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Research Article

Geographic Indications, Sustainability and Sustainable Development: A Bibliometric Analysis

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ABSTRACT

Geographical Indications (GIs) are intellectual property assets related to products or services that are characteristic of their place of origin. As a field of research, its study associated with the concept of sustainability and sustainable development is still scarce in the literature, with research beginning in the late 2000s. The objective of the present study is to establish the research results on GIs linked to the scope of sustainability and sustainable development, which, as they are multidisciplinary concepts, cover the most diverse areas of knowledge. Through scientific maps, built using VOSviewer®, o SciMAT® and the Web of Science knowledge platform, the analysis of the most relevant studies in this field was carried out to verify how research with GIs has evolved in areas related to the concept of sustainability and sustainable development. The results showed the predominance of four lines of research on the topics of interest: a) local socioeconomic impacts; b) conservation of the environment and preservation of biodiversity; c) governance and effectiveness of legal systems to protect GIs; d) post analysis-GI. Furthermore, the research showed that the topic has evolved, but is still little discussed, especially on the Asian and African continents.

Keywords: Geographical Indications, Sustainability, Sustainable development, Regional development, Bibliometrics.

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INTRODUCTION

Geographical Indication (GIs) is considered Intellectual Property (IP) assets that highlight a specific product or service, belonging to a specific geographic environment, differentiating them from similar products or services. It ensures that traditional knowledge, belonging to peculiar regions, can be valued, known and transmitted through generation, in that location, enabling economic growth and local social development.

Recognition is beneficial, both for the produced, as it adds value to their product, giving them a premium price and for the consumer, who is willing to pay more for the guarantee of higher quality. Furthermore, it influences sustainable development, as its uniqueness tends to generate conservation and better use of resources in the community in question.[1-3]

Despite being secular objects of law, mainly in Europe, it was in recent decades that interest in GIs grew considerably.[4-6] This is due to the modernization and greater efficiency of the bodies responsible for granting GIs, such as the National Institute of Intellectual Property (INPI), in Brazil and to the perception of regional communities in participating in a global market that has more than nine thousand GI concessions with a turnover volume of approximately EURO 68 million.[7]

In relation to sustainability, there is evidence that GIs encourage this process in its three fundamental pillars: environmental, social and economic. From an environmental point of view, related to the use of natural resources, GIs favor more sustainable production systems integrated with production models that optimize the use of natural resources, using, for example, smaller amounts of water, pesticides and energy, contributing to environmental preservation and reduction of Greenhouse Gas (GHG) emissions.[8-10]

Regarding the social pillar, referring to people's living conditions, GIs encourage local development, recognizing the notoriety of a region and a people in producing specific goods, valuing the community, keeping it in its place of origin and protecting their intellectual property.[11,12]

From an economic point of view, which involves the production, distribution and consumption of goods and services, GIs appear as a development factor. By promoting the differentiation of

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products and services, the add value and quality, allowing producers to sell their goods with greater profits, while at the same time predisposing consumers to pay more in exchange for unique products that could only be purchased in specific regions.[13-15]

Although the concepts of sustainability and sustainable development are interconnected, there are subtle differences between them. Sustainability seeks to harmonize economic, social and environmental elements, while sustainable development aims to achieve this balance through specific practices and policies. Sustainability represents a more comprehensive objective. Thus, sustainable development is a strategy to achieve sustainability. In other words, it is the process to accomplish that purpose. Despite the differences between the terms, in this research we will use them as synonyms, given the broad dimensions in which both terms are used in scientific research.

Despite the growing academic interest in GIs and the evidence of their association with the theme of sustainability, there is still little works in the literature that organizes and systematizes these two pillars. The relative presence of scientific information on this link (GIs and Sustainability), associated with new information technologies, encourages researchers to investigate new ways of systematizing these large volumes of data. The use of bibliometric research can generate robust and reliable indicators that are useful for measuring and comparing concepts such as academic performance and mainly understanding the structure and pattern of science development.[16,17]

Furthermore, the studies analyzed have not yet determined the quantity or quality of research on the topic of interest (GIs and Sustainability) in the different areas of knowledge. Although some studies have been carried out, they have been limited either to general questions about the Evolution of GI concessions,[18,19] or to specific themes, such as GIs and sustainable rural development.[20]

Therefore, the objective of the present study is to reduce this gap, analyzing the quantity and quality of studies on GIs and sustainability in the most varied areas of knowledge over time. To this end, the article presents a bibliometric analysis using the software VOSviewer® (Center for Science and Technology Studies, Leiden University, Leiden, Netherlands) and SciMAT® (University of Granada, Spain), with an evaluation of time intervals using the Web of Science knowledge base, which allowed mapping a series of bibliometric indicators (citation analysis, Co-citation and bibliographic coupling, for example), as well as checking future research trends in the field of study.

GEOGRAPHIC INDICATIONS AND SUSTAINABILITY

The identification of a GI is linked to the distinction of certain items or services available on the market and their safeguarding. This concept has been developing over the years, globally, increasingly, as producers and consumers noticed that some areas began to be identified according to the attributes that link them to the origin of a product or service, associating them with the excellence or heritage that makes them unique.

GIs constitute a legal and economic instrument that seeks to identify the origin of products or services from a specific geographic region and give them a status of quality, authenticity and tradition. The emergence and development of GIs over time represents a complex convergence between historical, cultural, economic and legal factors.

GIs are classified into two categories: Indication of Origin (IO) and Designation of Origin (DO). The first is associated with a geographical name of a country, city or region that has become known as a production center for a certain product or service. In other words, IO is listed as a center of excellence for the production of certain unique items, requiring the presentation of documents that prove this characteristic, known as "know-how".

On the other hand, the DO deals with geographic name of a country, city or region that designates a product or service whose qualities or characteristics are due exclusively or essentially to the geographic environment, including natural and human factors. The DO is linked to the qualities and characteristics of the product or service that stands out, exclusively or essentially, because of the geographic environment and the natural and human factor present there. To request a DO, it is necessary to present documents that describe the qualities and characteristics of the highlighted products, exclusively and essentially, because of the geographic environment and the human and natural factors present.[5]

The first historical registration of a GI in the world was granted in 1776, in France, for wine from the *Châteauneuf-du-Pape* region, located in the south of the country, in the Rhône Valley.[5] This wine region is known for its long tradition in producing high quality wines and the Geographical Indication, in the form of DO, was created to protect the reputation and authenticity of these wines, ensuring that only genuine products from this region could be marketed under this denomination.

Although the first official concession dates to the end of the 17th century, GIs had their regulation recognized for the first time in the Paris Convention of 1883v.[21] At this event, protection measures against unfair competition were introduced. In 1891, in Spain, The Madrid False Indications and Border of Measures Agreement were regulated, reinforcing the Paris Convention. However, it was throughout the 20th century that such concepts began to gain greater relevance, especially with the Lisbon treaty for identification of origin in 1958 and the implementation of the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS), of 1994, which govern the international registration of GIs.[22-24]

Strict legislation on GIs has boosted local and global trade. Products recognized for their geographic origins often enjoy quality premiums, which can lead to higher prices in the market. This, in turn, can increase the income of local producers and encourage sustainable productions practices. Furthermore, the preservation of traditional techniques and local knowledge associated with GIs contributes to the promotion of cultural diversity.

Examples of different regions of the world illustrate the direct relationship between the advancement of legislation and the increase in GIs. The European Union is known for its strict GI protection system, which covers products such as Port Wine and Roquefort cheese.[25,26] In Peru, the Pisco Denomination of Origin is an example of how legislation has strengthened the identity of the distillate produced in the region.[27]

In Argentina, which has a tradition of protecting agricultural products, beverages and artisanal products, as well as notable good that include Malbec wine from Mendoza, olive oil from the Cuyo region, cheeses such as "*Cabra Serrano*" (Mountain Goat), as well as traditional products like "*Lã da Patagonia*" (Wool of Patagonia), has invested in modernizing legislation to make its products more competitive.[28]

Still in Latin America, Brazil, which according to INPI,[29,30] has 112 geographical indications (79 in IP modality and 33 in DO), with 72% of concessions being carried out in the last 10 years. Brazilian context shows that the modernization of legislation, in which a GI is linked, starts from the understanding that this recognition effectively aims to improve the potential of the product and the delimited region, promoting sustainable territorial development.

In Asia, Marie-Vivien,[31] showed that there are several GIs registered in these countries that have not yet been "awakened", that is, they have not yet been effectively discovered by the market. The author believes that more rigorous management of the State, through the implementation of more effective legal provisions, could provide greater involvement of collective organizations to bring together stakeholders in the value chain that must play a central role in the elaboration and management of GIs.

The evidence, highlighted in the literature, shows that the advancement of legislation in relation to GIs has clearly promoted the proliferation and increase of these indications throughout the world. Legal protection of GIs not only adds economic value to products associated with specific regions, but also preserves cultural traditions and fosters sustainable development. Continuing to develop and improve Geographical Indications protection legislation is essential to ensure a balance between innovation, trade and cultural preservation.

Despite the proliferation of GIs, studies that associate them with aspects of Sustainability are still scarce. Proof of this is that in this research, only 153 works were found in the Web of Science database that address this topic (further details are provided in the methodological section).

In general, the articles researched focus on the three main aspects of sustainability: social, environmental and economic. In relation to the social pillar, research addresses different themes, such as: food security,[32,33] which discuss the competitiveness between protected goods and the production of basic foods; and themes that explore the contradiction between GIs and the use of land by traditional communities, such as indigenous communities.[34]

Regarding he environmental aspect, studies discuss from the relationship between GIs and climate change,[35] to more traditional themes, such as the influence of registrations, especially in the area of food, with environmental conservation.[11,36] Furthermore, review research on specific certifications is demonstrated,

Figure 1: Dimensioning of research topics, by quadrant, according to the algorithm used by SciMAT. Source: Martins *et al*., 2019.

such as cheese certification in Spain[15] and eucalyptus honey exploration in Italy[37] and their relationship with preservation of the environment.

From an economic point of view, the studies explore cross-cutting themes, from the analysis of specific production chains, such as coffee,[4,38] which analyze the economic impact of implementing strategies of encouraging the registration, in order to make the product more competitive, evaluating how GI registrations related to typical foods and drinks can encourage tourism, especially rural tourism.[21,39,40]

The only bibliometric article found in the research, Singh and Bharti,[20] analyzes, using keywords, the relationship between GI and sustainable rural development. The study systematized knowledge in this area, highlighting the main publications and prominent countries, providing evidence for future research on the topic. Thus, despite the lack of studies, the research shows that there is a growing trend in publications in the area of interest (GIs and Sustainability), making work that seeks to demonstrate and systematize the development of knowledge about GIs and their relationship with the pillars of sustainability crucial, as well as capturing trends for future studies.

METHODOLOGY

This section presents the steps followed during the research. Initially, a brief description of the bibliometric research was offered. Then, the selection of the source of information was substantiated and the procedure coding steps, metrics and approaches used in bibliometric analysis were displayed, in addition to the software used, as well as the criteria defined to produce the corresponding results.

Bibliometric Analysis

The bibliometric research technique emerged at the beginning of the 20th century as an alternative approach to deepen the understanding of scientific production and communication, as well as to direct them. It acts as a quantitative tool that allows evaluating the past impact of the scientific activity of research entities and the same time, predicting their future research potential. In essence, bibliometric studies aim to illustrate the orientation of research in a given field of knowledge.[41,42]

This article takes a retrospective approach and employs a bibliometric analysis of secondary data. This type of analysis produces valuable insights for researchers examining the evolution of scientific activity. In this way, bibliometric analysis using keywords enables detailed investigation of the main research topics within a delimited field of knowledge.[43,44]

Adopting the criteria proposed by Castillo-Vergara, Alvarez-Marin and Placencio-Hidalgo,[45] this study followed the following steps: a) delimiting the scope of the research; b) choice and processing of the database; c) adjustment of search parameters; d) categorizing of the selected material; e) analysis of the information generated.

Research Database Selection

The sample of articles analyzed by this research was selected using keywords. The repository used was Clarivate's Wed of Science, which brings together articles from reputable journals, as well as books, book chapters and conference papers. The selection of this database was established on its interdisciplinary nature and its scope.

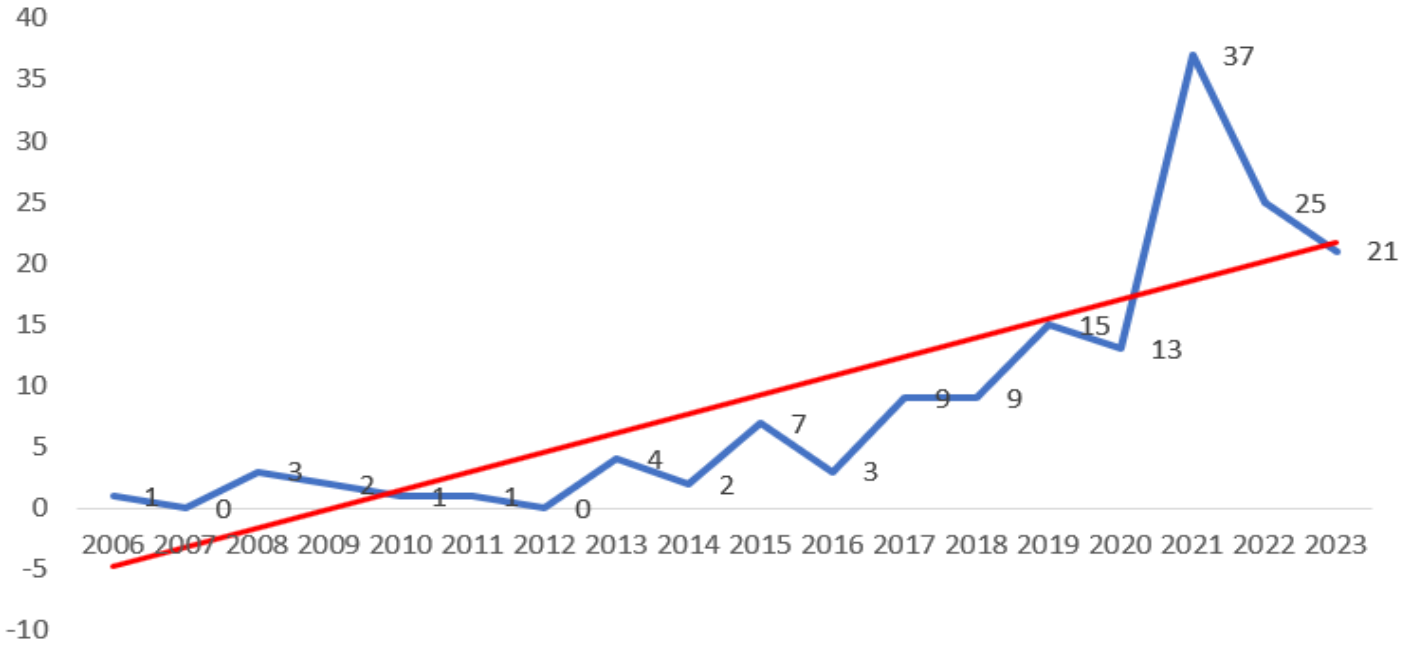

Figure 2: Annual distribution of publications on GIs and sustainability (2008 to 2023). Source: Web of Science - Own Elaboration.

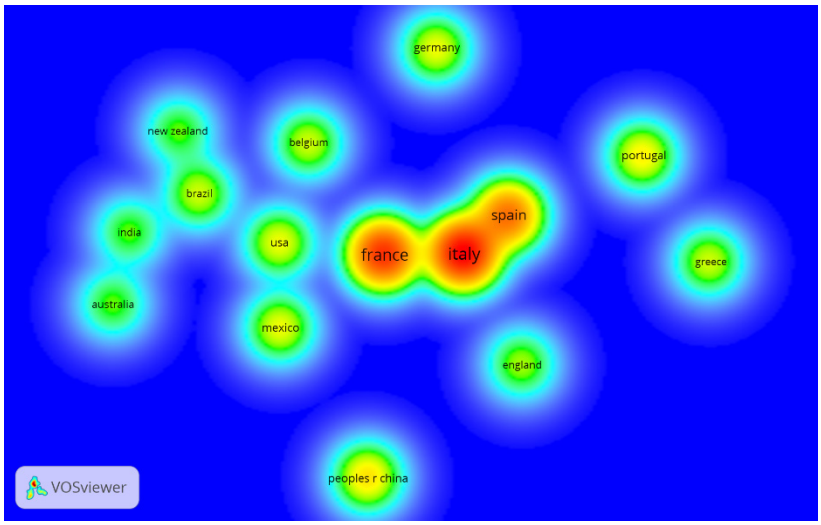

Figure 3: Heat map of citations by country. Source: VOSviewer from Web of Science-Own Elaboration.

The research analyzed publications from 2006 (first year of occurrence of analyzed terms) until 2023. The Keywords included in the research were: "Geographical Indication", "Geographical Indications", "Indication of Origin", "Appellation of Origin", "Sustainability" and "Sustainable Development". The Boolean operator "OR" and "AND" were used. The terms were searched in the title, abstract and Keywords. The search string was outlined in the advanced field as follows:

TS=(("Geographical Indication*" OR "indication of origin" OR "appellation of origin") AND ("sustainability" OR "Sustainable Development"))

In order to provide breadth to the study, we did not define the language, areas of knowledge or type of documents. In other words, the research is made up of articles, review articles, books, book chapters and conference Papers in all available languages and areas of knowledge. Using these parameters, the Search returned 153 articles. All were qualitatively reviewed. There was no need to eliminate any of them, as the publications contained all the established Search parameters, meeting the research objectives. The standardization of the Search string, selection and collection of data and analysis and reading of articles were carried out between July 4th and November 20th, 2023.

Coding Process

After collecting and analyzing the data, we created a unique information base, consisting of a simple file, in "txt" format, containing a complete record of the variables used for analysis: citation information (authors, document title, year of publication, source, volume, edition, number of pages, citations, type of document and publication stage); bibliographic information (affiliations, serial identifiers, publishers, original language of the document, correspondence address and abbreviated source title); summary and keywords (summary, author keywords and indexed keywords); funding details (number, acronym and funder); and other necessary information (trade names, conference information and bibliographic references).

We also defined three time-intervals [(2006-2012), (2013-2018) and (2019-2023)] consistent with the number of publications per period. The division into periods helped to visualize the Evolution of the number of publications and identify subtopics of interest over the years.

Indicators And Bibliometric Methods Used

We use quantitative indicators that measure the productivity of countries and authors in terms of the number of publications and citations and the recurrence of Keywords, based on the methodology established by Zupic and Čater.[16] These indicators aim to measure the Frequency with which a work or author is cited in other research, relating works, authors, research groups, countries and keywords according to the chosen method, mapping the units of analysis according to this metric.

The units of analysis used were countries, authors and Keywords. For each unit of analysis, we use different indicators. For countries, we use citation analysis. For authors, the methods chosen were citation analysis, Co-citation and bibliographic coupling. And for keywords, we use co-occurrence analysis.

Citation analysis uses the number of citations as a measure of influence. The assumption is that the most cited authors, works and countries are more influential or more engaged (in the case of countries) in the research area. Co-citation analysis used the Citation of two works as a measure of similarity, demonstrating the group of authors that is systemically cited by a specific group of works. Bibliographic coupling analysis does the opposite, that is, uses the number of references shared by two works, as a measure of similarity between them. The assumption is that the more two works cite similar research; the more their content

is related, highlighting the latest research fronts in the area of interest.

Software Used

We use two tools to help process the data. The first one was VOSviewer, a free information technology software developed by Waltman and van Eck,[46] aimed at building and visualizing graphical representations of bibliometric maps. A feature of this program, in contrast to most information technology software for bibliometric mapping, is its emphasis on visual representations of maps. This proves to be particularly advantageous when dealing with extensive maps, simplifying interpretation. This tool is mainly used to create maps that are based on network data.[47]

The second tool used was SciMAT developed by the "SECABA" group at the University of Granada, in Spain; this resource enables the creation of scientific maps and provides a more in-depth view of evolution within the scope of a scientific field.[48]

SciMAT is also open source and designed to conduct longitudinal scientific mapping analyses. The system offers a range of features that help researchers conduct workflows aimed at mapping science. In this study, three streams were outlined: the first focused on managing the knowledge base and its characteristics, such as year and number of publications, as well as academic efficiency indexes; the second aimed at analyzing and mapping scientific evolution, identifying prominent trends; and a third flow established to present the results and maps generated.

SciMAT allowed the creation of three strategic maps, incorporating analyzes by temporal intervals: (2006-2012), (2013-2018) and (2019-2023), using centrality and density measures. This division into periods made it possible, based on the keywords used, to identify patterns in publications within the area of interest.

The software operates with an algorithm that classifies Science into four quadrants (Q1 to Q4). The focal themes, or driving themes, are those that have substantial development and fundamental importance in the construction of the scientific domain, exhibiting high centrality and density. Peripheral themes are internally relevant and well developed, but isolated from other themes, playing a marginal role in the evolution of academic research. Emerging themes are seminal, often associated with exploratory and discursive research, while basic themes are relevant to scientific advancement, but are still scarcely investigated.[49] Figure 1 summarizes the algorithm adopted by SciMAT for mapping the scientific scenario.

In the SciMAT operational environment, we use co-occurrence analysis on keywords as a tool to build networks; equivalence index as a measure of similarity; simple center algorithm for cluster detection and strategic diagrams. Mapping, according to these criteria, allowed the recognition of search patterns and trends on terms of interest.

SciMAT is a powerful bibliometric tool used to analyze and visualize the structure and evolution of scientific research. Here are detailed insights into its key features and processes:

Similarity Measure: Equivalence Index

Co-Occurrence Analysis: SciMAT uses co-occurrence analysis to identify relationships between keywords in scientific publications. This involves analyzing how frequently pairs of keywords appear together in the same documents, allowing researchers to build networks of related terms.

Network Building: These networks help visualize the connections and clusters of research topics, showing how different areas of study are interlinked.

Similarity Measure: Equivalence Index

Equivalence Index: This index measures the similarity between nodes (keywords) in the network. It considers the shared occurrences of keywords across documents to determine their equivalence or relatedness.

Cluster Detection: Simple Center Algorithm

Simple Center Algorithm: This algorithm detects clusters within the network of keywords. Clusters represent groups of closely related keywords, indicating a coherent research theme or area.

Strategic Diagrams

These diagrams provide a two-dimensional visualization of the clusters. They typically plot clusters based on two axes: centrality (importance of the theme within the entire network) and density (internal coherence of the theme). This helps in identifying core and emerging areas of research.

Temporal and Longitudinal Analysis

Temporal Analysis: SciMAT allows for the analysis of research themes over different time periods. By dividing the dataset into temporal slices, researchers can study the evolution of themes, track the development of specific topics and identify emerging trends.

Longitudinal Analysis: This involves examining the progression of research areas over a longer timeline, providing insights into how certain themes have grown, merged, or declined over time.

Identification of Research Areas

Identification of Research Areas: By clustering keywords and analyzing their relationships, SciMAT helps in identifying distinct research areas within a broader scientific field. This identification process is crucial for understanding the structure of scientific knowledge and the main topics of interest.

Linkages in Themes

Linkages in Themes: SciMAT highlights the connections between different research themes. By visualizing these linkages, researchers can see how different areas of study influence each other, revealing interdisciplinary connections and potential collaboration opportunities.

Performance Analysis of Topics

Performance Analysis: SciMAT includes tools for assessing the performance of different research topics. Metrics such as citation counts, publication volume and impact scores can be used to evaluate the significance and influence of various themes within the scientific community.

RESULTS

Descriptive Analysis

As detailed in the methodology section, we identified 153 publications in the Web of Science database on GIs and Sustainability. The distribution of publications in the period of analysis (2006 to 2023) is illustrated in Figure 2. In 2006 (first year of the series), only one article was published on the topic of interest. The number of works remained low until 2008,

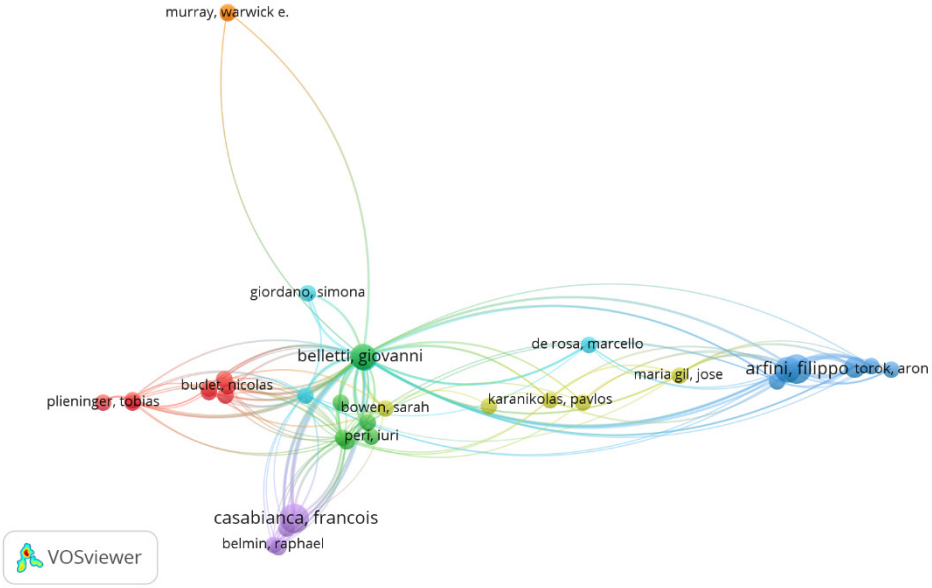

Figure 4: Map of authors Citation. Source: VOSviewer from Web of Science - Own Elaboration.

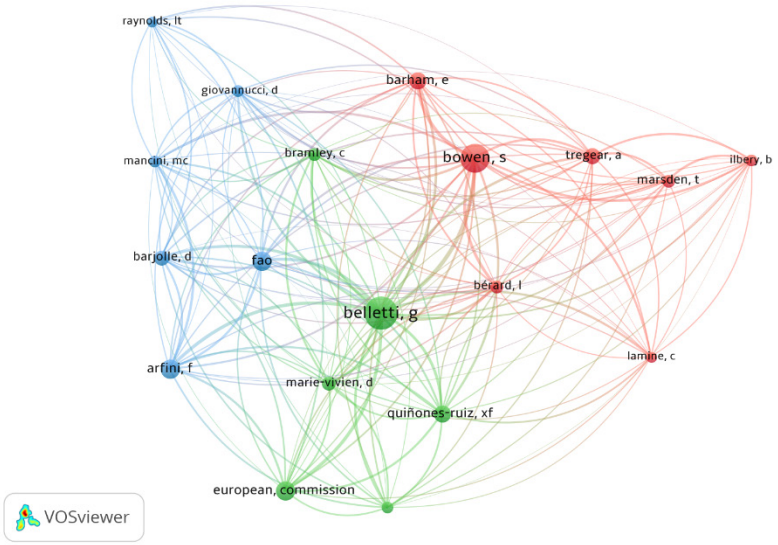

Figure 5: Co-citation analysis between author clusters. Source: VOSviewer from Web of Science-Own Elaboration.

Table 1: Number of publications and citations of the main researched authors.

Authors	Publications	Citations	h-index	Average
Arfini F	5	61	3	12.2
Casabianca F	5	56	4	11.2
Belletti G	4	250	4	62.5
Mancini MC	4	89	2	22.3
Marescotti A	3	250	4	62.5
Gil JM	3	91	2	30.3
Guareschi M	3	60	1	20.0
Lebret B	3	147	1	49.0

Source: Web of Science-Own elaboration.

presenting an average of four publications per year. From 2019 to 2023, the average number of publications rose to 22 and shows a linear growth trend as shown as the red line on the graph.

The origin of the articles is concentrated in Europe, with Italy being the country that publishes the most in the area (36), followed by France (29), Spain (20) and Portugal (9). These countries have a long tradition in granting GIs, with France being credited with the first historical record, in 1776. Italy and Portugal also have a strong tradition in granting GIs for food products, especially cheeses, wines and, olive oil.

Outside Europe, China (10), Mexico (8), United States (8) and Brazil (7) stand out. Brazil and the United States, despite the low number of publications, compared to European countries, have a high number of citations, 332 and 4884, respectively. The map in Figure 3 indicates the countries that cited the articles studied and it is important to note that Italy, France and Spain are the core of relations between Europe and America.

According to the analysis of the information, Arfini F and Casabianca F are the authors who published the most on the topic of GI and sustainability (five articles each, 6.7% of the total). However, the most cited author was LAmbin EF, who has Only two publications, the article "*Effectiveness and synergies of policy instruments for land use governance in tropical regions*" (Lambin *et al*., 2014), which considers GIs as a policy instrument public policy to promote sustainable development in tropical countries, the most cited (267).

Table 1 shows the eight authors with more than two published studies for a total of 518 authors. In addition to the number of publications, the table also shows the number of citations for each author, the h-index and the average number of citations. It is noted that Lambin EF, the most cited author, does not appear in the table, due to having only two articles on the topic of interest. The Hirsh index, or h-index, was included for each author. This is a measure of the professional quality of authors based on the number of times their scientific articles have been cited.[50]

Although Table 1 shows the authors who published the most on the topic of interest to this research, their works are not among the most cited. The most cited paper, as previously mentioned, was that of Lambin EF. The research is a collaboration between authors from the United States and Latin America countries, which evaluates hybrid public policy instruments, such as GIs, which regulate land use, promoting sustainable development.

The second most cited paper is "*Geographical indications, terroir, and socioeconomic and ecological sustainability: The case of tequila*",[33] with 166 citations. In this work, the authors use the case of tequila, which hac its GI recognized in 1974, as a parameter to examine the potential of GIs to contribute to sustainability. They showed several limitations of GI in contributing to economic sustainability. These limitations are linked to factors such as economic insecurity of agricultural families, increased use of chemical inputs and failure to follow traditional production practices. Figure 4 shows the most cited authors, with at least four published works on the topic of interest, with emphasis on Arfini F, Casabianca F and Belletti G.

The relational Citation analysis carried out using Co-citation and bibliographic coupling methods allowed us to analyze and understand the structural relationships of theoretical-methodological connectivity of the research domain under study. Co-citation identifies the connection or similarity of two cited documents, through their reference list of citing authors.[51] The bibliographic coupling technique does the opposite. It occurs when two articles reference at least one publication in common, establishing a connection between these two works, by using the same reference. The joint analysis of the two indicators can highlight the latest research fronts in the area of interest.

In relation to Co-citation analysis, it is possible to identify three clusters of authors who are systematically cited by other works. The first is led by author Belletti G. This cluster analyzes issues related to sustainable development, geopolitics and the use of GI as an instrument of public and territorial policy. The second cluster is led by Arfini F. His work points to a connection between researches that explores themes linked to agriculture and food. This collaboration suggests a shared concern for food security,

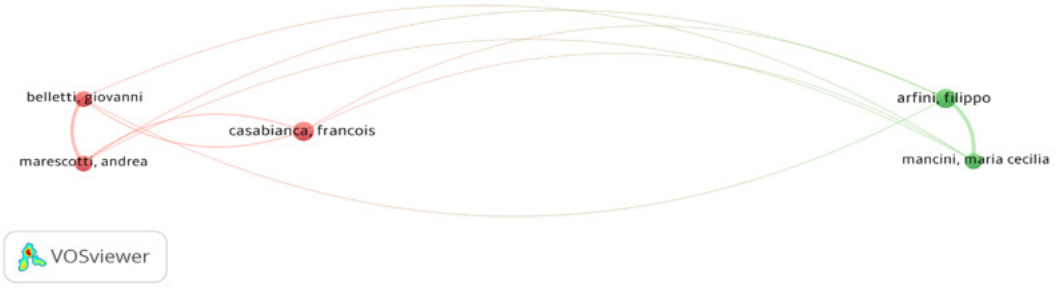

Figure 6: Bibliometric coupling analysis between author clusters. Source: VOSviewer from Web of Science-Own Elaboration.

sustainable agricultural practices and issues related to sustainable rural development.

The third cluster, represented mainly by Bowen S and Barham E, forms a network that transcends conventional disciplinary boundaries. This indicates that they collaborate in areas of research that address complex and interrelated topics, possibly combining elements of social sciences, economics and humanities. They argue that GIs can be important instruments for environmental and diversity conservation, offering an opportunity to think about agriculture in a more sustainable way, through an innovative approach that conserves biodiversity and traditional knowledge.[52] Figure 5 illustrates these relationships, highlighting the commented authors.

The bibliometric coupling analysis demonstrates the authors who produced syntheses on GIs and sustainability that brought together a body of literature, demonstrating how the structure of this research lines reflects the diversity of theoretical approaches.

Using the parameter of at least four documents per author, we identified two clusters that are systematically cited by a set of works. The first cluster is led by Arfini F. Her work seeks to understand GIs as public policy instruments to promote sustainable development, especially in Europe.

The second cluster is formed by four authors: Balletti G, Marescotti A, Mancini MC and Casabianca F. The works produced by the cluster strengthen the link between traditional products, designed through GIs and sustainable development. They evaluate the entire agri-food system chain of certain GIs, such as the Corsican grapefruit[53] or specific sectors, such as artisanal cheeses,[54] to understand the impact of implementing the GIs in various aspects of sustainability, especially economic and social aspects. Figure 6 demonstrates these clusters and their interactions.

These themes highlighted the complexity of Co-citation networks and bibliographic coupling between the mentioned authors. The interconnection of ideas and collaboration in different fields of study highlight the interdisciplinary nature of contemporary research in the area of GIs and Sustainability, where boundaries between disciplines are often crossed to address complex and globally relevant problems. The Synergy between these authors contributes to the construction of a rich and diverse body of knowledge on the topic of interest.

Longitudinal Analysis

For the purposes of longitudinal analysis, the study period was divided into three blocks (2008-2012, 2013-2018 and 2019-2023). In the last block there is a gradual increase in the number of publications. The year 2021 was the year that presented the most articles on the topic of interest, with 26. However, the 10 most cited works are found in the first and second block. Figure 7 shows the number of publications analyzed for each period.

The first strategic diagram, 2006-2012, represented by Figure 8, exposed only one focal theme: Geographical Indications, which had high centrality and density. Centrality measures the dree of interaction with other research networks. It also measures the strength of external ties with other themes, analyzing their importance in the development of the analyzed research field.[55] On the Other hand, density measures the internal strength of the network among all the keywords that describe the research topic. In Other words, it is a measure of development of a given theme.

Despite the scarcity of themes captured by the SciMat algorithm, given the limited number of articles in the period (only eight), Figure 8 illustrates that the theme has links with themes related to Sustainability, Rural Development, Places and other Products. Some of these themes became focal in later periods. The number five represents the frequency of documents published in the period, with the term Geographical Indications.

The most cited works from this period are "*Geographical indications, terroir, and socioeconomic and ecological sustainability: The case of tequila*", with 166 citations, "*Contesting the neoliberal project for agriculture: Productivist and multifunctional trajectories in the European Union and Australia*",[56] with 127 citations. Both works highlight the importance of GIs for promoting sustainable development in various Fields, including agriculture and sustainable rural development.

The second block of analysis, 2013 to 2018, presented three topics of interest, two focal themes (Geographical Indications and Government) and one emerging theme (Impacts). "Government" is related to research that analyzes policies and legislation that

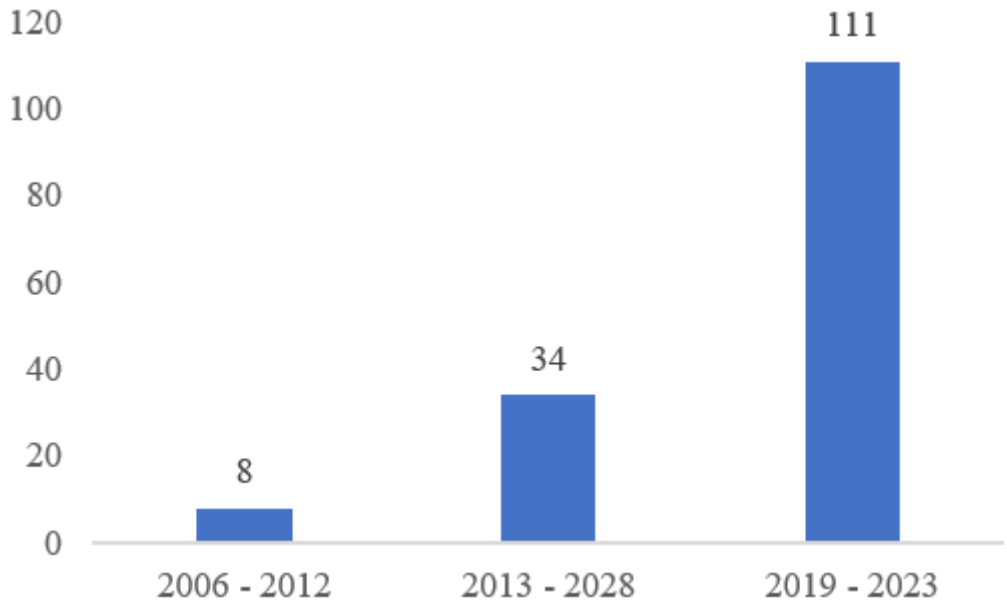

Figure 7: Number of articles per period of time. Source: Web of Science, 2023.

define the criteria for granting and protecting GIs, which is crucial to guarantee the reputation of products associated with these indications. Among the most cited articles from this period and consistent with this theme, the following stand out: *Effectiveness and synergies of policy instruments for land use governance in tropical regions*,[57] *Geographical Indications, Public Goods, and Sustainable Development: The Roles of Actors Strategies and Public Policies*[58] and *Linking protection of geographical indications to the environment: Evidence from the European Union olive-oil sector*.[59] The three publications deal with the interdependent and synergistic relationship between IGs and government management.

"Impacts" (emerging theme) is related to studies that aim to estimate possible impacts of implementing GIs in territories. Examples of works in this sense are *Factors Constraining Building Effective and Fair Geographical Indications for Coffee: Insights from a Dominican Case Study*[60] and *Geographical Indications: A Corner Stone in Poverty Alleviation and Empowerment in the Indian Himalayan Region*.[61] Figure 9 demonstrates the topics of interest in the period from 2013 to 2018.

In the last period (2019 to 2023), the topics of interest increased dramatically (27 themes), with emphasis on the terms "Geographical Indications" (as a basic theme, quadrant 3,) "Sustainability" (as a focal theme, quadrant 2) and "Sustainable Development Goals"-SDG (as a peripheral theme, quadrant 1). Other focal themes are "Rural Development", "Government", "Agriculture" and "Scientific Prospecting". As emerging themes, the terms "Landscape" and Intellectual Property stand out.

The Geographical Indications, in this period as a basic theme, stands out once again both in density and centrality, becoming a guiding theme in this field of research. Among the most cited articles from this period and consistent with this theme, stands out *Are Geographical Indication Products Fostering Public Goods? Some Evidence from Europe*[62] by correlating the generation of public goods incorporated in products with GIs regarding cultural heritage issues, socioeconomic themes and natural resources.

Regarding the focal themes, the article *Quality and origin of mountain food products: the new European label as a strategy for sustainable development*[63] is one of the most cited and works on the relationship between the themes of rural development and sustainability at the European level. In the same line, the article *Are Protected Geographical Indications Evolving Due to Environmentally Related Justifications? An Analysis of Amendments in the Fruit and Vegetable Sector in the European Union*[64] presents an evolution of the geographical indication of fruits and vegetables in Europe in the development of a new market.

Regarding emerging themes, the term "Landscape" stands out, which is addressed in the discussion of the article *Labelling in Mediterranean agroforestry landscapes: a Delphi study on relevant sustainability indicators*[65] how geographical indication can be added to the labeling of agroforestry products in a sustainability bis even though this was not the initial purpose of creating the GIs, according to the authors. Figure 10 illustrates the strategic diagram for the period from 2019 to 2023, highlighting the themes related to publications in the series.

DISCUSSION

As mentioned in the methodological section, 153 publications were selected from the Web of Science database, distributed across 25 major areas of knowledge. The main area, "Environmental Studies", has 49 works (32.3%). Next comes the area of

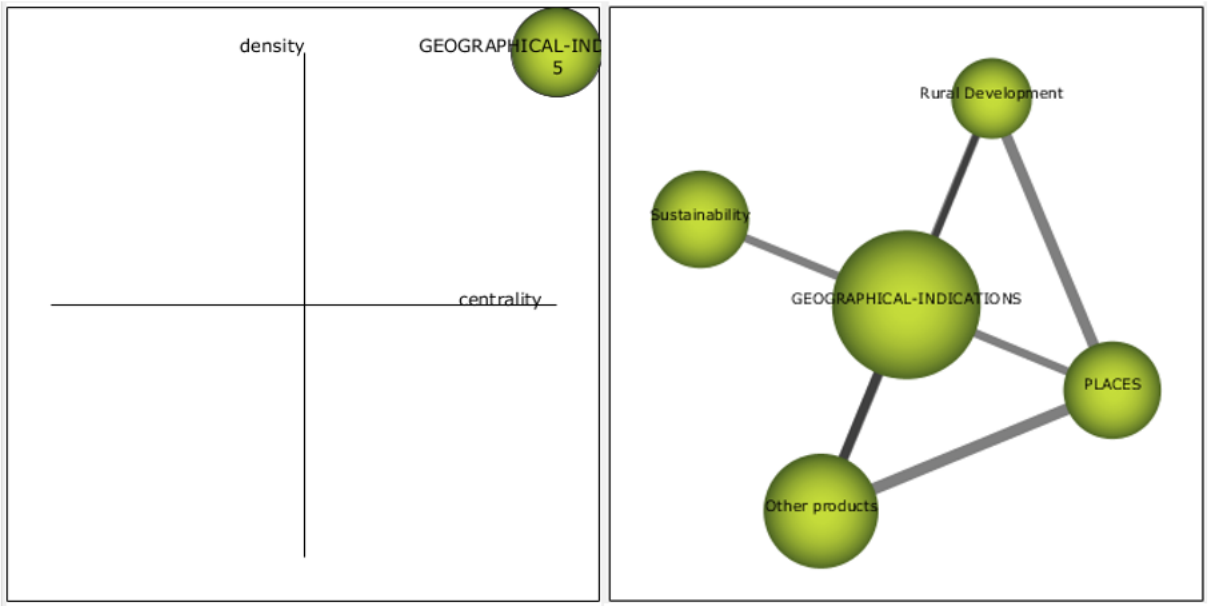

Figure 8: Strategic Diagram (2006-2012). Source: SciMat from Web of Science-Own Elaboration.

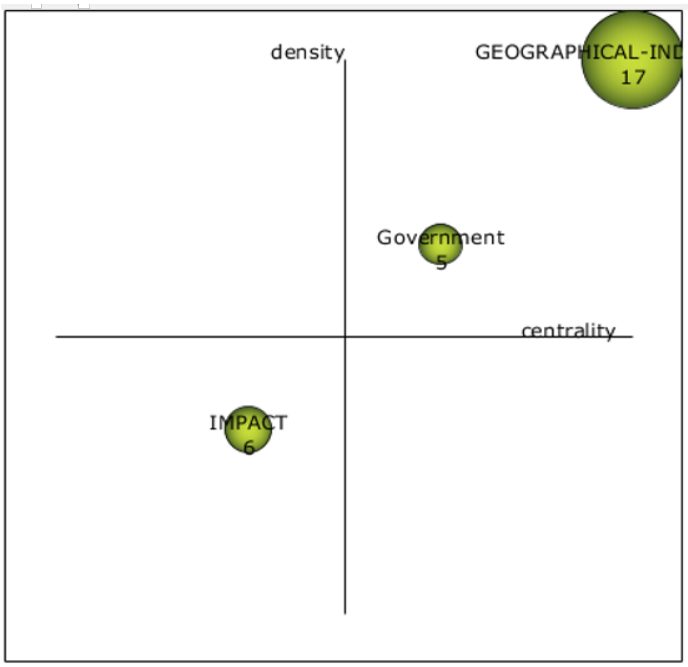

Figure 9: Strategic diagram (2013-2018). Source: SciMat from Web of Science-Own Elaboration.

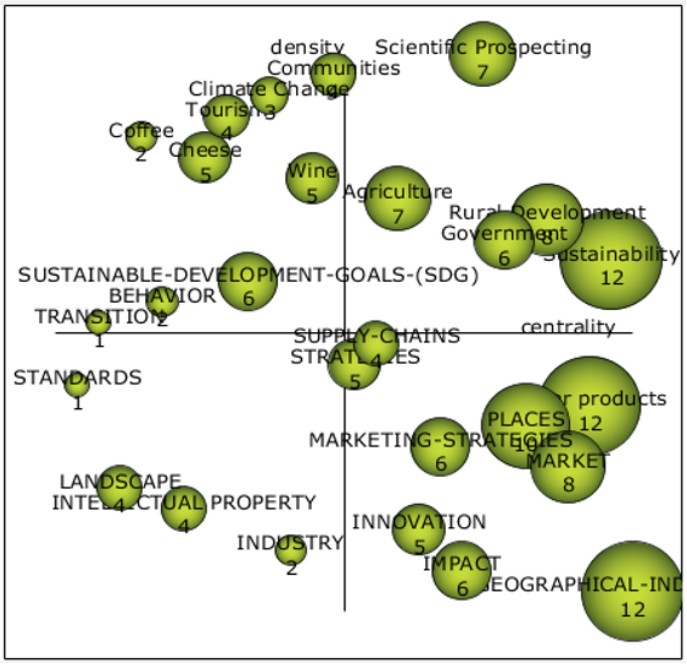

Figure 10: Strategic diagram (2019-2023). Source: SciMat from Web of Science-Own Elaboration.

"Environmental Sciences" with articles (30.1%) and "Green Sustainable Science Technology" with 40 publications (26.1%).

Fourteen of the 20 most cited articles on the topic of interest were generated between 2013 and 2018, with high h-index values. The most cited documents have a direct Affinity with the study of GIs and their relationship with sustainable development, covering peripheral themes such as SDG and the impacts of studies on specific GIs, such as wine and cheese. Emerging themes such as "Landscape" and "Intellectual Property" re also recurrent, accentuating the close relationship between GIs and sustainability.

At the end of the analysis, it was found that the most developed and most important theme for Building knowledge in the scientific field of interest in this research (except for Geographical Indications) was "Sustainability", which has strong centrality and high density. By analyzing the keyword co-occurrence network, it was possible to verify that the research is focused on the various dimensions of sustainability (economic, environmental and social) in the most diverse studies on GIs, from those that address more traditional issues, such as, for example, feasibility analysis of implementing GIs,[6,66] to studies that relate GIs as an instrument

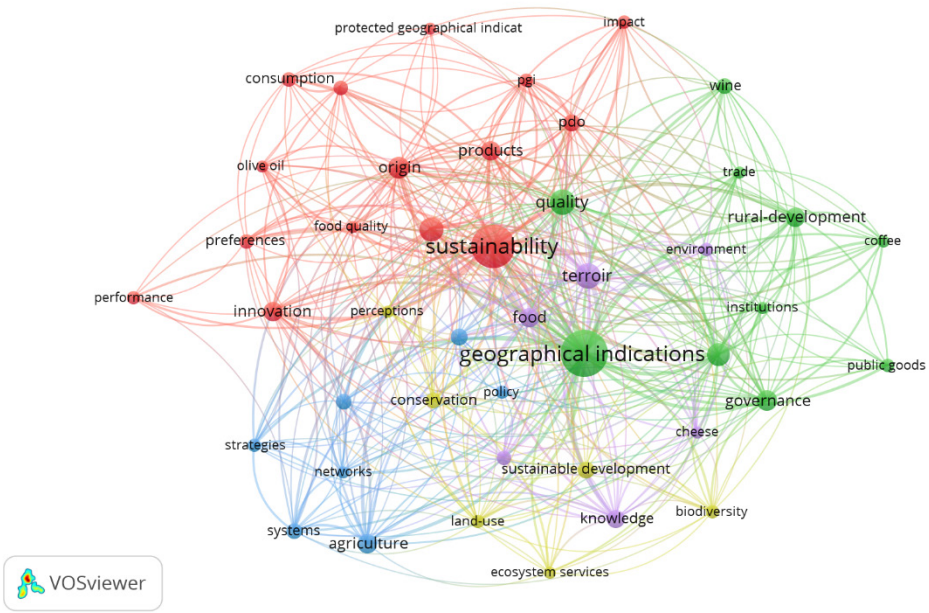

Figure 11: Strategic map of key words. Source: VOSviewer from Web of Science - Own Elaboration.

of public policies and drivers of sustainable development,[67] as well as post-implementation impact analysis research of GIs.[68-70] The diagram in Figure 11 complies the main key terms of interest, highlighting Sustainability and geographical indications.

Research on environmental Sustainability is concentrated in the areas of "Environmental Studies", "Environmental Sciences" and "Geography". In these areas, the main work is associated not only with the protection of traditional knowledge, but especially with the preservation of biodiversity and the sustainable management of natural resources such as.[71-73]

In relation to the social dimension, the main work is concentrated in the broad areas of "Food Science Technology", "Regional Urban Plan" and "Agriculture". In the first one, in addition to concerns related to the quality of products from GIs,[74,75] there are also concerns of a social nature. Verdi,[76] discussed how urban and industrial expansion provides negative externalities for the planting of grapes for wine production in the countryside of the state of São Paulo, Brazil.

In "Regional Plan" knowledge area, aspects of cultural preservation and local identity,[73] environmental conservation[15] are discussed, as well as research on the opportunities and challenges of implementing GIs.[31] These require an interconnection between adequate infrastructure, Community education and legal protection. Overcoming these obstacles requires a collaborative approach between governments, non-governmental organizations and local communities.

In the economic sphere, publications are concentrated in the areas of "Economics" and "Agricultural Economics Policy". In general, the works discuss the role of GIs in different aspects. Belletti[58] analyzed the process of implementing GIs as a public policy instrument. Focusing on the wine and coffee value chain, the authors showed how products with a protection seal contribute to improving the provision of public services and illustrate how this contribution can be threatened by failures that can occur in valorization strategies and in legal protection policies.

There are also studies that analyze the role of the state in the legal protection process. These researchers illustrate how GIs, if properly supported by the State, can serve as instruments for economic, social and environmental development. Therefore, there is applied research to identify the economic and social impacts of protected products, such as olives, wines and olive oil in the regions of origin, especially in Europe.[77-79]

It is also important to highlight the Evolution of key terms, which conditioned studies on GIs and sustainable development in the periods analyzed. In the first period (2006 to 2012), the Geographical Indications theme was observed as a focal theme, that is, a well-developed and important subject for the construction of the scientific field. In the second period (2013 to 2018), the topic continues to be highlighted and in the same position. However, the "Impact" theme is consolidated as an emerging topic. The emerging themes are characterized as exploratory and discursive research, that is, they are initial works that explore perspectives that may become important in the future for the research field of interest.

In the last period (2018 to 2023), topics of interest proliferated, expanding research on GIs and sustainability to address aspects such as SDG (peripheral topic) and "Intellectual Property"

(emerging topic). The topic "Impact" went from an emerging theme to a basic theme, that is, there was the consolidation of studies aimed at analyzing the externalities brought to the territories after the implementation of GIs.

This observation is corroborated by the emergence of recent research, concerned with measuring the social, economic and institutional impact caused by GIs in their respective locations. Vakoufaris and Gocci[36] examined the impacts of implementing four product categories in the fruit and vegetable sector in Europe. Using a series of indicators to measure the economic, social and environmental dimensions, they concluded that the protection seal had successful results, especially with regard to improving product innovation processes and business and, marketing processes.

In a more specific study Poetschki *et al.*,[77] analyzed the impact of GIs on agricultural income in the olive and wine sectors, also in the European Union. The central hypothesis of the article was that GIs increase the value of the sector's agricultural exports, especially in less favored areas of Europe. Using statistical analysis, the authors showed that the adoption of the protection sign significantly improved producers' earnings from wine and olive oil exports, positively impacting economic and social indicators.

In the same manner Mancini *et al.*[80] verified the technological and innovation-related impacts Applied to agri-food systems carrying the product Parmigiano Reggiano (PR), in Italy, which has a recognized GI. The PR system is recognized worldwide in terms of Governance, territorial reputation and quality perceived by consumes. The article analyzed three determinants: consumer needs, value chain, strategies and rural development. The research results showed that the main aspect perceived for maintaining product quality and the economic value of production is government action.

Recent studies, as well as the interdisciplinary topics highlighted by this research indicate that future perspectives for study of GIs are aimed at assessing impacts on the economic, social, environmental and institutional dimensions of sustainable development. In some countries, such as Brazil, there are already institutions that have specific sectors to deal with, which some authors are already calling "Post-GI Analysis",[5,81] such as the Brazilian Agricultural Research Corporation (EMBRAPA)[1] and the Brazilian Micro and Small Business Support Service (SEBRAE)[2].

CONCLUSION

The bibliometric analysis showed that the topic of GI and Sustainability has become a relevant topic in several areas of research, especially in recent years. It was possible to demonstrate the development of the research field, starting from a broad perspective to a more specific analysis. GI initially appears as an isolated topic, aimed only at predetermined communities and territories. However, over the Years, the topic has evolved, becoming and important public policy instrument and a vector of regional growth and development.

The present study shows the Evolution of scientific research on GIs, Sustainability and sustainable development between 2006 and 2023, according to publications available on Web of Science. The study analyzes the trend, considering a broad view of three distinct intervals over times from 2013 to 2018 and 2019 to 2023, periods in which the works had the most citations and the greatest number of publications, respectively. The countries with the most published articles are Italy (36) and France (29), confirming Europe as the cradle of GIs tradition. However, the articles that have the most citations come from America, specifically the United States (484 citations) and Brazil (332), countries Where GIs have spread, especially in the last decade.

The areas that most concentrate publications on the topic of interest were "Environmental Studies" (49), "Environmental Science" (46) and "Green Sustainable Science Technology" (40). The journal with the largest number of articles is Sustainability, with 35 publications, approximately 23% of the total research. The remaining works are distributed in over 106 articles published in periodicals, 11 conference papers and three books.

The analysis shows that the topic discussed in this research, despite being important, is still little discussed and still needs to be explored in some parts of the world, such as Asia (with the exception of China, which has 10 publications), but especially Africa, where we identified practically no research (with exception of one article from South Africa and another from Kenya). The limitation in the number of research in these regions can be explained by the lack of resources, challenges related to infrastructure and lack of regional cooperation. Particularly in Africa, the history of colonial exploitation, coupled with socioeconomic challenges, may have negatively impacted local communities, reducing the ability to develop and promote GI-based products.

The most frequent lines of research are "Environmental Sciences Ecology", "Science Technology Other Topics", "Agriculture", "Food Science Technology and Geography". These lines, in accordance with the objectives of this research, tend to understand GIs as institutions that drive sustainable development and partners in the pursuit of sustainability objectives. According to the current analysis, we believe that the field of study (GIs, Sustainability and sustainable development) addresses four main axes. The first focuses on local socioeconomic impacts. This axis analyzes how GIs can influence the socioeconomic aspects of local communities. This includes creating Jobs, increasing local income, preserving traditional cultural practices and promoting social inclusion.

The second axis focuses on the impacts of GIs on environmental conservation and the promotion of biodiversity. The studies involve the analysis of sustainable agricultural practices, natural

resource management and preservation of local ecosystems associated with GI products. The third axis addresses issues related to the Governance of GIs, including the effectiveness of legal systems in protecting these indications. This involves analyzing existing laws, their practical application and their effectiveness in preventing misappropriation of geographical designations. And finally, the fourth axis, which was identified mainly in the most recent studies, which are the analyzes of the impact of the implementation of GIs. These studies, according to this work, are the current front of research in the area of interest, with the possibility of developing innovative and interdisciplinary studies.

Another important implication of the study is related to the change in positioning of the term Geographical Indications in the longitudinal analysis. In the first period analyzed (2006-2012), it was a focal theme, associated with "Rural Development", "Sustainability", "Miscellaneous Products" and "Localities". From the second period onwards (2013-2018), it was still presented as a focal theme, however, with a greater level of density and centrality, indicating the gain of academic interest in the topic.

From 2019 to 2023 (Third period of analysis), the term Geographical Indications went from a focal theme to a basic theme, that is, it continued with high centrality (an important theme and well connected with other themes), but with low density (Important topic, but not yet completely developed internally). The study confirmed this change in behavior, since, from 2019 onwards, several themes, adhering to GIs, began to be developed, such as impact analysis and post-GI analysis.

Because of this, future research should aim to develop innovative methodologies for analyzing the social, economic, environmental and institutional impacts of GIs on the territories they were granted. The evaluation of these indicators, through methods that offer greater accuracy, as well as greater possibilities for inference, can help communities, producers, government and investors to participate more actively in the process of granting and developing new GIs.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

[1]EMBRAPA has a consolidated methodology for evaluating post-GI, successfully used in the analysis of the externalities of the first GI granted in Brazil, in "Vale dos Vinhedos" (Wine Valley), in the south of the country.

[2]SEBRAE also has a consolidated methodology to analyze the feasibility of implementing GIs.

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