Int. J. Contemp. Math. Sciences, Vol. 8, 2013, no. 1, 31 - 40
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A Multicriteria Approach for Developing New Human Development Index

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Abstract

The National Planning Institute (NPI) computes the Human Development Index (HDI) to rank countries all over the world. The HDI is based on Life expectancy, literacy rate and enrollment of all different educational stages and Income. In this research, a new HDI is developed using a multicriteria approach and it is used to rank the Governorates of Egypt. The proposed new index is compared with the NPI index and other developed index. We found that our new index is more applicable and convincible to others.

Keywords: Human Development Index, Multicriteria, TOPSIS, Egypt

1. Introduction

Since 1990 Successive Annual International Human Development Reports issued by the United Nations development program (UNDP) to monitor what has been achieved in human development among the world countries through the Human Development Index, which consists of three subdirectories represent health, education and standard of living.

As Egypt was the first countries among the world in the issuance of Annual National Human Development Report that prepared by the National Planning Institute with the lines of the international report starting from 1994.This national report includes measurement of human development index (HDI) three-dimensional at the level of each government of the Republic governorates. Also, it has been Order the governorates according to their relative performance in the

field of human development according to this measure. Where Institute of National Planning fellow same approach worldwide to measure human development, it has been calculated the index based on the level of three major areas represent health, education and standard of living through four indicators:
1 - Life expectancy at birth: the assumption that the outcome of the various health indicators that show the extent to which succeeded health policies and programs in improving the health conditions of the population.
2 - literacy rate and enrollment of all different educational stages: the indexes together presumably reflect the different educational indicators reflecting the outcome of answers multiple questions, for example, does the majority of Egyptians have received adequate education, either through the formal education system or otherwise? Egypt has succeeded in achieving the full absorption of sons and daughters in basic education? What are the challenges to achieve the full absorption rate? And how to eliminate illiteracy?.
3 - Income: is the index assumes that reflects the standard of living and welfare of the people.
Engineer et al. (2008) consider the implications of using the HDI as a criterion for economic development plans. They examine the consequences of pursuing plans that maximize the HDI score for a given country. To do this, They construct an economic model where a planner chooses expenditures to maximize a well-defined objective function that includes the HDI as a special case. They get two main results. First, the planner tends towards minimizing consumption and maximizing expenditures on education and health. They get this result despite the fact that the HDI includes an income index as one of its components. Second, the optimal plan tends to imply equitable allocations even though inequality aversion is not explicitly modelled in the HDI.
Multiple criteria decision making (MCDM) is a modeling and methodological tool for dealing with complex engineering problems. Decision makers face many problems with incomplete and vague information in MCDM problems since the characteristics of these problems often require this kind of information. There are some methods that can deal with these problems such as Technique for Order Preference by Similarity to Ideal Solution (TOPSIS). TOPSIS is an approach for dealing with complex systems related to making a preferred choice among several alternatives and which provides a comparison of the considered options (Gumus, 2009).

2. Problem description

The problem of the study is about the methodology criticism that used by the National Planning Institute (NPI) to calculate the Human Development Index (HDI). This HDI is used to rank Egypt Governorates, hence the importance of this study is to prepare a new more reliable index to help in the rearrangement of the governorates of Egypt according to the level of performance in the human development.

This study aims to build a new index for measuring human development and use it to rank the Egyptian governorates using multi-criteria decision-making approach.

3. The Methodology

In order to create a new human development index, we use Technique for Order Preference by Similarity to Ideal Solution (TOPSIS).

TOPSIS is based on a simple and intuitive concept; it enables consistent and systematic criteria, which is based on choosing the best alternative having the shortest distance from the positive ideal solution and the farthest distance from the negative ideal solution. The positive ideal solution is the one with the most benefits and lowest cost of all alternatives, the negative ideal solution is the one with the lowest benefits and highest cost. Subsequently the alternatives are ranked with respect to the relative closeness to the ideal solutions. The purpose is to find the order of preference of various improvement alternatives that are closest to positive ideal solution and farthest from the negative ideal solution (Joshi et al., 2011).

The general TOPSIS process has following steps: [IC and Yurdakul (2010), Yue (2011), Jahanshahloo et al. (2006), Tsaur (2011)]

1- Establish the decision matrix for the problem data.

The problem data is represented in a decision matrix where the rows represent set of *m* feasible alternatives and the columns represent a finite set of attributes.

2- Construct normalize the decision matrix.

There are benefit attributes and cost attributes in the real problems. In order to measure all attributes in dimensionless units and facilitate inter-attribute comparisons, the following formulas are introduced to normalize each attribute value x_{ij} in decision matrix into a corresponding element r_{ij} in normalized decision matrix given

$r_{ij} = x_{ij} / \sqrt{\sum_{i=1}^{m} (x_{ij})^2}$, for benefit attribute x_{ij}; $i \in M, j \in N$ and

$r_{ij} = 1 - x_{ij} / \sqrt{\sum_{i=1}^{m} (x_{ij})^2}$, for cost attribute x_{ij}; $i \in M, j \in N$

Where x_{ij} and r_{ij} are the original and normalized score of decision matrix respectively.

3- Construct the weighted normalized decision matrix

Suppose that $W = \{w_1, w_2, \dots, w_n\}^T$ is the weight vector of the attributes where $w_j \geq 0, \sum_{j=1}^{n} w_j$. $w_{ij} = w_j r_{ij}$.

4- Determine the positive ideal and negative ideal solutions

$A^+ = \{v_1^+, \dots, v_n^+\}$ positive ideal solutions where $v_i^+ = \{\max(v_{ij}) \text{ if } j \in J; \min(v_{ij}) \text{ if } j \in J^-\}$, $A^- = \{v_1^-, \dots, v_n^-\}$ negative ideal solutions where $v_i^- = \{\min(v_{ij}) \text{ if } j \in J; \max(v_{ij}) \text{ if } j \in J^-\}$

5- Calculate the separation measures for each alternative.

The separation from positive ideal alternative is $S_i^+ = [\sum(v_i^+ - v_{ij})^2]^{\frac{1}{2}}, i = 1, \ldots, m$. Similarly, the separation from negative ideal alternative is $S_i^- = [\sum(v_i^- - v_{ij})^2]^{\frac{1}{2}}, i = 1, \ldots, m.$

6- Calculate the relative closeness to the ideal solution C_i

$C_i = \frac{S_i^-}{S_i^+ + S_i^-}, 0 < C_i^* < 1$, select the alternative with C_i close to 1.

Since $S_i^+ \geq 1$ and $S_i^- \geq 1$ then $C_i \in [0, 1]$

7. Rank the preference order.

A set of alternatives then can be ranked by preference according to the descending order of C_i; in other words, larger C_i means better alternative.

Applying the above TOPSIS method for the Egypt human development index, table 1 shows the decision matrix and the normalized decision matrix for the Egyptian Governorates.

Table 1: The decision and normalized decision matrices

Governorates	The decision matrix			Normalized decision matrix R		
	Life expectancy at birth (years)	Education	Real GDP per capita (ppps)	Life expectancy	Education	Real GDP
Cairo	71.30	74.83	7024.00	0.0372	0.0382	0.0272
Alexandria	72.00	77.57	8162.10	0.0379	0.0410	0.0367
Port Said	72.70	79.10	9590.60	0.0386	0.0427	0.0507
Suez	72.30	81.10	7950.70	0.0382	0.0449	0.0348
Damietta	72.60	78.57	7166.80	0.0385	0.0421	0.0283
Dakahlia	71.80	73.53	8283.20	0.0377	0.0369	0.0378
Shrkia	71.20	71.23	7909.50	0.0371	0.0346	0.0345
Kalyoubia	72.70	72.53	7394.90	0.0386	0.0359	0.0301
Kafr El Sheikh	70.60	70.00	8116.30	0.0364	0.0334	0.0363
Gharbia	72.30	74.43	7999.60	0.0382	0.0378	0.0352
Menoufia	71.50	73.37	8958.20	0.0374	0.0367	0.0442
Behera	71.50	68.13	8592.40	0.0374	0.0317	0.0407
Ismailia	70.90	77.40	8154.70	0.0367	0.0409	0.0366
Giza	69.50	79.37	7493.40	0.0353	0.0430	0.0309
Beni Suef	71.60	64.23	8052.20	0.0375	0.0281	0.0357
Fayoum	69.50	63.00	7667.00	0.0353	0.0271	0.0324
Menia	69.30	63.87	7869.00	0.0351	0.0278	0.0341
Assiut	70.70	65.10	7290.60	0.0365	0.0289	0.0293
Suhag	70.50	67.50	6663.40	0.0363	0.0311	0.0245
Qena	70.50	69.73	5806.80	0.0363	0.0332	0.0186
Luxor	69.80	75.97	8277.80	0.0356	0.0394	0.0377

Table 1 (continued): The decision and normalized decision matrices

Aswan	71.20	76.87	6415.80	0.0371	0.0403	0.0227
Red sea	71.20	82.30	7691.50	0.0371	0.0462	0.0326
New valley	71.20	81.97	11529.30	0.0371	0.0458	0.0732
Matrouh	71.10	67.63	9405.50	0.0369	0.0312	0.0487
North Sinai	71.20	76.80	8076.30	0.0371	0.0402	0.0359
South Sinai	71.10	77.77	11322.30	0.0369	0.0412	0.0706

Note: the education column is computed using the Adult literacy rate (+15) and the Combined lst, 2nd & 3rd level gross enrolment ratio by multiplying the adult literacy rate by 2/3 and the combined gross enrollment ratio by 1/3 and sum the results.
We have assigned the same weight (1/3) for each of the three criteria according to the recommendations of some experts specialized in the human development research area. Table 2 shows the weighted normalized decision matrix.

Table 2: the weighted normalized decision matrix

Governorates	The weighted Normalized decision matrix		
	Life expectancy	Education	Real GDP
Cairo	0.0124	0.0127	0.0091
Alexandria	0.0126	0.0137	0.0122
Port Said	0.0129	0.0142	0.0169
Suez	0.0127	0.0150	0.0116
Damietta	0.0128	0.0140	0.0094
Dakahlia	0.0126	0.0123	0.0126
Shrkia	0.0124	0.0115	0.0115
Kalyoubia	0.0129	0.0120	0.0100
Kafr El Sheikh	0.0121	0.0111	0.0121
Gharbia	0.0127	0.0126	0.0117
Menoufia	0.0125	0.0122	0.0147
Behera	0.0125	0.0106	0.0136
Ismailia	0.0122	0.0136	0.0122
Giza	0.0118	0.0143	0.0103
Beni Suef	0.0125	0.0094	0.0119
Fayoum	0.0118	0.0090	0.0108
Menia	0.0117	0.0093	0.0114

Table 2 (continued): the weighted normalized decision matrix

Assiut	0.0122	0.0096	0.0098
Suhag	0.0121	0.0104	0.0082
Qena	0.0121	0.0111	0.0062
Luxor	0.0119	0.0131	0.0126
Aswan	0.0124	0.0134	0.0076
Red sea	0.0124	0.0154	0.0109
New valley	0.0124	0.0153	0.0244
Matrouh	0.0123	0.0104	0.0162
North Sinai	0.0124	0.0134	0.0120
South Sinai	0.0123	0.0137	0.0235

After that, we obtained the positive ideal solutions and negative ideal solutions from the weighted normalized decision matrix. Table 3 shows these solutions.

Table 3: The positive and negative ideal solutions.

Criteria	Life expectancy	Education	Real GDP
Positive ideal solutions (Max)	0.0129	0.0154	0.0244
Negative ideal solutions (Min)	0.0117	0.0090	0.0062

The separations measures from the positive and negative ideal solutions for each alternative are computed as shown in tables 4,5.

Table 4: the separation measure from the positive solutions

Governorates	The separation measure from positive solutions			Sum	SQRT
	Life expectancy	Education	Real GDP		
Cairo	2.4126E-07	7.11254E-06	0.000235552	0.000243	0.0156
Alexandria	6.09029E-08	2.95859E-06	0.000148214	0.000151	0.0123
Port Said	0	1.37829E-06	5.652E-05	5.79E-05	0.0076
Suez	1.99692E-08	1.98656E-07	0.000163833	0.000164	0.0128
Damietta	1.25324E-09	1.86363E-06	0.000224269	0.000226	0.0150
Dakahlia	1.00398E-07	9.64327E-06	0.000139444	0.000149	0.0122
Shrkia	2.76572E-07	1.49167E-05	0.000166919	0.000182	0.0135
Kalyoubia	0	1.18156E-05	0.000206375	0.000218	0.0148
Kafr El Sheikh	5.37571E-07	1.8132E-05	0.000151565	0.00017	0.0130
Gharbia	1.99692E-08	7.85487E-06	0.000160187	0.000168	0.0130
Menoufia	1.77745E-07	9.99201E-06	9.35433E-05	0.000104	0.0102
Behera	1.77745E-07	2.3467E-05	0.000117735	0.000141	0.0119

Table 4 (continued) : the separation measure from the positive solutions

Ismailia	3.96605E-07	3.164E-06	0.000148754	0.000152	0.0123
Giza	1.22915E-06	1.16198E-06	0.000198711	0.000201	0.0142
Beni Suef	1.49562E-07	3.62129E-05	0.000156287	0.000193	0.0139
Fayoum	1.22915E-06	4.06332E-05	0.000185321	0.000227	0.0151
Menia	1.38369E-06	3.75093E-05	0.000169964	0.000209	0.0145
Assiut	4.88273E-07	3.32114E-05	0.000214534	0.000248	0.0158
Suhag	5.89164E-07	2.5397E-05	0.000264191	0.00029	0.0170
Qena	5.89164E-07	1.88605E-05	0.000331796	0.000351	0.0187
Luxor	1.01375E-06	5.19133E-06	0.000139832	0.000146	0.0121
Aswan	2.76572E-07	3.86431E-06	0.000283874	0.000288	0.0170
Red sea	2.76572E-07	0	0.000183444	0.000184	0.0136
New valley	2.76572E-07	1.54914E-08	0	2.92E-07	0.0005
Matrouh	3.14241E-07	2.49858E-05	6.66441E-05	9.19E-05	0.0096
North Sinai	2.76572E-07	3.9564E-06	0.000154508	0.000159	0.0126
South Sinai	3.14241E-07	2.72064E-06	7.54346E-07	3.79E-06	0.0019

Table 5: the separation measure from the negative solutions

Governorates	The separation measure from negative solutions			Sum	SQRT
	Life expectancy	Education	Real GDP		
Cairo	4.69391E-07	1.37454E-05	8.22296E-06	2.24E-05	0.0047
Alexandria	8.64005E-07	2.16631E-05	3.64934E-05	5.9E-05	0.0077
Port Said	1.38369E-06	2.70442E-05	0.000114432	0.000143	0.0120
Suez	1.07121E-06	3.51496E-05	2.93282E-05	6.55E-05	0.0081
Damietta	1.30166E-06	2.50927E-05	1.04953E-05	3.69E-05	0.0061
Dakahlia	7.3865E-07	1.06867E-05	4.1045E-05	5.25E-05	0.0072
Shrkia	4.23023E-07	6.31113E-06	2.80431E-05	3.48E-05	0.0059
Kalyoubia	1.38369E-06	8.62614E-06	1.48188E-05	2.48E-05	0.0050
Kafr El Sheikh	1.96348E-07	4.47852E-06	3.48582E-05	3.95E-05	0.0063
Gharbia	1.07121E-06	1.27575E-05	3.08998E-05	4.47E-05	0.0067
Menoufia	5.69581E-07	1.03259E-05	7.29913E-05	8.39E-05	0.0092
Behera	5.69581E-07	2.34131E-06	5.42389E-05	5.71E-05	0.0076
Ismailia	2.98704E-07	2.112E-05	3.6226E-05	5.76E-05	0.0076
Giza	4.5745E-09	2.80525E-05	1.69644E-05	4.5E-05	0.0067
Beni Suef	6.23422E-07	1.27232E-07	3.26474E-05	3.34E-05	0.0058
Fayoum	4.5745E-09	0	2.11786E-05	2.12E-05	0.0046
Menia	0	6.24646E-08	2.68141E-05	2.69E-05	0.0052
Assiut	2.28043E-07	3.73914E-07	1.27326E-05	1.33E-05	0.0037
Suhag	1.67063E-07	1.78189E-06	3.8468E-06	5.8E-06	0.0024

Table 5 (continued) : the separation measure from the negative solutions

Qena	1.67063E-07	4.12719E-06	0	4.29E-06	0.0021
Luxor	2.87143E-08	1.67769E-05	4.08349E-05	5.76E-05	0.0076
Aswan	4.23023E-07	1.9436E-05	1.86792E-06	2.17E-05	0.0047
Red sea	4.23023E-07	4.06332E-05	2.18192E-05	6.29E-05	0.0079
New valley	4.23023E-07	3.90619E-05	0.000331796	0.000371	0.0193
Matrouh	3.79126E-07	1.89291E-06	0.000101036	0.000103	0.0102
North Sinai	4.23023E-07	1.92312E-05	3.3468E-05	5.31E-05	0.0073
South Sinai	3.79126E-07	2.23254E-05	0.000300909	0.000324	0.0180

Finally, we determine the relative closeness to the ideal solution for each alternative which we call it the new human development index. Table 6 shows the new index compared with the prepared by the National Planning Institute (NPI) and Cobb-Douglas Model (Khater, 2012).

Table 6: The new index compared with NPI and Cobb-Douglas

Governorates	The new Index		the NPI Index		Cobb-Douglas Model	
	Value	Rank	Value	Rank	Value	Rank
Cairo	0.2331	23	0.743	17	0.735	14
Alexandria	0.3845	9	0.765	6	0.753	6
Port Said	0.6110	3	0.783	2	0.770	2
Suez	0.3873	7	0.776	4	0.765	4
Damietta	0.2877	19	0.764	7	0.750	7
Dakahlia	0.3723	11	0.751	13	0.736	12
Shrkia	0.3041	17	0.733	19	0.722	17
Kalyoubia	0.2522	21	0.746	15	0.732	16
Kafr El Sheikh	0.3252	15	0.731	21	0.716	19
Gharbia	0.3403	14	0.754	10	0.741	10
Menoufia	0.4735	5	0.753	11	0.739	11
Behera	0.3887	6	0.733	20	0.714	20
Ismailia	0.3809	10	0.758	8	0.747	8
Giza	0.3212	16	0.752	12	0.746	9
Beni Suef	0.2940	18	0.717	22	0.696	22
Fayoum	0.2339	22	0.699	27	0.683	27
Menia	0.2640	20	0.702	26	0.685	26

Table 6 (continued) : The new index compared with NPI and Cobb-Douglas

Assiut	0.1882	25	0.710	25	0.693	25
Suhag	0.1238	26	0.711	23	0.695	23
Qena	0.0996	27	0.711	24	0.699	21
Luxor	0.3858	8	0.748	14	0.736	13
Aswan	0.2155	24	0.745	16	0.735	15
Red sea	0.3691	12	0.773	5	0.764	5
New valley	0.9727	1	0.794	1	0.781	1
Matrouh	0.5146	4	0.734	18	0.717	18
North Sinai	0.3665	13	0.757	9	0.694	24
South Sinai	0.9024	2	0.778	3	0.767	3

Figure 1 shows the rank of each governorate according to the three approaches where MCI refers to our proposed multicriteria approach, NPI refers to the National Planning Institute approach and the last one refers to the Cobb-Douglas approach. From figure 1, we can conclude that some governorates have the same rank for the three approaches such as governorate number 18, 24
Some are near ranks such as governorate number 3, 27, some ranks are very far such as 5, and 26.

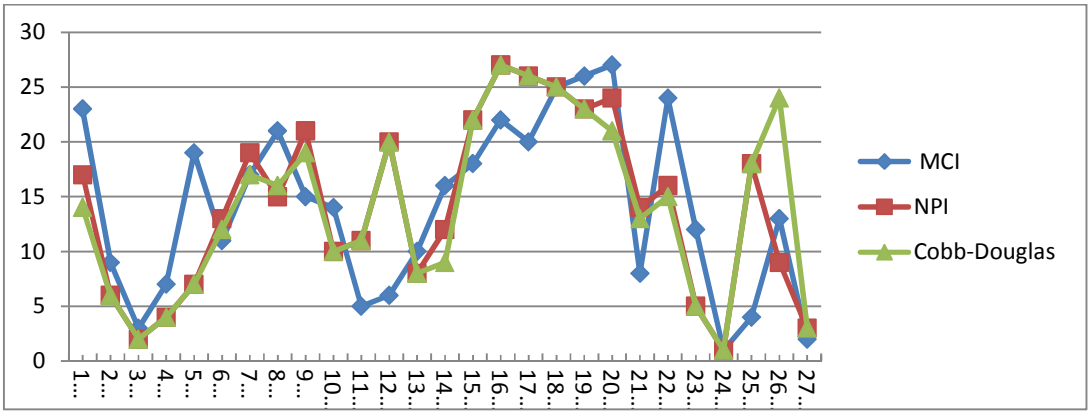

Figure 1: Governorates rank according to the three approaches

Conclusions

The HDI is a commonly used as a measure of well being in different countries. Here, we developed a new HDI based a multicriteria approach, used the same data used by NPI and we get a new rank for the Egyptian governorates. We compared the result of our proposed approach with NPI approach and other developed approach.

For further points for research, we recommend that other factors must be taken into account such as the quality of education. Also, we recommend using other approaches for modeling the HDI such as the fuzzy approaches.

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Received: October, 2012