TÍTULO: Integrated Management Control System: Measuring and Managing Social, Economic and Environmental Brazilian Corporate Indicators

ABSTRACT

The search for business sustainability has created opportunities for the development of frameworks and instruments to manage corporate strategies and actions regarding sustainable development. The purpose of this study is to propose requirements for the construction of a management control system which allows the measurement and assessment of social, economic and environment actions of Brazilian corporations. The Integrated Environmental Evaluation model put forward by UNEP/UNESCO (1987) is applied to calculate an equilibrium index between the corporate actions in the three perspectives mentioned. The model uses the Composition Programming methodology (CtP) and the performance indicators proposed by the Global Reporting Initiative (GRI). In Brazil, approximately 72 companies publish reports based on the GRI guidelines. Indicators of a sample of 14 companies belonging to several economic sectors will be collected in the general survey from the disclosed reports. This work presents partial results of the overall survey, analyzing the performance of Companhia Paranaense de Energia Elétrica (COPEL), of the Energy Utilities sector, in the year 2009. As a result, we present the requisites for implementation of the proposed methodology in the managerial control system of the companies. This integration may provide the proper definition of plans and allocation of resources in the planning process; the implementation of plans and monitoring in the execution process and assessment of the performance of the indicators in the corporate control process, thus assisting in the implementation of sustainable strategies.

1 Introduction

The 21st century faces a strong environmental and social crisis. At present, effects such as global warming, biodiversity loss, depletion of farmable land among other great environmental impacts (referred to as planetary limits), already pose immeasurable challenges (Rockström et al, 2009). Add to this pressure the social inequalities; considering only countries in development, poverty strikes one fourth of the population (WB, 2008) and worldwide, around 2.6 million people do not have access to clean water (WHO, 2010). In this scenario, it is important for companies to apply a development model that may overcome not only financial challenges, but also environmental and social ones – the sustainability triple bottom line (TBL) (Elkington, 1999).

The assessment of sustainable companies, grounded on the three pillars, has been carried out with the use of indexes. They have been growing in importance because of their ability to summarize technical-scientific information and allow its condensed transmission to all stakeholders (Moldan and Dahl, 2007). The Dow Jones Sustainability index (DJSI) in New York was the first to be launched for the assessment of sustainable actions of companies (in 1999); following the US experience, the London Stock Market and the Financial Times launched the FTSE4Good in 2001; in 2003, South Africa was the first emerging country to incorporate sustainability into the stock market, by launching the SRI (Socially Responsible Investment) (Krosinsky and Robins, 2008). Brazil also followed this movement and launched the ISE (Corporate Sustainability Index) in 2005.

Globally, in the information disclosure aspect, the highlight is on the Global Reporting Initiative (GRI), an institution that leads the drafting of sustainability reports and proposes a performance indicator structure to represent the economic, social and environmental perspectives of companies in the view of multiple stakeholders. In 2010, almost 2 thousand companies published reports following their indicators and, in Brazil, around 72 companies disclosed reports following their guidelines (GRI, 2010).

In addition to the verification and disclosure of the indicators, it is important to measure the range of the action represented by these indicators. Within a social standpoint, we highlight the proposal of the Millennium Ecosystem Assessment, which aims to interpret data through the human health view, finding equilibrium between ecosystemic services and life quality (Freitas et al., 2007). From an environmental point of view, measurements are based in life cycles and resilience of natural resources (Tyteca 1996, Ammenberg et al. 2002, Zobel et al. 2002, Ruffing 2007).

However, in order to assess the sustainable performance of the companies, it is required to obtain indicators considering the environmental, social and economic aspects in an integrated way. There are some attempts towards this direction. Epstein and Roy (2001) propose a structure to understand and analyze corporate sustainability drivers. Dias-Sardinha and Reijnders (2005) base on the performance measurement structuring of the strategy and environmental and social factors with the use of the Balanced Scorecard (BSC) approach. Epstein and Wisner (2001) also use the BSC as a structure to implement the sustainability strategy. Azapagic (2004) develops a structure with sustainability indicators, compatible with the GRI, for the mining and minerals industry.

From the point of view of the managerial control systems, companies need to be able not only to measure and report sustainability indicators, but also to assess their performance and demonstrate continuous improvements through time. (AZAPAGIC, 2004).

In order to do so, it is important for companies to have at their disposal a support system to the decisions concerning the aspects with an impact on the performance of the indicators. The application of this approach involves the simultaneous treatment of countless and several types of qualitative and quantitative indicators. (JOERIN, 2010).

One solution that has been used is the Multicriteria Support Methodologies to Decision (MCDA). The MCDA are characterized by the capacity of analyzing complex problems, incorporating both quantitative and qualitative criteria (Figueira et al., 2005). This methodology is commonly employed in several areas. Joerin (2010) demonstrates its use in clean water treatment and Loken (2007), in electric system planning. In a review carried out by Steele et al. (2009), it is possible to verify the several uses MCDA may have to assess environmental performance. The Integrated Environmental Assessment Model was developed by the Scientific Expert Group (UNEP/UNESCO, 1987) to evaluate the socioeconomic and environmental impacts resulting from the implantation of water basins. The model employs the MCDA with the Commitment Programming (CtP) approach to calculate the sustainability index representing the equilibrium between corporate decisions regarding the economic, social and environmental aspects. Using the MCDA to assess the sustainability indicators may present solutions to the need of an integrated and equitable view of the three pillars. It has the ability to help decision makers not only in aggregating information but also in framing the decision problem. (JOERIN, 2010).

Thus, the purpose of this work is to analyze the requisites for integration, to the managerial control systems, of a mathematical methodology for measurement and assessment of the performance of economic, social and environmental indicators of companies. The CtP approach and the structure of indicators proposed by the GRI/G3 are used. In order to illustrate the application of the methodology and analyze the operationalization and the requisite, this work used data from Companhia Paranaense de Energia Elétrica (COPEL), of the Energy Utility sector, disclosed in the company's 2009 Sustainability Report.

This work is a partial result of the Research Project called "Corporate Sustainability: Evaluation of the Economic, Social and Environmental Equilibrium of Brazilian Companies" funded Foundation for Research Support of the State of São Paulo – FAPESP. The Project has two stages, the first is the formulation of the theoretical model, which involves the construction of a database with the GRI indicators of the 72 Brazilian companies and the proposition of requirements for application of the model. The second stage includes an empirical analysis through interviews with a sample of companies. The expected result is a theoretical and conceptual basis, as well as the integration into the managerial control systems, for the development of a managerial instrument, allowing simulations of the impacts managerial decisions may cause in the assessment of their sustainability indicators.

2 Theoretical Framework

2.1. Construction of Indicators and Sustainability Indexes

The definition of indicators representing the sustainable development or the sustainability of a company in this context is presented as a challenge. According to Moldan and Dahl (2007), sustainability is the capacity of a system or process to maintain itself indefinitely. The sustainable development is, thus, the development of a social, human and economic system which is indefinitely maintained in unison with the biophysical systems of the planet.

In the 21^{st} Agenda (WSSD World Summit on Sustainable Development) the sustainable developed is grounded on three aspects or pillars: social, economic and environmental. This definition supports the TBL approach for the action of the companies (Elkington, 1999) and has motivated the proposition of indicator sets to represent these constructs. In addition, a fourth institutional pillar was proposed in the structure adopted by the Commission on Sustainable Development (CSD).

TBL, according to Elkington (1999), involves measuring and reporting economic, social and environmental performances simultaneously. The International Consulting Group SustainAbility, specialized in business and sustainable development strategies, expresses more widely that the TBL involves accessing the values of an entity, as well as its strategies and practices, and how they may be used to achieve the economic, environmental and social goals.

According to Rickard et al (2007), the main purpose of any structure of indicators is to provide some architecture of information comprehensively and highly accessible. This architecture must correspond to a relevant and comprehensible policy for the society and help people decide what to do.

Some important requirements for the construction of efficient indicators are presented by Moldan and Dahl (2007): credibility (scientifically valid), legitimacy in the eyes of users and stakeholders and relevance for decision-making.

One of the most important initiatives in this line is the GRI guidelines for the elaboration of sustainability reports, whose goal is to meet this informational necessity, offering a framework for a report making that incorporates the concepts of sustainability and that may be used by entities of all sizes, sectors and places (GRI, 2006). One of its important characteristics that make it comprehensive and useful is the incorporation of the joint view concerning social, environmental and economic parameters, coherent with the TBL approach. Each one of the presented aspects is made up of one or more specific indicators. These indicators are classified as essential or additional.

The essential indicators were developed by using multistakeholders processes that aim to identify the indicators usually applicable and considered relevant for most organizations. The additional indicators represent emerging practices or approach items that may be relevant for some organizations, but not all of them. In addition to these categories of indicators, there are sectorial indicators, specific for the activity of certain organizational sectors. These indicators must be treated as essential, being disclosed except if deemed non-relevant.

For the GRI (2006), stakeholders are organizations or individuals who may be significantly affected by the activities, products and/or services of the organization, such as shareholders, consumers, employers, governments, the community and the public in general, and whose actions may significantly affect the capacity of the organization to implement its strategies and achieve its goals successfully.

The indicators proposed by the GRI (which shall be the basis of this work), represent the third generation of guidelines for preparing sustainability reports, called GRI/G3. The performance indicators are organized in categories: Economic (codes EC1 to EC9); Environmental (codes EN1 to EN30); and Social, subdivided in Society (codes SO1 to SO8), Labor Practices and Decent Work (codes LA1 to LA14), Human Rights (codes HR1 to HR9) and Product Responsibility (codes PR1 to PR9). Each category is subdivided in some aspects described below, to which is linked a corresponding set of essential and additional indicators (Verify GRI, 2006a to 2006f).

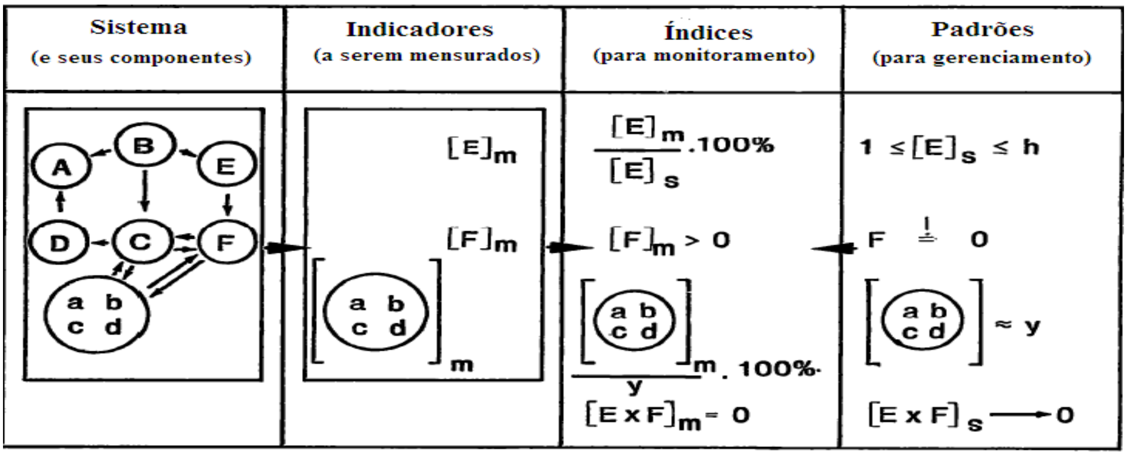
Notwithstanding the great effort required for the construction of structures and report of indicators, there is still an awesome, and yet little explored, challenge, which is its assessment in order to comprehend whether there are improvements and if they are in fact achieving the expected results. For Karlsson et al (2007), all these approaches are limited in that they address isolated elements of sustainability. Sustainability and sustainability development are characteristics of integrated systems with multiple linkages, feedback loops, and interdependencies. Although political approaches to sustainable development often are narrowly sectorial, with little focus on integration in practice, decision makers are increasingly asking for indicators to help build mutually reinforcing links between pillars.

Moldan e Dahal (2007, p.11) distinguish indicators and indexes according to their construction method:

- Indicator: this includes results from the processing (to various extents) and interpretation of primary data.
- Aggregated indicator: this combines, usually by an additive aggregation method, a number of components (data or sub-indicators) defined in the same units.
- Composite indicator: This combines various aspects of a given phenomenon, based on a sometimes complex concept, into a single number with a common unit.
- Index: This generally takes the form of a single dimensionless number. Indexes mostly require the transformation of data measured in different units to produce a single number.

Thus, the indicators may be defined to represent some constructs regarding the system under analysis and may be aggregated or composed to make up an index. Figure 1 illustrates the approach of UNEP/UNESCO (1987) to manage the performance of the system. In this case, the indicators must be quantified as desirable and undesirable goals and, therefore, are useful to establish standards.

Figure 1 – System management through indicators



Legend: The figure was extracted from UNEP/UNESCO (1987) and presents the interaction of components of a an economic-ecological system; the construction of indicators that represent measurable aspects of the components; the construction of indexes which represent relations between indicators and are used for monitoring; and the definition of standards used for management.

In this approach, Bauler et al (2007) propose the construction of a structure which decomposes the concept of sustainable development in hierarchical sets of sub-dominions, represented in a first level by the economic, social and environmental dominions. The subsequent levels are constituted by a set of indicators aggregated from the basic data and have a link between the several hierarchical levels. For the authors, the aggregation plays an important role in extracting useful information from the data and in the communication with users. When indicators are aggregated with certain criteria, they may provide a picture of the entire system concentrating in few key points. The criteria proposed by Bauler et al (2007) are: purpose; measurability; representativeness; reliability and feasibility e communicability.

The definition of a structure of levels of data, indicators and indexes hierarchically interconnected was also used in the proposition of the integrated environmental assessment methodology proposed by the UNEP/UNESCO (1987) and used by Garcia, Lima and Oliveira (2009).

For Bauler et al (2007), this definition is the first step to build a consistent and useful structure in the development of non-ambiguous indicators for decision-making. In order to meet this need, aggregation techniques may be considered and their possible weaknesses may be minimized by applying the criteria proposed for the construction of indicators.

2.2 Indicators Performance Assessment

The indicators performance management comprises the actions undertaken by managers aiming to improve indicators along time. This aspect presupposes the implementation and integration of control systems focused on the sustainability concept.

For Antony and Govindarajan (2007), managerial control is the process whereby managers influence other members of an organization to implement the organization strategies. According to the author, the managerial control activities involve: planning of actions, coordination of activities of several parts of the organization, communication of information to members of the organization, information assessment, decision between action alternatives and inducement of behaviors in the organization.

Careyns (2010) carries out a wide review of the control systems and concludes that the current trend is the combination of the formal use of the systems (accounting information systems), with financial and non-financial indicators, with informal systems, creating a "control package", which allows the control of relevant variables of the system so that the company may achieve its goals.

The indicators and indexes plan an essential role in the operation of the managerial control system, from the planning process to the assessment process, which comprises the analysis of the indicators with regard to a goal or a standard.

Some initiatives have been presented with the purpose of implementing sustainability strategies using indicators. Epstein e Wisner (2001), Dias-Sardinha and Reijnders (2005) propose the incorporation of social and environmental performance measures in a balanced scorecard. The BSC structure of concepts (Kaplan, 1996) provides a potent managerial control system. Its use in sustainability strategies allow the inclusion of metric regarding the social and environmental goals in planning and, consequently, in monitoring, communication and periodical assessment of indicators.

Other initiatives have been proposed with the purpose of assessing indicators, providing a more specific structure for certain sectors of the economy (see Azapagic, 2003; Epstein and Roy (2001)), but which comprise only some activities regarding planning and monitoring of deviations as for the goals proposed for the indicators.

The incorporation of the social and environmental aspects of a control system requires the use of indicators composed and aggregated in a hierarchical structure, as described by Bauler et al (2007). This structure, according to the authors, is complex, since it involves the multidimensionality of dominions (a set of indicators in each hierarchical level), the complexity of the social environmental system in analysis and the presence of crossed effects and impacts (in time and space). They also state that the translation of these aspects in coherent procedures and substantive methods determine the quality of the assessment tool. The integrated environmental assessment methodology proposed by UNEP/UNESCO (1987) to evaluate water basin implantation projects deals with the aspects listed by Bauler et al (2007) and presents the following requirements to solve these difficulties (UNEP/UNESCO, 1987, p.39):

a) achieve a numerical value as a result which characterized the current state of the investigated system under the joint perspective between the environment and socioeconomics;

b) allow the adaptation to different system scales – from simple investment projects to a business venture as a whole;

c) allow, from the application of the methodology, general comparisons between the investigated systems, provided that there is a uniform standard for assessment;

d) be capable of reflecting changes of importances or preferences in time and space;

   - between the third-level indicators, that is, between the (socioeconomic) development and (environmental) preservation;

   - between second-level indicators, such as Materials, Energy, Water, Economic Performance, Community, etc.;

– between first-level indicators, that is, basic indicators belonging to each second-level indicator (ex. total water withdrawn per source, basic indicator for formation of the second-level indicator – Water).

e) be a simple methodology, which favors the use of graphic and interactive computing;

f) make the numerical value representing he current state of the system the basis for the selection between possible options that improve the performance of this same system.

In this sense, the methodology proposes: the construction of a balanced index, representing the socioeconomic and environmental aspects, formed from the aggregation of indicators in several hierarchical levels. The use of a standardization technique allowing the treatment of several types and scales of indicators (b); the use of sets of standard indicators to assess similar systems (c); the use of a mathematical methodology considering weights and weighting between the indicators to include the preferences or needs of managers (d) and the use of a decision support methodology (MCDA), which allows the analysis of trade-offs between the indicators and simulation of alternatives to improve performance (f).

The MCDA is a set of methods which allows the simultaneous treatment of complex matters involved in the decision-making process, whether of economic, social, environmental, political nature and others. They have been applied to support and lead decision makers in the assessment and choice of solution-alternatives in different contexts (Joerin, 2010; Loken, 2007, Steele et al., 2009).

2.3 Decision making for sustainability

The decisions regarding sustainability involve an important dilemma to managers with regard to the weighting of the social and environmental advantages with the economic and financial results, which are reported in a traditional approach in the annual reports of the companies. It is clearly a problem with multiple conflicting goals, comprising the assessment of multiple criteria for variables with different measuring scales that may be grouped in multiple levels.

The treatment of this decisions process through formal methods presents potential benefits and require that they be well applied (Steele et al., 2009). The MCDA are aimed to help managers in decision processes presenting multiple criteria and which several goals have to be achieved simultaneously.

The Commitment Programming (CP) and Composition Programming (CtP) are multicriterial methods (MCDA) with specific characteristics. The CP was developed by Yu (1973) and Zeleny (1974) with the basic idea of determining of a set of efficient solutions that are near an ideal and unachievable point. This set is named set of commitment solutions and its metric corresponds to a distance to the ideal solution. The CtP (introduced by Bardossy in 1984) is an extension of the CP, which introduces goals in multiple levels, given the CP limitation in not providing a structure for the organization of the attributes and/or goals in a hierarchical form. It is known a multilevel multicriterial programming method, in which the a general multiobjective problem, with *m* goals, is transformed into a problem with one sole goal.

According to Brostel (2002), the CP and the CtP are techniques using a progressive articulation of preferences of the decision-makers. The deciding agent acts along the decision-making process, and may change opinions in case the solution to the problem does not reach the proposed goals. Formally, the MCDA application involves the following elements (GOMES; ARAYA; CARIGNANO, 2004):

a) Decision-maker: Decision subject, decision agent or decision taker. It is the individual or group of individuals who, directly or indirectly, provides the final value judgement which may be used at the moment of evaluating the available alternatives, with the purpose of identifying the best choice.

b) Analyst: Individual or group of individuals in charge of interpreting and quantifying the opinions of decision-makers, structuring the problem, preparing the mathematical model and presenting the results. The analyst must keep a constant dialogue and interaction with decision-makers in a constant learning process;

c) Attributes and Criteria: The attributes are properties or abilities of the alternatives to meet the needs and/or wishes, even though in different amounts or intensities; The criteria make the preferences of a decision-maker explicit and operative as for the alternatives for a certain attribute;

d) Weights: As a result of the preferences of the decision-makers, some attributes have higher importance than others. The measure of the relative importance of the attributes for the decision-makers is referred to as weight or weighting.

There are situations in which the evaluation criteria weights result from the problem structure and the possibility of establishing an interactive process with managers, with the possibility, in some cases, of being defined exclusively in the analyst’s view and, subsequently, submitted to verification and approval by the one(s) responsible for making the decision. However, according to Goecoechea *et al.* 1982, *apud* Brostel, 2002, the determination of the weights may be done by using two approaches: the one derived from the observer, when judgment on the decision-maker is simulated, or the one explained by the client when the weight values are obtained directly from the deciding agent.

The CtP methodology allows the calculation of the current situation of a system and its distance to an ideal situation, which provides an assessment measure for the system under analysis and for the indicators and variables involved in its composition. It also allows the consideration of several scenarios and the prescription of concrete actions in the most deficient social, economic and environmental conditions. Thus, it is possible to establish a condition considered “dominant optimum” and carry out simulations in the indicators to reach this solution.

In the context of the decision-making process in companies in search of sustainability, this involves making decisions about conflicting action plans when, for instance, there is the possibility of investing in a project to reduce electric power consumption and another technology project which will increase financial gains. The use of a formal method to support the decision may help promote the required balancing in the adoption of alternatives in the triple bottom line approach.

3 Methodological Procedures

For the calculation of the social, environmental and economic equilibrium of the COPEL company, a description of the problem situation was initially developed, hierarchically representing the indicators in the social, environmental and economic perspectives in three levels: indicator (level 3), sub-index (level 2) and variable (level 1). Level 1, understood as operational, corresponds to the value of primary variables measured or obtained to calculate the value of the subsequent levels. The GRI structure was used as protocol of development indicators. Since its hierarchical structure has over 3 levels, in order to compose the level-3 social perspective, intermediate sub-index sets were considered in level 2. Table 1 illustrates the operational method of the indicators used.

Table 1: GRI indicators classified in levels

Indicator (Level 3)	Sub-index (Level 2)	Sub-index (Level 2)	Variable (Level 1)
ECONOMY		Economic Performance	EC1, EC3
		Market Presence	EC4 a EC7
		Indirect Economic Impacts	EC8
ENVIRONMENT		Materials	EN1, EN2
		Energy	EN4, EN6 a EN7
		Water	EN8 a EN10
		Biodiversity	EN11 a EN15
		Emissions, Effluents and Waste	EN16 a EN23, EN25
		Products and Services	EN26
		Conformity	EN28
		Overall	EN30
SOCIAL	Society	Community	SO1
		Corruption	SO3, SO4
		Public Policies	SO5
	Labor practices	Employment	LA1 a LA3
		Relationships between Workers and Management	LA4, LA5
	Decent Work	Work Health and Safety	LA6 a LA9
		Training and Education	LA10 a LA12
		Diversity and Equality of opportunities	LA13, LA14
		Investment Practices and Purchase Processes	HR1, HR2
		Child labor	HR6
		Forced Work or Analogous to Slave Work	HR7
		Indians' Rights	HR9
	Product Liability	Client's Health and Safety	PR1, PR2
		Labeling of Products and Services	PR5
		Marketing Communications	PR6, PR7
		Client's Privacy	PR8
		Conformity	

The GRI indicators of the company were collected from reports disclosed in the year 2009. For calculation of the indicators, which represent the social, environmental and economic perspectives, the variables and sub-indexes were aggregated by using an adaptation of the CtP. In order to compare the values of the indicators obtained in the studied companies with an ideal situation, thus verifying its performance, an adaptation of the CP, as developed by Zeleny (1974), was used. Therefore, the procedures for calculation of the index were established in four stages:

Stage 1) Standardization of the variables (level 1). As demonstrated in Table 1, the study variables are presented in different scales, making their aggregation a difficult process. Thus, the standardization process allows the values of variables not comparable between themselves to be standardized into the same scale, making their aggregation viable. In general, the standardization process uses the maximum and minimum value for the definition of a scale in which the variable value is situated between the worst and the best value defined for it. Index 0 is commonly considered the worst value, whereas Index 1 is considered the best value. The choice between the two following expressions was made considering S_i always positive:

$$S_i = \frac{Z_i - (Z_{i-})}{(Z_{i+}) - (Z_{i-})} \quad (1) \qquad S_i = \frac{(Z_{i+}) - Z_i}{(Z_{i+}) - (Z_{i-})} \quad (2)$$

S_i: standardized value for Z variables;

Z_i: current variable value;

Z_{i-}: minimum value defined for the variable;

Z_{i+}: maximum value defined for the variable;

In summary, index S_i indicates the distance from Z_i to the best and the worst parameter. These parameters may be defined in terms of goals for the achievement of variables in a specific period of analysis, and be obtained by technical parameters or benchmarks. In an ideal application process in the companies, this definition would be made by managers, preferably in a periodical planning process. The definition of the maximum and minimum values for each indicator was exclusively based on the information disclosed by the companies in their annual reports. In this stage of the research, there has been no interactive process with the company's managers so as to capture their preferences. The definition of parameters by a team of researchers was chosen, considering the following criteria:

A. Minimum Values:

a) Values calculated in the previous year, in 2008;

b) Current value, when the company is not expected to backtrack on certain characteristics;

c) Whenever applicable, the worst condition of the indicator was used, that is, value 0 was used;

d) Whenever applicable, the same decrease variation observed for the indicator in the years 2008 and 2009 was applied;

e) For the qualitative indicators, the worst condition assigned to the indicator was zero.

B. Maximum Values:

a) Goals established by the Company for the year 2010 or, in some cases, the existing goal for the year 2009;

b) Current value, when there were no established goals. The company was assumed to be at its maximum capacity level;

c) Growth variation projections observed between the years 2008 and 2009 for the indicator, in case of indicators with clear advance goals;

d) For the qualitative indicators, the best condition assigned to the indicator was one.

__Stage 2) Definition of the weights for level-2 variables and sub-indexes__

The definition of weights of each variable reveals the degree of importance of the same in the analyzed situation. In the mathematical equations this weight is represented by α. The two parameters α and P act as a mechanism of double ponderation. The first expresses the relative importance of variables within a group of second-level sub-indexes and, subsequently, the relative importance of sub-indexes for each indicator. The P parameter reflects the importance of the maximum deviation (max S_{ij}). For P=1, all divergences are equally weighed.

Given the subjectivity inherent to the process of attribution of ponderation structures in MCDA methodologies, the approach derived from the observer (Goecoechea *et al.* 1982, *apud* Brostel, 2002) was chosen, using in this research stage the definition through a group of researchers. Thus, variables were deemed to have the same weight, since it was not possible to establish an importance predominance relationship of the variables and sub-indexes in each group.

__Stage 3) Calculation of the Indicators__. Using the values standardized in Stage 1 and the weights defined for the sub-indexes in Stage 2, it is then possible to develop the calculation of the sub-indexes. According to Table 1, it is observed that the sub-indexes are made up of one or more variables. Then, for each one of the companies, the sub-indexes, the indicators and the final sustainability index are measured in the concept of distance to an ideal point, according to the composition process defined in the Commitment Programming (CtP) technique. For that purpose, it is highlighted that in this work all sub-indexes were considered as equally important, as described in Stage 2. The aggregation of information for the final sustainability indicator composition was carried out in two stages:

__Composition – 1st Stage__

Consists in defining the second-level composite distances, which were calculated for all second-level sub-indexes (in two stages, due to the Social perspective), by using the following equation:

$$L_j = \left[\sum_{i=1}^{n_j} \alpha_{ij} \, S_{ij}^{\;P_j} \right]^{1/P_j} \quad , \qquad \sum_{i=1}^{n_j} \alpha_i = 1$$

L_j: composite distance, from the ideal point, of the group of i standardized variables making up the j second-level sub-indexes:

S_{ij}: calculated value of the i standardized index for each variable making up the j second-level sub-indexes;

n_j: number of variables making up the j second-level sub-indexes;

α_{ij}: weights expressing the relative importance of n variables of the j second-level group. The sum of weights in any group is always equal 1;

P_j: equilibrium factor between sub-indexes of a j group. It is equal or higher than 1. The value will depend on the emphasis the researcher wishes to give to stress great divergences or deviations.

__Composition – 2nd Stage__

From the calculation of the composite distances for each second-level sub-index, the three third-level composite distances (indicators) were calculated:

$$L_k = \left[\sum_{j=1}^{m_k} \alpha_{jk} \, L_{jk}^{\;P_k} \right]^{1/P_k}$$

L_k: composite distance from the ideal point of m numbers of L_js constituting the third-level group k;

m_k: number of L_j elements linked to the third-level group k;

L_{jk}: second-level composite distances constituting third-level group k;

α_{jk}: weights representing the relative importance of m numbers L_js constituting the third-level group k;

P_k: equilibrium factor for the third-level group k.

Thus, the 2nd State resulted in the composition of the L_1 distances for the Environmental perspective, L_2 for the Social perspective and L_3 for the Economy perspective.

Stage 4) Calculation of distances to the ideal point. The last step was the final composition between the third-level distances. This composition was executed through the following formula:

$$L = \left[\sum_{k=1}^{n_g} \alpha_{kg} \, L_{kg}^{\;p_g} \right]^{\frac{1}{p_g}}$$

L: composite distance characterizing the current state of the system;

n_g: number of third-level L_k elements;

L_{kg}: third-level composite distances forming the index:

α_{kg}: weights expressing the relative importance between the third-level elements k;

P_l: equilibrium factor for composition of the index.

The calculations used the same weight for the three perspectives and the equilibrium factor P=3.

The calculations used the same weight for the three perspectives and the equilibrium factor P=3. According to UNEP/UNESCO (1987), this definition has shown to be applicable for conflicting situations (trading off) between the socioeconomic and environmental aspects.

4 Results

The calculation of the equilibrium index of the COPEL company requires a composition of indicators representing the social, economic and environmental perspectives of the company. The value of these indicators was obtained from the GRI/G3 indicators protocol, referred to as variables and sub-indexes for the purposes of this research.

The 1st Level variables (basic indicators) were collected from the Sustainability Report of the Company in the year 2009. In the Report, the acronyms of the GRI indicators are presented in a summary, with the respective page in which the indicator is commented in body of the Report. The collection procedure comprised the reading of the pages indicated in the summary, since most of them were not highlighted in the text, which demanded its interpretation. Additional data referring to the goals for variables, when presented, where also collected to provide for Stage 1 of standardization of variables.

4.1 Sample Characteristics

In addition to the indicators in the three perspectives, COPEL also discloses sectorial indicators, since it belongs to the Energy Utilities sector, these data was treated to compose the fourth perspective, the Sectorial one (Sectorial indicator). Table 2 presents the number of indicators used in the research.

Table 2: GRI - COPEL – 2009 Indicators

Indicators (3rd Level)	Sub-indexes (*)	GRI proposed amount	GRI proposed %	COPEL Disclosed (2009)	% Disclosed	Excluded **	Amount used	% Used
Economic Perspective	EC	9	8,3%	8	7,3%	1	7	6,4%
Environmental Perspective	EN	30	27,5%	29	26,6%	3	26	23,9%
Social Perspective	LA	14	12,8%	14	12,8%	0	14	12,8%
	HR	9	8,3%	9	8,3%	4	5	4,6%
	SO	8	7,3%	5	4,6%	1	4	3,7%
	PR	9	8,3%	7	6,4%	1	6	5,5%
Sectorial Perspective	EU	30	27,5%	15	13,8%	2	13	11,9%
	Total	**109**	**100,0%**	**87**	**79,8%**	**12**	**75**	**68,8%**

Legend: The Table shows the amount and percentage of performance indicators used in the research compared with the amounts and percentages proposed by the GRI and disclosed by the company COPEL in 2009.
(*) The numbers of basic variables are presented (1st level) which represent 2nd level sub-indexes (EC; EN) and the 2nd level sub-indexes (LA, HR, SO, PR) which represent the 3rd level Social Perspective.
(**) Justifications for the exclusions are presented in the text. EC: Economic; EN: Environment; LA: Labor Practices and Decent Work; HR: Human Rights; SO: Society; PR: Product Liability and
EU: Indicators of the Energy Sectorial Supplement.

COPEL disclosed 87 GRI indicators and 12 of them were excluded since: there was no information about them; they were not clearly defined; they were not found in the Report; or the information presented did not allow the establishment of goals on the indicators. The excluded indicators were: EC2 (Economic Perspective); EN5, EN24 and EN29 (Environmental Perspective); HR3, HR4, HR5, HR8, SO8, PR9 (Social Perspective) and EU5 and EU15 (Sectorial Perspective). Disregarding the sectorial perspective, which is still under construction, the amount disclosed was of 72 indicators, representing 91.14% with regard to the GRI recommendation.

4.2 Equilibrium Index

The collected variables went through the standardization process, whose values are situated in a scale between 0 and 1. The standardized variables were aggregated in the 1st Stage to compose the 2nd Level sub-indexes, which, in turn, were aggregated to compose the 3rd level indicators. Two applications of this procedure were carried out to obtain an equilibrium index from the indicators of the Economic, Social and Environmental Perspective and another index including the Sectorial indicator. Table 3 presents the result of the aggregation of indicators in the three composition levels.

Table 3: Results of the Aggregation Process - COPEL - 2009

Indicators	Variables and Sub-indexes		Aggregation Stages		
			1st Stage	2nd Stage	Index
ECONOMIC	EC1, EC3	Economic Performance	0,504815	0,4428	0,4664
	EC4 a EC7	Market Presence	0,577357		
	EC8	Indirect Economic Impacts	0		
ENVIRONMENTAL	EN1, EN2	Materials	0,709366	0,6055	
	EN4, EN6 a EN7	Energy	0,60995		
	EN8 a EN10	Water	0,57735		
	EN11 a EN15	Biodiversity	0,229416		
	EN16 a EN23, EN25	Emissions, Effluents and Waste	0,562979		
	EN26	Products and Services	0		
	EN28	Conformity	1		
	EN30	Overall	0,595409		
SOCIAL	SO1	Community	0	0,2998	
	SO3, SO4	Corruption	0		
	SO5	Public Policies	0		
	LA1 a LA3	Employment	0,353553		
	LA4, LA5	Relatonships between workers and management	0		
	LA6 a LA9	Work Health and Safety	0,790569		
	LA10 a LA12	Training and Education	0,377964		
	LA13, LA14	Diversity and Equality of opportunities	0,412245		
	HR1, HR2	Investment Practices and Purchase Processes	0		
	HR6	Child labor	0		
	HR7	Forced Work or Analogous to Slave Work	0		
	HR9	Indian´s Rights	0		
	PR1, PR2	Client’s Health and Safety	0,816497		
	PR5	Labeling of Products and Services	0,011628		
	PR6, PR7	Marketing Communications	0,57735		
	PR8	Client´s Privacy	0		

Legend: The table shows the distances obtained in each aggregation stage. The values for the sub-indexes are obtained in the 1st Stage, the values for the indicators are obtained in the 2nd Stage and, subsequently, the equilibrium index.

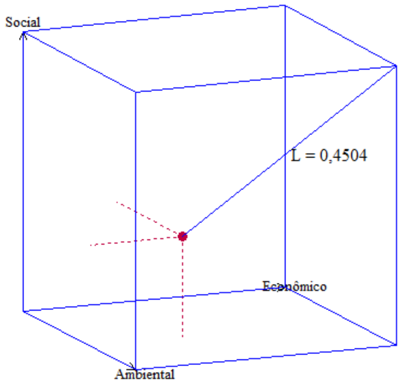
Considering the three Perspectives, the equilibrium index calculated was of 0.4664. This measure represents the distance in which the equilibrium level of the social, environmental and economic actions by COPEL are at a utopic point of ideal equilibrium representing in this case 53.36% of achievement as for the ideal point.

The indicator calculated to represent the economic perspective is 0.4428, representing

55.72% of achievement; the environmental indicator is 0.6055, representing 39.45% of achievement; and the social perspective indicator is 0.2998 representing 70.01% of achievement.

Having three indicators, their interpretation may take place in a tridimensional space (Garcia, Oliveira and Lima, 2009), wherein the point (1,1,1) represents an ideal maximum equilibrium situation between the social, economic and environmental aspects and the L index represents the distance to this ideal point. Figure 2 presents the representation of this distance in the tridimensional space.

Figure 2: COPEL Sustainability Index - 2009



Legend: The Figure shows the distance of the L index obtained by COPEL in the year 2009 from the indicators representing the social, economic and environmental perspectives.
(*) The graphic representation is an illustration since the metric used is only based in the Euclidean distance.

When the sectorial perspective is inserted, the equilibrium value decreases, since the value of the distance to the ideal point in the sectorial perspective is 0.4409. This result improves the total equilibrium value of the Company, decreasing the distance to the standard established as ideal. The new distance found is of 0.4789, representing 52.11% of achievement as for the ideal point.

The analysis of the current situation of COPEL may be executed in each one of the hierarchical levels considered, by interpreting the indicators and sub-indexes presenting higher magnitude (greater distance to an ideal situation) as performance relative deficiency. However, since the CtP methodology allows simulations, it is possible to establish a target point and prescribe concrete action for the variables (basic GRI indicators) in the most deficient social, economic and environmental conditions and allow the equilibrium measure obtained to shift towards the ideal point.

As an illustration, the sustainability index L = 0.40 and the distances L_1 = 0.40, L_2 = 0.40 and L_3 = 0.40 were considered. The goal is to determine the priorities of actions for the economic perspective to go from 0.44 to 0.40, the environmental to go from 0,60 to 0.40 and the social to go from 0.30 to 0.40, simulating a performance tradeoff between the perspectives. Thus, some managerial alternatives could be proposed, such as: in the environmental perspective, improvement of the material indicators; energy; water and emissions, effluents e residues in 33.93%; in the social perspective, it is possible to reduce investments in Marketing Communications in 33.43%. The choice of alternatives depends on the analysis by the managers.

5 Discussion

The purpose of this research is to propose a structure to manage corporate strategies and actions regarding sustainable development. In order to do so, we have analyzed the requirements for integration, to the managerial control systems, of a mathematical methodology for measurement and assessment of economic, social and environmental indicators. The application was made in a Brazilian company in the energy utility sector by using, in this stage, external data disclosed in the company's sustainability report.

For integration to the managerial control systems (...), in periodical planning, it is required to incorporate a measurement subprocess of the indicators. In this case, given the characteristics of the CtP methodology, some important aspects regarding the performance of the managers and the conditions of the information system of the company are relevant. The measurement process of the indicators, which results in the calculation of the sustainability index, comprises the following stages:

1) Definition of the indicators: The structure of GRI indicators is a proposition defined for disclosure of information incorporating proper requisites (according to Bauler et al, 2007) and which are adopted by the GRI for construction of indicators and their measurement units. This definition is made by multiple stakeholders, so its use incorporates the influence of these agents in the corporate decision process. However, in an internal application, its use depends on managers, the capacity of the information systems to capture this data and, mainly, on the possibility of establishing goals for the basic GRI indicators. The hierarchical structure of indicators proposed by the GRI is also compatible with the interpretation by Bauler et al (2007) on the aggregation of indicators in hierarchical levels.

2) Definition of goals for the indicators: For operationalization of this methodology, it is required to define a minimum standard and maximum standard of achievement for each basic indicator. In the illustrative application made on the COPEL company, criteria were established in the analyst's view. However, a managerial application requires interaction of several areas of the company due to the nature of the indicators and the possibilities for their proper management and monitoring. This definition involves only the influence of decision-makers, which may be minimized by the existence of performance technical standards and performance benchmarks between companies, mainly of the same economic sector.

3) Definition of the preference structure (weights and weighting measures): This definition involves the definition of predominance of importance of indicators and groups of indicators. In the illustrative application made, in the analyst's view, no preference relation was defined. In the managerial application, it is possible to establish differentiated weights for variables as a result of the preferences or needs of managers. According to Bramont (1996), the multicriterial methodologies contribute to help the decision-maker, but choose and prefer are exclusive tasks of the latter.

4) Simulation of an aimed performance: With the operationalization of this methodology, from the quantification of the basic indicators, it is possible to obtain a current equilibrium situation of the three perspectives and the performance data referring to the other hierarchical levels. It is possible, from this point, to define an achievable plan of goals of improvement of the indicators along time and simulate the results that will be achieved. It is also possible to simulate a better performance situation for the sustainability index and analyze the several alternatives of action that may be implemented to achieve the index.

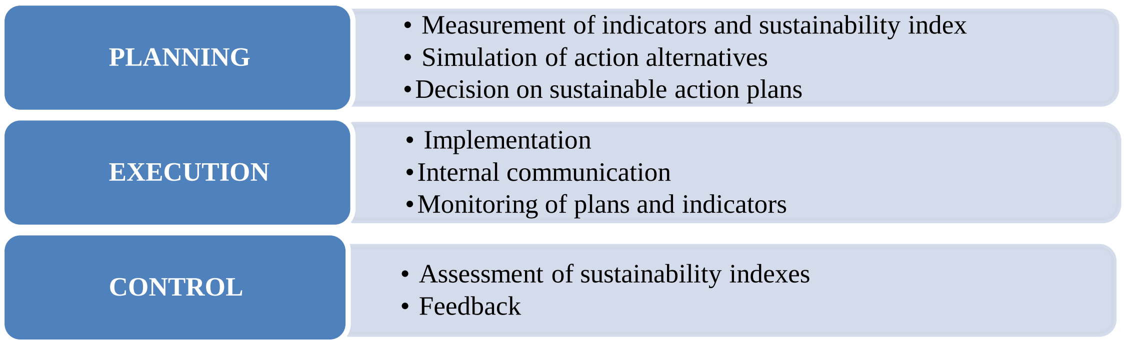
5) Definition of action plans to the aimed performance: It involves the choice between alternatives of action for improvement of the performance of the indicators and definition of action plans that should be incorporated to the corporate planning to achieve the performance.

The incorporation of this definition in the planning process is important because the assignment of limited resources of the company compete in the decision-making, considering all other organizational plans. It is also possible to execute the quantification of the plans in the budget.

In the execution process, it is required that the action plans be communicated, implemented and that the performance of the plans and indicators be monitored. The operational systems must have capacity to capture the results of the implemented actions which impact the measurement of the indicators.

In the corporate control process, the indicators are required to be assessed, verifying their achievement with regard to the aimed goals (standard). The methodology is required to be once again applied with data executed in the period. Feedbacks and learning processes are highlighted in this stage, providing better understanding of the indicators and actions that may improve their performance for the next period.

Figure 3: Integration Structure of the Managerial Control Process



Legend: The Figure shows the interaction of the planning, execution and control processes with the subprocesses proposed for implementation of this assessment methodology of the performance of the economic, social and environmental indicators.

The COPEL company data was gathered in disclosed reports, the goals for the indicators, as well as, the weights for the groups of indicators in the several hierarchical levels were defined by a team of researchers. Thus, the results for the calculated sustainability index do not represent the preference structure of internal managers nor the internal conditions of the company for implementation of this methodology. In this regard, the essential contribution of the case is the illustration and structuring of application and not the specific result found, which may not be used to assess the sustainability of the company.

For the overall structuring of the application, indicators of several other companies have been collected in our Project. We have found many incompatibilities of information from one year to the other, such as changes of parameters and measurement scales and even absence of basic indicators and unfoldings. This may affect the applicability of the model by the companies because it suggests that the information base of the GRI indicators is not internally appropriate.

Few studies have put forward propositions to assess the performance of social, economic and environmental indicators integrated with the corporate scope. There are also few studies on the implementation of sustainable strategies in companies, mainly regarding the incorporation of mathematical tools structured to support decision.

This work has contributed with the proposition of a methodology for measurement and decision-making on socioeconomic and environmental indicators, as well as the proposition of a structure of integration of the methodology to the managerial control system of companies. This integration may provided a proper definition of plans and allocation of resources in the planning process; implementation of plans and monitoring in the execution process and assessment of performance of indicators in the control process of companies, thus helping the implementation of sustainable strategies.

Future studies could consider the empirical application, with effective participation of managers, in case studies of companies and, thus, widen the discussion and definition of requisites for application of the methodology considering the view of managers.

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6 References

AMMENBERG, J.; HJELM, O.; QUOTES, P. The Connection Between Environmental Management Systems and Continual Environmental Performance Improvements. **Corporate Environmental Strategy**. v. 9, n. 2, p. 183-192, 2002.

ANTHONY, R. N. e GOVINDARAJAN, V. **Management Control Systems**. McGraw Hill Companies, 12o.Ed., 2007. 769 p.

AZAPAGIC, A. Developing a framework for sustainable development indicators for the mining and minerals industry. **Journal of Cleaner Production** . n. 12, p. 639–662, 2004.

BAULER, T. et al. Identifying Methodological Challenges. In: HÁK, T.; MOLDAN, B.; DAHL, A. L. (Orgs). **Sustainability Indicators: a scientific assessment.** Washington: Island Press 2007. 413 p.

BROSTEL, R. C. **Formulação de modelo de avaliação de desempenho global de estações de tratamento de esgotos sanitários (ETE's)**. 2002. Dissertação (Mestrado em Tecnologia Ambiental e Recursos Hídricos) – Programa de Pós-Graduação em Tecnologia Ambiental e Recursos Hídricos, Universidade de Brasília, Brasília, 2002. Brazil.

CARENYS, J. Management Control Systems: A Historical Perspective. **International Bulletin of Business Administration.** n.7, p.37-54, 2010.

COPEL – Companhia Paranaense de Energia. Relatório Anual de Gestão e Sustentabilidade, 2009. <Disponível em: http://www.copel.com/> Acesso em 23 de junho de 2010

DIAS-SARDINHA, I.; REIJNDERS, L. Evaluating environmental and social performance of large Portuguese companies: a balanced scorecard approach. **Business Strategy and the Environment**. v. 14, n. 2, p. 73-91, 2005.

ELKINGTON, J. **Cannibals with Forks:** The Triple Button Line of 21st Century Business. Oxford: Capstone. 1999. 410p.

EPSTEIN, M. J.; ROY, M. Sustainability in Action: Identifying and Measuring the Key Performance Drives. **Long Range Panning**, n. 34, p. 585-604, 2001.

EPSTEIN, M. J.; WISNER, P. S. Using a Balanced Scorecard to Implement Sustainability. **Environmental Quality Management**, Winter 2001/1, p. 1-10. 2001.

FIGUEIRA, J.; GRECO, S.; EHRGOTT, M. **Multiple Criteria Decision Analysis: State of the Art Surveys**. New York: Springer. 2005. 1040 p.

FREITAS, C. M.; SCHÜZ, G. E.; Oliveira, S. G. Environmental sustainability and human well-being indicators from the ecosystem perspective in the Middle Paraíba Region, Rio de Janeiro State, Brazil. **Cadernos de Saúde Pública**, n. 23. v. 4., p. 513-528. 2007.

GARCIA, S. ; LIMA, F. G. ; OLIVEIRA, P.H.D. . Corporate Sustainability: Evaluation of the social, economic and environmental equilibrium of companies in the three dimensional euclidean space. **In: 5th Conference on performance measurement and management control.** Nice, França, set 2009. CDRoom.

GOMES, L. F. A. M.; ARAYA, M. C. G.; CARIGNANO, C. **Tomada de decisão em cenários complexos: introdução aos métodos discretos do apoio multicritério à decisão**. São Paulo: Pioneira Thomson Learning, 2004. Brazil.

GRI. Global Report Initiative. Downloaded in: <http://www.globalreporting.org/ReportServices/GRIReportsList/>. Accessed on: 27 May 2011.

JOERIN, F.; COOL, G.; RODRIGUEZ, M. J.; GIGNAC, M.; BOUCHARD, C. Using multi-criteria decision analysis to asses the vulnerability of drinking water utilities. **Environmental Monitoring and Assessment**, n. 166, v. 2, p. 313-330. 2010.

KAPLAN, R.S. e NORTON, D.P. **The Balanced Scorecard: Translating Strategy Into Action**. Boston: Harvard Business School Press. 1996.

KARLSSON, S. et al. Meeting Conceptual Challenges. In: HÁK, T.; MOLDAN, B.; DAHL, A. L. (Orgs). **Sustainability Indicators: a scientific assessment.** Washington: Island Press 2007. 413 p.

KROSINSKY C.; ROBINS N. **Sustainable Investing: The Art of Long Term Performance.** London: Earthscan. 2008. 244p.

LOKEN, E. Using of Multicriteria Decision Analysis Methods for Energy Planning Problems. **Renewable and Sustainable Energy Reviews**, n. 11, p. 1584-1595. 2007.

MOLDAN, B.; DAHL, A. L. Challenges to Sustainability Indicators. In: HÁK, T.; MOLDAN, B.; DAHL, A. L. (Orgs). **Sustainability Indicators: a scientific assessment.** Washington: Island Press 2007. 413 p.

RICKARD, L. et al. Ensuring Policy Relevance. In: HÁK, T.; MOLDAN, B.; DAHL, A. L. (Orgs). **Sustainability Indicators: a scientific assessment.** Washington: Island Press 2007. 413 p.

RUFFIN, K. Indicators to Measure Decoupling of the Environmental Pressure from Economic Growth. In: HÁK, T.; MOLDAN, B.; DAHL, A. L. (Orgs). **Sustainability Indicators: a scientific assessment.** Washington: Island Press 2007. 413 p.

ROCKSTRÖM, J.; STEFFEN, W.; NOONE, K. et al. A safe operating space for humanity**. Nature**, v. 461, p. 471-475, 2009.

STEELE, K.; CARMEL, Y.; CROSS, J.; WILCOX, C. Uses and Misuses of Multicriteria Decision Analysis (MCDA) in Environmental Decision Making. **Risk Analysis**, n. 29, v. 1, p. 26-33. 2009.

TYTECA, D. On the Measurement of the Environmental Performance of Firms: A Literature Review and a Productive Efficiency Perspective. **Journal of Environmental Management**. v. 46, n. 3, p. 281-308, 1996.

UNEP/UNESCO. **Methodological Guidelines for the Integrated Environmental Evaluation of Water Resources Development**. Paris, 1987. Disponível em: <http://unesdoc.unesco.org/images/0008/000897/089740eb.pdf>. Acesso em: 10 Dec. 2010.

YU. P. L. A class of solutions for group decision problems. **Management Science**, vol 19, p. 936-946, 1973.

WB – World Bank. **World Development Indicators: Poverty Data**. Washington: World Bank, 2008. 28 p.

WHO – World Health Organization. **Progress on Sanitation and Drinking-Water.** Geneva: UNICEF, 2010. 60p.

ZELENY, M. A concept of compromise solutions and the method of the displaced ideal. **Computers and Operations Research**, vol. 1, p. 479-496, 1974.

ZOBEL, T.; ALMROTH, C.; BRESKY, J.; BURMAN, J. Identification and assessment of environmental aspects in an EMS context: an approach to a new reproducible method based on LCA methodology. **Journal of Cleaner Production**. v. 10, n. 4, p. 381-396, 2002.

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