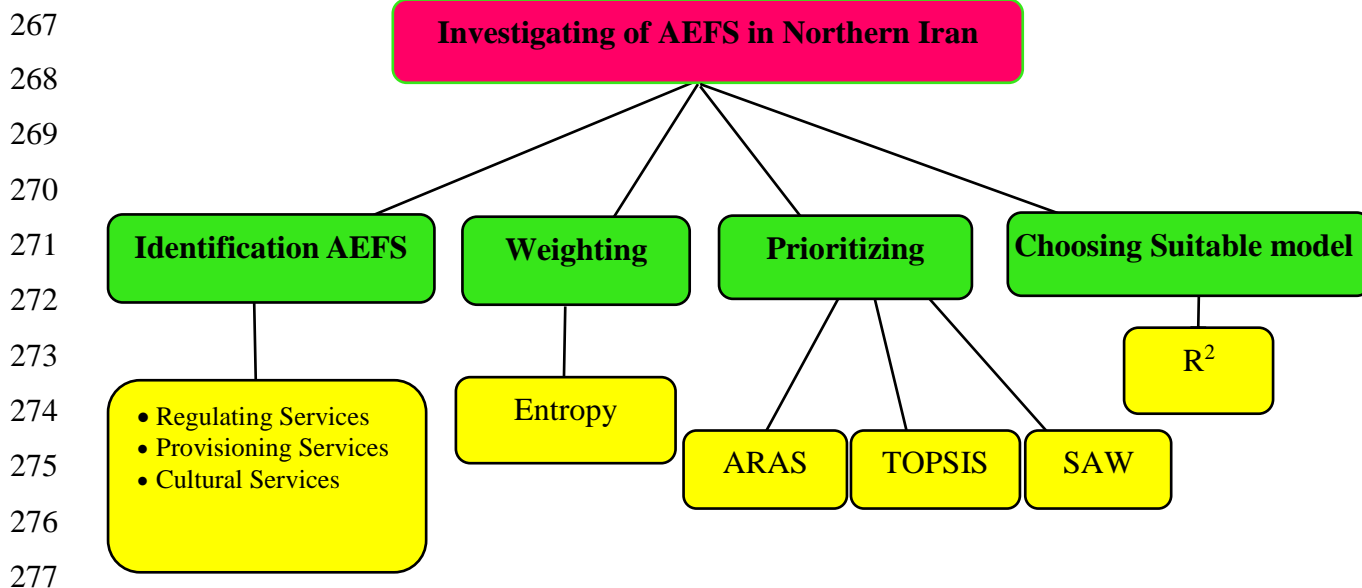
$$257 \quad d_{i-} = \{ \sum_{j=1}^n (V_{ij} - V_j^-)^2 \}^{0.5} ; i = 1, 2, \dots, m$$

258 • **The fifth step: Calculating the relative proximity of A_i to the ideal solution (cl_{i+})**
 259 **using Eq 15:**

$$260 \quad cl_{i+} = \frac{d_{i-}}{(d_{i+} + d_{i-})} ; 0 \leq cl_{i+} \leq 1 ; i = 1, 2, \dots, m \quad (15)$$

261 • **The sixth step: Ranking the options based on cl_{i+} descending.**

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278 **Figure.2.** Methodology steps for investigating of agricultural ecosystem functions and
279 services in Northern Iran.

280 RESULTS

281

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

285 - Identifying the AEFS of the Northern Iran

286

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

293 **Table 1.** Delphi members to identify the positive functions and services of the northern Iran
294 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

295

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

Table 2. The AEFS of northern Iran.

Functions	Services	Description
Regulating services	Local and regional climate regulation	The plants of the agricultural ecosystem can create a more additive 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.
Provisioning services	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.
	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.
Security	The establishment of protection units and recreational activities in the vicinity of the agricultural ecosystem increases security and reduces crime for agritourism.	

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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 $\alpha = 0.97$ which it was confirmed.

- Weighing and prioritizing the AEFS of Northern Iran

After collecting and analyzing the questionnaires, the SWARA technique in order to

308 determine the weight of the AEFS, the SAW, ARAS and TOPSIS method have been used for
 309 priority AEFS. The findings models are presented below.

310
 311 - **Determining the weight of the AEFS of Northern Iran with the SWARA**
 312 **technique**

313 The results of AEFS weighting indicated in Table 3. The weighting findings showed that
 314 the food supply, employment, supply of genetic materials, and educational and research
 315 services respectively have the highest weight.

316 **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
Provisioning services	Primary production	0.0301
	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	
Cultural services	Fauna and Flora habitat and shelter	0.0239
	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	

317
 318 According to the results of Table 4, the provisioning function has the most weight among
 319 other functions of the agricultural ecosystem in northern Iran (Table 4).

320

321 **Table 4.** Calculating the weight of agricultural ecosystem functions in
 322 Northern Iran using the SWARA.

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

323

324 - **Determining the priority of the AEFS in northern Iran**

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

327

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

Code	Services	Models		
		ARAS	SAW	TOPSIS
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

328

329

330

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

331

332 The final weight of the agricultural ecosystem functions with ARAS, TOPSIS and SAW

333 models is indicated in table (7). The finding showed that the provisioning functions have

334 gained more weight among other functions at the three models (Table 7).

335 **Table 7.** The final weight and priority of the agricultural ecosystem functions in Northern

336 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

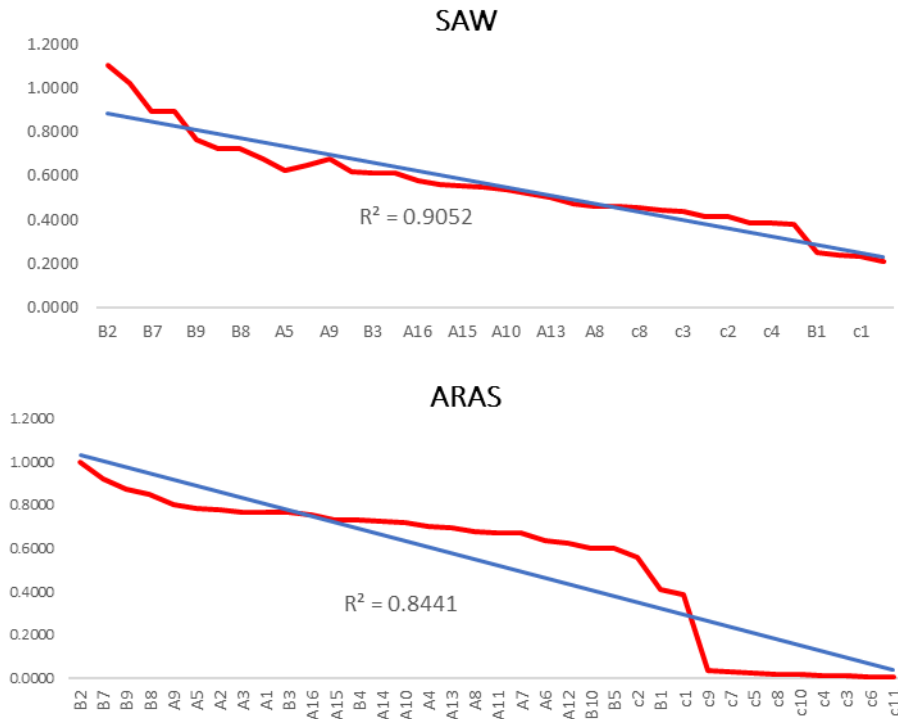
337

338 - **Statistical analysis of selecting the appropriate model for prioritizing the AEFS**
339 **in Northern Iran**

340 In order to compare the models for prioritizing the AEFS in northern Iran, the curve slope

341 (R^2) of the factor weight used in three models (Figure 3). The slope curve of the relative

342 proximity of the weights in the SAW model is a descending exponential function with an
 343 explanatory degree of 0.90, which indicates the obvious difference between the AEFS of
 344 Northern Iran.

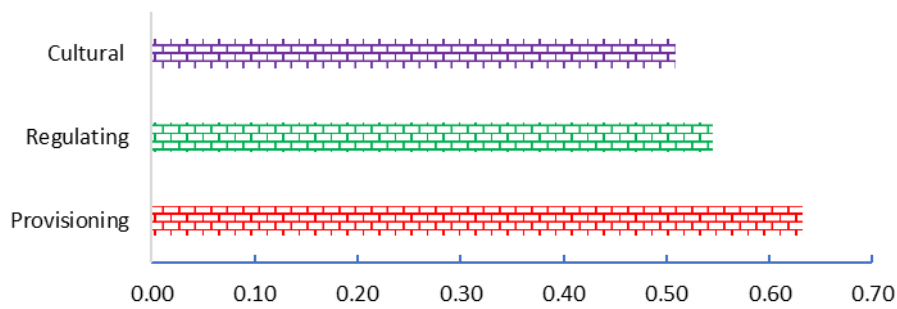


346 **Figure. 3.** Curve slope (R^2) in ARAS, TOPSIS and SAW models.
 347
 348

349 The R^2 in the SAW model is higher and closer to one than the other models. Based on the
 350 finding and the consensus of some experts, the result prioritization of the AEFS of Northern
 351 Iran in the SAW model has been closer to reality. Therefore, the SAW model is suggested as
 352 a suitable model for prioritizing the AEFS in Northern Iran.

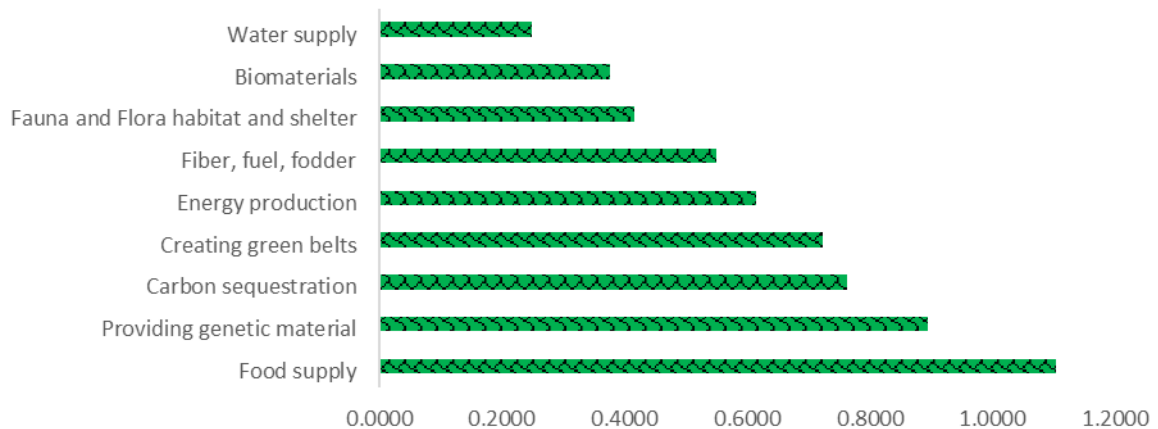
353
 354 **4- Prioritizing the AEFS in Northern Iran based on suitable model (SAW model)**

355 Based on the results of the best model for prioritizing the AEFS of Northern Iran (SAW
 356 model), provisioning, regulating and cultural functions are the most important functions of
 357 the agricultural ecosystem of Northern Iran respectively.
 358

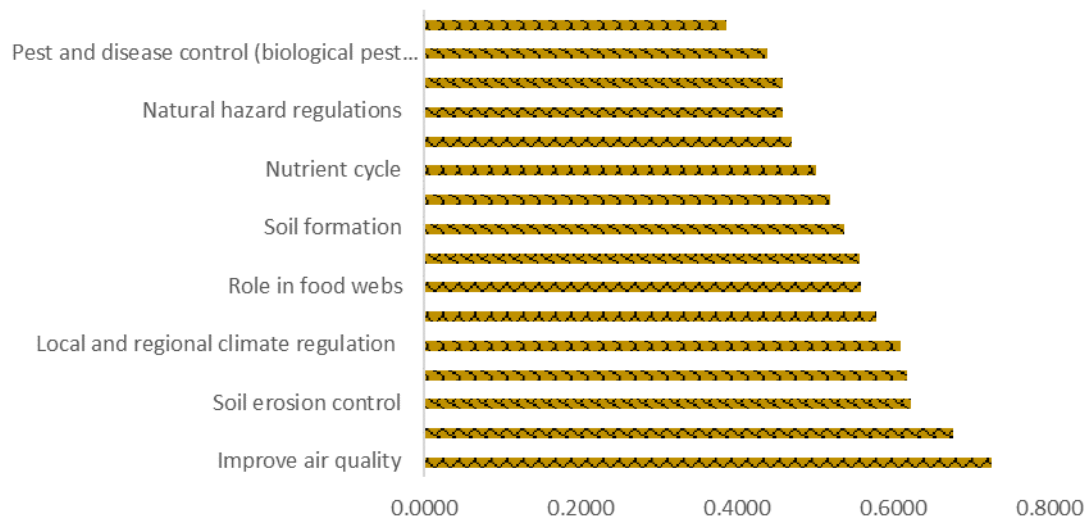


359
360 **Figure 4.** The priority of the functions of the agricultural ecosystem of
361 Northern Iran in the SAW model.

362
363 The findings of prioritizing agricultural ecosystem services in Northern Iran with the
364 SAW model are presented in figures 5, 6 and 7. The results indicated that food supply,
365 employment, air quality improvement services of provisioning, and cultural regulating
366 functions had the first priority respectively compared other agricultural ecosystem services in
367 the north of Iran.



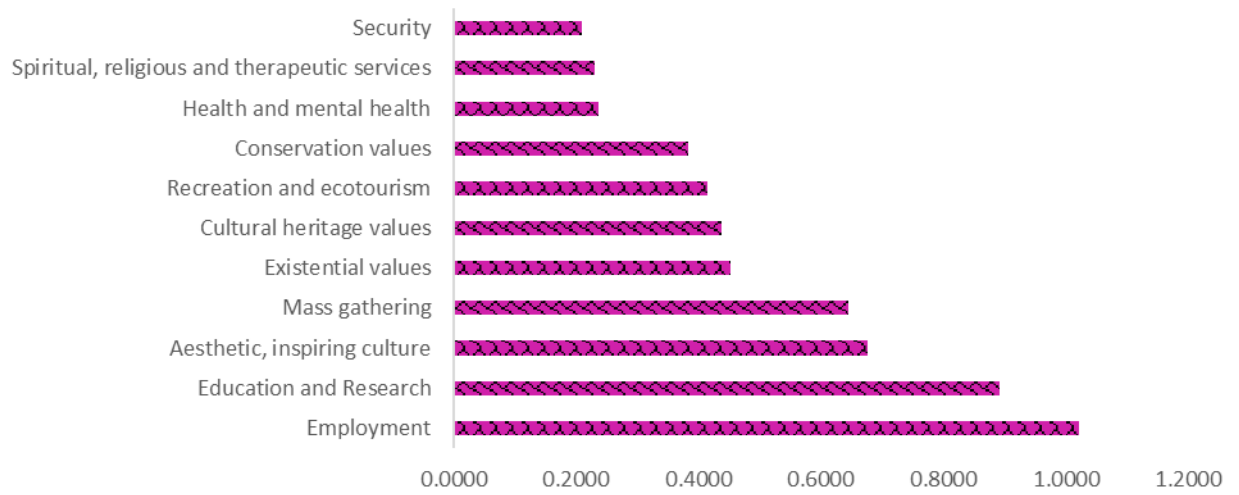
368
369 **Figure 5.** The priority of the provisioning services.



370

371

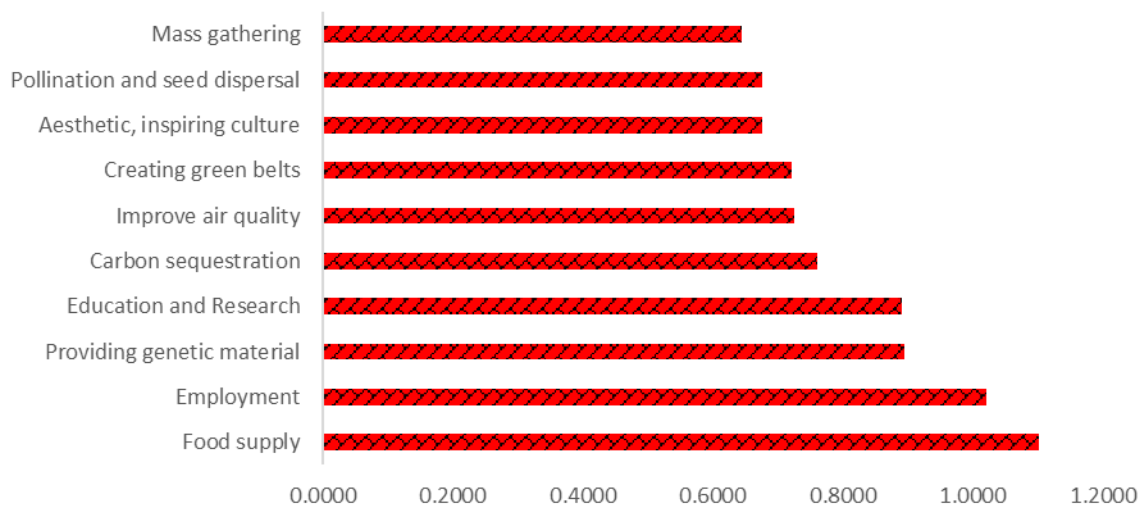
Figure 6. The priority of regulating services.



372

373

Figure .7. The priority of cultural services.



374

375

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

376 **DISCUSSION and CONCLUSIONS**

377 Although the primary goal of agriculture is to produce food, the importance of agriculture
378 is beyond the production of crops (Swinton et al., 2015). And a set of ecosystem services that
379 human life depends on is provided by agriculture (Rabbinge & Bindraban, 2012). The
380 knowledge and skills of farmers in managing agro ecosystems can play an essential role in
381 improving the balance between ecosystem services. Based on this, the management approach
382 of each agro ecosystem is very important, so that sustainable agro ecosystems are involved
383 with ecosystem services. However, the main management approach is based on maintaining
384 these services for use Future generations are stable (Altieri, 2018).

385 The AEFS prioritization results in Northern Iran using MCDM models indicated that the
386 provisioning and regulating functions have the first priority at among all the prioritization
387 models. In other words, provisioning and regulating functions are the most important
388 functions of the agricultural ecosystem in Northern Iran. According to the agricultural
389 specialist experts' opinions of Northern Iran, the higher priority of the provisioning function
390 is due to the fact that the agricultural ecosystem of Northern Iran was one of the richest
391 ecosystems in terms of providing food, genetic material, carbon sequestration, creating a
392 green belt and etc., that each of them has many benefits for the region communities. The
393 result is in accordance with the findings studies of Jia et al. (2021) and Heinze et al. (2022).
394 Also, De Groot et al. (2012) stated regulating services include maintaining essential
395 ecological processes and environmental protection systems. The study results showed that the
396 agricultural ecosystem regulating services such as air quality improvement, pollination and
397 seed dispersal, soil erosion control have the highest priorities compared to other services in
398 northern Iran.

399 Cultural services provide opportunities for spiritual, aesthetic, educational and scientific
400 enrichment. In this regard, the results obtained from the prioritization of agricultural
401 ecosystem services in the north of Iran indicated that the services of creating employment,
402 education and research are the most important agricultural ecosystem cultural services. In
403 other words, the agricultural ecosystem of Northern Iran has created many employment,
404 educational and research opportunities for various academic researchers. Also, the presence
405 of beautiful landscapes on the edge of the agricultural ecosystem of Northern Iran has
406 provided a suitable potential for tourism and ecotourism. The improvement of recreational
407 conditions and tourism facilities provided tourism income for investment this area which it is
408 one of the reasons for getting higher priority of employment creation services from the point

409 of view of communities on the edge of the agricultural ecosystem in Northern Iran. The
410 studies' result Sohrabi et al. (2021) in Iran and Assandri et al. (2018) confirm these results in
411 the Trentino, Italy. The findings showed that the cultural function was one of the most
412 important functions of the agricultural ecosystem.

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

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

432

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438

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544

545 بررسی کارکردها و خدمات اکوسیستم کشاورزی در شمال ایران

546

ساره حسینی، و فهیمه کریمپور

547

چکیده

548 اکوسیستم کشاورزی کارکردها و خدمات مختلفی را برای انسان فراهم می کند. لذا بررسی نقش و اهمیت آنها در برنامه
549 ریزی و مدیریت اراضی کشاورزی یکی از اهداف تحقیق می باشد. برای شناسایی کارکردها و کالاها و خدمات
550 اکوسیستم کشاورزی از طبقه بندی مشترک بین المللی خدمات اکوسیستمی (CICES) استفاده گردید. همچنین جهت
551 وزن دهی و اولویت بندی کارکردها و خدمات اکوسیستم کشاورزی از تکنیک های تصمیم گیری چند معیاره شامل
552 تحلیل نسبت ارزیابی وزن دهی تدریجی (SWARA) به منظور محاسبه وزن کارکردها و خدمات، و مدل های مجموع
553 ساده وزین (SAW)، ارزیابی نسبت جمعی (ARAS) و تکنیک ترجیحات بر اساس مشابهت به راه حل ایده آل
554 (TOPSIS) برای اولویت بندی آنها استفاده شده است. در این مطالعه داده های پژوهش به صورت پیمایش میدانی،
555 نمونه گیری تصادفی و با تکمیل پرسشنامه دلفی توسط 40 نفر از خبرگان کشاورزی در شمال ایران استخراج گردید تا
556 نمایان شود کدامیک از کارکردها و خدمات مثبت اکوسیستم کشاورزی دارای اهمیت بیشتری در مدیریت بهینه آن می
557 باشند. همچنین برای مقایسه مدل های اولویت بندی از ضریب R^2 استفاده شد. یافته های تکنیک SWARA نشان داد
558 که کارکردهای تامینی، تنظیمی و فرهنگی به ترتیب با کسب وزن های 0/0298، 0/0286 و 0/0250 بیشترین وزن
559 را به خود اختصاص داده اند. همچنین نتایج نشان داد که مدل SAW با کسب $R^2 = 0/90$ به عنوان مدل مناسب
560 انتخاب گردید. طبق نتایج اولویت بندی این مدل، کارکردهای تامینی، تنظیمی و فرهنگی با وزن های 0/6319،
561 0/5448 و 0/05092 به ترتیب در اولویت اول تا سوم جهت مدیریت بهینه اکوسیستم کشاورزی شمال ایران قرار
562 گرفتند. همچنین در میان خدمات اکوسیستمی، خدمات تامین غذا، اشتغال، تامین مواد ژنتیکی و خدمات آموزشی و
563 پژوهشی جزء خدمات مهم و مثبت اکوسیستم کشاورزی شمال ایران نسبت به سایر خدمات می باشند. لذا پیشنهاد می
564 شود برنامه ریزی مناسب تر و تحقیقات بیشتر توسط سازمان های ذیربط جهت مدیریت پایدار اکوسیستم های
565 کشاورزی صورت پذیرد.