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Research Article

Efficiency Assessment Model in Turkish Agriculture with Multi Criteria Decision Making Methods

Muhammet Fatih Ak[1*]

[1] Antalya Bilim Üniversitesi, Mühendislik Fakültesi, Endüstri Mühendisliği Bölümü, İstanbul, Türkiye (ORCID: 0000-0003-4342-296X)

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Abstract

People have learned and has been developing agriculture for years. The surrounding land has become the best way to use as a result of years of observations. Over the centuries, cities have grown significantly and observable changes in land usage come up with the help of expanded and developing technology. Although Turkey has a huge and suitable land for agriculture, agricultural activities are gradually decreasing every year. The main reason why people of rural areas migrate rapidly to the cities and why agricultural activities are decreasing can be explained with the lack of adequate productivity in the production layer; moreover, fertile soils are not used effectively. As a result of the low level of productivity on agriculture, the production of agricultural products does not meet domestic demand.

A significant amount of funding is planned for future agriculture projects. Nevertheless, agricultural development in Turkey is still facing major obstacles due to efficiency. Currently, significant inflation rate increase in Turkey can be observed due to economical and geopolitical events. One of the most important reasons for the serious increase in inflation is the efficiency problems in agricultural items and activities. This study aims to develop a detailed risk analysis model of the whole system to increase productivity and efficiency with multi-criteria decision-making methods (MCDM). The findings obtained are an analysis of in agricultural productivity in order to make an improvement and it is important to be a preliminary study of the steps to be taken for efficiency. At the end of the study proposed risk analysis model aims to help all kinds of agricultural products to be planned and to be produced with detailed scientific investigations.

Keywords: Multi Criteria Decision Making Methods, Agriculture, Productivity, Risk Assessment, Optimization

Türk Tarımında Çok Kriterli Karar Verme Yöntemleri ile Verimlilik Değerlendirme Modeli

Öz

İnsanlar yıllarca tarım öğrendi ve tarım da gelişmeye ve geliştirilmeye devam etmektedir. İnsanları çevreleyen yapılar yıllarca yapılan gözlemler sonucunda en iyi şekilde kullanılmaya başlandı. Yüzyıllar boyunca, şehirler önemli ölçüde büyümüştür. Genişleyen ve gelişen teknoloji sayesinde arazi kullanımında gözlenebilir değişiklikler ortaya çıkmıştır. Türkiye'nin tarıma elverişli ve büyük alanları olmasına rağmen, tarımsal faaliyetler her yıl giderek azalmaktadır. Kırsal alandaki insanların şehirlere hızla göç etmelerinin ve tarımsal faaliyetlerin azalmasının ana nedeni, üretim katmanında yeterli verim alınamaması ile açıklanabilir; bunu yanı sıra, toprakların verimli kullanılmaması da buna sebep teşkil etmektedir. Tarımda verim düşüklüğünün bir sonucu olarak da, tarımsal ürünüretimi iç talebi karşılamayacak noktadadır.

Gelecek yıllarda uygulanması planlanan tarım projeleri için önemli miktarda finansman ayrılması hedeflenmektedir. Bununla birlikte, Türkiye'deki tarımsal gelişme, verimlilik nedeniyle hala büyük sorunlarla karşı karşıya kalmaktadır. Günümüzde, ekonomik ve jeopolitik olaylar nedeniyle, Türkiye'de önemli bir enflasyon artışı gözlemlenmektedir. Enflasyondaki ciddi artışın en önemli sebeplerinden biri tarımsal ürün ve faaliyetlerdeki verimlilik problemleridir. Bu çalışma, çok kriterli karar verme yöntemleri (ÇKKV)

[*] Sorumlu Yazar: Antalya Bilim Üniversitesi, Mühendislik Fakültesi, Endüstri Mühendisliği Bölümü, İstanbul, Türkiye, ORCID: 0000-0003-4342-296X, xxxx@xxx.xx.xx

ile üretkenlik ve verimliliği artırmak, tüm sistemi temel manada inceleyek bir risk analiz modelini geliştirmeyi amaçlamaktadır. Elde edilen bulgular, tarımsal verimliliğin artırılması ve iyileştirme amacıyla bir analiz niteliğinde olup verimlilik için atılacak adımların ön incelemesi olması noktasında önem arz etmektedir. Çalışmanın sonunda önerilen risk analiz modeli, her türlü tarımsal ürünün planlanmasına ve detaylı bilimsel araştırmalarla üretilmesine yardımcı olmayı amaçlamaktadır.

Anahtar Kelimeler: Çok Kriterli Karar Verme Yöntemleri, Tarım, Üretkenlik, Verimlilik Değerlendirmesi, Optimizasyon

1. Giriş

Turkey has a generally mountainous terrain. There is a close link between dominant winds and the sea because they bring the north and south under the influence of climatic features with Turkey landform features. Turkey has 77.9 million hectares of land assets. 26.3 million of it agricultural lands. Turkey's growing population and agricultural land features indicates that productivity is a key element to be considered. The variety of agricultural products and their yields can be increased with the usage of valid and proper optimization and planning. Agriculture and food policies are effective in the development and implementation of new technologies and new planning strategies. Nowadays, one of the most important reasons for the increasing inflation rate is it the price increase in agricultural products .

Agricultural value added constitutes 3% to 6% of the world GDP according to different approaches. It is known that this rate has decreased less than %10 which should be increased for the benefit of Turkey. Agriculture in Turkey has been developed for more than 90 years. Agricultural production potential can still satisfy the domestic agricultural demand although the system has several impediments. Figure 1 shows most produced commodities of Turkey for 23 year period. Although there is a significant increase can be observed, the price of agricultural products tends to increase. This makes productivity and planning problem that Turkey has been facing.

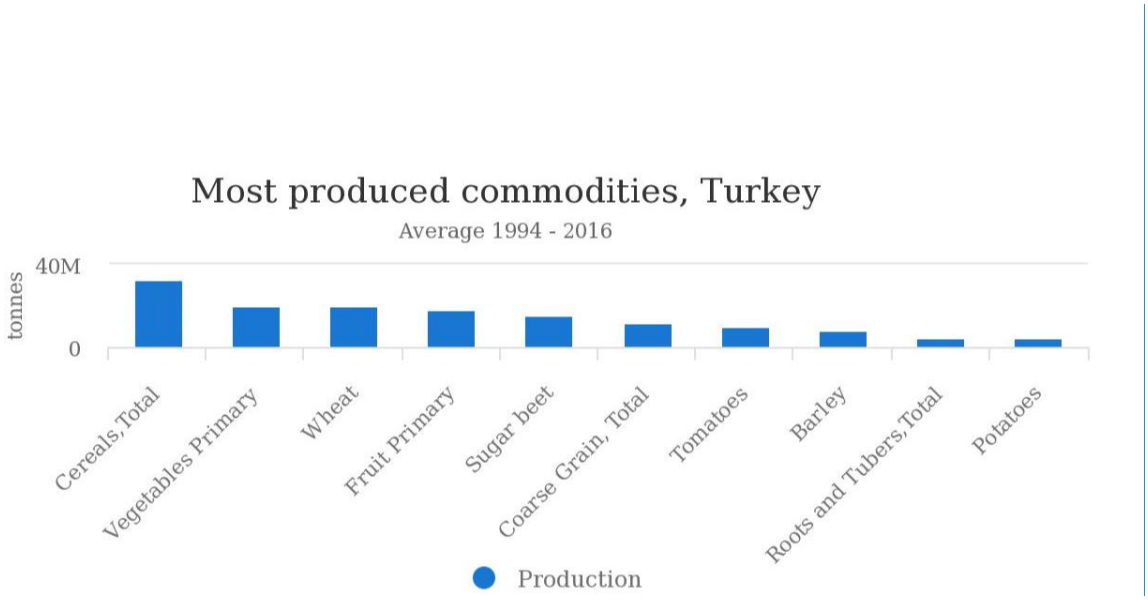

Figure 1. Most produced commodities with respect to year period between 1994-2016

In Figure 2 one of the most important agricultural product, rice production of Turkey can be observed. In Figure 3 top ten producers of rice are shown. Almost half of the total production of the rice produced by China. Food and non-alcoholic beverages are at the rate of 23% in the inflation basket and they are the most effective group in calculation of inflation rate.

Productivity in agricultural products is one of the most important indicator.

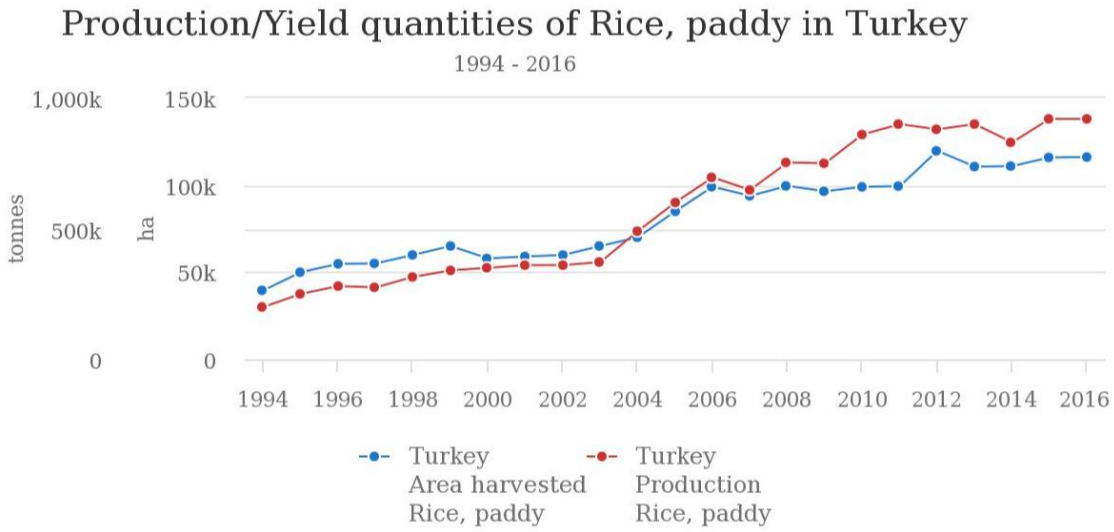

Figure 2. Rice production quantity of Turkey with respect to year period between 1994-2016

Figure 2 indicates obvious positive trend between time and total amount of production with the increase in population in Turkey. Especially in year period 2003-2006 it can be observed that positive linear increase existed.

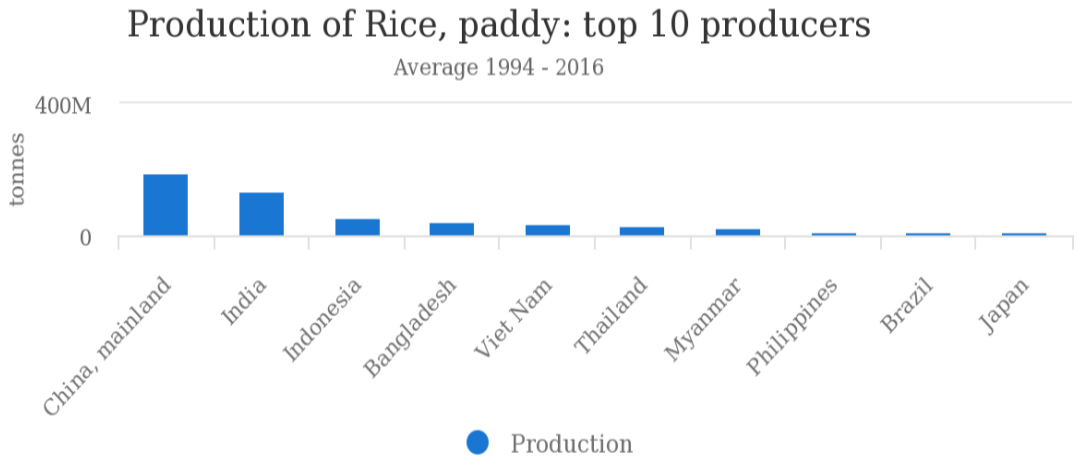

Figure 3. Top 10 producers of rice with respect to year period between 1994-2016

In Table 1 it can be shown that although Turkey has 20 times larger agricultural land than the Netherlands, agricultural goods export is approximately 5 times less. In 2017 the Netherlands exported €91.7 billion in agricultural goods while Turkey exported approximately €16 billion. When it is compared the total population between Netherland and Turkey it can be seen that Netherlands has a population of 17 million while Turkey has approximately 80 millon. Turkey has relatively large agricultural land when it is compared with all of the European Union .

In order to increase productivity in agricultural products, the detailed risk analysis is required for any process of production. There are many risk analysis studies exist in the literature where Gul and Guneri (2016) has used benefit of fuzzy logic with the application in Analytic Hierarchy Process to determine weights of criteria with the aim of prioritization of the alternative groups in manufacturing. On the other study Ebrahimnejad et al (2010) used MCDM methods to identificate risks with the help of fuzzy logic while Vahdani et al (2015) used parameters of failure mode and effects analysis (FMEA) to determine the preference of cause failures.

Table 1. Agricultural Land, Permanent Pasture, Hectares, 2017

Location	At the beginning of 2017 (thousand hectares)
United States	265 266.27
United Kingdom	11 277.00
Turkey	**14 616.69**
Switzerland	1 095.91
Spain	6 471.39
Slovenia	276.25
Slovak Republic	521.44
Romania	4 521.38
Portugal	1 875.85
Poland	3 175.50
Norway	649.8
New Zealand	10 006.00
Netherlands	**729.89**
Mexico	81 034.91
Luxembourg	67.08
Lithuania	775.6
European Union (28 countries)	59 349.06

In this study, MCDM based efficiency assessment model is prososed with using risk analysis of general components of Turkish agriculture. The risk is the inability to achieve a targeted result, loss or damage over a period of time. Turkish agricultural studies indicate significant risks due to efficiency problems. In order to minimize this possibility, economic and related risks are determined by risk analysis, and the scales of these risks and the areas to be taken are determined. Risk management is the process of identifying, controlling, eliminating, or minimizing uncertain events that may affect system resources. Risk assessment process requires and contains necessary actions are taken without delay for undesired trends or results. The importance of the issue in the management of the Turkish agriculture will be examined with a content that provides practical solutions and explains how it can identify and meditate their risks. Risk assessment studies gives an opportunity to identify potential hazards for the general system and indicate the significant and base problems of it. It also indicates the factors that effect the agricultural system and gives proactive measures in order to deal with problems.

2. Method

2.1. Multi Criteria Decision Making Methods

In this study, multi criteria decision making based model has been proposed with the most important indicators to be considered. First of all, organization and planning of cultivable lands for whole suitable agricultural lands of Turkey is needed. Optimization and selection of which agricultural products have to be produced with the concern of value added. Agricultural lands should be divided groups according to domestic and global demands. Systematic approach should be applied to agricultural goods especially for potential value added products. Decreasing import amounts of agricultural products in which Turkey has paid more money is one of the main objectives.

2.1.1. Analytic hierarchy process

Analytic hierarchy process (AHP) model can be used in agricultural risk analysis with considering main objectives of Turkey. Thomas L. Saaty developed AHP in 1980 as a measurement theory of intangible criteria (Aragon_es-Beltr_an et al. 2009). AHP exposes relevant priority vector when interpreting information preferred by decision makers based on a set of pairwise comparison values of objects. The AHP is based on the hierarchical structure and it is a kind of MCDM method. Goal, criteria and alternatives are 3 important elements of AHP. Goal shows the aim of the problem. Criteria is problem related elements that can be used for decision process. Saaty's scale of 1–9 has been used for each hierarchical level and pairwise comparisons are made with judgments using numerical values .

AHP has a ability to evaluate hierarchical structure.as a whole of both quantitative and qualitative criteria. The pair wise comparisons are organized in a matrix and priorities are derived from the matrix as its principal eigenvector. Consistency of decision makers can be checked in AHP with the help of consistency ratio(CR). 0.1 value is the maximum limit to ensure that judgment is adequately done. Steps of AHP are shown below: (Guneri et al. 2015; Tzeng and Huang 2011):

Step 1: Definition of problem and identifying target of problem
Step 2: Criteria, sub-criteria and alternatives are determined by creating hierarchical structure.
Step 3: Pairwise comparison matrix is created with respect to experts
Step 4: Computation of λmax(average) of values from previous step.
Step 5: Computation of consistency index, CI = (λmax - n)/(n - 1) .
n : total number of items being compared.
Step 6: Estimation of CR and CI and obtaining random index (RI)

2.1.1. VlseKriterijumska Optimizacija I Kompromisno Resenje

VIKOR (the VlseKriterijumska Optimizacija I Kompromisno Resenje) is one of the most common MCDM methods developed by Opricovic (1998) for multi-criteria optimization problems and compromise solutions. Ranking of alternatives and determination of compromise solution can be done with VIKOR. Solution shows the "ideal" which means closest to the optimal solution. This method focuses on selecting and sorting alternatives when there are conflicting criteria. The multi-criteria decision based on the basis of the proximity to the ideal solution "is also defined as the ranking index. VIKOR method steps are shown below:

Step 1: Creating alternatives and determining criteria

Step 2: Create a decision matrix: where $A_i$represents ith alternative, $i = 1,2,3,\dots m$; Cx_j : jth criterion, j =1, 2,..n; and x_{ij} separate performance of an alternative .

Step 3: The normalization step as follows: $F = \left[f_{ij}\right]_{m\times n}$

Here, $f_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}}$, $i = 1,2,3,\dots m$; x_{ij} : performance of A_i with respect to the jth criterion.

Step 4: Determination of the best and worst values of all criterion functions $j = 1,2,,\dots n$. If the jth function represents a benefit then:

$f_j^* = \max_i f_{ij}$, $f_j^- = \min_i f_{ij}$

Step 5: Estimation of utility measure (S) and regret measure (R): S and R for each alternative are calculated as :

$\boldsymbol{S_{ij} = w_j \frac{(f_j^* - f_{ij})}{(f_j^* - f_j^-)}}$, $\boldsymbol{S_i = \sum_{j=1}^{n} w_j \frac{(f_j^* - f_{ij})}{(f_j^* - f_j^-)}}$

$R_i = \max_j\left(S_{ij}\right) = \max_j(w_j \frac{(f_j^* - f_{ij})}{(f_j^* - f_j^-)})$

where, S_i and R_i , represent the utility measure and the regret measure, respectively, and w_j is the weight of the jth criterion, expressing the relative importance of each criterion. w_j can be calculated by AHP or Entropy method.

Step 6: Computation of VIKOR index (Q_i) for ith alternative by the following relation:

$$Q_i = \frac{v(S_i - S^-)}{(S^* - S^-)} + \frac{(1-v)(R_i - R^*)}{(R^* - R^-)}$$

where: Q_i represents the ith alternative VIKOR value, $i = 1,2,3,\dots m$;

$S^* = \max_i S_i$, $S^- = \min_i S_i$

$R^* = \max_i R_i$, $R^- = \min_i R_i$

where "v" denotes: weight of the maximum group utility. It ranges between 0 and 1, and is based on the level of compromise among decision makers. The higher the term v, the compromise is greater. In most cases, it is to be set to 0.5 (v =0.50).

Step 7: Rank the alternatives, sorting by the values S, R and Q, from the minimum value to the maximum. The results are three ranking lists.

Step 8: Ranking list by the measure Q (minimum) is proposed if the following two conditions are satisfied:

C1) Alternative A_1 must also be the best ranked by S or/and R

C2) Acceptable advantage: $Q(A_2) - Q(A_1) \geq DQ$; where DQ=1/(m-1); m is the number of alternatives.

3. Research Findings and Discussions

After MCDM methods application has been determined to deal with and avoid risks, it can be easily set up production planning according to obtained results. Agricultural risk analysis comes up with benefits of productivity and easiness of planning. Since Turkey has larger agricultural lands than lots of countries, productivity and planning should be considered properly. In this point advantages of AHP and VIKOR can be seen and agricultural strategy of Turkey can be revised. Optimization of agricultural lands with proper agricultural goods could increase significantly export of Turkey among other countries. More research and development studies should be done and implemented systematically in the agricultural area.

In this study agricultural productivity and planning problem is considered and MCDM method based structure have been proposed. For the future work, more detailed and specific product group base criteria set and detailed risk analysis could be applied to increase total number of value added agricultural products in Turkey.

4. Results

AHP and VIKOR are two important MCDM methods and applied in order to find each agricultural risk analysis criteria to increase productivity. Criterias are defined and found with the help of 8 experienced agricultural engineers

a) Unit domestic price of product
b) Unit export price of product
c) Export demand of product
d) Domestic demand of product
e) Local value of product
f) Global value of product
g) Unit cost of production of product

In this study each of criteria weights have been found with using AHP and ranking and prioritization of alternatives have been done with the help of VIKOR method. In Figure 4 AHP application interface can be seen. In Figure 5 AHP Application on Superdecision Program interface for this problem can be seen too.

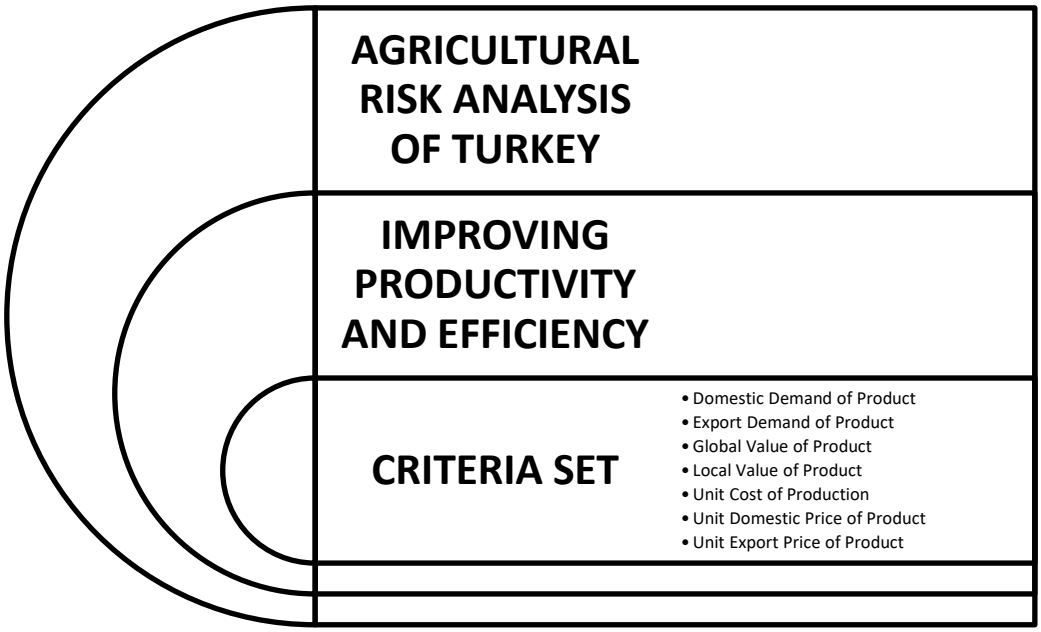

Figure 4. AHP Application Flow Chart

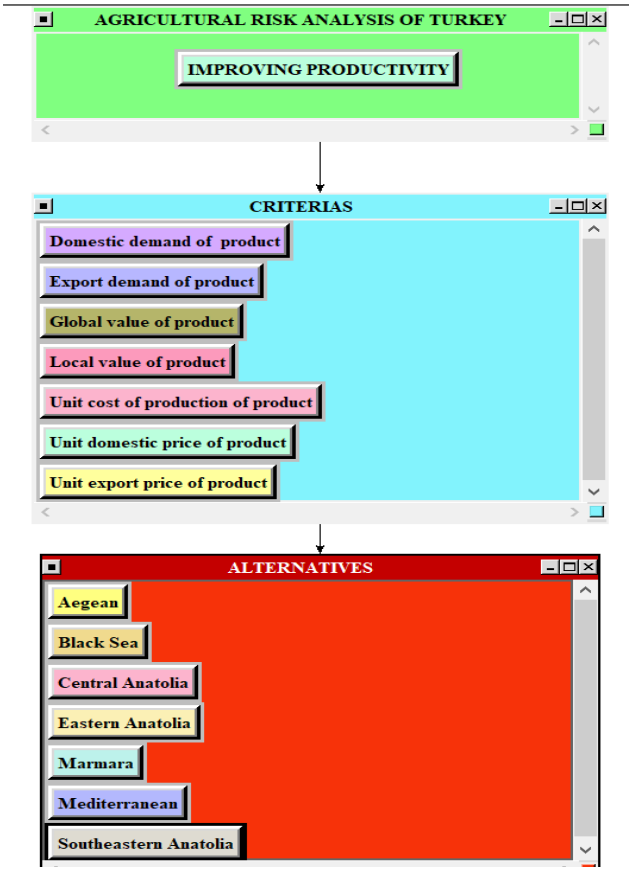

Figure 5. AHP Application on Superdecision Program.

After pairwise comparisons and finishing each steps each criteria weights are found in Table 2.
Global value of product has the highest weight and unit export price of product , export demand of product, domestic demand of product , local value of product, unit domestic price of product are sorted orderly.

Table 2. Subjective Weights Of Criterias

Criteria	**Normalized Weights**
Domestic demand of product	14.3%
Export demand of product	19.4%
Global value of product	27.2%
Local value of product	9.4%
Unit domestic price of product	8.2%
Unit export price of product	21.5%

According to the AHP application, evaluations of the agricultural engineers in 9 scale matrixes are used to evaluate the relative weights of each group by pairwise comparisons. Table 2 shows the obtained results.
After determining the weights of six risk parameters by AHP, the evaluations of each risk parameter of Turkish agriculture VIKOR is applied. In the first step of VIKOR weights of each risk parameter are used.
In the following step, the best f_j^* and the worst f_j^- values of all risk parameter ratings are determined by equations which are mentioned above. The normalized distance is calculated for each alternatives as shown in Table 3.

Table 3. Normalized Distances Of Risk Parameters.

Criteria	Normalized Weights
Domestic demand of product	14.3%
Export demand of product	19.4%
Global value of product	27.2%
Local value of product	9.4%
Unit domestic price of product	8.2%
Unit export price of product	21.5%

Figure 6. VIKOR Results.

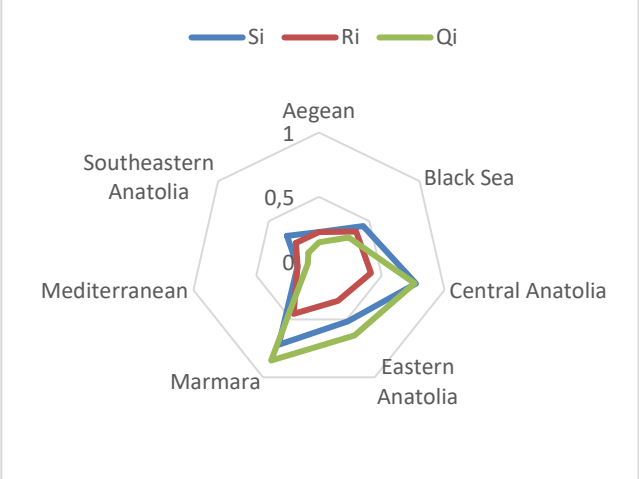

Table 4. Ranking of Alternatives

Alternatives	Aegean	Black Sea	Central Anatolia	Eastern Anatolia
Si	0.2268	0.44	0.77295	0.517143
Ri	0.2268	0.37	0.414571	0.34
Qi	0.1479	0.3	0.762009	0.638411

Table 5. Obtained Parameter Results For Alternatives

Alternatives	Marmara	Mediterranean	Southeastern Anatolia
Si	0.7188	0.1697	0.3164
Ri	0.4531	0.1697	0.2278
Qi	0.8551	0.09	0.1041

The required parameter values (Q,S,R) are calculated for all alternatives as in Table 4 and Table 5. The risk priority orders of the alternatives types by S, R, and Q in the decreasing order are obtained.

Figure 6 shows the parameter values for each alternatives. In this figure minimum values are indicating the best alternative, while alternatives having S, R, and Q values closest from 1 is ranked and indicating the worst. Obtained results indicate that the most important alternatives to produce agricultural good are in the whole system of the Turkey are stemmed from Mediterranean, Aegean, Black Sea, Southern Anatolia, Eastern Anatolia, Central Anatolia and Marmara respectively.

After MCDM methods application has been determined to deal with and avoid risks, it can be easily set up production planning according to obtained results. Agricultural risk analysis comes up with benefits of productivity and easiness of planning. Since Turkey has larger agricultural lands than lots of countries, productivity and planning should be considered properly. In this point advantages of AHP and VIKOR can be seen and agricultural strategy of Turkey can be revised. Optimization of agricultural lands with proper

agricultural goods could increase significantly export of Turkey among other countries. More research and development studies should be done and implemented systematically in the agricultural area.
In this study agricultural productivity and planning problem is considered and MCDM method based structure have been proposed. For the future work, more detailed criteria set and detailed risk analysis should be applied to increase total number of value added agricultural products in Turkey.

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