Measuring Social Sustainability in Venezuela through Synthetics Indicators

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Abstract: - In this work it was used a statistical methodology for obtaining an indicator of social sustainability for Venezuela. It was used information from the sustainable development social dimension for each of the Venezuelan states during 2007-2009. For building the social sustainability indicator (SSI) it was used the first two principal components obtained from the analysis for each year and as aggregation method the sum of components was used. The resulting values of social sustainability indicator is decomposed into 5 levels in similar way to the sustainability barometer and federal entities with the corresponding SSI level were assigned. It's proposed, the use of the Euclidean distance, for determining the optimal setting proximity. An interesting relationship between the value of SSI and distance is found.

Key-Words: - sustainability indicators, sustainable development, sustainability barometer, principal components, distance.

1 Introduction

For more than forty years it has been investigated the impact on the physical-natural environment that has been created by the human life development and the man's needs satisfaction to improve their quality of life. For this reason it has created the concept of sustainable development as Hák and others (2007) as scheme of human, social and economic development that is able to stay indefinitely in harmony with the planet's biophysical systems. To measure and evaluate it, indicators have been formulated that provide information on each of the following dimensions: social, environmental, institutional and economic [3].

The objective of this research is to design a social sustainability indicator for Venezuela, and there will be used 17 state-level variables for the years 2007, 2008 and 2009 which will assess the social dimension of sustainable development.

To formulate the social sustainability indicator (SSI), a statistical methodology was applied, using multivariate analysis techniques as the principal components, which are added using a sum of the scores of the principal components [1]. It´s also used Cluster analysis which allows to observe the similarity between the states and to form homogeneous groups according to social characteristics included in the study.

2 Methodology

Originally when referring to development, it was only considered the economic growth to improve the quality of human life; however, this growth has

led to changes with negative effects on the environment, and that is why the concept of sustainable development has emerged, based on a system of balance between social, environmental and economic.

Since the completion of the First Earth Summit, and the adoption of Agenda 21, a comprehensive plan of action for the benefit of sustainable development, the use of indicators is established as a mechanism to measure this type of development. An indicator is simply the measurement of a phenomenon through a set of variables that are associated to this phenomenon. A formal definition was proposed by Schuschny and Soto (2009), which define it as a measuring instrument built theoretically to be applied to a set of analysis units in order to produce a number that quantifies the concept associated with that group [11].

Quiroga (2007) conducted a research based on experiences carried out in Latin America for this type of development measure using indicators. This research highlights the participation of some countries of the region in the pilot sustainable development indicators proposed by the UN committee concerned with the topics and subtopics framework [9]. Some countries follows the proposed scheme presented by the Organization for Economic Cooperation and Development scheme (OECD) Pressure-State-Response (PSR), others use a system of sustainable development indicators (SIDES) funded by the World Bank and other international organizations.

With regard to the social dimension of sustainable development, it can be highlighted the investigation presented by Kronemberger (2009) in Brazil, in which a set of indicators of social cohesion is presented, with aims to formulate policies towards sustainable development. This study defines social cohesion as the capacity of a society to ensure the welfare of all citizens, minimizing disparities and avoiding polarization [4].

The selected indicators for Brazil's experience was made according to the following criteria: data validation availability, specification, reliability, and communicability. In this research, socioeconomic gaps are analyzed in two ways: gaps compared to the average and gaps compared to reference values, and an adaptation of the sustainability barometer presented by Prescott Allen (1997), which is that each variable used in the social cohesion indicator is transformed to a performance scale [8].

In Venezuela experiences have been made to measure sustainable development through the use of indicators, and these experiences are summarized in Table 1. The social dimension of sustainable development is included in most of the experience, but has not been obtained an index for social sustainability for some dimensions but has been obtained synthetic or composite indicators.

Table 1. Experiences on sustainable development held in Venezuela

Source	Scope	Dimensiones	Objective	Indicators
INE (2006)	National	Environmental Economical Social	Define relationship between environment and occupation based on the concept of sustainability	Partial indicators for the dimensions and the environmental quality index (ICA) as a synthetic indicator of the 3 considered dimensions.
Pérez y Hernández (2009)	National	Environmental Economical Social	Evaluate the methodology proposed by the INE, and perform statistical treatment of the variables included in the calculation of the ICA	
Pérez, Rincón, Montiel y Urdaneta (2002)	Local (rural)	Environmental Economical Social	Sustainable Development for 3 farming communities of Zulia state Desarrollo sostenible de 3 comunidades agrícolas del Estado Zulia	Partial indicators for each dimension, biograms indicators and sustainable development index S^3 Synthesis of the dimensions included in the study.
Márquez y Cuétara (2006)	Local	Environmental Economical Social Institutional Cultural	Get indicators of sustainable development for the Municipality Patanemo.	Partial indicators for each dimension, biograms and global sustainable development index IDSG synthesis of the dimensions included in the study.
Narayán, Díaz, Moreno, y Cegarra (2010)	Regional	Environmental	Determine the impact of human activities on the different components of the ecosystem	Indicators based on air, water, solid waste, forestry, fishing and farming, considering the conservation, preservation and sustainable use of natural resources.
Pérez (2011)	Local (urbano)	Environmental Economical Social Institutional	Measure sustainability in mountain towns.	Partial indicators for each dimension, and urban sustainability index (ISU) synthesis of the four dimensions
Velásquez y D'Armas (2013)	Local	Environmental Economical Social Institutional	Develop a methodology for developing a system of indicators for sustainable development.	

Source: Own preparation

2.1. Social Sustainability indicator for Venezuela

To obtain social sustainability indicator (SSI) for Venezuela in the period 2007-2009, an extensive process of information gathering was conducted with reference to the themes and sub-themes proposed in the UN framework. It managed to cover

5 topics 10 subtopics and 17 variables, as shown in Table 2, and information is available at State level.

Table 2. Variables selected for construction of the ISS

Topic	Subtopic	Indicators
Equity	Poverty	Percentage of population living in extreme poverty
		GINI coefficient
		People Percentage from households that exceed the basic basket
		Average age of mother at first birth
		HDI
	Gender equity	Ratio of average female salary/ average male salary
Health	Nutritional Status	Percentage of death caused by nutritional deficiencies in children under five years old.
		Child Survival
	Mortality	Mortality rate under four years
		Life expectancy at birth
	Sanitary	Sanitary Sewer and Sanitation Access
	Access to drinking water	Access to aqueduct
Education	Educational level	School attendance (%)
		Combined enrollment rate
		Average years of schooling of the population over 15 years
Population	Population changes	Density of population
Others	Employment	Employment rate

Source: Own preparation from Quiroga (2009).

Once consolidated databases for the study period, it was proceed to perform the descriptive statistical analysis. Also it was decided to standardize all variables included in the study to eliminate the effect of measurement units and magnitudes of value before performing the principal component analysis.

To perform the principal component analysis it was decided to decompose the correlation matrix R. To determine whether this analysis is appropriate, measures KMO sampling adequacy and Bartlett's test of sphericity are examined. The results for the period 2007 - 2009 indicates that the data are suitable for the principal components analysis, the KMO is greater than 0.5 and with the sphericity test the null hypothesis is rejected concerning no correlation between the considered variables [5], that is, the variables are correlated as shown in Table 3.

Table 3. Measures of sampling adequacy

Year	KMO	Bartlett's test of sphericity		
		Aproximate Chi Square	Degrees Freedom	p- value
2007	0,640	370,330	136	0,000
2008	0,613	327,378	136	0,000
2009	0,526	334,418	136	0,000

Source: Own preparation

Based on the experiences of Castro and Morillas, Azqueta and Escobar (2004), and Peña - Trapero (2009) for the methodological approach of social sustainability indicator (SSI), it is taken as a starting point the analysis of principal components, for this [2,1,7]. It will consider the first three principal components, which explain the percentage of variation that is shown in Table 4 in the three years included in the study, the largest percentage is during 2007.

Table 4. Percentage of variance explained by the three components retained

Years	Accumulated %
2007	71,326
2008	62,879
2009	67,586

Source: Own preparation

To define an indicator based on principal components there are several proposed procedures, Castro and Morillas (2002) explain that one of the ways is adding these components considering the scores and the interpretation of the components. For this reason from the first three components the interpretation of SSI will be expressed as follows:

$$SSI = CP_1 - |CP_2| + CP_3$$

The interpretation of the first three principal components for the period under study is as follows:

First Component: is a shape component and it can be defined as a component of human development and well-being, in which two groups of States are opposed with the following features: A group of States that relates directly and positively with those variables associated with better living conditions, because in them there is a greater proportion of households with access to basic services and increased access to health services because they have more hope distinguishes at birth and higher infant survival rate, the greater the average age of mother at first birth, there is generally a higher human development index, higher employment and equality between female and male average salary average. The percentage of households that exceed the basic food basket, are generally the most populated states. This group opposes those States associated with higher percentages of people living in extreme poverty and in which higher infant mortality rate and percentage of deaths from malnutrition in children under four years is recorded.

Second Component: This component is a form component, which is mainly and directly associated

with those states in which the percentage of people living in extreme poverty, the highest percentage of deaths from malnutrition in children under four years is higher and mortality rate under the age of four years old, so the negative sign is justified in the expression for SSI.

Third Component: is a form component, and can be expressed as a component of equity in the distribution of income, as it is related to the Gini coefficient, and virtually any other relevant variable can be found in this component.

To improve the outcome of the SSI, it is first necessary to calculate the optimum value for each year of the study period. This optimum value of the indicator represents the ideal situation of social sustainability, where the negative effects of some variables are minimized (such as poverty) and maximize the positive effects of other variables (living conditions, health education, among others). The optimum values are presented in Table 5.

Table 5. Optimum value of SSI

2007	4,16
2008	4,19
2009	4,84

Source: Own preparation

Once determined the scores for each state, an adaptation of the sustainability barometer with the aim of establishing a scale for classifying each State at a sustainability level is done. SSI classification depends on the score for a particular state, that is, if there is a positive and close to the optimum value rating means it has high social sustainability, as if the state has a negative score means it is socially unsustainable. The ranges for each level of sustainability and for each year is presented in Table 6.

Table 6. SSI values score based on sustainability barometer

Sustainability Level	**2007**	**2008**	**2009**
Sustainable (Very Good)	3,37≤SSI≤4,5	3,37≤SSI≤4,5	3,75≤ISS≤5,0
Quasi Sustainable (Good)	2,25≤SSI<3,37	2,25≤SSI<3,37	2,5≤SSI<3,75
Intermediate	1,12≤ SSI< 2,25	1,12≤SSI<2,25	1,25 ≤ SSI < 2,5
Quasi Unsustainable (Poor)	0 ≤ SSI< 1,12	0 ≤ SSI < 1,12	0≤ SSI < 1,25
Unsustainable (Bad)	SSI ≤ 0	SSI ≤ 0	SSI ≤ 0

Source: Own preparation

Table 7 shows the classification of the states of Venezuela at a particular sustainability level for the period 2007 - 2009. It is noteworthy that only one state ranks as sustainable in 2007 and corresponds to the state of Miranda, while the other states are classified in other sustainability levels, except for the quasi sustainable level that no state is classified.

Another interesting finding is related to the large number of States that during the three years of the study were classified as unsustainable, where Amazonas, Apure, Barinas, Guárico, Lara, Portuguesa, Sucre and Trujillo have been unsustainable the three consecutive years.

Table 7. Comparative table using the sustainability barometer for 2007 to 2009.

Sustainability level	**2007**	**2008**	**2009**
Sustainable (Very Good)	Miranda		
Quasi Sustainable (Good)			
Intermediate	Aragua	Carabobo, Distrito Capital, Vargas	Distrito Capital, Miranda
Quasi Unsustainable (Poor)	Anzoátegui, Bolívar, Carabobo, Distrito Capital, Falcón, Monagas, Zulia,	Bolívar, Mérida, Miranda, Nueva Esparta, Táchira, Yaracuy	Anzoátegui, Carabobo, Cojedes, Falcón, Monagas, Nueva Esparta, Yaracuy, Táchira, Vargas,
Unsustainable (Bad)	Amazonas, Apure, Barinas, Cojedes, Delta Amacuro, Guárico, Lara, Mérida, Nueva Esparta, Portuguesa, Sucre, Táchira, Trujillo, Vargas, Yaracuy	Amazonas, Anzoátegui, Apure, Aragua, Barinas, Cojedes, Delta Amacuro, Falcón, Guárico, Lara, Monagas, Portuguesa, Sucre, Trujillo, Zulia,	Amazonas, Apure, Aragua, Barinas, Bolívar, Delta Amacuro, Guárico, Lara, Mérida, Portuguesa, Sucre, Trujillo, Zulia,

Source: Own preparation

Indicators based on distance

The distance between two cases or two individuals refers to the similarity or dissimilarity between them. To calculate this distance there are several procedures that consider the nature of the variables that have been measured on the considered cases.

Generally it´s named distance or dissimilarity between two individuals i and j, the d_{ij} measure of the degree of difference between the two individuals in relation to a number of quantitative and/or qualitative characteristics. The value of d_{ij} is always a non-negative value and the higher the value, the greater the difference between individuals i and j [6, 12].

Synthetic indicators based on the concept of distance, are based on the calculation of the difference between a value of each indicator and another value taken as a reference, and have the goodness to solve the problem of heterogeneity of the measurement units [7, 13].

Such indicators are based on the comparison by difference, in absolute or quadratic terms, between each indicator in territorial units or relative to a considered baseline [7].

Mathematically, the approach can be expressed as follows: Let X be a nxp data matrix where n represents the territorial units and p the indicators. The x_{ij} value represents the ith indicator status, i = 1,...,p, in territorial unit j, j=1,...,n.

It is denoted by $X^* = [X^*_{1,} X^*_{2,...,} X^*_p]$ the references indicators vector. The p-metric distance is defined by

$$D_p = \left\{ \sum_i \left| X_{ji} - X_i \right|^p \right\}^{\frac{1}{p}}$$

The Family of indicators based in the latter case are called synthetic distance indicators that verify the conditions required by the distance in a metric space (no negativity, commutativity and triangular condition).

Table 8. Euclidean Distances

State	2007	2008	2009
Amazonas	7,34	9,84	9,75
Anzoátegui	3,9	4,54	4,34
Apure	5,84	5,24	5,89
Aragua	2,6	6,17	7,37
Barinas	6,2	6,96	7,52
Bolívar	3,66	3,63	5,19
Carabobo	3,38	2,84	4,03
Cojedes	4,41	5,56	3,76
Delta Amacuro	9,02	7,63	8,48
Distrito Capital	3,32	2,26	3,3
Falcón	3,12	4,87	4,62
Guárico	5,18	6,44	7,2
Lara	5,07	5,64	6,63
Mérida	5,14	3,43	5,25
Miranda	0,36	3,27	3,05
Monagas	3,92	4,26	3,69
Nueva Esparta	5,26	3,2	3,92
Portuguesa	6,4	5,35	7,32
Sucre	7,44	4,41	6,93
Táchira	4,48	3,31	4,74
Trujillo	5,81	5,78	6,45
Vargas	5,88	2,93	3,88
Yaracuy	4,83	3,84	4,71
Zulia	3,5	4,65	5,01

Source: Own preparation

Within this family of indicators based on distance are included indicators based on

Euclidean distance, Mahalanovis, Frechet, Ivanovic and DP2 [7,13].

In this research an indicator based on distance is defined, considering the normalized Euclidean distance. The selection of this kind of distance is because it has only been obtained a synthetic indicator, in this case has been obtained the synthetic indicator from the principal components method, and then it has been determined for each state the distance between the value obtained in SSI and the optimum value obtained above. Normalized Euclidean distance can be expressed by the following expression:

$$d(x,y) = \frac{\sum_{i=1}^{p}\left(\frac{x_i - x_i^*}{\sigma_i}\right)^2}{p}$$

Table 8 shows the distances obtained by each State regarding the optimal value and for the period included in the study. An interesting finding in this study is related with the scores obtained in the SSI and distances: those states with the highest score in the SSI and better classification according to the barometer have smaller distances from the optimum value, and vice versa. States with smaller distances correspond to those located in the central region.

3 Conclusions

Based on the importance of sustainability in Venezuela, this study refers to the social dimension of sustainable development. Specifically this dimension seeks to measure the living conditions of citizens, including aspects such as health, education, access to services, gender equality, security, poverty, population changes, among others.

In this paper a social sustainability indicator (SSI) for Venezuela is presented, obtained through a statistical methodology that uses as input the principal component analysis. Importantly, al the moment of the development of this research, for Venezuela was not reported any indicator of this type, and it should be promoted the use of indicators as monitoring instruments.

In the proposed methodology, information analysis begins with a comprehensive exploratory data analysis, in order to highlight the most important features of states and detecting outliers. In social studies, statistics orders as maximum and minimum are relevant, because can be used for identifying those states that are better or worse compared with some variable.

Reducing the information in the original data matrix through principal component analysis, allows the use of principal components scores to define a composite indicator. This indicator is an aggregative indicator, and aggregations are performed in accordance with the interpretation of the components. For Venezuela the SSI has been obtained using the principal components analysis for three successive years.

Another interesting issue is related to determining the optimal values of the SSI for three years under study, which were similar, indicating that the methodology is consistent. The results for the years 2007, 2008 and 2009 indicate that the priority states in social care aspects are: Amazonas, Apure, Barinas, Guárico, Lara, Portuguesa, Sucre and Trujillo.

The time classification presented by the States is interesting to analyze. It was expected an improvement in social sustainability, and in this investigation a stagnation or reverse of social sustainability in Venezuela is evident. It was expected that scores on the ISS will increase from one year to another, and thereby the distances from the optimum value decrease, however, it has not happened and this represents an alarming fact.

Venezuela was part of the countries that signed or agreed to Agenda 21 at the Summit of the Earth, a global action plan for the reduction of extreme poverty and aiming to increase the living conditions of citizens and the Millennium Development Goals, and in this research is not really evidence the commitment made over 20 years ago.

Policies must be implemented at the state level to improve the score of each entity in the SSI, through the fight against extreme poverty and social exclusion related to improving areas such as education, access to health, also improvements in access to basic services, prioritizing the states with levels of social sustainability poor or bad.

For further studies it's recommended to propose the use of distance-based indicators to assess the social sustainability in Venezuela.

Finally, it's recommended using the SSI to measure social sustainability in Venezuela and take it into account when making decisions for the design of policies and programs that yields to social sustainability.

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