

EVALUATION MODEL TO AID THE MANAGEMENT OF SUSTAINABLE PROCUREMENT IN BRAZILIAN FEDERAL HIGHER EDUCATION INSTITUTION: A CASE STUDY

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Public Administration is able to use its great purchasing power to develop structural changes in the productive sectors, providing environmental protection and economic social development. The present study proposes the structuring of a multicriteria evaluation model to support sustainable procurement management at the Federal University of Rio Grande. The constructivist multicriteria decision aid methodology – MCDA-C was used, consequently resulting in the development of the evaluation model. This made it possible to identify the current performance of sustainable contracting in the institution and point out its improvement potential, based on the established indicators. The model resulted in 29 performance indicators for sustainable contracting in the institution and, after evaluation, 11 indicators with unsatisfactory performance were pointed out, for which MCDA-C recommends directing efforts to leverage performance, improvement actions were proposed.

Keywords: sustainable public procurement, evaluation model, MCDA-C

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MODELO DE AVALIAÇÃO PARA APOIAR A GESTÃO DE CONTRATAÇÕES SUSTENTÁVEIS EM UMA INSTITUIÇÃO FEDERAL DE ENSINO SUPERIOR: UM ESTUDO DE CASO

A Administração Pública é capaz de viabilizar transformações estruturais nos setores produtivos por meio de seu grande poder de compras, favorecendo a proteção ao meio ambiente e o desenvolvimento econômico e social. Este artigo propõe a estruturação de um modelo multicritério de avaliação para apoiar a gestão de compras sustentáveis na Universidade Federal do Rio Grande. Utilizou-se da Metodologia Multicritério de Apoio à Decisão - Construtivista - MCDA-C e, como resultado, o modelo de avaliação desenvolvido na pesquisa permitiu identificar a performance atual das contratações sustentáveis na instituição e apontar o seu potencial de aperfeiçoamento, a partir dos indicadores estabelecidos. O modelo resultou em 29 indicadores de desempenho para as contratações públicas sustentáveis na instituição e, após avaliação, foram apontados 11 indicadores com desempenho insatisfatório, para os quais a MCDA-C recomenda direcionar esforços para alavancar o desempenho, ações de melhoria foram propostas.

Palavras-chave: contratações públicas sustentáveis, modelo de avaliação, MCDA-C

MODELO DE EVALUACIÓN PARA APOYAR LA GESTIÓN DE LA CONTRATACIÓN SOSTENIBLE EN UNA INSTITUCIÓN FEDERAL DE EDUCACIÓN SUPERIOR: UN ESTUDIO DE CASO

La Administración es capaz de posibilitar transformaciones estructurales en los sectores productivos a través de su gran poder adquisitivo, favoreciendo la protección ambiental y el desarrollo económico y social. Este artículo propone la estructuración de un modelo de evaluación multicriterio para apoyar la gestión sustentable de compras en la Universidad Federal de Rio Grande. Se utilizó la Metodología de Apoyo a la Decisión Multicriterio - Constructivista - MCDA-C y, como resultado, el modelo de evaluación desarrollado en la investigación permitió identificar el desempeño actual de la contratación sustentable en la institución y señalar su potencial de mejora, en base a los indicadores establecidos. El modelo resultó en 29 indicadores de desempeño para contratos públicos sostenibles en la institución y, luego de la evaluación, se identificaron 11 indicadores con desempeño insatisfactorio, para lo cual el MCDA-C recomienda dirigir esfuerzos para apalancar el desempeño, se propusieron acciones de mejora.

Palabras clave: contratación pública sostenible, modelo de evaluación, MCDA-C

1. INTRODUCTION

The public sector demands large volumes of goods and services around the world and government contracting involves 15% of the country's Gross Domestic Product (GDP), on average (XU *et al.*, 2016; DEAMBROGIO *et al.*, 2017; DELMONICO *et al.*, 2018). In Brazil, the value of procurement processes announced in 2020 was over R\$ 700 billion, or approximately 10% of GDP (BRASIL, 2021a).

Public policies capable of promoting sustainable patterns of production and consumption have been one of the great challenges for government officials, since the United Nations Conference on Environment and Development (UNCED), better known as Rio-92 (BIDERMAN, 2008; IPEA, 2014). The Declaration of Rio de Janeiro, proclaimed during UNCED, established the 27 guiding principles of sustainable development for States, key sectors of society and individuals. Among these, Principle 8 mentions that "to achieve sustainable development and a higher quality of life for all, States must reduce and eliminate unsustainable patterns of production and consumption and promote adequate demographic policies" (MACHADO, 2012).

From the mid-1990s onwards, the linear economy model characterized by the use of natural resources without considering their limitation, transforming them into products that, for the most part, are discarded without due use, began to be questioned. In opposition to this model, the concept of a circular economy is presented, whose fundamental principle consists of a cyclical process in which waste is reinserted in the production process, either as a source of energy or as by-products. The circular economy involves an awareness of all those involved: supplier, producer, consumer, and government (DE ASSUNÇÃO, 2019).

A change in attitude has been detected in public institutions, demonstrating increased initiatives in favor of sustainable procurement as a tool for public authorities to move towards a more sustainable consumption and production pattern (ERAUSKIN TOLOSA *et al.* 2017). In this regard, the European Union (EU), through its executive body, the European Commission (EC), issued a Directive (Directive 2004/18 / EC)¹ on government procurement, in which environmental requirements were explicitly considered during the acquisition and signing of a contract (BIDERMAN, 2008).

In the Brazilian legal context, since the 1988 Federal Constitution and Law No. 8666, of June 21, 1993, the legal bases for sustainable public procurement by the Federal Public Administration have been updated, chronologically, with the inclusion of new legislation: Normative Instruction (IN) SLTI/MPOG No. 1, of January 19, 2010; Law No. 12,305, of August 2, 2010; Law No. 12,349, of December 15, 2010; Decree No. 7746 of June 5, 2012; Normative Instruction SLTI/MPOG No. 10,

¹ The old Directives (Directive 2004/18/EC and Directive 2004/17/EC) were replaced by the Public Procurement Directive 2014/24/EU; and Directive 2014/25/EU, respectively, on contracts concluded by entities operating in the water, energy, transport and postal services sectors. The new rules seek to ensure greater inclusion of common social objectives in the procurement process (EUROPEAN COMMISSION, 2018).

of November 12, 2012; Decree 10.024, of September 20, 2019 and Law No. 14,133 of April 1, 2021. Among these, IN SLTI/MPOG No. 1/2010 stands out for dealing specifically with the inclusion of the sustainability criteria in the acquisition of goods, in contracting services and in the execution of construction works, which support the construction of the evaluation model presented in this study.

Traditionally, Sustainable Public Procurement (SPP), is framed in the triple bottom line concept (TBL), a corporate accounting structure, based on people, planet, and profit, with limited potential for the public sector (Uehara, 2020). Understanding that this limitation does not contribute to sustainable development, the classification by Freitas (2012) supports that the dimensions of sustainability are not limited to the environmental, ecological, and social 'tripod', adding to it the legal-political and ethical dimensions. Uehara (2020), in turn, understands that ethics, culture, safety, diversity, inclusion, justice, human rights and the environment are also important aspects of sustainable public procurement.

The concept of sustainability, as a constitutional principle, is in line with the proposal by Freitas (2012, p. 41), "which determines, with direct and immediate effectiveness, the responsibility of the State and society for the solidary realization of material and immaterial development, socially inclusive, durable and equitable, environmentally clean, innovative, ethical and efficient, in order to ensure, preferably in a preventive and precautionary way, in the present and in the future, the right to well-being." Furthermore, the duty to implement through policies, programs, and public actions "a socially inclusive, lasting and egalitarian, environmentally clean, innovative, ethical and efficient development model must be recognized, in order to guarantee the right to well-being in the present and in the future, preferably in a preventive and cautious way." (FREITAS; VILLAC, 2020, p. 4)

Sustainable contracting ends up influencing production and consumption trends, stimulating innovation and diversifying products and services offered in a country's market (SILVEIRA *et al.*, 2020). However, it encompasses highly complex issues due to the multiple criteria involved in sustainable procurement, generating doubts and inaccuracies and, therefore, requiring attention for further research on development of methodologies that ensure clarity of indicators, systematic evaluation of their results and impacts, transparency and public control of processes.

Given this concern, this study aims to present an evaluation model for sustainable procurement at a federal higher education institution, in the light of constructivism, based on criteria established in the specific legislation. To structure the model proposed in this work, the concept of Sustainable Public Procurement will only be based on the integration of environmental criteria to bids, considering the multiplicity of variables involved in the selection and evaluation of these criteria.

To achieve the goal set for this research, the article is structured in five sections. Following this introduction, Section 2 presents the literature review on the main aspects of sustainable procurement, in terms of the criteria involved and their evaluation. Section 3 presents the methodological aspects of the research. Next, Section 4 describes the construction of the evaluation

model of the case study. Finally, section 5 discusses the research findings and final considerations.

2. LITERATURE REVIEW: SUSTAINABLE PROCUREMENT AND SUSTAINABILITY CRITERIA ASSESSMENT

The pillars of sustainable development are: i) economic viability; ii) social homogeneity, fair income distribution, job creation and better quality of life; and iii) sustainable processes, characterized by the good use of natural resources and raw materials, as well as the final destination of waste produced by human action (CARVALHO, 2019).

Early research on sustainability issues for public procurement focused on the management of environmental impacts on supply chains, and in particular on the threats and strategic opportunities associated with environmental issues (Brammer; Walker, 2011), or the relevance of contractual terms of environmental, that is, the existence and applicability of environmental criteria in procurement contracts (Palmujoki, 2010). Such studies sought to provide evidence of connections between the sustainability policy goals included in public procurement and their achievement through procurement, and to prove their effectiveness in environmentally and socially influencing responsible objectives (Aman *et al.*, 2014).

The economic efficiency of public procurement today requires decisions to migrate from a single price criterion to a multicriteria approach where various dimensions of quality as well as price are considered (DIMITRI, 2013). Sustainable contracting in government organizations emerges as an important tool to achieve sustainable economic growth, combining social development and environmental benefits, in addition to improving the supplier selection process (CHENG *et al.*, 2018). However, implementing sustainability in public procurement implies the reformulation of some concepts that range from ethical principles and intentions involved in decision-making to political and institutional issues (NORA, 2020).

The Brazilian legislator has shown care with sustainable development since the Constitution of the Federative Republic of Brazil, promulgated on October 5, 1988, whose text expresses the right to an ecologically balanced environment in its article 225 (Brasil, 1988). Regarding public contracts, Law no. 8,666, of June 21, 1993, later amended by Law No. 12,349 in 2010, which modified its art. 3rd, caput is still in force, with a view to promoting sustainable national development (Brasil, 1993).

In order to provide the environmental sustainability criteria to be observed by the Federal Public Administration in its acquisitions of goods and contracting of construction works and services, the former Ministry of Planning, Development and Management (now Ministry of Economics) published on January 19, 2010, Normative Instruction No. 1 - IN no. 1/2010 (Brasil, 2010). The specifications contained in its text are now used as a reference for booklets, guides, and manuals, intended to dictate the rules to be adopted on environmental sustainability in procurement processes in the federal public sphere (Machado, 2017).

Since then, other norms have been incorporated into the Brazilian legal framework, such as Decree No. 7746, of June 5, 2012, which regulated art. 3 of Law No. 8.666, establishing criteria,

practices, and general guidelines for the promotion of sustainable national development through contracts carried out directly by the federal, autarchic and foundational public administration and by dependent state-owned companies, and established the Interministerial Commission for Sustainability in Public Administration (CISAP) (BRASIL, 2012a). Additionally, in 2012, Normative Instruction No. 10 established rules for the preparation of Sustainable Logistics Management Plans referred to in art. 16, of Decree No. 7746 (BRASIL, 2012b).

On April 1, 2021, a new procurement law was published, Law No. 14,133, bringing important advances to the inclusion of sustainability in bidding processes. Sustainable national development, for example, is mentioned in its principles (art. 5) and objectives (art. 11, item IV). The concern with environmental impacts is seen in articles 6 (items XXIV and XXV), 18 (item XII) and 34 (paragraph 1), to name a few. In turn, article 25 deals with the contractor's responsibility for environmental licensing. Another innovation addressed in art. 144 of the new law provides for the establishment of variable remuneration, linked to the performance of the contractor, for construction works and services based on environmental sustainability criteria, among other aspects (BRASIL, 2021b).

Nevertheless, when evaluating sustainable contracting in relation to good practices adopted in Brazil, Machado (2017) informs that the technical specification of the object, the contractor's obligations, and the qualification requirements are still the items that managers have to ensure the success of public contracts based on existing criteria. Leveraging the use of assessment methods depends on laws, regulations, and general standards for SPP and should refer to specific criteria, which may have a different degree of sustainability depending on the country or public organization (Chiarini, 2017).

In order to contribute to the theme on the evaluation of sustainability criteria in bidding processes, specifically, focusing on environmental aspects, this article deals with the development of a constructivist model to support the purchasing manager of the Federal University of Rio Grande in the identification, operationalization and measurement of the indicators involved in sustainable contracting, using the multicriteria decision support methodology as an intervention instrument.

3. RESEARCH METHODOLOGY

This study was structured according to the classification proposed by Roesch (2010) and, in relation to the purpose, it is presented as an applied research, as it intends to generate potential solutions to the problems of evaluating sustainable public procurement, based on indicators proposed by the decision maker according to the criteria established in Normative Instruction 01/2010 in order to aid the manager in her decision-making process.

As for the method, or design, this research is classified as exploratory, as it seeks the researcher's understanding of how sustainable public procurement is evaluated and which tools are used by managers for this purpose.

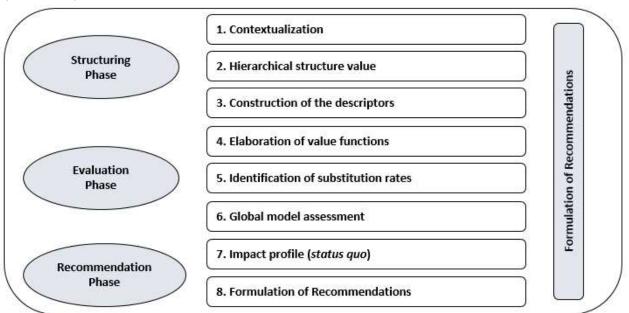
Regarding the approach, the research uses qualitative and quantitative steps (ROESCH,

2010). It is characterized as qualitative during the survey phase of publications relevant to the theme and during the structuring phase of the model. It can be typified as a quantitative approach during the MCDA-C evaluation phase, when the multi-criteria mathematical model is constructed, by transforming ordinal scales into cardinal scales, determining the compensation rates between criteria, and identifying the profile of stock performance (Longaray; Ensslin, 2014).

The data collection plan is based on primary and secondary data (ROESCH, 2010). The collection of secondary data comes from articles in the bibliographic portfolio, identified as relevant to the theme under study. The primary data are the result of semi-structured interviews with the decision maker to identify the relevant aspects of sustainable contracting evaluation, which were used in the model proposition.

The data analysis plan comprises the description and analysis of data collected from secondary and primary sources and will be detailed in the following section, which deals with the intervention instruments used in the research. To procedure the case study it was used the Constructivist MultiCriteria Decision Aid - MCDA-C as an intervention instrument. Figure 1 illustrates the three phases of MCDA-C.

Figure 1 | Phases of the Multicriteria Constructivist Decision Support Methodology (MCDA-C)



Source: adapted from Longaray et al. (2019).

The structuring phase aims to identify the actors involved in the context, determine the characteristics of the decision context, and model them according to the manager's perception (Ensslin *et al.* 2016. Through this phase, the hierarchical structure of the decision maker's views and value judgments is elaborated and, finally, the model descriptors are constructed (Longaray; Ensslin, 2014).

The use of descriptors makes it possible to define how actions in each point of view will be evaluated, but it is necessary to go beyond and quantify the performance of these actions according

to the value systems of decision makers. Thus, the evaluation phase represents the quantitative part of the work in which ordinal scales are transformed into cardinal scales (measurement) in order to allow the construction of the decision support model (Ensslin *et al.* 2016).

The recommendations phase proposes improvement actions to modify the context and reach the decision maker's preferred objectives, according to the strategies developed (Ensslin *et al.* 2016). These actions are the result of the analysis of performance profiles, which seeks to identify criteria on which the decision maker wants to improve performance (Longaray; Ensslin, 2014).

Thus, by using a constructivist logic, MCDA-C seeks to develop in the decision maker the knowledge necessary to understand the consequences of its decisions, from the aspects that it (the decision maker) considers as important (BORTOLUZZI *et al.*, 2011).

4. BUILDING A SUSTAINABLE PUBLIC PROCUREMENT AND PROCUREMENT EVALUATION MODEL USING THE MCDA-C METHODOLOGY

The objective of this study was to develop an evaluation model for sustainable public procurement at the Federal University of Rio Grande (FURG), from the decision maker's perspective on the studied context, contributing to the decision-making process and management improvement. In this paper, sustainable public procurement (SPP) is considered as the processes related to the acquisition of goods and the contracting of services and construction works for public administration entities. As a result, the evaluation model allowed to evaluate the current performance (*status quo*) of sustainable contracting in the institution, identifying its improvement potential, based on the established indicators.

4.1 Case Study: the Federal University of Rio Grande (FURG)

The Federal University of Rio Grande (FURG) was created in 1969 and serves more than 12,000 undergraduate students, with over 3,000 of these being distance-learning undergraduate students, and about 2,500 graduate students. It has 61 undergraduate courses, 14 medical residence courses, 18 specialization courses, 31 masters and 13 doctoral programs courses and 150 CNPq-certified research groups. Additionally, it has a staff of more than 900 professors and about 1,200 administrative technicians in education.

With numbers of this magnitude, it is natural for the university to allocate a significant portion of the budgetary resources to the acquisitions and contractions necessary for the maintenance of its teaching, research and outreach activities, as well as those that maintain administrative hours and ensure the conservation and maintenance of its buildings and other assets, in addition to urbanized or natural spaces, located in the municipalities of Rio Grande, Santa Vitória do Palmar, São Lourenço do Sul and Santo Antônio da Patrulha, all in the state of Rio Grande do Sul. It is assumed that such contracts include criteria for environmental sustainability, as recommended by federal legislation, and, to guide the structuring of the model, the decision maker used the criteria set out in Normative Instruction No. 01/2010.

The unit of analysis defined for the case study was the Directorate of Administration of Materials (DAM), which is responsible for all processes of goods acquisition, contracting of services, and construction works, as well as other attributions, and the university's sustainable procurement evaluation model was built according to its director's perception, based on the information obtained through semi-structured interviews and/or management reports of the Bid Support System (SAL). The director was chosen to act as the model's decision maker because she has the necessary decision-making skills on sustainable procurement at FURG.

The importance of this study is justified by the need to improve public procurement management practices, especially regarding governance capacity and responsibility in the use of public resources. The SPP is relevant insofar as it induces the bodies of the Federal Public Administration to carry out structural changes in the main productive sectors, directing the market towards the adoption of practices aimed at preservation and sustainable development. Since federal legislation provides for the need for sustainable acquisitions, but does not determine which procedures should be adopted for this purpose, it is up to managers to survey indicators based on the criteria indicated in the existing legal standards.

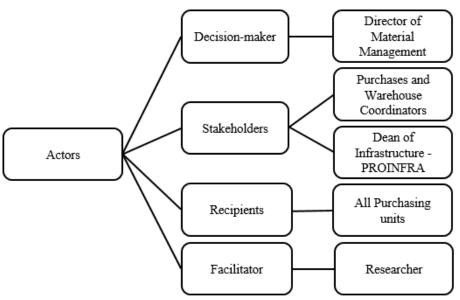
As for the opportunity, it is understood that there are multiple sources of information for the inclusion of indicators and sustainable criteria in the bidding processes, being essential to have an assessment tool that supports the procurement manager in his decision. The constructivist logic, used in structuring the model, seeks to enhance the knowledge necessary for the decision maker to understand the consequences of their decisions, based on the aspects that they themselves consider to be important.

4.2 Structuring phase

The structuring phase of MCDA-C consists of three steps: (i) contextualization, (ii) development of the hierarchical value structure; and (iii) construction of the descriptors.

The contextualization began with a semi-structured interview between the facilitator and decision maker, in which the problem label was defined as "Evaluation of sustainable public procurement at FURG" and, from there, the objective was to lead the decision maker to a better understanding, delimitation, and organization of this problem. It is worth noting that, for contextual purposes in this study, the decision maker relied on the criteria indicated in a single legal norm: Normative Instruction 01/2010. For conceptual purposes, the director understood that the sustainability criteria to be evaluated in the model should only consider the environmental aspects of sustainability. In this interactive activity, the actors involved in the decision context were also identified, as presented in Figure 2.

Figure 2 | Actors of the decision context



Source: elaborated by the authors (2019).

The second stage of the evaluation model structuring phase comprises: (i) identification of the Primary Elements of Evaluation (PEE); (ii) construction of concepts, with present and opposite pole; and (iii) construction of the family of Fundamental Points of View (FPV). Based on the problem label, through a semi-structured interview on the decision maker's perception in relation to the strategic objectives, goals, concerns, desires, and restrictions involved in FURG's sustainable procurement processes, 38 candidates for PEEs were identified, which, after being transcribed by the facilitator, were validated by the decision maker.

Table 1 | Concepts defined from the first five PEEs

PEE	Description	Concept	Description
1	Purchase goods according to environmental sustainability criteria	1	Carry out processes for purchasing goods with environmental sustainability criteria Purchase goods without requirements for environmental sustainability criteria
2	Hire services according to environmental sustainability criteria	2	Hire services with requirements for environmental sustainability criteria hire services without requirements for environmental sustainability criteria
3	Contract works/projects according to environmental sustainability criteria	3	Contract works/projects with requirements for environmental sustainability criteria allow works/projects without requirements for environmental sustainability criteria
4a	Comply with legal requirements for sustainable procurement	4	Ensure compliance with IN 01/2010 requirements for procurement of goods neglect compliance with legal requirements for environmental sustainability in procurement of goods
4b		5	Ensure compliance with IN 01/2010 requirements for contracting services neglecting compliance with legal requirements for environmental sustainability contracting services

PEE	Description	Concept	Description
4c		6	Ensure compliance with IN 01/2010 requirements for constructions neglect compliance with legal requirements regarding environmental sustainability in constructions
5	Acquire eco-efficient A4 paper	7	Acquire A4 paper with environmental sustainability criteria Acquire A4 paper without environmental sustainability criteria

Source: elaborated by the authors (2019).

After the validation of the PEEs, they were expanded and transformed into concepts, each consisting of a present pole and an opposite pole. The present pole is based on the action it suggests, or preferred direction, and to define it, the decision maker pointed to the desirable performance of the PEE. At the opposite pole is the respective psychological opposite, for which the decision maker indicates the worst acceptable situation for the same PEE (Ensslin *et al.*, 2001). The present and opposite poles are separated by ellipses, which indicate the expression "rather than" or "preferable to". Thus, the 38 initial PEEs resulted, by the end of the process, in 69 concepts. Table 1, above, exemplifies the expansion of concepts for the first five PEEs.

Based on the knowledge generated up to this point, similar concepts were grouped into large areas, perceived as areas of concern (Ensslin *et al.*, 2010), which should be perceived as necessary and sufficient for managing the context under study (Ensslin) *et al.*, 2016). Three areas of concern were defined: (i) SPP Bidding Processes; (ii) SPP management, and (iii) Knowledge and Awareness.

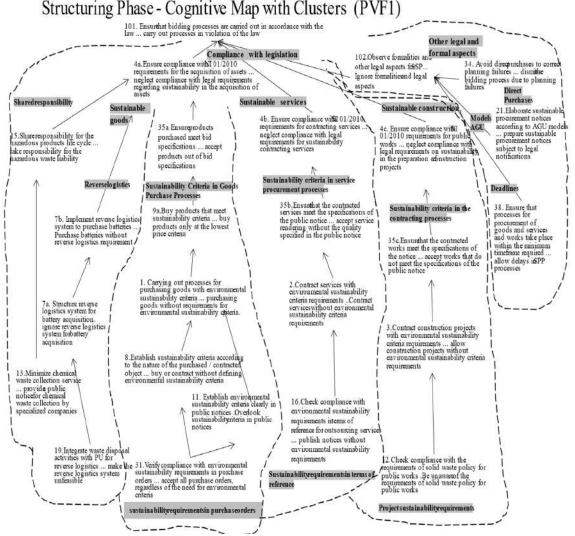
In order to establish the hierarchy and influence relations between the concepts and to measure the decision maker's objectives, cognitive maps or means-end relations maps were constructed (Longaray et al., 2019, Flores, 2018, Ensslin et al., 2016), addressing issues such as those proposed by Ensslin et al. (2001): "why is such a concept important?" (Towards the ends) or "how could one obtain such a concept?" (Towards the means). The hierarchy of concepts established in the cognitive map forms a structure in which the underlying concepts are intertwined with the concepts of the levels above, forming a means-ends relationship. Once the maps are constructed, the concepts should be grouped internally into smaller maps, or clusters, which can be defined as sets of nodes with a strong thematic relationship and can be analyzed independently (Ensslin et al., 2013). In addition, each cluster can be designated as an Elementary Point of View (EPV) of the Hierarchical Value Structure.

In carrying out this step, the decision maker was asked to point out similar concepts and label them according to their meaning, as seen in Figure 3, which exemplifies a cognitive map (means-ends relationship map) with its clusters for the "SPP Bidding Processes" area of concern.

The next step comprises the transition from the influential linkage structure to the Hierarchical Value Structure (HVS), where the latter is represented by an arborescent structure that has the objective of delineating a decision-making framework, which contains the strategic objectives of the decision makers projected from fundamental points of view (FPV) and the set of

all potential actions possible to achieve these goals (Longaray; Ensslin, 2014).

Figure 3 | Means-ends relationship Map of the "SPP Bidding Processes" area of concern



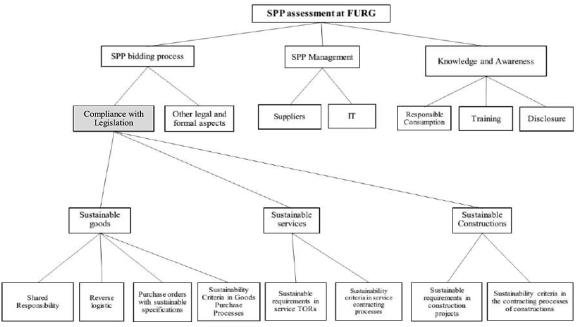
Source: elaborated by the authors (2019).

Measuring the criteria of an arborescent structure uses the decomposition logic, where a more complex criterion is decomposed into easier-to-measure criteria, thus creating a structure in which the upper hierarchical level is explained by the links of the lower levels (Flores, 2018, Ensslin *et al.*, 2001). The lower levels are called Elementary Points of View (EPV) and subEPVs. Figure 4 presents the EPV for FPV1 "Compliance with Legislation".

To evaluate the potential actions of the model's evaluation axes, it is necessary to build a criterion that allows measuring the performance of each action evaluated from each point of view (Ensslin *et al.*, 2001, p. 145). To this end, Ensslin *et al.* (2001) explain that two tools are needed: a descriptor and a value function associated with this descriptor. Descriptors are tools that allow a better understanding of the decision-makers' concern when measuring a certain dimension of the decision context. In addition, the value functions provide information about differences in attractiveness between descriptor levels.

Figure 4 | Hierarchical Value Structure for FPV1 "Compliance with Legislation"

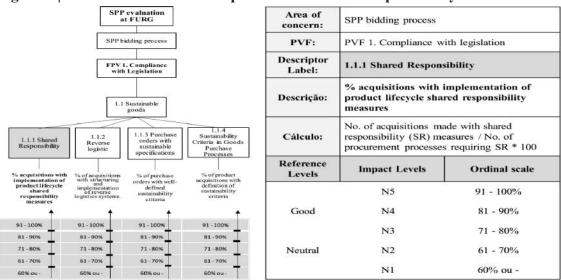
Structuring Phase - Hierarchical Value Structure



Source: elaborated by the authors (2019).

A descriptor, or attribute, is a set of impact levels that serve as a basis for describing the acceptable performance of potential actions for each FPV (ENSSLIN *et al.*, 2001). Descriptors are ordinal (qualitative) scales and measure attributes that differ in degree or intensity (LONGARAY; ENSSLIN, 2014).

Figure 5 | Detail of subEPV Descriptor 1.1.1 "Shared Responsibility"



Source: elaborated by the authors (2019).

In this process of constructing the descriptors, there was an interaction with the decision maker, who was encouraged to express a scale that represented, according to her value judgment, the intensity and ordering of the attributes of each point of view. Figure 5, above, illustrates the

detail of construction of the descriptor of subEPV 1.1.1. In this process, 29 descriptors were built from the points of view of the model.

Impact levels are ranked in terms of preference to enable descriptors to be compared, using two reference levels for each descriptor: one "neutral" below which performance is considered compromising and the other "good", above which performance is considered excellent. In the interval between these two levels, performance is perceived as competitive.

4.3 Evaluation phase

This stage follows the structuring phase of the model when the alternatives are evaluated by means of a mathematical model, ordinally and cardinally, locally and globally. The evaluation phase consists of four steps: (i) elaboration of value functions; (ii) identification of substitution rates; (iii) overall assessment; and (iv) impact profile of the current situation.

The use of descriptors makes it possible to define how the actions in each point of view will be evaluated, but it is necessary to go further and quantify the performance of these actions according to the decision-makers' value systems. This process of quantifying performance is necessary to evaluate actions, understand the problem clearly, and better understand the impact that each option generates on its values (Ensslin *et al.*, 2001).

The value functions are used as an instrument to help decision makers to express their preferences numerically. According to Ensslin *et al.* (2001, p. 187), a value function can be seen as a tool accepted by decision makers to aid the articulation of their preferences, being used to order the intensity of preference (difference of attractiveness) between pairs of impact levels or potential actions.

In this study, the semantic judgment method was chosen to construct value functions and the operationalization of this process was performed using the Measuring Attractiveness by a Categorical Based Evaluation Technique (MACBETH) (BANA E COSTA; VANSNICK, 1995).

To determine the function of a value (cardinal interval scales), MACBETH compares the attractiveness difference between the scale levels in such a way that the decision maker can express the intensity of his preference of one level above all the others. (Longaray *et al.*, 2019). The decision maker is asked to state his preference among the potential alternatives for each of the model's criteria, indicating the perceived difference from one level of impact to another by means of a semantic scale with seven categories: 0 (I) - none (indifference); 1-very weak; 2-weak; 3- moderate; 4-strong; 5-very strong; or 6-extreme. Thus, for each descriptor reference level, a comparison is made with the other levels, to convey the absolute judgments of the attractiveness differences, according to the scale.

From the responses obtained during the interaction process with the decision maker, it was possible to construct the MACBETH judgment matrix. With the interval scales defined, each descriptor obtained a numerical value of 0 for level N2 (neutral) and 100 for level N4 (good) to calculate scale normalization (Longaray *et al.*, 2019). Figure 6 demonstrates the process for turning ordinal scales into cardinal scales.

Judgment Matrix of Difference in Attractiveness 1.1.1 1.1.1 Shared Responsabilidade Compartilhada Shared Responsibility Responsibility 6 extrema atual N5 140 N4 4 6 % acquisitions with 3 % acquisitions with implementation of product implementation of product N3 2 4 40 lifecycle shared responsibility lifecycle shared responsibility N2 measures measures 0 nula N1 60 91 - 100% 140 200 81 - 90% 100 140 40 71 - 80% 100 100 61 - 70% 0 60% ou --60 3 4 5 -60 -100 Descriptor - ordinal scale Criterion - Cardinal Scale Value function graph

Figure 6 | Process for transforming ordinal scales into cardinal scales

Source: elaborated by the authors (2019).

The analysis of potential actions in a multicriteria model will hardly point out a potential action that is better than the others in all the model criteria, and it is necessary to establish a way to aggregate the various dimensions of evaluation (Ensslin *et al.*, 2001). Therefore, in MCDA-C, the replacement, or compensation, rates that reflect the performance loss that a potential action must suffer in one FPV must be determined to offset the performance gain in another, according to the judgment of a decision maker (Longaray; Ensslin, 2014). As pointed out by Ensslin *et al.* (2001, p. 219), "substitution rates are parameters that decision makers deem appropriate to offset local performances (in the criteria) in a compensatory way in a global performance". In this research, the method used to identify the compensation rates of the model of this research was the pairwise comparison in MACBETH, in a procedure similar to that used for the construction of value functions, using the semantic judgments matrix and its preference levels.

To define the evaluated alternatives, each point of view is compared in relation to the other. Once the alternatives are identified, they must be scored and sorted in descending order and, in the MCDA-C methodology, such ordering is performed using the Roberts matrix. After ordering the alternatives, in a procedure like that employed to evaluate the attractiveness level of the descriptors, the M-MACBETH software was used to evaluate the attractiveness differences of the potential actions.

Al (RESP) A2(LOG) dentification of alternatives A3 (PED) A4 (PROC) A0 (All inf.)

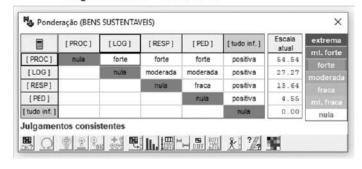
Figure 7 | Process for Identifying Compensation Rates - EPV1.1 "Sustainable Goods"

Roberts' Matrix

	A1	A2	A3	A4	A0	Sum	Order
A1		0	1	0	1	2	3°
A2	1		1	0	1	3	2"
A3	0	0		0	1	1	4°
A4	1	1	1		1	4	10
A0	0	0	0	0		0	5°

A4>A2>A1>A3>A0

Judgment Matrix - MACBETH



Source: elaborated by the authors (2019).

This process was performed to determine all substitution rates among EPVs, FPVSs and areas of concern within the hierarchical structure of the FURG sustainable public procurement evaluation model. Figure 7 presents the process of constructing compensation rates for EPV 1.1 "Sustainable Goods".

The next step is the global assessment, whose objective is to transform a model that has multiple criteria into a single criterion model, allowing the calculation of the overall score of a potential action in relation to other competing actions (Longaray; Ensslin, 2014).

The global assessment of a potential action (a) is calculated by the additive aggregation formula (BANA E COSTA, 1993), shown in equation (1):

$$V(a) = w1.v1(a) + w2.v2(a) + w3.v3(a) + ... + wn.vn(a)$$
(1)

Where:

V(a) - overall value of action a;

vi(a) - partial value of action a in the i-th criterion with i = 1, 2, 3, ..., n;

wi - weight or compensation rate of the *i*-th criterion with i = 1, 2, 3, ..., n;

n - model criteria number

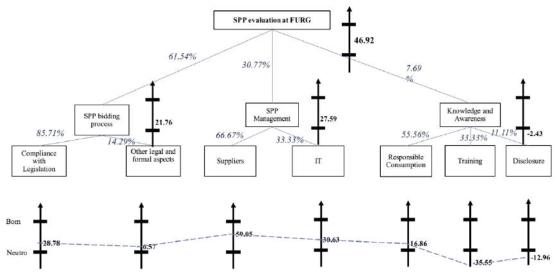
Once aggregations of areas of concern, which encompass FPVs, EPVs, and subEPVs, were performed, it was possible to aggregate the performance of an action (a) into a single performance V(a) using the global additive function equation (1) (Longaray; Ensslin, 2014):

$$V\left(a\right) = 0.6154 * V_{Bidding\ Processes}\left(a\right) + 0.3077 * V_{SPP\ Management}\left(a\right) + 0.0769 * V_{Knowledge\ and\ Awareness}\left(a\right)$$
 (2)

Thus, *V* (a) expresses the global evaluation formula for the model (2) whose analysis of constants shows the decision maker's weighted preferences for the areas of concern: "SPP bidding process" corresponds to 61.54%, "SPP Management" 30.77% and 7.69% for "Knowledge and Awareness". The score obtained in the global assessment model was 46.92 points. According to Longaray and Ensslin (2014), this score in MCDA-C serves only as an anchor for possible comparisons between different profiles.

Once the global evaluation model has been defined, the current situation (*status quo*) should be diagnosed in order to build understanding of the performance considered compromising, competitive (acceptable) or excellent, as well as to establish parameters for future strategies (Flores, 2018).

Figure 8 - Impact profile of FURG's status quo on the areas of concern and fundamental viewpoints of the built model



Source: elaborated by the authors (2019).

To illustrate the current performance profile of the sustainable procurement process at FURG, the performances for each of the 29 descriptors were identified by collecting primary data from management reports (available from SAL) and interviewing the decision maker. In this activity, 11 descriptors were identified as having compromising performance. Figure 8, above, presents the *status quo* impact profile in the model built for FURG SPP assessment.

4.4 Recommendations phase

The recommendations phase of MCDA-C seeks to support the decision maker in the use of the global evaluation model, aiming at the construction of alternatives and allowing the understanding of their consequences on the performance of sustainable procurement processes at FURG.

From the definition of the current performance and the disclosure of the 11 descriptors that presented compromising performance, one must proceed to a detailed analysis of these criteria in order to identify their influence on the overall evaluation of the model (BASTOS, 2018). The analysis is generally used as the main strategy from two perspectives: (i) horizontal analysis - involving the areas of concern and the respective FPVs; and (ii) vertical analysis - from the descriptors with compromising performance, verifying their contribution to the global performance of the model. In this study, a further comparative analysis was performed between the criteria established in IN 01/2010 and the indicators specially developed for the FURG sustainable procurement evaluation model.

Through the horizontal analysis of the structure, the authors sought to identify the score of each area and how much each of them impacts the built evaluation model. Thus, in order to illustrate the case in point, it was observed that the global score of the model was 46.92 points (see Figure 8), for which the area of concern "SPP Bidding Processes" contributes 21.76 points, "SPP Management" has 27.59 points, and "Knowledge and Awareness" has the lowest model score, equivalent to -2.43 points, much lower than the average points in the other two areas.

Through an investigation of the reason for such a low score in this last area, it was found that the FPV 6 "Training" presented a negative score of -35.55 points and obtained substitution rate equivalent to 33.33% in the representation of the area. The descriptor that operationalizes the EPV 6.1 "DAM Team (training)" had a compromising performance (cardinal scale = -140), due to the low level of training in relation to the identified demand for the employees of the DAM directorate (less than 60%). In turn, this EPV 6.1 strongly impacted the FPV 6, with a substitution rate of 83.33% and, for this situation, the decision maker understood that a strategy of disclosure of knowledge about sustainable procurement legislation is necessary for the entire team, based on the provision of a clear project for training, to be implemented jointly with the Dean of Human Resources Management.

In addition to the score obtained in the model, the substitution rates calculated in the additive function should also be observed and, in this analysis, it was noticed that "SPP Bidding Processes" represented the highest preference among the three areas of the structure (61.54%), being responsible for the greatest potential for positive impact on the model, according to the judgement of the decision maker. The "SPP Management" area had a rate of 30.77% and "Knowledge and Awareness", which corresponds to the lowest rate, had 7.69%.

Furthering the analysis of the hierarchical value structure towards the fundamental points of view that make up each area, it was found that in the first, "SPP Bidding Processes", FPV

1 "Compliance with legislation" has a strong potential to influence the global performance of the constructed model, because it presented a substitution rate of 85.71% and, therefore, a high preference in the judgment of the decision maker, compared to FPV2 "Other legal and formal aspects", which represents 14.29%.

Proceeding to the analysis from the vertical perspective, the EPVs and subEPVs that make up the FPVs of the hierarchical structure were observed, as well as the respective descriptors that operationalize them. In this perspective, the authors sought to identify those with compromising performance, or close to the minimum acceptable performance, and verify their contribution to the overall performance of the model, and then propose improvement actions. In this process, the 11 descriptors identified by the decision maker with unsatisfactory performance were analyzed, in their current situation, as well as their contribution (impact) to the model, for which improvement actions were proposed in the form of an action plan. Table 2 exemplifies an action plan for the descriptor that operationalizes subEPV 1.1.1 "Shared Responsibility".

Table 2 | Improvement Actions for subEPV 1.1.1 "Shared Responsibility"

EPV or subEPV	1.1.1 Shared Responsibility		
Descriptor	% acquisitions with implementation of shared responsibility measures throughout the product life cycle		

Proposed Actions:

- establish a description of the activities involved in the SPP process flow in the Procedures Manual at DAM, related to shared responsibility for the product life cycle;
- create a working group (WG), within the framework of DAM, to elaborate, adapt and / or improve the processes related to SPP
- establish a schedule of meetings for the working group;
- verify the existence of clauses, in the Terms of Reference for the acquisition of goods, that stipulate the need for the products to contain recycled and recyclable materials, in their composition, or in the packaging;
- request the Dean of Planning and Administration arrangements with Dean of Infrastructure PROINFRA to promote selective waste collection within the scope of FURG, with a view to the reuse of solid waste from disposal after use, directing these to their production chain or to other production chains, via referral to waste picker associations for recycling.

Responsible	Purchasing Coordination and Warehouse Coordination and DAM Secretariat		
Attendance deadline	Second semester / 2019 and first semester / 2020		
Supervision Frequency	Monthly		
How will be supervised the action	Monitoring of the schedule with the WG and monitoring of other actions		
Responsible for supervising	Director of Administration of Materials		
Expected result	Pass from descriptor ≤60% to 81 -90%		
Impact on descriptor	Move from level N1 (-60) to level N4 (100)		

Source: elaborated by the author.

Once the recommendations and their impacts on the improvement on performance are defined, the score that will be reached with the new levels proposed can be calculated. Table 3 presents the values of the cardinal scale in the current situation and the values achieved with the proposed actions. The table also shows the current and future scores and the respective impact

they have on the hierarchical value structure, in the ascending direction, until the new global score of the model is obtained, which will go from 46.92 points to 88.64, that is, an increase of 41.72 points.

Table 3 | Impact of actions to improve results in EPV1.1

EPV1.1	Subst. rate	Status quo	Score	Prop. actions	Score
subEPV1.1.1	0.1364	-60	-8.18	100	13.64
subEPV1.1.2	0.2727	0	0.00	100	27.27
subEPV1.1.3	0.0455	60	2.73	60	2.73
subEPV1.1.4	0.5454	-100	-54.54	100	54.54
Impact on EPV 1.1			-59.99		98.18
	Substitute rate		Current Score		Proposed Score
Impact on FPV1	0.5		-29.997		49.09
Impact on Area	0.8571		28.78		63.48
Global Impact	Global Impact 0.6154		46.92		88.64

Source: elaborated by the author.

The example above, elaborated from the descriptors with unsatisfactory performances for the EPV1.1 "Sustainable goods," is addressed in more detail in order to demonstrate the scope of the intervention through the MCDA-C decision support methodology, under the light of the constructivist paradigm. Nevertheless, EPV1.1 was also identified as the most representative in the FPV1 "Compliance with legislation", by the decision maker and is accordingly the most important in FURG's sustainable public procurement strategy.

Additionally, for the model built for the evaluation of sustainable procurement at FURG, a comparative analysis was performed between the criteria set forth in IN 01/2010 (BRASIL, 2010) and the indicators elaborated in this paper. It is worth mentioning that in the structuring phase of the model, other concerns were identified by the decision maker in addition to the criteria laid down in IN 01/2010, which were incorporated into the model, as prescribed by the MCDA-C methodology. These concerns generated indicators that, despite going beyond the criteria established in the legal norm such as in the areas of SPP process management and knowledge and awareness, were necessary to achieve the institution's sustainable objectives. After a detailed analysis between the indicators proposed in this case study and the criteria provided in the IN, the complementation of the model through the construction of new descriptors was suggested, which would provide the decision maker with a complete and robust instrument for the evaluation sustainable purchases and contracting at the university, impacting the scope of its strategies.

5. FINAL CONSIDERATIONS

The present study aimed to present an evaluation model for sustainable procurement at a federal higher education institution, based on criteria established in current legislation, in the light of constructivism. Due to the complexity of the theme under study and the multiple management

aspects involved in the government procurement process, Constructivist Multicriteria Decision Aid (MCDA-C) was used to construct the sustainable procurement evaluation model proposed for the Federal University of Rio Grande (FURG).

The construction of the evaluation model, using the MCDA-C methodology, began with the Structuring phase. From the label of the problem, semi-structured interviews were conducted in accordance with the decision maker's perception of the strategic objectives, goals, concerns, desires and constraints involved in FURG's sustainable procurement processes. At this stage, 38 Primary Evaluation Elements (PEE) were identified, and later expanded, generating 69 concepts, which gave rise to cognitive maps. Once the maps were drafted, it was possible to identify the areas of concern, and define the Fundamental Views (FPV), later decomposing them into the Elementary Points of Views (EPV) and/or subEPVs. This arborescent structure is called the hierarchical structure of value.

At this stage, three areas of concern and seven FPVs were defined: (i) Compliance with legislation; (ii) SPP management; and (iii) Knowledge and awareness; the FPVs were: FPV1 SPP Bidding processes; FPV2 Other legal and formal aspects; FPV3 Suppliers; FPV4 IT; FPV5 Responsible Consumption; FPV6 Training; and FPV7 Disclosure. From the definition of the FPVs, EPVs and subEPVs, it was possible to create the descriptors, which are the evaluation criteria, used in the process management. Thus, at the end of this stage, as a result of the joint work of the facilitator and the decision-maker, who contributed with her opinions, perspectives and objectives, 29 descriptors were defined for the SPP evaluation model at FURG.

The Evaluation phase allowed the global integration of the model by quantifying the performance of each descriptor, according to the decision maker's value systems. To help her express her preferences numerically, the functions of values were used as an instrument. The ordinal scales of the descriptors were converted to cardinal scales using M-MACBETH software, which allowed pairwise comparison of the difference in attractiveness between potential actions.

Next, compensation (or substitution) rates were calculated, reflecting the performance loss that a potential action must suffer in one FPV to offset the performance gain in another, according to the decision maker. After this step, which again made use of the M-MACBETH software and Roberts matrix, the equations of the areas of concern were defined, as well as the global equation of the evaluation model.

Once the global evaluation model was defined, the current situation (*status quo*) was diagnosed, in order to build understanding about the performance considered compromising, competitive (acceptable) or excellent, as well as to establish parameters for future strategies. In order to outline the current performance profile of the sustainable procurement process at FURG, initially the performances for each of the 29 descriptors were identified, and it was then possible to distinguish at which points the process in question performed above the competitive level (good level); at the competitive level (between good and neutral); and compromising (below neutral). For the 11 criteria identified as below neutral (compromising) and neutral (minimum acceptable), for which MCDA-C recommends directing efforts to leverage performance, improvement actions

were proposed.

Once the recommendations were presented, the next step was to demonstrate their impacts on performance improvement, calculating the score to be achieved with the proposed new levels. To this end, the descriptors with poor performance in EPV1.1 "Sustainable goods" according to the decision maker's perception, were taken as an example. These descriptors were identified as strongly impacting the model (high representativeness) and it was considered that, after the implementation of the actions, there would be a level increase in the scale of these descriptors from N1 or N2 to N4. The result showed that there was a jump in the overall score from 46.92 to 88.64 points, i.e. an increase of 41.72 points, or 88.9%.

Regarding the fulfillment of the requirements set forth in Normative Instruction No. 01/2010, whose criteria guided the comparison with the descriptors proposed by the decision maker in the model, partial compliance with the standard was verified. Thus, it can be concluded that, although the structured model for the FURG goes beyond the criteria laid down in the legislation, especially in the issues related to process management and awareness of the different actors, there is still much to do to fully comply with this normative instruction, whose contribution is given by the results of this research.

It is worth noting that the improvement actions proposed in this study do not end with this work, since the evaluation model built here allows the decision maker to analyze where to concentrate efforts and what impacts this has on the performance of the sustainable procurement process at FURG. It is also emphasized that during all phases of the MCDA-C methodology, the decision maker's opinions, perspectives and objectives are taken into consideration, which ends up promoting a better understanding of the process and, thus, contributing to her knowledge construction.

The scientific contributions of this study, point out to the enhancement of the decision-maker's knowledge on the context of a complex situation such as the multicriteria involved in sustainable procurement; decision aid, provided by the structuring of the SPP evaluation model, allowing its performance to be evaluated; and the description and application of all stages of the MCDA-C methodology in the context proposed for analysis.

The Constructivist Multicriteria Decision Aid (MCDA-C) provided the improvement and development of the specific context of SPP at FURG. Showing the feasibility of using this constructivist methodology to achieve the goals set, not only in IN 01/2010, but also in other legal norms that address sustainability issues in public procurement.

The main limitations of the work are: the need for constant interaction between facilitator and decision maker to validate the model in all its stages; the high demand for time; and the high degree of commitment of the decision maker in the process. Moreover, since the constructed model is specific to the analyzed institution and reflects the decision maker's perceptions, it is not possible to make generalizations to other contexts.

For future research, we suggest the monitoring and evolution of sustainable procurement at FURG and the use of the MCDA-C methodology in other contexts, especially the public administration, aiming to provide instruments that serve as a reference for improving public management.

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