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MEASURING NATIONAL GREEN ECONOMY DEVELOPMENT

Green Economy is one of the important criteria of the sustainable development of a country. UNEP defines the green economy as "one that results in improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities. It is low carbon, resource, efficient, and socially inclusive" [1].

The concept of green economy has to replace brown economy as world economic development progress. Decades of creating new wealth through a 'brown economy' model based on fossil fuels have not substantiality addressed social marginalization environmental degradation and resource depletion. In addition the world is still far from delivering on the Millennium Development Goals by 2015 [1].

In order to investigate the Green Economy problem it is necessary to use all conceptions about evolution, revolution and involution in the social systems.

United Nation Department of Economic and Social Affairs [2] having analyzed over 80 publications on the green economy and green growth concepts offers economic, social and ecological indicators to measure level of green economy development. Also, it is suggested to use Global Green Economy Index [2] – GGEI and NASDAQ OMX Green Economy Benchmark Index (QGREEN), in order to estimation level of Green Economy. GGEI estimated by using following indicators so as **Clean energy technology, Sustainable forms tourism and Improved domestic environmental quality**. QGREEN includes following – **Energy efficiency, Clean fuels, Renewable energy generation, Natural resources, Water, Pollution mitigation and Advanced materials.**

The green economy will emerge in different forms and in different regions, depending on the local economic strengths and weaknesses.

This paper focuses on National Green Economy Index (NGEI) to define development level of green economy in Azerbaijan. To meet this objective we follow twelve indicators: **Ecological quality – ECQ, Renewable energy – REE, Protection land – PRL, Green tourism – TOR, Quality of life – QOL, Green GDP- EPP, Energy intensity - ENI, Organic agriculture – ORA, Worldwide governance index – WGI, International Innovation Index - III, Transport greenhouse gas emissions per capita -GHG.**

In order to achieve this we have primarily applied data available from Azerbaijan and international organizations (UNEP, OECD). In order to solve problem of the National Green Economy Index (NGEI) we have used fuzzy set and fuzzy logic theory.

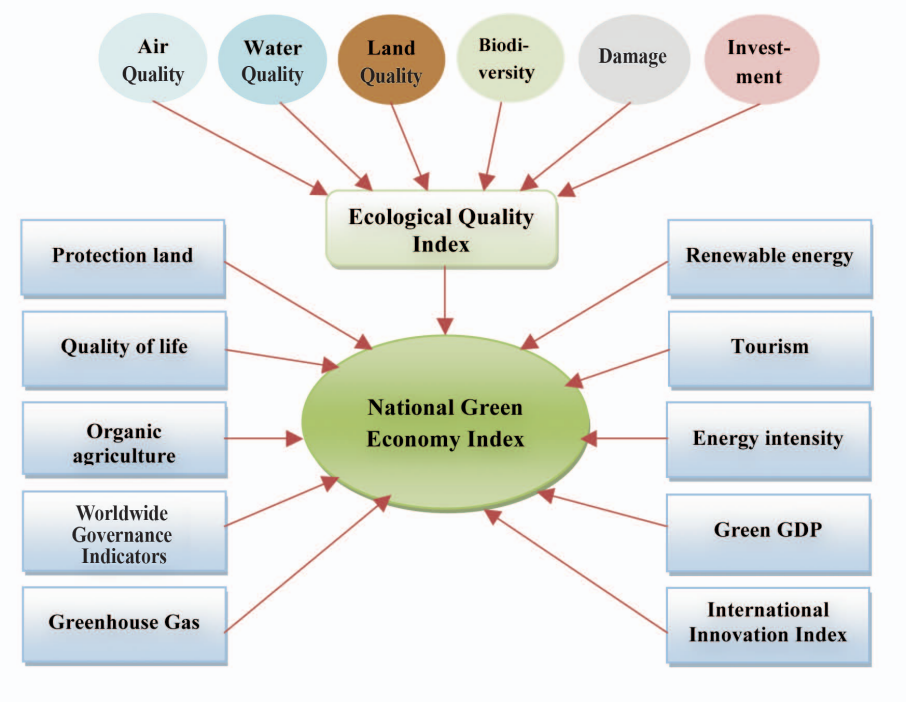

Fig.1. Structure of the elements Green Economy Quality.

Indicators of Green Economy

1. **Ecological Quality Index**– main indicator, which describes the level of development of the national green economy and it is characterized by quality of air, water, land, biodiversity, environmental protection investments, environmental damage.

2. **Renewable Energy**– is derived from natural processes that are replenished constantly. In its various forms, it derives directly or indirectly from the sun, or from heat generated deep within the earth. Included in the definition is energy generated from solar, wind, bio-

mass, geothermal, hydropower and ocean resources, and biofuels and hydrogen derived from renewable resources [3]. IEA estimates that about 11% (percent) of world marketed energy consumption is from renewable energy sources, with a projection for 15% (percent) by 2040 [4].

3. **Protected Area**– "land and/or sea especially dedicated to the protection and maintenance of biological diversity, and of natural and associated cultural resources, and managed through legal or other effective means" [5].

4. **Tourism in Green Economy**– refers to tourism activities that can be maintained or sustained, indefinitely in their social, economic, cultural, and environmental contexts "sustainable tourism". Sustainable tourism is tourism that takes full account of current and future economic, social and environmental impacts, addressing the needs of visitors, the industry, the environment and host communities. It is not a special form of tourism; rather, all forms of tourism may strive to be more sustainable [6].

5. **Quality of Life Index**– includes the following subindexes [7]: - Health; Education; Wealth; Democracy; Peace; Environment.

6. **Green GDP Index**= (GDP – EPE) / GDP, where GDP – gross domestic product, EPE – environmental protection expenditure.

7. **Energy Intensities**– expressed as total primary energy supply in tones of oil equivalent (TPES) per unit of GDP and per capita. Total primary energy supply (TPES) equals production plus imports minus exports minus international bunkers plus or minus stock changes [8]. In our investigation we use energy intensity indicator, which expresses proportion TPES/GDP.

8. **Organic Agriculture –** "An ecological production management system that promotes and enhances biodiversity, biological cycles, and soil biological activity. It is based on minimal of off-farm inputs and on management practices that restore, maintain, or enhance ecological harmony. The primary goal of organic agriculture is to optimize the health and productivity of interdependent communities of soil life, plants animals, and people" [9], [10].

9. **World Governance Index (WGI) –** includes the following aspects [11]: Peace and Security; Rule of Law; Human Rights and Participation; Sustainable Development; Human Development.

10. **International Innovation Index –** proposed by Boston Consulting Group and "tooks into account two types of innovation output; Tangible Outcomes. New products, knowledge, formulas, designs, and expertise that are easily quantified and can be legally protected through patents or other intellectual-property vehicles; Intangible Outcomes. New processes or ways of doing business that lead to a competitive advantage, such as a new company-wide production process that results in higher quality and greater productivity. Intangible outcomes aren't themselves easily quantified but can have a major impact on quantifiable results, such as overall business performance. They generally cannot be legally protected" [12].

11. **Transport Greenhouse Gas Emissions per capital (GHG)–** Transport-sector CO2 emissions represent 23% (globally) and 30% (OECD) of overall CO2 emissions from fossil fuel combustion. The sector accounts for approximately 15% of overall greenhouse gas emissions. Global CO2 emissions from transport have grown by 45% from 1990 to 2007, led by emissions from road sector in terms of volume and by shipping and aviation in terms of highest growth rates [13].

Model Estimation Ecological Quality Index

In order to construct a fuzzy model estimation ecological quality index we use ecological information from the International Organization and Azerbaijan.

Table fuzzy model given in table 1.

Parameter	Definition	Terms and its values					Azer-baijan
I Air Quality Index (AQI)		**Very bad**	**Bad**	**Moderate**	**Good**	**Very Good**	
		0 - 20	19 40	39 - 60	59 – 80	79-100	
1.Annual Average SO_2 **(SO_2)**	mgr/m^3	Very high > 40	High 30-45	Moderate 20-35	Low 10-25	Very low 0-15	Low 15
2.Annual Average NO_2 **(NO_2)**	mgr/m^3	Very high > 60	High 50-60	Moderate 40-50	Low 30-45	Very low 20-35	High 50
3.Annual Average TSP **(TSP)**	mgr/m^3	Very high > 50	High 35-50	Moderate 30-40	Low 15-30	Very low 10-20	Very high 300
II Water Quality Index (WQI)		Very bad 0-20	Bad 20-40	Moderate 40-60	Good 60-80	Very good 80-100	Bad 21.8
4. Dissolved oxygen concentrations (milliliters of dissolved oxygen per liter of water) **(DOC)**	(ml/l)	Very bad > 14	Bad 11-14	Moderate 9-12	Good 7-10	Very good < 7	Good 8.27
5. Fresh water resources **(FWR)**	m3/per capital	Very bad < 3500	Bad 3000-6000	Moderate 5500-9000	Good 8500-12000	Very good 11500-15000	Very bad 948
6. Fresh water withdrawal 40 % of available water **(FWW)**	% of internal resources	Very low > 79	Low 80-59	Moderate 60-39	High 40-19	Very high 20-0	Very low 150
III Land Quality Index (LQI)		Very bad 0-20	Bad 19.5-40	Moderate 39.5-60	Good 59.5-80	Very good 79.5-100	Moderate 49.5
7. Percentage of agricultural land **(AGL)**	% of land area	Very low 0-15	Low 14.5-25	Moderate 24.5-50	High 49.5-70	Very high > 69.5	High 58

8. Annual average forest area **(AAF)**	% of land area	Very bad 0 - 10	Bad 9-20	Moderate 19-30	Good 29-40	Very good 39-50	Bad 11.3
IV Environmental Biodiversity Index (EBI)		Very bad 0 - 20	Bad 19 - 40	Moderate 39 60	Good 59 – 80	Very good 79-100	Bad 29.5
9. Territories under protection **(TUP)**		Very bad <8	Bad 7-15	Moderate 14-22	Good 21-30	Very good > 29	Bad 10.1
10. Percentage of the country territory in the threatened ecoregions (TTER)	%	Very bad > 40	Bad 0-40	Moderate 20-30	Good 10-20	Very good 0-10	40
11. National Biodiversity Index **(NBI)**	0-1	Very bad < 0.20	Bad 0.19-0.40	Moderate 0.30-0.50	Good 0.45-0.65	Very good 0.6-1	Good 0.534
V 12. CO2 and particulate emissions damage	MT per capita	Very high > 4.5	High 3.5-5	Moderate 2.3-3.6	Low 1.1-2.4	Very low 0-1.2	High 4.4 (2009)
VI 13. Capital investments for environmental protection programs	% of GDP	Very low 0-1.2	Low 1.1-2.3	Moderate 2.2-3.5	High 3.4-5	Very high > 4.9	Very low 0.5 (2009)
QNE		0-20	19-40	39-60	59-80	70-100	

In order to solve stated problem, which correspond to model, algorithm of the weighted rules [14] has been used. Steps of algoritms are as the following:

Fuzzification is carried out as the first step, and a Gaussian function of accessories is applied. Further, on the basis of quantity of terms, initial fuzzy rules are defined (for example, if quantity of terms 3, quantity of initial rules to equally three). On a following step by Cartesian product of terms in initial rules are defined other possible rules.

Then the peak point of each corresponding interval on the basis of what the matrix $C = (c_{ij})$ where the i-index corrected is under construction $C = (c_{ij})$, j – an index of terms is defined c_{ij} $C = (c_{ij})$. Initial rules are expressed on the basis c_{ij}.

After that by means of the below-mentioned formula product of degree of an accessory of linguistic variables which enter in anticident each rule is calculated:

$$\mu(x) = \prod_{j=1}^{n} \exp\left[-\frac{1}{2}\left(\frac{x^i - c_j^i}{\sigma_j^i}\right)^2\right] \qquad (1)$$

Where n - number of input variables; x – terms; i – an index of term; c_j^i - a peak point of corresponding terms i; s_j^i average quadratic deviation of an interval of a corresponding term.

The following step by means of the mentioned below formula defines exact values of target variable rules:

$$f(x \mid [c_j, \sigma_j, b_i]) = \frac{\sum_{i=1}^{R} b_i \prod_{j=1}^{n} \exp[-\frac{1}{2}(\frac{x_j^i - c_j^i}{\sigma_j^i})^2]}{\sum_{i=1}^{R} \prod_{j=1}^{n} \exp[-\frac{1}{2}(\frac{x_j^i - c_j^i}{\sigma_j^i})^2]} \quad (2),$$

$$\theta = [c_j, \sigma_j, b_i]$$

Where $x(x_j^i)$ vector-line $(x_1^i, \ldots, x_7^i)$ of corresponding terms, - the θ vector, which elements are calculated by using. $c_j^i s_j^i$, s_j^i, s_y and b_i - exact value of target rules.

After that weighted anticident of initial rules are defined:

$$w_i = \frac{\mu_i(x)}{\sum_{i=1}^{n} \mu_i(x)} \qquad (3) \quad \sum_{i=1}^{n} w_i = 1,$$

Where w_i - weighted anticident of initialed rules, $\mu_i(x)$- degree of indistinct variables entered in the anticident a part of rules.

Substituting value of the formula (1) in the formula (3), we will receive:

$$w_i = \frac{\prod_{j=1}^{n} \exp\left[-\frac{1}{2}\left(\frac{x_j - c_j^i}{\sigma_j^i}\right)^2\right]}{\sum_{i=1}^{R} \prod_{j=1}^{n} \exp\left[-\frac{1}{2}\left(\frac{x_j - c_j^i}{\sigma_j^i}\right)^2\right]} \quad (4)$$

Then calculated w_i construct a matrix Φ:

$$\Phi = \begin{pmatrix} w^T(x^1) \\ w^T(x^2) \\ w^T(x^3) \\ w^T(x^4) \\ w^T(x^5) \end{pmatrix}$$

At the subsequent stage it is calculated $\Phi = (\Phi^T \Phi)^{-1} \Phi^T Y$, where the Φ^T transposed form Φ, Y - a vector of the target variables expressed in values and, using equality $f(x/\theta) = \theta^T * w(x)$ are defined weight of rules.

Then, using the fixed values of entrance variables and weights of rules, set of the selected rules is defined; on the basis of these rules composition operation is undertaken that allows definition of corresponding fuzzy figure.

At last, defuzzification of fuzzy numbers is carried out using Centroid method.

Model of Green Economy

In order to modeling quality of the Green Economy the following terms are used: Very Low (VL), Low (L), Medium (M), High (H) and Very High (VH), which are scaled in the interval [0, 1]. In modeling

process we use also terms – very bad (VB), Bad (B), Moderate (M), Good (G), and Very Good (VG).

In order to estimation indices of the level of development of Green Economy were proposed method, which is based on L.Zadeh's composite rules of inference [15] and consist of the following steps:

Development of a table describing parameters of the model on the basis of information obtained from international organizations and experts. In the first column of the table shows the input parameters of the model, and in the following columns - terms and their intervals. The last column specifies crisp meaning of input parameters for a fixed period;

Table Model of Green Economy table 2.

##	Categories	Source Indicators	Development level					
			World Indicators					
			Very low	Low	Medium	High	Very high	Azerbaijan
1	**Ecological quality - ECQ**	2010	0 - 0,2	0,18 - 0,4	0,38 - 0,6	0,58 - 0,8	0,78 - 1	L 0,25
2	**Renewable energy - REE**		0 - 0,2	0,18 - 0,4	0,38 - 0,6	0,58 - 0,8	0,78 - 1	VL 0.013
3	**Protection land - PRL**	2012	0 - 0,2	0,18 - 0,4	0,38 - 0,6	0,58 - 0,8	0,78 - 1	VL 0,102
4	**Green tourism - TOR**		0 - 0,2	0,18 - 0,4	0,38 - 0,6	0,58 - 0,8	0,78 - 1	VL 0,012
5	**Quality of life - QOL**	2011	0 - 0,2	0,18 - 0,4	0,38 - 0,6	0,58 - 0,8	0,78 - 1	M 0,548
6	**Green GDP**		0 - 0,2	0,18 - 0,4	0,38 - 0,6	0,58 - 0,8	0,78 - 1	VL 0,008
7	**Energy intensity- ENI**	2010	VB 0,56 – 0,45	B 0,44– 0,33	M 0,32- 0,21	G 0,2 – 0,09	VG 0,08 →0	G 0,1

8	**Organic agriculture - ORA**		0 - 0,2	0,18 - 0,4	0,38 - 0,6	0,58 - 0,8	0,78 - 1	M 0,5
9	**Worldwide governance index - WGI**	2008	0 - 0,2	0,18 - 0,4	0,38 - 0,6	0,58 - 0,8	0,78 - 1	M 0,578
10	**International Innovation Index - III**		VB (-2) – (-1,1)	B (-1,2) – (-0,3)	M (-0,4) – 0,5	G 0,4 – 1,3	VG 1,2 - 2	B -0,54
11	**Transport greenhouse gas emissions per capital -GHG**		20 - 10	9,5 - 3	2,9 - 1	0,9 – 0,5	0,4 - 0	H 0,55

Definition of membership degrees of the crisp meaning of the input parameters to the relevant terms. For this aim were used Gaussian membership function:

$$\mu_A(x, c_i, \sigma_i) = e^{-(x-c_i)^2/2\sigma_i^2}$$

Where c_i is the center of the ith fuzzy set and σ_i is the width of one of the ith fuzzy set.

1. Determination of the minimum degree of membership to the corresponding term of input parameters, i.e. $\min_j \mu_{ij}$;

2. Determination of the maximum of the minimum values of the degrees of membership to the corresponding term, i.e. $\max_i \left(\min_j \mu_{ij} \right)$;

The obtained value will reflect the quality of the National Green Economy.

The proposed methodology is tested on the basis of information on quality parameters of the model of Green Economy (Table 2). The source materials are obtained from the international organizations and

Azerbaijan Republic [16], [17]. Information on the Green Economy indicators of Azerbaijan, given in the last column of Table 2 .

At the second stage we have determined the degree of membership of national indicators of green economy to the appropriate term.

Very low (VL)	Low (L)	Medium (M)	High (H)	Very High (H)
$\mu_{REE} = 0{,}03$	$\mu_{ECQ} = 0{,}55$	$\mu_{QOL} = 0{,}29$	$\mu_{ENI} = 0{,}05$	0
$\mu_{PRL} = 1$	$\mu_{III} = 0{,}38$		$\mu_{GHG} = 0{,}08$	
$\mu_{TOR} = 0{,}03$		$\mu_{ORA} = 0{,}96$		
$\mu_{EEP} = 0{,}02$		$\mu_{WGI} = 0{,}06$		
min:0.02	min:0,38	min:0.06	min:0.05	min:0

Among the minimum values the maximum value is determined, which is equal to 0.38. This value corresponds to the term - “low”, thus defining index of level of development of Green Economy.

Conclusion.

Research that has been undertaken, using fuzzy logic methods, on the National Green Economy Development Index for Azerbaijan shows, that very low value of this index is primarily influenced by the very low level of renewable energy use, low levels of protected land, green tourism and ecological quality in Azerbaijan. Problem of investments distribution between sectors of Green Economy has to be researched in order to improve this situation in the future.

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