Renewable and Sustainable Energy Reviews 78 (2017) 878–885

Contents lists available at ScienceDirect

Renewable and Sustainable Energy Reviews

journal homepage: www.elsevier.com/locate/rser

Assessment of Latin American sustainability

Olfa Toumi[a,*], Julie Le Gallo[b], Jaleleddine Ben Rejeb[a]

[a] LAMIDED, ISG Sousse, University of Sousse, 4000 Sousse, Tunisia
[b] CESAER UMR1041, AgroSup Dijon, INRA, 26 Bd Petitjean, 21079 Dijon Cedex, France

ARTICLE INFO

Keywords:
Sustainable development
Entropy method
Evaluation
Latin America

ABSTRACT

This paper aims at assessing the sustainability of development in eleven Latin American countries. For that purpose, we establish an evaluation index system grouped into four subsystems (economic subsystem, social subsystem, ecologic subsystem and institutional subsystem). The weights for the index subsystems of sustainable development are based on the concept of entropy. The empirical results show that the sustainable development strategy in this group of countries is not efficient and is characterized by a lack of coordination between the four dimensions. This quantitative evaluation provides a new perspective for research in sustainable development researches and guidance for public policies.

1. Introduction

Given the global degradation of the environment, climate change due to human activities and trends of environmental, technological and economic globalization, implementing a sustainable development strategy has become an important issue. The concept of "sustainable development" was introduced in the context of the Earth Summit in Rio de Janeiro in 1992, the purpose of which was to find agreements between countries on actions and measures to be taken for saving natural resources and protecting the environment. The concept of sustainable development not only refers to the durability of environment quality, but it also points to social, economic and institutional aims. Later, the Kyoto protocol of United Nations Framework Convention on Climate Change (UNFCC) (1997) was regarded as the first global collective effort to address climate change, notably by ensuring financial support for lean energy projects. The main mechanism included in the protocol is the Clean Development Mechanism (CDM), which requires projects to guarantee sustainable development to receive financial assistance. More recently, the Conference of Parties (COP) (2011) resulted in a legally binding agreement on climate.

In this context, correctly assessing the level of sustainability has become of utmost importance for international organizations, governmental institutions and in also the academic literature [1–5]. The purpose of these indicators should be to meet the goals, clarify and define the basic conditions for sustainable development, to assess quantitatively the subsequent amendments as well as the stage reached in the development and the sources that support it,i.e. the policies of environmental protection and socio-economic development. A range of indicators has been suggested to quantify this complex and multi-dimensional notion. In particular, in order to ensure a good coordination of the four dimensions of sustainable development mentioned earlier, various authors (e.g [4].) suggest to use a sustainable development index that combines the four systems, namely the economic, social, environmental and institutional subsystems, including indicators that are relevant, understandable, reliable and available.

The main objective of this article is to assess the level of sustainable development in Latin American countries. Indeed, Latin American countries have implemented their own set of national policies and strategies to achieve sustainable development [6,7]. For instance [8], distinguishes core areas for sustainable development in Argentina: food industry, communication and technology, mining, tourism and forest conservation [9]. focuses the sustainability of aquaculture in Chile. Case studies for several countries in Central and South America are presented in [6]. In this paper, using the method set out by [4] and [2], we measure the degree of importance of each indicator in the development of each subsystem and the weight of the latter in the global evaluation to determine the sources of development using the entropy weight method. To the best of our knowledge, this is the first time that the sustainability of the whole Latin American region is quantitatively assessed in this comprehensive and unified way.

* Corresponding author.
E-mail addresses: olfa_toumi_22@hotmail.fr (O. Toumi), julie.le-gallo@agrosupdijon.fr (J. Le Gallo), Jaleleddine.BenRejeb@esct.rnu.tn (J. Ben Rejeb).

http://dx.doi.org/10.1016/j.rser.2017.05.013
Received 10 February 2016; Received in revised form 1 April 2017; Accepted 4 May 2017

The outline of the paper is as follows. The next section focuses on the different methods used to assess sustainable development in the economic literature and points out the advantages of the entropy weight method applied in this paper. The third section details the methodology adopted. Then we present the set of indicators on which we apply the entropy weight method and comment our results. The fifth section provides some policy implications and concludes.

2. Literature review

According to the definition of the World Summit (1987) on Environment and Development, sustainable development means that the needs of the generation today should be met without undermining the ability of future generations to meet their own needs. The summit pointed out the need to achieve economic development, to respect limits of planet and to promote social justice. Reaching sustainable development requires the combination of four dimensions of sustainable development: the environmental, economic, social and institutional dimensions. In spite of various political and strategic commitments and popularity of the sustainability concept, its practical implementation is difficult [10–12]. Indeed, when it comes to cover the gap between wishes and implementation, it is necessary to consider sustainable development as a decision-making strategy [12]. In this context, we argue that indicators that allow evaluating sustainability in a quantitative way are important tools of decision-supporting development as they play a significant role by replying to three challenges: information-structuring, interpretation and leverage. However, the measurement and assessment of sustainable development are very complex because of its intrinsic holistic characteristics and multi-dimensionality. Since the 1990s, many substantial and often promising sustainability assessment and indicators have been made.

For the last three decades, various countries (Germany, Brazil, China, USA, France…) and international organizations (UN, OECD, European Union…) have taken the initiative to construct sustainable development indicators. However, to date, an agreement of the relevant range of sustainable indicators has not been reached. In 1999, the inter-institutional working team of the United Nations on Sustainable Development identified no less than 400 indicators to assess sustainability. Then it urged to reduce this figure to 30 indicators, as assessing sustainable development in a set of countries with such a large number of indicators is nearly impossible. Finally, it chose 40 indicators to assess the United States sustainable development. For the European Union, these indicators vary from one country to another within a range of 10–100 [13].

International agencies mainly use qualitative analysis to evaluate sustainable development without providing a quantitative measure. However, since the turn of the century, the academic literature in economics and mathematics has moved towards finding a suitable method that allows determining a quantitative sustainable development indicator. Indeed, as we have argued before, a quantitative evaluation is important to evaluate the policies adopted to achieve sustainability. Assessing sustainability is a complex task as it necessitates integrating all dimensions of sustainable development. This multidimensional concept therefore requires the development of adequate techniques that are able to aggregate all the indicators in a meaningful way [14]. We now briefly review some of these techniques.

In their study of forest sustainability [15], use a multi-attribute programming method to realize the aggregation of indicators while [16] merged multi-criteria approaches with fuzzy logic theory to assess the sustainability of some policies related to forest management. They pointed out that the limit of sustainable development assessment was caused by of the scarcity and the quality of data. These two tools have been combined by [17] who also incorporates the spatial dimension. In order to merge indicators in an acceptable way [18], and [19] follow a methodology based on mathematical programming [20]. evaluate the sustainability in Italy by using the indicator compounds method while [21] applied principal component (PCA) analysis for the National Assessment. However, as pointed out by [22], the dynamic dimension of sustainable development is ignored in these studies.

Focusing on the different dimensions of sustainable development that we mentioned earlier, we find notably the study by [23]. They use a multi-criteria method for decision making (MCDM) to evaluate the three subsystems (economic, social and environmental) for the years 2000 to 2011in Lithuania [4]. use the technique of coefficient of importance (weight) to measure the statistical evaluation of sustainable development: this method aims at measuring the weight of each indicator in the overall evaluation without assessing the weight of each subsystem. Their study covers 11 countries in South East European region and in former Yugoslavia using cross-sectional data.

It should be noted that the methods of overall assessment based on the computation of weights for the subsystems often use subjective weighting methods (AHP, Delphi method, ARAS, etc.). These methods have some drawbacks [2,24], such as a non-standardized evaluation index system and results that may not consistent with actual data because of the subjective weights. Conversely, the so-called objective methods determine the weights by solving mathematical models without considering the preferences of the decision-maker as they are based on the inherent quantity of information provided by the indicators.

In order to avoid the problems raised by subjective methods, this paper is based on the entropy weight method, which is an objective method, to assess the overall sustainable development of Latin American countries. This method is based on the Shannon entropy coefficient [25] that has a number of desirable properties and allows determining the weights solely based on the amount of information, from a statistical point of view, provided by the indicators. As such, it is an appropriate method for assessing sustainable development. Its application to a set of countries then allows evaluating the policies adopted by the national and international organizations to achieve sustainable development [26]. also argue that this method yields results that are more compatible with the actual situation.

3. Methodology

In this section, we first rely on the definition of sustainable development to determine the system of indicators required for its assessment taking into account the dynamic nature of the process. Then, we present the entropy weight method.

3.1. Selecting the evaluation indicator system

In accordance with the division of development indicators by Agenda 21 into four subsystems -economic, social, ecological and institutional subsystems - the indicators used in this study are the most acceptable according to [4] and [23]. These indicators represent a wide range of typical socioeconomic, environmental and institutional indicators and allow measuring the impact of policies on the objectives aimed by sustainable development.

Table 1 describes all the variables that we collected for 12 countries in Latin America for the period 1995–2012. As some data were not available for all countries and for all the years, we averaged each indicator for each period of three years to six periods to mitigate measurement errors. The table also indicates the desirable trend of each indicator to foster sustainable development.

3.2. The entropy weight method

The algorithm of the entropy weight method is based on the entropy indicator developed by [25]. It has been applied to develop sustainable indices by inter alia [2]. We detail the steps necessary to implement this algorithm below.