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USING THE FUZZY NETWORK ANALYSIS PROCESS TO PRIORITIZE THE FACTORS AFFECTING THE ENVIRONMENTAL PERFORMANCE INDEX FROM THE PERSPECTIVE OF FOOD INDUSTRY EXPERTS IN IRAN

Shahram eidizadeh[1], Hossein mohammadi[2], Mohammadreza kohansal[3]

[1]PhD Candidate of Agricultural Economics, Ferdowsi University of Mashhad, Mashhad, Iran.
[2]Associate Professor of Agricultural Economics, Ferdowsi University of Mashhad, Mashhad, Iran.
[3]Professor of Agricultural Economics, Ferdowsi University of Mashhad, Mashhad, Iran.

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ABSTRACT: Today, sustainability indicators are widely used as an effective tool to help decision makers and policy makers in making effective decisions. One of the important indicators of countries' development is their status in terms of environmental performance or environmental development. This index compares the situation of countries in terms of environment and emphasizes the two main goals of environmental protection, namely reducing environmental pressures on human health and improving the condition of ecosystems, as well as proper management of natural resources. Since sustainable economic development requires the proper use of natural and human resources and the preservation of the environment, therefore protecting the environment and preventing its degradation is one of the most important challenges in any society. In the process of economic growth and moving towards economic development, production and exports have increased and environmental degradation has increased in many countries. Therefore, it is important to pay attention to the fact that in the process of growth of production and exports, the environment is not seriously damaged and environmental performance indicators do not deteriorate. In the present study, an attempt has been made to prioritize environmental development indicators in the Iranian economy using the opinions of experts in the food industry section. The data collection tool was the questionnaire and the study population included exporters and producers of food products, executive experts related to export and production, academic experts and private sector organizations in food industry. Fuzzy network analysis method was used to prioritize the factors affecting environmental development indicators in the Iranian economy. According to the results, the effects of health, air quality, water quality and health status are the most important factors affecting the index of environmental pressures on human health and factors such as climate and energy, water resources and air pollution are the most important factors in the index of improving ecological status and natural resource management.

KEYWORDS*:* Environmental Development Indicators, Iranian Economy, Fuzzy Network Analysis Process, Prioritization, Food Industry

I. INTRODUCTION

Indicators are tools that provide complex and quantitative information to the public and decision makers in a quantifiable and understandable way. In other words, indicators show where we are, how we are moving and whether we are moving toward our projected goals (zamani& javaherian, 2015) The Environmental Performance Index emphasizes two main goals of environmental protection, including reducing environmental pressures on human beings and improving the status of ecosystems and the proper management of natural resources. These two components are measured by 24 indicators in 10 areas: "Impacts on health, air quality, water quality, water resources, agriculture, forestry, fisheries, biodiversity and habitats, climate and energy and air pollution". The following are the backgrounds and indicators of environmental performance.

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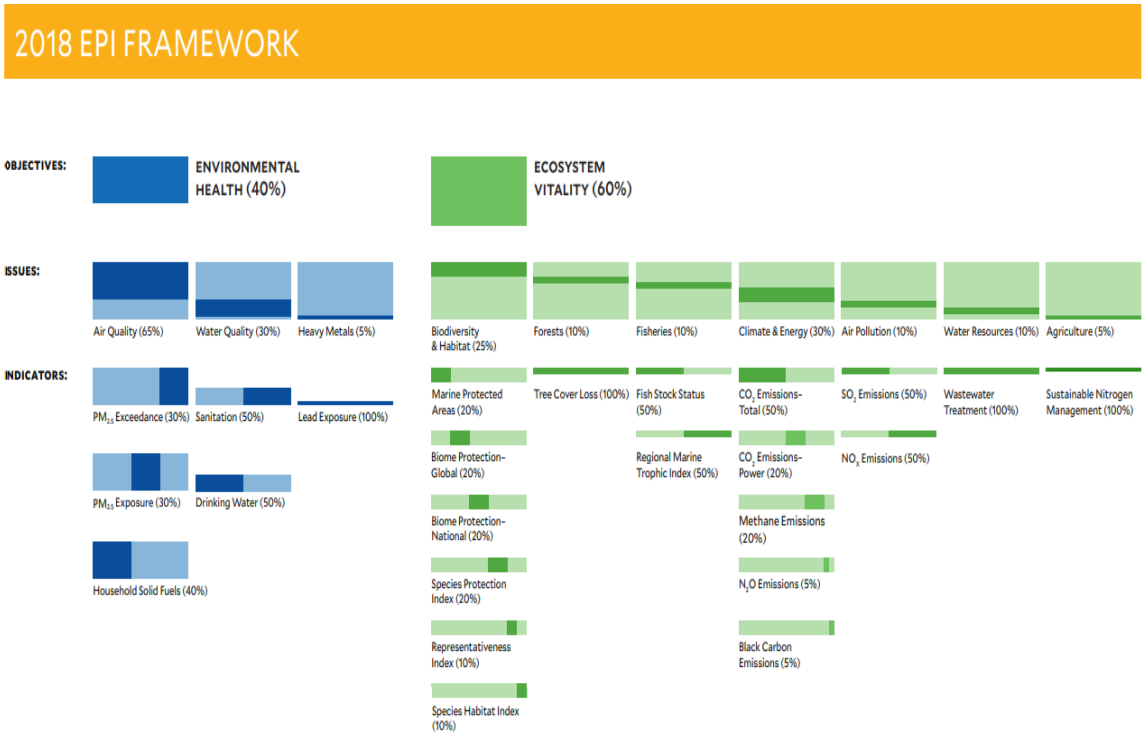

Figure 1: EPI FRAMEWORK-2018

The value of the environmental performance index ranges from zero to one hundred, which is 100 according to the target and zero is the worst case. In 2006, Iran ranked 53rd in the world environmental performance index, 67th in 2008, 60th in 2010 and 114th in 2012. Then, in 2014, it was ranked 51st out of 178 countries. In its 2016 report on environmental performance, it dropped from 66 to a ranking of 105 out of 180 countries. According to the latest report released in 2018, Iran ranked 58th out of the 180 countries studied in the Environmental Performance Index, ranking it among the countries with relatively poor performance in the environment. Switzerland, France and Denmark are ranked first to third in the environmental performance index, according to the report.

In the last few years in Iran, expanding the use of water, soil and natural resources and increasing industrial production and consequently increasing exports of agricultural products and industries, worsening the environmental situation and worsening its related crises and trends. Air pollution has been increasing in the capital and other industrial cities. Some researchers have examined the impact of export and the opening up of the economy and its impact on environmental degradation, including: Jafari Samimi and Gholami (2013), in their study of the effect of globalization of economy on environmental sustainability and comparison of developing and developed countries, compared this issue during the period 2005-2011 using panel data method. The results show that the globalization of the economy has a significant and negative effect on the environmental sustainability of developing and developed countries. Baek and et al(2009) also explored the dynamic relationship between trade, income, and the environment in developed and developing countries, and showed that growth in trade and income increases the environmental quality of developed countries while having adverse effects on It has environmental quality in developing countries. Managi and et al(2009) also showed that the effects of trade openness on the environment have a devastating effect on the environment of OECD countries. Gumilang and et al(2011) showed that trade liberalization has marginal effects on Indonesia's environment. In their study, Aghali and et al (2010) concluded that there is a positive relationship between the degree of openness of the economy and environmental damage in the long and short term. In their study, Sadeghi and Feshari (2010) showed that there is a long-run equilibrium relationship between export variables and environmental quality indices and export and foreign direct investment variables have a significant negative impact on environmental quality indices. Other scholars such as Antle and Heidebrink(1995), Wheeler (2001), Frenkel & Rose (2002), Vaughan (2003), Baylis and Cole (2005), etc. The impact of economic openness and trade and exports on environmental impacts Have expressed. Therefore, it is important to examine and prioritize the views of producers and exporters of products on environmental performance indicators.

In a study conducted by the Deputy of Research for Infrastructure and Production Affairs of the Parliament of Iran Research Center (2017) titled Iran's Position in Environmental Performance Index (EPI) and Comparison with Some Top Ranked Countries; Iran was evaluated during 2006-2016 and comparisons were made between Iran and countries in the region and countries with favorable environmental performance indicators. The results

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show that among the countries surveyed in the Middle East, Saudi Arabia and Turkey show a better environmental performance than Iran. Also, one of the reasons for the low performance of Iran's environmental performance index is the lack of prioritization of environmental issues in the country.
Summing up the studies, we find that no study has so far prioritized environmental performance indicators from the export point of view, so in this study we prioritize environmental performance indicators from the perspective of food industry producers and exporters. The fuzzy network analysis approach will be used to determine the best performance and successful policy models using the results of the research on specific environmental problems and priorities and policy makers to solve this problem.

II. MATERIALS AND METHODS:

The method used in this research is applied-developmental and in terms of (descriptive-correlation). In addition, the required data collection method was used in compiling research literature, library and questionnaire. The target population of this study includes experts in the field of exporting food products to the country. Experts of this research, considering the subject of research and the aims of university professors and growth centers, expert experts of organizations such as industry, mining and commerce, agricultural jihad, economics and finance, customs, etc., private sector organizations, They are exporters and economic activists. In the present study, a questionnaire was prepared to prioritize environmental performance indicators in Iranian economy. The questionnaire consisted of 2 sections of general and specific questions. The general information section of the questionnaire includes the subjects' subjects such as gender, age, level of education and the second part of the questions related to the specific questions regarding indexing priority.
Descriptive and inferential statistics were used for data analysis. Descriptive statistics techniques in the form of central indices and inferential statistics techniques were used to judge the data obtained from the sample group based on probability theory. For this reason, in this research, using the fuzzy network analysis (ANP) process, environmental performance indicators are prioritized in the Iranian economy and finally, the most important priorities will be identified, which will be discussed below.

2.1. Fuzzy Network Analysis Process (ANP)

One of the most widely used methods in multi-criteria decision making is the process of network analysis. This is the expanded AHP method. In the network analysis process, interactions, dependencies, whether internal (within a cluster) or externally (between indices), are clearly present between elements and clusters as well as options and criteria. Elements of one cluster may affect each other or elements of another cluster.
To solve a problem in this way, a network of goals, criteria, sub-criteria, options and relationships between them must first be identified and mapped. In the next step, all pairwise comparisons are performed and analyzed. Then, in order to prioritize these features, pairwise comparisons are carried out in a super-matrix (Saaty, 2013).

This process can be divided into three stages to facilitate understanding of how ANP works.

2.2. Step One: Paired Comparisons and Estimates of Relative Weight:

All criteria and clusters compared are compared before pairwise comparisons. Here are three types of connection. One way, two way and loop connection. If there is only one unidirectional connection between the two clusters, there is only one dependency, and this is shown by a straight line. If there is a two-way dependency between the clusters is displayed with two-way arrows. Loop attachment indicates inter-cluster dependence. Pairwise comparisons are made on a scale of 1 to 9. The numbers 1,3,5,7,9 represent equal importance, relatively significant, stronger significance, much stronger significance and extremely significant respectively, and numbers 2,4,6,8 for the intervals between these values used .

Table 1: Scale of Verbal Variables with Triangular Fuzzy Numbers

Triangular fuzzy numbers	Linguistic variables
(1,1,1)	**Equal importance**
(23,4)	**Relatively important**
(4,5,6)	**Important**
(6,7,8)	**Very important**
(8,9,10)	**Extremely important**

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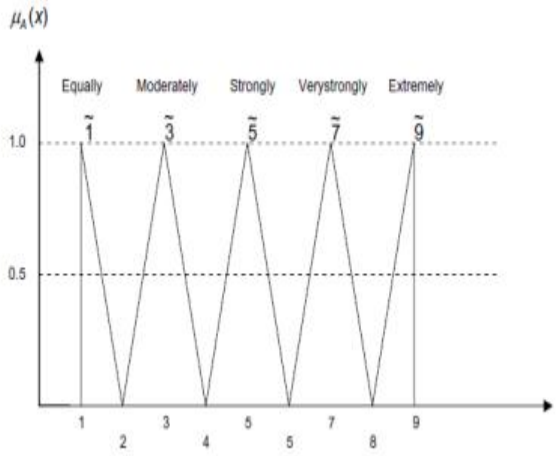

Figure 2: Scale of Verbal Variables with Triangular Fuzzy Numbers

The value of aij in the pairwise comparisons matrix indicates the relative importance of the j-element element to the i-column element. The inverse value of 1 / aij is used when j is more important than element I. If there are n elements to compare with each other, matrix A is defined as follows (Zarei and Khademi Zare, 2009).

$$A = \begin{bmatrix} w_1/w_1 & w_1/w_2 & \dots & w_1/w_n \\ w_2/w_1 & w_2/w_2 & \dots & w_2/w_n \\ \vdots & \vdots & & \vdots \\ w_n/w_1 & w_n/w_2 & \dots & w_n/w_n \end{bmatrix} = \begin{bmatrix} 1 & a_{12} & \dots & a_{1n} \\ 1/a_{12} & 1 & \dots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ 1/a_{1n} & 1/a_{2n} & \dots & 1 \end{bmatrix}$$

All relationships between clusters and between cluster elements are evaluated by the pairwise comparisons matrix, and after completing the pairwise comparisons matrix, a special vector (AW) is calculated as an estimate of the relative value of the elements.

$$AW = \lambda_{max}$$

λ(max) is the largest value of the pairwise comparisons matrix.

Step Two: Forming the Primary Super Matrix Weighting Super Matrix

Initially, all weight vectors are normalized to form the initial weight vectors. Then, to determine the final weight, the initial weight vectors enter the super matrix. The super matrix (w) is a hierarchical representation of the three levels shown below.

$$W = \begin{array}{c} \\ Goal(G) \\ Criteria(C) \\ Alternatives(A) \end{array} \begin{array}{c} \begin{array}{ccc} G & C & A \end{array} \\ \begin{pmatrix} 0 & 0 & 0 \\ W_{21} & 0 & 0 \\ 0 & W_{32} & I \end{pmatrix} \end{array} \qquad W = \begin{pmatrix} 0 & 0 & 0 \\ W_{21} & W_{22} & 0 \\ 0 & W_{32} & I \end{pmatrix}$$

W21: Vector represents target effect on benchmark, W32: Vector denotes benchmark effect on each option, I: Single matrix. If the criteria are interrelated, the W22 will be non-zero.
Any value of zero in a super matrix can be replaced by a matrix if there is an internal connection between the elements within a cluster, or between two clusters.

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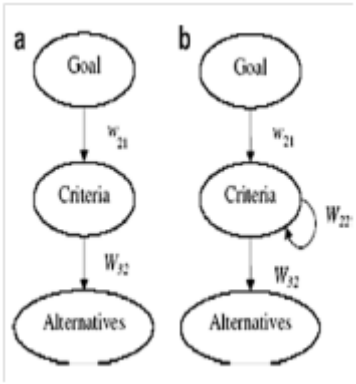

Figure 3: Hierarchical process and network analysis process

Step Three: Forming a Super Limit Matrix

Since W is a random weight matrix, all relationships between elements are made by w. To converge weights, we enable the super-matrix, which results in the creation of a super-matrix.
Fuzzy sets: In classical theory, a number of objects, persons, or phenomena that have a common property are called sets. The members of this set have a membership degree in set A and other real numbers have a membership degree of zero, this view belongs to classical set theory. .
The fuzzy set A of the reference set U is shown in the following order pairs

$$\tilde{A} = \{(X, \mu\tilde{A}(x))|X \in U\}$$

In the above relation x are certain elements or elements of the classical set A that have the characteristic of this set to some extent.

Fuzzy Network Analysis Process:

In the presented methodology, the fuzzy network analysis process is used to rank environmental performance indicators. This method is used for situations where there are many internal and external dependencies between cluster elements or between clusters themselves. Take it. In this method, the matrix is made by pairwise comparisons between criteria and sub-criteria at each level, and the values of each component of the matrices are converted to triangular fuzzy numbers. Pairwise comparisons are made on a scale of 1 to 9. The numbers 1,3,5,7,9 represent, respectively, equal importance, relatively significant, stronger significance, much stronger significance and extremely significant, and numbers 2,4,6,8 for intervals between values. And the pairwise comparisons matrix is formed using triangular fuzzy numbers (L mu).
A triangular fuzzy matrix m × n is shown below.

$$\tilde{A} = \begin{pmatrix} (a_{11}^l, a_{11}^m, a_{11}^u) & (a_{12}^l, a_{12}^m, a_{12}^u) & \cdots & (a_{1n}^l, a_{1n}^m, a_{1n}^u) \\ (a_{21}^l, a_{21}^m, a_{21}^u) & (a_{22}^l, a_{22}^m, a_{22}^u) & \cdots & (a_{2n}^l, a_{2n}^m, a_{2n}^u) \\ \vdots & \vdots & \vdots & \vdots \\ (a_{m1}^l, a_{m1}^m, a_{m1}^u) & (a_{m2}^l, a_{m2}^m, a_{m2}^u) & \cdots & (a_{mn}^l, a_{mn}^m, a_{mn}^u) \end{pmatrix}$$

The a_{mn} element is a comparison of the criterion m with the criterion n. If A˘ is a matrix of triangular fuzzy pair comparisons, it follows all the principles of fuzzy numbers, and then A: is:

$$\tilde{A} = \begin{pmatrix} (1,1,1) & (a_{11}^l, a_{11}^m, a_{11}^u) & \cdots & (a_{1n}^l, a_{1n}^m, a_{1n}^u) \\ \left(\frac{1}{a_{11}^u}, \frac{1}{a_{11}^m}, \frac{1}{a_{11}^l}\right) & (1,1,1) & \cdots & (a_{2n}^l, a_{2n}^m, a_{2n}^u) \\ \vdots & \vdots & \vdots & \vdots \\ \left(\frac{1}{a_{1n}^u}, \frac{1}{a_{1n}^m}, \frac{1}{a_{1n}^l}\right) & \left(\frac{1}{a_{2n}^l}, \frac{1}{a_{2n}^m}, \frac{1}{a_{2n}^u}\right) & \cdots & (1,1,1) \end{pmatrix}$$

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There are various methods for estimating the fuzzy W 1_i priority

$$\tilde{w}_i = (w_i^l, w_i^m, w_i^u), i = 1, 2, \ldots, n$$

One of these methods is the logarithmic least squares method (Chen, Hwang: 1992), which is a good and effective method for this research. This procedure involves the following steps.

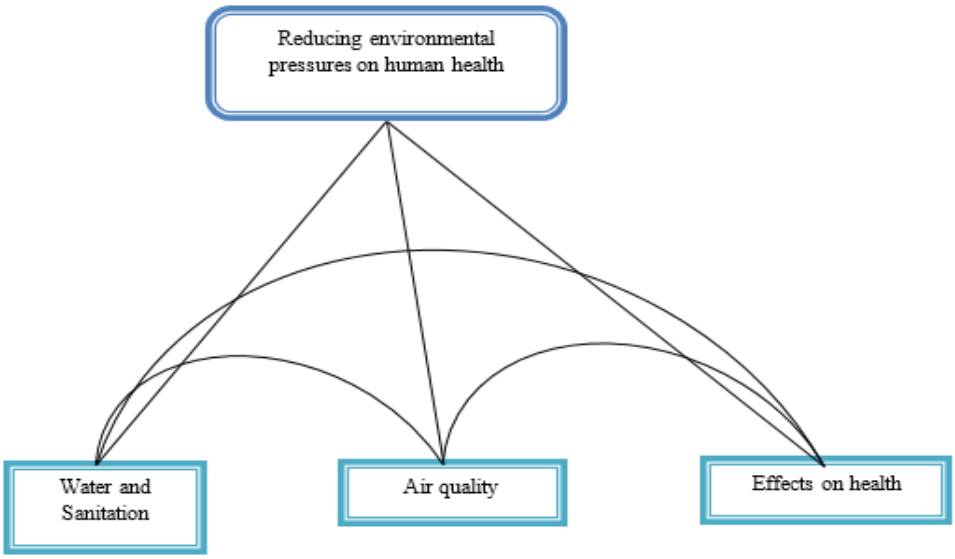
$$\tilde{w}_k = (w_k^l, w_k^m, w_k^u) \quad k = 1,2,3,\ldots,n,$$

$$w_k^s = \frac{\left(\prod_{j=1}^{n} a_{kj}^s\right)^{1/n}}{\sum_{i=1}^{n}\left(\prod_{j=1}^{n} a_{ij}^m\right)^{1/n}}, \quad s \in \{l, m, u\}.$$

III. DISCUSSION AND FINDINGS

After describing the fuzzy network analysis model, environmental performance indicators will be prioritized in the Iranian economy. To this end, experts were asked to determine the extent of their impact on environmental performance indicators. The following table shows how effective these factors are.

Prioritizing environmental stress reduction indicators on human health



In this section, according to the above figure, the paired comparative table is done and we are trying to calculate the weight of each component of the reduction of environmental pressures on human health.

Table 2: Mean paired comparisons of indices of environmental pressures on human health - Matrix w21

w_{21}	Effects on health	Water and Sanitation	Air quality
Air quality	(0.79,1,1.26)	(0.44,0.59,0.79)	(1,1,1)
Water and Sanitation	(0.25,0.33,0.5)	(1,1,1)	(1.26,1.71,2.29)
Effects on health	(1,1,1)	(0.35,0.41,0.5)	(0.79,1,1.26)

Table 3: W22 Matrix Indicators for Reducing Environmental Stress on Human Health

W_{22}	Effects on health	Water and Sanitation	Air quality
Air quality	(0.45,0.5,0.56)	(0.22,0.23,0.32)	(0,0,0)
Water and Sanitation	(0.45,0.5,0.56)	(0,0,0)	(0.21,0.25,0.31)
Effects on health	(0,0,0)	(0.65,0.77,0.88)	(0.61,0.75,0.87)

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Table 4: Wi matrix of indicators of environmental pressures on human health

Wi	Effects on health	Water and Sanitation	Air quality
Air quality	(0.41,0.58,0.87)	(0.41,0.51,0.77)	(0.71,0.89,1.30)
Water and Sanitation	(0.57,0.75,1.01)	0.27,0.39,0.60()	(0.62,0.75,0.95)
Effects on health	(0.77,1.01,1.30)	(0.86,1.07,1.31)	(1.30,2.07,3.09)

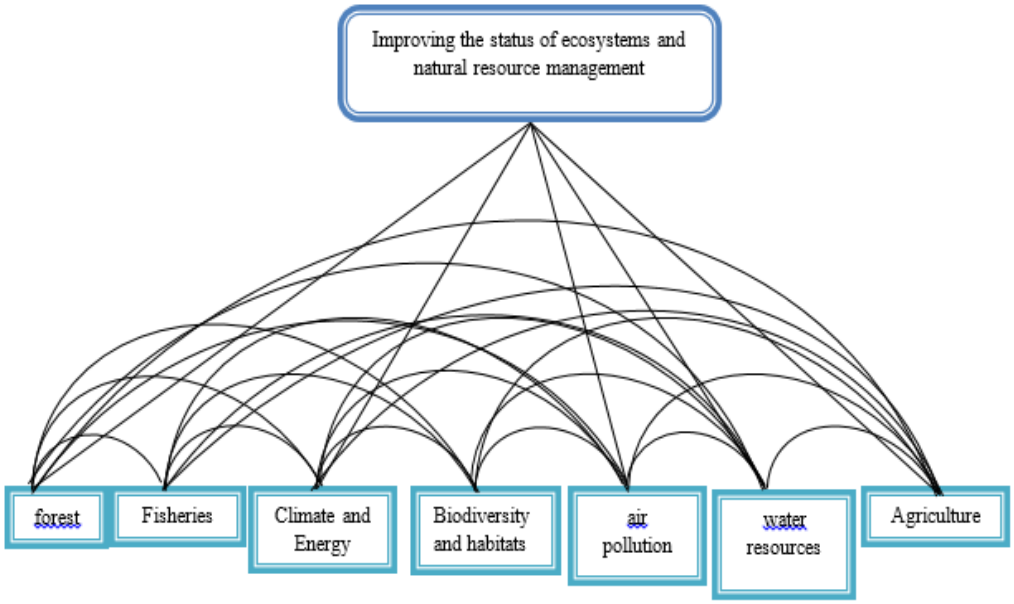
Table 5: Fuzzy weight of each of the indicators of environmental pressure reduction on human health

Factors	Fuzzy weight	Weight	Rank
Air quality	(0.19,0.25,0.37)	0.26	**2**
Water and Sanitation	(0.18,0.24,0.33)	0.22	**3**
Effects on health	(0.37,0.51,0.68)	0.52	**1**

Prioritize indicators of ecosystem conservation and natural resource management

In this section, following the paired comparison table below, we attempt to calculate the weight of each component of biomass improvement and natural resource management.

Table 6: Mean paired comparisons of the components to the target - matrix w21



w_{21}	Fisheries	Agriculture	Biodiversity and habitats	forest	Climate Energy	and water resources	air pollution
air pollution	(5.24,6.56,7.27)	(3.18,4.22,5.24)	(2,2.47,2.88)	(2.52,3.56,4.58)	(1.26,1.44,1.59)	(1.59,2.08,52)	(1,1,1)
water resources	(3.63,4.72,5.77)	(2.52,3.56,4.58)	(1.26,1.44,1.59)	(2.52,3.56,4.58)	(0.5,0.69,1)	(1,1,1)	(0.40,0.48,1)
Climate and Energy	(4.58,5.74,6.84)	(3.18,4.22,5.24)	(1.26,1.44,1.59)	(3.18,4.22,5.24)	(1,1,1)	(2,3,4)	(0.63,0.69,0.79)
forest	(1,1.44,2)	(1,1,1)	(0.38,0.49,0.63)	(1,1,1)	(0.19,0.24,0.32)	(0.22,0.28,0.40)	(0.22,0.28,0.40)
Biodiversity and habitats	(2.29,2.76,3.18)	(2,2.47,2.88)	(1,1,1)	(3.18,4.22,5.24)	(0.63,0.69,0.79)	(0.63,0.69,0.79)	(0.37,0.41,0.5)
Agriculture	(1.26,1.44,1.59)	(1,1,1)	(0.37,0.41,0.5)	(1,1,1)	(0.19,0.24,0.32)	(0.22,0.28,0.40)	(0.19,0.24,0.32)
Fisheries	(1,1,1)	(0.63,0.69,0.79)	(0.5,0.52,0.55)	(0.5,0.69,1)	(0.14,0.17,0.22)	(0.17,0.21,0.28)	(0.17,0.21,0.22)

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Table 7: W22 Matrix Indicator Components of Ecosystem Conservation and Natural Resource Management

W_{22}	Fisheries	Agriculture	Biodiversity and habitats	forest	Climate Energy	and water resources	air pollution
air pollution	(0.08,0.096,0.12)	(0.16,0.20,0.24)	(0.13,0.16,0.20)	(0.1,0.12,0.15)	(0.2,0.26,0.33)	(0.24,0.26,0.33)	(0,0,0)
water resources	(0.15,0.18,0.22)	(0.22,0.28,0.34)	(0.08,0.1,0.13)	(0.15,0.18,0.21)	(0.10,0.13,0.17)	(0,0,0)	(0.26,0.32,0.36)
Climate and Energy	(0.22,0.26,0.29)	(0.19,0.22,0.27)	(0.23,0.31,0.38)	(0.21,0.26,0.31)	(0,0,0)	(0.26,0.30,0.34)	(0.20,0.24,0.32)
forest	(0.08,0.10,0.12)	(0.06,0.07,0.09)	(0.21,0.27,0.34)	(0,0,0)	(0.04,0.05,0.07)	(0.04,0.05,0.06)	(0.04,0.06,0.07)
Biodiversity and habitats	(0.12,0.15,0.19)	(0.14,0.17,0.20)	(0,0,0)	(0.16,0.19,0.21)	) 0.02,0.26,0.3 (2	(0.11,0.13,0.16)	(0.09,0.11,0.16)
Agriculture	(0.18,0.21,0.25)	(0,0,0)	(0.07,0.09,0.11)	(0.14,0.18,0.22)	(0.20,0.24,0.29)	(0.47,0.18,0.21)	(0.13,0.17,0.22)
Fisheries	(0,0,0)	(0.02,0.06,0.07)	(0.05,0.06,0.07)	(0.06,0.07,0.09)	(0.04,0.05,0.06)	(0.04,0.05,0.06)	(0.09,0.11,0.14)

Table 8: Wi matrices of the components of ecosystem conservation and natural resource management

W_i	Fisheries	Agriculture	Biodiversity and habitats	forest	Climate Energy	and water resources	air pollution
air pollution	(2.50,3.80,5.49)	(1.83,2.87,4.20)	(0.87,1.20,1.62)	(2.02,3.26,4.56)	(0.51,0.72,1.04)	(0.77,1.19,1.79)	(0.37,0.51,0.84)
water resources	(2.63,4.01,5.39)	(1.83,2.92,4.42)	(0.98,1.39,1.90)	(1.83,3.05,4.58)	(0.51,0.75,1.11)	(0.78,1.81,1.76)	(0.41,0.56,0.92)
Climate and Energy	(3.66,5.22,7.73)	(2.52,3.92,5.64)	(1.25,1.79,2.41)	(2.35,3.76,5.51)	(0.73,1.02,1.38)	(1.16,1.91,2.87)	(0.57,0.78,1.16)
forest	(1.92,2.81,4.16	(1.31,2.05,3.18)	(0.64,0.85,1.18)	(1.28,2.08,3.19)	(0.41,0.53,0.72)	(0.67,1.17,1.87)	(0.29,0.37,0.55)
Biodiversity and habitats	(1.58,3.02,4.4.38)	(1.11,2.26,3.23)	(0.59,1.07,1.48)	(1.04,3.62,3.66)	(0.30,0.61,0.91)	(0.43,0.77,1.12)	(0.26,0.45,0.72)
Agriculture	(1.56,3.18,4.51)	(1.87,2.32,3.35)	(0.93,1.14,1.56)	(1.97,2.61,3.62)	(0.55,0.67,0.92)	(0.71,1.01,1.55)	(0.44,0.50,0.69)
Fisheries	(1.29,1.30,1.48)	(0.62,0.76,1.11)	(0.45,0.50,0.60)	(0.76,0.85,1.22)	(0.11,0.18,0.26)	(0.28,0.32,0.5)	(0.17,0.15,0.24)

Table 9: Fuzzy weight of each of the components of ecosystem conservation and natural resource management index

Factors	Fuzzy Weight	Weight	Rank
air pollution	(0.11,0.16,0.23)	0.17	**3**
water resources	(0.11,0.18,0.24)	0.18	**2**
Climate and Energy	(0.15,0.23,0.32)	0.23	**1**
forest	(0.08,0.12,0.18)	0.09	**6**
Biodiversity and habitats	(0.06,0.13,0.19)	0.13	**5**
Agriculture	(0.1,0.15,0.2)	0.15	**4**
Fisheries	(0.05,0.04,0.06)	0.05	**7**

The results of the fuzzy network analysis show that among the indicators of environmental pressure reduction on human health, the factors affecting health, air quality and water and sanitation rank first and third, respectively. Also among the indicators of indicators of improvement of ecosystem status and management of natural resources, climate and energy factors, water resources and air pollution according to experts' view are ranked first to third indicators and then other components are considered.

III. CONCLUSION:

A set of environmental issues prompted the World Economic Forum to work together with the Yale University Environmental Law and Policy Center and Columbia University's International Geosciences Information Center to provide benchmarks for countries' comparative environmental studies. This will provide both the status and the environmental score of the specific countries and the conditions needed to achieve the sustainable development goals. The Environmental Performance Index provides a method for assessing the effectiveness of environmental policies against related performance goals. In order to compare the indices, each of them is measured from 0 to 100, and is based on measurements related to two main objectives, namely: reducing environmental stress on human health and protecting the environment. Ecosystems and Natural Resources Management. Since numerous studies have proved the impact of trade and export on the environment of countries, therefore, the aim of the present study is to prioritize environmental performance indicators in Iranian economy in the context of fuzzy network analysis process from the perspective of exporting food products. is. For this purpose, after reviewing internal and external studies on the research topic, the research method was described and finally fuzzy network analysis was used to rank the components. The results show that according to the viewpoints of experts and economic activists, among the indicators of environmental pressure reduction on human health, the factors affecting health, air quality and water and health are ranked first to third, respectively. they take. Also among the indicators of indicators of improvement of ecosystem status and management of natural resources, climate and energy factors, water resources and air pollution according to experts' view are ranked first to third indicators and then other components are considered.

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