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SUSTAINABLE FOREST MANAGEMENT: ANALYSIS OF ECO-INNOVATION PROCESS IN AMAZON

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Abstract:

Evaluation of eco-innovation practices in companies has been widely studied, however, there is a gap in the literature on the adoption of eco-innovative practices in companies located in the Amazon/Brazil. Therefore, the objective of this research is to analyze the eco-innovation process in an industry located in the Amazon related to sustainable forest management. The purpose of the research was to conduct an exploratory case study (in-depth case) in a logging company located in the Amazon/Brazil. The relevance of the study lies in the process of making the eco-innovations developed by the company clearer and being able to compare them with the existing literature through a form that allows the evaluation of eco-innovative activities within an organization.

Keywords: eco-innovation; sustainable forest management; SMEs; Amazon.

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1. Introduction

Natural disasters are becoming more intense and frequent and in recent years there has been unprecedented hot weather around the world. Environmental risks are dominating the Global Risks Perception Survey; three of the top five risks from impact are environmental (World Economic Forum, 2020a). The 2008 economic crisis and negotiations to combat climate change must be seen as opportunities for adjustment toward a green economy (Organization for Economic Co-operation and Development, 2009a).

The emergence of Covid-19 in the city of Wuhan (China) caused unprecedented changes in the world economy due to the high rate of transmission of the virus and the need to protect individuals (Chen et al., 2020; Cheng et al., 2020; Guo et al., 2020).

More than half of the generation of economic value is moderately or highly dependent on nature and its services, which can become material risks to businesses when they directly affect their operations, supply chain performance, real estate asset values, physical security, and business continuity (WEF, 2020b). Encouraging sustainable consumption, as well as sustainable production and management of natural resources, taking action on climate change (United Nations General Assembly, 2015).

The technologies of the Fourth Industrial Revolution are changing the lines between the physical, digital, and biological spheres of production systems, through a new economic paradigm to ensure profitable, equitable, and sustainable growth in a safe operating space. Since the 1970s, the concept of circular economy has spread to society by characterizing business models that employ concepts of reduction, reuse, recycling, and recovery in complex global value chains where companies and governments struggle to expand these business models (WEF, 2017; 2018a; 2018b; 2019).

In this context of economic, social, political, and environmental issues, eco-innovation can be understood as the production, assimilation, or exploration of a product, production process, services, management, or business method that is new to the organization (developed or adopted) and where the results, throughout the life cycle, generate a reduction of the risks of the environment, pollution and other negative impacts of the resources used (including the use of energy) compared to the relevant alternatives (Kemp & Pearson, 2007).

Innovation activities include all development, financial and commercial activities carried out by a company that results in innovation for it (OECD, 2018). Sustainable manufacturing or eco-innovation is at the heart of industrial policies and practices. These concepts have become increasingly popular among policymakers and entrepreneurs through the encouragement of business solutions and entrepreneurial ideas to combat environmental changes (OECD, 2009b).

Many studies have investigated eco-innovation from different points of view, such as life cycle assessment (Ferreira et al., 2017), eco-innovative and non-eco-innovative companies in Spain (Scarpellini et al., 2018), green product development processes, and small and

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medium-sized companies in Brazil (Medeiros et al., 2018), green and non-green innovations (Liu et al., 2019), green innovation with financial activities in multinationals (Rezende et al., 2019), and green technology innovations (Du et al., 2019).

Thus, the objective of this research is to analyze the eco-innovation process in an industry located in the Amazon related to sustainable forest management. The second section deals with the literature review regarding the concepts and recent research on eco-innovation. Section three presents the study methodology and the approach used; section four is dedicated to the characterization of the company; section five deals with the eco-innovation practices observed in the study and the results of the eco-innovation form; section six discusses the results, and finally, the last section presents the conclusion with the final positioning of the study.

2. Eco-innovation

The term eco-innovation came up by Fussler and James (1996) in the book "Driving Eco-innovation: A Breakthrough Discipline for Innovation and Sustainability". Ecological innovations are driven by environmental and economic concerns (Kemp, 2009), in addition to the need for a greater emphasis on knowledge-based competitiveness and its relationship with eco-innovation to understand the nature and scope of green competitiveness and the growing role it plays in the globalized economy (Andersen, 2008). Green innovation isolated from other innovations in companies does not contribute to their financial progress (Przychodzen et al., 2020), but they are well regarded by the capital market and also have an impact on economic growth and resource availability (García-Sánchez et al., 2019), however, the lack of significant data creates doubts for companies and government officials who are willing to change (Barbieri et al., 2016).

The ability of ecological innovations to provide new business opportunities and contribute to a transformation into a sustainable society depends on the interaction of its key dimensions (design, user, product service, and governance) and the engagement of the main stakeholders in the innovation process (Carrillo-Hermosilla et al., 2010). The sustainable innovative organization is a response to institutional pressures by an organization that is capable of innovating efficiently for economic aspects but with social and environmental responsibility (Barbieri et al., 2010). Eco-innovations determine efficiency, productivity, and processes within the organization that are different from those it does not employ (Garcia-Pozo et al., 2018).

Thus, eco-innovation can be understood as the production, assimilation, or exploration of a product, production process, services, management, or business method that is new to the organization (developed or adopted) and where the results, in the entire cycle of generating a reduction in the risks of the environment, pollution and other negative impacts of the resources used (including the use of energy) compared to the relevant alternatives (Kemp & Pearson, 2007). It does not necessarily involve new knowledge or new technologies and may not originate in the environmental domain (OECD, 2011), and has its differences depending on the applications (because it is a large area) and because it interferes in other areas (Wang et al., 2020).

The challenges of eco-innovative companies are not only linked to the introduction of products but also the risks, location, and categories, as well as the benefits of activities and implementations in the technological areas, products and services, companies, and the innovation system (Ociepa-Kubicka & Pachura, 2017). Eco-innovations also make the best possible use of waste of all possible types generated by industries, save energy and help preserve biodiversity (Sarkar, 2013).

Eco-innovation can be developed by companies or non-profit organizations and can be commercialized or not and its nature can be (1) technological, (2) organizational, (3) social, or (4) institutional (Rennings, 1998). From the point of view of Bleischwitz et al. (2009), the types of eco-innovation can be grouped into three main categories: (1) process, (2) product, and (3) innovation systems. Business performance is affected by product and organizational eco-innovations. Organizational eco-innovation significantly influences the effects of process and product eco-innovations and their relationships (Brasil et al., 2016).

Frondel, Horbach, and Rennings (2004) distinguish two different types of environmental innovations: the first, called cleaner production, and the second, called end-of-pipe technologies. Eco-innovations can be categorized by how companies introduce environmental innovations into strategic eco-innovators, strategic eco-adapters, and passive and non-eco-innovators (Kemp & Pearson, 2007).

Many studies have investigated eco-innovation related to the role of intermediaries in the performance of a small and medium-sized company (SME) for corporate sustainability with a focus on eco-innovation (Klewitz, 2012), green jobs (Cecere & Mazzanti, 2017), green investments (Inderst et al., 2012), eco-patents (Oltra et al., 2010), the main eco-innovation influencers for small and medium-sized Brazilian companies (Pacheco et al., 2018), the advance in the search for savings sustainable initiatives focused on the circular economy (Cainelli, et al., 2019), financial performance in multinationals (Rezende et al., 2019) and proactive environmental management at the company level for the production of sustainable technology by regulatory project standards (Potrich et al., 2019).

Other studies have investigated the knowledge drivers of eco-innovation firms by maintaining the diverse nature of their target (Marzucchi & Montresor, 2017), developed an analytical framework (Xavier et al, 2017) to explore the diversity of eco-innovation models, and presented suggestions according to the various classification criteria (research area, model approach, model characterization, application sectors, generalization level, among others), build a theory of eco-innovation in agri-business circular (Shih et al., 2018) or work on the concept of environmental rebound effects (Vivanco et al., 2015).

Garcia-Granero, Piedra-Munoz, and Galdeano-Gomez (2018) provided a literature review on performance

indicators in eco-innovations. The study identified 30 performance indicators most cited by researchers and classified them into four different types of green innovation (product, process, organizational, and marketing). Buttol et al. (2012) presented an example of a platform of how tools can support SMEs on the path of eco-innovation by disseminating a structural approach to all stages of the process (awareness and training; analysis; product (re) design; communication/certification) and by providing a user-friendly service system to reduce the main barriers to product innovation.

In the same sense, Andersen (2008) presented a taxonomy involving five main types of eco-innovations that are defined by the role that these innovations play in the market and not their environmental effects. Cheng and Shiu (2012) used an instrument to measure the implementation of eco-innovation in general, as well as, eco-organization, eco-process, and implementation of ecological product innovation. Szopik-Depczyńska et al. (2017) carried out a comparative analysis of the disparities between European Union member states related to the uniformity of changes observed in the field of sustainable development. They used a relatively dynamic taxonomy to observe the spatial diversity of sustainable development among EU members.

García-Granero, Piedra-Muñoz, and Galdeano-Gómez (2020) Contributed to the research stream by providing a new measurement of multidimensional eco-innovation covering all types of companies. It offers a holistic view of what types of eco-innovation offer the greatest opportunities to meet environmental requirements. López-Arceiz et al. (2020) analyzed the influence of cultural and legal contextual characteristics on the design and internal functioning of sustainability performance indicators.

Studies indicate the relationship between social and eco-innovation. Social innovation is a systematic form of innovation for sustainable development, moving innovation activities away from a weak or pale greening of business activities towards innovation activities in which environmental protection and social value are internalized rather than externalized. (Diepenmaat et al., 2020). In social innovation, a key role is played by people and the community (Ceschin & Gaziulusoy, 2016).

Therefore, it is necessary to consider sustainability as a guiding principle for spatial development, ensuring the use of public facilities, temporarily ignoring some regulations, and benefiting underprivileged populations and under-served areas (Jhagroe & Loorbach, 2015). In this sense, the concept of collective system building is introduced; this concept describes processes and activities in which the networks of actors can be strategically involved to collectively build an environment favorable to their innovative sustainability technology (Planko et al., 2016).

Thus, companies can develop their community to improve their shared values. The health, safety, and employment of company workers are benefits that return to the community, which can be more involved and open to the generation of new ideas, according to the stakeholders and shared value creation theories (Segarra-Oña et al., 2017). An organization can influence a society and its socio-environmental behavior, publicizing its social and environmental actions, in addition to contributing to the formation of Environmental Awareness in the community (Severo et al., 2017).

3. Research method

The present study is characterized as qualitative research. Qualitative research makes it possible to address broad issues of science, as opposed to methods centered on an accurate analysis of specific issues (Beer, 1988), seeking to understand the processes by which actions and events occur (Maxwell, 1998). In the organizational field, the use of qualitative methods offers a great opportunity to increase our knowledge of organizational behavior (Rialp, 1998).

The purpose of this research was to conduct an exploratory case study (McCutcheon & Meredith, 1993) in which the conclusions obtained from the analysis of the data will be based on empirical evidence. The choice of a single case is justified by the need for greater depth in the research framework (Voss et al., 2002).

The case study is a methodological procedure in which it examines a phenomenon as a whole, using multiple data collection methods to collect information from one or a few entities, such as people, groups, or organizations. It examines contemporary events where the behavior of the research subjects cannot be manipulated, having a generalized character to the theoretical prepositions. It can also be used to analyze processes of longitudinal change, thus, it aims to expand and generalize theories and not populations and universes (Benbasat et al., 1987; Eisenhardt, 1989; Yin, 1994).

The research framework used in the study aimed to assess the current state of the company about the topic, for which it is structured in three dimensions: (1) input of eco-innovations, (2) technical tasks, and (3) output of eco-innovations. The input of eco-innovations dimension sought to determine the essential elements for the development of an environment conducive to innovations; sectioned into four variables: (1) specialist for environmental issues; (2) training and development programs; (3) capacity for eco-innovations; and (4) R&D for environmental issues.

The dimension of the technical task focused on key aspects of actions and/or activities essential to the execution of innovative activities in five variables: (1) production technology; (2) technical actions; (3) standardization and environmental management systems; (4) technologies used; and (5) new products or processes design. Finally, the output of the eco-innovations dimension presents the results of the innovations implemented by the organization into three variables: (1) introduction of innovations in products (goods or services) and processes; (2) organizational and marketing innovations; and (3) results and benefits of introducing innovations in products and processes.

In total 12 variables unfold in 19 questions. Therefore, the eco-innovation form considered the standard process flow (input, transformation, and output) aimed at a better

visualization and evaluation of the activities related to these activities within the company.

The form applied at the company to support the assessment of eco-innovation practices was adapted and updated by Coelho (2015), which was based on the work of Arundel & Kemp (2009), used in the eco-innovation module applied in the Community Innovation Survey (CIS) of European Union; in the questions presented in Horbach & Rennings (2007) and Götzfried (2006); and in the form used by ABDI (2019). Table 1 shows the details of the form by dimensions, variables, number of questions, and authors.

Table 1: Dimensions, variables, questions and authors used in the eco-innovation form.

Dimension	Variable	Authors
Input of eco-innovations	Experts for environmental issues	Adapted from Arundel and Kemp (2009)
	Training and development programs	
	Capacity for eco-innovations	
	R&D for environmental issues	Adapted from Horbach and Rennings (2007)
Technical Tasks	Production technology	Adapted from Horbach and Rennings (2007)
	Technical actions	
	Standardization and environmental management systems	
	Technologies used	Adapted from ABDI (2019)
	New product or process designs	Adapted from ABDI (2019)
Output of eco-innovations	Introduction of innovations in products (goods or services) and processes	Adapted from Arundel and Kemp (2009)
	Organizational and marketing innovations	Adapted from Horbach and Rennings (2007)
	Results and benefits of introducing innovations in products and processes	Adapted from Arundel and Kemp (2009) and Gotzfried (2006)

Source: Adapted and updated by Coelho (2015) and based on Arundel and Kemp (2009); Horbach and Rennings (2007); Gotzfried (2006); ABDI (2019).

The universe was delimited by the criterion of accessibility to the industry located in the Amazon/Brazil. The sample surveyed was of an intentional non-probabilistic character (Marconi & Lakatos, 2002).

The research techniques used were (Marconi & Lakatos, 2002): (1) indirect documentation (documentary and bibliographic research); (2) intensive direct observation (individual semi-open interviews); and (3) extensive direct observation (application of form).

The study was carried out in four moments: (1) semi-open individual interviews (Vergara, 2009) took place with the manager and employees of the company's operations management department based on a script to understand the company's history, the production process, and the hand of employed work; then, (2) the eco-innovation form was applied to the operations management department with the manager and employees; (3) an analysis of the company's indirect documents (company website and documents provided) was carried out to complement the information; and (4) qualitative data were analyzed and tabulated. Communication with company officials took place to adjust the information understanding during data analysis.

The quantitative data obtained from the answers to the script and the documentary analysis were tabulated in a summary table, grouped according to the content, and stratified according to the structure of the form to assess eco-innovation practices. For qualitative data, dis-course analysis (Bardin, 1977) was used based on the following steps: (1) pre-analysis (systematization and establishment of interpretation indicators), (2) data exploration (coding, classification, and categorization), and (3) treatment of results, inference, and interpretation. A summary of the methodological procedures used is presented in Table 2.

Table 2: Summary of the methodological procedures.

Stage	Method	Comments
Approach to the problem	Qualitative	Interpretation of the opinion of the interviewees Use of indirect company documentation
Type of research	Exploratory case study	Logging company located in the Amazon/Brazil
Procedure	Indirect documentation Intensive direct observation Extensive direct observation	Reports, internal reports, and website
Data gathering	In-depth case study Open structured interview = 25 hours of interview Form application = 14 days	Operations management department Interviews with company managers, and employees Application form with company managers and employees
Analysis of data	Analysis of content	Description, understanding, and explanation of research framework (evaluation of eco-innovation practices from the following steps: (1) pre-analysis, (2) data exploration, and (3) treatment of results, inference, and interpretation.

Source: Author.

4. Company

The company studied is located in the Amazon/Brazil, being considered a medium-sized logging company with approximately 260 employees divided into five areas: (1) patio, (2) sawmill, (3) operations, (4) office, and (5) maintenance. More than 85% of the company's sales are in the foreign market, with the main customers in the Netherlands, the United States, and China. Its main products are sawn wood, veneers, and semi-finished and finished products. The company is considered a national and international reference in the process of sustainable forest management.

The responsible wood production cycle begins when the entrepreneur or community decides to explore a

native forest, elaborating the management plan that must be approved by the local environmental agencies, considering three principles: (1) ecologically correct, (2) socially fair, and (3) economically viable.

The two main activities involve (1) sustainable forest management based on planning, execution, and monitoring and (2) wood processing that occurs in the sawmill. For the proper functioning of the two activities, operational planning is necessary (mainly due to the seasonality of the wood cutting period), identification of market demands, inventories (planned based on seasonality), and production (processing).

The company's monthly production is 10 000 m^3 of processed logs or approximately 2500 m^3 of sawn wood. In general, the production process consists of eight stages: (1) sawmill, (2) sharpening, (3) maintenance, (4) drying, (5) immunization, (6) "plainagem", (7) packaging, and (8) expedition. The sharpening and maintenance steps are considered supportive.

The sawmill involves cutting wood to the dimensions requested by the customer; drying is the process of drying the wood outdoors or in a greenhouse; immunization aimed at protecting wood from chemical, physical and biological agents; packaging aims at forming packages according to the dimensions requested by customers; and the expedition dealing with the shipment of the product.

5. Results

5.1. Eco-innovation practices

The company's main innovation concerns the improvement in the sustainable forest management process (eco-innovation 1). Forest management is the administration of the forest to obtain economic, social, and environmental benefits while respecting the mechanisms for sustaining the ecosystem. The enterprise comprises an area of 506 thousand hectares, 227 thousand hectares of which are dedicated to forest management, in addition to 33% of these hectares to be preserved.

Sustainable forest management works with the concept of reduced impact exploitation, that is, the planned extraction of only a few trees from an ecosystem. In the case of the company studied, the forest was divided into 35 parts and each of them will be explored for a year.

The exploration of the first area occurs during the drought period (May to September) and at that moment, paths are created in the forest to access the area, in addition to the identification of trees that can be removed according to the criteria defined in the management plan. Thus, the trees are removed, preserving the youngest trees and enabling the regeneration of this ecosystem (imitating the natural dynamics of the environment without human intervention). At the end of one year, the exploration of this area is interrupted with a view to its regeneration, and the following year the second area will be explored. This system takes place year after year and at the end of 35 years, the forest will be explored sustainably in all its extension.

The certified forest management process can be understood as follows: (1) before the forest harvest, the planning and inventory and prospecting stages take place; (2) during the forest harvest the stages of cutting, pre-dragging, drag-ging, bucketing, and transportation (chain of custody) take place; and finally (3) after the forest harvest, impacts are monitored, measurements of protected plots, forest protection, and infrastructure maintenance.

During the planning, the preparation of the area (macro zoning) takes place with the use of GPS to locate the trees (eco-innovation 2) by the teams within the forest. Then, there is the forest inventory (eco-innovation 3) by surveying each tree of commercial and preservation interest. Trees are counted from 40 cm in diameter resulting in a harvest map with all trees from 50 cm in diameter.

During the forest harvest, a low-impact exploration model (eco-innovation 4) is used, in this model a team cuts an average of 30 trees per day using the directional cutting technique; then the pre-drag takes place through a winch of the logs using a track skidder. Each piece of equipment squeaks approximately 60 logs a day. Continuing, you have to drag the logs only on planned trails. At that moment, a skidder is used which drags approximately 120 logs a day.

After the drag, the logs are transferred with a control system followed by transport in trucks. Each truck trip takes approximately 40 m^3 of wood.

All these steps are called the chain of custody (eco-innovation 5), wherefrom the inventoried tree a code is generated that accompanies each log from the stages before the harvest, through the stages during the harvest and the processing or process of industrialization of wood so that on the invoice this code will serve as a source for tracking by the company and customers (eco-innovation 6).

Finally, after the harvest, monitoring of the impact and recovery of the managed forest takes place, this monitoring takes place annually and results in the assessment of the physical, biotic and anthropic aspects. The managed forest grows on average 4 m^3 per hectare per year, while the natural forest grows on average 1 m^3 per hectare per year. The regeneration of the forest as a result of forest management absorbs carbon and helps to reduce pollution.

Another eco-innovative practice of the company deals with the social innovation process. The company conducts a socio-economic survey of local communities (eco-innovation 7) inserted in its forest management area, collecting information on health, education, housing, and occupation, among others. This information results in projects with local communities involving training, environmental education, support for events, planting, and fairs, in addition to the search for new sources of income in the assisted communities.

Among the projects developed with the community is the development of sustainable environmental monitors (eco-innovation 8), i.e., members of the communities themselves are responsible for preserving the environment, respecting the cut-off periods, receiving financial assistance, and inspecting the management against predatory hunting and fishing, land conflicts, illegal logging, and garbage dumping. A project was also developed to train beekeepers in communities (eco-innovation 9).

Regarding improvements in the production process, the main problem that existed in the company was related to the raw material, because as the company works with the natural forest, there are difficulties in finding good quality wood (average use of 30% of the wood). The company solved this problem by decreasing its tolerance for defects in wood from harvesting during forest management. In this way, there was an improvement in the yield of the raw material, changing to an average use of 70% of the wood.

There is still a need to seek alternatives to improve the yield of production processes. The company acquired wood production and drying equipment (eco-innovation 10) resulting in a change in the production layout and changes in the production flow.

About the product development process, the company can adapt to the various dimensions of the products demanded by customers. Within this process, the company highlights the partnerships with universities and local and national research centres (eco-innovation 11) aiming at perfecting the production process and improving the development of products to meet the requirements of national legislation and, mainly, of international customers.

The wood residues generated during the processing at the sawmill are used as raw material to drive the turbines of a thermoelectric plant with an energy capacity of 9MWh that supplies the company itself and the municipality where the company is located (eco-innovation 12).

5.2. Results of Eco-innovation form

The input of the eco-innovations dimension deals with the necessary inputs for the development of technological innovations. The company studied does not have people employed for innovative activities daily, however, it does have forest engineers to monitor all stages of the forest management process and other professionals, such as engineers, to identify possible improvements in other production processes.

The company conducts training and development of employees aiming at increasing their skills, that is, both the employees related to the processing and industrialization process and the teams that work within the forest undergo training frequently aiming at updating, such as training on new techniques for cutting trees and using GPS during the inventory. The company does not set aside specific time for implementing eco-innovations and has no budget for R&D, however, forestry engineers and other employees have the autonomy to improve processes.

The cooperation process between the company and local and national research institutions stands out to improve practices and techniques related to forest management, resulting in sustainable internal processes.

In the dimension of the technical task, which deals with the transformation process involving eco-innovative activities related to the “production technology” variable, the company has as the main residue from the production process the leftover lumber that is sent to a thermoelectric plant that uses this wood as raw material for energy production using biomass.

In the case of the variable “technical actions”, there were significant changes in production technologies, in this case, the company’s forest management process is considered a reference in Brazil and worldwide, as it minimizes environmental impacts, generating income for the impacted communities and being economically viable.

Regarding the “standardization and environmental systems” variable, the company has certifications that represent the adoption of consistent environmental management practices. The organization is certified by the Forest Stewardship Council (FSC), Cerflor, and Program for the Endorsement of Forest Certification (PEFC). The highlight of FSC is an international non-profit organization composed of environmental groups, social movements, organizations of indigenous people, and representatives of forestry companies and the wood trade sector. In 1997, the company was the first forest management company in Brazil to be certified by the FSC.

The variable “technologies used” shows that within the company’s internal processes, there is a predominance of the use of technologies aimed at soil and water decontamination (1/3 of the manageable area is preserved). The company uses a low-impact exploration model that results in a forest regeneration process faster than natural growth and reduces air and soil pollution. The warehouses where the sawmill area is located use the concept of ventilation natural due to high humidity in the Amazon region. In the variable “projects for new products and processes”, the company did not mention any ongoing projects.

The output of the eco-innovations dimension concerns the final results, as well as the benefits achieved through eco-innovations. In the variable “introduction of innovations in products and processes”, the main reasons why the studied company introduced innovations in the process were due to the existence of environmental regulations considering that the company adopted the low-impact exploration model, the result of several existing regulations in the Amazon. Additionally, there is a demand for new markets, mainly the Asian market, causing internal improvements in the production process aiming at greater penetration and adaptation to the needs of this new market. This market is characterized as more demanding with the guidelines for the acquisition of wood.

The company has adequate instruments for the identification, mapping, and reduction of its environmental impacts. Since 1997, the company has been certified by the FSC (Forest Stewardship Council) ensuring that sustainable forest planning ensures the protection of local

biodiversity. Thus, forest management from its planning and implementation is regularly monitored as part of this certification process. The company is periodically audited in its environmental management processes.

According to the eco-innovations presented previously and according to the responses to the form, in recent years the company has introduced innovations in processes, where products (wood) go through an inventory process (chain of custody), where this material can be monitored during the production process and after the acquisition by the customers, verifying the origin of the product. In terms of organizational innovations, in the case of social innovations, several social actions were developed with the local communities, as well as with the municipality where the company is located. Regarding delivery, transportation, and distribution innovations, the company adopted the Chain of Custody, enabling customers to verify the origins and guarantee the traceability of products.

The predominance of innovations pointed out by the company in the form is innovations in processes unrelated to the existence or anticipation of environmental policy measures. Especially, forest management and its various developments with the acquisition of new technologies, new systems for collecting raw materials, and transportation are the company's main eco-innovations.

In the "organizational and marketing innovations" variable, support for riverside communities for the adoption of sustainable practices stands out. The company makes various information available on the institutional website informing consumers of the actions taken to reduce environmental impacts, including periodic environmental reports.

In terms of the results mentioned in the introduction of new products and processes, the studied company mentioned as criteria with greater relevance for the objectives of the products and processes: (1) the entry into new markets or increase of the market share; (2) improving the quality of goods and services; (3) reduction of materials and energy per unit of output; (4) reduction in regulatory requirements; (5) satisfaction of regulatory requirements; and (6) increase in added value. All received grade 4, on an importance scale from 1 to 4, showing the importance of the objectives of products and processes indicated by the company. Figure 1 shows the degree of importance of products and processes pointed out by the company.

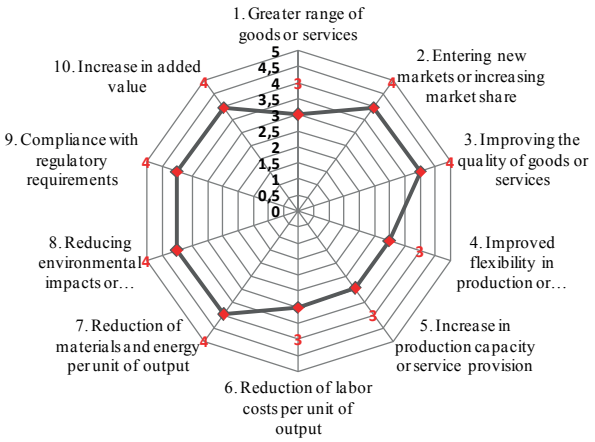

Figure 1: Degree of importance of the objectives of products and/or innovation processes - Company studied. Source: Author.

About the environmental benefits of producing goods or services, they were indicated with "yes": (1) reduction of energy used per unit of output (Waste from the production process is transformed into energy for the company and community, without the need for consuming from the local supplier); (2) reduction of CO_2 emissions by the company (forest management helps in this process); (3) reduction of water and soil pollution (1/3 of the management area is preserved, mainly, close to water sources).

Finally, regarding the environmental benefits after the sales of the goods by the end-user, the company indicated that there were no returns concerning the three criteria of the form.

6. Discussion

The company presented an innovative process in which it uses concepts of sustainable manufacturing and sustainable innovative organization (OECD, 2009b; Barbieri et al., 2010), involving not only economic but also social and environmental issues, generating a reduction of environmental impacts and risks (Kemp & Pearson, 2007; Kemp, 2009).

About the eco-innovation practices adopted, the results indicate that the organization implemented its innovation process through the processing and industrialization of wood from forest management in a low-impact exploration model.

The eco-innovation practices presented in this research move towards the search for green competitiveness (Andersen, 2008), through the engagement of the main stakeholders and influencers in the eco-innovative process (Carrillo-Hermosilla et al., 2010; Pacheco et al., 2018) and preservation of biodiversity (Sarkar, 2013).

In this sense, the following stand out in terms of eco-innovations: (1) forest management; (2) use of GPS to locate trees; (3) forest inventory; (4) low-impact exploration model, (5) chain of custody; (6) wood tracking by the company and customers; (7) socioeconomic survey of local communities; (8) development of sustainable environmental monitors; (9) training bee-keepers in communities; (10) wood production and drying equipment; (11) partnerships with local and national universities and research centres; and (12) wood waste as a raw material for the production of electricity.

It is observed that the process of adopting eco-innovation practices is a result of the characteristics of the business model adopted by the company, as well as, the location that requires a series of compliments to Brazilian and Amazonas legislation. Thus, we have eco-innovation practices induced by legislation and locality.

There were also social eco-innovations through several actions mentioned above (socioeconomic survey,

training, environmental education, etc.). In this case, there is a strong relationship in the Amazon between eco-innovations and social aspects, due to the economic fragility of communities, often isolated, characterizing innovation in this region as a "situated Amazon eco-innovation". The relationship between the social and the research eco-innovations rein-force the results of Diepenmaat et al. (2020), Ceschin & Gaziulusoy (2016), and Jhagroe & Loorbach (2015), in particular, the socio-environmental actions that seek to build a favorable environment are similar to Planko et al. (2016) and Segarra-Oña et al. (2017) influencing society in its surroundings and changing the behavior of local populations (Severo et al., 2017).

Table 3 summarizes the main eco-innovations identified in the study, and their classification according to the type and novelty of the innovation implemented, considering Rennings (1998) and Bleischwitz et al. (2009).

Table 3: Innovations, type of innovation and the novelty of implemented innovation - Company studied.

Innovation	Type of innovation	Innovation novelty
Forest management	Process	New to the market
Using GPS to locate trees	Process	New to the company
Forest Inventory	Process	New to the market
Low impact model	Process	New to the company
Chain of custody	Process	New to the company
Company and customer tracking	Social	New to the company
Socio-economic survey of communities	Social	New to the company
Sustainable environmental monitors	Social	New to the company
Training beekeepers in communities	Social	New to the company
Wood production and drying equipment	Process	New to the company
Partnerships with local and national universities and research centers	Organizational	New to the company
Wood waste management	Process	New to the company

Source: Author.

In the technical task dimension, production technologies, technical actions, and new processes stand out. Regarding the technologies used, the company needs to implement sustainable initiatives in the company's infrastructure. Finally, in the output of eco-innovations dimension, the company has environmentally innovative final products, with solidified processes over the years regarding sustainability, which allowed the development of social actions with local communities and which result in benefits, such as new products in new markets, improvement of the quality of the final product, reduction of environmental impacts, the satisfaction of regulatory requirements and reduction of CO_2 emissions in the environment (Ceschin & Gaziulusoy, 2016; Planko et al., 2016; Segarra-Oña et al., 2017; Severo et al., 2017).

The environmental innovations developed at the company are characterized as cleaner production according to Frondel et al. (2004) and a strategic eco-innovative company (Kemp & Pearson, 2007) due to becoming a national and international reference in its area of operation. This study is similar to the work of Medeiros et al. (2018), Liu et al. (2019), Du et al. (2019), and Ma et al. (2018) on the presentation of green innovations influencing efficiency, productivity, and internal processes (Garcia-Pozo et al., 2018) and interfering in other areas (Wang et al., 2020).

The methodology used made it possible to understand the eco-innovation practices carried out in the studied company through the eco-innovation form, structured interviews, and indirect documentation. The approach used in the study moves towards a deep level of detail, which is not often observed in most studies on eco-innovation. Therefore, the methodology comes close to the works developed by Cheng and Shiu (2012).

7. Conclusion

This research aimed to carry out an analysis of the eco-innovation process in an industry located in the Amazon concerning sustainable forest management. The research framework made it possible to understand the eco-innovation practices carried out in the company through the eco-innovation form, structured interviews, and indirect documentation. The contributions of this research are relevant to the academic and professional environment.

The theoretical contribution of the research is in the expansion of the limited body of knowledge related to eco-innovation practices in Amazon. Considering the Amazon as the largest tropical forest in the world, few studies have been developed over the years emphasizing the sustainable innovations that are developed in this region. This research contributes to the body of knowledge about eco-innovation considering the context of presenting the innovative activities developed in an organization considered a national and international reference in forest management. The paper's greatest contribution is an instrument for evaluating eco-innovation practices based on previous studies (Arundel & Kemp, 2009; Horbach & Rennings, 2007; Götzfried, 2006; ABDI, 2019) which makes it possible to offer insights on the adoption of innovations within the productive process.

Among the managerial implications, the proposed methodology can help organizations to better understand the eco-innovation process internally, present the current state of the company and serve as a basis for planning future projects for green improvements. The study can contribute to improving the involvement and participation of all employees.

Findings reveal that eco-innovation in the organization's internal processes receives significant influence from external factors, mainly from environmental legislation in the region. The social eco-innovations observed in the study are also the result of external pressures related to legislation, as well as the local government that influences the adoption of social responsibility actions as a way to reduce environmental impacts. The greatest contribution of the paper, from the point of view of managerial implications, is to observe that business

models to become successful in Amazon need to adequately connect aspects related to the development of innovations that (1) reduce environmental impacts, (2) meet the legislation of the region and (3) develop income alternatives for the populations that result in significant social impacts.

In conclusion, the company studied can be considered a strategic eco-innovator by using techniques for forest management that promote the maintenance of local biodiversity, in addition to enabling the creation of income for the affected communities resulting in social and environmental inclusion of these communities.

The limitations of the research are associated with limited sample size, although the study was carried out in the form of an in-depth case, which enabled a greater level of deepening of the reality of the organization; however, it does not allow the realization of longitudinal analysis. For future research, it is recommended to conduct similar research on other companies that develop eco-innovations in the Amazon, expanding the literature on the subject.

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