

# The effects of the adoption of forest cropping technologies on sustainability dimensions: a multi-stakeholder perspective

Leônidas de Oliveira Leite<sup>1</sup>, Sergio Evangelista Silva<sup>2\*</sup>  and Andre Luís Silva<sup>3</sup>

<sup>1</sup>Departamento de Engenharia de Produção, Universidade Federal de Ouro Preto, Joao Monlevade, Minas Gerais, Brazil. <sup>2</sup>Departamento de Engenharia de Produção, Universidade Federal de Ouro Preto, Rua 36, 115, Loanda, 35931-008, Joao Monlevade, Minas Gerais, Brazil. <sup>3</sup>Escola de Minas, Universidade Federal de Ouro Preto, Campus Morro do Cruzeiro, Pilar, Ouro Preto, Minas Gerais, Brazil. \*Author for correspondence. E-mail: [sergio.silva@ufop.edu.br](mailto:sergio.silva@ufop.edu.br)

**ABSTRACT.** New technologies are an important instrument to face the global challenges and reach sustainability. Their adoption triggers different perspectives, interests and discourses of different stakeholders' groups involved in this phenomenon. Therefore, analyzing the different perspectives of diverse stakeholders' groups through their respective discourses is a fundamental instrument to assess the potential barriers and the viability of its adoption. This article analyzes how different stakeholders perceive the impacts on sustainability regarding the andadoption of new harvesting technologies in the forest industry in Brazil, through the dimensions of triple bottom line. The combination of qualitative and quantitative approach is used to analyze a set of stakeholders' documents that reflect their perception and positions on the adoption of these technologies. As a result, the different stakeholders' perspectives are mapped in a two-dimensional framework, based on the discursive focus (narrow versus broad), and the discourse valence (negative, neutral or positive). As contribution, this article shows the possibility to map the different stakeholders' perspectives about a same phenomenon, which is a useful tool for perceive the possibilities of action of stakeholders through the intentions expressed in their discourse.

**Keywords:** stakeholders; sustainability; technology adoption; triple-bottom-line; forest industry; innovation impact.

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## Introduction

Currently, the humankind faces huge challenges related to the leveraging its existence with well-being patterns, that requires the conciliation of sociopolitical issues with environmental conservation (Suphasomboon & Vassanadumrongdee, 2023; Voinov et al., 2016). Therefore, it is necessary the development of institutional frameworks capable of coordinate actions of different actors to facilitate the adaptation of societies to a novel paradigm that addresses both environmental and social challenges (Chaudhry et al., 2021). In addition, the development of new technologies capable of pave the transition path for a more sustainable future is still necessary (Andrade Filho, Sousa Neto, Silva Dias, Medeiros, & Batista, 2013; Losacker, Heiden, Liefner, & Lucas, 2023; Mukhtarov, Dieperink, & Driessen, 2018).

Even though from the perspective of whole society a technology can produce positive impact, it is important to highlight that from the perspective of specific groups of stakeholders, this general perspective cannot generate the same perception (Hörisch, Freeman, & Schaltegger, 2014; Muhar et al., 2018). In another words, while for whole society a technology can generate benefits, some specific groups can perceive it as a threat to its interests (Okorie, Obi, Russell, Charnley, & Salonitis, 2021; Talwar, Dhir, Islam, Kaur, & Almusharraf, 2023; Reed et al., 2018).

The sustainability literature that addresses the stakeholder construct has been based on a corporate centric perspective, that considers the sustainability issues as an instrument for attain more competitiveness (Pérez, 2015), mainly focused on the client (Freudenreich, Lüdeke-Freund, & Schaltegger, 2020). In a comprehensive perspective, some studies approach the sustainability issues of several interdependent agents in the same supply chain (Bezerra, Vieira, & Rezende, 2019; Gupta, Chen, Hazen, Kaur, & Gonzalez, 2019; Harrison, Bosse, & Phillips, 2010). However, there remains a need for a holistic perspective capable of approach the interactions of stakeholders with different interdependent levels within each specific context.

Largely, the impacts of actions of individuals and organizations in sustainability is assessed and narrated in the discourse landscape (Noland & Philips, 2010; Velde, Hugé, Friess, Koedam, Dahdouh-Guebas, 2019).

The stakeholders who produce discourse will normally shape it according to their knowledge and interests (García-Sánchez & Noguera-Gámez, 2017; Reed et al., 2018). Whereas the interpretation of a phenomena depends on the subjectivity action according to attention and motivations (Barnett, 2014), there are several forms to assess the impacts of other stakeholders' actions under the sustainable indicators. As a result, the same phenomenon can be narrated from different forms and perspectives according to the knowledge and interests involved (Braccini & Margherita, 2018; Jum'a, Zimon, Ikram, & Madzík, 2022; Khan, Ahmad, & Majava, 2021). In this scenario, it is necessary a more structured view about how discourses are tailored in the perspective of the impact of adopting new technologies under the sustainability concept (Barnett, 2014). The assessment of the impacts of this adoption can be performed based on the perspective of the triple bottom line, an approach that considers the sustainability as the conjunction of economically viable activities with social and environmental responsibility (Pérez, 2015; Gupta et al., 2019).

Among the several existing economic sectors, the forest cropping industry is directly related to the environmental preservation and to important economic activities, due to the production of cellulose and wood energy (Boukaousa et al., 2021). Accordingly, despite the economic aspects, it is important to use sustainable practices in all stages of management in the forest sector (Sharma & Henriques, 2005; Velde et al., 2019). Similar to other economic sectors, this sector is also marked by different stakeholders' groups, with varying interests and multiple levels of inter-relations (Baldwin et al., 2023). Researching their actions more comprehensively could provide valuable insights.

This article analyses how different stakeholders perceive the sustainability impacts of the adoption of new harvesting technologies in the Brazilian forest industry, through the dimensions of triple bottom line. The combination of qualitative and quantitative approach is applied to screening a set of stakeholders' documents relative to their perception and positioning about the adoption of new harvesting technologies. This analysis was carried out under the triple bottom line, considering the dimensions of economic, environmental, and social. The analysis was performed through the documentary examination of discourses of the following types of stakeholders: academic researchers, clients, employees' unions, environmentalists, equipment manufacturers, foment agencies, and press. Two research questions guided this study: 1 - What is the discursive positioning of different stakeholders' groups about the adoption of new harvesting technologies in forest crop industry in Brazil under the dimensions of triple bottom line? 2 - How this discourse reflects their interests?

In addition to this first section, the subsequent part presents the two conceptual basis that guided this study, the sustainability from the triple bottom line perspective, and the stakeholders' perspectives on sustainability issues. The third section presents the methodology. The fourth section presents the results, that are followed by their discussion in relation to the extant literature in fifth section. The sixth and last section conclude the study presenting its contributions and suggestions for future studies.

## Literature review

### Sustainability and triple bottom line

The triple bottom line model considers the sustainability in an anthropogenic perspective through three basic dimensions: economic, environmental, and social (Gimenez, Sierra, & Rodon, 2012; Goh, Chong, Jack, & Faris, 2020). In fact, achieving sustainability poses a fundamental challenge within an economic system governed by private interests and the fulfillment of individual needs of consumers and clients (Gu, Wang, Hua, & Liu, 2021). In this scenario, the qualitative expansion and transformation of the economic systems stand out as the main path for achieving economic development, while currently preserving the environment and maintaining social well-being (Pradhan, Costa, Rybski, Lucht, & Kropp, 2017; Sauermann et al., 2020). While some studies state that the performance of firms in the indicators of triple bottom line are positively related (Braccini & Margherita, 2018; Jum'a et al., 2022), other presents the existence of trade-offs (Khan et al., 2021; Liute & De Giacomo, 2022), such as, between economic and social indicators (Hollo, Blome, & Foerstl, 2012), between social and environmental (Sun, Gao, Tian, & Guan, 2023) and between economic and environmental (Hollo et al., 2012).

While the majority of sustainability literature is centered on the firms' issues (Hussain, Rigoni, & Orij, 2018), some studies mention other stakeholders, such as consumers (Nichols, Kirchoff, Confente, & Stolze, 2023) and policymakers (Neri, Cagno, Lepri, & Trianni, 2021). Additionally, some contemporary studies have a perspective that goes beyond the single organizational boundaries, considering the effects of multiple agents of a supply chain on sustainability (Bezerra et al., 2019; Gold, Hahn, & Seuring, 2013). Recent works

have provided a more realistic perspective of the effective actions taken by agents to attain sustainable outcomes. In certain situations, agents may cooperate to achieve sustainable outcomes (Gupta et al., 2019), while in others, they may resist against sustainable actions due to perceived threats to their economic interests (Okorie et al., 2021).

In certain scenarios, firms seek sustainability to become more competitive (Svensson et al., 2018). Conversely, in other instances, they avoid sustainable actions that could decrease the performance of some competitive criteria, important for their target markets (Shou et al., 2019). Over the long term, a firm's decisions to improve its sustainability performance are under their strategy, whereas different companies can improve their performance with distinct emphasis on different dimensions (Aytac et al., 2023; Thürer, Godinho Filho, Stevenson, & Fredendall, 2015).

Triple bottom line dimensions inspired the development of several indicators in different economic sectors. For instance, Ahmad and Wong (2019) propose a set of indicators to assess the impact of the food industry, namely: economic: cost and profit; environmental: material and energy used, air emissions and residues generated; and social: labor rights, working conditions, labor wellbeing, customer satisfaction, community, and society wellbeing. In the context of a firm, Svensson et al. (2018) present the following indicators: economic: cost, brand and profitability; environmental: footprint and decarbonizing; and social: corporate reputation and culture. In this respect, Neri et al. (2021) present indicators such as: economic: return on investment, market share, customer satisfaction; environment: energy use, water use, material use; social: stakeholder relationship, philanthropic investments, occupational health safety, labor turnover and employee satisfaction.

Finally, although in the short term the simultaneous increase in the performance of different sustainable indicators may be limited by current technologies, in the long term the development of new technologies can break these trade-offs through the development of radical innovations (Markard, 2020; Mendonça, 2013). In the sustainability context, this can be reached by the sustainability-oriented innovation policy, where firms seek to adopt new technologies considering their impact on sustainability indicators (Jum'a et al., 2022).

### **Stakeholders' perspective sustainability**

From a sociological perspective, a stakeholder group is a set of individuals or organizations with common characteristics which are related to a phenomenon (Talwar et al., 2023). They can be directly related to some phenomenon through their direct involvement on it, or be affected by its repercussions in some manner (Lema & Kapinga, 2023). There are also stakeholders' groups that, even though are not directly related to some phenomena, have some level of interest on it, such as academic researchers and press (Marino, Crowley, Williams Foley, McDonald, & Hodgson, 2023).

In the sustainability literature, stakeholders groups are identified according to their importance to the studied context, as follows: in corporate context: competitors, clients, customers, employees and owners (Fernandez-Feijoo, Romero, & Ruiz, 2014; Harrison et al., 2010); in financing systems for sustainability: government agencies, banking institutions, insurance entities, nonprofit organizations (Kuhn, 2022); about future perspectives of circular economy, administrators, economists, and academic researchers (Van Langen et al., 2021); in small and middle enterprises: competitors, community, environmental organizations, customers, suppliers, shareholders (Singh, Del Giudice, Chiappetta Jabbour, Latan, Sohal, 2022); in urban renewal: local government, residents, developers, designers (Bai, Wu, & Zhang, 2023); in water use: engineers, local authorities, and citizens (Lienert, Schnetzer, & Ingold, 2013).

Besides the examples above, the management literature is replete of studies about stakeholder interaction, spanning from situations of convergence of values and interests to situations of conflict (Bennett, Kemp, & Hudson, 2016; Marino et al., 2023; Muhar et al., 2018). It is important to consider that any stakeholder action starts in the subjectivity, whereas an individual, that pertains to a specific stakeholder group (e.g., suppliers, clients, consumers, unions) will deploy or interpret actions of other individuals associated with different stakeholders' groups (Barnett, 2014; Perrini & Tencati, 2006).

Individuals belonging to a specific stakeholders' group typically contribute to the formation of a common perspective about a specific phenomenon (Cox, Spence, & Pidgeon, 2020). On the other hand, the same phenomena can be understood from different perspectives from diverse stakeholders' groups (Nawaz & Satterfield, 2022; Puppala, Peddinti, Tamvada, Ahuja, & Kim, 2023; Reed et al., 2018; Velde et al., 2019). For instance, in the context of urban renewal, Bai et al., (2023) found that each stakeholder perceived these

activities from different perspectives. While the citizen perceived it as an opportunity to increase income, the government perceived it as a form of increase employment. Due to the different perspectives, there are several possible configurations of the positioning of stakeholder's groups in relation to a specific phenomenon, that can range from the coalition until the polarization (Gupta et al., 2019; Marino et al., 2023), and sometimes even against a common interest (Okorie et al., 2021).

A stakeholder action takes place in two possible forms, through a concrete action in the real world (e.g., the effective management of lands (Bai et al., 2023), and water (Lienert et al. 2013)), or through the production of discourse (Cotton, 2015; Huang & Mabon, 2022; Reed, 2008). The discursive space is a fundamental arena for stakeholders to interact and create linguistic artefacts that express their interests (Nawaz & Satterfield, 2022; Noland & Phillips, 2010; Fernandez-Feijoo et al., 2014). Considering the lack between factual occurrences and their corresponding narratives (Diouf & Boiral, 2017), the existence of information asymmetry among agents (García-Sánchez & Noguera-Gámez, 2017), and the potential influence of discourse on other individuals (Reed, 2008), the lack of transparency in sustainable reporting is plausible (Boiral, & Heras-Saizarbitoria, 2020). Therefore, several companies try to construct a favorable image by using a positive language to describe their actions (Diouf & Boiral, 2017). This includes instances where agents seek to manipulate the public opinion (Diouf & Boral, 2017).

Another aspect is the use of sustainable actions solely as instrumental means, where the sustainability is a tool to achieve other purposes (Cowell, Bristow, & Munday, 2011), such as gain of competitiveness, or meet clients' values (Khan, Yu, & Farooq, 2023; Nichols et al., 2023), rather than being implemented for its own sake (Pérez, 2015). Therefore, also in discursive space, some stakeholders' groups can exert pressure against companies for the adoption of sustainable actions (Singh et al., 2022). In several cases, the social exposition and pressure can stimulate companies to adopt actions that affect positively the sustainability indicators (Wolf, 2014), as for instance the environmentalist organizations that pressures companies for more sustainable actions (Harrison et al., 2010). To gain a comprehensive understanding, it is important to analyze the multiple discourses representing each stakeholder group's perspective (Velde et al., 2019), and also the existing interrelationships among them (Linert et al., 2013; Reed et al., 2009).

## Material and Methods

### Research approach and the context

This study combines the qualitative and quantitative approach to investigate how different stakeholders involved in the forest harvesting process produce discourses about the adoption of new harvesting technologies. This analysis is based on the tree dimensions of sustainability, posed by the triple bottom line model. The qualitative approach was used for identifying the content of discourse pieces in documents, considering its essence, such as a text that present positive/negative or neutral perspective about the use of a technology in the harvesting process. Then, the several discursive pieces of different stakeholders were accounted through the descriptive statistics to create a general picture of the discursive production within different stakeholders' groups. This study is based on documental analysis of the discourse pieces from different stakeholders.

The main activities related to the forest harvesting process and the technologies used in this process are: cutting, in this stage the wood is felled, delimbed and twisted. Two types of machines are currently used in this process: the feller-buncher (woodcutter-accumulator) and the harvester; extraction, involves the dragging the wood close to the road or even to nearby yards takes place. The technologies most used for this operation are articulated tractors or skidders; transport in the setting, involves the moving volumes of wood already organized into piles. For this operation, forwarders or agricultural tractors are generally used; loading, in this operation the wood is deposited on the vehicle body in a longitudinal or perpendicular direction to the vehicle. The most advanced technologies in this sense are those of tracing grapples and cranes; transport, generally trucks intended for transporting wood usually have adapted bodies called bunks.

### Data source

The search for documents was carried out on the Google® platform, as well as on specialized websites and social media pages focused on topics relating to forest harvesting in Brazil. The search criteria always included terms associated with forest harvesting and were specifically tailored to encompass environmental, economic, and social sustainability criteria.

The stakeholders were identified according to the reading of the documents, what rendered the following categories: environmentalists: people or organizations that establish types of correlation between forest harvesting activities and the environment conservation; scientific community: people that carry out studies and researches aimed at implementing innovations in the forest harvesting process; suppliers: organizations that provide technologies for the forest harvesting process; clients: organizations that use technologies for the forest harvesting process; foment entity: organizations that provide guidance on best practices and encourage the execution of forestry processes; press: communication vehicles that, among other topics, create articles and reports on forest harvesting; unions: entities defending the rights of workers of the forest harvesting process.

The research consisted of two rounds of documents searches. In the first round, 28 documents were obtained, totaling 786 pages. Following a thorough additional search with exhaustive efforts, 34 new documents were found, totaling 907 pages at the end of the two stages.

### **Description of the analysis method and its validity**

After collecting the documents, they were decoded from sustainability perspectives, through content analysis. In parallel with this decoding, stakeholders were identified and classified according to their social role. For each document, it was possible to carry out the analyzes in two stages. In this sense, a data analysis protocol was implemented, focusing on key constructs including stakeholders, technologies used in the forest harvesting process, and their respective economic, social, and environmental impacts.

The first step involved categorizing the document's approach based on perspectives, namely:

a) positive: documents emphasizing positive aspects of forest harvesting technologies within sustainability dimensions.

b) neutral: documents without a clear negative or positive perspective about the harvesting technology, presenting information without explicit value judgment.

c) negative: documents asserting that the impact of forest harvesting technologies is negative from the perspective of sustainability.

The identification of a positive or negative position on the use of a certain technology occurred mainly through the identification of predicates (adjectives) that qualify their use in a certain perspective, from a certain economic, social, or environmental perspective.

Furthermore, an analysis was carried out in accordance with the environmental, economic, and social criteria established. For this evaluation, a valence matrix was established, where the criteria received a score of "+", when the document takes a positive approach to the criterion; a score of 0, for neutrality, or a "-" score when it express negativity about the application of the harvesting technology.

## **Results**

The results presented here describe the perspective of the stakeholders mentioned in previous section, namely: clients, environmentalists; foment agencies, scientists, suppliers, press, and unions. Each stakeholder group's perspective on the adoption of harvesting technologies is detailed within the three sustainability dimensions: environmental, economic, and social. The representation of this perspective involves a positive "+", neutral "0" or negative "-" view about each stakeholder group (see Table 1).

The screening of the text in each sustainability dimension allowed the identification of several indicators. The following subsection will respectively discuss the economics, environmental and social perspective of the stakeholders' groups about the adoption of the harvesting technologies.

### **The perspective of the stakeholders' groups about the economic impact of adopting harvesting technologies**

Table 1 shows that all stakeholders' groups addressed at least one economic criterion in the assessment of the impact of adopting forest harvesting technologies. However, only suppliers and foment agencies comprehensively covered the five criteria, where both presented only a positive view of the adoption of the new technologies, for criteria such as agility, client satisfaction, cost, productivity, and quality. Environmentalists also presented a positive view of all criteria, except agility. With a more focused perspective, clients emphasized only cost and productivity.

**Table 1.** The valences and criteria approached by stakeholders' groups.

Dimensions	Indicator	Stake holders						
		Client	Environmentalists	Foment agencies	Press	Supplier	Scientists	Unions
Economic	Agility			+	0	+		
	Client satisfaction		+	+		+		
	Cost	+	+	+	0	+	+/0	+/0
	Productivity	+	+	+	0	+	+/0	
	Quality		+	+	0	+	+/0	
Environmental	Biodiversity		+/-	+	0		0	
	Energy	+	+/-	+	0	+	0	
	Effluents and waste	+	+/-	+	0	+	0	
	Soil		+/-	+	0		0	
	Water		+/-	+	0		0	
Social	Employment		+/-	+	+/-/0			-
	Health and assurance	+	+/-	+	+/-/0	+	-	
	Relationship with communities		+/-	+	+/-/0			

The narrowest perspective was observed on unions, that considered only the impact of harvesting technologies in cost. Below are some statements reflecting the economic view of application of harvesting technologies from the perspective of suppliers, clients and foment agencies, all presenting a positive perspective.

"These new fellers bunchers redefine the machine availability, the productivity and the low daily operational costs." (Quotation 1 – Supplier)

"The fleet renewal represents the use of machine with recent enhancement, making production more agile, economic and sustainable for the firm." (Quotation 2 – Client)

"[...] the new technologies increase the productivity of forestry, guarantee the durability of investment, and add value for the product. [...]" (Quotation 3 – Foment Agency)

### **The perspective of the stakeholders' groups about the environmental impact of adopting harvesting technologies**

Regarding the environmental dimension, environmentalists, foment agencies and scientists address all the five criteria: biodiversity, energy, effluents and waste emission, soil, and water. However, the valences of the discourse diverge. Environmentalists consider both positive and negative impacts of adopting new harvesting technologies in these criteria, while foment agencies and suppliers only consider positive impacts. On the other hand, press and scientists produce a neutral discourse concerning these criteria.

Clients and suppliers only consider positive impact of technologies in terms of energy consumption and diminishing in emission of effluents and waste, while unions do not consider any environmental criteria in their discourse. The following quotations respectively express a negative and a positive view in the environmental dimension.

"A report reveals that, after the three years of forest harvesting, all the captured carbon is released again" (Quotation 4 – Environmentalist)

"The impacts of this process [adoption of new technologies] has reconciled environmental and social benefits" (Quotation 5 – Foment Agency)

### **The perspective of the stakeholders' groups about the social impact of adopting harvesting technologies**

Only environmentalist, foment agencies and press considers all the three social impacts of adopting of new harvesting technologies. However, environmentalists present both positive and negative points of these technologies, while foment agencies present only a positive view, and press presents a discourse that encompasses neutral, positive, and negative perspectives about these technologies.

Clients and suppliers address only the positive impact of technology adoption in terms of health and assurance of workers. Conversely, scientists present a negative view in this same aspect, and unions express a negative view about the effects of technologies in health and employment. The following statements present both positive and negative perspectives.

"The report states that, based on the analysis of activities performed in the harvester and forwarder machines, there are evident situations that characterize ergonomic risk and threat for workers health" (Quotation 6 – Union)

"Comfortable and on the control: [...] developed for forest professionals, the new cabin is quieter and spacious" (Quotation 7 – Client)

"[...] The precarious labor relations predominate in the forest harvesting sector [...]" (Quotation 8 – Scientist)

### **A general view of the stakeholder groups**

For a better understanding of the discursive positioning of the different stakeholders' groups, Table 1 can be interpreted from two dimensions. In the vertical axis, the width of the discourse is presented, ranging from broad (considering several criteria,) to narrow (focusing on fewer criteria). For instance, foment agencies present the widest discourse by considering all thirteen identified criteria, while unions exhibit a narrow discourse by focusing on only a few criteria. In the horizontal axis, the predominant valence of discourse is considered, varying among negative, neutral, and positive view.

Regarding the discourse valence, the analysis of the discourse strategies among the stakeholders allows for the identification of two main groups of agents. The first group comprises those with direct economic interests in the adoption of new harvesting technologies, namely clients, equipment suppliers, and unions. The two first stakeholders' groups present solely a positive view about the adoption of harvesting technologies, with an emphasis on economic and environmental issues. On the other hand, unions, representing the employees' interests, have a more critical perspective, presenting positive, neutral, and negative assertions about the use of technologies. However, they only consider two criteria: cost and employment.

It is also possible to observe the occurrence of stakeholder's groups with a broad focus, such as environmentalists, foment agencies and press, approaching twelve out of thirteen criteria, but with differences in valence. Environmentalists have a more critical view, highlighting several negative impacts of harvesting technologies. In contrast, foment agencies maintain a predominantly positive view, and the press presents various discourses encompassing neutral, negative, and positive views. Scientists address nine criteria with varied emphasis, predominantly leading towards a neutral discourse.

## **Discussion**

This article assumes that stakeholder's action also can take place through the production of discourse (Cotton, 2015; Huang et al., 2022; Reed 2008). Aligned with Barnett's (2014) perspective, this premise is associated with the three dimensions of sustainability - economic, environmental, and social - to analyze the discourses of different stakeholders' groups in the context of forest harvesting process in the Brazilian context. In part, this study confirms the notion present in the literature (Hörisch et al., 2014; Muhar et al., 2018), that the same phenomenon, such as the adoption of harvesting technologies, can generate different perceptions and viewpoints.

This research partially supports the view of García-Sánchez and & Noguera-Gámez (2017) and Reed et al. (2018), which consider that stakeholders seek for their interests. In this study, the positive discourse of suppliers reveals their interest in selling equipment. While the interest of unions, which seek to defend the employees' interests, address aspects related to work conditions and rent related to the equipment, what is revealed in some critic view of it. However, there are also stakeholders with no direct interests, like scientists and press, who can produce diffuse discourses, emphasizing various criteria in the sustainability context with different valences.

Considering the sustainability criteria identified in the documents, this research aligns with authors (Ahramad & Wong, 2019; Neri et al., 2021; Svensson et al., 2018) regarding indicators such as cost, productivity, client satisfaction, energy. However, it also introduces new attributes, such as agility, quality, biodiversity, employment, and relationship with communities.

This research identified seven relevant stakeholders' groups: clients, environmentalists, foment agencies, press, suppliers, scientists, and unions. This alignment corresponds with the stakeholders identified in the researched literature (Bai et al., 2023; Fernandez-Feijoo et al., 2014; Harrison et al., 2010; Van Langen et al., 2021; Singh et al., 2022)

This article contributes to the current discourse analysis perspective by proposing a two-dimensional framework that considers two important dimensions of discourse: focus, which ranges from narrow to broad,

and the valence, encompassing negative, neutral and positive positions. Besides the valence, the wideness of a discourse implies that stakeholder's groups, while pursuing their interests through discourse production, may ignore criteria deemed important. Instead, they are likely to address and emphasize aspects considered relevant to their perspectives.

## Conclusion

This article analyzes how different stakeholders' groups perceive the impacts of new harvesting technologies, from the perspective of the triple bottom line, based on the economic, environmental, and social dimensions. Addressing the two research questions presented: 1 – What is the discursive positioning of different stakeholders' groups about the adoption of new harvesting technologies in forest crop industry in Brazil under the dimensions of triple bottom line? This article identifies considerable differences in the stakeholder discursive positioning of, based on two dimensions: the focus of discourse, which varies from narrow, where stakeholder groups address few topics, to a broad perspective, where several issues are addressed. Another dimension is the valence of discourse, which varies among negative, neutral, and positive.

Considering the question: 2 – How does this discourse reflect their interests? This article shows the alignment of interests of some stakeholders and their discourse. In the case of clients, suppliers, and unions, with direct economic interests in the use of technologies, their discourse considers several statements supporting their respective interests. In contrast, for foment agencies, scientists, and press, where economic interest was not discernible, these stakeholder groups showed diffuse perspectives about the effects of adopting new technologies in the forest harvesting process.

A primary contribution of this article is the proposal of a framework that permit to identify the mutual relations of stakeholders within a discursive arena addressing the same phenomenon. This framework permit to understand the current scenario of different stakeholders' groups about the adoption of harvesting technologies in the Brazilian context. While the sustainability challenge of the contemporary society is widely recognized as urgent for several different actors, the effective implementation of measures for attain sustainability in the three dimensions depends on the action of different stakeholders' groups. Although a discourse may not necessarily reveal the true intentions of an agent, the discourse analysis is a good start point for comprehending their world view and the potential actions regarding a specific phenomenon. Consequently, this article presents a useful instrument to assess the probable positions and actions of different agents in relation to sustainability issues, and to develop policies aimed at achieving a more sustainable society.

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## References

- Ahmad, S., & Wong, K. Y. (2019). Development of weighted triple-bottom line sustainability indicators for the Malaysian food manufacturing industry using the Delphi method. *Journal of Cleaner Production*, 229, 1167-1182. DOI: <https://doi.org/10.1016/j.jclepro.2019.04.399>
- Andrade Filho, J., de Sousa Neto, O. N., da Silva Dias, N., de Medeiros, J. F., & Batista, R. O. (2013). Cotton production using secondary domestic sewage. *Acta Scientiarum. Technology*, 35(2), 213-220. DOI: <https://doi.org/10.4025/actascitechnol.v35i2.13157>
- Aytac, S., Bautista-Puig, N., Orduña-Malea, E., & Tran, C. Y. (2023). Contribution of carbon footprint research towards the triple bottom line of sustainability. *Environmental Science and Pollution Research*, 30(38), 88331-88349. DOI: <https://doi.org/10.1007/s11356-023-28799-w>
- Barnett, M. L. (2014). Why stakeholders ignore firm misconduct: A cognitive view. *Journal of Management*, 40(3), 676-702. DOI: <https://doi.org/10.1177/0149206311433854>



- Bai, Y., Wu, S., & Zhang, Y. (2023). Exploring the key factors influencing sustainable urban renewal from the perspective of multiple stakeholders. *Sustainability*, 15(13), 10596. DOI: <https://doi.org/10.3390/su151310596>
- Baldwin, E., McLaughlin, D. M., Jasso, V., Woods, D., Breshears, D. D., Lopez-Hoffman, L., ... & Lien, A. (2023). Diverse stakeholders and their interests matter to the US Forest Service: A network of action situations analysis of how stakeholders affect forest plan outcomes. *Sustainability Science*, 18, 27-42. DOI: <https://doi.org/10.1007/s11625-022-01173-4>
- Bezerra, P. R. C., Vieira, M. M., & de Rezende, J. F. D. (2019). Measurement of the eco-efficiency of small business in the supply chain oil and gas, applying the taxonomy CE7. *Acta Scientiarum. Technology*, 41, e37730.
- Boiral, O., & Heras-Saizarbitoria, I. (2020). Sustainability reporting assurance: Creating stakeholder accountability through hyperreality?. *Journal of Cleaner Production*, 243, 118596.
- Bennett, S., Kemp, S., & Hudson, M. D. (2016). Stakeholder perceptions of Environmental Management Plans as an environmental protection tool for major developments in the UK. *Environmental Impact Assessment Review*, 56, 60-71. DOI: <https://doi.org/10.1016/j.eiar.2015.09.005>
- Boukaous, N., Abdelouahed, L., Chikhi, M., Taouk, B., Meniai, A. H., & Kebabi, B. (2021). Optimization of energy valorization from lignocellulosic biomass and their pure woody pseudo-components using a green technology.
- Braccini, A. M., & Margherita, E. G. (2018). Exploring organizational sustainability of industry 4.0 under the triple bottom line: The case of a manufacturing company. *Sustainability*, 11, 36. DOI: <https://doi.org/10.3390/su11010036>
- Chaudhry, I. S., Ali, S., Bhatti, S. H., Anser, M. K., Khan, A. I., & Nazar, R. (2021). Dynamic common correlated effects of technological innovations and institutional performance on environmental quality: Evidence from East-Asia and Pacific countries. *Environmental Science and Policy*, 124, 313-323. DOI: <http://dx.doi.org/10.1016/j.envsci.2021.07.007>
- Cowell, R., Bristow, G., & Munday, M. (2011). Acceptance, acceptability and environmental justice: the role of community benefits in wind energy development. *Journal of Environmental Planning and Management*, 54(4), 539-557. DOI: <https://doi.org/10.1080/09640568.2010.521047>
- Cotton, M. (2015). Stakeholder perspectives on shale gas fracking: a Q-method study of environmental discourses. *Environment and Planning A*, 47(9), 1944-1962. DOI: <https://doi.org/10.1177/0308518X155971>
- Cox, E., Spence, E., & Pidgeon, N. (2020). Incumbency, trust and the Monsanto effect: Stakeholder discourses on greenhouse gas removal. *Environmental Values*, 29(2), 197-220. DOI: <https://doi.org/10.3197/096327119X15678473650947>
- Diouf, D., & Boiral, O. (2017). The quality of sustainability reports and impression management: A stakeholder perspective. *Accounting, Auditing and Accountability Journal*, 30(3), 643-667.
- Fernandez-Feijoo, B., Romero, S., & Ruiz, S. (2014). Effect of stakeholders' pressure on transparency of sustainability reports within the GRI framework. *Journal of business ethics*, 122, 53-63. DOI: <https://doi.org/10.1007/s10551-013-1748-5>
- Freudenreich, B., Lüdeke-Freund, F., & Schaltegger, S. (2020). A stakeholder theory perspective on business models: Value creation for sustainability. *Journal of Business Ethics*, 166, 3-18.
- García-Sánchez, I. M., & Noguera-Gámez, L. (2017). Integrated reporting and stakeholder engagement: The effect on information asymmetry. *Corporate Social Responsibility and Environmental Management*, 24(5), 395-413. DOI: <https://doi.org/10.1002/csr.1415>
- Gimenez, C., Sierra, V., & Rodon, J. (2012). Sustainable operations: Their impact on the triple bottom line. *International journal of production economics*, 140, 149-159. DOI: <https://doi.org/10.1016/j.ijpe.2012.01.035>
- Goh, C. S., Chong, H. Y., Jack, L., & Faris, A. F. M. (2020). Revisiting triple bottom line within the context of sustainable construction: A systematic review. *Journal of Cleaner Production*, 252, 119884. DOI: <https://doi.org/10.1016/j.jclepro.2019.119884>
- Gold, S., Hahn, R., & Seuring, S. (2013). Sustainable supply chain management in “Base of the Pyramid” food projects—A path to triple bottom line approaches for multinationals? *International Business Review*, 22(5), 784-799. DOI: <https://doi.org/10.1016/j.ibusrev.2012.12.006>

- Gu, W., Wang, J., Hua, X., & Liu, Z. (2021). Entrepreneurship and high-quality economic development: Based on the triple bottom line of sustainable development. *International entrepreneurship and management journal*, 17, 1-27. DOI: <https://doi.org/10.1007/s11365-020-00684-9>
- Gupta, S., Chen, H., Hazen, B. T., Kaur, S., & Gonzalez, E. D. S. (2019). Circular economy and big data analytics: A stakeholder perspective. *Technological Forecasting and Social Change*, 144, 466-474. DOI: <https://doi.org/10.1016/j.techfore.2018.06.030>
- Harrison, J. S., Bosse, D. A., & Phillips, R. A. (2010). Managing for stakeholders, stakeholder utility functions, and competitive advantage. *Strategic management journal*, 31, 58-74.
- Hörisch, J., Freeman, R. E., & Schaltegger, S. (2014). Applying stakeholder theory in sustainability management: Links, similarities, dissimilarities, and a conceptual framework. *Organization and Environment*, 27(4), 328-346. DOI: <https://doi.org/10.1177/1086026614535786>
- Huang, Y. C., & Mabon, L. (2022). Making sense of how proponents conspire to thwart environmental impact assessment processes: insights from the Miramar Resort controversy in Taiwan. *Journal of Environmental Planning and Management*, 65(9), 1685-1707. DOI: <https://doi.org/10.1080/09640568.2021.1944846>
- Hussain, N., Rigoni, U., & Orij, R. P. (2018). Corporate governance and sustainability performance: Analysis of triple bottom line performance. *Journal of business ethics*, 149, 411-432. DOI: <https://doi.org/10.1007/s10551-016-3099-5>
- Hollos, D., Blome, C., & Foerstl, K. (2012). Does sustainable supplier co-operation affect performance? Examining implications for the triple bottom line. *International Journal of Production Research*, 50(11), 2968-2986. DOI: <https://doi.org/10.1080/00207543.2011.582184>
- Jum'a, L., Zimon, D., Ikram, M., & Madzík, P. (2022). Towards a sustainability paradigm; the nexus between lean green practices, sustainability-oriented innovation and Triple Bottom Line. *International Journal of Production Economics*, 245, 108393. DOI: <https://doi.org/10.1016/j.ijpe.2021.108393>
- Khan, I. S., Ahmad, M. O., & Majava, J. (2021). Industry 4.0 and sustainable development: A systematic mapping of triple bottom line, Circular Economy and Sustainable Business Models perspectives. *Journal of Cleaner Production*, 297, 126655. DOI: <https://doi.org/10.1016/j.jclepro.2021.126655>
- Khan, S. A. R., Yu, Z., & Farooq, K. (2023). Green capabilities, green purchasing, and triple bottom line performance: Leading toward environmental sustainability. *Business Strategy and the Environment*, 32(4), 2022-2034. DOI: <https://doi.org/10.1002/bse.3234>
- Kuhn, B. M. (2022). Sustainable finance in Germany: mapping discourses, stakeholders, and policy initiatives. *Journal of Sustainable Finance and Investment*, 12(2), 497-524. DOI: <https://doi.org/10.1080/20430795.2020.1783151>
- Lema, M. W., & Kapinga, A. G. (2023). Identifying potential stakeholders for the management of Lower Mgeta and Upper Zigi water catchments of Tanzania. *East Africa: Environmental Quality Management*.
- Lienert, J., Schnetzer, F., & Ingold, K. (2013). Stakeholder analysis combined with social network analysis provides fine-grained insights into water infrastructure planning processes. *Journal of environmental management*, 125, 134-148. DOI: <https://doi.org/10.1016/j.jenvman.2013.03.052>
- Liute, A., & De Giacomo, M. R. (2022). The environmental performance of UK-based B Corp companies: An analysis based on the triple bottom line approach. *Business Strategy and the Environment*, 31(3), 810-827. DOI: <https://doi.org/10.1002/bse.2919>
- Losacker, S., Heiden, S., Liefner, I., & Lucas, H. (2023). Rethinking bioeconomy innovation in sustainability transitions. *Technology in Society*, 74, 102291. DOI: <https://doi.org/10.1016/j.techsoc.2023.102291>
- Mendonça, S. (2013). The "sailing ship effect": Reassessing history as a source of insight on technical change. *Research Policy*, 42(10), 1724-1738. DOI: <https://doi.org/10.1016/j.respol.2012.12.009>
- Markard, J. (2020). The life cycle of technological innovation systems. *Technological forecasting and social change*, 153, 119407. DOI: <https://doi.org/10.1016/j.techfore.2018.07.045>
- Marino, F., Crowley, S. L., Williams Foley, N. A., McDonald, R. A., & Hodgson, D. J. (2023). Stakeholder discourse coalitions and polarisation in the hen harrier conservation debate in news media. *People and Nature*, 5(2), 668-683. DOI: <https://doi.org/10.1002/pan3.10437>

- Muhar, A., Raymond, C. M., Van Den Born, R. J., Bauer, N., Böck, K., Braitto, M., ... & Van Riper, C. J. (2018). A model integrating social-cultural concepts of nature into frameworks of interaction between social and natural systems. *Journal of Environmental Planning and Management*, 61(5-6), 756-777. DOI: <https://doi.org/10.1080/09640568.2017.1327424>
- Mukhtarov, F., Dieperink, C., & Driessen, P. (2018). The influence of information and communication technologies on public participation in urban water governance: A review of place-based research. *Environmental Science and Policy*, 89, 430-438. DOI: <https://doi.org/10.1016/j.envsci.2018.08.015>
- Nawaz, S., & Satterfield, T. (2022). On the nature of naturalness? Theorizing 'nature' for the study of public perceptions of novel genomic technologies in agriculture and conservation. *Environmental Science and Policy*, 136, 291-303. DOI: <https://doi.org/10.1016/j.envsci.2022.06.008>
- Neri, A., Cagno, E., Lepri, M., & Trianni, A. (2021). A triple bottom line balanced set of key performance indicators to measure the sustainability performance of industrial supply chains. *Sustainable Production and Consumption*, 26, 648-691. DOI: <https://doi.org/10.1016/j.spc.2020.12.018>
- Nichols, B. S., Kirchoff, J. F., Confente, I., & Stolze, H. (2023). When brands behave badly: signaling and spillover effects of unethical behavior in the context of triple bottom line sustainability. *Journal of Product and Brand Management*. DOI: <https://doi.org/10.1108/JPBM-07-2021-3569>
- Noland, J., & Phillips, R. (2010). Stakeholder engagement, discourse ethics and strategic management. *International Journal of Management Reviews*, 12, 39-49. DOI: <https://doi.org/10.1111/j.1468-2370.2009.00279.x>
- Okorie, O., Obi, M., Russell, J., Charnley, F., & Salonitis, K. (2021). A triple bottom line examination of product cannibalisation and remanufacturing: A review and research agenda. *Sustainable Production and Consumption*, 27, 958-974. DOI: <https://doi.org/10.1016/j.spc.2021.02.013>
- Pérez, A. (2015). Corporate reputation and CSR reporting to stakeholders: Gaps in the literature and future lines of research. *Corporate communications: An international journal*, 20, 11-29. DOI: <https://doi.org/10.1108/CCIJ-01-2014-0003>
- Perrini, F., & Tencati, A. (2006). Sustainability and stakeholder management: the need for new corporate performance evaluation and reporting systems. *Business strategy and the environment*, 15(5), 296-308. DOI: <https://doi.org/10.1002/bse.538>
- Pradhan, P., Costa, L., Rybski, D., Lucht, W., & Kropp, J. P. (2017). A systematic study of sustainable development goal (SDG) interactions. *Earth's Future*, 5(11), 1169-1179. DOI: <https://doi.org/10.1002/2017EF000632>
- Puppala, H., Peddinti, P. R., Tamvada, J. P., Ahuja, J., & Kim, B. (2023). Barriers to the adoption of new technologies in rural areas: The case of unmanned aerial vehicles for precision agriculture in India. *Technology in Society*, 74, 102335. DOI: <https://doi.org/10.1016/j.techsoc.2023.102335>
- Reed, M. S. (2008). Stakeholder participation for environmental management: a literature review. *Biological conservation*, 141(10), 2417-2431. DOI: <https://doi.org/10.1016/j.biocon.2008.07.014>
- Reed, M. S., Graves, A., Dandy, N., Posthumus, H., Hubacek, K., Morris, J., ... & Stringer, L. C. (2009). Who's in and why? A typology of stakeholder analysis methods for natural resource management. *Journal of environmental management*, 90(5), 1933-1949. DOI: <https://doi.org/10.1016/j.jenvman.2009.01.001>
- Reed, M. S., Vella, S., Challies, E., De Vente, J., Frewer, L., Hohenwallner-Ries, D., ... & van Delden, H. (2018). A theory of participation: what makes stakeholder and public engagement in environmental management work?. *Restoration ecology*, 26, S7-S17. DOI: <https://doi.org/10.1111/rec.12541>
- Sauermann, H., Vohland, K., Antoniou, V., Balázs, B., Göbel, C., Karatzas, K., ... & Winter, S. (2020). Citizen science and sustainability transitions. *Research Policy*, 49(5), 103978. DOI: <https://doi.org/10.1016/j.respol.2020.103978>
- Singh, S. K., Del Giudice, M., Chiappetta Jabbour, C. J., Latan, H., & Sohal, A. S. (2022). Stakeholder pressure, green innovation, and performance in small and medium-sized enterprises: The role of green dynamic capabilities. *Business Strategy and the Environment*, 31, 500-514. DOI: <https://doi.org/10.1002/bse.2906>
- Sharma, S., & Henriques, I. (2005). Stakeholder influences on sustainability practices in the Canadian forest products industry. *Strategic management journal*, 26(2), 159-180. DOI: <https://doi.org/10.1002/smj.439>

- Shou, Y., Shao, J., Lai, K. H., Kang, M., & Park, Y. (2019). The impact of sustainability and operations orientations on sustainable supply management and the triple bottom line. *Journal of Cleaner Production*, 240, 118280. DOI: <https://doi.org/10.1016/j.jclepro.2019.118280>
- Sun, Y., Gao, P., Tian, W., & Guan, W. (2023). Green innovation for resource efficiency and sustainability: Empirical analysis and policy. *Resources Policy*, 81, 103369. DOI: <https://doi.org/10.1016/j.resourpol.2023.103369>
- Svensson, G., Ferro, C., Høgevold, N., Padin, C., Varela, J. C. S., & Sarstedt, M. (2018). Framing the triple bottom line approach: Direct and mediation effects between economic, social and environmental elements. *Journal of cleaner production*, 197, 972-991. DOI: <https://doi.org/10.1016/j.jclepro.2018.06.226>
- Suphasomboon, T., & Vassanadumrongdee, S. (2023). Multi-stakeholder perspectives on sustainability transitions in the cosmetic industry. *Sustainable Production and Consumption*, 38, 225-240. DOI: <https://doi.org/10.1016/j.spc.2023.04.008>
- Talwar, S., Dhir, A., Islam, N., Kaur, P., & Almusharraf, A. (2023). Resistance of multiple stakeholders to e-health innovations: Integration of fundamental insights and guiding research paths. *Journal of Business Research*, 166, 114135. DOI: <https://doi.org/10.1016/j.jbusres.2023.114135>
- Thürer, M., Godinho Filho, M., Stevenson, M., & Fredendall, L. (2015). Small and medium sized manufacturing companies in Brazil: is innovativeness a key competitive capability to develop?. *Acta Scientiarum. Technology*, 37(3), 379-387. DOI: <https://doi.org/10.4025/actascitechnol.v37i3.26531>
- Van Langen, S. K., Vassillo, C., Ghisellini, P., Restaino, D., Passaro, R., & Ulgiati, S. (2021). Promoting circular economy transition: A study about perceptions and awareness by different stakeholders groups. *Journal of Cleaner Production*, 316, 128166. DOI: <https://doi.org/10.1016/j.jclepro.2021.128166>
- Velde, K. V., Hugé, J., Friess, D. A., Koedam, N., & Dahdouh-Guebas, F. (2019). Stakeholder discourses on urban mangrove conservation and management. *Ocean and coastal management*, 178(2), 104810. DOI: <https://doi.org/10.1016/j.ocecoaman.2019.05.012>
- Voinov, A., Kolagani, N., McCall, M. K., Glynn, P. D., Kragt, M. E., Ostermann, F. O., ... & Ramu, P. (2016). Modelling with stakeholders—next generation. *Environmental Modelling and Software*, 77, 196-220. DOI: <https://doi.org/10.1016/j.envsoft.2015.11.016>
- Wolf, J. (2014). The relationship between sustainable supply chain management, stakeholder pressure and corporate sustainability performance. *Journal of business ethics*, 119, 317-328.
- Yi, L., & Li, T. (2021). Stakeholders' environmental preferences based corporate environmental information influencing factors research. *Environmental Quality Management*, 30(4), 113-125. DOI: <https://doi.org/10.1002/tqem.21743>