UNIVERSIDADE ESTADUAL DE CAMPINAS
FACULDADE DE CIÊNCIAS APLICADAS

ADRIANA MARCELA BAYONA ALSINA

PATTERNS OF KNOWLEDGE-INTENSIVE ‘GREEN’ ENTREPRENEURSHIP: AN ANALYSIS OF THE PIPE PROGRAM IN THE STATE OF SÃO PAULO, BRAZIL

PADRÕES DE EMPREENDEDORISMO “VERDE” INTENSIVO EM CONHECIMENTO: UMA ANÁLISE DO PROGRAMA PIPE NO ESTADO DE SÃO PAULO NO BRASIL

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Orientador: Bruno Brandão Fischer

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RESUMO

A velocidade da industrialização nos últimos anos teve consequências negativas para o meio ambiente, incluindo problemas como o aquecimento global, emissão de gases, poluição tóxica e produtos químicos no solo. Por isso, o interesse em estudar aspectos VERDES também aumentou, buscando soluções para esses problemas e considerando-os como parte do desempenho das organizações. Portanto, o empreendedorismo verde e a inovação foram reconhecidos como uma opção para enfrentar essa realidade.

Para entender melhor esse contexto, esta pesquisa, enquadrada na linha de pesquisa de empreendedorismo e sustentabilidade, realiza uma análise apoiada por um programa chamado PIPE (Pesquisa Inovativa em Pequenas Empresas) dentro do programa FAPESP (Fundação de Amparo à Pesquisa do Estado de São Paulo) que apoia a pesquisa científica e/ou tecnológica em pequenas e médias empresas no estado de São Paulo, no Brasil. A pesquisa concentra-se em identificar os padrões de projetos empreendedores intensivos em conhecimento com foco ambiental no contexto brasileiro, no estado de São Paulo.

A abordagem da pesquisa é Qualitativa-Quantitativa, utilizando um conjunto de processos sistemáticos, empíricos e críticos que envolvem a coleta e análise de dados quantitativos e qualitativos permitindo uma melhor compreensão do problema. A análise de clusters foi a técnica selecionada para esta pesquisa, considerando que o foco da clusterização hierárquica é a comparação dos objetos com base em variáveis estatísticas que representam as características de cada objeto. Para esta pesquisa foram analisados 1844 projetos.

Na pesquisa, foi explorado o novo conceito de Empreendedorismo intensivo em conhecimento verde, reconhecendo-o como um tipo específico de Empreendedorismo intensivo em conhecimento, compreendendo a transição do Empreendedorismo intensivo em conhecimento para o Empreendedorismo intensivo em conhecimento verde, como transição sustentável e dentro das dimensões do Ecossistema Empreendedor. Foi possível identificar o papel do ecossistema líder no desencadeamento de transições sustentáveis, a falta de abordagens empreendedoras para subconjuntos específicos dos ODS e a heterogeneidade das áreas em relação aos problemas sociais e ambientais.

Palavras-chave: Empreendedorismo Intensivo em Conhecimento, Empreendedorismo Verde, Ecossistema Empreendedor, Brasil.

ABSTRACT

The speed of industrialization in recent years has had negative consequences for the environment, including problems such as global warming, emission of gasses, toxic pollution and chemicals in the soil. For this, the interest in studying GREEN aspects has also increased, seeking solutions for these problems and considering them as part of organizations' performance. Therefore, green entrepreneurship and innovation have been recognized as an option to address this reality.

For understanding better this context, this research, framed within the entrepreneurial and sustainability research line, conducts an analysis supported by a program called PIPE (Innovative Research in Small Enterprises) inside the FAPESP program (São Paulo Research Foundation) that supports the scientific and/or technological research in small and mid-sized companies in the São Paulo State in Brazil. The research focuses on identifying the patterns of knowledge-intensive entrepreneurial projects with an environmental focus in the Brazilian context in the State of São Paulo.

The research’s approach is Qualitative-Quantitative, using a set of systematic, empirical and critical processes that involve a collection and analysis of quantitative and qualitative data allowing a better understanding of the problem. The Cluster analysis was a technique selected for this research, considering that the focus of hierarchical agglomerative clustering is the comparison of the objects based on statistical variables that represent the characteristics of each object. For this research 1844 projects were analyzed.

In the research was explored the new concept of Green KIE, recognizing it as a specific type of KIE, understanding the transition from KIE to the Green KIE, as sustainable transition and inside the Entrepreneurial Ecosystem’s dimensions. It was possible to identify the role of leading ecosystem in triggering sustainable transitions, the lack of entrepreneurial approaches to specific subsets of SDGs and the heterogeneity of the areas toward social and environmental problems.

Keywords: Knowledge-Intensive Entrepreneurship, Green Entrepreneurship, Entrepreneurial Ecosystem, Green KIE, Brazil.

LIST OF TABLES

LIST OF GRAPHS

TABLE OF CONTENTS

1. INTRODUCTION

The speed of industrialization in recent years has had negative consequences for the environment, including problems such as global warming, emission of gasses, toxic pollution and chemicals in the soil (Geng et al., 2017; Peng & Lin, 2008). Nowadays this problem is considered in the business environment as a part of the performance of organizations, for this reason, entrepreneurship and green innovation were recognized as an option to leave this reality and seek technologies that allow us to achieve sustainability (Muangmee et al., 2021; Nawaz, 2021; Li et al., 2021).

Entrepreneurship is a process that transform knowledge into growth (Ács & Varga, 2005), evaluating opportunities that lead to the creation of products and services for the future, considering how to do it, who is going to do it and what are the consequences (Shane & Venkataraman, 2000; Queirós & Brito Oliveira, 2021; Xie et al., 2022). With this reality, interest in entrepreneurship was born, recognizing sustainability as a relevant part of the solution (Allen & Malin, 2008). The population understood that the current world is under pressure and it is necessary to think about sustainable performance that ultimately, considers the triple bottom line (Silva et al., 2021). Green Entrepreneurship is noted for achieving this environmental performance within the business environment (Xie et al., 2022).

Sustainable Development originated in the late 1960s to the early 1970s, as a call on society to recognize the situation for economic growth. After this, the concept was very important in the Brundtland Report guiding principle environmental and humanitarian problems (United Nations World Commission on Environment and Development, 1987). With this sustainable path, the millennium development goals arose, which were guiding force for many issues for 15 years, designed as a framework for developing policy priorities around the states (Caprani, 2016). In 2015 the UN defined 17 goals for continuing with the work established in the first document of the WCED and in the MDG’s. These goals were aimed at, achieving a better situation for the world by 2030 with an action plan to seek sustainability in all countries (Lange Salvia et al., 2019; Dhahri et al., 2021).

With this background, Sustainable Development is recognized as an emerging concept with positive impacts on the natural environment, creating benefit for society in local communities (Gast et al., 2017; Astadi et al., 2022; Hall et al., 2010), but it is the participation of different stakeholders which generates a success factor for entrepreneurship ecosystem creation (Simatupang et al., 2015). With that emerges a new type of entrepreneurship that is in harmony with the environment, the Green Entrepreneurship.

This Green Entrepreneurship is wrapped within a context of knowledge. The Knowledge Intensive Entrepreneurship (KIE) is recognized in the modern economy as the most important type of entrepreneurship, and operates as a fundamental source of macroeconomic competitiveness and innovative capabilities with effects for sustainable development (Fischer et al., 2018). This study is developed considering two parts. The first is the green part, which considers the impacts on the natural environment and operates on a triple bottom line, thinking how every process affects society, the economy and the environment. The second part is the Knowledge Intensive inside this process, creating relationships between entrepreneurs, entrepreneurial firms, knowledge and economic and social context. The union of this, generates the Green KIE and new technologies. This type of KIE is beyond the scope of the general knowledge, is unusual, and is characterized by the double externality issue, because it has positive impacts in both the innovation stage and the diffusion stage, reducing environmental harm compared to conventional technologies (Cojoianu et al., 2020).

This new concept does not have much information found in literature, and is a process that is currently under construction. The search results in large databases like Scopus are astounding, with this description: TITLE-ABS-KEY (green AND knowledge AND intensive AND entrepreneurship), 6 articles are found. This lack of direct information visible in the literature allows the construction of a new concept that addresses current issues.

For understanding this new type of KIE, this study has considered PIPE (Innovative Research in Small Enterprises) which is FAPESP’s program (São Paulo Research Foundation) that supports the scientific and/or technological research in small and mid-sized companies in the São Paulo State in Brazil (IBGE, 2016). The information about the approved projects of PIPE was consolidated in the dataset. To understand the participation of the Green Projects inside the program, an analysis of the data was conducted to look for the relationship between every project with the “green” thinking in the sustainable context, according to the definition of the new type of KIE, Green KIE.

Based on the arguments above, this study represents an opportunity for understanding the new concept in the entrepreneurial area, considering the current lack of information (Fischer et al., 2022), finding the origin of the concept, the motivation to study it from practitioners and academics, and in general the construction of the topic. The understanding of this concept and the ecosystem where it is immersed allows to define the dimensions that characterize it, showing the necessary conditions of the system for this type of entrepreneurship. With this theoretical part in place, it is possible to analyze a situation in practice to find even more details. For this, the analysis of the database of a PIPE program in the state of São Paulo will help define patterns within the projects presented to understand in detail the configuration of this new concept. This could help decision makers to know that it is influential for the economic, social and environmental growth of a region, and to promote green policies and management guidelines for companies in this area.

1.1 Research Question

What are the patterns of knowledge-intensive entrepreneurial projects with an environmental focus in the Brazilian context in the State of São Paulo?

1.2 Main and Specific Goals of the Research

The main objective of the research is to identify the patterns within the knowledge intensive context that have a green focus through the analysis of the dataset in an innovative program development in the State of São Paulo in Brazil . For achieving this goal, this study considers the following objectives:

- Explore the new concept of Green KIE by understanding the origin and creating a definition for it.
- Compare the Green KIE with the concept of a traditional KIE
- Definition of the Entrepreneurial Ecosystem’s dimensions for Green KIE
- Analyze the database of the PIPE program creating clusters from statistical variables
- Identify the patterns inside this type of entrepreneurship with cluster analysis

2. LITERATURE REVIEW

Aligned with the goals of the research and looking for a way to understand the new concept of Green Entrepreneurship, this part was divided in four steps. Beginning with the rise of sustainability as a strategic issue, where sustainable development is recognized from its origin, considering changes over time until the definition of the SDG for the United Nation and the definition of the Green Entrepreneurship as a new type of entrepreneurship (Lotfi et al., 2018).

After this, the Knowledge Intensive Entrepreneurship as a phenomenon derived from the scientific and technological assets available in small companies in diverse sectors operating as a fundamental source of macroeconomic competitiveness and innovative capabilities and recognized as the most important type of entrepreneurship (Malerba & McKelvey, 2020), and how KIE improve the expansion of the innovation across the interactions among actors inside the entrepreneurial ecosystem. In the part of system embeddedness, the entrepreneurial ecosystem is explained from its origin in the biological concept to the definition of its dimensions and characteristics.

In the third part, the transition from the KIE to the Green KIE is explained from the traditional KIE to the new "Green" line and its impact on the environmental ecosystem. The final step is to present a comparison between KIE and Green KIE with the scope beyond that of the general knowledge, generating positive impacts in the innovation stage and reducing environmental impact (Cojoianu et al., 2020).

2.1 The Rise of Sustainability as a Strategic Issue

Sustainable development has its origin in the late 1960s to the early 1970s. Some scientists, economists and humanists from ten countries created The Club of Rome, an informal, international association of around 100 people, all of them with a mutual concern over population growth, limited natural resources, ecological degradation and the role of economic development in these problems. The club of Rome published two influential texts - Limits to Growth, in 1972 and Mankind at the Turning Point, in 1974, both publications as a calling on society to recognize the situation for economic growth and to find alternatives (Fakuda-Parr & Muchhala, 2020; Mitcham, 1995).

The shift from "Limits to Growth" to "Sustainable Development" was initiated by two other reports: the *World Conservation Strategy,* that its name implies, is a strategy document with a set of general objectives of conservation, a set of priorities for national action and for international action. This document was aimed at government policy makers, conservationists, and development practitioners (Mitcham, 1995). The other report, Our Common Future, the UN World Commission on Environment and Development (WCED) stated that achieving development requirements “meets the needs of the present generation without compromising the ability of future generations to meet their needs” (WCED, 1987). This concern was reflected some years later in the Millenium development goals in the 2000 years, as a strategy for changing the world's degradation in the social, economic and environmental way, working in a public concern about poverty, hunger, disease, unmet schooling, gender inequality and environmental degradation (Mahida et al., 2021).

This first attempt was focused on a single issue in a global context, but over time it became clear that the work should be more focused on a local context working in an integrated manner (The Partnering Initiative and UNDESA, 2022). Thus, in 2015 the UN defined 17 goals for continuing with the work established in the first document of the WCED and in the MDG’s, for achieving a better situation for the world by 2030 with an action plan to seek sustainability in all countries (Lange Salvia et al., 2019; Dhahri et al., 2021). These Sustainable Development Goals are universal, and have an integrated and transformative vision for a better world for a shared prosperity, peace and partnership with focus on the climate change rooted in gender equality and respect for the rights of all (Mahida et al., 2021).

These processes through the years helped to recognize that the industrial modernization and its rapid push for growth has led to negative problems in the environment, and has generated big impacts such as greenhouse gas emissions, toxic pollution and chemical spills (Peng & Lin, 2008; Geng et al., 2017). With this understanding, a new era inside Sustainable Development and a green management is becoming one of the most important strategic decisions in companies in developed countries and emerging markets (Li et al., 2021).

The sustainable development emerged as an influential concept for entrepreneurship policy, practice and theory (Hall et al., 2010), defined as a process with positive impacts on the natural environment, and creating benefit for society as a whole for local communities (Gast et al., 2017; Astadi et al., 2022; Hall et al., 2010). The cities are understanding that through industrial ecology it is possible to achieve sustainability (Cohen, 2006). The participation of different stakeholders is a success factor for entrepreneurship ecosystem creation (Simatupang et al., 2015) and the entrepreneurs are recognized as the key drivers of social and economic progress. Entrepreneurial enterprises are important sources of innovation, productivity growth and employment and for this, many governments are trying to promote this, through various forms of support (World Economic Forum, 2013).

Based on this background, green entrepreneurship emerges as a new type of entrepreneurship that is in harmony with the environment. It is not only a business, it is an activity that has as a main objective of protecting and preserving the natural environment (Lotfi et al., 2018). Sustainability arises as a strategic issue because it represent the balancing of social equity, economic health and environmental resilience offering opportunities for win-win solutions (Cohen & Winn, 2007) It is a promise for a more equitable world where the natural environment are preserved and cultural achievements are promoted for generations to come (Dyllick & Hockerts, 2002)

2.2 Knowledge Intensive Entrepreneurship

The Knowledge Intensive Entrepreneurship (KIE) is a phenomenon derived from the scientific and technological assets available in small companies in diverse sectors, considering innovation capabilities (Malerba & McKelvey, 2020). The KIE operate as a fundamental source of macroeconomic competitiveness and innovative capabilities, generating effects upon local level employment, highlighting its relevance for city planning and policy (Fischer et al., 2018) and in the modern knowledge economy, recognized as the most important type of entrepreneurship (Malerba & McKelvey, 2020).

According to Malerba & McKelvey, 2020, “KIE ventures are new firms that are innovative, have significant knowledge intensity in their activity, are embedded in innovation systems and exploit innovative opportunities in diverse evolving sectors and contexts”. Each characteristic within the system where this process is involved, defines the Entrepreneurial Ecosystem (EE). The idea of Entrepreneurial Ecosystem emerged in the 1980s and 1990s based in a study that shows an entrepreneurship from a community rather than an individual perspective, identifying that is not enough to consider only the behaviors of individual entrepreneurs, but that it requires key roles from numerous entrepreneurs to develop an industrial infrastructure in the innovation context (Stam & van de Ven, 2019). The EE is recognized as a set of interconnected business actors, business organizations, institutions and entrepreneurship processes that together can connect, mediate and govern performance in the entrepreneurial environment (Alves et al., 2019; Stam & van de Ven, 2019; Fischer et al., 2022). The expansion of the innovation depends on collaborative arrangements among the actors inside the ecosystem (Rossi et al., 2022). The elements in the ecosystem depend on the entrepreneurs, and the entrepreneurs depend on these elements sustaining the entrepreneurial ecosystem (Stam & van de Ven, 2019).

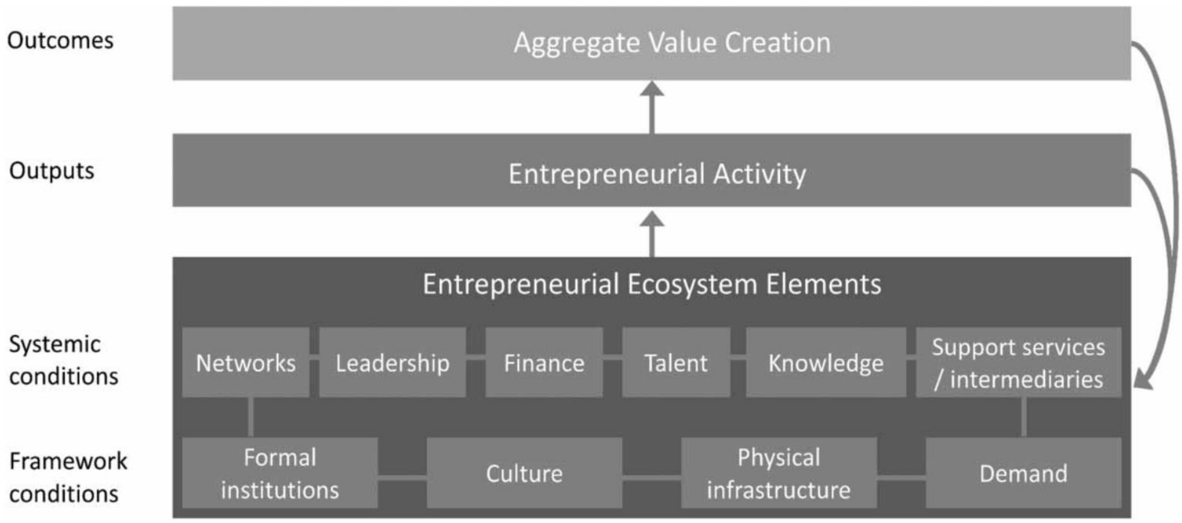
2.2.1 System Embeddedness

Entrepreneurs are important for innovation, and the new firms are important for the growth in a region showing that entrepreneurship aggregates positive socio-economic effects in a territory (Acs et al., 2017). From this, the recent interest in the concept of the Entrepreneurial Ecosystem and the enormous popularity within policy, research and practitioner fields in the last decade (Wurth et al., 2021).

The concept of the entrepreneurial ecosystem has the origin in the biological concept of an ecosystem (Audretsch et al., 2021), considering that an ecosystem was initially an interactive system of living organism, the biotic component, within their physical environment, with the abiotic component (Cavallo et al., 2018). This is the union of different actors in a system, investment capital, universities, cultural outlooks, social networks and active economic policies that create environments supportive of innovation-based ventures. It is a combination of social, economic, political and cultural elements within a region to support the growth of innovative startups and encourage nascent entrepreneurs and other actors in the process of creation and development of high-risk ventures (Spigel, 2017; Rocha & Audretsch, 2022). The entrepreneurial ecosystem approach has been developed as a transition from entrepreneurship policy to policy for an entrepreneurial economy (Stam, 2015).

Entrepreneurial ecosystems give priority to the role of the entrepreneur as an organizational, innovation and community leader, showing their ability to disrupt the existing structures and create new paths from their individual characteristics; other actors influencing how this creation operates in the ecosystem (Wurth et al., 2021; Stam, 2015). Entrepreneurs exchange knowledge, and the presence of many entrepreneurs in a region build networks of investors, advisors and mentors. The advantages of the entrepreneurial ecosystem are in the spread of the entrepreneurship process as a startup culture and access to financing (Spigel, 2017). To integrate the different aspects inside the Entrepreneurial Ecosystem and understand it as a single set, Erik Stam, 2015 presented a new model as shown in Table 1 that consider the key elements, outputs and outcomes of the entrepreneurial ecosystem.

Table. 1 Key elements, outputs and outcomes of the entrepreneurial ecosystem



Source: (Stam, 2015)

Analyzing the information in the articles and his background in the literature, and understanding the definitions of Entrepreneurial Ecosystem, the model presented for Stam was considered for this research. The elements in the model includes the framework conditions with a social part (informal and formal institutions) and the physical conditions enabling human interaction and a systemic condition as a heart of the ecosystem: networks of entrepreneurs, leadership, finance, talent, knowledge and support services. The interaction between the framework and systemic generate the entrepreneurial activity as an output and this aggregate value creation.

The development in every characteristic of EE helps to build the configuration of the KIE generating pervasive effects upon development and showing relevance for city planning and policy (Fischer et al., 2018).

2.3 A "Green" perspective on KIE

The efficient use of resources, mitigating environmental risks and perils, and ensuring cultural and social quality can lead for the sustainable entrepreneurs that play a relevant role helping policymakers accomplish the goals of sustainable development. This kind of entrepreneurship causes institutional, social and legal changes in the marketplace and generates economic, social and environmental values (Gholamrezai et al., 2021; Suriyankietkaew et al., 2022).

Sustainable Development is an influential concept for the entrepreneurship policy, practice and theory (Hall et al., 2010) that creates benefits for society with positive impacts on the natural environment (Gast et al., 2017; Cojoianu et al., 2020). The Green management in the firm is recognized as the most important strategic decision in developed countries and emerging markets (Li, Yang, Liu, & Zhuang, 2021), showing sustainable entrepreneurship as one of the most important concepts in recent years. This process considers new technologies, the reason why green entrepreneurial activity can be perceived as a specific type of KIE (Fischer et al., 2022).

The KIE receives important levels of attention from academics and policymakers (Audretsch et al., 2020). The transition from the KIE to the Green KIE depends on different aspects. First of all, sustainable transitions, which are geographical processes defined for different factors such as the political environment and the knowledge of the local environment, showing that green entrepreneurship is highly localized and place-dependent (Hansen & Coenen, 2015). Secondly, green entrepreneurship contributes with new solutions for urban areas, connecting the location itself to sustainable transitions from a bottom-up approach (Mullins, 2017). Other aspects concern the contributions of the entrepreneurs, for the implementation of green buildings, implementation of green smart-city tools, creating transportation networks, smart grids, and applied artificial intelligence to water management reducing environmental impacts (Gebhardt, 2019).

The source of green entrepreneurship opportunities are new ideas and knowledge created in different places such as universities, firms, and research organizations. This type of KIE is beyond the scope of the general knowledge, is unusual, characterized by the double externality issue, because it has positive impacts in both the innovation stage and the diffusion stage, reducing environmental harm compared to conventional technologies (Cojoianu et al., 2020). This double intention has a policy relevance, because an environmental regulation is an incentive for firms to introduce innovations across green technologies (Colombelli & Quatraro, 2019).

The new green ventures are positively influenced by the creation of knowledge from diverse and heterogeneous knowledge sources from complementary fields and by the creation of more green knowledge. The regions with strong pro-environmental social norms produce greener entrepreneurship (Cojoianu et al., 2020).

2.4 A Comparison between KIE and Green KIE

Based on the background presented for the KIE, recognizing it as a fundamental source of macroeconomic competitiveness and innovative capabilities, generating effects upon local level employment (Fischer et al., 2018) and as the most important type of entrepreneurship (Malerba & McKelvey, 2020), is possible to identify the Green KIE as a specific type of KIE (Fischer et al., 2022). This Green KIE have the scope beyond that of the general knowledge, characterized by the double externality issue, generating positive impacts in both the innovation stage and the diffusion stage, reducing environmental harm compared to conventional technologies (Cojoianu et al., 2020), it is possible to build, from the empirical, a proposition for identifying the differences between these concepts.

To construct this proposal, the previous literature and the new model presented for Stam, 2015 were considered. Both concepts are within a context of Entrepreneurial Ecosystem according with the previous definitions in literature and with a similar framework conditions and systemic conditions.

In the framework conditions, the formal institutions with universities establishing knowledge exchange networks (Alves et al., 2021) and incubators and technology parks connecting these universities, entrepreneurs and the community (Zou & Zhao, 2014), diffusing green technology (Hall et al., 2019). The Culture, with diverse and heterogeneous population with strong positive effects in fostering KIE, allowing the interchange of ideas between individuals (Florida, 2019). The Physical infrastructure facilitating the urban connections, labor mobility and knowledge flows (Alves et al., 2019). The Demand, with an ecosystem close to the economic center. Multinationals establishing the stage for the emergence of new knowledge-intensive entrepreneurship (Alves et al., 2019).

In the Systemic conditions, the Networks in an economy with robust technology transfer regulations providing a better ecosystem for entrepreneurship (Guerrero & Urbano, 2019). The Leadership providing direction for entrepreneurial ecosystem (Stam, 2015) and playing a relevant role helping policymakers accomplish the goals of sustainable development (Gholamrezai et al., 2021). The Finance as a key for equity financing (Shuwaikh & Dubocage, 2022). The talent, with people inside the initiatives for entrepreneurship survival and performance (Malerba & McKelvey, 2019). Knowledge with incubators and technology parks connecting these universities, entrepreneurs and the community (Zou & Zhao, 2014) and Support services for reducing the entry barriers for new entrepreneurial projects and innovation (Stam, 2015).

With the recent attention for this new type of KIE from the academics and policymakers (Audretsch et al., 2020) and considering that this kind of entrepreneurship generates environmental value (Gholamrezai et al., 2021), this research aims at shedding further light on this concept by analyzing a database in the state of São Paulo in Brazil with the intention of identifying patterns within the entrepreneurial ecosystem.

3. RESEARCH METHODOLOGY

The objective of this chapter is to show the process for understanding the analysis of the selected panel dataset. The PIPE (Innovative Research in Small Enterprises) is a FAPESP program (São Paulo Research Foundation) that supports the scientific and/or technological research in small and mid-sized companies in the São Paulo State in Brazil. The program promotes research to increase the competitiveness between the companies, increasing the contribution for environmental development (Fapesp, 2023).

The information of the approved projects of the PIPE program are consolidated in the selected dataset. This data has information about the process number, the title, the large area, the area, the sub-area, the principal topic, the abstract and the data information.

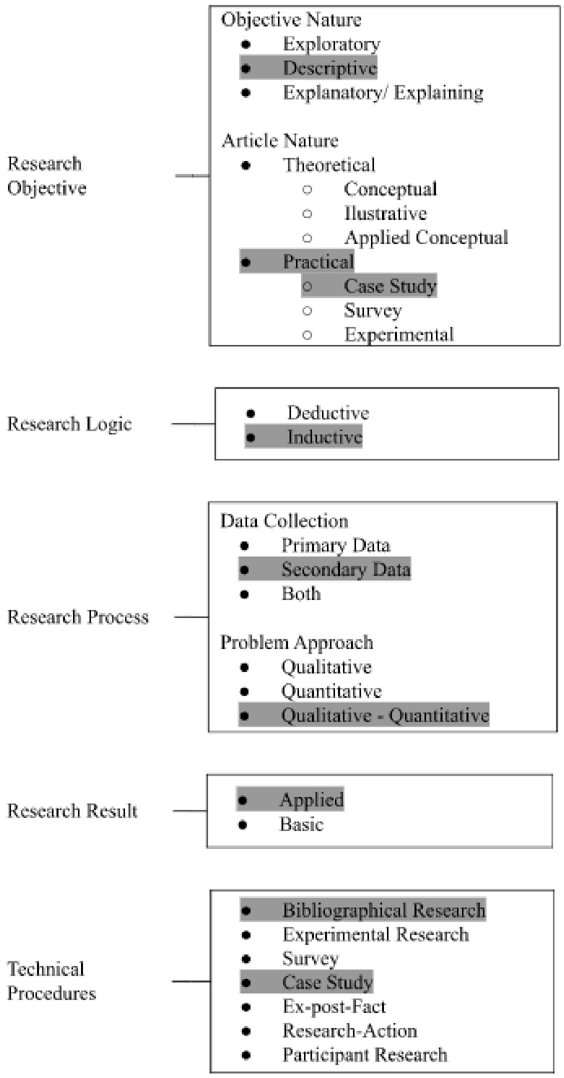
According to Hernández Sampieri (2014) justify research is a request for this process. Nowadays, industrialization generates negative consequences for the environment with problems such as greenhouse gas generation, toxic pollution and chemicals in the soil (Geng et al., 2017; Peng & Lin, 2008). Organizations are now recognizing entrepreneurship and innovation as an option to get out of this reality by creating technologies that achieve sustainability (Muangmee et al., 2021; Nawaz, 2021; Li et al., 2021). The state of São Paulo concentrates approximately 30% of innovative companies in the country (IBGE, 2016) and is a central economic hub. It has FAPESP, program that encourages scientific research and offers different databases for the academic environment.

The PIPE program receives many initiatives about different topics, but innovation in the proposal is very important for the program, ideas trying to solve a real problem related to the environment. To understand the participation of the Green Projects inside the program, an analysis of the data was done to look for the relationship between every project with "green" thinking in the sustainable context. The objective was to identify and codify projects embedded in the preservation of nature, life support and community pursuing opportunities to attend the market with different products, processes and services for gain, where gain implies consideration of environmental part in addition to the traditional definition of gain in terms of economic and social impact (Adomako et al., 2021).

3.1 Methodological Framework

The methodological framework specifies the methods, procedures and assumptions in the topic (Tasca et al., 2010). This research is descriptive in terms of its purpose and objectives (Gil, 2002). The research is a case study as a research strategy that pretends understanding the dynamics present within a single setting (Eisenhardt, 1989). The research logic is inductive because it works combining different data from qualitative and quantitative evidence, trying to define a conclusion for describing a process (Eisenhardt, 1989). The research process is with secondary data, because it is a database of the FAPESP, and the problem approach is Qualitative-Quantitative, because it is a set of systematic, empirical and critical processes that involve a collection and analysis of quantitative and qualitative data, as well as their integration and joint discussion, to make inferences as a result of all the information collected and achieve a better understanding of the phenomenon under study (Hernández Sampieri et al., 2014). It is expected to have applied results. The technical procedures are bibliographic, because the theoretical part of the research was obtained from scientific publications (Tasca et al., 2010) and Case Study, because the study seeks the answers related to the causes of a certain phenomenon to find (Gil, 2002) through the analysis of a database with cluster analysis methodology. The resume of this methodological framework is in Table 3 with the research characteristics.

Table. 2 Research Characteristics



Source: Adapted from (Tasca et al., 2010)

3.2 Inclusion Criteria

For this research 1844 projects were analyzed inside the large areas: agrotech, biology, health, exact sciences, human, social, engineering, interdisciplinary and linguistics. All these areas are part of the PIPE program, but only "linguistics" was excluded for this research, because it didn't consider an environmental line in some project Only "Approved" projects were selected inside the data of the program and only one phase of the project was selected (a project inside the PIPE program could have I, II or III phases). The unit of analysis is the project, so it is possible to see the same company several times. The time frame selected covers information for the period 1998-2020. Complete analysis was done since the project began for a representative number of data, finding 456 initiatives inside Green Entrepreneurship, 24,69% of the total ideas. The most representative areas are engineering with a participation of 43% and agrotech with 23%. No projects related to the pandemic era (COVID-19) were presented until the date selected for the research. This research is interested in the entrepreneurship part of each project, so the year will not be considered in the analysis.

In order to start the analytics process, after making the decision to use the selected database, the first step was organizing the information in the database. This was done according to the information defined by Bardin, 2012. There is a process prior to the analysis where the data is validated, verifying that there are not duplicate projects. This validation is with a unique code associated with the project. This unique data was contemplated within the analysis to have the understanding of the impact of every project in the PIPE program. With this initial cleaning of the database, it was possible to generate a codification, establishing whether each of the initiatives fit within green entrepreneurship, comprehending that Green Entrepreneurship considers the orientations of entrepreneurs towards environmentally friendly business activities (Fischer et al., 2022). To determine if each of the initiatives could be considered within the world of green entrepreneurship, after understanding the concept itself, each project was analyzed one by one. At this point the name and summary of each project was initially considered, reading each item, identifying market opportunities for greentech products or services (Trapp & Kanbach, 2021), and considering environmental orientation as an essential component of green entrepreneurial orientation (Cohen & Winn, 2007).

For the encoding process the following words were considered inside the title and in the abstract: "Green", "Entrepreneu*", "Eco-friendly", "Bio*", "Smart", "Renewable", "Sustainab*", "Agriculture", "Agro", "Environment*", "Innov*". After this, the following Areas were considered: "Agronomy", "Food Science and Technology", "Ecology", "Agricultural Engineering", "Sanitary Engineering", "Forest Resources and Forestry Engineering", "Zoology" as a priority inside the codification process for the relation with the general area, and in the end an analysis of the summary with the same words used in the title process was conducted. In Appendix A, examples of projects that were codified inside the group of Green Entrepreneurship are presented.

After these, a binary coding was attributed to the database. When the project considers green entrepreneurship within its approach, the coding is 1 and when it is not, it is 0. In this way, 456 initiatives were initially found within the concept of green entrepreneurship.

After the coding process, the categorization process begins. This categorization was framed into the Sustainable Development Goals (SDG), to consider into the analysis because it stimulates action in the critical and important areas for humanity and the planet and recent studies identify that they have energizing effects guiding organizational policy and action (Bebbington & Unerman, 2018).

In 2015, the United Nations defined 17 goals to continue with the work defined in the writing “Our Common Future”, goals for achieving a better situation for the world by 2030, establishing an action plan to seek sustainability in all countries (Lange Salvia et al., 2019). These 17 goals are grouped in 4 dimensions: Social problems (SDGs 1,2,3,4,5), Environment (SDGs 6,7,11,12,13,14,15), Economics (SDGs 8,9,10) and Institutional (SDGs 16,17), and every dimension with their group of objectives (Estratêgia ODS, 2023).

For this research were selected all the SDG inside the group of environment: 6,7,11,12,13,14,15 because this group of SDGs talk about the reversing deforestation, protecting forests and biodiversity, combating desertification, sustainable use of oceans and marine resources to adopting effective measures against climate change. It was selected an SDG 2, from the social dimension and SDG 9 from the economic dimension because the objective 9 addresses the use and depletion of natural resources, waste production, energy consumption, among other in relation with the environment, and the objective 2 with focus in zero hunger, because are several projects inside the PIPE program that present proposals with the aim of making sustainable agriculture and bioeconomy.

The objectives inside the institutional dimension, 16 and 17 were not selected because they are more focused in a behavior of the institutions (government, private sector and civil society), to achieve the sustainable development. This could surely be part of future research, to understand how through the connection of stakeholders the objectives can be met.

This is how a total of 9 objectives were selected for the investigation. The selected objectives are presented below, in Table 3:

Table. 3 Selected Objectives for research

No.	Name	Description
2	Zero Hunger	End poverty in all its forms everywhere
6	Clean water and sanitation	Ensure availability and sustainable management of water and sanitation for all
7	Affordable and clean energy	Ensure access to affordable, reliable, sustainable and modern energy for all
9	Industry, innovation and infrastructure	Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation.

11	Sustainable cities and communities	Make cities and human settlements inclusive, safe, resilient and sustainable
12	Responsible consumption and production	Ensure sustainable consumption and production patterns.
13	Climate action	Take urgent action to combat climate change and its impacts
14	Life below water	Conserve and sustainably use the oceans, seas and marine resources for sustainable development.
15	Life on land	Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss.

Source: United Nations, 2022

For this part, the name and summary of each project was initially considered, reading each item, understanding if each one fit within one or more objectives according to the description and its indicators. Some words were considered for this analysis according to the meaning of each objective. For this, words were defined within the projects with an environmental scope. All words are specified in table 4 within each objective.

Table. 4 Words considered in each objective for the analysis

No.	Name	Description
2	Zero Hunger	“Agro”, “Agricultural”, “Food”, “Bio”, “Eco”, “Tech”, “Population”,
6	Clean water and sanitation	“Sustainable”, “Water”, “Sanitation”, “Scarcity”, “Hydraulic”, “Potable”
7	Affordable and clean energy	“Sustainable”, “Energy”, “Clean”, “Renewable”, “Regeneration”, “Wind”
9	Industry, innovation and infrastructure	“Infrastructure”, “Industrial*”, “Innovation”, “Business”, “Efficiency”, “Systems”, “Process”, “Development”, “Technology”, “Improvement”
11	Sustainable cities and communities	“City”, “Cities”, “Safe”, “Resilient”, “Sustainable”, “Smart”, “Development”
12	Responsible consumption and production	“Sustainable”, “Consumption”, “Production”, “Technology”, “Business”, “Product”, “Service”

13	Climate action	“Damage”, “Flora”, “Fauna”, “Environment*”, “Global warming”, “Effects”, “Pollut*”, “Climate”, “Ecological”, “Biodiversity”
14	Life below water	“Sustainab*”, “Oceans”, “Seas”, “Marine”, “Resources”, “Sustainable development”, “Life”, “Bio”
15	Life on land	“Sustainab*”, “Resources”, “Sustainable development”, “Life”, “Bio”, “Terrestrial ecosystems”, “Forests”, “Desertification”, “Land”, “Biodiversity”

Source: Own Authorship

With the codification and categorization process it was possible to understand in the initial context that 24,69% of the total projects consider green entrepreneurship in a general way, approximately a quarter of the total. The relevant SDG inside the projects were the 9, Industry, innovation and infrastructure with 24,80% of the total, very similar to the result for codification for green entrepreneurship. This goal has a key role in introducing and promoting new technologies, this helps to facilitate international trade and enables the efficient use of resources. The next goal is the 12, Responsible consumption and production with 8,72% of the total projects, this goal is about doing more and better with less, increasing resource efficiency and promoting sustainable lifestyles, and the next goal is the 2, Zero hunger with 7,15% of the total projects, this goal is about swift actions to provide food and humanitarian relief to the most at-risk regions. This last objective makes sense considering that in the database a large number of projects related to bioeconomy are found.

3.3 Analytical Procedures

Aligned with the main objective of the research, which is to identify patterns within the understanding of the dataset in an innovative program development in the State of São Paulo in Brazil is the statistical procedure of Cluster analysis. This multivariate technique helps to add objects in a group based on its characteristics. This technique intends to classify the objects according to the relation with others (Hair, Jr. et al., 2009), sorting observations into similar sets or groups (Ketchen & Shook, 1996).

The focus of hierarchical agglomerative clustering is the comparison of the objects based on statistical variables that represent the characteristics of each object. This makes the definition of the variable a critical step in the analysis (Hair, Jr. et al., 2009). For this research 7 variables were defined. The set of variables is derived from the PIPE program (Innovative Research in Small Enterprises) managed by the Sao Paulo Research Foundation (Fapesp). This dataset offers a consistent source of knowledge-intensive entrepreneurship for the Brazilian context (Alves et al., 2021). For the research every project was classified inside every variable.

The first variable is the *Project*, consider every project in the database from 1 to 1844. The next variable is the *city*, the database considers 150 cities in the State of São Paulo in Brazil. This variable is from 1 to 150. The next variable is *Projects related to SDGs*, aligned with projects to address environmental challenges through the Sustainable Development Goals, that are a call for rethinking the way of the unsustainable development that humanity is pursuing today (Dhahri et al., 2021). This is a binary variable, 1 if the project is related to the SDGs, else 0. The *Quantity of SDGs* is a variable from 1 to 5 and considers a quantity of SDGs that are related in every project, because every project can are related to one or more goals, according to the description of the project. This definition was done with the resume of the project.

The *SDG Dimension*, considers 1 for Socioeconomic Challenge or 2 for Environment. The UN defined 4 dimensions for the SDGs, social, environment, economic and institutional (Estratêgia ODS, 2023), but for this research was considered only 3 dimensions, social, environment and economic that are related with the projects. For the quantity projects in the social dimension, was defined a new dimension: Socioeconomic Challenges that has the social and economic part. The *Leading Ecosystem* variable, is a binary variable, 1 if the project is inside cities that are leading the Green Entrepreneurship Ecosystem, else 0. This variable was defined because the database considers 150 cities, but 65% of the projects are inside 5 cities: São Paulo, São Carlos, Campinas, Piracicaba and São José dos Campos, these cities are Green Entrepreneurship Ecosystems.

The last variable is *KAG*, that is the Knowledge Area Group and define the area in which project is developed. In the original database of PIPE program are considered 9 areas (exact sciences, engineering, agricultural, biological, health, human, applied social, interdisciplinary, linguistics and arts) and every project is associated with an area. Considering that there are areas with similarities to each other, they were grouped in four big areas for the definition of the last variable: 1 for Exact Sciences + Engineering. 2 for Agricultural + Biological. 3 for Health. 4 for Human + Applied Social + Interdisciplinary. The Linguistics and arts area was not considered because only 5 projects are inside this category, and these projects don’t have relationship with the environmental part. Thus, the other 8 areas were unified into the 4 large ones. The resume of the variables is in a Table 5.

Table. 5 Statistical Variables

Variable	**Description**
Project	Number of projects, from 1 to 1844. The database has 1844 projects.
City	City where the project is presented. From 1 to 150. The PIPE program has 150 cities.
Project related to SDGs	Binary variable. 1 if the project is related to the SDGs, else 0.
Quantity of SDGs	Variable from 1 to 5. Quantity of SDGs that are related in every project.
SDG Dimension	Two dimensions for the database. 1 for Socioeconomic Challenge, 2 for Environment.
Leading Ecosystem	Binary variable. 1 if the project is inside cities that are leading the Green Entrepreneurship Ecosystem, else 0.
KAG	Knowledge Area Group. Area in which project is developed. 1 for Exact Sciences + Engineering. 2 for Agricultural + Biological. 3 for Health. 4 for Human + Applied Social + Interdisciplinary.

Source: Own Authorship

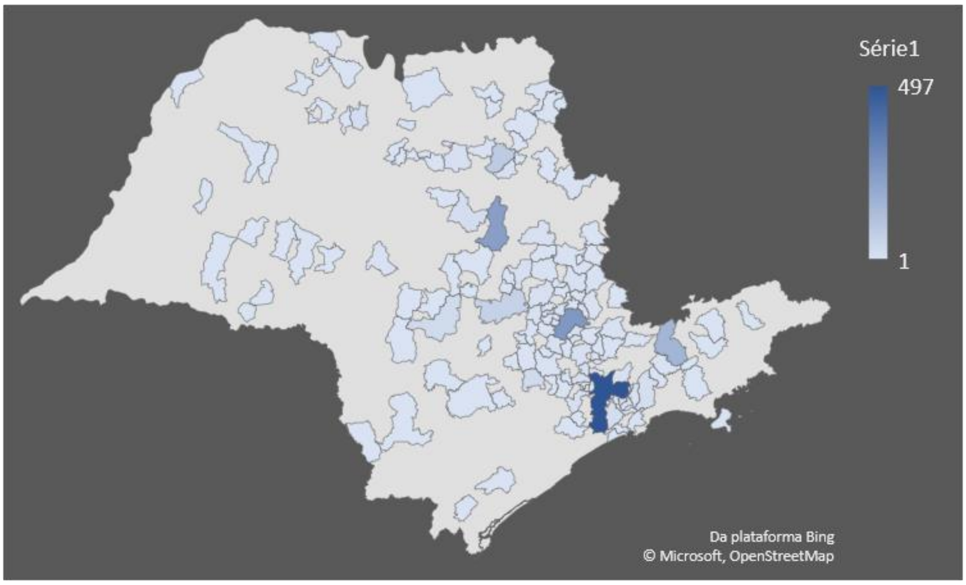
4. RESEARCH ANALYSIS AND FINDINGS

4.1 Sample Description

With respect to the data, the variables were defined from the PIPE program and have the following characteristics.

The total database has 1844 projects for the PIPE program, and every project was developed in a City in the State of São Paulo in Brazil. The database considers 150 Cities, and the city with the largest quantity of projects is São Paulo with 497. Graph 1 shows the density of the projects in every city in the state.

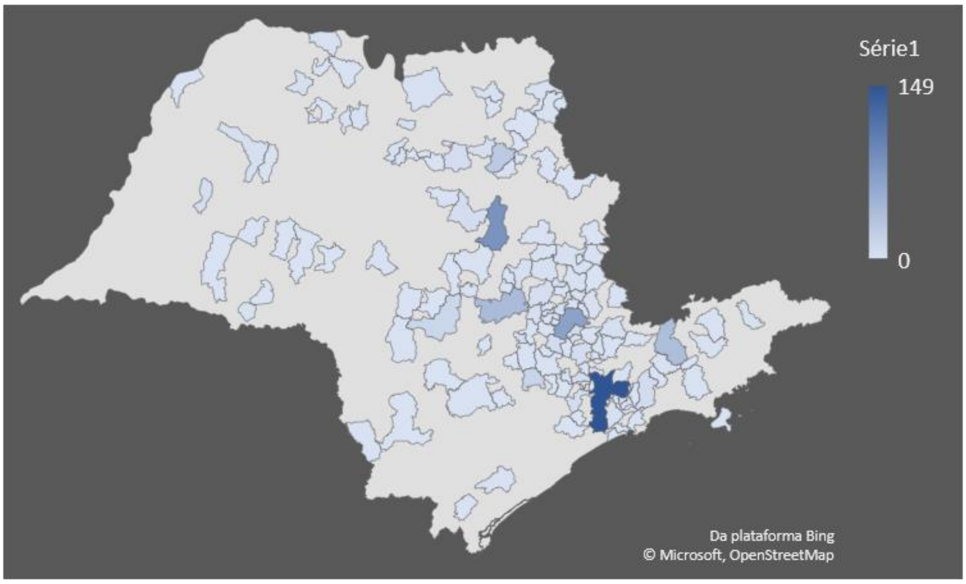
Graph 1 Quantity of projects per City



Source: Own Authorship

From the 1844 projects in the database, 615 are related to SDG. Within the projects that are related to SDG there are 100 cities, but 61,79% of them are within just five (5) cities: São Paulo (24,23%), São Carlos (13,66%), Campinas (11,06%), Piracicaba (6,67%) and São José dos Campos (6,18%). These are the most representative cities within the PIPE projects that consider sustainable development goals. These cities were defined as the Green Entrepreneurship Ecosystems leaders. Graph 2 shows the quantity of projects related to the SDGs per city, the leader is São Paulo with 149 projects.

Graph 2 Quantity projects related to the SDGs per City



Source: Own Authorship

Each project can be related to more than one objective. Within the 615 projects, 38% of them are related to one SDG, 46% are related to two SDGs, and 17% of the other projects are related to three SDGs or more. Details can be found in table 6, below:

Table. 6 Quantity of SDG related in every project

Quantity of SDG	**Projects related**	**% Percentage**	**%Accumulated Perc**
1	232	37,72%	37,72%
2	280	45,53%	83,3%
3	92	14,96%	98,2%
4	8	1,30%	99,5%
5	3	0,49%	100%

Source: Own Authorship

The projects that are related to the SDGs, 33% of the total projects of the program, are well defined within 1 or 2 goals. The table 6 shows how 512 projects have this characteristic.

This investigation contemplates 2 dimensions: Environment (SDGs 6,7,11,12,13,14,15) and Socioeconomic Challenges (SDGs 2, 9). The social and economics were joined generating a dimension of Socioeconomic Challenges for the quantity of projects in the social part.

Table 7 shows the 2 dimensions for the SDG in this research. The research considers 9 SDG. The group most representative is the "Socioeconomic Challenges" with the SDG 9: Industry, innovation and infrastructure and with the SDG 2: Zero hunger, with a 54% participation. The next group is "Environment" with 46%. For this classification, the summaries of the projects were reviewed again to validate which group was best suited.

Table. 7 SDGs in dimensions group

Number of dimensions	**Dimensions**	**SDGs**	**Quantity of projects**	**% Percentage**
1	Socioeconomic Challenges	2, 9	330	54%
2	Environment	6,7,11,12,13,14,15	285	46%

Source: Own Authorship

Each project is within an area, but for the analysis 4 Knowledge Area Groups were defined: Exact Sciences + Engineering, Agricultural + Biological, Health and Human + Applied Social + Interdisciplinary. Participation in the projects is found in Table 8. This grouping was carried out considering affinity between the areas.

Table. 8 Quantity of projects in the Knowledge Area Group

Number of KAG	**Knowledge Area Group (KAG)**	**Quantity of projects**	**% Percentage**	**%Accumulated Percentage**
1	Exact Sciences + Engineering	314	51,1%	51,1%
2	Agricultural + Biological	232	37,7%	88,8%
3	Health	22	3,6%	92,4%
4	Human + Applied Social + Interdisciplinary	47	7,6%	100%

Source: Own Authorship

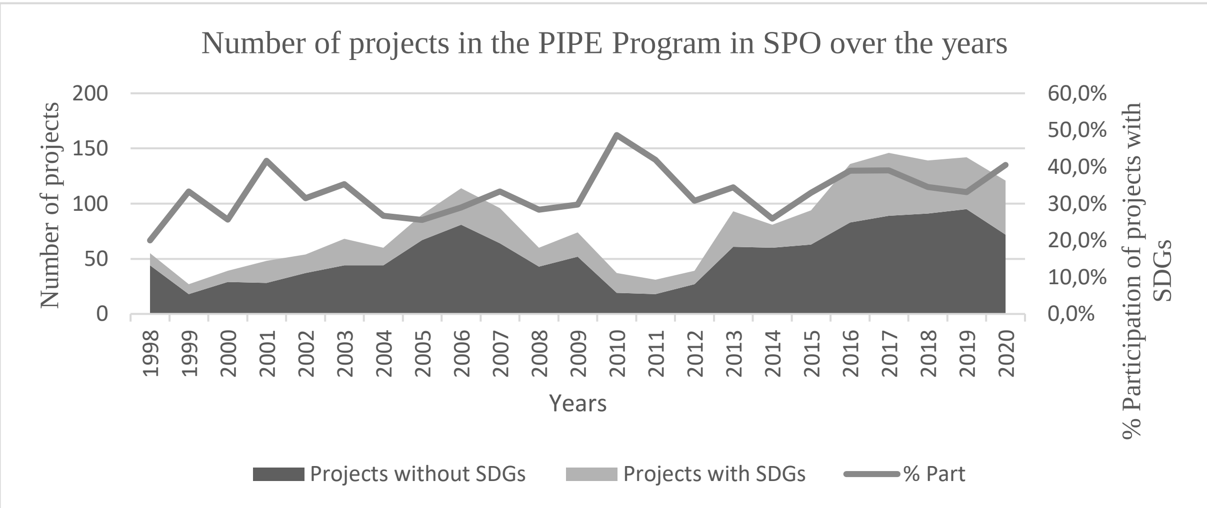
Table 8 shows that half of the projects are inside the Exact Sciences + Engineering (314 projects), 157 projects aligned in the dimension 1, socioeconomic challenges and 157 projects in the dimension 2, environment. The next largest group with a 37,7% participation is Agricultural + Biological (232 projects), where 139 projects are aligned in dimension 1 and 93 in dimension 2. These two areas represent 88% of the total projects that are related to the goals.

The understanding of groups allows us to see how the presence of projects is stronger within two areas, 88% of projects are within the exact sciences, engineering, agricultural and biological groups. These are the areas that are representing the largest trend among the PIPE projects. Possibly a good discussion for the future would be to understand why there are trends towards those areas (differential points within the ecosystem that motivate the projects in these areas) and what is missing within the ecosystem to promote the other two that have less participation within the projects.

As was previously mentioned, in this database 615 projects are related to the SDGs; this quantity of submitted projects has changed over the years, increasing from 1998 until 2020. In 1998 the program began with 11 projects and in 2020 had 49 projects. This change can be seen in graph 3. Since the beginning of the program a positive trend has been seen, however, between 2010 and 2012 a decrease in the number of projects presented is visible, both in the PIPE program and in relation to the goals. In the graph 3, the dark gray represents the projects that are not related with the SDGs, and the light gray represents the projects that are related with the SDGs, both areas together representing the total of PIPE projects. The line shows the percentage participation of the projects that are related to the SDGs on the total projects per year, with 2010 being the most representative, reaching approximately 50% of the total.

Graph 3 show how the participation of projects related to SDGs don’t have a trend of growth across the years, but the percentage has been relatively significant, the average of the percentage in the participation over the years is 33%.

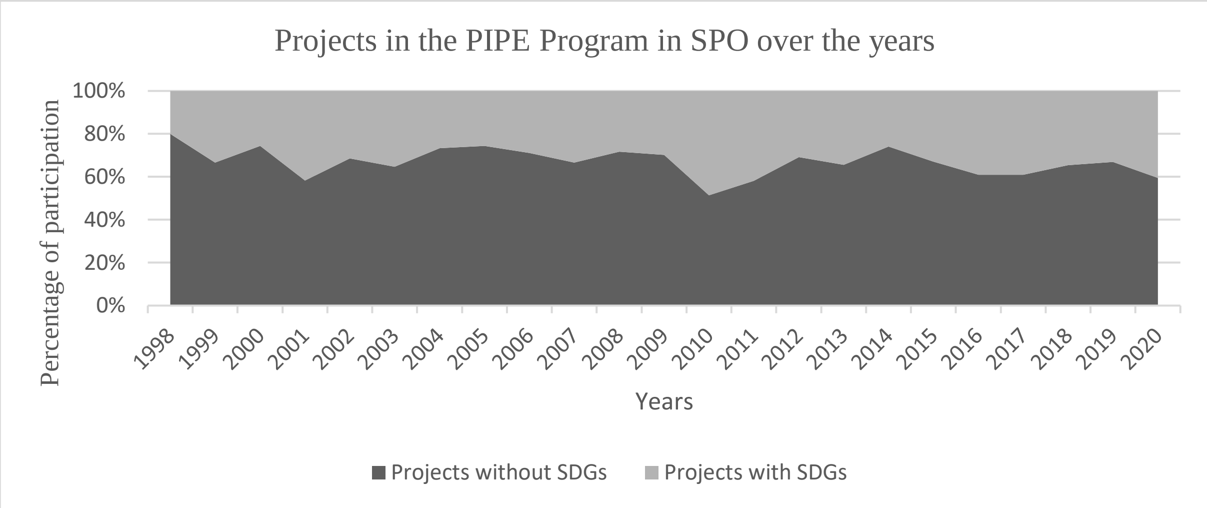
Graph 3 Number of projects in the PIPE Program in SPO over the years



Source: Own Authorship

Understanding of the participation of the projects related to the SDGs over the years can be found in graph 4. In the graph 4, the dark gray area represents the projects that are not related to the SDGs, and the light gray area represents the projects that are related to the SDGs. This shows that over the years, the projects inside the SDGs are present in the FAPESP program with a 33% on average, some years with more intensity, 2001, 2010, 2011 and 2020. These years have more than 40% of participation. In the beginning there was only 20% participation, and in the final year, there was 40.5% participation.

Graph 4 Participation of the projects that are related with the SDGs on the total projects over the years



Source: Own Authorship

This *"Sample Description section"* allowed for a detailed understanding of every one of the defined variables. It was observed the quantity of cities inside the PIPE program, and how the majority of sustainability projects are concentrated in only 5 cities. It was observed the quantity of SDGs within every project, and that the majority of projects are within 2 SDGs. Additionally, it was observed the dimensions that these projects cover and how the majority participation is in the Socioeconomic Challenge and with focus on only one SDG-9: Industry, innovation and infrastructure.

This section shows the participation inside the largest areas and the concentration of projects in two: Exact Sciences + Engineering, Agricultural + Biological with 88,8% participation, representing the trending areas within the projects. Finally, it was observed the participation of the projects that are related with the SDGs, with a participation of 33% on average throughout the years.

Finally, it is interesting to see that to submit a project to the PIPE program, it is not mandatory that there is a relationship with any of the sustainable development goals (Fapesp, 2023), however, this relationship exists over the years from the beginning of the program. Every year there are projects that are related to the SDGs.

After this sample description with the deep dive in every variable, it is necessary to find the connection between them to understand if groups with similar characteristics are created (this allows to understand the principal characteristics of each group). For this, the multivariate cluster analysis technique will be used in the next section.

4.2 Cluster Analysis

Cluster Analysis is a multivariate technique that classifies objects, each object is similar to the others within its grouping based on a set of chosen characteristics (Hair, Jr. et al., 2009). This research employed a two-step cluster analysis approach. Two-step cluster analysis was the selected technique for this study because it is the only type of cluster analysis in SPSS that forms clusters based on both categorical and continuous data (Rundle-Thiele et al., 2015).

The two-step cluster analysis retains full information for the researchers, providing rich explanation for decision-making purposes (Tkaczynski et al., 2015) and it is applicable with a relatively large data set (n = 1844 in this study), comparing to conventional cluster analyses, in reducing processing time (Hsu, C et al., 2015).

According to the statistical variables defined in the “Analytical procedures section”, a total of 6 for this first exercise (the “project number variable” was not considered), a table for the analysis in the software SPSS was created.

Table 9 shows a pre-visualization for the data in the software. In order from left to right in the table, every project from 1 to 1844, the city (number and name) where the project is presented in the PIPE program, the “project related to SDGs” as a binary variable to categorize if the project has relation with the SDGs, the “quantity of SDGs” to show how many objectives the project is related to, the “SDG Dimension” to show if the project is in a Socioeconomic Challenges or in a Environment dimension, the “leading ecosystem” to show if the project is developed inside the 5 principal cities considers in the leading ecosystem, and in the end, the “KAG” to show the knowledge area of the project.

Table. 9 Data visualization in SPSS

Project	City	CityName	ProjectrelatedtoSDGs	QuantityofSDG	SDGDimension	LeadingEcosystem	KAG
1	125	São Carlos	0	0	0	1	1
2	132	São Paulo	1	1	1	1	4
3	32	Campinas	0	0	0	1	4
4	132	São Paulo	0	0	0	1	4
5	139	Sorocaba	1	1	1	0	1
6	125	São Carlos	0	0	0	1	4
7	101	Piracicaba	1	3	2	1	2
8	132	São Paulo	0	0	0	1	1
9	125	São Carlos	0	0	0	1	2
10	78	Marília	0	0	0	0	1

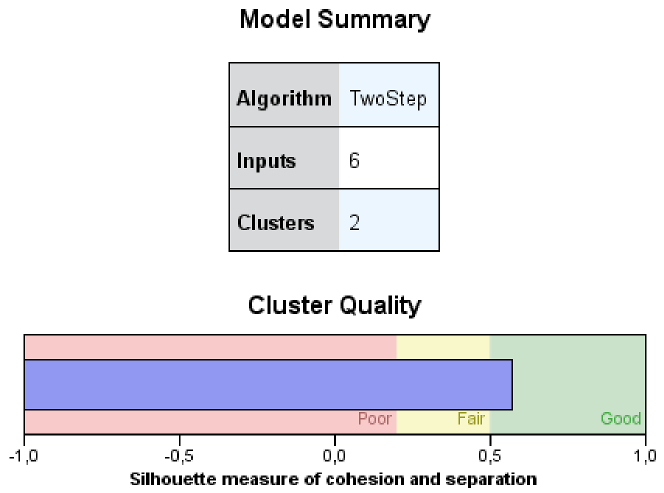
Source: Own Authorship

With the complete table of variables within the software, the first analysis was done.

4.2.1 General Cluster analysis

Considering that the first analysis has all the variables, this first clustering will be called *"General Cluster Analysis"*. The model summary for the General Cluster is found in Graph 5, indicating the two-step technique, 6 variables for the input and that 2 clusters were defined. The quality for the analysis inside the software is good, according to the silhouette measure of cohesion and separation.

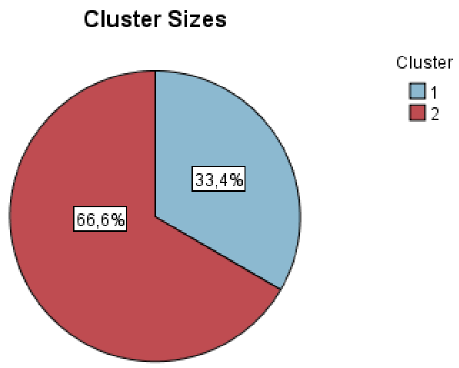
Graph 5 Model Summary for General Cluster Analysis



Source: Own Authorship

For *"General Cluster Analysis"*, the result was the segmentation of the data into two clusters. The first with a participation of 33,4% and the second with 66,6%. The second cluster is almost twice the size of the first (ratio of sizes: 1,99). This information is found in Graph 6.

Graph 6 Size of Clusters in the General Cluster Analysis

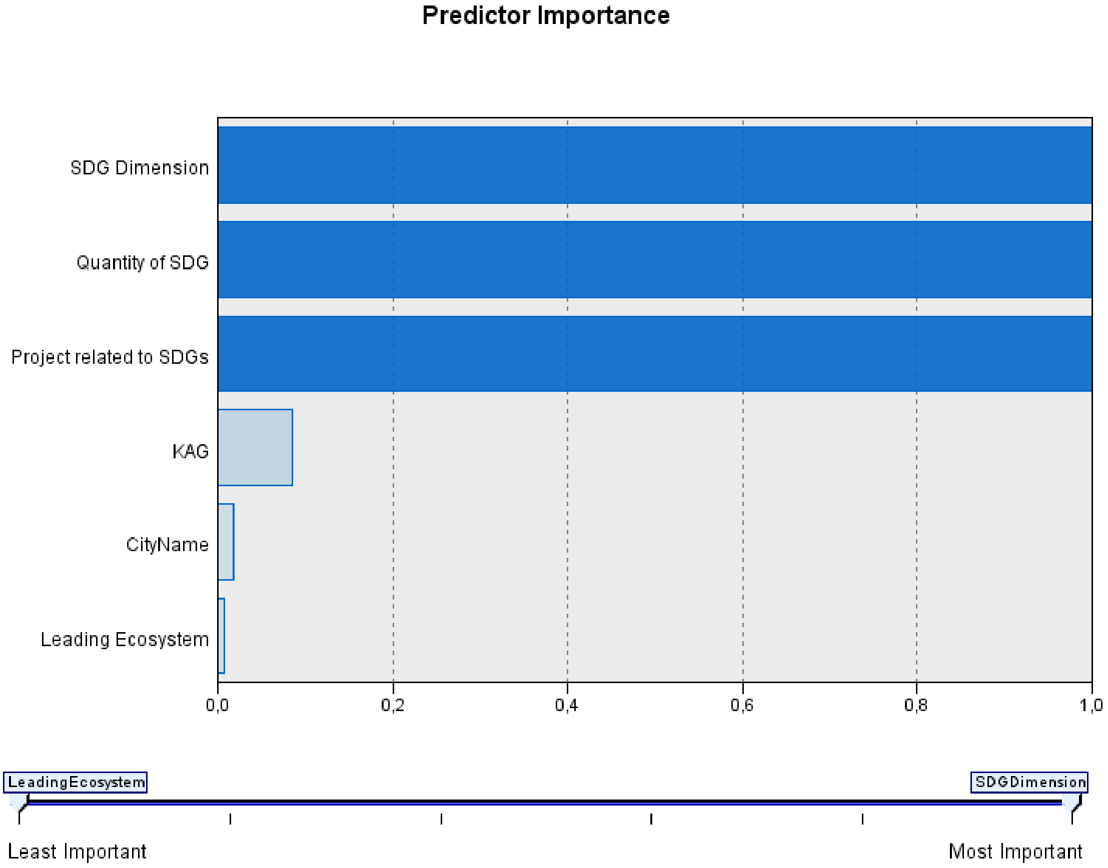


Size of Smallest Cluster	615 (33,4%)
Size of Largest Cluster	1224 (66,6%)
Ratio of Sizes: Largest Cluster to Smallest Cluster	1,99

Source: Own Authorship

The most important variables for the first cluster definition were mainly based on three of them: SDG dimension, Quantity of SDG and project related to SDGs. The detail is found in Graph 7.

Graph 7 Importance of the variables in the General Cluster Analysis



Source: Own Authorship

This first partial result shows the definition of the clusters from the SDGs, the summary is in Table 9. This General Cluster Analysis doesn't show relevant information, only the separation of the sample in relation to the SDGs.

Table. 10 Principal variables in the General Cluster Analysis

Variable	Cluster 1	Cluster 2
Project related to SDGs	615 projects are related to the SDGs	1224 projects that are not related to the SDGs
Quantity of SDGs	Projects that consider 1,2,3,4,5 SDGs	The projects not have relation with any SDG
SDG Dimension	The project is in some dimension (1,2)	The projects not have relation with any dimension of SDGs

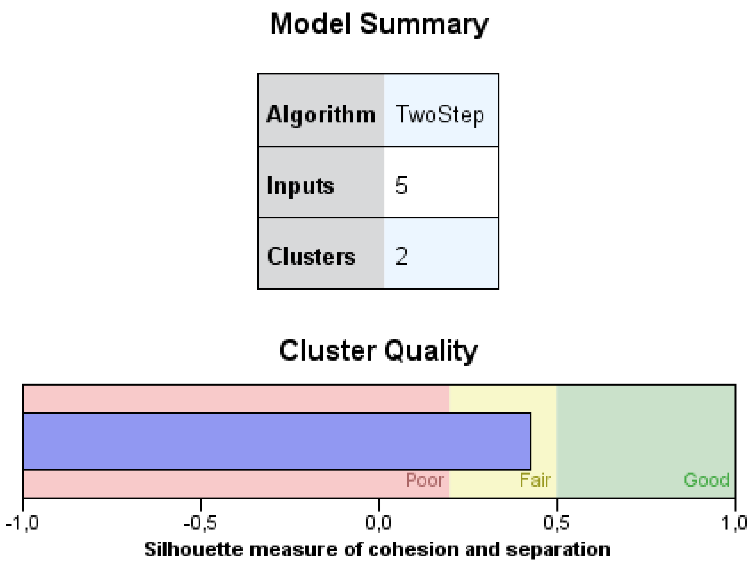
Source: Own Authorship

4.2.2 SDG Cluster Analysis

The General Cluster Analysis shows the separation of the sample in relation to the SDGs, but without relevant information. For this, in a second iteration, called “SDG Cluster Analysis”, in the software SPSS, the filter variable “Project related to SDG” was used, looking for a subsample (only SDGs = 1), because it is a binary variable, its original purpose was to separate the results. The other variables depend on if the projects are related or not to SDGs.

For this SDG Cluster Analysis, 5 variables were considered, without “Project related to SDGs”. Graph 8 shows the model summary. The result for this exercise was two clusters again and a fair cluster quality according to silhouette measure of cohesion and separation.

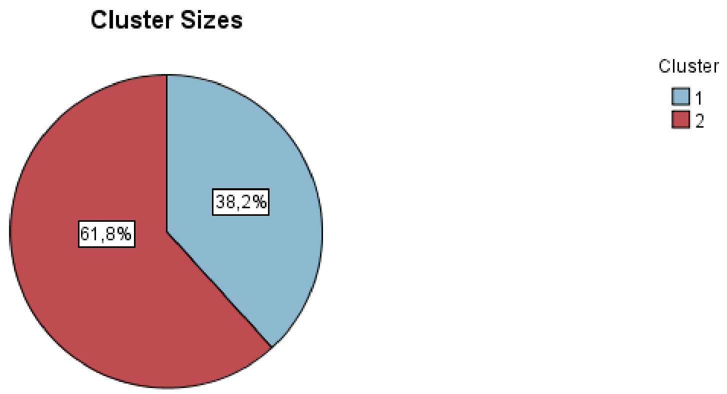
Graph 8 Model Summary for SDG Cluster Analysis



Source: Own Authorship

For this iteration of data, the result was the segmentation of the data into two clusters. The first with a participation of 38,2% and the second with 61,8%. The ratio size between the first and the second cluster is 1,62. This information is found in Graph 9.

Graph 9 Size of Clusters in the SDG Cluster Analysis

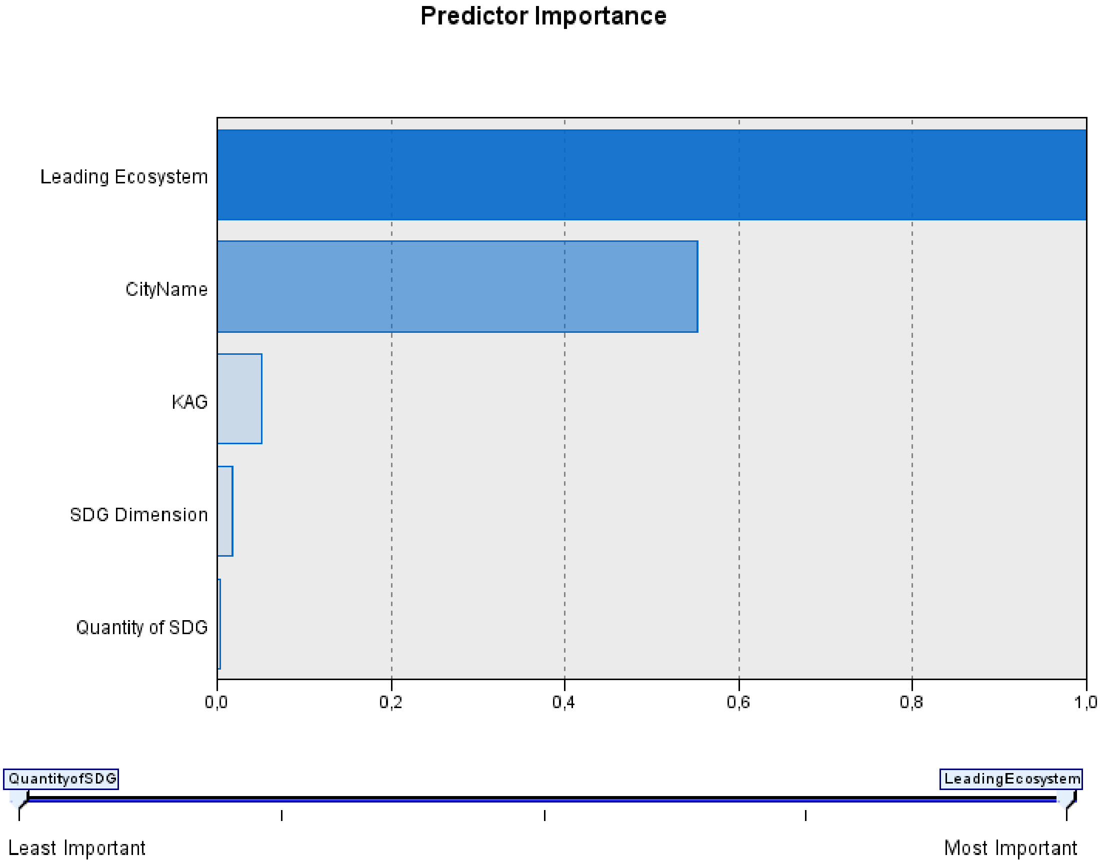


Size of Smallest Cluster	235 (38,2%)
Size of Largest Cluster	380 (61,8%)
Ratio of Sizes: Largest Cluster to Smallest Cluster	1,62

Source: Own Authorship

In the SDG Cluster Analysis, the representative variable inside the analysis is “Leading ecosystem”, variable that is placed as a relevant separator of the projects related to SDGs. The leading ecosystem for this research considers five cities, associated with the next relevant variable, “CityName”. This detail is found in Graph 10.

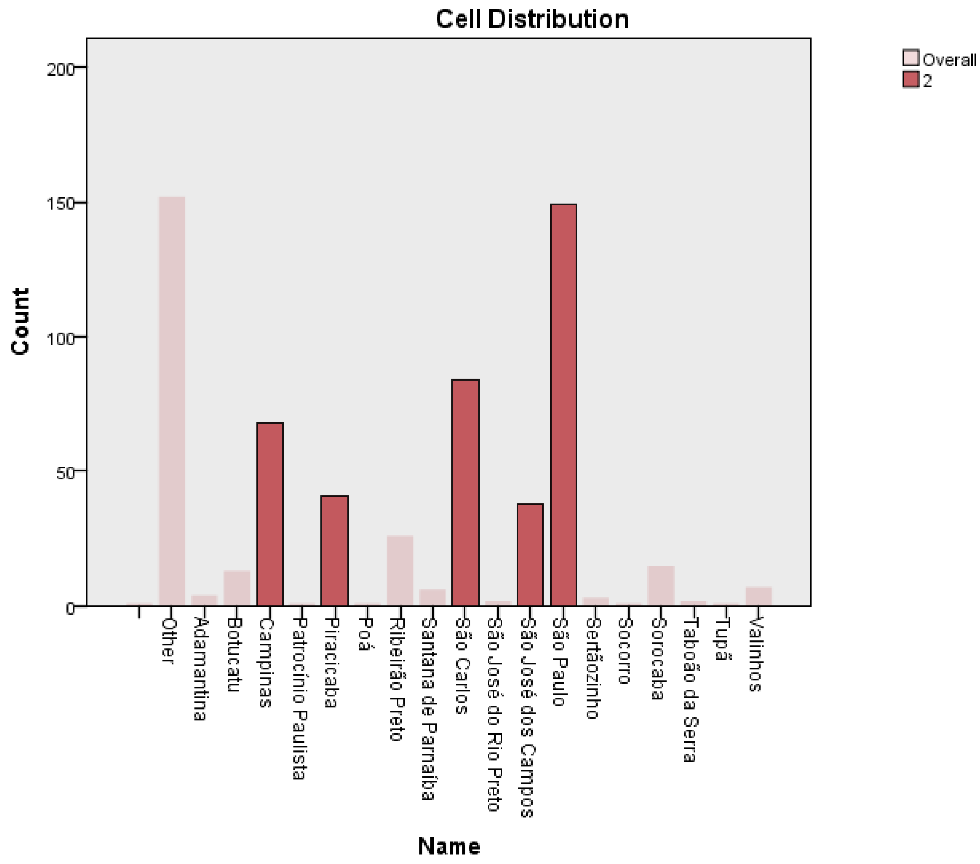
Graph 10 Importance of the variables in the SDG Cluster Analysis



Source: Own Authorship

Inside the variable "Leading ecosystem" are 5 cities (São Paulo, São Carlos, Campinas, Piracicaba and São José dos Campos) that are the most representative cities within the PIPE projects that consider the sustainable development goals ((Fischer et al., 2018; Schaeffer, P. R et al., 2021). The separation between the clusters in the result for this iteration is found in Graph 11 showing the participation only of these cities inside the leading ecosystem, results for the second cluster.

Graph 11 Participation of the cities inside the leading ecosystem

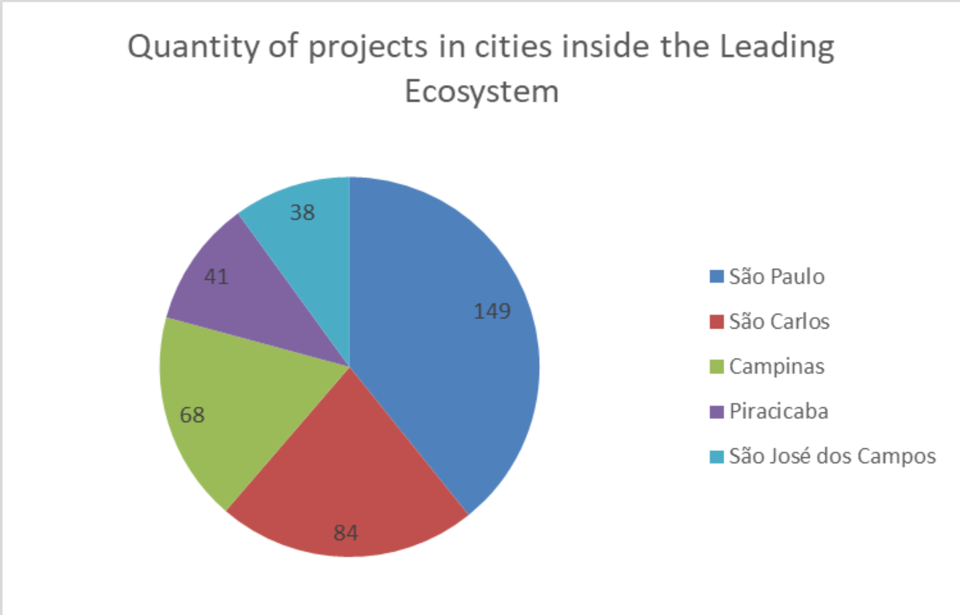


Source: Own Authorship

For this SDG Cluster Analysis, the second cluster has 380 projects that are related to SDGs and are inside the leading ecosystem. This cluster has 61.8% of participation over all projects that are related to SDGs, approximately 2/3 of these projects.

In Graph 12, only the cities inside the Leading Ecosystem were considered. This graph shows the ranking in the cities with the number of projects presented in the PIPE program that are related to SDGs. Two cities, São Paulo and São Carlos emerge as central clusters with the majority concentration of projects.

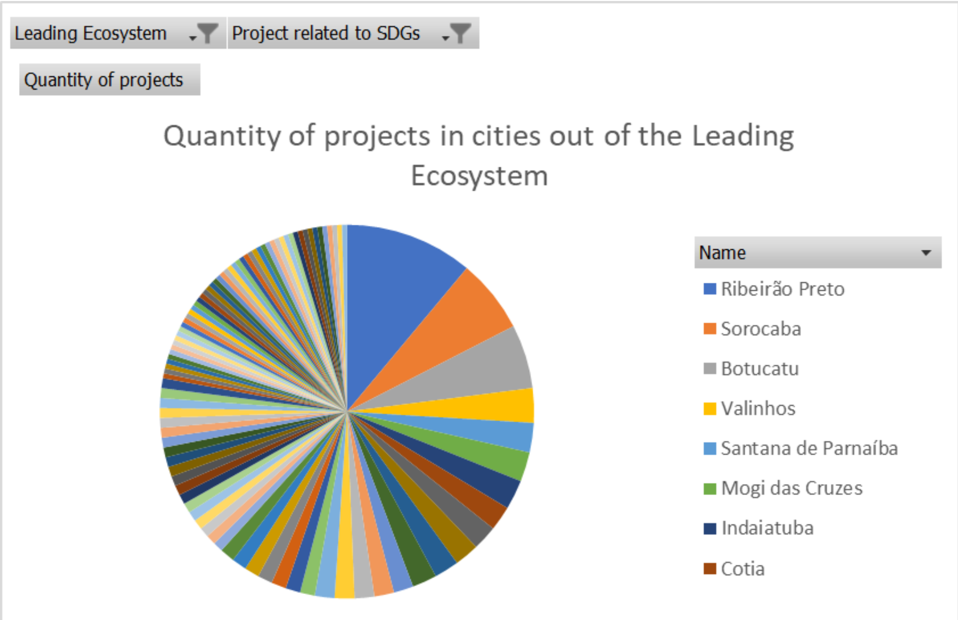
Graph 12 Quantity of projects in cities inside the LE



Source: Own Authorship

For the first cluster with the 235 projects (cities that are not inside in the Leading Ecosystem), approximately 1/3 of the projects related to the SDGs, there are many cities (95) for many projects (235), but the concentration of the projects is in seven cities. In descending order, Ribeirão Preto (26), Sorocaba (15), Botucatu (13), Valinhos (7), Santana de Parnaíba (6), Mogi das Cruzes (6) and Indaiatuba (6). These 7 cities consider 79 projects with 33,6% of the participation for this cluster, this information is found in Graph 13.

Graph 13 Quantity of projects in cities out of the LE



Source: Own Authorship

Until now, in the first iteration the variable that defined the clusters was “Projects related to SDGs” and in the second iteration was “Leading Ecosystem”. The variables, “Quantity of SDGs” and “SDG Dimension” have not been considered in the generation of the clusters. This means that the quantity of SDGs and the SDG dimension doesn’t represent relevance in the grouping.

After this first understanding of the data in two iterations, the third iteration was around the projects that are related to SDGs and are inside the leading ecosystem.

4.2.3 Leading Ecosystem Cluster Analysis

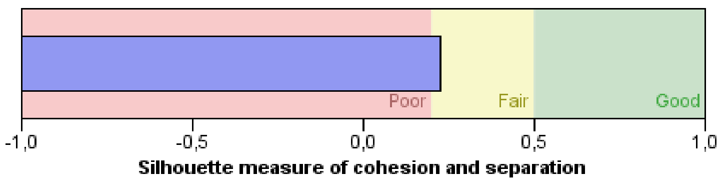
The third iteration was called “Leading Ecosystem Cluster Analysis” because consider projects that are related to SDGs and are inside the leading ecosystem. This analysis has 4 variables, KAG, Quantity of SDG, SDG Dimension and CityName. Graph 14 shows the model summary for this cluster analysis. The result for this exercise was four clusters and a fair cluster quality according to the silhouette measure of cohesion and separation.

Graph 14 Model Summary for Leading Ecosystem Cluster Analysis

Model Summary

Algorithm	TwoStep
Inputs	4
Clusters	4

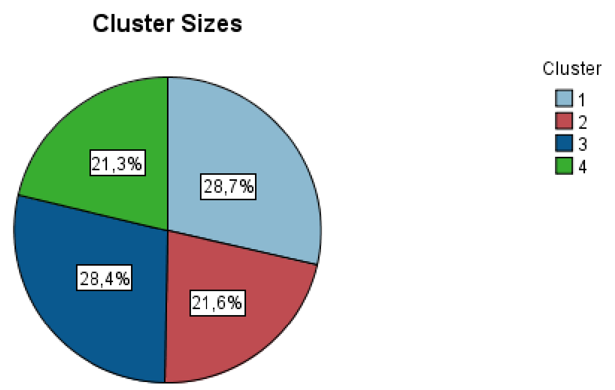
Cluster Quality



Source: Own Authorship

For this iteration of data, the result was the segmentation into four clusters. The first with a participation of 28,7%, the second with 28,4%, the third with 21,6% and the last with 21,3%. The ratio size between the smallest and the largest cluster is 1,35. This information is found in Graph 15.

Graph 15 Size of Clusters in the Leading Ecosystem Cluster Analysis

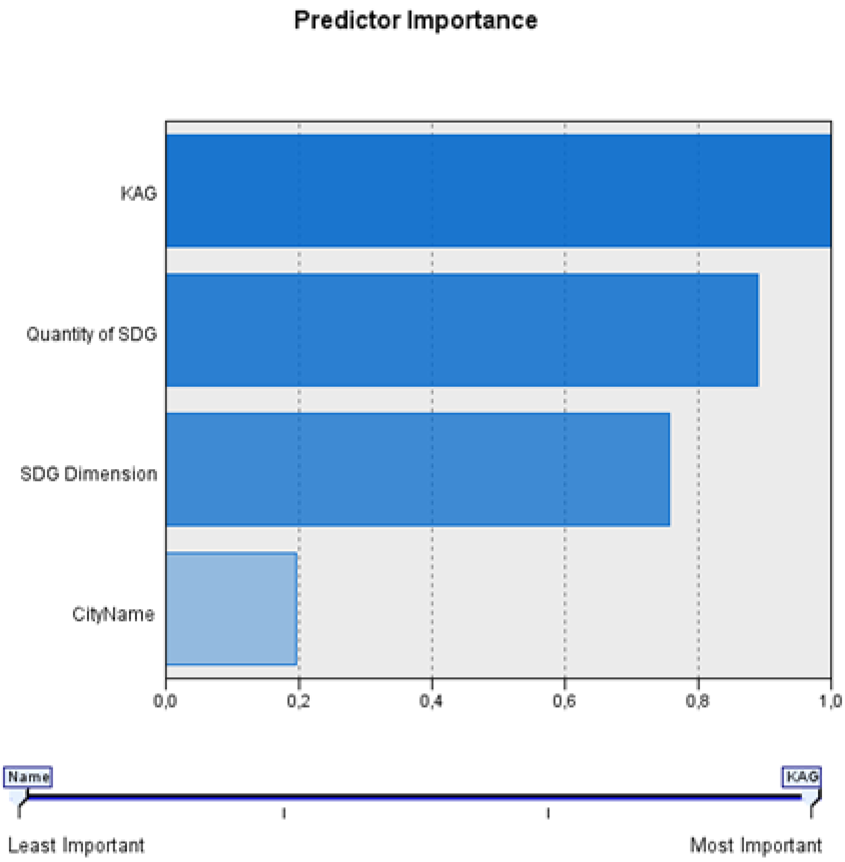


Size of Smallest Cluster	81 (21,3%)
Size of Largest Cluster	109 (28,7%)
Ratio of Sizes: Largest Cluster to Smallest Cluster	1,35

Source: Own Authorship

For this exercise, the representative variable inside the analysis is "Knowledge Area Group". The predictor importance is found in Graph 16.

Graph 16 Importance of the variables in the Leading Ecosystem Cluster Analysis



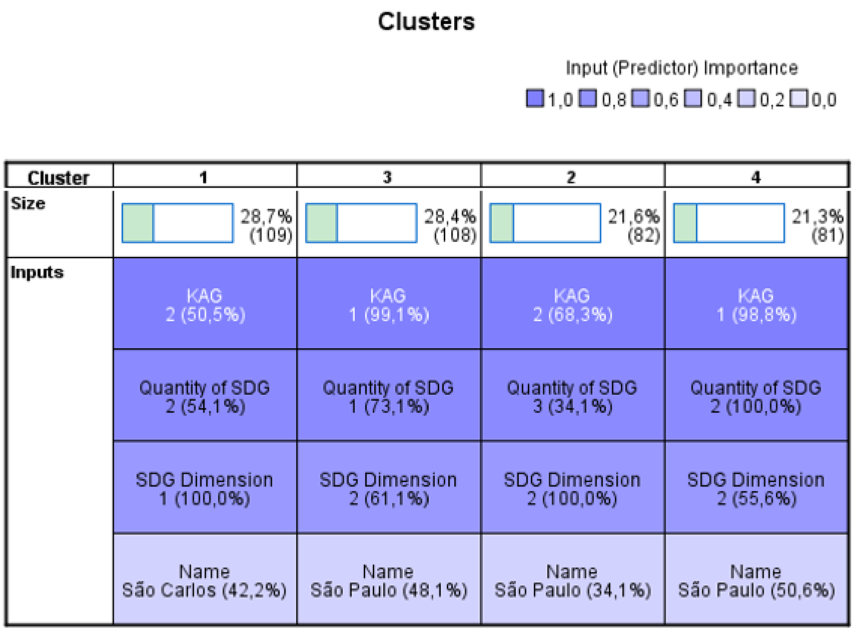
Source: Own Authorship

Graph 17 shows the summary of the Leading Ecosystem Cluster Analysis. Every cell with the color according to the importance of the variable for the definition of the clusters and with the information about the most frequent category and its percentage in every cluster.

For this group of data, the most frequent category for every variable is:

- KAG: 1 – Exact Sciences + Engineering
- Quantity of SDGs: 2
- SDG Dimension: 2 – Environment
- CityName: São Paulo

Graph 17 Description on inputs of clusters in the Leading Ecosystem Cluster Analysis



Source: Own Authorship

For this Leading Ecosystem Cluster Analysis, the principal variable is “KAG”, and the result is aligned with the conclusion from the two first iterations where the quantity of the SDGs, and the dimension doesn’t define the clusters.

Inside this dataset are considered 380 projects that are related to SDGs and are inside the Leading Ecosystem. All projects in the four Knowledge Area Groups are defined. Table 10 shows the information of the quantity of projects in every KAG.

Table. 11 Quantity of projects in every KAG

Knowledge Area Group	**Quantity of projects**
1. Exact Sciences + Engineering	225 (59%)
2. Agricultural + Biological	111 (29%)
3. Health	11 (3%)
4. Human + Applied Social + Interdisciplinary	33 (9%)

Source: Own Authorship

Table 10 shows the groups 1 and 2 as the principal KAGs. The Exact Sciences + Engineering with 59% and the Agricultural + Biological with the 29%. Combined, they have an 88% participation of the total projects, suggesting it is a specific business orientation.

5. DISCUSSION

The research has addressed the understanding of Green Entrepreneurship, as a new type of entrepreneurship (Lotfi et al., 2018) and discovering this new concept from the arise of the sustainable development through the years and recognizing it as an influential concept for entrepreneurship policy, practice and theory (Hall et al., 2010). The concept of Knowledge-Intensive Entrepreneurship (KIE) has also been explored, recognizing it as a phenomenon originating from the scientific and technological assets available in small companies across various sectors. This understanding involves assessing how KIE enhances innovation expansion through interactions among various actors within the entrepreneurial ecosystem, focusing on their innovation capabilities (Malerba & McKelvey, 2020).

The transition from Knowledge-Intensive Entrepreneurship (KIE) to Green KIE marks a crucial evolution in entrepreneurial endeavors. Initially, KIE revolved around leveraging scientific and technological knowledge to drive innovation and competitiveness across various sectors. However, as global awareness of environmental issues and sustainability has grown, there has been a distinct shift towards incorporating green and environmentally conscious practices within entrepreneurship. Green KIE represents a fusion of these concepts, where the knowledge-intensive approach is harnessed not only for economic gain but also to create environmentally sustainable solutions. This transition highlights the adaptability and responsiveness of entrepreneurial ecosystems to emerging societal and environmental challenges, emphasizing the need to align innovation and knowledge-driven entrepreneurship with green and sustainable goals.

Additionally, various geographical contexts have been studied to conduct a more comprehensive analysis of the spatial extent of ecosystem dimensions.

First, understanding *the role of leading ecosystems in triggering sustainable transitions*. The database of the PIPE program considers 151 cities, projects presented in the program from 1998 to 2021, but just in 5 cities the program has 380 projects, representing 61,7%. This group of cities was called “The Leading Ecosystem”. The question is: What do these cities have that the others don’t have?

These cities have a similar framework condition, with robust technology transfer regulations, with leadership, with access to financing, with talent, people inside the initiatives for entrepreneurship, with knowledge, incubators and technology parks connecting the universities, entrepreneurs and the community and support services for reducing the entry barriers (Fischer et al., 2022).

This situation is in accordance with Spigel, 2017 that talks about the advantages of the entrepreneurial ecosystem in the spread of the entrepreneurship process as a startup culture and access to financing. The entrepreneurial ecosystem is the union of different actors in a system, investment capital, universities, cultural outlooks, social networks and active economic policies that create environments supportive of innovation-based ventures. It is a combination of social, economic, political and cultural elements within a region to support the growth of innovative startups and encourage nascent entrepreneurs and other actors in the process of creation and development of high-risk ventures (Spigel, 2017; Rocha & Audretsch, 2022).

With the findings in the data analysis in accordance with the literature review, is relevant the leading ecosystem in the triggering sustainable transitions (Fischer et al., 2022). It is not possible to give importance only to the projects as a single unit, it is important to validate the ecosystem where the idea is being developed, because an idea that is within a leading ecosystem can probably be developed more easily. In the PIPE program, that promotes research to increase the competitiveness between the companies, increasing the contribution for environmental development (Fapesp, 2023), this finding leads us to think about the generation of policies within the program that promote these types of ideas, because green entrepreneurship contributes with new solutions for urban areas, connecting the location itself to sustainable transitions from a bottom-up approach (Mullins, 2017).

Second, for the PIPE program, to consider SDGs as a principal part of the project, is not a requirement to submit projects to the program but, since it began, some projects have relation to SDGs. In 1998 with a participation of 20% on the total projects presented, and growing across the years, with a participation of 40% for the year 2020.

The research considered 9 objectives: 2 Zero Hunger, 6 Clean water and sanitation, 7 Affordable and clean energy, 9 Industry, innovation and infrastructure, 11 Sustainable cities and communities, 12 Responsible consumption and production, 13 climate action, 14 Life below water, 15 Life on land.

General results indicate that not all SDGs have the same relevance inside the projects, which demonstrates *the lack of entrepreneurial approaches to specific subsets of SDGs*. In the database analysis, in the different iteration for definition of the cluster, the variables “Quantity of SDGs” and “SDG Dimension” doesn’t define the cluster’s separation, doesn’t represent relevance in the groupings, indicating concentration in specific groupings of SDGs, that is, little diversity. The PIPE program receives many initiatives about different topics, and the idea is to solve a real problem related to the environment (Fapesp, 2023), align with the intention of the Green KIE, that is generates economic, social and environmental values (Gholamrezai et al., 2021; Suriyankietkaew et al., 2022). This lack in the specific subsets of SDG create disparities in project outcomes. These disparities highlight the importance of a more targeted and informed approach in achieving the program's objective.

The sustainable development goals were created with the intention of achieving a better world for a shared prosperity, peace and partnership with focus on the climate change rooted in gender equality and respect for the rights of all (Mahida et al., 2021), these objectives don't have a different relevance inside the goal for the 2030. The best situation would be to have several projects working on several objectives, in order to achieve diversity. For future research, it would be interesting to understand why in Sao Paulo 25% of the projects are inside the goal number 9: Industry, innovation and infrastructure.

Third, the knowledge is created in different places such as universities, firms, and research organizations (Cojoianu et al., 2020) and for this research is a highlight inside the concept of the Knowledge Intensive Entrepreneurship. The KIE operate as a fundamental source of macroeconomic competitiveness and innovative capabilities, generating effects upon local level employment, highlighting its relevance for city planning and policy (Fischer et al., 2018) and in the modern knowledge economy, recognized as the most important type of entrepreneurship (Malerba & McKelvey, 2020).

For this research 4 areas were defined, which indicate the area in which a project is developed. With the results of the analysis, it is possible to conclude that there exists heterogeneity of knowledge areas in addressing societal/environmental issues. The database has 615 projects that are related to the SDGs, and in these projects the 4 areas are present. The minority of concentration in groups 3, Health and 4, Human + Applied Social + Interdisciplinary with 11,2%, and the majority, around the group 1, Exact Sciences + Engineering, and in the group 2, Agricultural + Biological, with the 88,8% on the total projects related to the SDGs, suggest a specific business orientation bias.

The PIPE program holds significant potential as an instrument to promote projects that encompass diverse knowledge domains while fostering a collaborative business network. This, in turn, can create a more conducive environment for entrepreneurial endeavors, especially when underpinned by well-defined technology transfer regulations, as highlighted in the work of Guerrero and Urbano (2019). An innovative approach could be to strategically align project calls within the purview of a business consortium, recognizing the inherent complexity of the issues at hand.

For future research, it would be interesting to understand what could be done within the Sao Paulo ecosystem to strengthen the presence of projects in the health, applied, human and in the interdisciplinary areas.

Lastly, the entrepreneurial ecosystem approach marks a shift from traditional entrepreneurship policies towards the formulation of policies designed to support the emergence of a thriving entrepreneurial economy (Stam, 2015), because environmental regulations motivate companies to drive innovation in the field of green technologies (Colombelli & Quatraro, 2019).

With this perspective in mind, the PIPE program becomes increasingly compelling for the development of Knowledge-Intensive Entrepreneurship (KIE) promotion policies that align systematically with the Sustainable Development Goals (SDGs). This approach seeks to enhance our comprehension of the underlying principles being promoted, thus enabling more precise and effective direction of initiatives aimed at facilitating these sustainable transitions.

6. CONCLUDING REMARKS

This research focused on finding the patterns of knowledge-intensive entrepreneurial projects with an environmental focus in the Brazilian context in the State of São Paulo. In order to achieve it, exploring the new concept of Green KIE, recognizing it as a specific type of KIE (Fischer et al., 2022), and understanding that this kind of entrepreneurship causes institutional, social and legal changes in the marketplace and generates economic, social and environmental values (Gholamrezai et al., 2021; Suriyankietkaew et al., 2022).

Understanding the transition from KIE to the Green KIE, as a sustainable transition, which are geographical processes defined for different factors such as the political environment and the knowledge of the local environment, showing that green entrepreneurship is highly localized and place-dependent (Hansen & Coenen, 2015). Green entrepreneurship contributes with new solutions for the urban areas, connecting the location itself to sustainable transitions from a bottom-up approach (Mullins, 2017).

This type of KIE is beyond the scope of the general knowledge, characterized by the double externality issue, because it has good positive impacts in both the innovation stage and the diffusion stage, reducing environmental harm compared to conventional technologies (Cojoianu et al., 2020).

This study explore the Entrepreneurial Ecosystem's dimensions in the ecosystem entrepreneurship for Green KIE, recognizing the ecosystem as the union of different actors, investment capital, universities, cultural outlooks, social networks and active economic policies that create environments supportive of innovation-based ventures and understanding that it is a combination of social, economic, political and cultural elements within a region to support the growth of innovative startups and encourage nascent entrepreneurs and other actors in the process of creation and development of high-risk ventures (Spigel, 2017; Rocha & Audretsch, 2022).

With this guidance from the literature, it became possible to conduct an analysis of the PIPE database, to understand the patterns of knowledge-intensive 'green' entrepreneurship within which projects are presented. This was achieved through a cluster analysis, revealing the opportunities present in the program concerning its alignment with the Sustainable Development Goals (SDGs). While the SDGs are not mandatory for project submissions, they have been integral to the program since its inception. For this, PIPE program could be developing project promotion policies for various SDGs, aiming to foster diversity with respect to the different existing objectives.

This analysis highlighted the low participation of certain knowledge areas within the analyzed projects. To address this, one could consider promoting projects presented by business networks as an entity, which encompasses diverse knowledge areas. This approach takes into account the complexity of the challenges posed by the SDGs. Encouraging collaboration between clusters increases the potential for leveraging knowledge and nurturing the creation of ecosystems.

Nonetheless, it's important to acknowledge the limitations of the findings. While this study has provided valuable insights by examining a database of a PIPE program in the state of São Paulo in Brazil, it recognizes that the estimations are constrained by a limited set of variables, offering only a partial view of the Green KIE and the Entrepreneurship Ecosystem.

Therefore, further investigations in this field are imperative to enhance the understanding of green entrepreneurial ecosystems. It would be interesting to study, *Why do some areas of knowledge have greater impact?* and to understand, *How are the projects developed in the EE, among a group of stakeholders or for only one unit?* To achieve a more comprehensive perspective, complementary methodologies are warranted to illuminate how ecosystems can more effectively foster environmentally-sustainable entrepreneurship.

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APPENDIX

Appendix A

Table with an information about 4 projects codified inside the group of Green Entrepreneurship

Title	Area	Abstract
Development of green-friendly cosmetics with bactericidal and healing effects for anti-acne application	Materials and Metallurgical Engineering	Despite the great advances made by the cosmetic and pharmaceutical industry in recent years, undesirable aesthetic effects caused by acne are far from being solved. The proof of this is that the sector is growing steadily, driven mainly by a new consumer profile. Although there are a great number of cosmetic products with anti-acne action available in the market, there is in this sector a constant search for materials able to kill bacteria that cause acne and to promote skin healing without bringing risks to the environment or to the final consumer. Therefore, the use of green-friendly additives became an important factor in new cosmetic developments. In this context, VETRA, a spin-off originated from CeRTEV (one of CEPID projects from FAPESP) presents different solutions not only to the medical market, but also dental, veterinary and cosmeceutical through the provision of an innovative bioactive glass patented worldwide, the F18.The bioglass F18 has marked bactericidal effect when in contact with aqueous medium, such as blood, saliva or sweat. Moreover, this glass releases specific ions that stimulate skin regeneration. Being a material composed of chemical elements already present in the human body, is non-toxic and presents no risk to the environment, and does not generate allergies or side effects. These properties are highly desirable in cosmetics aimed to eliminate acne and make this new biomaterial an excellent candidate as an additive of high performance in cosmetic formulations. Therefore, this project aims to study the incorporation of F18 bioglass in cosmetic formulations, as well as preliminary evaluate its efficacy in an anti-acne treatment and in

		skin healing. This is a technological project of great relevance. From it, the VETRA will be able to offer bioactive and innovative cosmetic products, which intend to eliminate bacteria and provide tissue regeneration. (AU)
Innovation of raw material in the process of manufacture of organic fertilizer	Agronomy	The search for sustainable and healthy food and agriculture has been a constant demand of society. To answer this demand, the use of biological products based on microorganisms as a substitute for chemicals, is increasing, since it does not harm the soil and the environment. Soil microorganisms are important for ecosystems, being fundamental in the organic matter decomposition process and the availability of nutrients, leading to the cycling of nutrients and maintenance of fertility, in addition, they are bioremediators of pollutants, promote the biological control of diseases and pest and promote plant growth, being fundamental the maintenance of microbial diversity to obtain good soil quality. The demand for sustainable practices in agricultural production is increasing and the development of biological products becomes important, mainly because it does not offer risks to the target microorganisms and the environment, however the supply of such products which maintains or increases the productivity without compromising the biological equilibrium of farming systems is still low. The present project aims to innovate the production of the organic fertilizer compound class A FertBokashiÂ® (commercial product with registration in MAPA NÂº Â° SP 08728 10014-8), replacing the raw materials of protein and starch source. In the current stage, the raw materials must undergo a cooking process, which makes the process costly and with low yield productive. It is expected that this replace will lead to a reduction in the time of manufacture and lower residues generation. The substitution for ready-to-the-use raw materials needs to be investigated in a way to do not change chemical, physical and biological characteristics of the commercial product and the results in the field remain efficient. This project also aims to identify

		bioactive compounds (molecules with potential growth promotion, phytohormones, organic acids and inhibitory compounds of phytopatogenic fungi) generated in the fermentative process. The company's participation in the FAPESP Innovative Small Companies Research/ PIPE - Stage 2 Direct - 4Âº Cycle/2018 is an opportunity for the FertBokashiÂ® product to become more competitive in the market, allowing cost reduction in its productive process, and generate fundamentals information for the development of new biological products line. (AU)
Development of a connectable crusher cart linked to a Caterpillar 930 tractor and its application in the production of organic material compost	Agricultural Engineering	The present project proposes to develop an adaptable implement for machinery of hydraulic action used in organic compost material (waste) services that deal with the operations of loading, selection and crushing of the material for improving the yield of the process and the standardization of the final product (compost), making possible the reduction of costs and the improvement of the efficiency of application of the compost to the soil. Compost spreading is an important process in the recycling of organic material on agricultural properties and in the systems of industrial solid waste and of municipal garbage, eliminating the risk of pollution through direct application of the waste to the soil, and reducing the environmental liabilities of land fill and rubbish dumps. Methods of natural compost formation using machinery of type retro-excavator and shovel-carrier type have shown themselves to be technically and economically viable for small and medium size enterprises. However, the use of these machines without the necessary adaptations for the activity, leads to some limitations in productivity and homogenization of the final product. (AU)
Nanoparticles as carrier systems in the treatment of soybean seeds aiming to soften the effects of drought stress	Agronomy	Considering the impacts of climate change in recent decades, where drought is the most important, the soybean growth is under threat. In this context, the use of osmoprotective physiological functions such as trehalose may be an alternative to improve

		plant establishment and performance, promoting low environmental impact. The correct plant establishment is a trigger for a profitable production. Under drought stress conditions, the seed ability to generate a normal seedling is impaired, compromising the crop establishment and yield. Trehalose is a non-glucose reducing disaccharide that mediates the defense responses of seeds and plants against biotic and abiotic stresses such as drought. Given this, the exogenous application of trehalose in seed treatment can be an effective solution under non ideal water conditions for the increase of germination and seedling development. Given the complex dynamics of the agricultural environment, the application technology and formulation of exogenous trehalose used in plants and seeds should be efficient and cost effective. Nanocarrier particles provide protection against degradation and gradual release of bioactive substances. Thus, the objective of the project is the development of a commercial product for seed treatment, which is formulated by nanoparticles containing trehalose, and with this, to evaluate the soybean seed germination and seedling establishment under drought stress. The nanoparticles that are going to be in the product will be defined from preliminary analysis to evaluate the release performance and protection of trehalose and based on their behavior in the agricultural environment. To evaluate the physiological impact of the product, it will be used soybean seeds of the cultivar MG / BR 46 (Conquista) submitted to its seed treatment in different concentrations. The analysis will be: germination test, 50% germination average time, seedling dry matter length and mass and accelerated aging test. Under simulated drought stress conditions the seeds will be submitted to five concentrations of polyethylene glycol (PEG) and the parameters mentioned above will be evaluated. Under conditions of drought stress in sand (at 30 and 60% water retention capacity) will be measured the emergence and seedling emergence speed index,

		seedling length and seedling dry mass. The reinduction of desiccation tolerance, trehalose quantification, confirmation and anatomical studies of nanoparticle penetration in seed tissues will be characterized. The data will be submitted to analysis of variance with means compared by Tukey at 5% probability. Globally, the perspective for grain production is the lack of water for optimal seed germination at the time of sowing, and there is nothing on the market that can offer seed and seedling tolerance to drought stress. The innovation of this present project has potential to be a solution on the establishment of crops under non-ideal water conditions, and thus, it can contribute strongly for the soybean production sustaining (future for other crops) and global food security. (AU)