Developing location indicators of agricultural service center location problem using Delphi-TOPSIS-FAHP

Abstract

The main goal of this paper is to construct objectives and attributes of agricultural service centers (ASC) location problem. The main contribution of this paper is constructing these location indicators. Since there was no similar literature in this discipline, so a Delphi survey is applied to quantify expert's attitudes about location problem of ASC and construct location selection attributes and ASC objectives. A TOPSIS survey is done to rank extracted attributes to import in FAHP study. Results showed that farm machinery number, support availability, distance of ASC to the customer farms, crop rotation and the ratio of irrigated to arid farm area, and population and cultivated area are the most important attributes of ASC location problem. Then a Fuzzy-AHP technique applied to compute the weight of these most important attributes using four objectives, which obtained by Delphi technique too, including service quality, service cost, service speed, and ASC profit, which are the main scopes of agricultural service centers establishment policy. In the simplest form with this assumption that all objectives have the same priority, the results illustrated that the service quality, service cost, service speed and ASC profit are first to last important objectives, respectively. At the end of this paper, the multi choice goal programming method recommended to use when the priorities of objectives are not the same. Finally the weight of ASC location attributes computed to consider in ASC location problem.

Keywords: Agricultural Service Centers (ASC), Location, Objectives, Attribute, Service, FAHP.

1. Introduction

Energy, labor, input costs, markets conditions, crop yielding and prices, machinery service availability, pest and disease infection, environmental conditions, and even economic and political strategies change the agricultural productivity (Lak and Almasi 2011). Among these dynamic variables, providing agricultural services in right way can have a strategic role to improve the agricultural productivity. Several services can be given to the whole of agricultural supply chain. Some services are for farms, specifically. In following section four types of them including: input supply, mechanization services, advisory services and financial services which considered in this research are introduced.

1.1 Input supply service

Unfortunately after market liberalization, a majority of the farm input supply companies remains concentrated in urban areas or central rural zones. Due to these changes millions of poor farmers in rural areas do not have access to agricultural inputs on time and in right way such as improved seeds, chemical fertilizers which are needed to help them improve their productivity. So poor development and weak performance of rural agricultural input markets explain the current low productivity of small holder farmers (Dorward and Chirwa 2011).

1.2 Agricultural mechanization service

The manufacture, distribution, repair, maintenance, management and utilization of agricultural tools, implements and machines are covered under mechanization services (Lak and Almasi 2011). The important point in mechanization services is that how supply mechanization services to the farmer in an efficient and effective manner. If mechanization is implemented in the right way, it will have a considerable effect on agricultural productivity improvement (Lak and Almasi

2011). In many countries, agricultural mechanization has made a significant contribution to the agricultural and rural development. After applying farm mechanization levels of production have increased, soil and water conservation measures were constructed, the profitability of farming improved, the quality of rural life enhanced, and development in the industrial and service sectors was stimulated so mechanization services is highly required to be supplied in an effective way (Bishop 1997). (Inns 1995) mentioned that agricultural mechanization development depends on the farmers' satisfaction and capability to identify opportunities for achieving sustainable benefits by improved and/or increased use of power and machinery, selecting the most worthwhile opportunity and carrying it through to successful implementation. Lack of consideration to the necessity of development in mechanization of agricultural sector, insufficient cooperation between industrial and agricultural sector, unrealistic selection of goals and objectives and perhaps, more importantly miss use and poor management of resources could all be counted toward the considerable fall back in the agricultural sector (Bagheri and Moazzen 2009). (Sims and Kienzle 2009) have done three mechanization supply chain case studies in three countries. They presented five elements for mechanization supply chain (see Fig. 1).

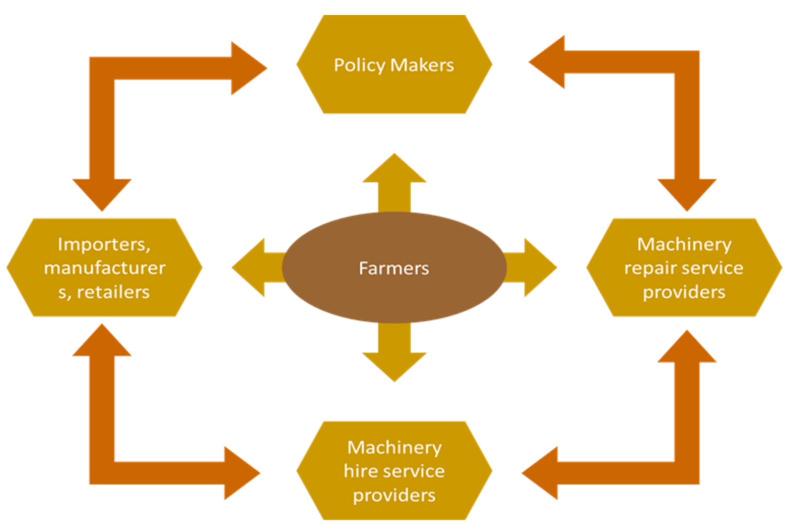

Fig. 1 Farm power and machinery supply chain stakeholders (Sims and Kienzle, 2009).

The role and activity of machinery hire service stakeholders should include following aspects: Coordination with other stakeholders; Business management; Quality control; Operator training; Maintenance and servicing; closely fallow farmers' needs (Sims and Kienzle 2009). The previous papers didn't consider to efficient manner of supplying and distributing the mechanization services for customers. In current research the strategy of providing mechanization services with all other agricultural services is considered. Therefore supplying high quality mechanization services in coordination with the needs of farms by agricultural service centers can lead to the improvement of productivity in whole supply chain of agricultural production.

1.3 Agricultural advisory service

Agricultural consulting services are known as activities that make new knowledge available to the agricultural producers and assist them to improve their farming and management skills. The services may include: Sharing the information, training and advice of farmers, testing new technologies on farms, developing farm management tools. The basic indicators for success of a demand-driven advisory service system in agriculture are: a) farmers have access to agricultural advisory services b) farmers use the advisory services c) advices lead to income's increase from the agricultural production and also d) competition among agricultural advisers (Chipeta 2006). Altogether the advisory is a critical need to the agricultural supply chain and the access to this service must be easy to encourage the farmers to use it. This can be obtained by locating service centers in accurate places. The demands from farmers in many cases are different. The advisory service demands which are formulated by various stakeholders of agricultural supply chain can be seen in Fig. 2.

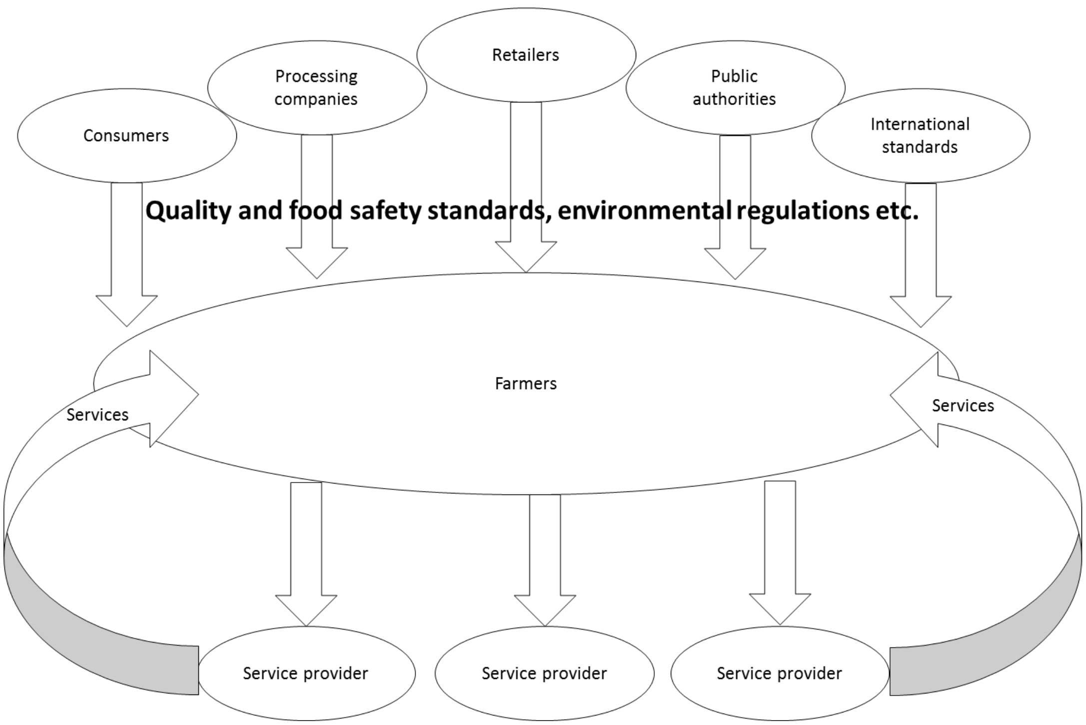

Fig. 2 Demands are formulated by various stakeholders (Chipeta 2006)

1.4 Financial service

Access to external financial resources in agriculture is constrained. This is due to low enterprise profitability in agriculture, accumulated debts, high inflation, risk and uncertainty and collateral problems (Johan et al. 1999). The limited access to financial resources may lead to several problems in agricultural production such as: disturb the time of farming operations (input supply, planting, trading and etc.), decrease the input quality and etc. So increasing the access to financial services including loan and insurance can improve the productivity in agriculture.

1.5 Location problem of agricultural service centers

Agriculture is the only major sector that uses the land surface as an essential input into its production function. This wide geographical dispersion of agricultural production has the important economic consequence; transportation becomes essential. Output must be transported for consumption by others and inputs; such as modern seeds, fertilizer, pesticides, or machinery, and all required agricultural services must be transported to the farm to raise output (Timmer et al. 1983). Therefore to success in providing and distributing agricultural services for improvement of productivity in this sector, the right location of such service centers should be selected. In this regard one of the initial steps to solve this location problem is finding related location objectives and attributes to use in MCDM (Multi-Criteria Decision Making) location models. In following section the MADM and MODM techniques is reviewed and appropriate decision making technique for agricultural service center location problem is selected.

1.6 MADM and MODM decision making techniques

There are various techniques for ranking alternatives. In many real-world problems, the decision maker likes to pursue more than one target or consider more than one factor or measure which called multi-objective decision making (MODM) problem and multi-attribute decision making (MADM) problem. There are many decision making problems that their information is spatial and known as location decisions problems. Facility location is a branch of operations research related to locating or positioning at least a new facility among several existing in order to optimize at least one objective function (Farahani et al. 2010).

There are many techniques which are used to solve the MADM problems. The most popular ones are as follows: lexicographic, permutation method, simple additive weighting (SAW), elimination and choice expressing reality (ELECTRE), technique for order preference by similarity to ideal solution) (TOPSIS), linear programming techniques for multidimensional analysis of preference (LINMAP), interactive SAW method and MDS with the ideal point (Hwang and Yoon 1981a).

Also there are many techniques which are used for the MODM problems. The most popular ones are as follows: metric LP methods, bounded objective method, lexicographic method, goal programming (GP), goal attainment method, method of Zionts–Wallenius, the methods as step method (STEM) and related method, sequential multi-objective problem solving (SEMOPS) and sequential information generator for multi-objective problems (SIGMOP) method, goal programming STEM (GPSTEM), C-constraint method and adaptive search method (Zionts (1979); Hwang and Masud (1979); Szidarovszky et al. (1986); Ulungu and Teghem (1994)).

The Analytic Hierarchy Process (AHP) is widely used by authors to solve MADM problems. García et al. (2014) generated a multi-criteria and multi-attribute assessment model that allows selecting the ideal location for warehouses for perishable agricultural products. In another paper Akıncı et al. (2013) determined suitable lands for agricultural use in Turkey by AHP. As García et al. (2014) newly reviewed the literatures, no papers has been seen which focused on agricultural service center location problem. A good paper on implementation of Fuzzy AHP and Delphi method in MADM problems is Cho and Lee (2013). They identified four decision areas and further prioritized the sixteen factors under a hierarchy model structured by fuzzy AHP (analytic hierarchy process) approach.

Location and the number of ASCs in each region is a key parameter to ensure the success of agricultural servicing. So the main scope of this study is constructing indicators for location selection of agricultural service centers to improve the performance of agricultural supply chain viewpoint of productivity, quality and competitiveness. Secondly to give primary weight to the objectives and location attributes, Fuzzy-AHP method is used. Also specifying the final weight of location attributes using Goal Programming method is provided at last step of this study. In other words an integrated approach which combines MADM and MODM is developed. First to third phase belongs to MADM and fourth phase is a MODM problem. Also Goal Programming is used to generalize proposed approach and make it utilizable for different/future real world applications. The managers can use developed approach to import their ideal values of agricultural supply chain goals to the model and get appropriate weight for the ASC location attributes. The results of current research are used in facility location problem of agricultural service centers in another paper of author.

2. Material and methods

In this research, the FAHP has been used to assess the location indicators (both objectives and attributes) of agricultural service centers. Using FAHP method, the ASC location attributes is prioritized based on objectives, which assumed that they have same importance. But another phase added to the framework to consider the possible difference between objectives using Multi Choice Goal Programming, i.e. in the case that the priority of objectives be not the same. So this research has four main phases for assessing the location attributes (see Fig. 3):

(1) Constructing initial location attributes and refining them and also location objectives using Delphi method.

(2) Ranking initial ASC location attributes using TOPSIS technique

(3) Developing the AHP hierarchal model containing the assessment of objectives and attributes, and determining the weights of objectives and attributes through FAHP.

(4) Prioritizing the attributes through Goal Programming.

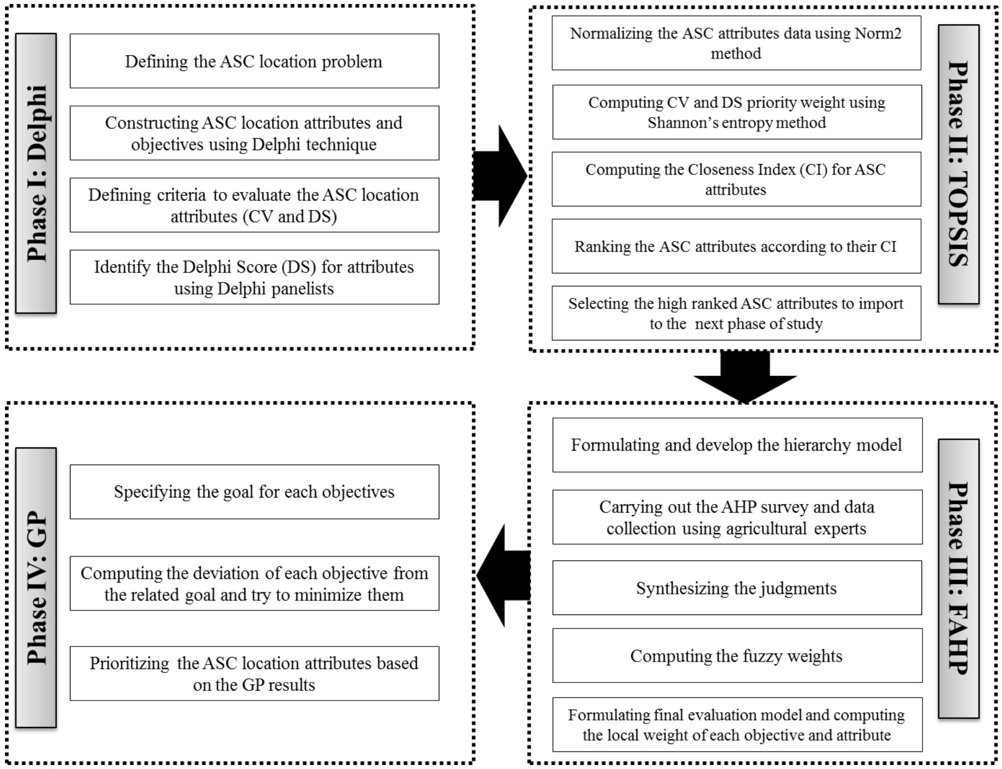

Fig. 3 The schematic process of overall research framework

2.1 Phase I

First of all the location problem of agricultural service centers is defined. Often the agricultural service center location problem occur in developing countries, but may occur in development ones where strategic decision be taken to improve the productivity of their agricultural supply chain. Services play a critical role in agricultural sector. Tractor and farm machineries are needed, but in developing countries considerable number of them are old and their efficiency has been reduced, so need to be replaced. Also other services such as advisory, input supply and financial services can improve the efficiency of agricultural production. In some developing countries (for example Iran) governments have been concluded that establishing ASCs and keep them update in the aspects of tractors, machineries and also other agricultural services will be improve the efficiency. So the main issue for this policy is selecting the location of these centers. This problem has many aspects, but it is multi attribute decision making problem and an analytic hierarchy process can solve it, primarily. It is common that in similar location problems, desired attributes be collected from literatures and similar studies. But in current problem no similar research study for the attributes found, so Delphi method was used to construct ASC location attributes.

Delphi method

Delphi is a technique of popular survey method which extract consensus of ideas among a set of experts or panelists by maintaining the unanimity among them. Delphi technique has been used for various purposes like setting goals, finding problems, developing system models, decision making and etc. (Prusty et al. 2010). In current research several rounds of Delphi survey is needed to construct the objectives and attributes of ASC location problem. In the following sections the process of Delphi survey has been described.

Delphi survey process

Design and administration of the initial questionnaire

There is no similar research about location of ASC in literatures, so the initial questionnaire was basically a brainstorming session among the selected Delphi panelists. Designer team was included four people who designed the open questions of first questionnaire and contributed in different steps of this research. The aim of this step of Delphi study was construction of the location selection indicators (both objectives and attributes) of ASC location problem. Each Delphi panelist was asked to answer two main questions as follows:

(1) What location can be appropriate to establish ASC? In other words what attributes should be considered to select a place for an ASC?

(2) What advantages can be achieved if an ASC located in best possible location (based on attributes you mentioned in previous question)? In other words what are the objectives of ASC location selection?

First question was designed to collect and construct agricultural service center location attributes and the second to determine main objectives of ASC facility location problem. Eight experts replied to the first round questionnaire. The composition of the panelists in this round is given in Table 1.

Table 1 Composition of experts in the first-round

Participant Type	Educations	Office	Number
Professor	PhD with average background of 12 years in the field of Agricultural engineering	University of Tehran, University of Zanjan	3
PhD Student	MSc in the field of Agricultural engineering	University of Tehran	3
Government Expert	BSc and MSc with average background of 14 years in the field of Agricultural Mechanization engineering	Agricultural department of Zanjan and Alborz provinces	2

The second questionnaire was designed with the objective of prioritizing the attributes raised in the first questionnaire and sent to the Delphi panelists. Attributes were rated with respect to priority criterion. The rating scale (see Table 2) was in the range of 1-9, with ‘1’ representing ‘not important’ and ‘9’ representing ‘very highly important’ meant that how much an attribute is important for each Delphi panelists participated in the survey to select best location of ASCs.

Table 2 Linguistic variables for the rating of attributes

Linguistic variable	Value
Not important	1
Very low	2
Medium low	3
Low	4
Fair	5
Medium	6
High	7
Medium high	8
Very high	9

There are several methods to calculate the score of each attributes to determine the most important attributes to use in Fuzzy-AHP method. The number of items for pairwise comparisons should be reduced in AHP to simplify judgment process and ensure the accuracy of results. So here Coefficient of Variation and Delphi Score are used simultaneously in a TOPSIS ranking survey to reduce the number of items.

If the absolute dispersion is defined as the standard deviation, and the average is mean, the relative dispersion is called the coefficient of variation (CV) or coefficient of dispersion. The CV is attractive as a statistical tool because it apparently permits the comparison of varieties free from scale effects, i.e. it is dimensionless. The coefficient of variation (CV) is defined as the ratio of the standard deviation σ to the mean μ (Brown 1998) (Eq. 1):

$$CV = \frac{\sigma}{\mu} \qquad (1)$$

The lower value of CV has preference to select one attribute as ASCs location indicator, i.e. Delphi panelist opinions is similar to each other and average of them is high about an attribute, illustrate that all panelists want to consider that attribute in study.

Another method to analysis the Delphi panelist's scores to select best indicators is Delphi score which proposed by Linstone and Turoff (2002) (Eq.2):

$$Delphi\ Score = \frac{(Lowest\ Score + Highest\ Score + 4) \times Average\ Score}{6} \qquad (2)$$

Against the CV higher values of Delphi score is preferred. Each attribute which have the most Delphi score can be selected to include in ASCs location selection process.

2.2 Phase II

In this phase the most important attributes will be selected according to their Delphi score and CV. Then the hierarchy model will be formulated and the AHP survey can be run. Here the TOPSIS technique is applied to rank attributes according to the value of CV and DS.

TOPSIS is a multiple criteria decision making method which is initially developed by Hwang and Yoon (Hwang and Yoon 1981b). The technique is based on the idea that the optimal solution should have the shortest distance from the positive ideal solution and the farthest from the negative ideal solution (Oztaysi 2014). In current research, the maximum value of each attribute is considered as positive ideal solution and the minimum value as negative ideal solution. This values is mentioned for positive attributes where higher value of them are preferred for the location of ASC, e.g. population of candidate location, while for negative attributes is vice versa.

2.3 Phase III

The main aim of current research is estimating the weights of objectives and attributes from the FAHP model which is developed. So the AHP questionnaire distributed to the agricultural professors and experts to respond to judge about relative weight of each pairwise comparison between objectives and attributes.

FAHP

AHP is a structured technique for organizing and analyzing complex decisions based on paired comparisons of both projects and criteria (Saaty 1986). The strength of the AHP method lies in its ability to construct complex, multi person, multi-attribute, and multi-period problem hierarchically (Chin et al. 2008). The judgments of conventional AHP method usually have ambiguity problem because the verbal attitudes of decision-maker's evaluation process contain vague and multiplicity of meaning (Lee 2010). Thus in order to overcome the verbal ambiguity of linguistic variables, fuzzy set theory has applied to the judgment as an extension of AHP method. Fuzzy set theory was first introduced by Zadeh (1976) to deal with the uncertainty.

2.4 Phase IV

In this research it is assumed that the importance of all objectives is the same, but for applying this approach to any agricultural region, the managers must consider their agricultural conditions and also their strategic decision to use ASC in their region. If the managers prefer to stress some objectives, in other words the managers follows specific level of each objective function to improve the performance of their ASC, so they strictly recommended prioritizing the objectives and then use Goal Programming (GP) technique (Chang 2007) to compute the final weight of ASC location attributes. Then they can use these weights to define the process of multi attribute decision making to find best location of agricultural service centers. Traditional GP can be used in this case when there is only one goal level in each objective function, but multi choice goal programming (MCGP) is another version of GP which considers several maximum or minimum goals in (Chang et al. 2014).

3. Results and discussions

The results of Delphi survey

The answers made by the Delphi panelists to the initial questionnaire covered a wide range of issues. According to the results, the panelists mentioned number of machinery available in the region, distances, future work condition of service centers in future and etc. Similarly, García et al. (2014) constructed attributes for perishable product warehouse which relatively is an agricultural service center including: accessibility, security, needs of the agricultural product warehouse, social acceptance that the warehouse may have on the environment where it is supposed to be built, the costs of product transportation, wages and salaries of workers and managers. After constructing the attributes various scores were obtained in the second questionnaire against each ASC location attributes. The title and scores of both evaluation methods (i.e. CV and DS) methods have been shown in Table 3.

Table 3 Score of ASC location attributes

No.	Attribute	CV	DS
C1	Surplus of tractor and machinery which concentrated in region	0.763	4.20
C2	Lack of tractor and machinery	0.393	6.50
C3	Easy reach of farmers to the ASC	0.447	5.73
C4	Easy reach to spare parts, repair , customer service center and gas station	0.225	6.90
C5	Easy reach to main roads and byroads	0.553	5.27
C6	Possibility to develop the workspace in future	0.525	5.27
C7	Minimum distance to the covered regions	0.435	5.80
C8	Easy reach to its villages and covered regions	0.313	6.23
C9	Easy reach to water, electricity, gas and telephone with minimum cost	0.484	5.67

C10	Existence of crop rotation with least fallow (irrigated be more than dry farming)	0.384	5.93
C11	Social acceptance by the farmers and bring their adoption	0.518	5.27
C12	Good climate for developing ASC operations and be safe from natural disasters	0.503	4.20
C13	Tractor and machinery being old and farmers could not be able replace them	0.479	5.20
C14	Maximum distance to other service centers or similar centers	0.334	5.60
C15	Possibility to extend new crop production in future	0.506	3.30
C16	The price of land for cheap extend	0.838	3.13
C17	Easy reach to required labor	0.569	4.23
C18	Enough security	0.594	4.63
C19	Visibility for farmers	0.859	4.27
C20	Minimum distance to residential areas	0.929	3.00
C21	Existence of progressive farmers	0.566	5.07
C22	Existence of good educations and tendency to modernism by farmers	0.536	4.70
C23	Good soil, good climate, less slope, big plot lands, and appropriate wind	0.516	5.00
C24	Existence of crowded population and vast cultivated area	0.316	6.60
C25	Minimum distance of villages to each other and large number of them (population being concentrated)	0.472	5.43
C26	Maximum number of crop types cultivated	0.503	5.47

Based on the main objectives of development of ASC establishment policy, four objectives was made for ASC location problem shown in Table 7, by consulting agricultural experts using Delphi method (the second question in first round questionnaire is related to the objectives). It can be said that the objectives constructed here is almost the main objectives of agricultural supply chain. The quality is the first and the most important objective in any supply chain management. All actions are done to improve the quality. So this study strictly focused on quality of services in accomplishing our research. The quality of services in agricultural operations such as mechanization and inputs can directly affect the quality and quantity of production. Competitiveness of agricultural production directly related to their quality and price. The farmers always try to reduce their costs and compete with other markets. Here the location attributes is defined which can minimize the agriculture service costs and consequently product cost. Locations which are near to their customers can reduce their transportation cost, so according to the objective of service cost, location attributes could be selected which minimized the distance between service centers and the farms/farmers. Time is a critical factor in agricultural commodities, and extremely can influence the quality and price of agricultural production because of being perishable, dependence on whether and etc. The location and also capacity of service centers affects the service time. Therefore the attributes reflects these items can improve the location selection results. Service centers must be sustainable to provide appropriate services to the farms, so their profitability can be considered in this case.

Table 4 ASC location selection objectives made after first-round Delphi survey

Objectives	Objective Function (Max/Min)	Abbreviations
Quality of agricultural services	Max	Service Quality (O1)
Cost of agricultural services paid by farmers instead of delivering services	Min	Service Cost (O2)
Speed of service	Max	Service Speed (O3)
Profitability of ASCs	Max	ASC Profit (O4)

Refinement of attributes by TOPSIS

Attributes were analyzed to refine and reduce their size, and also by selecting the most important ones. If too many factors be included in AHP model, then the number of pairwise comparisons will be increased, so the accuracy of AHP judgments may reduce. Also it is necessary to make them mutually exclusive and non-redundant. So to find five best attributes after the second round Delphi survey, a TOPSIS survey designed to rank ASC attributes which have highest Delphi score and lowest CV simultaneously. Then they were selected as alternatives in the AHP model to make judgment easy and possible for experts and increase their accuracy. The results of TOPSIS technique is illustrated in Table 5 and Fig. 4.

Table 5 The results of TOPSIS survey

Attribute	Normalized data		Distance to positive ideal solution	Distance to negative ideal solution	Closeness index to ideal solution	Rank
	CV	DS				
C1	0.208	0.666	0.345	0.116	0.252	23
C2	0.055	1.594	0.063	0.396	0.863	3
C3	0.072	1.240	0.160	0.304	0.655	7
C4	0.018	1.796	0.000	0.458	1.000	1
C5	0.110	1.047	0.220	0.244	0.526	15
C6	0.099	1.047	0.218	0.249	0.534	13
C7	0.068	1.269	0.152	0.313	0.673	6
C8	0.035	1.466	0.093	0.372	0.800	4
C9	0.084	1.212	0.170	0.293	0.632	9
C10	0.053	1.328	0.133	0.332	0.714	5
C11	0.096	1.047	0.217	0.250	0.535	12
C12	0.091	0.666	0.321	0.182	0.362	20
C13	0.082	1.020	0.222	0.251	0.530	14
C14	0.040	1.183	0.172	0.305	0.639	8
C15	0.092	0.411	0.391	0.158	0.287	22
C16	0.252	0.370	0.433	0.042	0.089	25
C17	0.116	0.676	0.321	0.168	0.343	21
C18	0.126	0.810	0.287	0.186	0.394	19
C19	0.264	0.687	0.357	0.102	0.223	24
C20	0.309	0.340	0.458	0.000	0.000	26
C21	0.115	0.969	0.242	0.225	0.482	17
C22	0.103	0.833	0.276	0.203	0.423	18
C23	0.096	0.943	0.245	0.228	0.482	16
C24	0.036	1.644	0.045	0.414	0.903	2
C25	0.080	1.114	0.196	0.272	0.582	11
C26	0.091	1.128	0.194	0.271	0.582	10
Shannon's weight	0.726	0.273				

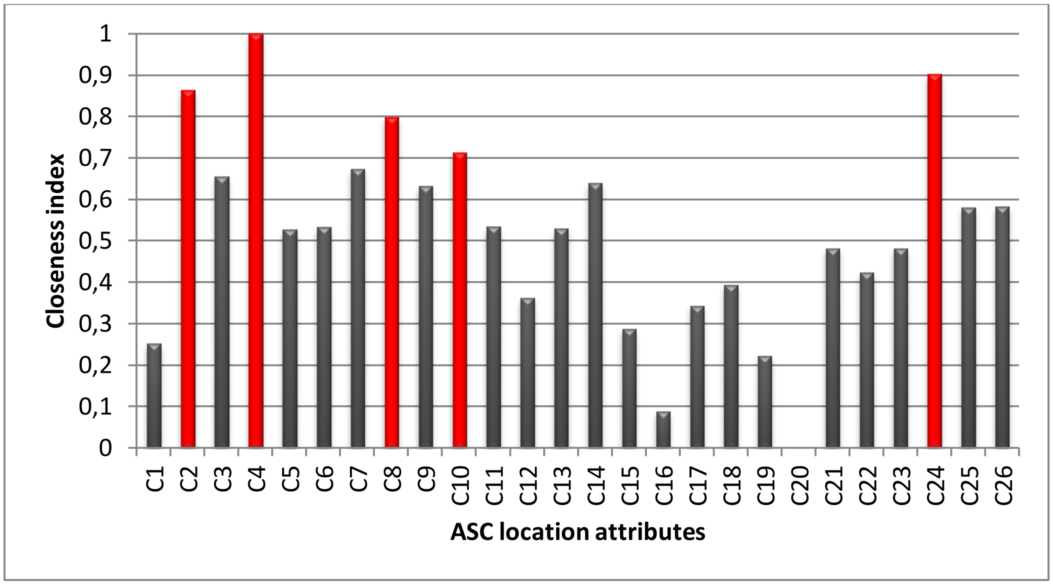

Fig. 4 The value of closeness index in TOPSIS ranking method

The highest rank ASC attributes has been introduced in Table 6.

Table 6 The most important attributes based on Delphi survey

No.	Attribute	New abbreviation
C2	Lack of tractor and machinery	Machinery Lack (C1)
C4	Easy reach to spare parts, repair , customer service center and gas station	Easy Support (C2)
C8	Easy reach to its villages and covered regions	Easy Reach (C3)
C10	Existence of crop rotation with least fallow (irrigated be more than dry farming)	Crop Rotation (C4)
C24	Existence of crowded population and vast cultivated area	Population and Area (C5)

Process of the AHP survey

The hierarchy model of ASC location problem formulated and developed as shown in Fig. 5.

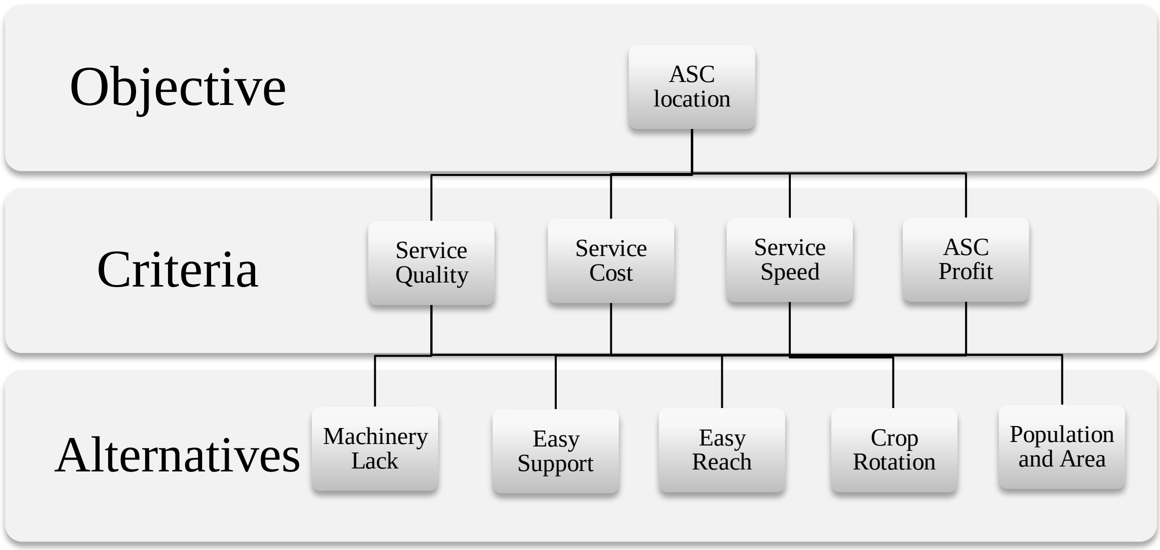

Fig. 5 Analytic hierarchy process model, for location selection of the ASCs

To find the weight of the ASC location selection attributes, an AHP questionnaire was designed with a 9-point scale and pair wise comparison format. The questionnaire was distributed to 10 agricultural experts. Approximately 3 of 10 participants had more than 10 years of work experience in agricultural sector and also have related higher academic educations. Other experts almost are professor and PhD student of agricultural engineering. They were asked to make a pair wise comparison judgment and give the relative importance amongst the performance objectives and attributes. The pair wise judgment is conducted from the first level to the third level. Finally each participant individually expressed their preference between each pair of elements.

FAHP model development

Computing the pair wise comparison matrices of objectives and attributes using fuzzy numbers

By using triangular fuzzy numbers, the fuzzy pair wise comparisons matrix for the main objectives is constructed as follows in Table 7.

Table 7 Pair wise comparison matrix for objectives

	O1	O2	O3	O4	Normalized weight
O1	(1.000, 1.000, 1.000)	(0.200, 1.415, 6.000)	(0.200, 1.711, 6.000)	(0.200, 1.533, 6.000)	0.257
O2	(0.166, 0.706, 5.000)	(1.000, 1.000, 1.000)	(0.200, 1.245, 7.000)	(0.250, 1.570, 6.000)	0.252
O3	(0.166, 0.567, 5.000)	(0.142, 0.785, 5.000)	(1.000, 1.000, 1.000)	(0.166, 0.880, 7.000)	0.245
O4	(0.166, 0.652, 5.000)	(0.166, 0.636, 4.000)	(0.142, 1.135, 6.000)	(1.000, 1.000, 1.000)	0.244
CR	0.001				

First, via pair wise comparison, the fuzzy synthetic extent values of the attributes were calculated in order to assess the priority weights of the main objectives. The values of the fuzzy synthetic extent of the four objectives were denoted $S_{Service\ Quality}$, $S_{Service\ Cost}$, $S_{Service\ Speed}$ *and* $S_{ASC\ Profit}$, respectively:

$$S_{Service\ Quality} = (1.600, 5.661, 19.000) \otimes (6.169, 16.841, 72.000)^{-1} = (0.022, 0.336, 3.080)$$

$$S_{Service\ Cost} = (1.616, 4.521, 19.000) \otimes ((6.169, 16.841, 72.000))^{-1} = (0.022, 0.268, 3.080)$$

$$S_{Service\ Speed} = (1.476, 3.233, 18.000) \otimes ((6.169, 16.841, 72.000))^{-1} = (0.021, 0.192, 2.918)$$

$$S_{AMSC\ Profit} = (1.476, 3.424, 16.000) \otimes \left((6.169, 16.841, 72.000)\right)^{-1} = (0.021, 0.203, 2.594)$$

The degree of possibility of S_i $(i \neq j)$ was determined.

$$V\left(S_{Service\ Quality} \geq S_{Service\ Cost}\right) = 1$$

$$V\left(S_{Service\ Quality} \geq S_{Service\ Speed}\right) = 1$$

$$V\left(S_{Service\ Quality} \geq S_{AMSC\ Profit}\right) = 1$$

$$V\left(S_{Service\ Cost} \geq S_{Service\ Quality}\right) = \frac{3.080 - 0.022}{(3.080 - 0.022) + (0.336 - 0.268)} = 0.978$$

$$V\left(S_{Service\ Cost} \geq S_{Service\ Speed}\right) = 1$$

$$V\left(S_{Service\ Cost} \geq S_{AMSC\ Profit}\right) = 1$$

$$V\left(S_{Service\ Speed} \geq S_{Service\ Quality}\right) = \frac{2.918 - 0.022}{(2.918 - 0.022) + (0.336 - 0.192)} = 0.952$$

$$V\left(S_{Service\ Speed} \geq S_{Service\ Cost}\right) = \frac{2.918 - 0.022}{(2.918 - 0.022) + (0.268 - 0.192)} = 0.974$$

$$V\left(S_{Service\ Speed} \geq S_{AMSC\ Profit}\right) = \frac{2.918 - 0.021}{(2.918 - 0.021) + (0.203 - 0.192)} = 0.996$$

$$V\left(S_{AMSC\ Profit} \geq S_{Service\ Quality}\right) = \frac{2.594 - 0.022}{(2.594 - 0.022) + (0.336 - 0.203)} = 0.950$$

$$V\left(S_{AMSC\ Profit} \geq S_{Service\ Cost}\right) = \frac{2.594 - 0.022}{(2.594 - 0.022) + (0.268 - 0.203)} = 0.975$$

$$V\left(S_{AMSC\ Profit} \geq S_{Service\ Speed}\right) = 1$$

The minimum degree of possibility was stated as follows:

$$\acute{d}(Service\ Quality) = \min(1.000, 1.000, 1.000) = 1.000$$

$$\acute{d}(Service\ Cost) = \min(0.978, 1.000, 1.000) = 0.978$$

$$\acute{d}(Service\ Speed) = \min(0.952{,}0.974{,}0.996) = 0.952$$

$$\acute{d}(AMSC\ Profit) = \min(0.950{,}0.975{,}1.000) = 0.950$$

Accordingly, the weight vector was derived as $\acute{W} = (1.000{,}0.978{,}0.952{,}0.950)$ and the normalized weight was given by $W = (0.257{,}0.252{,}0.245{,}0.244)^T$. By applying the same calculation process to the remaining attributes, priority weights could be calculated.

From the calculated results listed in Table 8, it can be concluded that, by comparing the weights of objective in Level 2, Service Quality and Service Cost are more important than Service Speed and ASC Profit objective.

Table 8 Pair wise comparison matrix for Service Quality

Service Quality	C1	C2	C3	C4	C5	Normalized weight
C1	(1.000, 1.000, 1.000)	(0.125, 0.322, 4.000)	(0.142, 0.792, 4.000)	(0.142, 1.086, 5.000)	(0.142, 0.569, 5.000)	0.189
C2	(0.250, 3.101, 8.000)	(1.000, 1.000, 1.000)	(1.000, 3.282, 8.000)	(1.000, 3.702, 8.000)	(1.000, 2.907, 6.000)	0.225
C3	(0.250, 1.261, 7.000)	(0.125, 0.304, 1.000)	(1.000, 1.000, 1.000)	(0.125, 1.584, 5.000)	(0.125, 0.977, 6.000)	0.195
C4	(0.200, 0.920, 7.000)	(0.125, 0.270, 1.000)	(0.200, 0.630, 8.000)	(1.000, 1.000, 1.000)	(0.166, 0.812, 3.000)	0.190
C5	(0.200, 1.756, 7.000)	(0.166, 0.343, 1.000)	(0.166, 1.022, 8.000)	(0.333, 1.231, 6.000)	(1.000, 1.000, 1.000)	0.199
CR	0.007					

Table 9 Pair wise comparison matrix for Service Cost

Service Cost	C1	C2	C3	C4	C5	Normalized weight
C1	(1.000, 1.000, 1.000)	(0.142, 0.344, 2.000)	(0.142, 0.468, 3.000)	(0.166, 0.892, 4.000)	(0.200, 0.753, 4.000)	0.186
C2	(0.500, 2.905, 7.000)	(1.000, 1.000, 1.000)	(0.142, 1.492, 4.000)	(0.250, 2.334, 8.000)	(0.250, 1.614, 6.000)	0.214
C3	(0.333, 2.134, 7.000)	(0.250, 0.670, 7.000)	(1.000, 1.000, 1.000)	(0.333, 1.231, 6.000)	(0.333, 0.719, 6.000)	0.205
C4	(0.250, 1.120, 6.000)	(0.125, 0.428, 4.000)	(0.166, 0.812, 3.000)	(1.000, 1.000, 1.000)	(0.166, 0.748, 2.000)	0.192
C5	(0.250, 1.326, 5.000)	(0.166, 0.619, 4.000)	(0.166, 1.390, 3.000)	(0.500, 1.335, 6.000)	(1.000, 1.000, 1.000)	0.200

CR	0.01

Table 10 Pair wise comparison matrix for Service Speed

Service Speed	C1	C2	C3	C4	C5	Normalized weight
C1	(1.000, 1.000, 1.000)	(0.111, 0.455, 3.000)	(0.111, 0.483, 6.000)	(0.200, 1.157, 3.000)	(0.200, 0.950, 4.000)	0.193
C2	(0.333, 2.197, 9.000)	(1.000, 1.000, 1.000)	(0.250, 0.821, 9.000)	(0.333, 2.099, 5.000)	(0.250, 1.876, 6.000)	0.209
C3	(0.166, 2.069, 9.000)	(0.111, 1.216, 4.000)	(1.000, 1.000, 1.000)	(0.200, 1.586, 9.000)	(0.142, 1.290, 6.000)	0.207
C4	(0.333, 0.863, 5.000)	(0.200, 0.476, 3.000)	(0.111, 0.630, 5.000)	(1.000, 1.000, 1.000)	(0.333, 0.835, 2.000)	0.207
C5	(0.250, 1.052, 5.000)	(0.166, 0.533, 4.000)	(0.166, 0.774, 7.000)	(0.500, 1.196, 3.000)	(1.000, 1.000, 1.000)	0.191
CR	0.1					

Table 11 Pair wise comparison matrix for ASC Profit

ASC Profit	C1	C2	C3	C4	C5	Normalized weight
C1	(1.000, 1.000, 1.000)	(0.200, 1.453, 7.000)	(0.200, 2.065, 7.000)	(0.200, 2.432, 8.000)	(0.166, 1.000, 4.000)	0.207
C2	(0.142, 0.688, 5.000)	(1.000, 1.000, 1.000)	(0.200, 1.048, 8.000)	(0.333, 2.334, 6.000)	(0.166, 0.679, 4.000)	0.201
C3	(0.142, 0.484, 5.000)	(0.125, 0.954, 5.000)	(1.000, 1.000, 1.000)	(0.250, 1.231, 8.000)	(0.142, 0.357, 5.000)	0.196
C4	(0.125, 0.411, 5.000)	(0.166, 0.428, 3.000)	(0.125, 0.812, 4.000)	(1.000, 1.000, 1.000)	(0.166,0.328, 1.000)	0.183
C5	(0.250, 1.000, 6.000)	(0.250, 1.472, 6.000)	(0.200, 2.794, 7.000)	(1.000, 3.047, 6.000)	(1.000, 1.000, 1.000)	0.210
CR	0.1					

The local weights of the relative importance are computed to the attributes against the objectives; and also the global weights, which are the relative importance attributes against the goal. To derive the global weight of each attribute, its local weight was multiplied by the local weight of each corresponding objectives. In this study, all consistency ratios range from 0.001 to 0.1 and overall CR is 0.04, which fell within the acceptance level of 0.10 as recommended by Saaty (1994). This shows that the survey respondents have assigned their weights consistently after examining the priorities of success attributes of location selection for agricultural service centers.

Local weights based on the synthesized judgments

Tables 9 to 11 hierarchically display local weights according to the Level 3, with the CR using a 5*5 matrix. In the Level 3 attributes of Service Quality, 'easy support' (local W: 0.255) and 'population and area' (local W: 0.199) attributes rank first and second, respectively. Also 'easy reach' (Local W: 0.199), 'crop rotation' (local W: 0.190) and 'machinery lack' (local W: 0.189) rank the third to fifth, respectively. To visualize this result, Figs. 6 and 7 show the local weights of the attributes under Service Quality and Service Cost objectives in a radiated diagram.

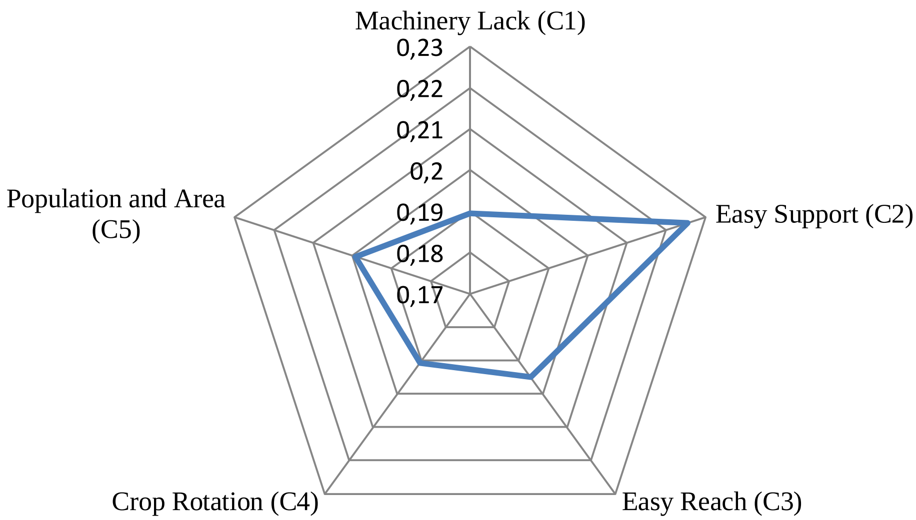

Fig. 6 Radiated diagram of local weight of attributes under Service Quality objectives

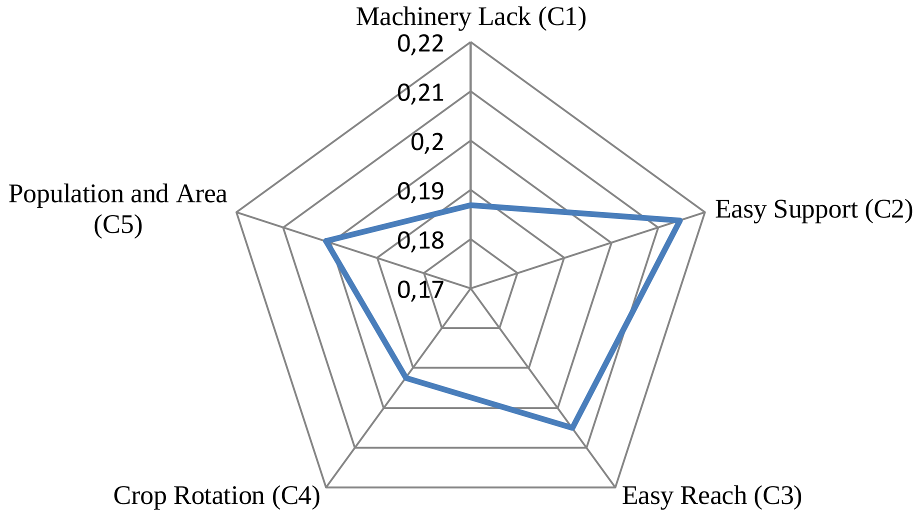

Fig.7 Radiated diagram of local weight of attributes under Service Cost objectives

Similarly from Figures 8 and 9 the priority of attributes under 'Service Speed' and 'ASC Profit' can be seen.

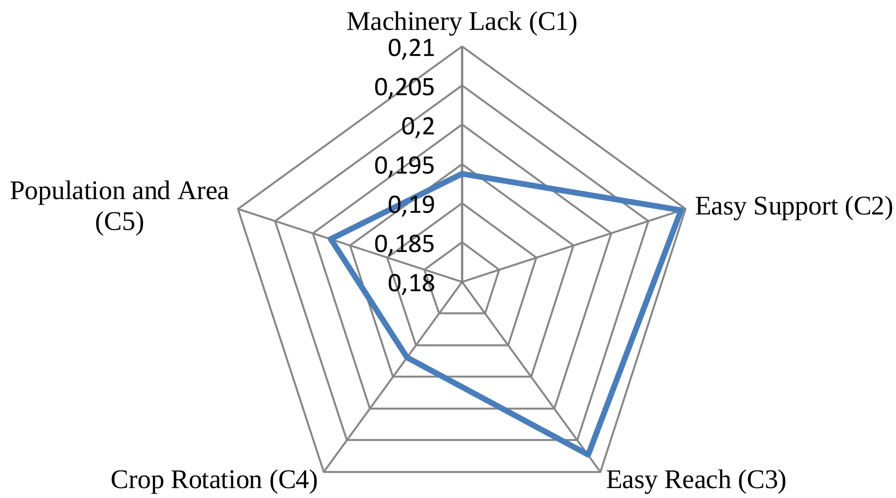

Fig. 8 Radiated diagram of local weight of attributes under Service Speed objectives

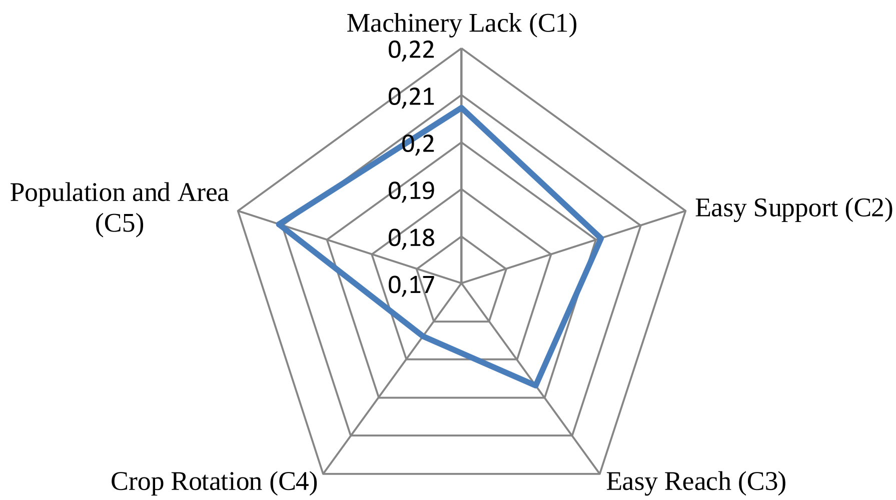

Fig. 9 Radiated diagram of local weight of attributes under ASC Profit objectives

Global weights based on the synthesized judgments

To determine the overall prioritization of the five attributes with respect to the goal of best location of agricultural service centers, the global weights of the attributes were calculated. Table 12 shows the prioritization of the four objectives and five attributes in terms of the global weights based on the synthesized judgments of evaluators.

Table 12 Global weight and prioritization of objectives and attributes

Objectives	Global W	Prioritizations	Attributes	Global W	Prioritizations
Service Quality (O1)	0.257	1	Easy support (C2)	0.212	1
Service Cost (O2)	0.252	2	Population and Area (C5)	0.202	2
Service Speed (O3)	0.245	3	Easy Reach (C3)	0.201	3
ASC Profit (O4)	0.244	4	Machinery Lack (C1)	0.194	4
			Crop Rotation (C4)	0.189	5

From the Level 2 objective weights, we can derive the prioritization of four objectives. Table 12 shows that 'Service Quality' (Global W: 0.257) is most important criterion for assessing the ASC location attributes. ‘Service Cost’ (Global W: 0.252), ‘Service Speed’ (Global W: 0.245) and ‘ASC Profit’ (Global W: 0.244) are the second to fifth most important objectives, respectively in this level.

For Level 3 perspective, the global weight of each attributes was calculated by multiplying the local weight of each attribute under each criterion to global weight of related objectives and calculating sum of them for each attribute. As can be seen in Table 12 the attribute ‘Easy Support’ (Global W: 0.212) has relatively higher value than other attributes. ‘Population and area’ (Global W: 0.202) and ‘Easy reach’ (Global W: 0.201) with less difference are the second and third important attributes. Also ‘Machinery lack’ (Global W: 0.194) and ‘Crop rotation’ (Global W: 0.189) are the less important attributes for location selection of ASC.

The attributes selected in this research are interested to use in facility location problem of agricultural service centers. Service centers should be located on places which can reach to their required inputs to provide the services for farms. Easy support attribute means that candidate location is better to have access to fuel stations, agricultural input markets, human workers and etc. The second important attribute is population and area, which directly influence on the service cost and centers profit. Locations which are near to more customers can reduce their costs and get more profits. Accessibility to service centers is almost related to the distance between farmers and centers. But in agricultural areas the accessibility may related to centrality of centers location among villages, because farmers of around areas needed to travel between their farms/home and the center several times in each season. Easy reach to service center will increase the service lead time and center profit. Transportation and also distance are key factors in location problems. Since in this research we assume same priority for objectives, the easy reach ranked third, but if in a situation the service cost and service speed be more important than quality and profit for service centers, then the easy reach will be the most important location attribute, because the transportation directly affect cost and speed of service. The number of available tractors and machineries in any region can be considered as an attribute, because the service centers should provide mechanization services to the farms which have no machinery or needs some machinery, therefore the centers can be located there. The last attribute is crop rotation which means that service centers can locate on regions that several types of crops are cultivated. Agricultural operations are completely seasonal; means that some operations in one month of a year are needed and its facilities will remain useless until next season. This phenomenon is not favorable for service centers economically. As our expert team selected the work for the facilities should be available in all time of season. It can be obtained where several crops cultivated in the region.

In this research we assumed that all objectives has same importance in normal case, but if any manager/researcher want to use this approach with other assumption about objectives and make priority, they are recommended to use the Goal Programming method introduced through the paper. They can use some targets/goals for the objectives and then prioritize the location attributes of service centers. It can be very useful to manage the agricultural systems to be efficient.

4. Conclusions

The main contribution of this paper was to identify the list of objectives and attributes for assessing the best location for establishing agricultural service centers. The paper elaborated upon a hierarchically assessment model and identified important objectives and their weights to evaluate the relative importance of the ASC location selection problem. This paper contributes to experts by applying the TOPSIS and Fuzzy AHP model with the Delphi method, which is considered one of the most structured techniques for industrial and managerial decision making. Based on literature review and Delphi study, a TOPSIS, and an AHP model was generated by incorporating four decision objectives. In addition, we used the fuzzy approach to make the conventional AHP model more sophisticated with more precise judgment. The results of the FAHP method indicated that agricultural service quality is the most important objective to assessing the ASC location attributes. It can be concluded that the service quality is the main expectation from agricultural services. Further several location attributes is adopted for ASC location and found that support for ASC is the main attributes. Tractors and agricultural machineries have too depreciations because of their working conditions. So these centers need continual repairs both in working season and off-season for next working season. This paper also proposed multi choice goal programming to prioritize the objective functions and define targets for them and then rank the attributes based on them. Using this approach to rank ASC location attributes can be another contribution of this research, because it is generalizable to other regions and other conditions. In future studies, extended research is needed to investigate the effect of current situation of services in agricultural supply chain on priority of location problem objectives in model developed in this paper into a variety of different areas.

5. Acknowledgement

The financial support provided by University of Tehran is duly gratefully acknowledged. Thanks and appreciations of authors also go to colleagues in Aalborg University and people who have willingly helped us with their abilities.

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