Agricultural Marketing and Commercialization Journal
6(2), 204-219, 2022, ISSN Print: 2676640X, ISSN online: 2676-7570

Optimal location of fields and markets for fruits, vegetables, and agricultural products using the Analytical Hierarchy Process model

M. Abaidalah [1]

Received: 10 August 2022/ Revised: 15 October 2022/ Accepted: 25 December 2022/ Published: 31 December 2022

Abstract

The creation of new public service centers requires considerable expenditure, and it is necessary to determine their optimal location such that it can effectively benefit all citizens. The convenient access of citizens to all kinds of urban services is considered an important goal of urban planning. Fruit and vegetable fields and markets can be considered special places for the supply of daily necessities of citizens that significantly affect the optimal management of urban transportation. Given the importance of this topic, this article aims to determine the optimal location for fruit, vegetable, and agricultural product fields and markets using the Analytical Hierarchy Process (AHP) model. This is an applied, descriptive-correlational, and survey study in terms of the objective, nature, and method, respectively. The study area was fruit and vegetable fields in districts of the Alexandria metropolis. The statistical population included agricultural experts of the fruit and vegetable field organization of Alexandria Municipality in 2013. The study sample was determined by the purposive sampling method, and ten experts were selected for the markets in districts of Alexandria Municipality. In this research, the location and socioeconomic indicators were considered the dependent and independent variables, respectively. The relationships and prioritization of the criteria in this research were determined using multi-criteria decision-making models and the AHP model. Data were analyzed using Super Decision software. The results of District showed that the economic and social criteria with normalized weights of 0.807 and 0.193 were in the first and second priorities, respectively. The highest economic and social priorities belonged to the sub-criteria of the regional land value and access to fuel stations, respectively. The results of District 22 indicated that the economic and social criteria with normalized weights of 0.805 and 0.195 were in the first and the second priorities, respectively. The highest priorities of economic and social indicators belonged to the sub-criteria of the regional land value and personal/social security, respectively.

Keywords: Economic Indicator, Fruit and Vegetable Markets, Hierarchical Analysis, Optimal Location, Social Indicator.

Introduction

The rapid population growth, the need for paying attention to and responding to their basic needs, and the need to save costs on the one hand, and the ineffectiveness of the traditional ways of service provision to customers, on the other hand, have persuaded organizations to more quickly provide new services to customers according to their capabilities and capacities to achieve customer satisfaction. As such, the provision of facilities by organizations in the form of new methods of services and facilities will pave the ground to attract more customers (Cheng et al., 2003).

Individuals, households, and institutions purchase various goods to fulfill their daily needs. The distribution of goods passes

[1] Plant Production Department (Horticulture- Pomology), Faculty of Agriculture, Saba Basha, Alexandria University, Egypt.

through various stages at least at the level of wholesale or semi-wholesale and partial trade, except in rare cases (direct sales from production to consumption). This distribution hierarchy is a function of the urban hierarchy. According to municipal law, the creation of daily markets and fruit and vegetable fields is among the urban services provided by the municipal administration to provide the daily needs of citizens rapidly and appropriately. These fields are specific places that are assigned to facilitate the preparation and distribution of fruits and agricultural products. Local fields and daily markets serve one or more neighborhoods (between 20,000 and 50,000 people). Facilities (booths) and sometimes tents or cabins and containers are sometimes used in these fields (Saaty, 1980).

Since the service level of fruit and vegetable markets can average more than several thousand people per day, which is an important factor in making traffic, the optimal management of this issue can greatly contribute to traffic jam reduction in metropolises, especially during peak hours (Zucca & Fabbri Andrea, 2008).

Another issue that is always raised in fruit and vegetable marketing in developing countries, including Egypt, is the difference between the producer's price, i.e., the price received by the producer and that paid by the consumer. However, it should not be supposed that this price difference is only for developing countries, as such a difference exists in developed countries as well so that the price received by the producer is sometimes about 25% of that paid by the consumer. This price difference is mostly related to services such as product packaging, grading, and conversion whereas post-harvest services are very scarce in developing countries. A known factor criticized as the cause of this difference is the mediator agent (middleman), who is also called the field agent. With usually few numbers, middlemen control fruit and vegetable fields in cities and create some kind of monopoly, thereby playing a determining role in the prices to some extent, which helps them to earn huge profits (Dyer & Forman, 1991).

The location procedure and establishment of urban daily markets by managers based on correct and appropriate planning will significantly influence the success or failure of invested projects and can prevent staggering economic costs, transportation, and incompatibility with the environment and even people's culture to effectively manage urban traffic and improve citizens' well-being. The term location refers to modeling, formulating, and solving those issues that seek to find the best place to establish centers and facilities (Chang Chou, 2007).

In other words, location means choosing a place for new facilities that minimize the cost of production and distribution of goods and services for potential customers (Berrittella et al., 2007).

The final locations should satisfy all the required conditions and terms as far as possible; thus, failure to evaluate these conditions and terms before implementing such projects will lead to many undesirable results. To implement a successful location, all the effective factors should be examined throughout the study area, and the location should be offered to managers and final decision-makers who choose the appropriate choices based on the existing policies and the priorities of each result (Hill et al., 2006).

Most importantly, the location issue means finding a suitable place to install and establish equipment or facilities in general such that 1) it facilitates access to the required resources; for example, compliance with traffic laws and the environment; 2) it does not make a problem for the surroundings; 3) it meets the needs of the located place in its surrounding; 4) it eliminates or reduces cost parameters; 5) it facilitates consumer access; 6) it should provide little transportation to reach the new location as far as possible.

In recent years, traffic management in metropolises has been raised as one of the major problems for managers and urban planners. Purchase from fruit and vegetable markets is, in turn, one of the most effective factors in lowering intra-city trips and, consequently, reducing traffic and other expenses of Alexandria citizens. Choosing the best place to construct a fruit and vegetable market plays a significant role in this critical issue. Organization managers connected to this sector can use scientific decision-making methods to relocate fruit and vegetable supply centers. One of the mentioned methods is location using the Analytical Hierarchy Process (AHP) model. Accordingly, this research aims to investigate the effect of socioeconomic indicators on the location of fruit and vegetable fields in Districts of Alexandria using a hierarchical analysis approach.

Empirical Background

(Ramanathan, 2001) studied the location of urban daily markets using the multi-facility placement method and the hierarchical analysis process and selected District (with a priority factor of 0.424) urban districts in Alexandria as the optimal location for building an urban market. In their research, the optimal district was selected by a very efficient methodology according to the necessary criteria in the location of such markets by multi-facility location problems.

(Onut & Soner, 2008) investigated the optimal location of distribution centers in the marketing process using a mathematical model and proposed a model for the location of sales centers and after-sales services of Talia Company. Through library studies and interviews with experts in this company, they identified factors affecting this issue, which include two categories of indicators and limitations. The first category includes marketing and customer-oriented indicators, and the second category consists of financial, investment, and geographical limitations. In each of the districts in Alexandria, three properties with administrative-commercial use, a total of 66 options, were selected through data search and collection and interviews with investment experts and real estate consultants. Since pairwise comparisons were not possible to choose several optimal centers from 66 options due to the presence of two categories of indicators and the limitation, they employed a combination of the TOPSIS pairwise comparison model (pairwise comparisons to obtain the weight of indicators) and zero and one programming for factors in the first and second categories, respectively. Finally, six sales and after-sales service centers were selected from these choices.

(Lu et al., 2010) compared and evaluated ranking methods and AHP in locating parking lots (case study: Quarter 4 of District 15 in Alexandria). They presented a suitable model for locating optimum parking lots in Quarter 4 of District 15 in Alexandria using GIS and compared different weighting methods of parking location layers. Four parking location scenarios were created using weighting methods such as statistical correlation, structured AHP, three-degree AHP, and fuzzy AHP. To convert the area of the scenario in each class into points, the areas obtained for each scenario according to standardization methods were divided into three classes, high, medium, and low desirability. According to the calculated methods, the second scenario (the fuzzy AHP method) was finally the most suitable scenario for the parking location in the study area.

(Samudra et al., 2019) studied the optimal location of multi-story parking lots as a case study in District 7 of Alexandria Municipality. They examined parameters affecting the location of public parking lots from three viewpoints: 1) parking proximity to travel centers, 2) traffic factors, and 3) the problem of freeing up land, especially in the central areas of cities. The authors prepared a conceptual model of parking location according to these three points of view. In their article, different methods for weighting and information integration, such as point allocation weighting, nine-degree AHP, fuzzy AHP, and index and fuzzy overlay methods, were used as integration methods. Finally, the results of these methods were compared with each other to propose the appropriate methods.

(Siddhartha et al., 2017) examined the optimal location of sports spaces in Zanjan city using the AHP model and GIS. They reported that the distribution of sports spaces was not appropriate in Zanjan city. Therefore, the optimal location scenario of the sports space led to the following results. The lands of Zanjan city consist of fully unsuitable land (0.13 ha, 1%) for the location of urban sports space, relatively unsuitable land (1.56 ha, 7%), indifferent or average land (11.04 ha, 44%), relatively suitable land (4.9 ha, 43%), and fully suitable lands (1.4 ha, 6%).

(Milanović et al., 2020) researched ATM locations using the AHP in a case study on Bank in District 10 of Municipality. Given the high cost of ATM installation, their study aimed to present a method to choose the most suitable place to increase the efficiency and service of these machines. Based on similar studies in other countries, decision-making criteria and the opinions of experts and managers of this bank were extracted to identify desirable locations for establishment using spatial modeling and information integration. In the end, the cost and profit of each proposed location were calculated using the ideal planning model, and the most suitable locations and the number of devices were determined to cover the demand of the studied area.

(Berrittella et al., 2007) evaluated transportation policies to reduce the effects of climate change in Italy using the AHP. They selected the best choice by considering four indicators and six choices. The results indicated the preference of the "tax program aimed at promoting environmentally friendly transportation" choice, which aims to reinforce the public transportation system and, consequently, reduce traffic and the presence of fewer vehicles.

(Lu et al., 2010) conducted a study on a sustainable management framework and economic value assessment for watershed resources in Taiwan. They highlighted the significant role of ecological factors in the sustainability of watershed resources in Taiwan according to the three indicators of ecological stability, economic compatibility, and social acceptability using the AHP.

(Gajdić et al., 2018) studied an appropriate forestry development model using the AHP model in the Zagros region of Egypt. They discussed the role of three public development models, the cooperative development model, and the private development model. Based on the results, the importance values of the cooperative development model, the public development model, and the private development model were 39.8%, 34.6%, and 25.5%, respectively, the cooperative development model was identified as the most appropriate option.

Methods

The present research is an applied, descriptive-correlational, and survey study in terms of the objective, nature, and method, respectively. The studied area is the fruit and vegetable fields of Districts in Alexandria Metropolitan Municipality. The statistical population includes agricultural experts of the fruit and vegetable field organization of Alexandria Municipality in 2013. The studied sample was determined by the purposive sampling method, and 10 skilled experts were selected for the markets of districts in Alexandria Municipality. In the current research, the location and socioeconomic indicators are considered the dependent and independent variables, respectively.

The relationships and prioritization of the criteria in this research were determined using multi-criteria decision-making and AHP models. Data were collected using Thomas L. Saati's nine-point expert questionnaire, which is formed based on paired comparisons between the questions. The number of comparisons (questions) is obtained from the formula n (n-1)/2, where *n* expresses the number of criteria considered in a comparison. An AHP questionnaire includes one or more questionnaires depending on the number of criteria and sub-criteria. This research includes a target level, a criterion level, and a sub-criterion level, which are compared in pairs with each other. Therefore, two questionnaires, namely expert questionnaire 1 and expert questionnaire 2, together form the main questionnaire in this model.

In expert questionnaire 1, two socioeconomic indicators are compared in pairs, which include a comparison (question) based on the n (n-1)/2 formula. These comparisons are made between economic and social criteria. The answers represent the prioritization resulting from the comparisons and are presented in a nine-point spectrum, from an

equal value (1) to completely preferred (9).
They are selected according to (Table 1).

Table 1. Prioritization in pairwise comparisons of sub-criteria

Option i									Option j								
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**
Full priority	Priority 7-9	Very high priority	Priority 5-7	High priority	Priority 3-5	Low priority	Priority 1-3	Equal value	Priority 1-3	Low priority	Priority 3-5	High priority	Priority 5-7	Very high priority	Priority 7-9	Full priority	Full priority

The expert questionnaire includes pairwise comparisons between sub-criteria. There are six sub-criteria for each criterion.
1. The economic index includes personal and social security for the client, regional population density, age and gender structures of the regional population, and total traffic in the region, access to public transportation stations and areas, and access to fuel stations.
2. The social index includes household income levels, land value, land size for building parking, access to banking services, private sector investment, and the importance of commercial competitors.

In this research, data obtained from the questionnaire were analyzed using Super Decision software.

Results

Results of data analysis for District

The experts' comments were consolidated using the geometric mean method (GMM). According to (Table 2), the economic and social criteria with normalized weights of 0.807 and 0.193 are the first and the second priorities, respectively.

Table 2. Determining the priority of the main criteria

Row	Economic	Social	Geometric mean	Eigenvector
Economic	1.000	4.169	2.042	0.807
Social	0.240	1.000	0.490	0.193

Prioritization of economic sub-criteria

The economic sub-criteria are composed of households' income levels, land value, land area for building parking, banking services, private sector investment, and commercial competitors. As it consists of six indicators, 15 pairwise comparisons were made for this criterion. This comparison was also made from the viewpoints of five experts, as shown in (Table 3).

Table 3. Comparison of economic sub-criteria from experts' viewpoints

Row	S11-S12	S11-S13	S11-S14	S11-S15	S11-S16	S12-S13	S12-S14	S12-S15	S12-S16	S13-S14	S13-S15	S13-S16	S14-S15	S14-S16	S15-S16
Expert 1	1.7	1	1.4	1.3	1.3	4	4	5	6	1	2	2	4	4	1.2
Expert 2	1.3	3	1.3	1.3	3	5	5	3	5	1	1	3	1	3	5
Expert 3	7	8	1	2	1	7	2	1.6	5	1.4	1	1.5	5	3	1
Expert 4	5	5	5	5	5	6	6	6	6	4	2	4	2	2	2
Expert 5	1.4	1.3	1.5	1.5	3	5	1.5	1.3	5	1.3	1.5	1.3	6	5	5

Here, experts' opinions were gathered using the GMM. (Table 4) summarizes the calculations to determine the priority of the sub-criteria of economic factors (Figure 1).

Table 4. Determining the priority of economic sub-criteria

Row	S11	S12	S13	S14	S15	S16	Geometric mean	Eigenvector
Households' income levels	1	0.839	2.091	0.608	0.740	1.719	1.052	0.155
Land value	1.191	1	5.305	2.169	1.380	5.378	2.161	0.318
Land area for building parking	0.478	0.189	1	0.803	0.956	1.099	0.651	0.096
Bank services	1.644	0.461	1.246	1	2.993	3.245	1.447	0.213
Private sector investment	1.351	1.046	1.046	0.334	1	1.904	0.990	0.146
Commercial competitors	0.582	0.186	0.910	0.308	0.525	1	0.502	0.074

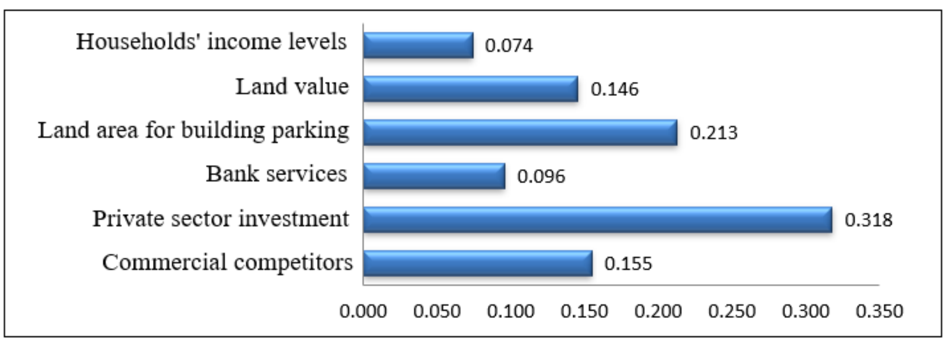

Figure 1. The priority vector of economic sub-criteria

Based on the obtained special vector:
- The highest priority belongs to the regional land value sub-criterion with a normalized weight of 0.318.
- The sub-criterion of banking services with a normalized weight of 0.213 is the second priority.

- The sub-criterion of households' income levels with a normalized weight of 0.155 is the third priority.
- The private sector investment sub-criterion with a normalized weight of 0.146 is the fourth priority.
- The sub-criterion of land area for building parking with a normalized weight of 0.096 is the fifth priority.
- The sub-criterion of commercial competitors with a normalized weight of 0.074 is the sixth priority.

A consistency coefficient of 0.03 was also obtained for the comparisons, which is smaller than 0.1, ensuring the accuracy of comparisons.

Prioritization of social sub-criteria

The social sub-criterion is only one of the six sub-criteria personal and social security, regional population density, age and gender structures, regional traffic, access to stations, and access to fuel stations. Therefore, 15 pairwise comparisons are needed to determine the final priority of the sub-criteria. This comparison was also made based on the opinions of five experts (Table 5).

Table 5. Comparison of economic sub-criteria based on experts' opinions

Row	S21-S22	S21-S23	S21-S24	S21-S25	S21-S26	S22-S23	S22-S24	S22-S25	S22-S26	S23-S24	S23-S25	S23-S26	S24-S25	S24-S26	S25-S26
Expert 1	3	1.3	2	3	1	1.3	2	1	1.3	3	3	2	1.2	1.2	1.2
Expert 2	1	3	5	5	3	3	5	5	1.3	3	3	1.3	1.3	1.5	1.5
Expert 3	1	3	6	1	3	1.3	7	2	3	7	7	3	1.3	1.5	1
Expert 4	5	5	3	1.5	1.5	5	5	1.5	1.5	1	1.5	1.5	1.5	1.5	5
Expert 5	7	1.9	7	7	1.8	1.8	1.3	3	1.7	9	7	1.5	3	1.7	1.7

Here, experts' opinions were consolidated using the GMM. (Table 6) represents the calculations to determine the priority of the sub-criteria of economic factors (Figure 2).

Table 6. Prioritization of social sub-criteria

Row	S21	S22	S23	S24	S25	S26	Geometric mean	Eigenvector
Personal and social security	1	2.537	1.108	4.169	1.838	0.742	1.587	0.235
Regional population density	0.394	1	0.731	2.591	1.431	0.394	0.866	0.128
Age and gender structures	0.903	1.369	1	3.554	2.450	0.603	1.366	0.202
Regional traffic	0.240	0.386	0.281	1	0.506	0.225	0.379	0.056
Access to stations	0.544	0.408	0.408	1.974	1	0.590	0.687	0.102
Access to fuel stations	1.348	2.537	1.657	4.453	1.695	1	1.870	0.277

Agricultural Marketing and Commercialization Journal
6(2), 204-219, 2022, ISSN Print: 2676640X, ISSN online: 2676-7570

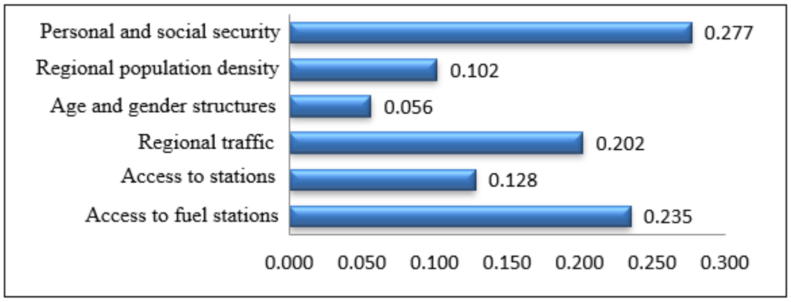

Figure 2. Prioritization of social sub-criteria

Based on the obtained eigenvector:
- The highest priority belongs to the sub-criterion of access to fuel stations with a normalized weight of 0.277.
- The personal and social security sub-criterion with a normalized weight of 0.235 is the second priority.
- The sub-criterion of age and sex structures with a normalized weight of 0.202 is the third priority.
- The regional population density sub-criterion with a weight of 0.128 is the fourth priority.
- The sub-criterion of access to stations with a weight of 0.102 is the fifth priority.
- The regional traffic sub-criterion with a weight of 0.056 is the sixth priority.

A consistency coefficient of 0.005 was obtained for the comparisons, which is smaller than 0.1 and confirms the accuracy of the comparisons.

Final prioritization of the indicators with the AHP technique

The final priority of the criteria is calculated in this step. The results of the comparisons of the research sub-criteria and their weights form the W2 matrix. To determine the final priority of the indicators with the AHP technique, the weights of the indicators based on each criterion (W2) is multiplied by the weights of the main criteria (W1). The weight of each indicator is calculated from the obtained weight of each main criterion (W1) and sub-criterion (W2). The results of the calculations and the weights of the indicators are shown in (Table 7) and (Figure 3).

Table 7. The final priorities of AHP criteria

Main criterion	Cluster weight	Sub-criterion	Symbol	Initial weight	Final weight
Economic	0.807	Households' income levels	S11	0.155	0.125
		Land value	S12	0.318	0.256
		Land area for building parking	S13	0.096	0.077
		Bank services	S14	0.213	0.172
		Private sector investment	S15	0.146	0.117
		Commercial competitors	S16	0.074	0.059

Social	0.193	Personal and social security	S21	0.235	0.045
		Regional population density	S22	0.128	0.025
		Age and gender structures	S23	0.202	0.039
		Regional traffic	S24	0.056	0.011
		Access to stations	S25	0.102	0.020
		Access to fuel stations	S26	0.277	0.054

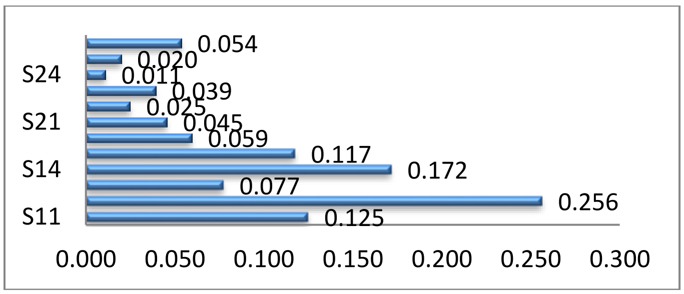

Figure 3. The eigenvector of the final priority of the indicators, the output of Super decision software

According to the calculations, the final weight of each model indicator was calculated with the AHP technique.

Results of the data analysis for Districts

The experts' opinions were consolidated using the GMM. Based on the calculations presented in (Table 8), the economic and social criteria with normalized weights of 0.805 and 0.195 are the first and the second priorities, respectively.

Table 8. Prioritization of the main criteria

Row	C1	C2	Geometric mean	Eigenvector
Economic	1.000	4.129	2.032	0.805
Social	0.242	1.000	0.492	0.195

Prioritization of economic sub-criteria

Economic sub-criteria consist of households' income levels, land value, land area for building parking, banking services, private sector investment, and commercial competitors. Fifteen pairwise comparisons were made because this criterion consists of six indicators. (Table 9) shows the comparisons based on the opinions of five experts.

Table 9. Comparisons of economic sub-criteria based on the experts' opinions

Row	S11-S12	S11-S13	S11-S14	S11-S15	S11-S16	S12-S13	S12-S14	S12-S15	S12-S16	S13-S14	S13-S15	S13-S16	S14-S15	S14-S16	S15-S16
Expert 1	3	1	5	1.5	1	4	1.3	5	1	1.3	1	1	1	1.3	1.5
Expert 2	1.8	5	1.5	1.6	4	8	6	6	8	1.5	1.7	1	1.5	3	6
Expert 3	1.5	4	1.5	5	5	9	3	6	8	1.4	1.5	1	1.6	8	7
Expert 4	1.2	9	3	4	7	9	5	7	9	1.7	1	4	7	8	4
Expert 5	5	4	5	7	7	5	7	7	7	1.3	1.3	5	1.5	5	5
Geometric mean	0.715	3.728	1.246	1.361	3.965	6.645	2.914	6.153	5.261	0.240	0.394	1.821	0.542	3.170	2.787

Here, the experts' opinions were consolidated with the GMM. The calculations to prioritize the sub-criteria of economic factors are summarized in (Table 10) and (Figure 4).

Table 10. Prioritization of economic sub-criteria

Row	S11	S12	S13	S14	S15	S16	Geometric mean	Eigenvector
Households' income levels	1	0.715	3.728	1.246	1.361	3.965	1.618	0.194
Land value	1.398	1	6.645	2.914	6.153	5.261	3.093	0.370
Land area for building parking	0.268	0.150	1	0.240	0.394	1.821	0.437	0.052
Bank services	0.803	0.343	4.169	1	0.542	3.170	1.120	0.134
Private sector investment	0.735	2.537	5.537	1.846	1	2.787	1.702	0.204
Commercial competitors	0.252	0.190	0.549	0.315	0.359	1	0.379	0.045

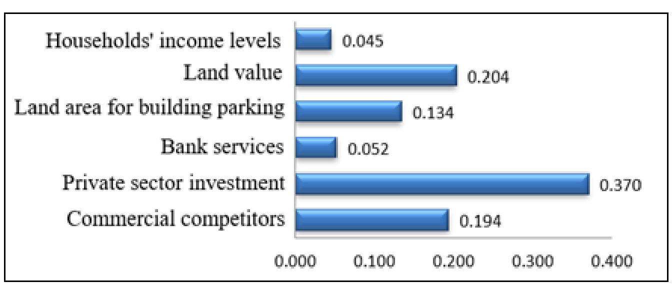

Figure 4. Prioritization of economic sub-criteria

Based on the obtained eigenvector:
- The highest priority belongs to the regional land value eigenvector sub-criterion with a weight of 0.370.
- The private sector investment sub-criterion with a normalized weight of 0.204 is the second priority.
- The households' income level sub-criterion with a normalized weight of 0.194 is the third priority.
- The banking service sub-criterion with a normalized weight of 0.143 is the fourth priority.
- The sub-criterion of land area for building parking with a normalized weight of 0.052 is the fifth priority.
- The sub-criterion of commercial competitors with a normalized weight of 0.045 is the sixth priority.

A consistency coefficient of 0.049 was estimated for the comparisons, which is smaller than 0.1 and confirms the accuracy of the comparisons.

Prioritization of social sub-criteria

The social sub-criterion comprises only one of the six sub-criteria personal and social security, regional population density, age and gender structures, regional traffic, access to stations, and access to fuel stations. Therefore, 15 pairwise comparisons are needed to determine the final priority of the sub-criteria. This comparison was made based on the opinions of five experts (Table 11) and (Figure 5).

Table 11. Comparisons of social sub-criteria based on experts' opinions

Row	S11-S12	S11-S13	S11-S14	S11-S15	S11-S16	S12-S13	S12-S14	S12-S15	S12-S16	S13-S14	S13-S15	S13-S16	S14-S15	S14-S16	S15-S16
Expert 1	3	1.3	3	3	1.3	5	1	1.5	3	3	1.5	1.5	1.3	3	5
Expert 2	8	8	8	8	1.6	1	1.6	1	1.7	1.6	1	1/6	7	1.5	8
Expert 3	7	6	5	9	2	7	8	1/6	3	9	7	4	1.8	1.9	1.6
Expert 4	5	7	7	1.5	5	4	9	1.4	4	8	1.2	5	1.7	1.8	1
Expert 5	7	7	9	5	3	1.5	5	1	1.5	5	1	1.6	1.5	1.9	5
Geometric mean	5.674	3.792	5.966	2.930	1.108	1.947	2.268	0.384	1.006	2.825	0.931	0.644	0.384	0.247	2.016

Here, the experts' opinions were consolidated using the GMM. The calculations to prioritize the social sub-criteria are presented in (Table 12).

Table 12. Prioritization of social sub-criteria

Row	S21	S22	S23	S24	S25	S26	Geometric mean	Eigenvector
Personal and social security	1	5.674	1.792	5.966	2.930	1.108	2.733	0.389
Regional population density	0.176	1	1.947	2.268	0.384	1.006	0.818	0.117
Age and gender structures	0.264	0.514	1	2.852	0.931	0.644	0.783	0.112
Regional traffic	0.168	0.441	0.354	1	0.384	0.247	0.368	0.052
Access to stations	0.341	1.074	1.074	2.605	1	2.016	1.129	0.161
Access to fuel stations	0.903	0.994	1.552	4.043	0.496	1	1.187	0.169

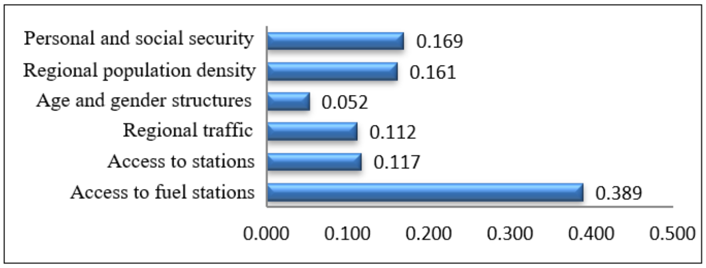

Figure 5. Prioritization of social sub-criteria

Based on the obtained eigenvector:

- The highest priority belongs to the personal and social security sub-criterion with a normalized weight of 0.389.
- The sub-criterion of access to fuel stations with a normalized weight of 0.169 is the second priority.
- The sub-criterion of access to stations with a normalized weight of 0.161 is the third priority.
- The regional population density sub-criterion with a weight of 0.117 is the fourth priority.
- The age and gender structure sub-criterion with a weight of 0.112 is the fifth priority.
- The regional traffic sub-criterion with a weight of 0.052 is the sixth priority.

A consistency coefficient of 0.043 was obtained for the comparisons, which is smaller than 0.1 and confirms the accuracy of the comparisons.

Final prioritization of the indicators with the AHP technique

The final priority of the criteria is calculated in this step. The results of the comparisons of the research sub-criteria and their weights form the W2 matrix. To determine the final priority of the indicators with the AHP technique, the weights of the indicators based on each criterion (W2) are multiplied by the weights of the main criteria (W1). The weight of each indicator is calculated from the obtained weight of each main criterion (W1) and sub-criterion (W2). The results of the calculations and the weights of the indicators are presented in (Table 13).

Table 13. Final prioritization of AHP criteria

Main criterion	Cluster weight	Sub-criterion	Symbol	Initial weight	Final weight
Economic	0.805	Households' income levels	S11	0.194	0.156
		Land value	S12	0.370	0.298
		Land area for building parking	S13	0.052	0.042
		Bank services	S14	0.134	0.108
		Private sector investment	S15	0.204	0.164
		Commercial competitors	S16	0.045	0.037
Social	0.195	Personal and social security	S21	0.389	0.076

		Regional population density	S22	0.117	0.023
		Age and gender structures	S23	0.112	0.022
		Regional traffic	S24	0.052	0.010
		Access to stations	S25	0.161	0.031
		Access to fuel stations	S26	0.169	0.033

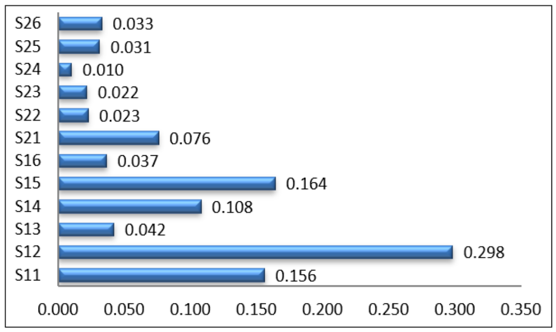

Figure 6. The final prioritization vector of the indicators, the output of Super decision software

According to the calculations, the final weight of each model indicator was calculated with the AHP technique. (Figure 6) depicts the final priority vector of the indicators.

Discussion and conclusion

The results of the analysis for the District questionnaire indicated that the highest priority belonged to the economic indicator based on the comparisons of economic and social criteria, suggesting the particular importance of paying attention to economic issues and problems. The comparison of economic sub-criteria revealed that the highest priority belonged to the regional land value sub-criterion. Given the importance of land, different types of services can be provided by considering the economic efficiency of services. According to experts' opinions, the land value can be an indicator affecting the selection of a place to build a fruit and vegetable field. The sub-criterion of banking services is the second priority. Access to ATMs or bank branches can help customers to obtain the money needed for purchases. The sub-criteria of households' income levels, private sector investment, land area for building parking, and commercial competitors are in the third, fourth, fifth, and sixth priorities, respectively. The comparisons of the social sub-criteria resulted in the following results. The highest priority belongs to the sub-criteria of access to fuel stations, which are important for easy transportation and easier access to vehicles, whether for customers or goods transportation to the fields. The personal and social security sub-criterion is the second priority. The presence of police forces in the areas targeted for building fruit and vegetable fields can lead to the safety of customers and reduce the presence of criminals and thieves in the area so that customers can comfortably purchase and prepare their needs. The age and gender structure sub-criterion is the third priority. Younger people can more easily use fruit and vegetable fields and are able to deal with the congestion in these places better than the elderly. The sub-criteria of regional population density and access to the stations are the fourth and the fifth priorities, respectively. The regional traffic sub-criterion is the sixth priority because even high traffic conditions will not prevent people from shopping in any situation.

According to the results of the analysis for the District 22 questionnaire, the economic and social criteria with normalized weights of 0.805 and 0.195 are the first and the second priorities, respectively. The results of the economic sub-criteria indicated the highest priority for the regional land value sub-criterion, which is important due to the use of land in other applications. The private sector investment sub-criterion is the second priority, which considers the existence of private sector competitors. The sub-criteria of households' income levels, banking services, land for building parking, and commercial competitors are the third, fourth, fifth, and sixth priorities, respectively. The results obtained for the social sub-criteria revealed the highest priority belonging to the personal and social security sub-criterion. The sub-criteria of access to fuel stations, access to stations, regional population density, regional traffic, and age and sex structure are the second, third, fourth, and, fifth, and sixth priorities, respectively. The results of the analyses are consistent with those of (Milanović et al., 2020), who studied ATM location in a case study on Bank in District 10 of Alexandria Municipality using the AHP. Due to the high costs of setting up ATMs, they aimed to provide a method to choose the most suitable location to increase the efficiency and service of these machines. Our findings are also close to those of (Berrittella et al., 2007), who evaluated transportation policies to reduce the effects of climate change in Italy using the AHP. They considered four indicators and six options to choose the best option. The results revealed the preference for the "tax program aimed at promoting environmentally friendly transportation" option, aiming to fortify the public transportation system, thereby reducing traffic and the presence of fewer vehicles.

References

- Cheng S. & Chan CW. & Huang GH. (2003). an integrated multi-criteria decision analysis and inexact mixed integer linear programming approach for solid waste management. Engineering Applications of Artificial Intelligence, 16(1): 543-554.
- Saaty TL. (1980). the Analytic Hierarchy Process, New York: McGraw Hill. International, Translated to Russian, Portuguese, and Chinese, Revised editions. Pittsburgh: RWS Publications.
- Zucca A. & Fabbri Andrea G. (2008). Application of spatial multi-criteria analysis to site selection for a local park: A case study in the Bergamo Province, Italy. Journal of Environmental Management, 88(1): 752-769.
- Dyer RF. & Forman EH. (1991). an Analytical Approach to Marketing Decisions. Prentic Hall, USA.
- Chang Chou C. (2007). A fuzzy MCDM method for solving marine transshipment container port selection problems. Applied Mathematics and Computation, 168(1): 435-444.
- Berrittella M. & Certa A. & Enea M. & Zito P. (2007). An Analytic Hierarchy Process for the Evaluation of Transport Policies to Reduce Climate Change Impacts. FEEM Working Paper.
- Hill MJ. & Lesslie R. & Donohue R. & Houlder P. & Holloway J. & Smith J. & Ritman K. (2006). Multi Criteria Assessment of Tensions in Resource Use at Continental Scale: A Proof of Concept with Australian Rangelands. Environmental Management, 37(5): 712-731.
- Kuo RJ. & Chi SC. & Kao SS. (1999). A Decision Support System for Locating Convenience Store through Fuzzy AHP. Computers & Industrial Engineering, 37(1): 323-326.

- Ramanathan R. (2001). A note on the use of the analytic hierarchy process for environmental impact assessment. Journal of Environmental Management, 63(1): 27-35.

- Onut S. & Soner S. (2008). Transshipment site selection using the AHP and TOPSIS approaches under fuzzy environment, Yildiz.
- Lu SC. & Peng SH. & Hwong Wen MA. (2010). A Study on the sustainable management framework and the economic value evaluation for Taiwan Reserviour Watersheed. Annals of warsam University of life Sciences- SGCW. Land Reclamation, 42(1): 219-225.
- Samudra HB. & Ujang S. & Megawati S. (2019). Analysis of distribution efficiency on bottled water product using data Envelopment Analysis method. Russian Journal of Agricultural and Socio-Economic Sciences, 94(10): 92-99.
- Siddhartha T. & Nambirajan T. & Ganeshkumar C. (2017). Distribution Methods Adopted for Self-Help Group Products: An Empirical Analysis. Journal of Operations Management, 16(4): 21-33.
- Milanović J. & Nikitović Z. & Garabinović D. (2020). The impact of customer contact as part of the agricultural products distribution channel on the increase of the competitiveness of agricultural holdings. Економика пољопривреде, 67(2): 359-75.
- Gajdić D. & Petljak K. & Mesić Ž. (2018). An exploration of distribution channels: Challenges and opportunities for organic food producers in Croatia. Економика пољопривреде, 65(4): 1461-82.