Innovation ecosystems and measures aimed at environmental sustainability: Cidade Pedra Branca case study

Os ecossistemas de inovação e suas ações de sustentabilidade ambiental: estudo de caso Cidade Pedra Branca

Los ecosistemas de innovación y sus acciones de sostenibilidad ambiental: estudio de caso Cidade Pedra Branca

Les écosystèmes de l'innovation et actions de durabilité environnementale: une étude de cas Cidade Pedra Branca

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Abstract: The proposal described herein is aimed at technological innovation, with a focus on product sustainability. The object of this study was six companies from the innovation ecosystem Cidade Pedra Branca, which sought to identify socio-environmental actions that also have the goal of generating significant results in economic terms. We concluded that, in general, the companies in Cidade Pedra Branca are committed to achieving social, environmental, and economic sustainability.

Keywords: technological innovation; sustainability; innovation ecosystems.

Resumo: Na presente proposta, o interesse se volta para a inovação tecnológica buscando a sustentabilidade nos produtos. O objeto de estudo foi 6 empresas do ecossistema de inovação "Cidade Pedra Branca", buscando identificar as ações socioambientais adotadas com vistas também a gerar resultados importantes na direção do quesito econômico. Concluiu-se que em geral as empresas da "Cidade Pedra Branca" têm uma preocupação importante em produzir com sustentabilidade, social, ambiental e econômica.

Palavras-chave: inovação tecnológica, sustentabilidade, ecossistemas de inovação

Resumen: En la presente propuesta, el interés se vuelve hacia la innovación tecnológica buscando la sustentabilidad en los productos. El objeto de estudio fue 6 empresas del ecosistema de innovación "Cidade Pedra Branca", buscando identificar las acciones socioambientales adoptadas con vistas también a generar resultados importantes en la dirección del aspecto económico. Se concluyó que en general las empresas de la "Cidade Pedra Branca" tienen una preocupación importante en producir con sustentabilidad, social, ambiental y económica.

Palabras clave: innovación tecnológica, sustentabilidade, ecosistema de innovación

Résumé: Dans la présente proposition, l'intérêt se tourne vers l'innovation technologique recherchant la durabilité dans les produits. L'objet d'étude était 6 entreprises de l'écosystème de l'innovation "Cidade Pedra Branca", cherchant à identifier les actions socio-environnementales adoptées dans le but de générer des résultats importants dans le sens de la question économique. Il a été conclu que, en général, les entreprises de "Cidade Pedra Branca" ont une préoccupation importante dans la production durable, sociale, environnementale et économique.

Mots-clés: innovation technologique, durabilité, écosystèmes d'innovation

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1 INTRODUCTION

In an ecosystem, the agents – government, universities, companies, and society – need to articulate to devise sustainable technological innovations, not restricted only to economic issues, but also regarding concrete action towards socio-environmental sustainability. It is worth mentioning that it is necessary to change the way we think about and act upon socio-environmental issues, seeing them much more as a source of opportunities than of costs, enabling the articulation of economic sustainability with socio-environmental sustainability.

The authors Elkington (1997), Kajikawa (2008), Schoolman *et al*. (2012) and Hansmann, Mieg and Frischknecht (2012) postulated that sustainability is an integrative concept which considers environmental, social, and economic aspects as three fundamental dimensions. These three dimensions have been denoted as pillars of sustainability, which reflect that responsible development requires consideration of natural, human, and economic capital or, in colloquial terms, the planet, people, and profits. Brown, Dillard and Marshall (2006) commented that such a balance is possible when the organization considers the integration between the three sustainability pillars (3Ps), which they describe as: people, or the human capital in an organization or society; the planet, related to the natural capital of an organization or society; and profit, concerning the positive economic outcomes of an organization. The most important aspect in the approach of the three features of managerial sustainability – economic, social, and environmental – is the dynamic balance between them.

The concepts of sustainability, according to Duic, Urbaniec and Huisingh (2015),are gradually permeating most science and engineering disciplines. Science and engineering together create technologies in the modern world, while the sustainability imperatives provide challenges and opportunities. They can be considered as steering the development of useful policies, education, products, technologies, management procedures and ethical principles that protect human health and wellbeing, the environment and future generations.

In this proposal, our interest is to turn to technological innovation when producing. According to the Oslo Manual (OECD, 2005), technological innovation encompasses the introduction of technologically new products and procedures, as well as significant improvements in the existing ones. Technological innovations comprise new or significantly modified technological products and processes, where technological novelty emerges, unlike improvements, from their performance characteristics (DIACONU, 2011). Technological innovation is not a static process, as in a game with a result known in advance. On the contrary, it is a dynamic process, replete with uncertainty and often involving controversies. However, it is now seen as a paramount element in differentiation strategies, competitiveness, and the rise in the number of enterprises.

Etzkowitz (2009) emphasizes that innovation is spreading as the interactions between government, industry, and universities – known as the triple helix – also include technology incubators, technology parks, and venture capital firms. To Kimatu (2016), the innovative and sustainable economic development of a country depends not only on the presence of a strong government, universities and industries but even more so on how they mutually interact to achieve strategic objectives. The development and growth of the service sector, the Internet and globalization have created the need for informed watchdogs for the sustainable interactions in the triple helix. Studies have revealed that the evolution of the interactions of the innovation models has increasingly raised the need for a strong civil society in the triple helix. This development has

now transformed the triple helix into the quadruple helix. Carayannis, Barth and Campbell (2012) enhanced the triple helix, within the scope of innovation ecosystems, and society is sought as a fourth agent, forming the quadruple helix.

There has been an intensification in research on the so called "green industries", aimed at reducing emissions, the consumption of raw materials and the damage to the environment, contributing to a sustainable and economically viable future (ANITYASARI; RACHMAT, 2015; CHEN *et al*., 2017; ZHANG *et al*., 2017)

As stated by Baas and Hjelm (2015), in order to reinforce sustainable development, agent actions and established social roles need to be challenged by important changes in society. In this way, sustainable transition research emphasizes co-evolutive approaches involving a multitude of agents, including the entrepreneurial segment, the government, academics and, lastly, society.

To Santana *et al*. (2015), technological innovation is one of the major driving forces in fostering economic growth. However, in the current economic situation, where matters related to environmental protection and conservation play a key role, technological innovation can also be used as a driver of new production alternatives to reduce the harmful impacts of industrial development on society and nature.

Some authors have shown that environmental sustainability in the process of innovation in ecosystems involves: minimizing energy and material resources; product life-cycle optimization; facilitating product reuse; reducing carbon emissions derived from extractive activities, energy production and infrastructure projects (WEBER; CABRAS, 2017); water reuse (UPADHYAYA; MOORE, 2012) and ecosystem management (VOSS *et al*., 2014). In addition, we can consider the use of renewable energy sources, cleaner production processes, and improved quality of life-oriented actions.

Grandia (2016) highlights the importance of organizations promoting an increase in learning about environment and sustainability, in order to promote changes in behavior. The following are examples of socio-environmental sustainability actions: solid waste, effluent and gas control/ reduction/treatment; supply contracts having clauses concerning social and environmental issues; suppliers also have to fully comply with work legislation; the purchasing of environment-friendly raw materials; rational use of raw materials; reuse of used materials; practices that respect workers' rights and duties; work safety and occupational health; promotion of programs which develop community/society; worker training; and participatory management practices.

According to Constantini *et al*. (2016), the introduction of ecological technologies is the most profitable way to reduce environmental pressure without compromising economic competitiveness. Political and corporative governance strategies must be aimed at maximizing environmental profit that can be obtained through the development and adoption of clean technologies in processes.

In this context, Severo, Guimarães and Dorionb (2017) conducted a survey in 762 Brazilian companies of different sizes in the metalworking segment. The study showed that both Cleaner Production and Environmental Management positively impacted the achievement of Sustainable Product Innovation. The surveyed companies that developed financially sustainable product innovation showed better performance in comparison to those that did not.

Kılkış (2016) evaluated innovation systems oriented toward sustainability in a sample of emerging economies based on innovation, including Brazil, Russia, China, India, South Africa, Turkey and Singapore. A sustainable innovation index was developed to aggregate value, in which

Singapore had the highest score, and Brazil, Russia, India, China, and South Africa reached the average score. The results reflect the capacity of these countries to align priorities and performance towards obtaining more fully-fledged innovation systems for sustainable development.

Govindarajan and Trimble (2010) emphasize that companies were not created to innovate, but to be efficient. However, innovation has been a constant in today's organization agendas, since the recurring social and economic transformations require a process of change in companies, thus enhancing their competitive advantage, distinguishing them from their competitors.

The word innovation has its origin in the works of economist Joseph Schumpeter. According to this author, to innovate is to produce other things, or the same things in a different way, combine different materials and forces, and, finally, make different combinations. Schumpeter (1934) presents five ways to innovate: new product development; the introduction of a new production method; a new market opening; discovery or achievement of a new source of raw material or semi-finished products; and the creation of a new industry or monopoly. In summary, all of the five ways seek the making of something new.

Hallstedt, Thompson and Lindahl (2013), from a survey conducted in six companies of the same group, identified that the incorporation of key elements in product innovation processes can be divided into four categories: organization; internal processes; attributions; and tools that stimulate the company to adopt a strategic sustainability perspective, which will sustain the business success in the long term.

The main objective of this study was to investigate the actions taken by innovation ecosystems to achieve socio-environmental sustainability, and to consider the economical results achieved by these actions. In order to operationalize the research, we conducted a pilot study in *Cidade Pedra Branca*, in the state of Santa Catarina, Brazil, which moves towards the concept of the quadruple helix. *Cidade Pedra Branca* is considered an innovation ecosystem, since it is linked to the fact that the State of Santa Catarina has as its mission, at this moment, to manage the implantation and consolidation of 13 innovation centers, including a center in the Region of *Grande Florianópolis*, where the *Cidade Pedra Branca* is located. It houses a university, incubators, a business association and several other companies with different activities.

Cidade Pedra Branca was conceived taking into consideration the concept of sustainability, seeking the possible balance between the well-being of the people, the protection of the environment and the promotion of the economic development of the region through the generation of jobs and the installation of new companies. The idea was not just to build a real estate project, but a community where people could live, work, study and have fun in harmony with nature within reach of a walk. On the road and building construction, the materials employed were purchased from local suppliers, which favored the structure endurance and the sparing of resources for maintenance. Moreover, in 2005, when the city was planned, there was a concern for ensuring environmental, social, and economic sustainability, with the use of ceramic materials in the buildings, in order to save on maintenance over the years; as well as a study on the wind behavior and natural lighting, to minimize the use of electricity.

2 METHODOLOGY

The *Cidade Pedra Branca houses* approximately 900 companies of different activities. To compose the sample of this study, we chose 6 companies, which are of the branches of education,

photocopies, fuel sales, food production (restaurant), a supermarket and a construction company, which created a portfolio of productive activities and services with different characteristics.In order to conduct the study and to record the best socio-environmental sustainability actions employed by the six companies involved in the *Cidade Pedra Branca* innovation ecosystem – as well as the economic outcome – we used structured interviews and documentary analysis. During the interviews with the entrepreneurs we sought to learn which socio-environmental sustainability-oriented actions were taken toward innovation. In the documentary analysis we highlighted the economic outcomes from those actions.

The interview tool was based on three important documents for the area of corporate sustainability, with a cut in the environmental and economic dimensions, seeking to account for the characteristics of the sample companies: Ethos Indicators; Global Report Initiative (GRI); and the NBR ISO 14001 (ASSOCIAÇÃO BRASILEIRA DE NORMAS TÉCNICAS [ABNT], 2005), all divided into dimensions and indicators, according to Frame 1. There is an explanation for each indicator, which facilitated the interviewee's understanding. Moreover, this study was aimed at measuring the economic outcome generated by the socio-environmental actions taken, using the Likert scale/score: 1 for poor; 2 for regular; 3 for satisfactory; 4 for good; and 5 for great economic impact. The sample used was six companies in different business segments.

Frame 1- Dimensions and indicators that comprise the interview tool (own frame).

Dimensions	Indicators
Sustainable Use	Raw materials; Water; Power.
Atmospheric Emissions	Direct and indirect gas emissions, which contribute to the greenhouse effect; Issue of chemical waste discharged directly to the soil.
Pollution Prevention	Concern with noise and visual pollution legislation; attention to the limits for odor emission; Investment and development of cleaner technologies.
Environmental Awareness	Worker training regarding environmental education; Campaigns to promote reduction in consumption, such as power, water, and others, and a selective waste collection program; acknowledgement of environmental education actions (3Rs/4Rs).
Distribution and Transportation Actions	Availability of worker transportation; Concern with the regulations by their logistics and transportation partners.
Reverse Logistics	The use of reverse logistics; Partnerships to deal with waste disposal (cooperative waste collectors, NGOs, and other companies).
Reuse	Production leftover reuse in making new products; recycling or disposal of defective products.
Products	The manufacture of recyclable products; Biodegradable final products.
Biodiversity and Natural Habitat Restoration	Corporate office or branch situated in an area with high biodiversity; The company participates in conservation and restoration plans for habitats in critical situation; Audited and certified management system, based in international standards.

Source: Authors' figure.

3 RESULTS AND DISCUSSION

In this section, the results yielded by the application of the interview tool (in all six companies), the analysis of documents and the relevant literature will be presented and discussed.

The first company to be analyzed acts in the area of education, more precisely, it is a university that is inserted in the innovative ecosystem of *Cidade Pedra Branca*, with approximately 7,500 students and 1,300 employees. The data collected led us to conclude that the company takes isolated measures to achieve socio-environmental sustainability, which produce noteworthy economic results (scoring from 4 to 5). Among these measures are: automated temperature monitoring in air conditioners; adequate treatment given to hazardous waste following the specific legislation; investment in devices (photovoltaic panels) for converting sunlight into electricity to power the lighting systems of university buildings; replacement of fluorescent light bulbs with LEDs; recycling of water (the water used by the company comes from a mineral water source in *Pedra Branca*); and training of staff in environmental education. However, it is important to highlight that this company needs to progress towards a policy of integrated environmental management, one that goes beyond the isolated measures. In addition, the company, via official documents retrieved from their website, asserts to contribute to recycling, reclaiming, and use of renewable energies, besides seeking sustainable alternatives for their methods and products.

The green measures taken by the university include the investment of approximately 500,000 Brazilian reais for the implementation of photovoltaic panels in February of 2017 with a power output (peak) of 37.2 kW (4585 kW-h/month), which resulted in a 30% reduction of electricity expenses. Mauleón (2017) noted some aspects of the contribution of photovoltaic energy to the general objective of sustainable development- mainly the reduction of CO_2 emissions to the environment, together with an evaluation of the finances required and the management of the implied risk. A water reclamation system was also installed where water collected is turned into distilled water- since 1,900 liters of tap water are needed to produce 50 liters of distilled water.

The second company, with 43 employees, operates in the food industry, serving 450 meals to students, employees of the companies based in *Cidade Pedra Branca*, and the general community of the neighborhood. Regarding the treatment of effluents, since it is located in a condominium, it has little interference in this process. The odors from the food made inside the restaurant are removed, to the best of their ability, through exhaust hoods. Containers and packages made of glass or cardboard are separated and commercialized along with the used frying oil, which produces a little profit and is also aimed at minimizing the environmental impact. Leftover fruits, vegetables and other food items, which are not reused and are described as the least cost-effective items, are either donated to animal farmers in the region, or posteriorly discarded in landfills. According to the production manager, the fruit and vegetable peel could be reused in alternative recipes, but this is not yet the case. Meat, in turn, is cut in such a way as to avoid waste and maximize profit. The pastry suppliers have certified quality. The fruits and vegetables come from the Santa Catarina Supply Center, they are not organic and an employee certifies the quality when the items arrive at the restaurant. Regarding the equipment, the sink faucets turn on and off automatically, to prevent waste. However, there are no devices employed to save electricity.

The workers have been trained in procedural measures to maximize hygiene and food safety during food handling. When the employees empty the food trays left by consumers, they

separate the residues according to type. With regard to the economic results, the company scored 4, that is, the measures adopted have been producing good financial results, with some room for improvement. Research carried out by Garrone *et al*. (2016) was aimed at combining the objectives of reducing waste and enhancing food security in an integrated way. The first contribution of the cited paper was to adapt the food waste hierarchy for food manufacturing companies, refining it by including more pertinent options. The second contribution was to identify, in a clear manner, the main critical factors that enable food manufacturing companies to set in place an efficient and effective process for managing surplus food and, more particularly, for supplying it to the food assistance sector.

The third company provides print and copy services for students, company employees and the general community from *Cidade Pedra Branca* printing around 300,000 A4 sheets of paper per month. Empty toner cartridges are collected by the supplier and given the appropriate disposal destination. In order to save electrical energy, the copy machines automatically switch to standby mode when not being used. There are investments in machines that save energy.

To minimize the environmental impact, the cutting plotters no longer work with solvents, but water. The loss of paper is expressive, yielding on average thirteen 150-liter sacks of paper per week, due partly to lack of training for workers, who might not be aware of the resulting economic and environmental impacts. The waste paper is collected weekly by a recycling company. Some studies (SCHMIDT *et al*., 2007; MERRILD; DAMGAARD; CHRISTENSEN, 2008, 2009; LAURIJSEN *et al*., 2010) have evaluated that the recycling of paper results in a lower demand for virgin paper, which reduces the demand for land or wood. In this respect, staff turnover also hinders the establishment of a workforce that is committed to the company's actions. The employees have not been trained for at least two years. There was once 5S quality standard courses offered, but today those who received training no longer work at the company. Moreover, the leftover paper and canvas is donated to a street cleaners' association. The mark for economic results was close to 3, that is, urgent measures are necessary to improve this grade.

The fourth company included in the study is in the construction business, and has built some of the buildings in *Cidade Pedra Branca*. This company achieved a mark of 5 for economic results as a consequence of the different measures taken to achieve socio-environmental sustainability.

Regarding water consumption, the buildings constructed by the company currently have a 10% loss, which according to the interviewee, is a small percentage that can be compared to that adopted in Japan. The low number achieved is due to devices installed throughout the buildings and to the implementation of telemetry for leak detection. The effluents are also mapped by telemetry, but they do not receive differentiated treatment, instead they are sent to the municipal treatment plant. The paper, cardboard, and plastic packages produced by the inhabitants of the neighborhood are collected by a specialized company and subjected to appropriate disposal. One of their buildings has received a Leadership in Energy and Environmental Design (LEED) award in the Gold category. LEED is a voluntary system of certification for green buildings. Introduced in 2000, LEED is a nongovernmental certification program developed by the U.S. Green Building Council (USGBC). It is an internationally recognized green building certification, adopted around the world (MONTANYA; KEITH, 2011).

Under the LEED program, projects are scored in five categories: sustainable sites, water efficiency, energy & atmosphere, materials & resources, and indoor environmental quality. The energy performance of buildings is evaluated based on simulated energy use, and the energy

efficiency of green buildings has been the subject of greatest interest to researchers (OWENSBY-CONTE; YEPES, 2012). This program is internationally known for promoting the implementation of high-performance environmental strategies and the energetic efficiency of projects and constructions. Among the reasons why the building mentioned received the certification are: the treatment of effluents, 60 bicycle parking spots, over 300 square meters of green area composed of native plants, and the recycling and reuse of over 95% of residues produced during construction. In addition, the enterprise is one of the participants of the Clinton Climate Initiative. Here, the objective is to invest in actions and technologies aimed at the reduction of carbon emissions related to transportation, energy, water, effluent and waste, besides promoting the saving of resources by the population inhabiting the condominiums.

The fifth company analyzed is in the fuel and combustibles market. Clean, potable water is used in the kitchen and bathroom sinks, while 95% of the cars are washed with harvested rainwater, which allows for notable savings both for the company and its clients. The investment to harvest rainwater was minimal in comparison to the amount that has already been saved in water expenses. Rainwater for domestic use has been studied in South American, as reported by Angrill *et al*. (2011) and Morales-Pinzon *et al*. (2011). These studies indicate some favorable scenarios for the implementation of rainwater as a sustainable alternative to the domestic water supply in urban areas. Savings in the energy consumption were achieved when LED light bulbs were installed. The initial investment was expressive, but today a 20% saving in electricity has been observed. Residues such as burned oil disposed of by car owners when changing the car oil is sold for a low price and the purchasing company disposes of it in an appropriate manner, following Resolution No. 362/2005 (BRASIL, 2005) of *Conselho Nacional do Meio Ambiente* (CONAMA).

The filters, stuffing and plastic wrapping used during oil changes are collected by yet another certified company, specialized in waste removal. In this case, the company needs to pay for the removal of the waste. The batteries that are removed from cars are sent back to the battery supplier. Moreover, trash bins for the disposal of residues are also made available to clients. The soil is inspected periodically by the agency responsible for approving and issuing environmental licenses. The inspection is conducted *in loco*, aimed at identifying possible leaks into the water table. In addition, the gas station has purchased a device which tracks possible leaks on a daily basis. For the car washing, biodegradable products are employed, minimizing the impact on the environment and on their customers' cars. The effluents, especially those produced from washing the cars, are conducted to separators, which function like filters, until the waste is fit to be returned to the environment. The mud which collects in the filtering process is removed by a specialized company. Here, the company's perception is that the socio-environmental sustainability measures employed up to now have yielded sound economic results (score 4).

The sixth interviewed company is also in food services (divided into a supermarket and a restaurant). Consumption of drinkable water is exclusive for the kitchen and bathroom sinks; for cleaning external areas, the company has adopted a system of rainwater harvesting, thus making better use of this resource. Furthermore, the company has a system of waste management, in which all workers have been trained. In relation to food items (fruits and vegetables), the company has a tracking program where consumers may learn the origin of the product via a QR Code. The company also runs a small organic food crop growing area. In addition, the company uses a sustainable freezing gas to conserve their produce, which gives benefits in terms of energy consumption and has a low contribution to global warming.

The food leftovers from the restaurant are donated to a street cleaners' association and that which cannot be donated for consumption is sent to a company specialized in turning food waste into compost. The used frying oil from the restaurant, pastry shop, and bakery are sent to an organization that turns this saturated fat into soap (REOIL). The company also collects batteries and ensures their proper disposal. Another of many sustainable measures the company has adopted is the employment of reusable canvas bags (natural biodegradable canvas). Due to all these measures the company has been awarded an international certificate of reuse of 97% of the residues produced by their branches, where only 3% of the waste is sent to landfill sites. Partner companies carry out the transportation of goods. These partners are required to have all documentation (e. g., sanitary license) up to date, and the company conducts periodic inspections to ensure compliance. The company nutritionists also inspect the suppliers.

All of these measures taken by the company have yielded important economic results, scoring a grade of 5. Even so, the company is constantly seeking new innovative ways to improve.

Frame 2 is presented as a summary to finalize the results and the discussion of the field study, based on the dimensions of frame 1, explaining important information of the companies.

Frame 2- Important environmental actions adopted by the companies analyzed (own frame)

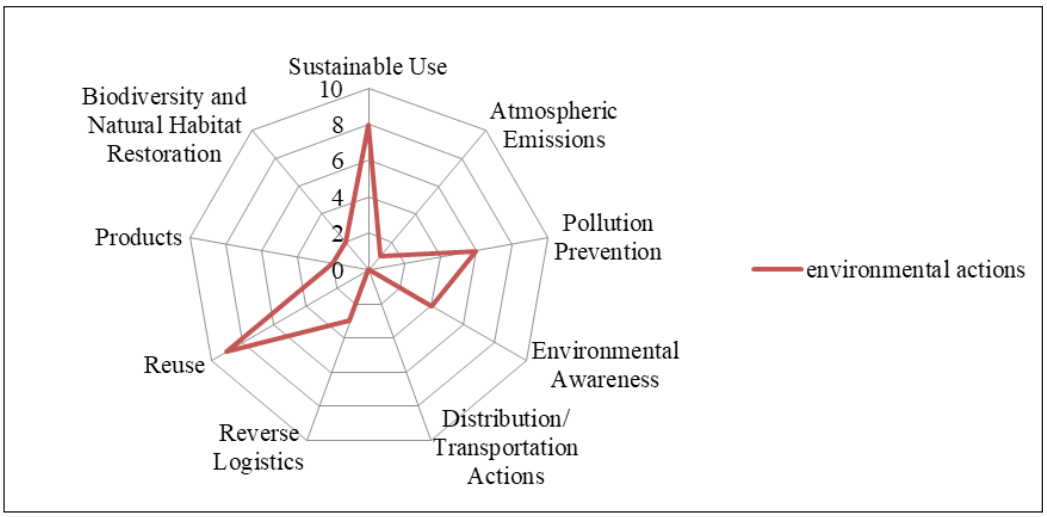
Dimensions	Companies	Important environmental actions
Sustainable Use	.University	. Automated temperature monitoring; . Photovoltaic panels; . Fluorescent light bulbs with LEDs
	. Food industry	. The sink faucets turn on and off automatically to prevent waste.
	. Copy services	. The copy machines automatically switch to standby mode when not being used.
	. Construction business	. Implementation of telemetry for water leak detection; . LEED certificate.
	. Combustibles market	fluorescent light bulbs with LEDs
Atmospheric Emissions	. Construction business	Reduction of carbon emissions
Pollution Prevention	. Copy services	. The cutting plotters no longer work with solvents, and but water
	. Construction business	. Treatment of effluents,
	. Combustibles market	. The soil is inspected periodically; . Biodegradable products are employed.
	. Supermarket	. Sustainable freezing gas; . Reusable canvas bags
Environmental Awareness	. University	. Training of staff in environmental education
	. Food industry	. The workers have been trained in procedural measures to maximize hygiene and food safety.
	. Combustibles market	. Training of the workers in environmental education
	. Supermarket	. Training of the workers in environmental education
Distribution and Transportation Actions	Not applicable	Not applicable

Dimensions	Companies	Important environmental actions
Reverse Logistics	. Copy services	. Empty toner cartridges are collected by the supplier
	. Combustibles market	. The batteries and filters are collected
	. Supermarket	. The batteries and ensures are collected
Reuse	. University	. Recycling of water
	. Food industry	. Containers and packages are separated and commercialized; frying oil reuse; . Leftover fruits, vegetables and other food items, which are not reused and are described as the least cost-effective items;
	. Construction business	. Paper, cardboard and plastic; . Recycling and reuse of over 95% of residues produced during construction
	. Combustibles market	. Reuse of rainwater
	. Supermarket	. Reuse of rainwater; . Food waste into compost; . Reuse of 97% of the residues produced.
Products	. Copy services	. The waste paper is collected weekly by a recycling company
	. Supermarket	. Frying oil
Biodiversity and Natural Habitat Restoration	. Construction business	. 300 square meters of green area composed of native plants,
	. Supermarket	. Small organic food

Source: Authors' figure

Figure 1 shows that the most accomplished environmental actions are those related to the reuse of production leftovers in the manufacture of new products and recycling or elimination of defective products, but also actions for the sustainable use of water, energy and raw materials and also those aimed at pollution prevention and environmental awareness.

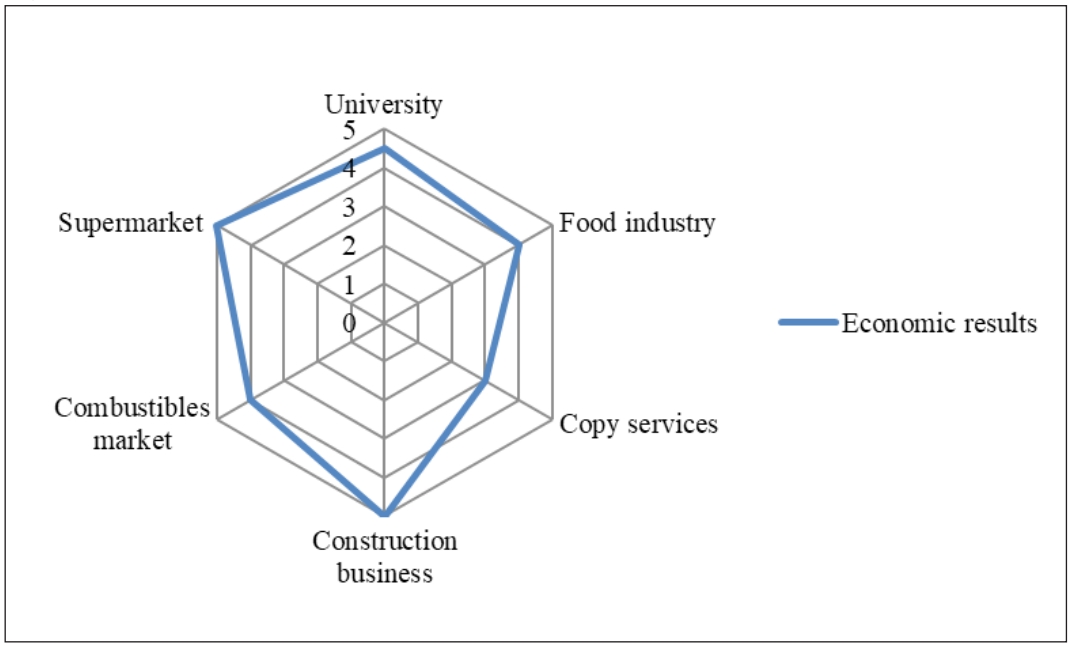
Figure 1- Number of environmental actions carried out by the 6 companies in relation to the dimensions dimensions assessed in the frame 2 (own frame)



Source: Authors' figure

In figure 2, based on important environmental actions aimed at preserving the environment, as well as minimizing environmental impacts, we show the economic results generated using the Likert scale as a metric. It is possible to identify that 5 companies analyzed had good economic results, since the copy service company had satisfactory results. These satisfactory results are closely linked to the lack of workers' training, causing loss of copies.

Figure 2- Economic results from environmental actions



Source: Authors' figure

4 FINAL REMARKS

The main objective of this study was achieved, that is, we analyzed six companies located in *Cidade Pedra Branca,* which represents an ecosystem of innovation. The companies surveyed adopt actions aimed at socio-environmental sustainability in the process of innovating their products and methods while seeking to improve financial results with the actions implemented. A synthesis of the noteworthy actions carried out is given below. Regarding energy consumption, four of the six companies surveyed make use of some type of technology in order to cut costs, either a simple measure, like leaving equipment in standby mode or automatized control of air conditioners, or complex technologies such as the installation of LED light bulbs and photovoltaic panels. However, two companies have not employed any energy-saving procedures. Knowing how to use energy consciously and investing in renewable sources is one the main contributions companies and society in general can make to sustainable development. According to Everett *et al.* (2012), energy and sustainability are the main concerns in today's world. The challenge lies in obtaining clean, safe and sustainable sources of energy, in spite of the growth in the population and the increasing economic development.

In relation to water consumption, all companies reclaim their water (two of them harvest rainwater for outdoor cleaning and car washing). Even though the Earth is composed of 70% water and every known life form is dependent on this resource, there are problems associated with the poor distribution of hydric resources on the planet. According to Benetti (2008) (as cited

in Asano *et al.*, 2007), in 2025 there will be 3.5 billion people living in regions suffering from water insufficiency, ranked in the Water Scarcity Index category as over 0.4. In this context, the conservation and recycling of water are essential tools in policies for the sustainable management of water resources.

Regarding the disposal of residues, all companies deliver their waste to third parties who then give it appropriate treatment. In addition, the sixth company analyzed collects batteries and recycles used frying oil into soap bars and food leftovers into compost. The National Policy for Solid Residues (BRASIL, 2010) imposes the implementation of systems of reverse logistics under the shared responsibility of consumers, companies and governments. Agenda 2030 for sustainable development seeks to reduce the environmental impact per capita of cities, paying special attention to the management of municipal residues, and aims at a 50% reduction in global food waste per capita at the consumer and retail levels, reducing food loss along the chain of supply and production, by 2030.

The companies interviewed make extensive use of technology and each has taken notable measures, for example, the use of photovoltaic panels, obtaining the Leadership in Energy and Environmental Design (LEED) certificate, making use of rainwater harvesting and others.

Diana *et al*. (2017), in a study conducted with Brazilian companies, demonstrated that critical success factors may influence the adoption of environmental technologies, and that there is a synergetic relation between critical success factors and the maturity of environmental management. Studies like this highlight how important it is for companies to adopt clean technologies in their processes and product innovations, which may result in numerous advantages, such as a reduction of resource consumption through the adoption of rainwater harvesting and recycling measures, LED lighting and the reuse of residues, among others.

Furthermore, all of the companies surveyed separate their waste for recycling. Notably, the sixth company (supermarket) had received an international award for reusing resources, and only 3% of the entire company's waste is disposed of in landfill sites. According to Rebehy *et al*. (2017), the management of urban solid waste in Brazil still faces many challenges in the process of transitioning to a model based on management with recycling and reuse.

The theme addressed in this article is of great relevance to the companies in Cidade Pedra Branca, with regard to producing sustainability, which converges with global challenges, this being among the various sustainable development objectives of Agenda 2030, established by UNO. In particular, the results of the survey reported herein are relevant to the ninth Sustainability Development Goal (SDG), which prioritizes the construction of resilient infrastructure, inclusive and sustainable industrialization and the encouragement of innovation.

In this regard, given the importance of this theme, the Special Volume (SV - 2015) of the Journal of Cleaner Production titled "Sustainable Development of Energy, Water and Environmental Systems" is focused on four main fields that are of strategic importance to sustainable development: energy resources and energy management, water management and wastewater treatment, environmental engineering and management, and the promotion of sustainability concepts (DUIC; URBANIEC; HUISINGH, 2015).

In summary, we observed that the six companies in *Cidade Pedra Branca* are concerned with producing responsibly with respect to society, the environment, and the economy.

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