Agriculture Policy Scores of Selected Countries Through the Technique for Order of Preference (TOPSIS) Method

Abdulahakim Madiyoh, Özlem Turan, *Serkan Gürlük

Bursa Uludag University, Bursa, Turkey

Abstract. The purpose of this paper is to demonstrate the performance of agricultural sectors in the Association of Southeast Asian Nations (ASEAN) countries using selected criteria, to identify the deficiencies in agricultural policies, to explore competitive advantages and to guide food and nutrition policies. The analyses of this research use the secondary of time series data between the years 1967 - 2016 from 10 countries including; Brunei Darussalam, Cambodia, Indonesia, Laos PDR, Malaysia, Myanmar, Philippines, Singapore, Thailand and Vietnam which are the member of ASEAN. This research uses the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) method and the data used for the mentioned countries include the following criteria; total agricultural production value of the land, self-sufficiency of animal products criteria, self-sufficiency of crop products criteria, rural population rate, greenhouse gas emissions from agriculture, and value of foreign trade in agricultural products. The result of proximity coefficients calculated with the TOPSIS method, which according to the number of proximity and maximum benefit analysis should be done according to the order of preference. It is stated that Thailand, Philippines and Indonesia were the most successful countries in the agricultural policy performance in 1967. As for last decades, Malaysia became the most successful country in agricultural policy performance. We can infer from the results that Malay industrial sector triggered the agricultural sector by supplying financial investment atmosphere.

Key words: TOPSIS method, ASEAN countries, agriculture policies.

Introduction

It is a fact that one-dimensional partial economic analyses are no longer sufficient to solve complex problems. The most important assumption in one-dimensional analyses is that the effects of the other dimensions are assumed to be fixed and only one dimension (factor) is examined at each time. However, events and objects in the environment are formed not by the influence of only one factor but by the common influence of a large number of internal and external factors and show a complex structure. For this reason, events and objects should be defined not only by one variable but also by a number of variables and their joint effects (Ishizaka & Nemery, 2013). Therefore, multi-criteria decision-making techniques have found plenty of possibilities in many areas. Agriculture is such a sector. As the sector depends on nature, it produces an absolute necessity and involves with environmental pollution, it is neces-

sary to analyse and make comparisons at this sector while evaluating agricultural policies' impacts. At this point, the use of multi-dimensional decision-making methods can also be used to design government policies. Multi-criteria decision making techniques have been used in many research studies in recent years (Gamper & Turcanu, 2007).

Agriculture has a very important place in South East Asian countries. Nearly 50% of the active population is still working in the agricultural sector. The region surveyed is in general a region that is economically agriculture dependent because of the average share of 20% in. ASEAN countries are Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, Philippines, Singapore, Thailand, and Vietnam. However, while there are strong economies in these countries that have accelerated the transition of industrialization from agriculture such as Thailand, Indonesia, Malaysia, Vietnam, Philippines, Cambodia and also Laos are

* Corresponding Author's email:
serkan@uludag.edu.tr

largely based on agriculture. Agriculture in the region is also the sole source of income in terms of rural areas, and it is expressed that %9.4 of the population is malnourished (FAO *et al.*, 2019). It is very important to produce qualified agricultural policies in order to ensure the economic stability of the region's geography and at least to provide sufficient economic resources from the globalizing world in terms of agriculture. In this context, it is very important to monitor the development of agricultural policies in the historical process, and to determine the success of agricultural policies on a country basis. It is of great importance to determine the performance of countries' agricultural policies in order to coordinate agricultural policies and to enable ASEAN countries to produce common agricultural policies. The aim of this research is to demonstrate the performance of agricultural sectors in ASEAN member countries using selected criteria, to identify the policy success, to explore competitive advantages.

This research primarily includes South East Asian countries where the agriculture sector is still very important and can be effective in the creation of funds that will allow for economic development. These countries are at a point where the agricultural sector can grow strategic products. However, they have not been as competitive as international competitors in agricultural trade. In addition, the presence of many sub-regions in the rural area in the study area increases the importance of research.

Current study contributes to existing literature by using new data set secured from agricultural policies. In addition, research results will help to understand agri-politic success or failures in the South Asian Region.

Materials and Methods

The analyses of this study use secondary of time series data between the years 1967-2016 from 10 countries including Philippines, Malaysia, Thailand, Indonesia, Singapore, Brunei Darussalam, Vietnam, Laos PDR, Myanmar and Cambodia which are the member of the Association Southeast Asian Nations. The data used are generally taken from Food and Agriculture Organization-FAO, the World Bank and each country's agricultural reports. The data used for the mentioned countries include the following 6 criteria. In selection of these criteria, we applied the related literature (Gürlük & Uzel, 2016).

Total agricultural production value of the land: the unit production amounts of the products grown in the land agricultural production system and the farm yard prices are taken into consideration. According to the performance criterion, it is an economic criterion to be maximized as this value is a good situation. (USD/ha

for Crop Production) (USD for Animal Production).

Self-sufficiency of animal products criterion: the amount per capita of the products produced in the basin agricultural production system is taken into account. According to the performance criterion, this increase is an economic criterion that can be maximized if it is a good situation. (Kg/person for animal products).

Self-sufficiency of crop products criterion: the amount per capita of the products produced in the basin agricultural production system is taken into account. According to the performance criterion, this increase is an economic criterion that can be maximized if it is a good situation. (Kg/person for crop products).

Employment in agriculture rate: the ability to leave rural people in the agricultural sector is an important performance indicator. Agriculture population / Active population can be measured. According to the performance criterion, increasing this value is an economic criterion to be minimized since it is a good situation.

Greenhouse gas emissions from agriculture: according to the performance criterion, increasing this value is an economic criterion to be minimized as it is a good situation.

Value of foreign trade in agricultural products: increasing share of foreign trade in agricultural products is an important agricultural policy performance indicator. It is therefore the criteria that can be maximized according to the methodology (Balci, 2017).

This paper uses the Technique for Order of Preference by Similarity to Ideal Solution-TOPSIS method. A positive ideal solution maximizes the benefit criteria or attributes and minimizes the cost criteria or attributes, whereas a negative ideal solution maximizes the cost criteria or attributes and minimizes the benefit criteria or attributes (Cristobal, 2012). The TOPSIS method is expressed in a succession of six steps as follows:

Step 1: Calculate the normalized decision matrix. The normalized value r_{ij} is calculated as follows:

$$r_{ij} = x_{ij} \sqrt{\sum_{i=1}^m x_{ij}^2} \quad i=1, 2, \dots, m \text{ and } j=1, 2, \dots, n. \quad (1)$$

Step 2: Calculate the weighted normalized decision matrix. The weighted normalized value v_{ij} is calculated as follows:

$$v_{ij} = r_{ij} \cdot w_j \quad i=1, 2, \dots, m \text{ and } j=1, 2, \dots, n. \quad (2)$$

Where w_j is the weight of the j^{th} criterion or attribute and $\sum_{j=1}^n w_j = 1$

Step 3: Determine the ideal (A^*) and negative ideal (A^-) solutions.

$$A^+ = \{(\max_{j \in C^+} v_{ij}), (\min_{j \in C^+} v_{ij})\} = \{v_j^+ | j = 1, 2, \dots, m\} \quad (3)$$

$$A^- = \{(\min_{j \in C^-} v_{ij}), (\max_{j \in C^-} v_{ij})\} = \{v_j^- | j = 1, 2, \dots, m\} \quad (4)$$

Step 4: Calculate the separation measures using the m-dimensional Euclidean distance. The separation measures of each alternative from the positive ideal solution and the negative ideal solution, respectively, are as follows:

$$S_i^+ = \sqrt{\sum_{j=1}^m (v_{ij} - v_j^+)^2} \quad j = 1, 2, \dots, m \quad (5)$$

$$S_i^- = \sqrt{\sum_{j=1}^m (v_{ij} - v_j^-)^2} \quad j = 1, 2, \dots, m \quad (6)$$

Step 5: Calculate the relative closeness to the ideal solution. The relative closeness of the alternative A_i with respect to A^+ is defined as follows:

$$RC_i^+ = \frac{S_i^-}{S_i^+ + S_i^-}, i = 1, 2, \dots, m \quad (7)$$

Step 6: Rank the preference order.

Figure 1 indicates hierarchical structure of the model employed in this paper. It is possible to understand the best agricultural policy in the region by looking at all variables that can affect the countries.

Figure 1. Hierarchical Structure of Selection the Most Successful Country in Agricultural Policy Performance.

Results and Discussion

A total of ten countries, such as the Philippines, Malaysia, Thailand, Indonesia, Singapore, Brunei Darussalam, Vietnam, Laos PDR, Myanmar and Cambodia were included in the evaluation. The main feature of all countries is the preference of agricultural policy performance. The evaluation criteria are based on 6 criteria such as gross production value, self-sufficiency of animal products, self-sufficiency of crop products, rural population rate, greenhouse gas emissions from agriculture and value of foreign trade in agricultural products.

Most of the comparison values of the countries

included in the application was obtained from Food and Agricultural Organization-FAO. Within the scope of the research, the weight values of the criteria were determined according to the advisor's recommendation. The analysis with the TOPSIS method began from 1967, 1980, 1990, 2000, 2010 and 2016 was announced as above. Table 1 indicates all employed data in the TOPSIS analysis, while Table 2 indicates the weight values of evaluation criteria.

Weights were deliberately selected to understand the self-sufficiency features of the implemented agricultural policies in selected countries. The reason that the weight values of the first three criteria (C1, C2 and C3) are higher than the other weighted values

Table 1

Decision Matrix (A)

ASEAN Country	Gross Production Value	Self-Sufficiency of Livestock Products	Self-Sufficiency of Crop Products	Rural Population	Greenhouse gas emissions from agriculture	Value of foreign trade in agricultural product
	(constant 2004-2006 1000 ID)	Livestock (kg/person)	Crops (kg/person)	(% of total population)	(Gigagram)	export/import (USD)
Brunei	50260.53	85.35	50.58	23.16	146.34	0.004
Cambodia	4779495.27	6.95	1432.75	79.94	18661.54	0.59
Indonesia	70140033.80	17.61	1396.82	45.09	169865.90	1.93
Laos	3060889.87	15.19	2115.22	63.8	8564.73	0.43
Malaysia	15474711.19	82.48	2971.65	24.56	12532.91	1.47
Myanmar	21165406.39	53.01	1110.25	67.46	69297.56	0.63
Philippines	21561916.31	20.26	858.12	55.81	51260.82	0.45
Singapore	31097.31	22.85	4.50	0.01	206.07	0.86
Thailand	32589599.88	42.00	2639.30	47.53	56974.46	2.46
Viet Nam	33348792.85	18.53	1144.98	65.5	56303.65	0.47

Table 2

Weight Values of Evaluation Criteria

	Gross Production Value	Self-Sufficiency of Livestock Products	Self-Sufficiency of Crop Products	Rural Population	Greenhouse gas emissions from agriculture	Value of foreign trade in agricultural product
	(constant 2004-2006 1000 ID)	Livestock (kg/person)	Crops (kg/person)	(% of total population)	(Gigagram)	export/import (USD)
	C1	C2	C3	C4	C5	C6
Criterion weights	0.20	0.20	0.20	0.2133	0.133	0.133

because the purpose of this research is to find out which countries have effective agricultural management in terms of utilizing agricultural land. The research is open to other research question by changing the weights.

According to the proximity coefficients calculated with TOPSIS methodology, the selected countries' historical agricultural policy successes are as in Table 3. According to Table 3, the results found in TOPSIS method are expressed from 1967, 1980, 1990, 2000, 2010 and 2016. In 1967, Thailand was the most successful country in agricultural policy performance, followed by Philippines and Indonesia. In 1980,

Thailand was still the most successful country in agricultural policy performance, but Malaysia and Singapore became the second and third as well. The most significant period was shown in the long run of four periods between 1990-2016 that Malaysia became the most successful country in agricultural policy performance and the second and third countries were Thailand and Indonesia.

In addition, if examined according to the first criterion (C1), the most successful country from 1967 to 2016 was Indonesia. However, according to other criteria, Indonesia was not in good condition, and it

Table 3

**Results of Analysis in ASEAN Countries for Six-Year Comparison
of the Performancen in Agricultural Policy by TOPSIS Method**

ASEAN Country	1967	1980	1990	2000	2010	2016
<i>Brunei</i>	7	6	6	4	4	4
<i>Cambodia</i>	4	10	9	10	10	9
<i>Indonesia</i>	3	5	3	3	3	3
<i>Laos</i>	9	8	7	8	8	6
<i>Malaysia</i>	6	2	1	1	1	1
<i>Myanmar</i>	8	7	10	9	6	8
<i>Philippines</i>	2	4	5	7	9	10
<i>Singapore</i>	5	3	4	5	7	5
<i>Thailand</i>	1	1	2	2	2	2
<i>Viet Nam</i>	10	9	8	6	5	7

has taken the third place in recent years after Malaysia and Thailand, respectively. If it is examined according to the fourth criterion (C4), the most successful country from 1967 to 2016 was Singapore. Of course, most of 100% in Singapore people live in urban areas. However, according to other criterion, Singapore's position was not good. Therefore, in 2016 Singapore took the sixth place in agricultural policy performance in ASEAN. In fact, Singapore's income does not mostly depend on agriculture as well. On the other hand, in 1967 the most unsuccessful country in agricultural policy performance was Vietnam; in 1980, it was Cambodia, in 1990 it was Myanmar, in 2000 and 2010 it was Cambodia, but in 2016 the most unsuccessful country in the performance of agricultural policies was Philippines. In recent years, the reason why Philippines and Cambodia are most unsuccessful in agricultural sector of ASEAN, might be self sufficiency of agricultural products number which is low, but agricultural production value is high while the country is experiencing international trade deficit in agricultural products. Rural population is still high, it is more than 50% of total population. These problems should be solved by government policy.

Surveyed study shows some inferences for the region. Southeast Asian countries are composed of countries with different levels of development. These countries are also called "Factory Asia" with the industrial moves they have developed. Many countries in the region reached over 5% of GDP in 2000-2016. In the same period, the population increased by 1.3% annually. These countries have begun to overcome food security problems with industrialization. The

malnutrition rate, which was 31% in the 1990s decreased below 10% between 2014-2016. Despite all these developments, the rural population is 50% or more. Unlike others, Malaysia has a rural population of 25%. The country with the most agricultural area in terms of surface area is Thailand. This country cultivates 43.2% of its total area. Vietnam and Cambodia follow this country at rates of 36% and 30%, respectively.

One of the important problems in the agricultural sector is the lack of productive enterprises. Business size stands out at this point. Over 80% and 70% of Vietnam and Indonesia agricultural holdings have less than 2 Ha of land, respectively. It is emphasized that the most important policies come from the Philippines in this region. Within the framework of the policy of redistribution of agricultural lands in the Philippines, it has been observed that the land per enterprise has increased rapidly. Despite all these developments, it can be said that the average farm size of the countries in the region is between 1 and 2 ha (Lowder, Skoet & Singh 2014; OECD, 2017).

Malaysia and Thailand are the two best countries in terms of designing agricultural policy among the countries in the region. The superiority of these two countries emerges with the production of industrial agricultural products. While Thailand ranks first in the world rubber production, Malaysia has an important position in palm oil production. These countries are not separated from the countries in the region in terms of agricultural policies that can be an example to other countries. However, it can be said that more importance is given to agricultural infrastructure with its strong economic structures. Malaysia has managed to bring the

rural population below 25%. Thailand has to cope with the dense rural population. Considering the unit income per agricultural worker, the superiority of Malaysia is outstanding. In addition, it can be said that Malaysia is the country that can move industry and agriculture sectors together among the countries in the region.

Another important factor is the 'budget' allocated to agriculture that was not included in the scope of research in terms of data deficiency; however, it determines the success of countries in agricultural policies. When we look at the data of 2018, the following sort of results emerges in terms of the budget allocated to agriculture among the countries subject to this research; Thailand (USD 3.5 billion), Indonesia (USD 1.7 billion), Malaysia (USD 1.5 billion), Philippines (USD 1.1 billion), Vietnam (USD 884 million), Myanmar (USD 676 million), Cambodia (USD 105 million), Brunei (USD 23 million). There is no data on the budget allocated to agriculture for Singapore and Laos. This parameter supports important phenomenon discussed in this paper.

Conclusions

In this paper, the overview of agricultural sector condition in ASEAN countries with comparison based on the main point as selected criteria which significantly impacts the agricultural sector in the country is presented. The result showed the agricultural sector condition of each country that is able to identify the deficiencies in agricultural policies based on selected criteria. Additionally, this paper can give some suggestions to explore competitive advantages and to guide food and nutrition policies especially to ASEAN country and also outside ASEAN countries that has a potential in the agriculture sector. Despite of this, the paper analysis has some limitations. There are other variables to be put into the model. For example, the number of agricultural machinery technology usage and number of employed in agriculture. These two variables are important and significantly impact agricultural sector, but because the data is incomplete, it is not included. To evaluate the policies implemented by a country, all domains need to be evaluated. However, difficulties in accessing data and financial deficiencies make it impossible to do such a study. However, the impact of the areas created by the policies and the changes it creates in the welfare of the society can be found with the help of certain criteria to be chosen. Based on this idea, the analysis of representative domains selected from the political impact set can also produce important information and results in many cases. Multivariate decision making methods fulfil an important function at this point. Although such methods seem to work mostly in the decision-making step of consumers in the fields of

business and marketing, they have been applied in areas such as agricultural policy and environmental economy in recent years. Indeed, the decisions to be made by the decision-makers with managerial power are also very important in increasing the welfare of the society (or may decrease in the opposite case). It will help us understand the issues such as whether these decisions made and the choices made create the right resource allocation, whether the resource efficiency is reached or not. In this research where agricultural policies are evaluated, the use of multivariate decision methods makes an important contribution to the literature.

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