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RESEARCH ARTICLE

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Unleashing proactive low-carbon strategies through behavioral factors in biodiversity-intensive sustainable supply chains: Mixed methodology

Nelson Stefanelli Oliveira[1] | Charbel José Chiappetta Jabbour[2] | Lara Bartocci Liboni Amui[3] | Jorge Henrique Caldeira de Oliveira[4] | Hengky Latan[5] | Pascal Paillé[6] | Martin Hingley[2]

[1]Mestrado Academico em Administracao e Contabilidade, FUCAPE Business School, Vitoria, Brazil

[2]Lincoln International Business School, Department of Management, University of Lincoln Brayford Pool, Lincoln, UK

[3]Department of Business, School of Business and Economics, University of São Paulo, São Paulo, Brazil

[4]Department of Management, School of Business and Economics, University of São Paulo, São Paulo, Brazil

[5]HLC Consulting, Semarang, Indonesia

[6]People and Organization Department, NEOMA Business School, Mont-Saint-Aignan, France

Correspondence
Charbel José Chiappetta Jabbour, Lincoln International Business School, Department of Management, University of Lincoln Brayford Pool, Lincoln, Lincolnshire LN6 7TS, UK.
Email: cchiappettajabbour@lincoln.ac.uk

Abstract

The aim of this research is to understand the complex and relatively understudied relationship between human and behavioral factors and low-carbon management practices from the perspective of the resource-based view (RBV). Research application is in the "biodiversity sector" and consists of a survey and multiple-case study in Brazil, the richest country globally in terms of biodiversity but a country that also faces challenges in protecting biodiversity. The research problem considers the relationship between human critical success factors and the adoption of low-carbon management practices. Quantitative analysis through structural equation modeling shows the three branches of hypothesis to be accepted—the first with a higher coefficient than the second and the second with a higher coefficient than the third. It was observed that human factors influence low-carbon product management practices the most, followed by process practices and finally logistics practices. Qualitative multiple-case study research shows that companies are at different stages of maturity in relation to low-carbon management organizational practices, ranging from the highest stage to the lowest. It was found that the intensity of the presence of human critical success factors was higher where organizations had greater adoption of low-carbon management practices.

KEYWORDS

behavioral factors, sustainable operations, low-carbon management practices, green human resources, resource-based view, biodiversity chains

1 | INTRODUCTION

Brazil is the country with the richest biodiversity in the world, and the Amazon is considered by many to be one of the most important assets of humankind, in terms of biodiversity (CBD, 2020b; UNESCO, 2021). Thus, what happens within Brazilian biodiversity tends to have global impact. At the same time, to date, there has been little research into how companies located in Brazil, and which interact with this biodiversity as part of their operations, are dealing with the challenges of the transition towards a low-carbon society. The role of behavioral (human) management-related factors has been even less studied; however, the behavioral dimension of modern supply chains is one of the most relevant topics in contemporary operations management globally (Fahimnia et al., 2019).

Business cases show that the success of business operations in relation to climate change and environmental issues depends on a range of different resources (Chen & Ho, 2019; Hoffman, 2005; Jabbour et al., 2015; Weinhofer & Hoffmann, 2010), because firms are both environmental and socially responsible for their operations (Feng et al., 2020). Among these resources are human resources, with studies showing the significant contribution of human critical success factors (HCSF) in improving companies' environmental performance (Jabbour et al., 2015). Daily and Huang (2001), for example, propose five factors (i.e., top management support, training, employee participation, teamwork, and the relationship between performance and rewards) and consider the contribution of each of these factors with respect to environmental performance.

The aim of this research is to understand the relationship between behavioral factors and low-carbon management practices from the perspective of the resource-based view (RBV) theory in the "biodiversity sector," through a survey and multiple-case study. By this, we mean companies whose operations are related to biodiversity (i.e., variety of organisms from all sources, diversity within species, among species and ecosystems), and that they may directly upon impact natural resources (e.g., companies that make intensive use of biodiversity-related raw materials or companies specialized in biodiversity-oriented products/services). Thus, the following research question is elaborated: What is the relationship between critical human factors of success and the adoption of low-carbon management practices? The RBV is the theory towards the analysis.

Our research into the relevant literature on this topic, ranging from 2014 to 2020 and conducted using high-impact databases and resources such as Scopus and Web of Science, shows a recent and evolving research area with room for new works that bring further effective contributions.

Importantly, there have been numerous publications on human resources and environmental management (Gomes et al., 2020; Chen & Ho, 2019; Fernández et al., 2017; Fayyazi et al., 2015; Zibarras & Coan, 2015; Freitas et al., 2011, Renwick et al., 2012; Daily & Huang, 2001). The same is true for the relationship between human resources and various other areas—for instance, strategy, supply chain management, finance, and marketing (Chaudhary & Prasad, 2010; Ewing & Caruana, 1999; Jabbour & Jabbour, 2015; Wright et al., 2001), which demonstrates the relevance of the human resources theme.

However, there are no existing studies using a mixed methodology approach to the relationship between behavioral factors and low-carbon management practices; as such, there is a degree of novelty and originality in investigating these relationships. In addition, the originality of this research is also evident in its focus on an emerging economy like Brazil, which plays an important role in Latin America and is part of the BRICS group (Brazil, Russia, India, China, and South Africa), which are understood to be emerging economies that are particularly prominent globally, while also facing many environmental challenges (Gunasekaran et al., 2014).

RBV theory has broad applicability to various business management disciplines, which has been demonstrated in recent years through the greater use of this theory; it is a paradigm originally derived from strategic management and has become increasingly popular in adjacent and complementary fields, such as operations management, marketing, human resources management, and entrepreneurship (Hitt et al., 2016).

2 | CONCEPTUAL BACKGROUND

The following section addresses the main conceptual background of this research, specifically: Section 2.1. Low-carbon management practices; Section 2.2. Human factors enabling low-carbon operations; Section 2.3. The RBV; Section 2.4. The biodiversity sector.

2.1 | Low-carbon management practices

The low-carbon operations management (LCOM) concept is based on the broader sustainable operations management (SOM) concept (Böttcher & Müller, 2015). It is a relevant topic in the current business environment, because companies are integrating decarbonization into their activities (Sartal et al., 2020). Using SOM, Böttcher and Müller (2015) propose that the concept of low-carbon operations is to integrate carbon efficiency into the planning, execution, and control of business processes, with the aim of obtaining competitive advantage. According to them, three low-carbon practices stand out:

- Low-carbon products: the development of low-carbon product innovations can be supported by carbon footprint assessment, which involves mapping GHG emissions during all stages of the product development process (Jabbour et al., 2015). Low-carbon products also incorporate an eco-design approach, that is, including concern for the environment at all development stages of a new product.
- Low-carbon production (or processes): adopting new (optimized) production processes or improving existing ones can be a key factor in an organization's attempt to mitigate its carbon emissions. In order to do this, it is essential for the organization to be able to identify and measure emissions and other factors to improve carbon management efficiency; thus, such information needs to be collected throughout the production process (Böttcher & Müller, 2015; Wong et al., 2012). Innovations in product development processes that incorporate environmental aspects (so-called eco-innovations) can occur in two complementary ways (Jabbour et al., 2015), namely, design for environment (DfE), in which product-related environmental attributes—such as recycling, reuse and disposal—are treated as objectives to be achieved and not as constraints (Jabbour et al., 2015; Pujari et al., 2004); and life cycle analysis (LCA), in which analysis of impacts covers the entire life cycle of a product, from raw material acquisition to disposal at the end of the process (Jabbour et al., 2015; Pujari et al., 2004).
- Low-carbon logistics: transportation of raw materials and products is one of the major sources of carbon emissions and is a constant and growing concern for organizations regarding the mitigation of impacts on the environment (Böttcher & Müller, 2015; Scholtens & Kleinsmann, 2011).

2.2 | Behavioral factors enabling low-carbon operations

Any environmental management initiative within a company requires support from its employees (Jackson et al., 2011). If the company wishes to be more environmentally conscious and takes action to do so, such actions must be supported by the behavioral side of the organization (i.e., human resources) (Daily & Huang, 2001; Jabbour et al., 2015). In addition, because human capital is essential for companies to succeed in this task, the challenge of finding and retaining talented professionals leads companies look for tools/actions with which they can differentiate themselves from their competitors (Leite et al., 2018).

Jabbour et al. (2015) provide a table summarizing HCSF for the successful promotion of environmental management practices; the factors that appear most frequently in the reviewed literature are as follows: (1) top management support for environmental practices; (2) environmental training; (3) empowerment of employees involved in environmental issues; (4) environmental teamwork (green teams); (5) performance evaluation and rewards based on environmental criteria; (6) employee engagement in supporting environmental management; 7) environmental organizational culture; and (8) environmental organizational learning.

For Jabbour et al. (2015), these aspects can be considered behavioral critical success factors, as identified in the prior works of Schuler and Jackson (1987), Laursen and Foss (2003), and Jimenez-Jimenez and Sanz-Valle (2005). There are variations around this concept; Daily and Huang (2001), for example, discuss a five-factor human contribution to environmental performance (top management support, training, employee participation, teamwork, and the relationship between performance and rewards).

In the following paragraphs, we provide subsections dedicated to each of the 10 variables analyzed by Jabbour et al. (2015), namely, (1) management support for environmental activities, (2) analysis and environmental description of job positions, (3) environmental selection and recruitment, (4) environmental training, (5) empowerment of employees involved in environmental issues, (6) environmental team work (green teams), (7) performance evaluation and rewards based on environmental criteria, (8) employee engagement in supporting environmental management, (9) environmental organizational culture, and (10) environmental organizational learning.

2.2.1 | Top management support for environmental activities

For Daily and Huang (2001), top management support involves four fundamental aspects:

- Communicating policy, plans, and other relevant information to employees;
- Providing rewards and employee empowerment in exchange for adjustments to be made and continuous improvement to occur;
- Analysis of how programs are being developed;
- Support for cultural change so that projects can be implemented and developed.

On the basis of other studies (Bhattacharya et al., 2014; Chin et al., 2008; Hu & Hsu, 2010; Patil & Kant, 2013; Routroy & Pradhan, 2013; Sambasivan & Fei, 2008) Jabbour et al. (2017) report that top management support is fundamental to ensuring awareness and commitment to the implementation of a corporate political vision that takes into account environmental issues throughout the organization (because strategic planning should incorporate environmental issues). In addition, according to the same authors, financial support and other resources should also be provided.

2.2.2 | Analysis and environmental description of job positions

Huffman and Klein (2013) highlight that organizations are in a developmental phase regarding the integration of technical skills and sustainability issues in the process of selecting and recruiting employees.

According to these authors, the elements that connect candidates to environmental issues are not yet those that determine hiring choices, nor are they incorporated as a fundamental premise in the early stages of selection. However, candidates who have experience, knowledge, or concern about this topic are already preferred in hire tiebreaking situations, ultimately making a difference in favor of an applicant for the vacancy who has such experience.

2.2.3 | Environmental selection and recruitment

Lacy et al. (2009) emphasize that sustainability concerns are constantly changing and that not only are companies prone to hire candidates with sustainability backgrounds but also employees who value sustainability may reciprocally be attracted to organizations that also value this theme; creating a bond of commitment and purpose that generates high performance. This view corroborates the work of Mandip (2012) and Bauer and Aiman-Smith (1996), who find that many of the best graduate candidates give preference to companies with a strong history and reputation for environmental performance to start their professional careers.

Jabbour et al. (2012) state that investing in skilled employees enables a greater willingness to collaborate from employees working in different sectors, which highlights another benefit of having environmentally qualified personnel.

Dmochowski et al. (2016) report that concern with the topic of sustainability makes higher education institutions strive to include issues on this theme in their curricula, developing future professionals under the assumption that organizations will increasingly seek out professionals who have integrated these issues into their skillset.

2.2.4 | Environmental training

According to Vidal-Salazar et al. (2012), there are several studies that highlight the importance of managers having environmental training to develop more environmentally friendly behaviors (Buysse & Verbeke, 2003; Henriques & Sadorsky, 1999; Hillary, 2004). In addition, other studies have evaluated the effects of environmental training on employees in implementing advanced environmental practices (Hart, 1995; Hunt & Auster, 1990; Jabbour & Santos, 2008).

Srivastava and Shree (2019) argue that to improve employee knowledge and skills, organizations need to design development programs where training is widely employed. Tang et al. (2018) develop the concept of environmental management training programs to foster the emotional involvement of participants (employees), contributing to improving environmental knowledge, attitudes, awareness, and environmental management skills.

2.2.5 | Empowerment of employees involved in environmental issues

Empowerment is linked to modern organizational precepts (such as horizontality of structure and organizational flexibility) that provide agility in the decision making process, improving the ability to solve problems (Daily et al., 2007).

Nejati et al. (2017) observe in their study the importance of empowering employees involved in environmental issues to support companies' "green" supply chains.

2.2.6 | Environmental teamwork ("green" teams)

Individual contributions to a company's environmental efforts are important, but not sufficient on their own, as teamwork is necessary for effective environmental management (Daily et al., 2007). Accordingly, these authors suggest that given their complexity, environmental problems cannot be exclusively solved by individual projects and require teamwork from so-called green teams.

2.2.7 | Performance evaluation and rewards based on environmental criteria

Performance evaluation based on environmental criteria has as its main aim the measurement of environmental performance standards in the various sectors of a company (Renwick et al., 2012). The authors argue that the relationship between strategic scope (environmental strategy) and the human resources dimension is a reality for some companies, such as Du Pont, for example. Here is a clear example of performance evaluation and rewards based on environmental criteria that there are monetary awards and rewards related to the achievement of environmental performance targets (Renwick et al., 2012).

2.2.8 | Employee engagement in supporting environmental management

Employee engagement (or participation) in supporting environmental issues can be supported by the creation of processes in the organization that ensure the viability of employee participation in proposing suggestions and solving problems related to environmental issues (Brío et al., 2007).

Employee participation (engagement) depends on a few factors. Ramus (2002) highlights aspects that are important in encouraging employee involvement in supporting environmental issues, including:

- Environmental communication—using a democratic approach to foster employee communication;
- Building environmental competence—encouraging employees to develop environmental competence;
- Management of environmental objectives—sharing environmental objectives with all employees, as well as responsibilities;
- Rewards linked to the environmental theme—providing rewards which reinforce the importance of environmental issues;
- Green innovations—being receptive to new ideas, encouraging employees to be creative/innovative in finding solutions to environmental problems.

For Proctor et al. (2018), engagement involves three Cs: connection (continual engagement with something or someone), commitment (important when times are tough), and communication (involves listening and speaking).

2.2.9 | Environmental organizational culture

The concept of environmental organizational culture is based on the concept of environmental strategy, because this culture can be understood as a set of initiatives and green factors (internal and external) that influence the implementation of environmental strategy (Evangelista et al., 2017; Wu et al., 2014).

Thus, top management should be aware of the relevance of organizational culture, because rigid ("fossilized") structures may take longer to respond to change. Therefore, in order to ensure a more effective implementation of environmental and low-carbon programs, more flexible (more responsive) structures are required (Daily & Huang, 2001).

2.2.10 | Environmental organizational learning

Organizational learning can be conceptualized as a process in which the level of dynamism exceeds the level of knowledge that an organization has reached at a given moment in time—thus, knowledge is produced within the organization, and organizational knowledge emerges from the way members of the organization interpret, understand, and assimilate existing internal information (i.e., tacit or explicit) (Dixon et al., 2007).

If traditional innovation processes are based on organizational learning processes, the same is true for environmental innovation processes, in this case based on environmental organizational learning (Jacomossi & Demajorovic, 2017), a topic in which researchers should shed lights in order to integrate both concepts: organizational learning and environmental concern (Hermelingmeier & Wirth, 2021), even though the research effort to link both themes (Wijethilake & Upadhaya, 2020)

2.3 | The resource-based view

The RBV has its origins in the works of Selznick (1957) and Penrose (1959). RBV argues that a company's competitive advantage depends on the capacities and resources required in its individual competitive scenario, showing that strategy is formulated based on an internal approach (Barney, 1991; Penrose, 1959). In RBV, the company acquires and/or sustains its competitive advantage through the development of valuable resources and capabilities, which consist of assets (tangible and intangible) that the company makes use of in formulating its strategies (Ray et al., 2004). Thus, the basic assumption of RBV is that organizational performance can be explained based on how resources are managed.

According to Barney (1991), resources include all assets, capabilities, organizational processes, attributes, information, and knowledge controlled by a company that allow it to formulate and implement strategies in order to effectively improve its efficiency, which results in competitiveness.

Organizations seek resources that are valuable, rare, and inimitable so that they cannot easily be replicated by competitors, enabling sustainable revenue generation, that is, resources that allow the organization to gain competitive advantage (Barney, 2001; Peteraf, 1993).

An interesting feature of RBV is that it helps to explain why some companies perform better than others by fundamentally analyzing internal resources and capabilities as sources of sustainable competitive advantage (Kraaijenbrink et al., 2010; Ramanathan et al., 2016).

Yusliza, Othman, and Jabbour (2017) argue that RBV provides conceptual foundations for research into the behavioral factors that promote "green" practices (so-called Green Human Resources Management [GHRM]). In addition, the authors point out that:

- Through the RBV, human resources or human factors can be considered essential to companies' competitive advantage and sustainability (Barney, 1991).
- The RBV has applications in understanding the relevance of human factors in adopting new practices (Wright et al., 1994).
- The RBV has provided a theoretical framework for understanding the expansion of GHRM in organizations (Jabbour et al., 2017).

2.4 | The Brazilian biodiversity sector

According to the Earthwatch Institute (2002), biodiversity consists of ecosystems, including all of the various types of species and genetic material that exist on the planet. Perhaps the most famous definition of biodiversity is that of the Commission on Ecological Diversity: "the variability of living organisms from all sources … and the ecological complexes, of which they are part, including diversity within species, between species and ecosystems" (CBD, 2020a).

According to the European Business and Biodiversity Campaign (EBBC), a consortium of partners that helps organizations from all sectors to integrate biodiversity into their corporate management, biodiversity has a number of important characteristics (EBBC, 2020), according to which biodiversity:

- Represents biological diversity among species, within species and among ecosystems;
- May change over time;
- Can be found anywhere;
- Is the foundation of human well-being and life on earth.

Such aspects are taken into consideration in this paper to define the "biodiversity sector" (companies whose operations are related to biodiversity and that they may directly upon impact natural resources). Brazil has been placed in prestigious positions according to various biodiversity rankings, e.g., first place in "Countries with the largest biological biodiversity" (Mongabay, 2020) and a prominent position in another "Top 10 countries in biodiversity" ranking (Sustainability For All, 2020).

In addition, the country is home to more than 20% of Earth's total number of species and is the most important among the 17 countries with the highest global biodiversity (Ministry of the Environment, 2020). These 17 countries are called megadiverse countries, a name given by the World Conservation Monitoring Center to countries with the largest number of species, thus confirming the greatest range of biodiversity.

Companies need to know how to extract natural resources from ecosystems with the least possible impact on biodiversity, but this knowledge alone does not guarantee full success in their operations, as they also require the approval of governments and various stakeholders (local communities, populations affected by operations, etc.) to operate in such ecosystems (Earthwatch Institute, 2002).

According to the Brazilian Ministry of the Environment (2018):

> In agriculture, Brazil has examples of international repercussions on the development of biotechnologies that generate wealth through the appropriate use of biodiversity components. Biodiversity products account for 31% of Brazilian exports, especially coffee, soybean and orange. Forestry and fishing activities employ more than three million people. Vegetable biomass, including sugarcane ethanol, wood and charcoal, derived from native and planted forests account for 30% of the national energy matrix - and in certain regions, such as Northeastern Brazil, account for more than half of industrial and residential energy demand.

Thus, biodiversity plays a leading role in the Brazilian economy, being important to many sectors of both agriculture and industry.

3 | RESEARCH MATERIAL AND METHODS

3.1 | Research type

This research is based on the triangulation of parameters method. Here, triangulation is performed on the combined use of qualitative and quantitative methods in order to be able to gain different perspectives on the same phenomenon (Cunningham, 1997; Jabbour, 2007).

3.2 | Quantitative phase

For the quantitative phase of this research, the survey research method was chosen, with the aim of improving the conceptual model of the relationship between HCSF and the adoption of low-carbon management practices. This model is discussed in the following subsection.

3.2.1 | Conceptual model

There are two major conceptual bases guiding this study: (1) HCSF and (2) low-carbon organizational management practices. As previously discussed, these can be divided into low-carbon product, process, and logistic management practices. We will demonstrate that the pursuit of connecting these two bases leads to the establishment of a coherent relationship, according to the conceptual model in Figure 1.

Thus, this research hypothesizes that behavioral factors are positively related to the adoption of low-carbon management organizational practices.

The hypotheses of this research are as follows:

Hypothesis 1a. There is a positive relationship between human factors and low-carbon product management practices.

Hypothesis 1b. There is a positive relationship between human factors and low-carbon process management practices.

Hypothesis 1c. There is a positive relationship between human factors and low-carbon logistics management practices.

3.2.2 | Elaboration of the data collection instrument

The quantitative phase of this research involved a survey. Self-administration was adopted for the questionnaire method (Jabbour, 2007; Synodinos, 2003). In this phase, an email containing a web link to the online survey was sent to respondents.

The questionnaire was prepared according to guidance from the literature and was submitted to a validation phase by a panel of experts (six academics—business and engineering background with sustainability-related research interests—and four business professionals—biodiversity industries, nonprofit association regarding biodiversity products, and a UN agency dealing with trade and development). This process led to continuous improvement of the questionnaire through the suggestions and criticism provided. For example, one of the panels suggested a more detailed explanation of some terms, such as "green teams" to increase the comprehensibility of the questionnaire. Ultimately, the questionnaire was developed to include three sections: (1) company characterization, (2) HCSF for the promotion of low-carbon management practices, and (3) low-carbon management practices. Subsequently, an online platform was created to deliver the final questionnaire. Upon completion of this process, the researchers

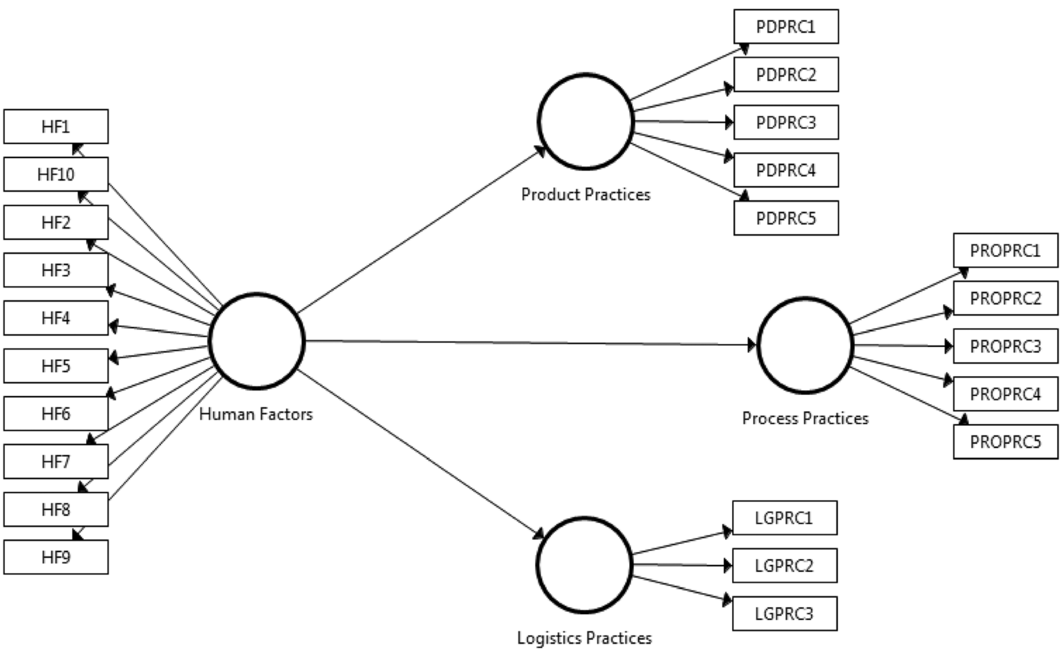

FIGURE 1 Conceptual model and relationships among variables

tested the web link extensively, as well as sending it to other researchers for review, in order to ensure the accuracy of the process.

3.2.3 | Sample composition (quantitative phase)

The profile of the intended respondents for participation in this survey possessed the following characteristics:

- Professionals working in biodiversity-related companies (companies that impact on natural resources or make intensive use of biodiversity-based raw materials, for example)
- Professionals in areas/sectors linked to sustainability

Initially, databases were searched using the respondent profile mentioned, but without success, because the respondent profile is multisector and has very specific characteristics in relation to professional activity. Therefore, a social network of professionals was used to seek the most flexible and direct form of contacting potential respondents, consisting of approximately 300 professionals who fitted the intended respondent profile. In addition, potential respondents identified through the social network were asked to pass on contact details of other professionals in their network who might be able to contribute to the survey.

Before the data analysis stage, some of the biases associated with the sample characteristics were tested for, in order to satisfy requirements on reporting the results of partial least squares (PLS) analysis (Latan, 2018).

First, nonresponse bias was examined to ensure that the sample of respondents who completed the survey has the same characteristics as the general population, by comparing early respondents with those who responded after the cutoff date, using the independent sample *t* test. The results did not find significant differences between early and late respondents, indicating that nonresponse bias is not present. Levene's test was conducted with $p > 0.05$, with the values shown in Table 1 showing that the assumption of variance homogeneity is fulfilled. In addition, we obtained $p > 0.05$ for equality of means in both sampling groups for the variables tested, and therefore we conclude that no response bias was found in our sampling method.

Second, common method bias was evaluated to avoid measurement errors due to correlations between items that measure constructs in the same way. This was tested using the average full collinearity variance inflation factor (AFVIF) (Kock, 2017), used to detect the presence of multicollinearity in data. The analysis results obtained an AFVIF value of 2.387 < 3.3, which indicates that the common method bias does not interfere with these measurement results.

TABLE 1 Nonresponse bias test

Construct	Levene's test	Sig. *t* test
Human factors (HF)	0.624	0.450
Product practices (PDPRC)	0.464	0.091
Process practices (PROPRC)	0.948	0.262
Logistic practices (LGPRC)	0.872	0.816

Most of the sample was made up of large companies (with 500 or more employees), and over 60% of companies surveyed have some type of environmental certification. Of the 83 respondents, the three sectors most present in the sample were 13 (15.66%) working directly in sustainability-related companies (varied sectors) and 11 (13.25%) from the sugar/energy sector and six from the cosmetics/chemical sector. Regarding the profile of individual respondents, more than half were aged 26–35, and of the total respondents, 45 (54.22%) were male and 38 (45.78%) female. Finally, 46 (55.42%) held coordination/leadership, management or, director positions, and the most common level of experience in the sample was between 5 and 10 years of company time (29 respondents, representing almost 35% of the sample).

3.2.4 | Data collection

With the questionnaire uploaded online and having contacted a range of professionals who fitted the sample profile, the data collection stage was initiated.

The questionnaire link was sent with a personalized message in an attempt to maximize the response rate and using the aforementioned professional social network. This strategy was used to demonstrate to the potential respondent the relevance of his/her participation in the execution of the research (Jabbour, 2007).

Approximately 300 messages were sent through the professional social network. The data collection process began in 2018 and ended in the same year, lasting approximately 6 months.

Overall, 83 completed responses from professionals were obtained, which represents more than the minimum number required for robust statistical analysis (as detailed below). In addition, the overall response rate was 26.67%. The sample of completed questionnaires could be considered small and may be identified as a limitation of this study; however, comparable studies published in prestigious journals in the "Green Production" field (related to sustainable operations) have worked with samples smaller than that of this work. For example, Holt and Ghobadian (2009) worked with 60 respondents, Rao (2002) with 52, Klassen and Whybark (1999) with 70, and Jabbour et al. (2016) worked on a survey with 75 respondents. In addition, sample size calculation procedures have shown that the number of responses achieved is greater than the minimum required size—these explanations and procedures are detailed in the next section.

3.2.5 | Analysis of the data collected

The analysis of the data collected (quantitative phase) was developed with support from the structural equations modeling (SEM) method, which is a multivariate technique that examines several dependency relationships simultaneously (Hair et al., 2009). The PLS method of SEM, also called partial least squares path modeling (PLS-PM) was chosen to execute the data collected and test the proposed hypotheses. This method was chosen mainly because (Latan, 2018; Ramli et al., 2018): (i) PLS-PM is a valuable method when the field of study is still in the early stages of exploration or advanced testing in the relationships between variables (Wold, 1989); (ii) PLS-PM serves as an intermediary between traditional model building and data analysis with a relative scarcity of theory and knowledge (Henseler et al., 2017; Wold, 1980).

Because the PLS algorithm follows nonparametric procedures, assumptions such as data normality are not required. However, the sample size required to execute the PLS algorithm must be sufficiently large. The use of small samples in PLS-PM is not recommended (Latan, 2018), because small samples can cause bias in parameter estimates, according to Hui and Wold (1982), who argue for consistency at large assumption. The minimum sample size requirements to execute the PLS algorithm were calculated using the gamma-exponential method (Kock & Hadaya, 2018).

A minimum sample size requirement of 57 respondents was found (where absolute minimum significant path coefficient = 2.97, significance level used = 0.05, and required strength level = 0.80). The sample size was also calculated using the G*Power software. The results of this calculation show that the minimum sample required in this study is 55 respondents (where effect size = 0.15, strength = 0.80, and significance level = 0.05), and the sample used also meets these requirements. In short, the process of data analysis and dissemination of results in this study follows the general disclosure standards proposed by Latan (2018), with this process going through seven steps.

3.3 | Qualitative phase

According to Yin (2010), the case study strategy consists of an empirical investigation whose objective is to investigate a contemporary phenomenon in a deeper way, having as reference its real context.

The use of multiple cases (rather than a single case) has some benefits; namely, (1) it provides more power to the analytical conclusions of the study; (2) it increases the level of understanding of the phenomenon under study; and (3) it reduces the level of uncertainty about outcomes (Jabbour et al., 2015; Yin, 2010).

3.3.1 | Conceptual model

The conceptual model used in the qualitative phase follows the model developed in the quantitative phase. However, at this point, the main focus was to investigate the relationship between behavioral factors and the adoption of low-carbon management practices from the perspective of the RBV.

According to Yin (2010, p. 106), it is important to elaborate the multiple-case study protocol (Table 2):

> It is a way of increasing the reliability of case study research, as it is intended to guide the researcher on data collection procedures […] having a case study protocol is desirable under all circumstances, but it is essential to conduct a multiple-case study.

TABLE 2 Multiple case study research protocol

Research question	**What are the human factors that enable the adoption of low-carbon management practices?**
Unit of analysis	The relationship between human factors and adoption of low-carbon management practices
Organizations	Six Brazilian companies related to the biodiversity sector (companies A, B, C, D, E, and F)
Time limitation	During 2018
Data sources and reliability	In-depth interviews with previously selected respondents and cross-checking between data collected from interviews, analysis of documents, and observation
Construct validity measures	Various sources of evidence (interviews/analysis of documents/observation)
Internal validity measures	Analysis of the most relevant human factors enabling the adoption of low-carbon management practices in each case study (cross-analysis) and an expert from each area (climate change, environmental management, and human resources) to evaluate the interview script
External validity measures	Discussion of empirical results in light of state-of-the-art literature on the topic
Examples of key questions	Is there top management support for environmental activities? How does this occur? Is there environmental training? How does this occur? Are performance evaluations and rewards based on environmental criteria?

Source: The authors.

3.3.2 | Elaboration of the data collection instrument

The interview script was prepared according to the relevant literature and was also submitted to the validation process with experts (academicians) in the fields of sustainability and human resources.

In addition to conducting interviews, the study also used two other tools: (1) observation, that is, the verification of the phenomenon in its natural context, and (2) analysis of documents, reports, websites, and voluntary publications of the organizations.

3.3.3 | Sample composition (qualitative phase)

The qualitative phase of this research, as already identified, involved a multiple-case study. In this phase, six cases of organizations relevant to the sample were analyzed.

A list of 10 organizations was first developed based on the researchers' contacts and the representativeness of organizations in relation to the research theme. After obtaining the contact details of the sustainability manager or more general company contact details, an email containing a detailed explanation of the survey was sent, requesting the participation of the company as one of the cases studied. Of the 10 organizations, only one readily accepted, which became the first case to be analyzed. The other organizations required a greater effort in making contact and explaining the study. Finally, six companies agreed to participate in the survey. The difficulty in obtaining organizations' approval to participate as research cases is noteworthy; in fact, it proved a very arduous process.

The first organization accepted to participate in the survey in early 2018 and is herein referred to as organization "A." In the subsequent months, five other companies confirmed their participation and will be referred to as organizations "B," "C," "D," "E," and "F."

This set of six companies met the requirements for sample composition, and the number of organizations analyzed took into account the concept of "theoretical saturation"; that is, when the incremental addition of new cases would no longer make significant contributions to the study (Yin, 2010).

3.3.4 | Data collection

As soon as each company confirmed its participation, contact was made to arrange a date to visit and conduct interview. Thus, the data collection for the qualitative phase lasted for 6 months in 2018.

During this period, data were collected using the aforementioned tools: interview, observation, and analysis of documents. Interviews were conducted with representatives of each company's sustainability department. In cases where there was no specific sustainability department, the interview was conducted with partners who were directly or indirectly responsible for this area.

Table 3 summarizes the characterization of the six cases under study, as well as the elements that composed the data collection process.

3.3.5 | Analysis of collected data

The collected data were analyzed according to the relevant qualitative research standards, following the strategy of Yin (2010), based on theoretical propositions.

The data collected from all cases were initially systematized through the transcription (or reconstitution) of the interviews conducted. This was performed as reliably as possible, always seeking to extract the largest amount of information. The data collection for all six cases was performed in 2018.

Subsequently, the data were aggregated and reorganized in order to identify and visualize patterns and trends. Finally, the systematized information was cross-referenced and compared in an attempt to develop an explanatory model.

4 | ANALYSIS OF QUANTITATIVE PHASE RESULTS

4.1 | Multivariate analysis

The SmartPLS 3 software was used to execute the data analysis and test our hypotheses (Ringle et al., 2015). The weighting scheme (path)

TABLE 3 Characterization of companies and data collection elements

		Data collection elements		
Company	Characterization	Interview	Observation	Documents
A	Cosmetics company, with large market share and known for its sustainable appeal	Interview with the sustainability manager	Technical visit Visit to conduct the interview	Sustainability report *Website* Folders and other materials about the company
B	Timber company operating in the reforestation segment	Interview with one of the company's partners, responsible for administration	Technical visit Visit to conduct the interview	Folders and other materials about the company *Website*
C	Chemical analysis company, including natural inputs	Interview with one of the company's partners, responsible for administration	Visit to conduct the interview	Folders and other materials about the company *Website*
D	Orange juice production company	Interview with the sustainability manager	Visit to conduct the interview	Sustainability report *Website* Folders and other materials about the company
E	Company in the sugar-energy sector	Interview with the engineering/ environment manager	Visit to conduct the interview	Folders and other materials about the company *Website*
F	Small-size cosmetics company	Interview with company partner responsible for product development	Visit to conduct the interview	Folders and other materials about the company *Website*

with a maximum number of iterations of 300 was selected in the PLS algorithm. In addition, in terms of bootstrapping, a corrected and accelerated bias (BCa) bootstrap was selected, with a new resampling number of 5,000 and 5% significance (one-tailed). The results obtained are described below and in Figure 2.

4.1.1 | Measurement model evaluation

The guidelines proposed by Latan (2018, p. 76) were followed when reporting the results of the step-by-step PLS-PM analysis. In the first stage, the reasons for choosing the PLS-PM were revealed, followed by testing the sample characteristics and reporting the specific settings in the software used in this study. In addition, the measurement model results were evaluated as the next step to assess the validity and reliability of construct indicators.

The measurement model evaluation involved the concepts of convergent validity, discriminant validity and construct reliability. Convergent validity was tested by examining factor loading and average variance extracted (AVE) values. The factor loading value for each indicator in the model should be >0.708, and AVE should be >0.5 (Hair et al., 2017; Henseler, 2021). In addition, construct reliability was tested using two measurements: Cronbach's Alpha and ρA. The general rule requires Cronbach's Alpha and ρA values greater than 0.70 (Henseler et al., 2017; Latan & Noonan, 2017). The analysis of the relevant results for the measurement model is shown in Table 4.

In addition, discriminant validity was assessed using the HeteroTrait MonoTrait (HTMT) ratio. According to Franke and Sarstedt (2019), HTMT is an estimator of unattenuated (perfectly reliable) correlations among constructs, preferable to the Fornell–Lacker criterion. The practical rule for assessing discriminant validity is that the HTMT value should be <0.90 or 0.85 for all constructs in the model (Franke & Sarstedt, 2019; Henseler, 2021). The results show that, on this basis, the discriminant validity for the correlation between the two construct measurements is satisfied. The results of this test are shown in Table 5.

4.1.2 | Structural model evaluation

After evaluating the measurement model, the next step is to evaluate the structural model, including determination coefficient (R^2), effect size (f^2), predictive relevance (Q^2) and variance inflation factor (VIF). The determination coefficient indicates the predictive power of the model and represents the amount of variance in the endogenous variable that can be explained by all exogenous variables. In addition, effect size measures the variance that can be explained by each predictor in the model.

Table 6 presents the results of the structural model evaluation. The R^2 and adjusted R^2 values obtained are good, ranging from 0.320 to 0.433 and thus falling into the medium and high ratio categories. In addition, a good effect size value was obtained for the predictor in the model (in this case, human factors), ranging from 0.488 to 0.765, thus being included in the high ratio category. The predictive relevance of the model resulting from the blindfolding procedure is good, with a value greater than 0 for each endogenous construct in the model. The VIF values for each predictor in the model are less than 3.3, which indicates the absence of vertical and lateral collinearity between independent and dependent variables (Kock & Lynn, 2012).

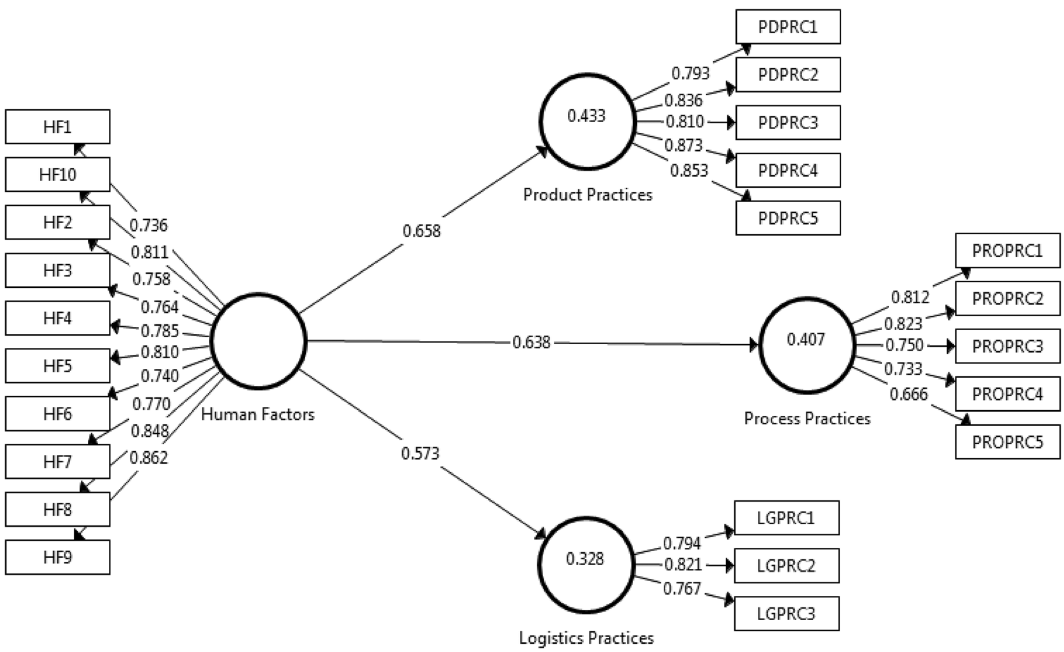

FIGURE 2 Evaluation of the measurement and structural models

TABLE 4 Indicators and measurement model of the human factors construct and the low-carbon management practices construct

Indicator/item	Code	CF[a]	AVE	α	ρ_A
A. Human factors (HF)			0.623	0.932	0.934
Does top management support environmental activities?	HF1	0.736			
Does analysis and description of job positions take into account the environmental perspective?	HF2	0.758			
Does selection and recruitment take into account the environmental perspective?	HF3	0.764			
Is there environmental training in the company?	HF4	0.785			
Do employees have decision-making power to deal with environmental issues?	HF5	0.810			
Are green teams formed (specific teams to deal with environmental issues)?	HF6	0.740			
Does performance and reward assessment take into account environmental criteria?	HF7	0.770			
Are employees engaged with the organization's environmental management?	HF8	0.848			
Is concern for the environment part of the organization's culture?	HF9	0.862			
Is the environmental theme part of organizational learning?	HF10	0.811			
B. Product practices (PDPRC)			0.695	0. 890	0.899
Is the lifecycle analysis tool used to assess a product's carbon emissions over its lifetime?	PDPRC1	0.793			
Is there substitution of carbon-intensive raw materials for renewable raw materials?	PDPRC2	0.836			
Is there substitution of carbon intensive raw materials for recycled raw materials?	PDPRC3	0.810			
Does product design take into account reduction of carbon emissions during production processes?	PDPRC4	0.873			
Are new production processes adopted or existing production processes improved in order to reduce carbon emissions?	PDPRC5	0.853			
C. Logistics practices (LGPRC)			0.631	0.713	0.724
Is there monitoring of distances traveled and associated fuel consumption with regard to the company's logistics processes?	LGPRC1	0.794			
Does the company use less polluting forms of transportation (hybrid engines in trucks, for example)?	LGPRC2	0.821			
Does the company use more carbon-efficient transport modes?	LGPRC3	0.767			
D. Process practices (PROPRC)			0.576	0.816	0.835
Are carbon emissions measured throughout the production process?	PROPRC1	0.812			
Is there an environmental management system (EMS) in place?	PROPRC2	0.823			
Is more energy efficient equipment used?	PROPRC3	0.750			
Is there use of low-carbon/carbon-free energy sources?	PROPRC4	0.733			
Are there recycling processes to dispose of carbon intensive materials?	PROPRC5	0.666			

[a]CF is factor load.

4.1.3 | Hypothesis testing

The hypothesis testing was conducted using the bootstrapping approach, with beta coefficients (β) and 95% confidence interval significance values being observed. As shown in Table 7, all path coefficients (direct effects) in the relationships among variables are supported and significant at $p < 0.01$ with 95% confidence interval.

Specifically, the relationships HF → PDPRC (human factors and product practices) and HF → PROPRC (human factors and process practices) were significant, with beta (β) values of 0.658 and 0.638, respectively, and significant at $p = 0.000 < 0.01$ and $p = 0.000 < 0.01$ with 95% BCa confidence interval (bootstrap percentile confidence interval). This indicates that H1a and H1b are accepted. In addition, it was found that the relationship HF → LGPRC (human factors and logistic practices) was significant, with beta (β) values of 0.573 and significant at $p = 0.000 < 0.01$ with 95% BCa confidence interval. This means that H1c is also accepted.

4.1.4 | Endogeneity assessment

Two robustness tests were performed to show that our main results are unbiased. Robustness testing is required as a supplement when reporting the results of PLS-PM analysis (Latan, 2018). First, endogeneity bias was tested to ensure that the relationships among variables in the model were not influenced by other variables (omitted variables), and that there is no

TABLE 5 Correlations and discriminant validity results

Construct	Mean	S.D	1	2	3	4
Human factors (HF)	3.58	1.17	**(0.900)**	0.681	0.715	0.712
Logistics practices (LGPRC)	3.23	1.32	0.573*	**(0.900)**	0.760	0.653
Process practices (PROPRC)	3.71	1.36	0.638*	0.739*	**(0.900)**	0.826
Product practices (PDPRC)	3.05	1.45	0.658*	0.529*	0.709*	**(0.900)**

Notes. Diagonal and bold elements are the square roots of the AVE (average variance extracted). Above the diagonal are the HTMT values. Below the diagonal are the correlations between the constructs.
* Correlation is significant at the 0.05 level (2-tailed).

TABLE 6 Results of the structural model

Construct	R^2	Adj. R^2	f^2	Q^2	VIF	AFVIF
Human factors (HF)	—	—	0.488–0.765	—	1.977	—
Product practices (PDPRC)	0.433	0.426	—	0.273	2.309	2.387
Process practices (PROPRC)	0.407	0.399	—	0.208	3.106	2.387
Logistics practices (LGPRC)	0.328	0.320	—	0.182	2.155	2.387

Abbreviation: AFVIF, average full collinearity variance inflation factor.

TABLE 7 Relationships among variables

Structural path	Coef(β)	Deviation	*p* value	95% BCa CI	Conclusion
HF → PDPRC	0.658	0.080	0.000**	(0.762, 0.486)**	H1a accepted
HF → PROPRC	0.638	0.063	0.000**	(0.723, 0.506)**	H1b accepted
HF → LGPRC	0.573	0.074	0.000**	(0.672, 0.418)**	H1c accepted

Abbreviations: HF, human factors; LGPRC, logistics practices; PDPRC, product practices; PROPRC, process practices.
**Statistically significant at 1%.
*Statistically significant at 5%.

TABLE 8 Endogeneity test

Structural path	Coef(β)	Deviation	*p* value	*z*	Conclusion
HF → PDPRC	0.355	0.046	0.000**	7.70**	No difference
HF → PRPPRC	0.324	0.045	0.000**	7.24**	No difference
HF → LGPRC	0.196	0.032	0.000**	6.16**	No difference

Abbreviations: HF, human factors; LGPRC, logistics practices; PDPRC, product practices; PROPRC, process practices.
**Statistically significant at 1%.
*Statistically significant at 5%.

reverse causality (Benitez et al., 2018). It was ensured that this bias does not interfere with our results through the Heckman test, with the aid of the Stata 16.0 software. No difference was found between the two results, demonstrating that this bias does not occur in our data. The endogeneity test results are shown in Table 8.

In addition, the problem of unobserved heterogeneity was considered as a serious threat to the validity of results. Latan (2018) argues that further analysis is necessary to ensure that this bias does not interfere with PLS-PM results. This bias was evaluated using the finite mixture PLS approach (FIMIX-PLS), according to the multimethod procedure proposed by Sarstedt et al. (2017). After performing this procedure, it was found that unobserved heterogeneity was not a threat to the validity of these results.

5 | ANALYSIS OF QUALITATIVE PHASE RESULTS

Table 9 illustrates general information on each case, as well as size variables. It was found that the largest company in terms of the number of employees is D (with 12,000 employees) and the smallest is C (with only 15 employees).

Most companies have only one plant, except for Cases A and D (with 2 and 4, respectively). The oldest company is E (71 years old), and the youngest is C (10 years old).

Of the six companies, only one is publicly traded; one is privately traded; three are family businesses, and one has four partners (not family members).

5.1 | Low-carbon management organizational practices

Of the six companies studied, there are only three that have a formally structured department dealing with environment/environmental management/sustainability (Cases A, D, and E). In Companies B and C, the managing director is responsible for issues related to environmental management (low-carbon management), but there is no structural department for this topic; in Company F, the product development director is responsible for issues related to environmental management, but there is again no specific department for this.

In Companies A and D, low-carbon organizational management (and also environmental management as a whole) is addressed by managers with extensive professional experience in this area. This was not observed in the other four companies (B, C, E, and F)—their relevant managers are experienced but not in this specific area.

Initially, the only company working with the LCA tool is Company A. The analysis of low-carbon product management practices is more evident in Companies D and E, and Company F is the one with the lowest number of practices adopted in this category.

Regarding low-carbon management practices, Companies A and D stood out, having implemented the adoption of all practices observed in this category.

The issue of recycling was highlighted in Company A, as pointed out by the interviewee: "there is a totally segregated waste center, solutions that add greater value to such byproducts are created; in addition, we are pioneers in the use of refill" (packaging with lower

TABLE 9 General information on the cases analyzed

		Cases analyzed					
		A	B	C	D	E	F
General information	Business sector	Cosmetics	Reforestation wood	Services in analytical chemistry	Citrus	Sugar and energy	Toiletries and cosmetics
	Capital composition	Publicly traded	Family business (4 partners)	4 partners	Privately traded	Family business (4 partners)	Family business (3 partners)
	Operating time	49 years	18 years	10 years	55 years	71 years	23 years
Size	Number of employees	Over 7,000	60	15	12,000 (during harvest)	1,000 (during harvest)	50
	Geographic coverage	Brazil, and exports to more than 70 countries	Mainly SP/sporadically to other states	Mainly SP (also RJ, GO, and other states in isolation	Brazil, and exports to more than 100 countries	Mainly SP	Mainly SP, MT, GO, TO, and also some states in the northern, northeastern and southern regions
	Number of plants/ factories	2	1	1	4 (3 in Brazil and 1 in the USA)	1	1

environmental impact that generates loyalty, because the product costs 20% less than a new equivalent in regular packaging).

Regarding low-carbon logistics management practices, the lowest achiever was Company C, which did not present the adoption of any of the practices in this category. Once again, Companies A and D showed positive results.

5.2 | Human factors enabling low-carbon operations

Regarding senior management support, in Companies A, D, and E, high commitment from top management regarding environmental activities was evidenced, especially company A, in which (in the interviewee's words): “in the Executive Committee (formed by the President and Vice-Presidents) one of the indicators of variable reward is related to environmental impact,” which corroborates the commitment to which he referred.

Regarding job descriptions and analysis taking into account the environmental perspective, only in Company D does this practice occur and only then for some positions. The same is true regarding whether selection and recruitment take into account the environmental perspective.

Regarding the theme of environmental training, Company D stands out: in his statement, this interviewee states that “there is an operational management system that surveys safety issues, which are the environmental impacts of each function, the PPE (*personal protective equipment*) that need to be used and an information sheet is objectively completed by each department, so each workstation is given an information sheet containing all items.”

Regarding employee engagement, Company E stands out: “At first there was a lot of resistance from management, but fortunately, there was a change and today engagement is greater, largely due to owners who support the environmental cause and have always done so.” This excerpt from the interviewee's speech also highlights the importance of top management support, which is far from purely financial.

On the question of whether “Concern for the environment is part of the organization's culture,” all companies reported that there is concern, but what was observed is that in four of them (B, C, E, and F), there are specific actions that occur informally.

5.3 | Strategic elements (RBV)

Concerning RBV, three aspects were observed in detail for each of the six cases, namely, (1) the main tangible resources of the company, (2) the main intangible resources of the company, and (3) the main competences of the company.

Table 10 shows the interviewees' responses to each of these three aspects.

As for tangible resources, Companies C and F emphasized equipment, whereas Companies B, D, and E their industrial plant infrastructure; D farms, ships, and terminals, whereas E emphasized their own land. Company A was the only one to mention distribution channels.

TABLE 10 Strategy elements (resource-based view) for the cases

	Cases analyzed					
	A	B	C	D	E	F
Main tangible resources of the company	Distribution channels	Plant infrastructure	Equipment	Plant infrastructure, farms, ships and terminals.	Plant infrastructure and own land	Equipment
Main intangible resources of the company	Relationship and sustainability ("is something that is in the brand's DNA")	Brand	Knowledge	Know-how (business knowledge in the field) and brand	Brand	Brand
Main competency of the company	How to develop a sustainable business model ("not just thinking about economic growth, but also thinking about a more collective issue and the impact that is generated for society")	Customer service (personalization in understanding customer needs)	Resilience to problem solving	Governance (risk management/ compliance/ internal controls)	Product quality resulting from very strong "human interaction" (family concept)	Produce with differentiated quality

Regarding intangible resources, Companies C, D, E, and F reported brand strength; Companies C and D mentioned knowledge and know-how (closely related concepts); Company A emphasized relationships and sustainability; according to this interviewee, "it is something that is in the brand's DNA."

Finally, regarding the main competences of the company, the responses were varied, with the only similarity being between E and F (quality). The competence emphasized by the interviewee of Company A stands out: how to develop a sustainable business model. In his words, "not only thinking about economic growth, but also about a more collective issue and the impact that is generated for society."

In summary, the results of our qualitative research show that companies are at different stages of maturity in relation to low-carbon management organizational practices, ranging from the highest to the lowest stage. This classification is explained further in the next section. It was found that the intensity of HCSF was higher as organizations had higher levels of adoption of low-carbon management practices.

6 | DISCUSSION

6.1 | Parallels between quantitative and qualitative phase

Quantitative analysis (through the hypothesis test) showed that the branches of the main hypothesis have been accepted—the first with higher coefficient than the second and the second with higher coefficient than the third. Thus, it was observed that behavioral factors influenced low-carbon product management practices more, followed by process practices and finally logistic practices.

Based on the evolutionary stages proposed by Jabbour and Santos (2006) and Jeswani et al. (2008), Table 11 has been prepared to classify the cases according to their stage of maturity in terms of low-carbon management practices.

It may be observed that only Cases A and D have reached the highest stage in both evolutionary stage models—this was evidenced in the previous section, regarding the practices adopted in each of these companies. Cases B, C, and F appear at lower levels (internal specialization and beginner), as their practices have the lowest level of systematic occurrence.

This classification into evolutionary stages is corroborated by the categorization of HCSF for the promotion of low-carbon management practices (Table 12), according to the intensity with which they occur in each case (white indicates no practice; gray indicates moderate practice; black indicates intense practice).

The strength of the human factors in Companies A and D is observed to be significant; the same is not true for Companies B and F, for example. It is noteworthy that Companies A and D had high ratings in terms of stage of maturity according to Jabbour and Santos (2006) and Jeswani et al. (2008), whereas B and F were at the lower levels.

Srivastava and Shree (2019) argue that in order to improve employee knowledge and skills, organizations need to develop development/training programs—it was verified in this research that only Companies A and D employed intense training programs.

To strengthen the classification of cases into evolutionary stages, an intensity coding for low-carbon practices was also developed in each case (Table 13).

The strength of low-carbon management practices in Companies A and D appears significant; this is not observed for Companies B and F, for example. Again, Companies A and D had high ratings for

TABLE 11 Stage of maturity of low-carbon management practices

	Case	Jabbour and Santos (2006)	Jeswani et al. (2008)	Justification
Stage of maturity of low-carbon management practices	A	External integration	Active	* Carbon management seeks innovation opportunities * Existence of environmental goals * Product innovations
	B	Functional specialization	Beginner	* Low-carbon management practices are not implemented * Where there is some practice, it is not formalized and/or not systematic.
	C	Functional specialization	Beginner	* Low carbon management practices are not implemented * Where there is some practice, it is not formalized and/or not systematic.
	D	External integration	Active	* Existence of environmental goals * Competence in risk management and health, safety and environment management
	E	Internal integration	Emerging	* There is mobilization of the company's departments for low-carbon management, but not globally * The environmental dimension is not strategically evaluated
	F	Functional specialization	Beginner	* Low-carbon management practices are not implemented * Where there is some practice, it is not formalized and/or not systematic.

TABLE 12 Human critical success factors for the promotion of low-carbon management practices in the cases analyzed (intensity coding)

	Cases analyzed					
	A	B	C	D	E	F
Does top management support environmental activities?						
Does the analysis and job description take into account the environmental perspective?						
Do selection and recruitment take into account the environmental perspective?						
Is there environmental training in the company?						
Do employees have decision-making power to deal with environmental issues?						
Is there formation of “green” teams?						
Does performance and reward assessment take into account environmental criteria?						
Are the company's promotions linked to the achievement of environmental goals?						
What happens if someone does not meet environmental goals?						
Are there actions to stimulate employee engagement to support the environmental theme?						
Is concern for the environment part of the organization's culture?						
Is the environmental theme part of the company's learning process?						
What is the number of people involved (impacted) in environmental learning initiatives?						

the stage of maturity according to Jabbour and Santos (2006) and Jeswani et al. (2008), whereas B and F showed the lowest levels.

6.2 | Implications for theory

This study, which set out with the aim of understanding how human factors relate to low-carbon management practices from the perspective of the RBV)in the biodiversity sector, presents contributions that can be considered significant. By conducting a survey with the use of Structural Equation Modeling and a multiple-case study involving six organizations, the first contribution is in developing work in an emerging field with a methodology that offers considerable robustness.

The integrative analysis (combining qualitative and quantitative phases) culminated in the classification of the cases analyzed into two frameworks presenting their respective evolutionary stages in terms of environmental management (Jabbour & Santos, 2006) and Jeswani et al. (2008)). It was found that not all companies were classified according to the same stages of environmental management (Jabbour & Santos, 2006), which allows us to state that possibly the maturity of low-carbon management practices varies according to the adoption of practices linked to behavioral factors, which in turn support the evolution of low-carbon management practices.

As previously discussed, the quantitative analysis shows that all branches of the main hypothesis have been accepted—the first with a higher coefficient than the second and the second with a higher coefficient than the third. Thus, human factors are considered to influence low-carbon product management practices the most, followed by process practices and finally logistics practices. In these cases, consistent behavior was observed: the higher the intensity of adoption of HCSF, the higher the intensity of adoption of low-carbon practices. In addition, another factor worth mentioning is that low-carbon logistics management practices were the least featured aspect in the intensity coding, as well as in the results of the quantitative stage.

6.3 | Management implications

The relationship between HCSF and the stage of maturity of low-carbon management practices is useful for companies to understand the level at which these practices are currently performing and how they (the companies) can develop practices with the help of behavioral factors.

With the RBV as a foundation, this research has evidenced how human factors can be viewed as strategic resources that can become a source of sustainable competitive advantage.

In addition, there are implications for both human resource managers and operations managers: the most prevalent human

TABLE 13 Low-carbon management practices (intensity coding)

	Cases analyzed					
	A	B	C	D	E	F
Is the lifecycle analysis tool used to assess a product's carbon emissions over its lifetime?						
Is there substitution of intensive carbon raw materials for renewable raw materials?						
Is there substitution of intensive carbon raw materials for recycled raw materials?						
Does the product design take into account the reduction of carbon emissions during production processes?						
Are new production processes adopted or existing production processes improved to reduce carbon emissions?						
Are carbon emissions measured throughout the production process?						
Is there is an environmental management system (EMS) in place?						
Is more energy-efficient equipment used?						
Is there use of low-carbon/carbon-free energy sources?						
Are there recycling processes to dispose of carbon-intensive materials?						
Is there monitoring of distances traveled and associated fuel consumption regarding the company's logistics processes?						
Does the company use less polluting forms of transportation (hybrid engines in trucks, for example)?						
Does the company use more carbon efficient transport modes?						

factors and the most common (and most commonly adopted) low-carbon management practices, respectively. Thus, if managers are aware that low-carbon management practices varies according to the adoption of practices linked to behavioral factors, they could plan and implement specific topics related to the human side of operations, for instance.

By exploring the Brazilian (developing country) context, this research may support managers in similar contexts in better understanding the reality of low-carbon management practices, specifically in the biodiversity arena.

7 | CONCLUDING REMARKS

7.1 | Research aims

The aim of this research was to understand how the relationship between behavioral factors and low-carbon management practices occurs from the perspective of the RBV in the biodiversity sector.

To achieve this aim, following a bibliographic survey (Section 2), the following aspects were investigated: (a) human factors enabling low-carbon operations and (b) low-carbon management practices. With this theoretical background, relevant aspects were identified for both quantitative and qualitative analysis.

The quantitative analysis (through hypothesis testing) showed that all branches of the main hypothesis have been accepted—the first with a higher coefficient than the second and the second with a higher coefficient than the third. Thus, it was observed that human factors influenced low-carbon product management practices the most, followed by process practices and finally logistics practices.

The qualitative research was based on a multiple-case study strategy, focusing mainly on the relationship between HCSF and the adoption and evolution of low-carbon management organizational practices.

The results show that companies are at different stages of maturity in relation to low-carbon management organizational practices, ranging from the highest to the lowest stage. It was found that intensity of HCSF was higher as organizations demonstrated greater adoption of low-carbon management practices, appearing at a higher level in the evolutionary scale.

7.2 | Limitations and possibilities for research advancement

Possibly, the greatest difficulty in this study involved data collection at the quantitative stage. This ultimately resulted in a reasonable sample size. However, on this point, two considerations are made:

(a) studies published in prestigious journals in the "Green Production" area (related to sustainable operations) have worked with samples smaller than that of this work; (b) the sample size calculation procedures show that the number of responses attained (83 respondents) is greater than the minimum size required.

This study does not develop a longitudinal analysis, which could identify the effect of using HCSF in adopting low-carbon organizational practices over time, but this could be for future researchers to adopt.

In addition, data collection for the quantitative phase sought professionals linked to the sustainability field, and the responses therefore reflect the perception of this type of professional—in this case, there are variables measured on each respondent's own measurement scale.

Moreover, social desirability bias may also occur, as the research theme, due to involving the environment, may lead the respondent to a response bias (both quantitative and qualitative): to overreport being in favor of everything that involves the environment. Thus, such bias is the tendency of survey respondents to answer questions in a way that others will appreciate.

In term of future research, the state-of-the-art literature would benefit from further evidence on:

- Analysis of the relationship between HCSF and low-carbon organizational practices in other industries (segments);
- Using support from other theories (other than the RBV) to verify unobserved aspects in this relationship;
- Use of other qualitative tools to test this relationship;
- Use of other types of data collection and analysis in qualitative research to verify new/different insights.

ORCID

Charbel José Chiappetta Jabbour https://orcid.org/0000-0002-6143-4924
Hengky Latan https://orcid.org/0000-0002-4107-6373

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