



RESEARCH ARTICLE

THE ANALYSIS OF HUMAN DEVELOPMENT LEVELS VIA MULTI-CRITERIA DECISION MAKING METHODS WITH DIFFERENT WEIGHTING TECHNIQUES: THE CASE OF EUROPEAN UNION MEMBERS, CANDIDATES AND POTENTIAL CANDIDATES

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ABSTRACT

The measurement of countries' human development levels goes beyond measuring gross domestic product in recent years. There is not a general concern about the structural expression of human development. United Nations Programme makes researches to measure development with human development index (HDI) based upon the perspective of "enlarging people's choices". On the other side, European Union (EU) analysis how to measure human development in European context. There is a huge necessity of alternative data and methods for the analysis. In this study, it is aimed to develop an approach to measure the human development level with a different method from the United Nations' human development index and rank the countries of European Union (EU) members, candidates and potential candidates according to their development levels. For this purpose, two of Multicriteria Decision Making Methods (MCDM): TOPSIS and WSA are used. These methods are applied by using three weighting techniques; equal weighted, point method and Saaty's method separately. The results obtained are compared with the values of HDI.

INTRODUCTION

Over the past quarter-century the world has changed and with it the development landscape. New countries have emerged, and our planet is now home to more than 7 billion people, one in four of them young. The geopolitical scenario has also changed, with developing countries emerging as a major economic force and political power. Globalization has integrated people, markets and work, and the digital revolution has changed human lives, (United Nations Human Development Programme, 2016). In 1990, United Nations Development Programme made the definition of human development as "a process of enlarging people's choices" (United Nations Human Development Programme, 1990), and the main aim of United Nations Human Development Index has been to go beyond monetary aspects in measuring human development. Human development is the notion that expresses a sophisticated improvement of people's life condition. United Nations Development Programme explains the human development concept in 2016.

Human Development Report as follows:

"Human development is a process of enlarging people's choices. But human development is also the objective, so it is both a process and an outcome. Human development implies that people must influence the processes that shape their lives. In all this, economic growth is an important means to human development, but not the end.

Human development is the development of the people through building human capabilities, by the people through active participation in the processes that shape their lives and for the people by improving their lives. It is broader than other approaches, such as the human resource approach, the basic needs approach and the human welfare approach. Human development is all about human freedoms: freedom to realize the full potential of every human life, not just of a few, nor of most, but of all lives in every corner of the world—now and in the future. Such universalism gives the human development approach its uniqueness" (United Nations Human Development Programme, 2016). Having long and healthy life, satisfying the basic needs like clean water and food, participating in social and political activities, opportunity of accessing more information and all other political and cultural rights could be defined as the basics of human development (Nartgün, et al., 2013). United Nations' human development index consists of three dimensions such as, long and healthy life, knowledge and a decent standard of living.

Long and healthy life has the indicator life expectancy of birth whose dimension index is "life expectancy index". The other dimension knowledge has two indicators which are expected years of schooling and mean years of schooling. These two indicators are combined within the dimension index "education index". The last dimension a decent standard of living has the indicator gross national income (GNI) per capita (PPP \$) and the dimension index "GNI index" (United Nations Human Development Programme, 2016).

The steps of calculating human development index are as follows:

Minimum and maximum values of indicators are determined in order to express each dimension index in scale of 0 to 1, and the dimension index is calculated by the formulation

$$\text{Dimension index} = \frac{\text{actual value} - \text{minimum value}}{\text{maximum value} - \text{minimum value}}$$

The human development index is the geometric mean of three dimension indices.

$$\text{HDI} = (I_{\text{Health}}, I_{\text{Education}}, I_{\text{Income}})^{1/3}$$

where I_{Health} is the dimension index of long and healthy life, $I_{\text{Education}}$ is the dimension index of knowledge and I_{Income} is the dimension index of a decent standard of living dimension.

United Nations Human Development programme classifies countries according to their HDI values as given below:

Table 1. Cutoff points of the HDI for grouping countries

Very high human development	0.800 and above
High human development	0.700-0.799
Medium human development	0.550-0.699
Low human development	Below 0.550

European Union is also doing regional researches about human development for EU member countries. The main objective of this project is to develop indicators that are capable of measuring and monitoring patterns and trends in human development across the regions of the EU member states. The human development index of United Nations cannot be applicable within the European context because of two reasons. One reason is that it measures human development at the aggregate country level only, while disparities across regions within the same country might well be larger than disparities across countries at large (Hardeman and Dijkstra, 2014). The other reason is, United Nations' human development definition is based on comparing performance of developing countries. In European context, there are more or less developed countries or regions. Consequently, EU proposed to include two indicators in each dimension such as; healthy life expectancy and infant mortality for health dimension, not in employment, education or training (NEET) and general tertiary education for knowledge dimension and net adjusted disposable household income and employment rate for income dimension. They assigned weights equally to each dimension, aggregated indicators by using arithmetic average and dimensions by using geometric average.

From the report, it is deductible that, there is not a general concensus about the structural expression of human development. There is the necessity of alternative data and methods for the analysis. Nowadays, different organisations are using various techniques for calculating and comparing the human development levels. In this study, we compared the EU member, candidate and potential candidate countries according to their human development levels. We generated the index by using two of Multicriteria Decision Making Methods; TOPSIS and WSA. These methods are calculated by using the weighting approaches; Equal Weighted, Point method and

Saaty's method separately. The results obtained are compared with the ranking of United Nations'.

MATERIALS AND METHODS

Multi-Criteria Decision Making Methods

Multi-Criteria Decision Making (MCDM) has seen an incredible amount of use over the last several decades. Its role in different application areas has increased significantly, especially as new methods develop, and as old methods improve (Velasquez and Hester, 2013). There are different methods used in the literature for the solution of MCDM problems, none of which provide a complete superiority over others (Dağdeviren, et al., 2007). The most widely used methods of MCDM are ELECTRE, TOPSIS, Promethee, Vikor, Oreste, Mappac and Weighted Sum Approach (WSA). These methods have always been developed according to historical order in order to overcome the theoretical deficiencies of the previous method. The objective of this study is calculating the United Nation's HDI by using a different method for the countries EU members, candidates and potential candidates. For this purpose, TOPSIS and WSA methods are used for measuring the human development levels.

TOPSIS Method

TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) was developed by Yoon and Hwang as an alternative to the ELECTRE method in 1980 (Hwang and Yoon, 1981). The basic concept of this method is that the selected alternative should have the shortest distance from the ideal solution and the farthest distance from the negative-ideal solution in a geometrical sense (Triantaphyllou, et al., 1998). TOPSIS is attractive in that limited subjective input is needed from decision makers. It has several advantages. It is easy to use, and the only subjective input needed is weights. A disadvantage is that its use of Euclidean distance does not consider the correlation of attributes. It is difficult to weight attributes and keep consistency of judgment, especially with additional attributes (Velasquez and Hester, 2013).

WSA Method

WSA (Weighted Sum Approach), aims to determine the choice that provides the maximum utility in the set of alternatives. It is based on calculation of alternatives' global utility values considering the normalized criteria weights (Doucek, 2012).

Weighting Variables

The process of determining weights is one of the most important steps of MCDM. In literature, there are different techniques for weighting variables. In this study, Equal Weighted method, Point method and Saaty's method are used for weighting variables. These methods are explained briefly in the following sections.

Equal Weighted Method

This method is based on weighting equally all criteria with assuming that all criteria that are used while comparing all alternatives have the same importance.

Point Method

Point method is one of the simplest weighting methods which depends on point allocation approach. It is expected from decision-makers to estimate the weights on a defined numerical interval. This method starts with assigning an arbitrary point to the most important criteria. In this study, 100 points are assigned to the most important criteria and low number points are assigned proportionally to the less important criteria in ranking. This process continues until the point is assigned to the least important criteria.

The Analytic Hierarchy Process (AHP)

The AHP method is basically based on pairwise comparison, and it is also known as Saaty's procedure (Saaty, 2005). Saaty's importance scale which is constituted for expressing the importance levels of criteria, is also used for weighting criteria in this study.

In the analysis, the countries "Kosovo under UN Security Council Resolution 1244" and "The Greek Administration of Southern Cyprus" are not put into account because of the lack of data in UN's report. Austria, Belgium, Denmark, Finland, France, Germany, Holland/Netherlands, Ireland, Luxemburg, Sweden.

The United Kingdom exist in the "very high development" group, and the other all EU members exist in the "high human development" group according to the UN's HDI values. In this study, WSA and TOPSIS methods are applied for ranking the countries to the degree of human developments. In the analysis, we applied the methods first without weighting and next weighting by using Saaty's scale and Point method. Calculating operations are performed with Sanna which is the add-on of Excel. A part of the data window of Sanna is as given in Figure 1.

Table 2. The data of countries

	Gross national income (GNI) per capita (PPPS)	Education Index	Life Expectancy Index	Human Development Index (HDI)	HDI Rank	
1	Albania	10252	0.715	0.892	0.764	31
2	Austria	43609	0.820	0.947	0.893	11
3	Belgium	41243	0.841	0.938	0.896	9
4	Bosnia and Herzegovina	10091	0.694	0.871	0.750	32
5	Bulgaria	16261	0.778	0.836	0.794	28
6	Croatia	20291	0.798	0.885	0.827	25
7	Denmark	44519	0.923	0.929	0.925	2
8	Estonia	26362	0.877	0.877	0.865	17
9	Finland	38868	0.847	0.939	0.895	10
10	France	38085	0.839	0.959	0.897	8
11	Germany	45000	0.914	0.940	0.926	1
12	Greece	24808	0.830	0.940	0.866	16
13	Holland/Netherlands	46326	0.897	0.949	0.924	3
14	Hungary	23394	0.834	0.851	0.836	23
15	Ireland	43798	0.910	0.939	0.923	4
16	Italy	33573	0.814	0.974	0.887	13
17	Latvia	22589	0.835	0.836	0.830	24
18	Lithuania	26006	0.882	0.823	0.848	20
19	Luxemburg	62471	0.783	0.952	0.898	7
20	Macedonia/ The former Yugoslav Republic of Macedonia	12405	0.673	0.854	0.748	33
21	Malta	29500	0.781	0.934	0.856	18
22	Montenegro	15410	0.797	0.868	0.807	26
23	Poland	24117	0.852	0.886	0.855	19
24	Portugal	26104	0.756	0.941	0.843	22
25	Romania	19428	0.769	0.844	0.802	27
26	Serbia	12202	0.760	0.847	0.776	29
27	Slovakia	26764	0.823	0.868	0.845	21
28	Slovenia	28664	0.886	0.932	0.890	12
29	Spain	32779	0.818	0.966	0.884	14
30	Sweden	46251	0.855	0.959	0.913	5
31	The Czech Republic	28144	0.878	0.904	0.878	15
32	The United Kingdom	37931	0.896	0.936	0.910	6
33	Turkey	18705	0.668	0.854	0.767	30

RESULTS

It is aimed to rank the countries; EU members, candidates (Albania, Montenegro, Macedonia, Serbia and Turkey), and potential candidates (Bosnia and Herzegovina and Kosovo) according to their human development levels by using the variables of HDI which are Gross National Income (GNI) per capita (PPPS), Education Index and Life Expectancy Index. For this purpose, the data (belongs to 2015) published in the human development report on 2016 are used. The data mentioned are given in Table 1.

DISCUSSION

The rankings of countries according to their human development levels by using TOPSIS and WSA methods with Equal weighted, with the weights of Saaty's scale and with the weights of Point methods are given in the Table 3, 4 and 5 respectively. There is the fact that determining one criteria how much important than others while using Point and Saaty methods. In most cases, the analyst takes the advantage of using usually valid statements or consulting expert opinion.

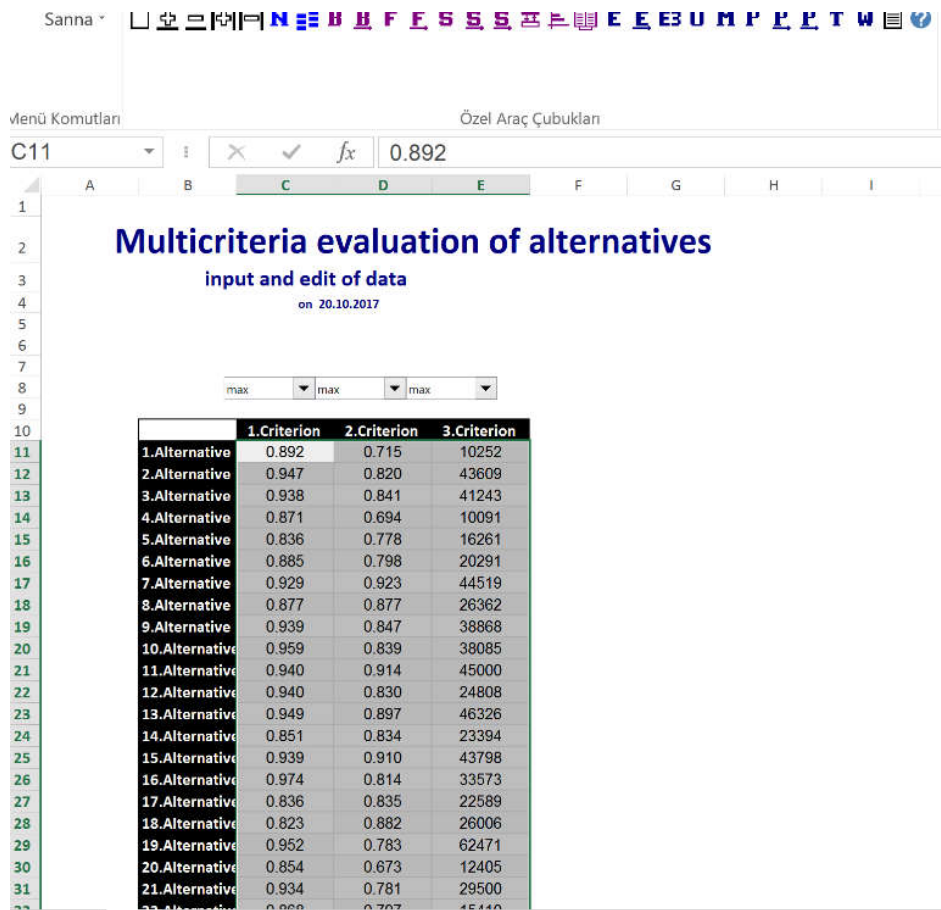


Figure 1. Sanna Plug-in Screen Shot

Table 3. The rankings according to the Equal Weighted Method

	Human Development Index (HDI)	HDI Rank	TOPSIS	TOPSIS RANK	WSA	WSA RANK
Albania	0.764	31	0.05464	31	0.21478	28
Austria	0.893	11	0.63995	7	0.68572	9
Belgium	0.896	9	0.59907	8	0.67825	10
Bosnia and Herzegovina	0.750	32	0.03583	33	0.13995	31
Bulgaria	0.794	28	0.13858	28	0.21175	29
Croatia	0.827	25	0.21413	25	0.37171	23
Denmark	0.925	2	0.66659	5	0.78642	4
Estonia	0.865	17	0.33508	17	0.49595	18
Finland	0.895	10	0.55655	9	0.67319	12
France	0.897	8	0.54246	11	0.70190	8
Germany	0.926	1	0.67537	4	0.80200	2
Greece	0.866	16	0.30412	21	0.56370	16
Holland/Netherlands	0.924	3	0.69880	2	0.80808	1
Hungary	0.836	23	0.27310	23	0.36346	24
Ireland	0.923	4	0.65310	6	0.78691	3
Italy	0.887	13	0.45866	12	0.67362	11
Latvia	0.830	24	0.25910	24	0.32653	25
Lithuania	0.848	20	0.32760	19	0.38102	22
Luxemburg	0.898	7	0.90532	1	0.76843	6
Macedonia/The former Yugoslav Republic of Macedonia	0.748	33	0.04778	32	0.08969	33
Malta	0.856	18	0.37744	15	0.51626	17
Montenegro	0.807	26	0.13637	29	0.30181	26
Poland	0.855	19	0.29204	22	0.46885	20
Portugal	0.843	22	0.31377	20	0.47742	19
Romania	0.802	27	0.18860	26	0.23780	27
Serbia	0.776	29	0.07712	30	0.18668	30
Slovakia	0.845	21	0.33025	18	0.40805	21
Slovenia	0.890	12	0.38035	14	0.64378	14
Spain	0.884	14	0.44436	13	0.65613	13
Sweden	0.913	5	0.69347	3	0.77478	5
The Czech Republic	0.878	15	0.36761	16	0.56820	15
The United Kingdom	0.910	6	0.54529	10	0.72465	7
Turkey	0.767	30	0.16150	27	0.12325	32

In scope of this study, the importance of criteria is determined in this way. There is the fact that determining one criteria how much important than others while using Point and Saaty methods. In most cases, the analyst takes the advantage of using usually valid statements or consulting expert opinion. In scope of this study, the importance of criteria is determined in this way. The most important indicator of human development of countries is the level of welfare, in other words GNI per capita (PPP \$) without doubt. Education and life expectancy indicators come after GNI per capita (PPP \$).

The pattern is the same in almost every country: people who are highly educated live longer on average than people who are less educated (Anon., 2016). From this point of view, in this study, the criteria are sorted from largest to smallest importance levels like this; GNI per capita (PPP \$), Education index and Life Expectancy index. The point values and the weights of Point method by using these values are given in Figure 2. The weights are obtained as 0.37037, 0.33333 and 0.29630 respectively.

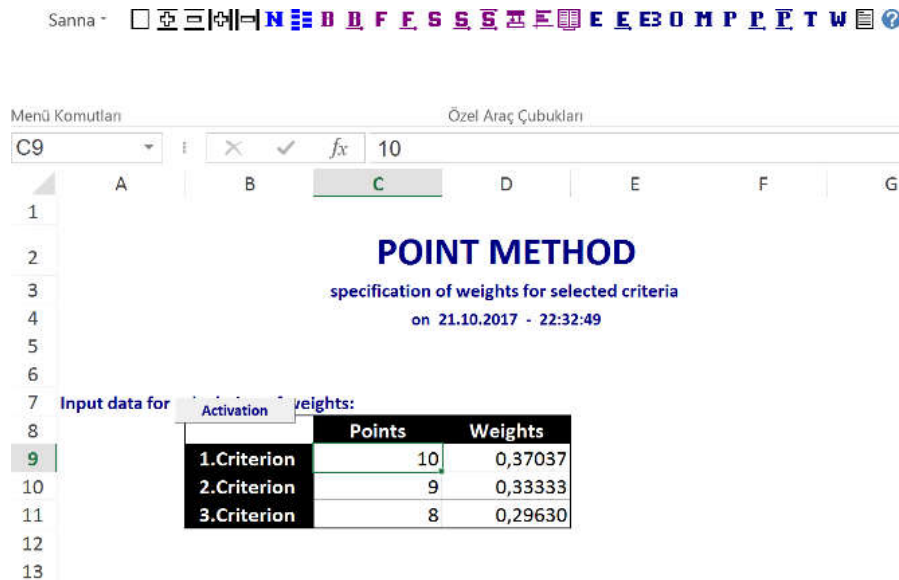


Figure 2. Weighting criteria according to the Point Method

Table 4. The rankings according to the Point Method

	Human Development Index (HDI)	HDI Rank	TOPSIS	TOPSIS RANK	WSA	WSA RANK
Albania	0.764	31	0.04632	32	0.19797	29
Austria	0.893	11	0.63967	7	0.67901	9
Belgium	0.896	9	0.59802	8	0.67207	10
Bosnia and Herzegovina	0.750	32	0.02993	33	0.12817	31
Bulgaria	0.794	28	0.13513	28	0.21293	28
Croatia	0.827	25	0.21029	25	0.36371	24
Denmark	0.925	2	0.66484	5	0.78476	3
Estonia	0.865	17	0.33076	17	0.49421	18
Finland	0.895	10	0.55490	9	0.66508	11
France	0.897	8	0.54042	11	0.68833	8
Germany	0.926	1	0.67359	4	0.79798	2
Greece	0.866	16	0.29891	21	0.54541	16
Holland/Netherlands	0.924	3	0.69731	2	0.80280	1
Hungary	0.836	23	0.26986	23	0.36600	23
Ireland	0.923	4	0.65117	6	0.78229	4
Italy	0.887	13	0.45578	12	0.65318	12
Latvia	0.830	24	0.25574	24	0.33218	25
Lithuania	0.848	20	0.32388	19	0.39227	22
Luxemburg	0.898	7	0.91398	1	0.77383	5
Macedonia/	0.748	33	0.04644	31	0.08373	33
The former Yugoslav Republic of Macedonia						
Malta	0.856	18	0.37546	14	0.50276	17
Montenegro	0.807	26	0.13040	29	0.29454	26
Poland	0.855	19	0.28756	22	0.46332	19
Portugal	0.843	22	0.31119	20	0.45980	20
Romania	0.802	27	0.18687	26	0.23925	27
Serbia	0.776	29	0.07173	30	0.18228	30
Slovakia	0.845	21	0.32815	18	0.40881	21
Slovenia	0.890	12	0.37516	15	0.63018	14
Spain	0.884	14	0.44138	13	0.63710	13
Sweden	0.913	5	0.69261	3	0.76699	6
The Czech Republic	0.878	15	0.36325	16	0.56110	15
The United Kingdom	0.910	6	0.54247	10	0.71662	7
Turkey	0.767	30	0.16196	27	0.12174	32

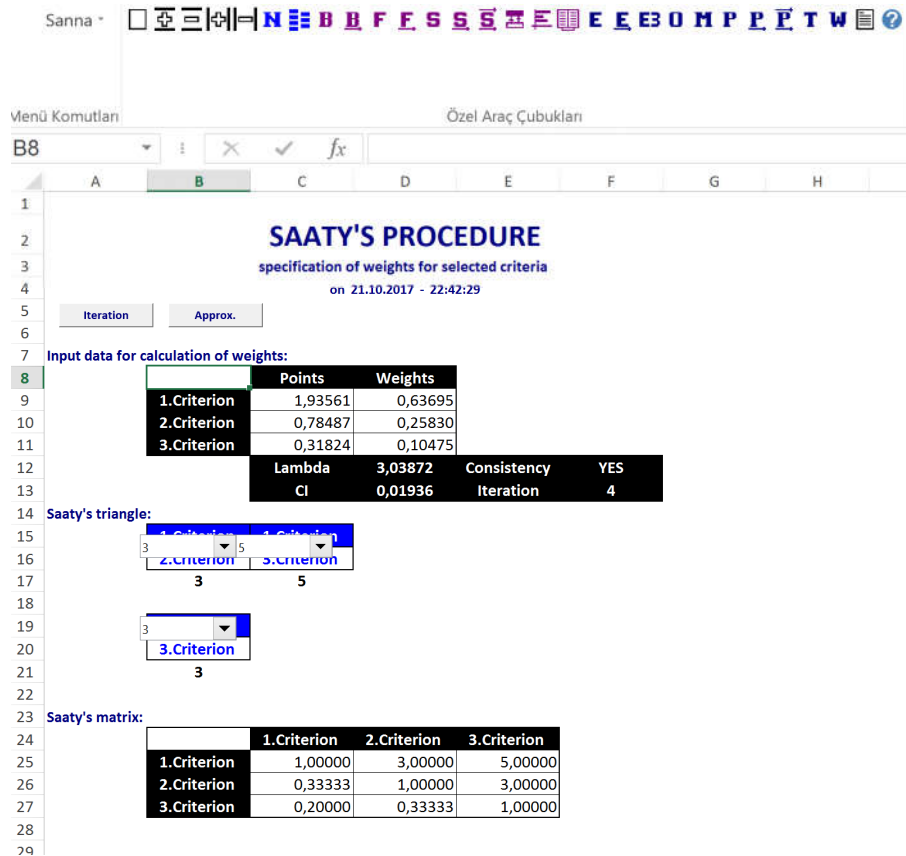


Figure 3. The weights obtained according to the Saaty's Method

Table 5. The rankings according to the Saaty's method

	Human Development Index (HDI)	HDI Rank	TOPSIS	TOPSIS RANK	WSA	WSA RANK
Albania	0.764	31	0.01618	32	0.09743	31
Austria	0.893	11	0.63968	7	0.64757	8
Belgium	0.896	9	0.59525	8	0.63383	9
Bosnia and Herzegovina	0.750	32	0.00938	33	0.05930	32
Bulgaria	0.794	28	0.12169	28	0.19547	28
Croatia	0.827	25	0.19779	25	0.29873	25
Denmark	0.925	2	0.65882	5	0.75048	4
Estonia	0.865	17	0.31495	18	0.44702	16
Finland	0.895	10	0.55032	9	0.61172	10
France	0.897	8	0.53533	10	0.60797	11
Germany	0.926	1	0.66785	4	0.75485	3
Greece	0.866	16	0.28405	21	0.42422	18
Holland/Netherlands	0.924	3	0.69280	2	0.75999	2
Hungary	0.836	23	0.25747	23	0.34934	23
Ireland	0.923	4	0.64500	6	0.73549	5
Italy	0.887	13	0.44922	12	0.53818	12
Latvia	0.830	24	0.24245	24	0.33016	24
Lithuania	0.848	20	0.30845	19	0.41030	19
Luxemburg	0.898	7	0.95938	1	0.84293	1
Macedonia/	0.748	33	0.04419	31	0.05471	33
The former Yugoslav Republic of Macedonia						
Malta	0.856	18	0.37111	14	0.42748	17
Montenegro	0.807	26	0.10800	29	0.22657	27
Poland	0.855	19	0.27189	22	0.40064	20
Portugal	0.843	22	0.30614	20	0.36572	22
Romania	0.802	27	0.18013	26	0.23041	26
Serbia	0.776	29	0.04854	30	0.13551	29
Slovakia	0.845	21	0.32042	17	0.39097	21
Slovenia	0.890	12	0.35856	15	0.52229	14
Spain	0.884	14	0.43426	13	0.52703	13
Sweden	0.913	5	0.69063	3	0.72348	6
The Czech Republic	0.878	15	0.34844	16	0.48844	15
The United Kingdom	0.910	6	0.53359	11	0.64788	7
Turkey	0.767	30	0.16388	27	0.12625	30

Table 6. The comparison of the methods according to the Equal Weighted Method

HDI “very high developed”	TOPSIS “very high developed”	WSA “very high developed”
Holland/Netherlands	Luxemburg	Holland/Netherlands
Ireland	Holland/Netherlands	Germany
Sweden	Sweden	Ireland
The United Kingdom	Germany	Denmark
Luxemburg	Denmark	Sweden
France	Ireland	Luxemburg
Belgium	Austria	The United Kingdom
Finland	Belgium	France
Austria	Finland	Austria
	The United Kingdom	Belgium
	France	Italy
		Finland
		Spain
		Slovenia
		The Czech Republic
		Greece
		Malta

Table 7. The comparison of the methods according to the Point Method

HDI “very high developed”	TOPSIS “very high developed”	WSA “very high developed”
Holland/Netherlands	Luxemburg	Holland/Netherlands
Ireland	Holland/Netherlands	Germany
Sweden	Sweden	Denmark
The United Kingdom	Germany	Ireland
Luxemburg	Denmark	Luxemburg
France	Ireland	Sweden
Belgium	Austria	The United Kingdom
Finland	Belgium	France
Austria	Finland	Austria
	The United Kingdom	Belgium
	France	Finland
		Italy
		Spain
		Slovenia
		The Czech Republic
		Greece
		Malta

Table 8. The comparison of the methods according to the Saaty’s method

HDI “very high developed”	TOPSIS “very high developed”	WSA “very high developed”
Holland/Netherlands	Luxemburg	Luxemburg
Ireland	Holland/Netherlands	Holland/Netherlands
Sweden	Sweden	Germany
The United Kingdom	Germany	Denmark
Luxemburg	Denmark	Ireland
France	Ireland	Sweden
Belgium	Austria	The United Kingdom
Finland	Belgium	Austria
Austria	Finland	Belgium
	France	Finland
	The United Kingdom	France
		Italy
		Spain
		Slovenia

The weights acquired by Saaty’s method are given in Figure 3. Accordingly, the weights of criteria as follows: 0.63695 for GNI per capita (PPP \$), 0.25830 for Education index and 0.10475 for Life Expectancy index.

Conclusion

In this study, the human development levels of the countries: EU members, candidates and potential members are examined. The variables, Life Expectancy index, Education index and

GNI per capita (PPP \$) are used. For this purpose, the rankings of human development levels of countries are constructed by using MCDM methods such as TOPSIS and WSA. These methods are applied separately for the weights obtained by Equal Weighted, Point and Saaty’s methods. As mentioned before in Section 3, the countries undertaking are separated into groups “very high developed” and “high developed” according to their HDI values. The human development levels obtained in this study are separated into two groups similarly,

to be able to make a comparison with the values of HDI. If the development level is greater than or equals to 0.5, the country takes part into the “very high developed” group and the other countries take part into the “high developed” group. The “very high developed” countries are compared with the values of HDI results. The findings are given in the following tables. It can be seen from the Tables 6-7-8 that; each human development method gives different ranking of “very high developed” countries. The countries take part into the HDI “very high developed” group are also being in this group according to the results of TOPSIS and WSA methods with the weights obtained by Equal Weighted method. In addition to this, Denmark and Germany are located into the “very high developed” group according to the Equal Weighted TOPSIS method and the countries Germany, Denmark, Italy, Spain, Slovenia, The Czech Republic, Greece and Malta are categorized into the “very high developed” group according to the Equal Weighted WSA method (Table 6).

The results obtained by TOPSIS with the weights of Point method (Table 7) are same as the results obtained by Equal Weighted TOPSIS (Table 6). The results of WSA method with the weights of Point method includes similar countries with the results of Equally Weighted WSA method, but they have different rankings. By comparison with the results obtained with Saaty’s method (Table 8), it is obvious that the results of TOPSIS method with the weights of Saaty’s method have same countries in “very high developed” countries with the methods Equal Weighted TOPSIS and TOPSIS method with the weights of Point method but there are small differences in rankings. It can also be seen that the countries The Czech Republic, Greece and Malta are taking part into the group “very high developed” according to the WSA method with the weights of Equal Weighted, Point methods, but they are not found in this group according to WSA method with the weights of Saaty’s method. Consequently, Germany, Denmark, Italy, Spain, Slovenia, The Czech Republic, Greece and Malta can be attached into the “very high developed” countries group, whereas they are not in that group according to the United Nations’ HDI values.

REFERENCES

- Anon., 2016. Max-Planck-Gesellschaft. [Online] Available at: <https://www.mpg.de/10795685/longevity-education> [22.10.2017].
- Dağdeviren, M., Eraslan, E. and Kurt, M., 2007. Makina Seçimi Problemi için TOPSIS, AHP, ELECTRE ve PROMETHEE Yöntemleri ile Karşılaştırmalı Bir Analiz. Yöneyem Araştırması ve Endüstri Mühendisliği 27. Ulusal Kongresi Bildiriler Kitabı.
- Doucek, W. J., 2012. Essentials of Management. 2 dü. Illinois: The Dryden Press.
- Hardeman, S. and Dijkstra, L., 2014. The EU Regional Human Development Index, Ispra: European Commission Joint Research Centre.
- Hwang, C. L. and Yoon, K., 1981. Multiple Attribute Decision Making: A State of the Art Survey. New York: Springer-Verlag.
- Nartgün, Ş. S., Kösterelioğlu, M. A. and Sipahioğlu, M., 2013. İnsani Gelişim İndeksi Göstergeleri Açısından AB Üyesi ve AB Üyelğine Aday Ülkelerin Karşılaştırılması. Trakya Üniversitesi Eğitim Fakültesi Dergisi, 3(1), pp. 80-89.
- Saaty, T. L., 2005. Theory and Applications of the Analytic Network Process. Pittsburg: PA:RWS Publications.
- Triantaphyllou, E., Shu, B., Sanchez, S. N. and Ray, T., 1998. Multi-Criteria Decision Making: An Operations Research Approach. Encyclopedia of Electrical and Electronics Engineering, Cilt 15, pp. 175-186.
- United Nations Human Development Programme, 1990. Human Development Report 1990, New York: Oxford University Press.
- United Nations Human Development Programme, 2016. Human Development Report 2016, New York: United Nations Human Development Programme.
- Velasquez, M. and Hester, P. T., 2013. An Analysis of Multi-Criteria Decision Making Methods. International Journal of Operations Research, 10(2), pp. 56-66.
