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Identification and Analysis of Development Components in the Medicinal Plant Cultivation System by DEMATEL Method, Iran

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Abstract – **Due to the importance of development of the medicinal plants cultivation system in economic development and thus the need to review the existing situation of this system through an examination of its development components, the main goal of the article is identification and analysis of these elements and separation of components into cause group and effect group in order to better understand the network of relationships between the selected elements. To achieve this goal, after detecting the development components of medicinal plants cultivation, 30 experts judged about the degree of impact of these elements on each other based on a Likert scale. Then the data were analyzed by DEMATEL method. The results showed that components such as communications, investigating the status of soil, checking the quality of irrigation water, product direct selling, supply source of seeds and seedlings and land consolidation were placed into the cause group as push factors. Also other components such as job creation, crop yield, diversity of cultivated crops, use of technology, product processing, economic efficiency of the farm, healthy crop production, use of non-chemical inputs and land management were placed into the effect group.**

Keywords – **Medicinal Plants, Iran, Development, Component, DEMATEL Method.**

I. INTRODUCTION

The global trend to consume medicinal plants increases the demand for medicinal and aromatic plants in the industry each year. The volume of global trade of medicinal plants from 60 billion dollars in 1996 rose to $ 100 billion in 2010. Also according to the World Bank, this trade is expected to grow to 5 trillion by the year 2050 [1]. The use of this opportunity leads to a significant positive effect on the development of Iran's national economy because Iran's economy relies on oil revenues now and the oil-based economy is unstable.

There are 11 known climate from 13 climate of the world in Iran. Also having 300 sunny days per year and existence 40 to 50 ° C temperature difference between the coldest and warmest part of the country, has provided suitable ecological conditions for Iran [2] and has set this country as the most talented in the world for the production of medicinal plants [3]. There are 8,000 species of medicinal plants in Iran now and more than 1,800 species of them are endemic which are considered as an exclusive capacity [1]. Unfortunately, despite mentioned potential, Iran does not have proper standing in the field of production and international trade of these products[4].In the field of medicinal plants cultivation, the area under cultivation has fallen from 46,005 hectares in 2007 to 41,605 hectares in 2013 [5]. Also about world trade of medicinal plants, Iran's share is less than %2[4].

To get the desired place, it is necessary to develop the cultivation system of medicinal plants for achieving the goals such as increasing the amount and quality of medicinal plant production, increasing the producer welfare, supply of the high quality raw materials for processing and promotion of the country's standing in international markets.

For the purpose of development of the medicinal plants cultivation system, it is essential that a comprehensive regional program is designed. The first step in the planning process for a phenomenon is recognizing the present situation for it[6]-[7]. To investigate the current status of medicinal plants cultivation system development level, it is necessary to identify the components of the development of this system and define the relationships between them [8]-[9]. Thus, according to the above-mentioned, the goals of this study are presented in the following:

1. Identification of development components in the medicinal plant cultivation system which can be obtained from literature review.
2. Analysis of the relationships and influences between these components by DEMATEL method.

To identify the components of the system, identifying the concepts, definitions and goals of the system is the inevitable necessity [10]. According to the definition given in the Oxford English Dictionary, meaning of the word “component” is a part or element of a larger whole that is used to achieve the objectives of the system.

Therefore in the study, development components in the medicinal plant cultivation system include all elements that must be considered to achieve development goals. The goals of development of medicinal plants cultivation system are as follows:

1.Increasing the community health [11]-[12].
2.Increasing the health and welfare of producers [13]-[14].
3.Reducing rural poverty [15]-[16]-[17]-[18]-[19].
4.Helping the development of other sectors such as industry and services [20]-[21]-[22].
5.Helping the country's independence [12]-[16]-[17].
6.Improving the productivity of production factors [12]-[23].
7.Conservation of the production basic resources such as water and soil [12]-[23]-[24].

8. Helping the environment improvement [12]-[16]-[25].

For reaching the goal of community health, it is necessary to consider such items as increasing the amount and diversity of production of medicinal plants for providing the community physical access to different species of these plants and using the technology for reducing the production costs and increasing the people's economic access to these products [1].

For achieving the goal of health and welfare of producers, it is important to consider such items as increasing producers' income [11] through rising the quantity and quality of production as well as selling of products directly.

For accessing the goal of rural poverty reduction, it is essential to consider the creation of the non-agricultural businesses [22] such as processing of medicinal plants for production of dried products, distillates, essential oils and other herbal products.

For achieving the goal of helping the development of other economic sectors, it is necessary to consider such items as increasing the production of raw materials needed for the medicinal plant industry, rising demand of medicinal plants producers for industrial inputs and rising demand for storage, transport, and distribution services [14].

For achieving the goal of helping the country's independence, it is necessary to consider such items as increasing the share of domestic production of medicinal plants in the supply of national requirements and rising exports of these products [12].

For reaching the goal of helping the environment improvement it is essential to consider the cultivation of medicinal plants in the low fertility land for improving environmental conditions through raising the amount of oxygen, reduction of carbon dioxide, and increasing the attractiveness of natural landscape [26].

For accessing the goal of conservation of the production basic resources, it is important to consider such items as decreasing the use of chemical fertilizers and pesticides, increasing the use of organic inputs and fallowing the part of the land [27].

Finally For reaching the goal of improving the productivity of production factors, it is necessary to consider such items as: the use of mechanization and new technologies, investigating the status of soil, checking the quality of irrigation water and the use of high quality seeds and seedlings [28].

So based on the above-mentioned items, development components in the medicinal plant cultivation system are presented in Table 1.

Table 1. Development components in the medicinal plant cultivation system

Symbol	Components
A1	Communication with important sectors such as research centers, processing companies and consumers of medicinal plants
A2	Diversity of cultivated medicinal plants
A3	Yield of cultivated medicinal plants
A4	Creation of the non-agricultural businesses such as processing of medicinal plants
A5	Supply of seeds and seedlings through specialized medicinal plants centers
A6	Investigating the status of soil
A7	Checking the quality of irrigation water
A8	The use of non-chemical fertilizers and pesticides
A9	Healthy or organic crop production
A10	Protection of the land consolidation
A11	Land management including such things as: fallowing the part of the land, cultivation in the low fertility land and dry farming of medicinal plants
A12	Using the technology
A13	Job creation
A14	Product direct selling
A15	The economic efficiency of the farm

II. Material and Methods

The present study is quantitative-qualitative in terms of its nature and non – experimental in terms of the degree of the variables and practical in terms of its goals. Also it was conducted in two phases. In the first phase, development components in the medicinal plant cultivation system were identified using the literature review and experts opinion. The results included 15 components are listed in Table 1. In the second phase these components were judged in terms of impact on each other by a panel which consisted of the 30 experts and professors of Tehran University and research centers of medicinal plants. Experts in the study were interviewed by using a questionnaire which was the main tool for data collection. Finally the relations structure of the components was determined by decision-making trial and evaluation laboratory (DEMATEL) method.

The Battelle Memorial Institute conducted the DEMATEL method project through its Geneva Research Centre [29]. The original DEMATEL was aimed at the fragmented and antagonistic phenomena of world societies and searched for integrated solutions. In recent years, the DEMATEL method has become very popular in Japan, because it is especially pragmatic to visualize the structure of complicated causal relationships with digraphs [30]. A tangible product of a DEMATEL exercise is a structural model appearing as a “causal diagram” which may divide components into cause group and effect group.

In particular, DEMATEL is able not only to demonstrate directed relationships of subsystems, but also to clarify the degree of interactions between subsystems [31].

The Implementation Process of DEMATEL Method:

Implementation of DEMATEL method involves five steps which are described below:

1. Formation of the initial direct-relation matrix Z using Acquiring and aggregating the assessments of professional panel by the Likert scale from 0 to 4(*0* = No influence, 1 = very Low influence, 2 = Low influence, 3 = High influence, 4 = very high influence). Average of the assessments about development components in the medicinal plant cultivation system was shown in Table 2, in which Z_{ij} is denoted as the degree to which the criterion i affects the criterion j.

2. Formation of the normalized direct-relation matrix X through "(1)" and "(2)", in which X is denoted as normalized matrix and Z is denoted as initial direct-relation matrix [32]. The normalized direct-relation matrix about development components in the medicinal plant cultivation system was presented in Table 3

$$X = s.Z \tag{1}$$

$$s = \frac{1}{\max \sum_{j=1}^{n} Z_{ij}} \tag{2}$$

3. Formation of the total-relation matrix T by using "(3)", in which I is denoted as the identity matrix [33]. The total-relation matrix about development components in the medicinal plant cultivation system was presented in Table 4.

$$T = X\left(I - X\right)^{-1} \tag{3}$$

4. Calculating the vectors of d and r. The sum of rows and the sum of columns are separately denoted as vector d and vector r within the total-relation matrix T. Values of d and r related to the total-relation matrix T, was shown in Table 4.

5. Acquiring a causal diagram by mapping the dataset of $(r_i + d_i, r_i - d_i)$, where the horizontal axis $(r_i + d_i)$ is made by adding d_i to r_i and the vertical axis $(r_i - d_i)$ is made by subtracting d_i from r_i [34]. The values of the calculations were summarized in Table 5. Also the casual diagram obtained from this calculation, was exhibited in Fig. 1

Table 2. The initial direct-relation matrix **Z** for development components in the medicinal plant cultivation system

	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15
A1	0	2.5	1.5	2	2.5	2	1	2	2.5	0	3	2	0	2	2
A2	0	0	0	3	0	0	0	0	0	0	0	0	0	0	3
A3	0	0	0	1	0	0	0	0	0	0	0	2	3	1	3
A4	1	1	0	0	0	0	0	0	0	0	1	0	3	1	0
A5	2	1.5	3	0	0	0	0	0	0	0	1.5	0	0	0	2.5
A6	2	2.5	3	0	0	0	1.5	2	2.5	0	3	0	0	0	2
A7	0	2.5	2.5	0	0	0	0	0	1	0	3	2	0	0	0
A8	0	0	3	0	0	0	0	0	3	0	0	0	0	0	1
A9	0	0	2	0	0	1	0	3	0	0	0	0	0	2	2
A10	0	0	0	0	0	0	0	0	0	0	1	4	0	0	0
A11	0	1.6	2	0	0	0	0	0	2	1	0	0	0	0	3
A12	2	0	1.5	0	0	0	0	0	0	0	0	0	3	0	1
A13	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0
A14	2.5	2	0	1.5	2	1	0	0	1	0	0	0	0	0	4
A15	1	2	1	2.5	2.5	2.5	0	1	1	0	0	2.5	1	1.5	0

Table 3. The normalized direct-relation matrix ***X*** for development components in the medicinal plant cultivation system

	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15
A1	0	0.1	0.06	0.08	0.1	0.08	0.04	0.08	0.1	0	0.12	0.08	0	0.08	0.08
A2	0	0	0	0.12	0	0	0	0	0	0	0	0	0	0	0.12
A3	0	0	0	0.04	0	0	0	0	0	0	0	0.08	0.12	0.04	0.12
A4	0.04	0.04	0	0	0	0	0	0	0	0	0.04	0	0.12	0.04	0
A5	0.08	0.06	0.12	0	0	0	0	0	0	0	0.06	0	0	0	0.1
A6	0.08	0.1	0.12	0	0	0	0.06	0.08	0.1	0	0.12	0	0	0	0.08
A7	0	0.1	0.1	0	0	0	0	0	0.04	0	0.12	0.08	0	0	0
A8	0	0	0.12	0	0	0	0	0	0.12	0	0	0	0	0	0.04
A9	0	0	0.08	0	0	0.04	0	0.12	0	0	0	0	0	0.08	0.08
A10	0	0	0	0	0	0	0	0	0	0	0.04	0.16	0	0	0
A11	0	0.06	0.08	0	0	0	0	0	0.08	0.04	0	0	0	0	0.12
A12	0.08	0	0.06	0	0	0	0	0	0	0	0	0	0.12	0	0.04
A13	0	0	0	0	0	0	0	0	0	0	0	0.08	0	0	0
A14	0.1	0.08	0	0.06	0.08	0.04	0	0	0.04	0	0	0	0	0	0.16
A15	0.04	0.08	0.04	0.1	0.1	0.1	0	0.04	0.04	0	0	0.1	0.04	0.06	0

Table 4. The total-relation matrix ***T*** for development components in the medicinal plant cultivation system

	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	r
A1	0.06	0.17	0.15	0.14	0.14	0.12	0.05	0.12	0.16	0.01	0.16	0.13	0.06	0.12	0.21	1.79
A2	0.02	0.02	0.01	0.14	0.02	0.02	0.00	0.01	0.01	0.00	0.01	0.02	0.03	0.02	0.13	0.45
A3	0.03	0.03	0.02	0.06	0.02	0.02	0.00	0.01	0.01	0.00	0.01	0.11	0.15	0.06	0.15	0.68
A4	0.05	0.06	0.01	0.02	0.01	0.01	0.00	0.01	0.01	0.00	0.05	0.02	0.13	0.05	0.03	0.46
A5	0.10	0.10	0.15	0.04	0.03	0.03	0.01	0.02	0.03	0.00	0.08	0.04	0.03	0.03	0.16	0.85
A6	0.10	0.15	0.19	0.05	0.03	0.03	0.07	0.12	0.15	0.01	0.15	0.05	0.04	0.04	0.18	1.36
A7	0.01	0.12	0.13	0.03	0.01	0.01	0.00	0.01	0.06	0.00	0.12	0.10	0.03	0.02	0.06	0.71
A8	0.01	0.01	0.14	0.02	0.01	0.01	0.00	0.02	0.13	0.00	0.00	0.02	0.02	0.02	0.08	0.51
A9	0.03	0.03	0.12	0.03	0.02	0.06	0.00	0.14	0.04	0.00	0.01	0.03	0.03	0.10	0.13	0.77
A10	0.02	0.01	0.02	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.04	0.17	0.02	0.00	0.02	0.32
A11	0.02	0.09	0.11	0.03	0.02	0.02	0.00	0.02	0.09	0.04	0.01	0.03	0.03	0.02	0.16	0.70
A12	0.09	0.02	0.08	0.02	0.02	0.02	0.00	0.01	0.02	0.00	0.02	0.03	0.14	0.02	0.07	0.55
A13	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.01	0.00	0.01	0.12
A14	0.14	0.14	0.06	0.12	0.12	0.08	0.01	0.04	0.08	0.00	0.04	0.04	0.04	0.04	0.23	1.17
A15	0.09	0.13	0.11	0.14	0.13	0.12	0.01	0.07	0.08	0.00	0.04	0.13	0.09	0.09	0.09	1.32
d	0.76	1.07	1.31	0.85	0.58	0.55	0.16	0.60	0.88	0.07	0.75	1.01	0.85	0.62	1.71	

Table 5. The hierarchy of development components in the medicinal plant cultivation system in terms of degree of effect

Components	(r)Values	Components	(d)Values	Components	(r + d) Values	Components	(r- d) Values
A1	1.79	A15	1.71	A15	3.04	A1	1.03
A6	1.36	A3	1.31	A1	2.55	A6	0.81
A15	1.32	A2	1.07	A3	1.99	A7	0.55
A14	1.17	A12	1.01	A6	1.91	A14	0.54
A5	0.85	A9	0.88	A14	1.79	A5	0.27
A9	0.77	A4	0.85	A9	1.65	A10	0.25
A7	0.71	A13	0.84	A12	1.56	A11	-0.05
A11	0.70	A1	0.76	A2	1.53	A8	-0.09
A3	0.68	A11	0.75	A11	1.45	A9	-0.11
A12	0.55	A14	0.62	A5	1.42	A15	-0.39
A8	0.51	A8	0.60	A4	1.31	A4	-0.39
A4	0.46	A5	0.58	A8	1.11	A12	-0.46
A2	0.45	A6	0.55	A13	0.97	A2	-0.62
A10	0.32	A7	0.16	A7	0.88	A3	-0.63
A13	0.12	A10	0.07	A10	0.39	A13	-0.72

III. Results and Discussions

The listed values in the column (r) of Table 5 show the impact of components on each other. So the component A1 (communication with important sectors) with having 15% of the total effect, had the highest effect on other components and the component A13 (job creation) with having 1% of the total effect, had the lowest effect on other components. As a general resulting, 5 components (communication with important sectors , investigating the status of soil, the economic efficiency of the farm, product direct selling and supply of seeds and seedlings through specialized medicinal plants centers) with having 55% of the total amount of influence had the highest impact on other factors.

The listed values in the column (d) of Table 5 show the impressionability of components from each other. So the component A15 (the economic efficiency of the farm) with having 14.5% of the total impressionability, had the highest permeability from other components and the component A10 (land consolidation) with having 0.6% of the total impressionability, had the lowest permeability from other components. As a general resulting, six components (the economic efficiency of the farm, yield of cultivated medicinal plants, diversity of cultivated medicinal plants, using the technology, healthy or organic crop production and processing of medicinal plants) with having 58% of the total amount of impressionability had the highest permeability from other factors.

The listed values in the column (r + d) of Table 5 show the sum of effectiveness and impressionability of components. So the component A15 (the economic efficiency of the farm) with having 12.9% of this sum, gained the highest rating. Also the component A10 (land consolidation) with having 1.6% of the sum, gained the lowest rating among other elements.

The listed values in the column (r - d) of Table 5 determine the final position of the components in the causal diagram presented in Fig. 1. The positive values in this column establish the cause group and the negative values create effect group. So six components (A1, A6, A7, A14, A5, A10) were placed in to cause group and nine components (A13, A3, A2, A12, A4, A15, A9, A8, A11) were placed in to effect group (Fig. 1 and Table 6).

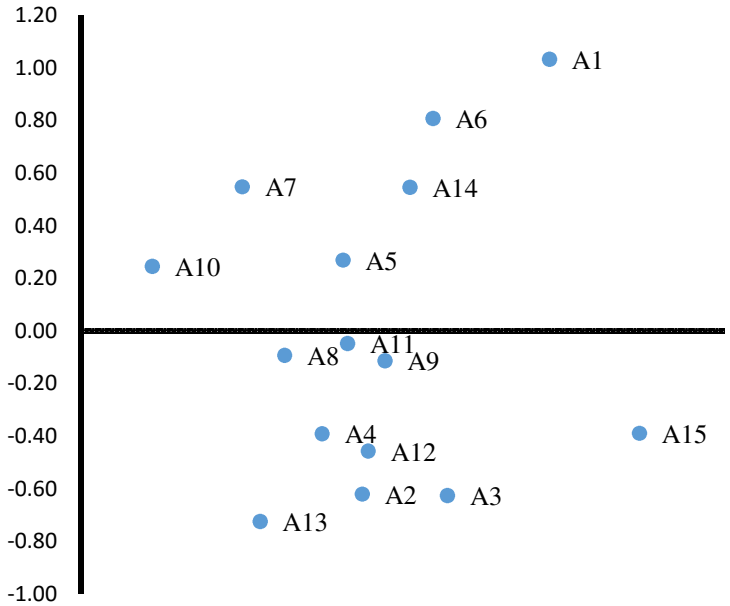

Fig. 1. The causal diagram of development components in the medicinal plant cultivation system

Table 6. Development components in the cause and effect group.

Components in the cause group	Symbol	Components in the effect group	Symbol
Communication with important sectors	A1	Job creation	A13
Investigating the status of soil	A6	Yield of cultivated medicinal plants	A3
Checking the quality of irrigation water	A7	Diversity of cultivated medicinal plants	A2
Product direct selling	A14	Using the technology	A12
Supply of seeds and seedlings through specialized medicinal plants centers	A5	Processing of medicinal plants	A4
Land consolidation	A10	The economic efficiency of the farm	A15
		Healthy or organic crop production	A9
		The use of non-chemical fertilizers and pesticides	A8
		Land management	A11

As a final result obtained of DEMATEL method, drawing the network of relationships between groups is very important. For achieving this goal, only the values of effectiveness presented in Table 4 were used and the values of impressionability were ignored (Fig.2). According to Fig. 2, job creation is affected by communications with the impact value = 0.06. Yield of cultivated medicinal plants is affected by five factors (communications, investigating the status of soil, checking the quality of irrigation water, supply of seeds and seedlings through specialized medicinal plants centers and product direct selling) and the strongest effect was related to investigating the status of soil with the impact value= 0.19. Also diversity of cultivated medicinal plants is affected by five above-mentioned factors and the strongest effect was related to communications with the impact value = 0.17. Using the technology is affected by 3 elements (communications, checking the quality of irrigation water and land consolidation) and the highest effect was related to land consolidation with the impact value = 0.17. Processing of products is affected by 3 elements (communications, investigating the status of soil and product direct selling) and the highest effect was related to communications with the impact value= 0.14. The economic efficiency of the farm received the greatest effect from product direct selling with the impact value= 0.23. Healthy or organic crop production received the strongest effect from communications with the impact value= 0.16. The use of non-chemical inputs received equal impact from both communications and investigating the status of soil with the impact value= 0.12. Finally Land management is affected by four factors (communications, investigating the status of soil, checking the quality of irrigation water and supply of seeds and seedlings through specialized medicinal plants centers) and the strongest effect was related to communications with the impact value = 0.16.

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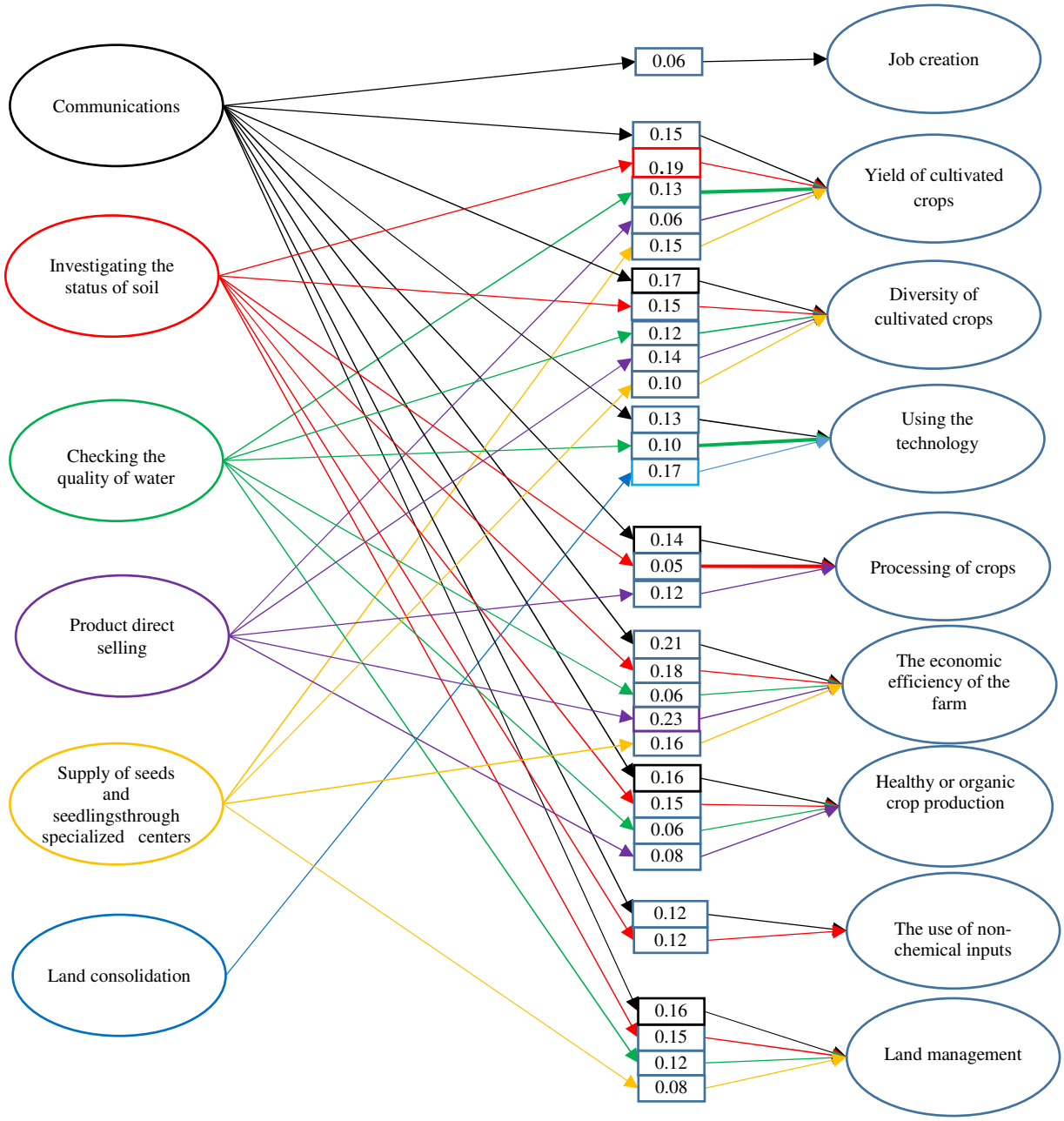

Fig. 2. The network of relationships between cause and effect group with impact values

IV. Conclusion

Component of communications, had the greatest effect on other elements. Also (r + d) index in this component was at the highest level after the economic efficiency of the farm. Although mentioned component was also influenced by other elements (j = 6.5%), it showed its dominant functional aspect as an effective element. This means that improving or weakening the situation of communication component causes the important effects on the status of other elements. Also improving the situation for five other penetrating components are listed in the cause group in the Table (6), can play a critical role in development of the medicinal plant cultivation system. Furthermore improving the situation for components are listed in the effect group in the Table (6) can cause the positive effects in development of the medicinal plant cultivation system, but in the condition of resources scarcity, paying attention to components in the cause group creates greater comparative advantage than components in the effect group.

Component of the economic efficiency of the farm was at the highest level in term of the sum of effectiveness and impressionability (r + d = 12.9%). The mentioned component was identified as the most important element. This means that economic efficiency of the farm both was influenced by other factors and affected on the same

factors. So weakening the status of this component causes instability in the present situation for other elements.

The network analysis of relationships between components showed that yield of cultivated medicinal plants was affected by five factors and the strongest effect was related to investigating the status of soil. Using the technology received the highest effect from land consolidation component. The economic efficiency of the farm received the greatest impact from product direct selling. The use of non-chemical inputs received equal impacts from both communications and investigating the status of soil. Other components such as job creation, diversity of cultivated crops, processing of crops, healthy or organic crop production and land management received the highest effect from communications component. As a result, it's very important to reinforce the most effective elements for development of medicinal plant cultivation system. So it's clear that fortifying connections between producers of medicinal plants and other sectors such as research centers, processing companies and consumers of medicinal plants is very necessary and critical for development of the cultivation system.

Finally, with regard to the separation of elements into cause group and effect group, it is suggested using this classification in Iran's regional planning for assessing the present situation of medicinal plants cultivation systems. Also it is necessary to consider the components in the cause group as development stimulants in medicinal plant cultivation system. Furthermore, it is necessary to consider the components in the effect group as determinative elements of development level of medicinal plant cultivation system.

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