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FORMULATION AND IDENTIFICATION OF SUSTAINABILITY INDICATORS AGRICULTURAL EXPLOITATION SYSTEMS THROUGH ANALYTICAL HIERARCHICAL PROCESS (AHP)

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ABSTRACT
Goal of current descriptive research is explaining the sustainability indicators of agricultural exploitation systems in the Mazandaran province. Study instrument is questionnaire that is based on the analytic hierarchy process technique. It was confirmed by experts. The statistical population comprised of all professionals and experts working in the field of sustainability aspects and farming systems with a deep understanding and sufficient information on the issue being selected through purposive and snowball sampling summing up to 15 subjects. The results of the analysis of data show that criteria of ecological, policy and social respectively were the highest priority. Also, the results of the explaining the sustainability indicators of agricultural exploitation systems in the province indicated that applying indicator of integrated and biological projects was identified as the most important indicator. Systematic use of basic resources, maintaining biodiversity, use of biological inputs, less use of chemical toxins, prevent fragmentation of lands, marketing and sales of products, farmers responsibility and affordable of production as important indicators identified for sustainability of crop farming systems in the Mazandaran province that were ranked respectively in next rank. Therefore, it can be concluded that mentioned indicators are as basic indicators for sustainability of agricultural exploitation systems.

KEY WORDS: Sustainable Agriculture Indicators, agricultural exploitation systems, Analytical Hierarchy Process.

INTRODUCTION

Previous studies in the history of agricultural development in Iran indicated the fact that the role of exploitation system in the agricultural development is of paramount importance. The exploitation system is always considered as one of the fundamental issues of Iran's agriculture in utilizing water and soil resources that have seriously been considered after the implementation of land reform. The issue is important because of the smallness and dispersion of agricultural land in some cases for applying agricultural techniques, equipping infrastructure, applying machinery, and efficient use of resources with appropriate yields created restrictions that agricultural decision makers have always been looking forward to finding ways against them (Daneshvar Khaki et al. 2000). Modern man have threatened basic and essential resources of water, soil, plant, and weather for the sake of his/her own life and for supplying basic needs he/she provided him/herself undesirable conditions. If modern societies do not reform their trend, they will face many crises (Hashemidaran 2001). Accumulation of these issues and numerous problems like soil reduced fertility, the incidence environmental problems due to the use of chemical material, exhaustion of non-renewable resources like oil and resources of phosphates' rocks, water pollution with the use of chemical inputs in agriculture, human health is endangered as a result of a direct contact of the field workers with chemical toxins, and problem of the residue of the toxin in agricultural product, substitution of small and familial farms with large farms causing self–employment, and lack of social and commercial infrastructure in rural communities that are the result of conventional agricultural system contributed to the introduction of sustainable agriculture (Allahyari 2008). Sustainable agriculture is a multidimensional concept defined by many researchers. MacRae et al. (2011) considered sustainable agriculture as a philosophy and a system of farming and stated that sustainable agriculture has roots in values that indicate a new awareness of ecological and social realities, and human capabilities in doing agricultural operations efficiently and productively. Sustainable agriculture requires the designing and management of the ways in which natural processes are being exploited in order to protect all resources, to improve the self-reliance and self-regulation of the domestic cultivators, to decrease the waste production and minimizes the adverse consequences of environment and At the same time maintain or improve the productivity and utility of agro ecosystem. Many researchers have described sustainable agriculture based on the removal and reduction of off-farm inputs (minimum dependence on chemical fertilizers and

pesticides) or based on alternative operation (application of organic fertilizer, crop rotation, minimum plugging) (Mahmoudi et al. 2008).

Achieving the development of sustainable agriculture regardless of the status of indicators of sustainable agriculture will have harmful and irreparable impacts on the community. By evaluating the indicators of sustainability, on the one hand, to take action toward setting realistic plans and on the other hand think of a basis for the impact of the agricultural extension plans. Although different countries have formulated indicators for sustainable agriculture in the national and provincial levels, no particular action in this regard has been taken in Iran. This is due to the unawareness about the status of sustainable agriculture and low amount of research in the field of indicators of sustainability (Poursaeed 2010). Accordingly, the current research intends to collect proper information peculiar to the indicators of sustainability in the agricultural exploitation systems in Mazandaran Province through investigating different resources.

Mohammadianfar *et al.* (2013) in a research, examined the sustainability of wheat ecological system, through stepwise regression and indicated that the most important determinant factors of sustainability indicators of this agricultural system, wheat yield, wheat cultivation area, agricultural income, availability of inputs, availability of loans, variety of chemical pesticides, diversity of crop species, and accessibility to experts and advocates. Investigation of the critical points of the system showed that training of farmers, reforming the management of crop production, water resources management, stabilizing farmers' economic instability have priority in order to improve its sustainability. Bayat and Khatoonabadi (2012) considered the evaluation of some aspects of economic and ecological agricultural cooperatives, and indicated that forming cooperatives contributes to the increase in the level of exploitation of members from mechanized equipment, increases in members' product yield, farm water efficiency, and reduces water erosion of soil in members' field. Also the result showed that the average consumption of nitrogen and phosphate fertilizer reduced but has not been impressive. Abbasizadeh-Qanavati *et* al. (2012) in a research with the title of analysis of stability of family exploitation systems indicated that family exploitation system is economically and environmentally unsustainable and socially semi-sustainable. Interest, reliance, organic manure fertilizer, nitrate fertilizers, frequent superficial plugging are the most important predictors of economic, social, and ecological aspects. Enayatirad et al. (2009) maintain that the explanation of sustainability activities among corn farmers showed that most farmers use crop rotation and micronutrient fertilizers to fertilize their farms. The use of green manures, animal manure, the use of legumes in alternation with corn and the application of integrated approaches to fight against weeds were inadequate. In addition, the result showed that the variables of age, number of children, the amount of pesticide used, type of farmers ownership have a negative and meaningful relationship with the act of sustainability operation. Multivariable regression analysis showed that the rate of pesticides used, contact rate of extension centers, rate of animal manure used, and corn yield rate explained 28% of the activities of stability changes. Karami (1997) examined the relationship between socio-economic structures and stable technical and agricultural knowledge among wheat farmers with using indicators such as the average wheat yield per unit area, observance of crop rotation, putting plants of cereal species in rotation, the use of organic and animal manures, the use of green manures, the use of plant residues or sometimes planting wheat, the trend of change in water and soil resources (soil fertility) over time. The use of conservation plough, the amount of chemical pesticides consumed per hectare in wheat farm during planting and protection, the amount of nitrogen and phosphate fertilizers used per ton of wheat production indicated that extension education services (EES), technical knowledge, application of technology, the amount of arable land, support services of service centers have a direct effect on the sustainability of farming systems.

Asadi *et al.* (2013) measured structural analysis of the factors affecting the sustainability of agriculture, and indicated that ecological, social, and economical sustainability have a positive effect on agricultural sustainability but ecological sustainability is more effective on agricultural sustainability compared with social and economic sustainability. Moumenihelali et al. (2013) investigated that, took action towards prioritizing ecological sustainability criteria and the most important criteria were respectively as follows: less consumption of chemical pesticides and chemical fertilizers per hectare, more use of biological fighting and bio-fertilizers, and conservation of water, and less frequent use of the plow and groove. Rezaei-Moghaddam and Karami (2008) in their research used a multiple criteria evaluation of sustainable agricultural development models using AHP, and showed that ecological criteria means rational use of resources, environmental protection, and the quality of product are the most important criteria for Iran's sustainable agriculture. Kallas et al. (2012) using AHP indicated that in economic sector the important objective is maximizing

total farm income in pursuit of improving the quality of rice. Farmers tend to use a minimum of chemical fertilizers to reduce costs and protect the environment.

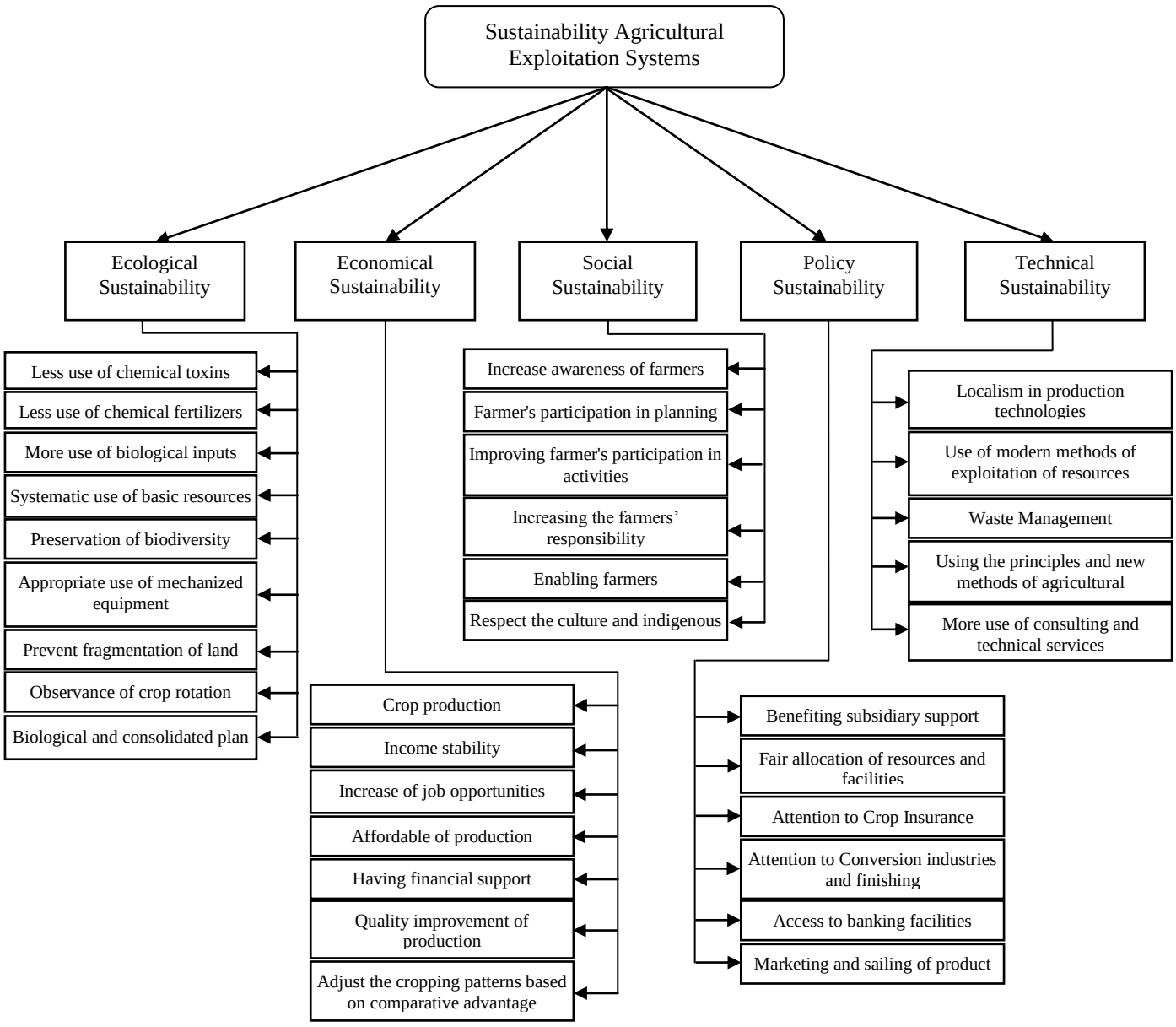

Figure 1: The conceptual model

Lopez et al. (2008) in their study of systematic comparative evaluation have used the efficiency of alternative multi-functional system of olive in Spain in AHP frame work for identifying the most suitable system of agriculture to extend olive in Spain through AHP as well. In this study, the four social, economical, technical and environmental criteria were identified that each of them has sub-criteria as follows: Economical criterion involves income, stability of income over time, independence from institutional subsidies, no foreign dependencies, business, sales situation. The technical criterion includes: profitability, predictability, quality, and sanitary work conditions of farmers. Social criterion

includes: Direct and indirect local employment, social justice in rural areas capable of competitiveness with local socio-cultural values, and hobby. Environmental criterion includes: less soil erosion, soil fertility, use of irrigation water, less water pollution, less atmospheric pollution, diversified environment. Poursaeed et al. (2010) in their research using participatory model of sustainable development of agriculture based on multi-criteria decision making in Iran, indicated that Reducing farmers' migration, employing agricultural engineer, land combination, increasing the awareness of farmers, crop rotation, using small amount of chemical fertilizer and pesticides, fertilizer recommendations, efficient allocation, which are significant criteria for sustainable agriculture in Iran.

Reviewing the related literature and collecting data through interviewing different experts in a firm conclusion dimensions and indicators of sustainable agricultural exploitation systems are introduced in Figure 1 according to the method applied in this study. Based on the importance of identifying indicators of sustainable agricultural exploitation systems, this study with the general goal of explanation of indicators of sustainable agricultural exploitation systems is in the design and implementation stage.

MATERIALS AND METHODS

The current study is a kind of descriptive and applied research and was conducted in 2014 in Mazandaran Province, Iran. The technique of analytical hierarchy process (AHP) was applied to show the objective of the study. Analytical hierarchy process is a mutli-criteria decision making method. This technique was based on the paired comparison and makes it possible for managers to check the different scenarios. In this method, the researcher tries to consider the most experts' comments from the most important units involved rather than using the quantity of decision makers. Analytical hierarchy process feature is welcomed by various users and administrators due to its simplicity and at the same time generality and has always been considered by academic circles. In order to solve a problem through AHP, the problem must be first identified with its details carefully and then sketches the structure of hierarchy of it. After devising a hierarchical problem, the relative importance of the various factors should be determined. The evaluation of these factors can be formed by decision makers or problem designers. It means these people discuss their opinions in relation to a criterion and its impact on each option. Then, these opinions are scored and will be ranked. After a number of stages, combined comments and the desirability of each of the available options will be estimated mathematically, and the option that has the highest number will be chosen as the best option (Qodsipour 2012). This study was conducted in four stages according to the goals of the research:

Studies conducted in the field of this study were analyzed and investigated in the first stage. After identifying indicators of sustainable agricultural exploitation systems, the indicators were set in five criteria of sustainability. In the second stage, a questionnaire was designed based on studies related to prior publications to compare the indicators of each criterion with the criteria of the research goal in pairs through the use of collected data.

The third stage involves selecting the desired sample. The random selection of individuals must be avoided in AHP (Mohammadian et al. 2009), because the subjects of the study must have a deep understanding of the issue under study. Therefore, through nonrandom sampling (purposely), all experts and specialists in the field of exploitation system giving enough information about topics in sustainability were considered. One of the techniques used is nonrandom sampling is purposive or judgmental sampling. This method is based on the assumption that the knowledge of the researcher about community for identifying the panel member is useful. In case that the researcher him/herself does not know the qualified people, s/he can apply snowball sampling, which is another kind of nonrandom sampling. In this method the researcher starts to identify individual or a group of conscious people and in this way reaches other proper individuals. This method is especially used when it is hard for the researcher to identify proper individuals. Therefore, in this study, 15 people were identified through nonrandom sampling and snowball sampling. Then, the questionnaires were distributed among them, and after filling the questionnaires out, they were all collected.

In the fourth stage, the data were analyzed in the software of Expert Choice version 11 in following stages.

1. First, the geometric mean was provided in order to be used in Expert Choice version 11.
2. In the second stage, a decision tree which suits the conceptual model of the study was designed in Expert Choice version 11 after extracting the suitable data. Then, data were inserted in the software. Each AHP tree involves three levels of purpose, criteria, and alternatives. The major question or the problem that is being solved in the research is called a purpose. The purpose is the highest level of the AHP tree and has just one parameter that its selection is the highest level of decision making in the project. The criteria are the touchstone of the purpose or its measurement. Criteria can be designed in this level horizontally according to

necessity to the required number. The criteria can be subdivided to sub-criteria, which can be divided to other sub-criteria. Alternatives are the destination of the purpose in the AHP tree and the answer to the purpose can be sought among alternatives. Alternative is the last level of AHP tree and is dependent on how to use AHP (Maghabl et al. 2014).

3. The third stage is devoted to the paired comparison of criteria and their prioritization regarding to the purpose and paired comparison of indicators and their prioritization regarding each criterion. For paired comparison in the software, first a questionnaire was designed for data collection. In the questionnaire, the numbers of questions were set based on the number of criteria and indicators. Answering each paired comparison will be done according to the material prior to itself through 9-fold range. This range involves the cardinal numbers from 1 to 9 and each number stands for the priority of criteria or indicators of comparison towards each other (table 1).

Table 1: Scale of Measurement for the AHP

Intensity of importance	Definition
1	Equal importance
3	Somewhat more important
5	Much more important
7	Very much more important
9	Absolutely more important.
2, 4, 6, 8	Intermediate values

4. In the fourth stage, the calculation of the incompatibility rate was done. The incompatibility rate is a mechanism through which the validity of the answers to the comparative matrices is evaluated. In AHP, the tolerable incompatibility rate is estimated less than 0.1 (Maghabl et al. 2014). The incompatibility rate in the Expert Choice is automatically calculated and displayed after the calculation of a group of paired comparison that if the result is less than 0.1, the comparison continues, and if this rate is higher than 0/1, it is identified the most incompatible comparison through software and can be improved.
5. In the fifth stage, a graphical diagram of the sensitivity analysis was investigated.The sensitivity analysis is used for evaluating the sensitivity of alternative against changing priority of criteria. To this end, the AHP benefits from five types of graphical sensitivity analysis. This five types includes sensitivity analysis of performance, dynamic, gradient, two-dimensional design, and differences (Qodsipour 2012)

To investigate the individual and professional characteristics of participants, the software of SPSS version 16 was used.

RESULTS

The individual and professional characteristics of participants

The average age of participants is 46/7 with the standard deviation of 3.63 that 13.3% of them were women and 86.7% men. 86.7% of the participants were experts from cooperative and 13.3% of the participants were the workers of Agricultural Jihad Organization. The average of years of experience of the participants in the field of exploitation systems with standard deviation 6.22 of is 16.47. 60% of the participants have BA degree, 33.3 of them have Masters' degree, and 6.7% of them have Associate Degree. 53.3% of them are graduates in the field of agriculture.

Table 2: The personal and professional characteristics of respondents

Variable	Age/ Year	Experience /Year	Gender	Educational level	Place of current service	Education field
Mean	46.7	16.47	Female: 13.3%	Associate Degree: 6.7%	Jihad-e-Agriculture: 13.3%	Agronomy: 53.3%; Plant Protection: 13.3%; economy: 6.7%; horticulture: 13.3%; Agricultural Extension and Education: 13.3%
Standard deviation	3.63	6.22				
Minimum	42	5	Male: 86.7%	BS: 60%		
Maximum	53	27		Masters: 33.3%	Cooperative Office: 86/7%	

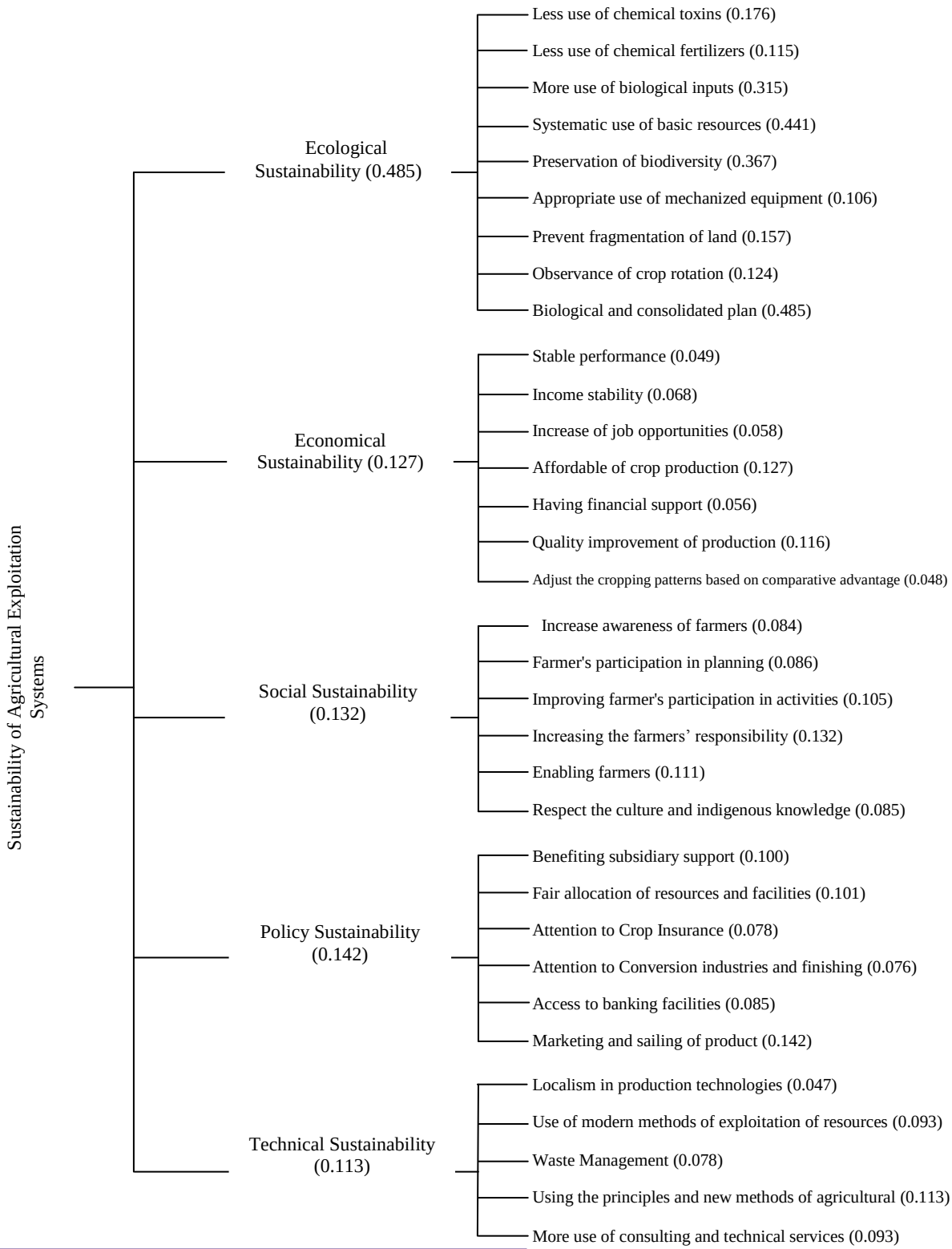

Figure 2: Ranking the criteria and indicators of agricultural exploitation systems sustainability

Ranking criteria of agricultural exploitation systems sustainability

In order to rank the criteria, five ecological, economic, social, policy, and technical criteria were compared two by two according to purpose of sustainable agricultural exploitation systems that in conclusion, the criteria of ecology with 0.485 has the highest rank. After that with great difference, the criteria of policy 0.142, social 0.132, economical 0.127, and technical 0.113 have ranks from two to five respectively (Figure 2).

Ranking the indicators of agricultural exploitation systems sustainability

In order to rank the indicators of sustainable agricultural exploitation systems based on each of the five criteria. The indicators of each criterion with regard to that criterion are compared in pairs. Accordingly, the ranking of each indicator is according to each criterion. For sustainability of ecology taking advantage of biological and consolidated plan with the average weight of (0.458), systematic use of basic resources with the average weight of (0.441), and preservation of biodiversity with the average weight of 0.367 have been ranked as the most significant indicators, respectively. The economic indicator of affordable of crop production with the average weight of 0.127, quality improvement of production with the average weight of 0.116, and income stability with the average weight of 0.068 have been identified as the most important of economic indicators, respectively. In social aspect increasing the farmers' responsibility with the average weight of 0.132, enabling farmers with the average weight of 0.111, improving farmer's participation in activities with the average weight of 0.105 have been given a rank from first to third, respectively. The indicators of marketing and sailing of product with the average weight of 0.142, fair allocation of resources and facilities with the average weight of 0.101, and benefiting subsidiary support with the average weight of 0.100 were given a rank from first to third respectively in policy sustainability criteria. Using the principles and new methods of agricultural for technical sustainability of agricultural exploitation systems with the average weight of 0.113 takes the highest rank of more use of consulting and technical services, and the use of modern methods of exploitation of resources received the other ranks (Figure 2).

DISCUSSION

The importance of identifying the sustainable indicators of agricultural exploitation systems was considered in the current research focused on formulation and identification of sustainable indicators of agricultural exploitation system.

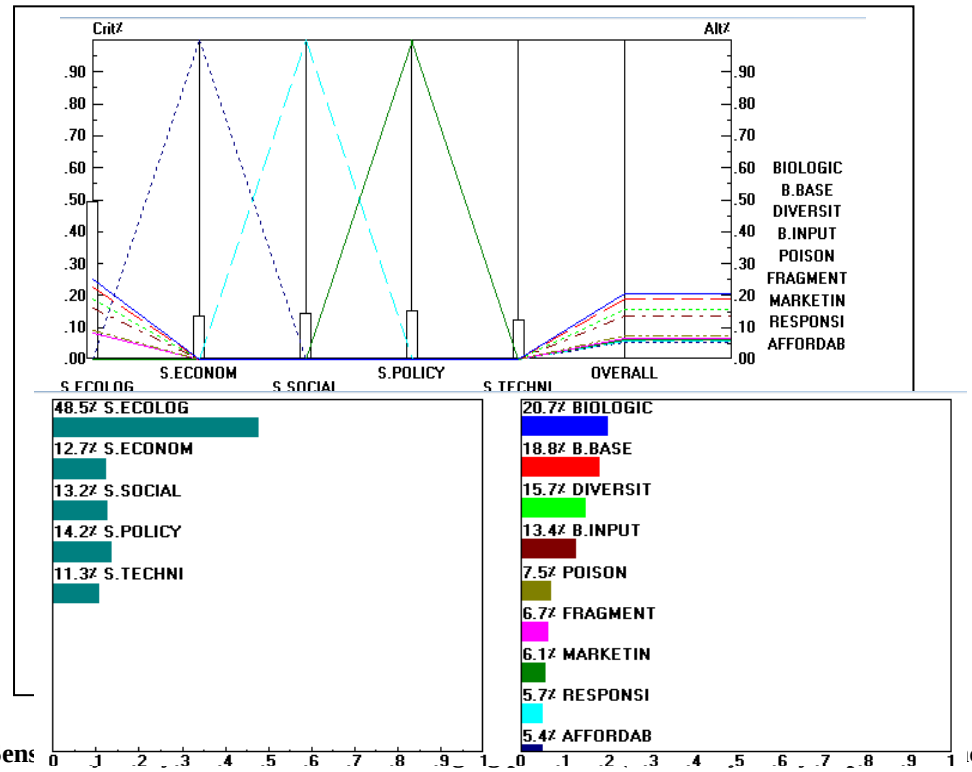

Figure 3: Sens ce and dynamic)

Therefore, the analysis of sensitivity (performance and dynamic) was applied in order to evaluate the sensitivity of alternatives against the changing priority of criteria as the important indicators of sustainability of agricultural exploitation systems. As Figure (3) illustrates, nine indicators of agricultural exploitation systems of Mazandaran province have been identified as the most important indicators in the collection of five criteria of ecological, economical, social, policy, and technical. Benefiting from indicators of biological and consolidated plan with the average weight of (20.7) is identified as the most important indicator in the agricultural exploitation systems in Mazandaran province. Enayatirad et al. (2009) indicated that consolidated methods is always emphasized as one of the major sustainability indicators. Systematic use of basic resources with the average weight of 18.8% (according to Mohammadianfar et al. 2013, Bayat and Khatoonabadi 2012, Moumenihelali et al. 2013, Rezaei-Moghaddam et al. 2008, Lopez et al. 2008), preservation of biodiversity with the average weight of 15.7% (according to Mohammadianfar et al. 2013, Lopez et al. 2008), use of biological inputs with the average weight of 13.4% (Mohammadianfar et al. 2013, Enayatirad et al. 2009, Moumenihelali et al. 2013, Abbasizadeh-Qanavati et al. 2012), less use of chemical fertilizers with the average weight of 7.5% (according to Bayat and Khatoonabadi 2012, Enayatirad et al. 2009, Moumenihelali et al. 2013, Poursaeed et al. 2010), preventing the fragmentation of land with the average weight of 6.7% (according to Poursaeed et al. 2010), marketing and sailing of product with the average weight of 6.1%, farmers' responsibility with the average weight of 5.7%, economical crop production with the average weight of 5.4% (according to Abbasizadeh-Qanavati et al. 2012, Kallas et al. 2012) were all identified as the important indicators of sustainable agricultural exploitation systems in Mazandaran province that took the other ranks respectively. Therefore, it can be concluded that the identified indicators are the major indicators for sustainable agricultural exploitation systems.

According to the results of the current study, it is suggested that the biological and consolidated plans in the framework of train-extension term of farm school should be designed and implemented (a few studies like Dinpanh and Alavi (2008), Osku et al. (2007), Dolly (2009), Mancini et al. (2007), Erbaugh et al. (2010) all indicate the effectiveness of the method of train-extension of school on farm about issues of sustainable agriculture). This should be done in order to train farmers how to use basic resources systematically, protect biodiversity, have a minimum use of chemical toxin in order to protect the environment from the damage, and give necessary training for economical production i.e. talking about fragmentation of land and benefits of consolidation of lands. In addition, it can be given necessary training to farmers how to introduce the produced product on the market in the form this training- extension course. Also, it is recommended to encourage the farmers to register as members in cooperatives of rural production in order to fulfill the identified indicators of sustainability agricultural exploitation systems because the purpose of cooperatives of rural production is to fulfill sustainability agriculture (Headquarters of rural cooperatives of Iran, office of exploitation systems, 2011). It should be considered that all these points will be fulfilled when the experts and those involved and explained well about the sustainability of agricultural activities and they all accept the current issue.

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