Technological Indicators and Plant Biodiversity: Systematic Review

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Abstract

The use of plant biodiversity in the elaboration of products or processes contributes to the progress of technological innovation and to the recognition of the profitable potential of biological resources. Therefore, this research aims to perform a systematic review on technological indicators of the use of *genetic patrimony, specifically of vegetal biodiversity, to identify concepts and measurement techniques. A systematic survey was carried out at the bases of Scopus, Web of Science, and Science Direct using thematic strings (Genetic Patrimony, Plant Biodiversity and Technological Indicator). The recovered files were exported for analysis in StArt software. There was no mention of the topic, so the systematic review analyzed articles selected by combining strings adopting inclusion and exclusion criteria. The research made it possible to identify relevant and guiding data on the subject studied, but did not reveal the existence of an indicator or index that relates the use of vegetal biodiversity to the production of patents.*

Keywords: scientific production, technological innovation, patents.

1. Introduction

Technological researchs on the use and access of plant biodiversity are extremily important for intellectual property, since it allows to assess the use of biodiversity and its significant role in the economic development of a country (ROQUE, ROCHA, LOIOLA, 2010; SEN et al. , 2011). Plant biodiversity is a source of raw material for industrial property, whose demand for modern and innovative products contributes to and favors the recognition of the profitable potential of biological resources (FERRO, BONACELLI, ASSAD, 2006).

The products and procedures invented from the genetic patrimony, coming from biodiverse countries, pass into the private and exclusive domain of the owners of intellectual property rights, strategically expanding the importance of biodiversity for the development of Science, Technology & Innovation (CT & I) (STÉFANO, 2013).

However, to assess the situation of biodiversity, Research & Development (R & D) is essential the analysis of indicators (FARIA, BESSI, MILANEZ, 2014). The information obtained through the analysis of the indicators allows systematically describing, classifying, comparing or quantifying aspects of a reality, reflecting the state or diagnosis of the object studied in order to implement public policies, plans and programs (BRASIL-SPI , 2009).

Indicators are methodological resources, quantitative or qualitative measures, used to organize and capture relevant information, designed to facilitate the understanding and monitoring of complex systems, or a specific and global phenomenon (CARDOSO, MACHADO, 2008; FARIA, BESSI, MILANEZ , 2014).

The analysis of the use of genetic resources and their technological application can be obtained by crossing data between the indicators of technological innovation and those of biodiversity, this information can enable the monitoring of global biodiversity and the modeling of scenarios on the technological use of the same (JONES et al., 2011; CORADIN, SIMINSKI, REIS, 2011).

Therefore, the objective of this work is to perform a systematic review on technological indicators related to the use of genetic patrimony, specifically of vegetal biodiversity, to identify concepts and techniques for measuring these indicators. Since the systematic review is a potential tool for analyzing scientific and technological production, and through quantitative and comparative methods it is possible to follow the historical and scientific evolution of this topic, identifying profiles (academic, scientific and technological) and assisting in the verification of novelties or gaps in scientific knowledge.(SACARDOS, HAYASHI, 2013, ALMEIDA, OLIVEIRA, RUSSO, 2016 and MOSCARDI, 2017).

2. Theoretical foundation

2.1 Indicators of Technological Innovation

The term technological innovation is used to refer all novelty applied to products or processes, implanting in the productive sector new knowledge or technologies (OECD, 2004).

The indicators of scientific and technological production presented an important rise as tools for analysis of the innovation activity and its relations with economic and social development, for this reason the construction of quantitative indicators has been encouraged by international organizations to promote research as a means to obtain a more accurate understanding of the orientation and dynamics of science, in order to subsidize the planning of scientific policies and evaluate their results (MORAIS, 2008, CRUZ et al, 2017).

The indicators of Science, Technology and Innovation (ST&I) are tools created to measure the innovative performance of a country and develop public development policies (GRUPP, MOGEE, 2004).

Patents can be one of the indicators of the outcome of research activities because the number of patents granted per company or country may reflect its technological dynamism, while patent class analyzes provide important information on technological changes, market failures and opportunities, and also helps in the analysis of the scenario of investments in R & D of countries and companies, proving to be effective for the scientific and technological monitoring (ALBUQUERQUE, 2000, OECD, 2004, BORGES, SANTOS, GALINA, 2008).

2.2 Indicators of Biodiversity

Biodiversity indicators represent tools for assessing events, trends and progress in the use of natural resources and related human activities (MMA, 2014). Their methods and systematization of data collection may be fundamental to infer about the probable changes in the state of the environment (BALMFORD et al., 2008; YOCCOZ et al., 2001).

These indicators provide selected scientific and statistical information to represent some aspects of the state of the environment (MMA, 2014). They may be direct metrics, such as relative abundance of species, or they may be composite metrics that combine data from a number of different monitoring programs (COLLEN et al., 2009).

The systems for identifying and monitoring the components of wealth and biological diversity are fundamental to the conservation and sustainable management of genetic resources, since environmental heterogeneity characterizes an integrated response of vegetation, climate and soil conditions. species is directly related to the productivity of terrestrial vegetation (COOPS et al., 2009 a).

Indicators of plant biodiversity are more adequate to monitor and evaluate the protection of species, and when associated with other indicators can help in the management of sustainable development policies, environmental and ecological, health, among others (IBGE, 2015). According to IBGE (2015), these indicators can be represented by three parameters: extinct and endangered species, protected areas and invasive species.

In Brazil, the Ministry of the Environment drafted a National Panel of Environmental Indicators (PNIA-2012) to measure and report on existing pressures on the environment and also the influence and impact of society on the conservation and conservation of the same (MMA, 2014). This panel presents 34 indicators divided into the following themes: Atmosphere and climate change; Governance, risk and prevention; Sustainable production and consumption; Environmental Quality; Earth and soil; Water resources; and Biodiversity and Forests, the latter with eight indicators (Table 1).

Table 1 - Biodiversity and Forests Indicators Panel, PNIA 2012

Indicator	Responsible Organization
1 Endangered species of fauna represented in Federal CUs	ICMBio
2 Wildlife species threatened with extinction with recovery action plans and Conservation	ICMBio
3 Remaining native plant cover	SBF
4 Annual deforestation by Biome	IBAMA
5 Heat focus	IBAMA
6 Territorial coverage of the Nature Conservation Units	SBF
7 Territorial coverage and population served by the Bolsa Verde Program	SEDR
8 Area of public forests intended for community use and management	SFB

Source: Adapted from MMA (2014). Caption: Chico Mendes Institute for Biodiversity Conservation - ICMBio; Inst. Bras. the Environment and Renewable Natural Resources - IBAMA; Secretariat of Extractivism and Sustainable Rural Development - SEDR; Brazilian Forest Service - SFB.

3. Methodology

A systematic survey was carried out between October and December 2018, using keywords correlated to the subject of study (Table 2). Followed by a systematic review based on the Systematic Search Flow method (FERENHOF, FERNANDES, 2015).

The keywords selected were "genetic patrimony," "plant biodiversity," and "technological indicators," which were translated into English and searched for their synonyms on the Thesaurus website. For these keywords, search strings were later investigated in the Web of Science, Scopus and ScienceDirect databases, and the string calibration was performed on the Web of Science (Table 2) website.

Table 2. Systematization of search keywords and strings

Keywords in Portuguese	Keywords in English	Synonyms	Strings
Patrimônio Genético	Genetic Patrimony	No synonyms	patrim*n*AND gen*tic
Biodiversidade Vegetal	Plant biodiversity	No synonyms	Biodiversi* AND (plant* OR vegeta*)
Indicador	Indicator	Index	indicat* OR index

Tecnológico	Technological	Technology Technological	Technolog* OR Tecnolog*

The Web of Science (WOS) website is one of the leading multidisciplinary bibliographic platforms and provides reliable access through citation metrics and linked content from various sources, as well as following a rigorous evaluation process, presenting only the most influential information, relevant and credible (BAKKALBASI et al., 2006).

The Scopus database is one of the largest database of abstracts and citations of peer-reviewed literature, which presents a comprehensive view of the results of global research in the fields of science, technology, medicine, social sciences and the arts and humanities, providing intelligent tools for track, analyze and visualize the research (SCOPUS, 2018). Science Direct is a platform for access to approximately 2500 scientific journals and more than 26000 e-books, operated by the Anglo-Dutch publisher Elsevier.

To verify the novelty on the theme "Technological indicators of the use of genetic patrimony and/or vegetal biodiversity" a quantitative criterion was used. It was considered unpublished on the theme when the combination of the strings referring to the keywords in question (Genetic Patrimony, Plant Biodiversity, Technological Indicator) in the three bases surveyed reached results equal to zero in the systematic survey, since, this fact indicates absence of publications .

The data of the rescued articles using the combination of the strings were imported for analysis using the JabRef and StArt Software 3.4. For a systematic review, only those that met the following inclusion criteria were selected: the document was of the type article, had been published in the last 10 years, had a quality score greater than 25 points, and the researches were correlated with biodiversity or description of concepts or methodologies.

The quality score was calculated according to the StArt program standard, where the words of interest in the title (5 points), the summary (3 points) and the keywords (2 points) were scored.

The exclusion criteria in the selection were the document not being of the type scientific paper published in periodical with Qualis Capes, being outside the temporal period of 2008 to 2018, not to obtain score superior to 25 points (value based on the amplitude of the scores found in this research) , and the exclusion criteria in the extraction stage were not available in the full text or in the English, Spanish and Portuguese languages.

In the data extraction stage, the translation and partial reading of titles and abstracts of the articles selected for systematic review were performed, according to inclusion and exclusion criteria (Figure 1). The Reading Strategy after the extraction of the articles was to identify in the summaries and later in the objectives and methodologies of the complete texts the approach on indicators of plant biodiversity and/or associated technological indicators.

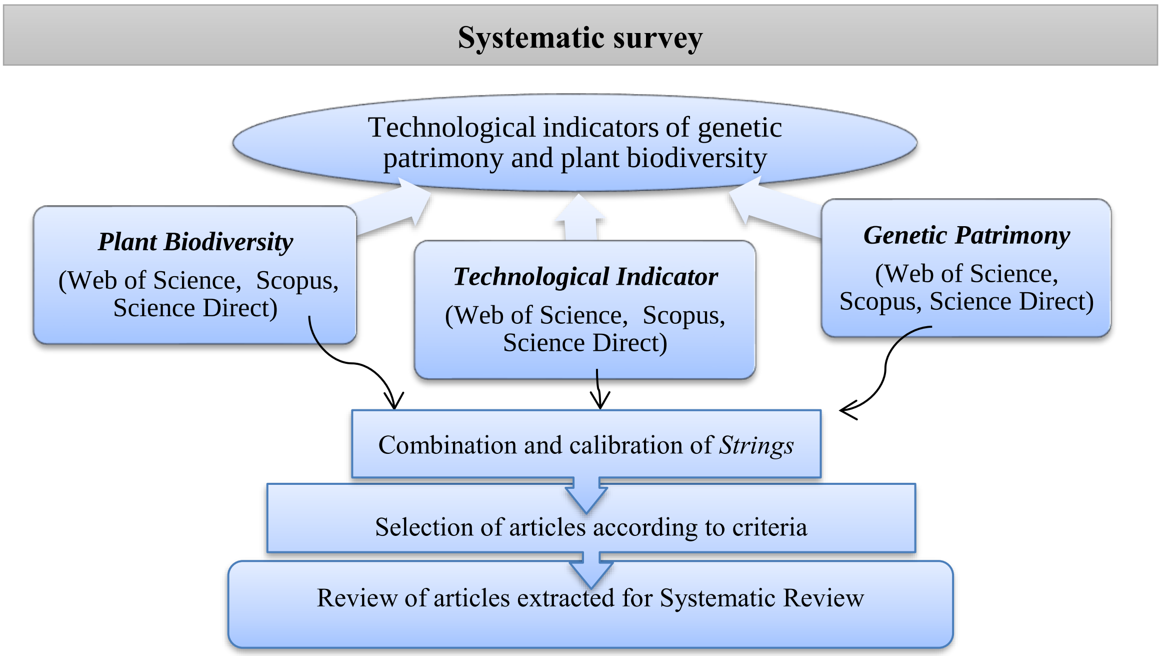

Figure 1. Research protocol (Prisma).

4. Results and Discussions

4.1 Systematic Survey

There was a systematic review of a wide publication on the themes Plant biodiversity (n = 1) and technological indicators (n = 3). Plant biodiversity was highlighted in Scopus (37,552) and in the Web of Science (33,811), while the Technological Indicator was the highlight of Scopus (62,464), the publication index for Genetic Patrimony (n = 2) was much lower , in the three bases, in relation to the other strings.
Among the combinations of themes, plant biodiversity and technological indicators (n = 6), or strings 1 and 3, had the highest number of publications, of which 92 were articles in the Web of Science and 152 in Scopus, while the combination of issues of plant biodiversity and genetic patrimony (n = 5), retrieved a few articles, Web of Science (3) and Scopus (7).
As for the combination of the terms Technological Indicators and Genetic Patrimony (n = 7) resulted in only one article (Table 3). The combinations of the three main strings resulted in zero publication, in the three bases surveyed, it was verified, then, the novelty on Technological indicators of genetic patrimony and plant biodiversity.

Table 3 –Systematic mapping to identify scientific panorama on the themes plant biodiversity, genetic patrimony and Technological indicator.

N	*Strings*	Web of Science	Scopus	Science Direct
1	(biodiversi* AND (plant* OR vegeta*))	33.811	37.552	50
2	((genetic) AND (patrimony))	45	61	132
3	((technolog*) AND (indicator* OR index))	37.438	62.464	934
5	Combinação dos *strings* 1 AND 2	3	7	0
6	Combinação dos *strings* 1 AND 3	92	152	1
7	Combinação dos *strings* 2 AND 3	1	0	0
8	Combinação dos *strings* 1 AND 2 AND 3▪	0	0	0

Source: Prepared by the authors, elaboration based on searches realized in October of 2018, in Web sites of Science, Scopus, Science Direct. Note: ▪ significant truncations referring to the objectives.

4.2 Systematic Review

Faced with the lack of publications on technological indicators of genetic patrimony and plant biodiversity, the review was carried out with the articles found in the combinations of the three thematic strings. Therefore, 256 articles were exported for analysis, being 96 articles from Web of Science, 159 from Scopus and 1 from Science Direct (Figure 2).

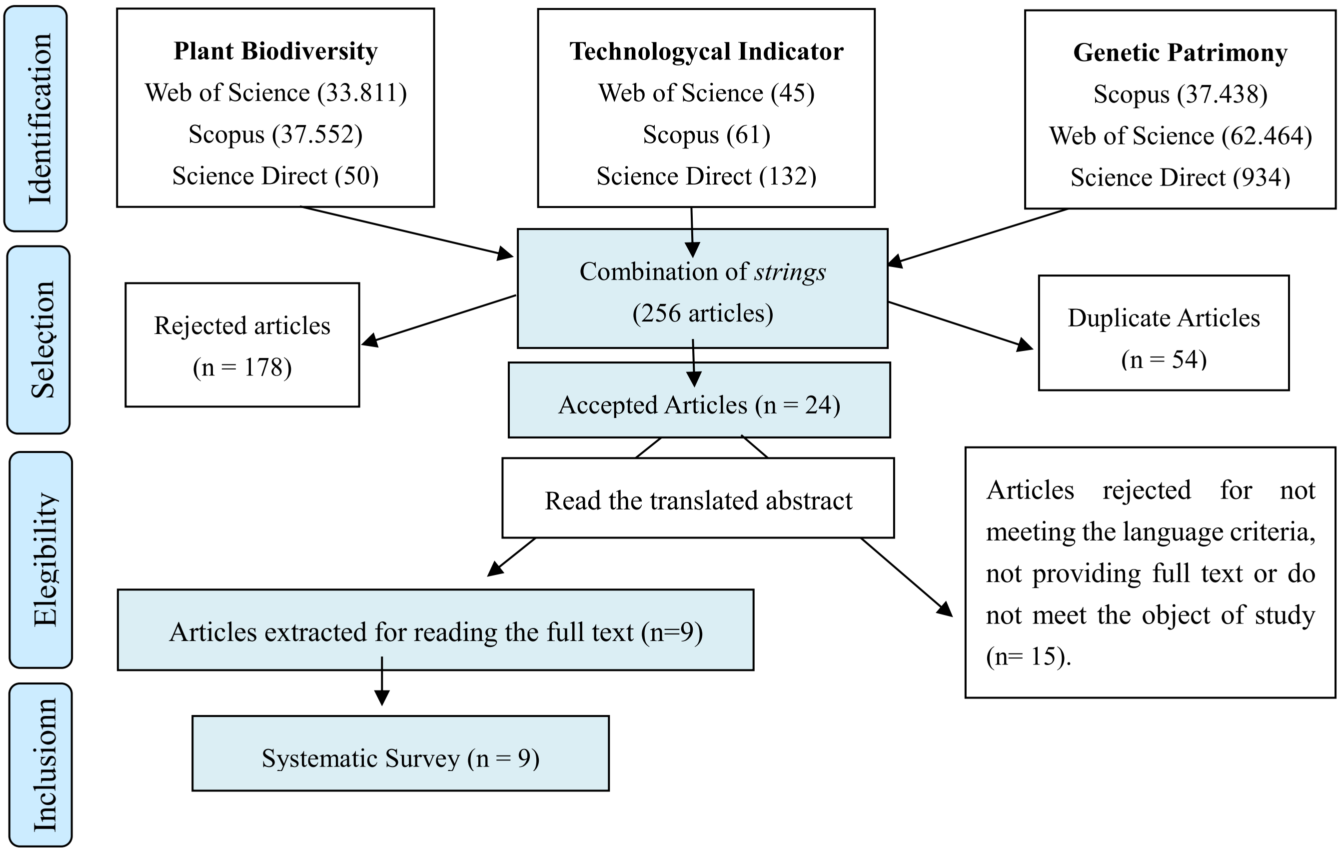

Figure 2 –Abstract of the data extraction of the research on Technological Indicators of use of Biodiversity and Genetic Patrimony, prepared by the authors and adapted from MOHER et al. (2009).

Only 14.9% of the exported articles (24) had a score higher than 25 points. After partial reading of titles and abstracts of these articles selected for systematic review, it was verified that only nine considered the research objective (Figure 2; Table 4).

Most of the articles presented the use of satellite imagery and image capture technology to assess climatic conditions, ecosystem and biodiversity status to propose environmental monitoring or the development and implementation of new indicators. It is noticeable when analyzing the frequency of keywords in the articles, since among those cited by the authors are biodiversity, habitat, index of dynamic habitat, MODIS, and remote sensing, and among indexed keywords, the most frequent were biodiversity, China , ecosystem, environmental monitoring, human, remote sensing, socioeconomic, vegetation, factorial analysis, sustainable development, urbanization and agriculture (Figure 3).

Figure 3. Main keywords indexed in articles as analyzed in the StArt Program.

In the systematic review it was verified that the nine articles comprise a period from 2009 to 2012, which the majority of the journals found is from the area of environment and ecology (Table 4). For, among the nine analyzed, eight addressed the theme of biodiversity indicators and one only addresses the relationship between technological development and use of biodiversity. Only the article published by Gomes Souza et al. (2017) in the journal Geintec reports on indicators related to technological innovation, seeking to analyze indicators presented in the Benefit Sharing Contracts (CURBs) involved with access and exploitation of National Genetic Patrimony (PGN) and Associated Traditional Knowledge (CTA) registered in Brazil . It also analyzed data related to the assessments, deliberations and benefit sharing registered by the Genetic Patrimony Management Council (CGEN), from 2002 to 2015. It also noted bioprospecting and technological development in Brazil as of 2006, and a decrease in these records from 2010. The business sectors with the greatest interest in the economic exploitation of the genetic resources of Brazilian biodiversity were cosmetics and pharmaceuticals (Gomes Souza et al., 2017).

The article with the highest score (53) was Chirici et al. (2012) published in the journal Forest Science, whose objective was to revise and present the possibilities offered by the National Forest Inventories - IFNs to harmonize the estimation of useful indicators for the monitoring and the elaboration of international reports on forest biodiversity (Table 4). He summarized the main conclusions of the E43 Action Task Force on the European Cooperation in Science and Technology (COST) and discussed definitions and techniques for harmonizing estimates of possible biodiversity indicators based on data from monetary institutions in

Europe and the United States. The results presented a list of possible biodiversity indicators, categorizing them in: forest, dead wood, forest structure, forest age, soil vegetation, naturalness and regeneration, and concluded that IFNs represent a main component for global biodiversity monitoring (CHIRICI et al., 2012).

Table 4. List of articles analyzed in the systematic review on Technological Indicators, Genetic Patrimony and Biodiversity.

n	Title	Authors	*Score*	Year	Journal
1	Demonstration of a satellite-based index to monitor habitat at continental-scales	Coops, N.C. ; Wulder, M.A.; Iwanicka, D.	42	2009	Ecological Indicators
2	An environmental domain classification of Canada using earth observation data for biodiversity assessment	Coops, N.C.; Wulder, .A.; Iwanicka, D.	28	2009	Ecological Informatics
3	Assessing biodiversity in forests using very high-resolution images and unmanned aerial vehicles	Getzin, S.; Wiegand, K.; Schöning, I.	27	2012	Methods in Ecology and Evolution
4	National Forest Inventory Contributions to Forest Biodiversity Monitoring	Chirici, G.; McRoberts, R.E.; Winter, S.; Bertini, R.; Braendli, U.; Asensio, I.A.; Bastrup-Birk, A.; Rondeux, J.; Barsoum, N.; Marchetti, M.	53	2012	Forest Science
5	What multiscale environmental drivers can best be discriminated from a habitat index derived from a remotely sensed vegetation time series?	Coops, N.C.; Schaepman, M.E.; Müller, C.A.	35	2013	Landscape Ecology
6	Socioeconomic influences on biodiversity, ecosystem services and human well-being: A quantitative application of the DPSIR model in Jiangsu, China.	Hou, Y.; Zhou, S.; Burkhard, B.; Müller, F.	44	2014	Science of the Total Environment
7	Assessment of eco-environmental quality of Western Taiwan Straits Economic Zone.	Ma, H.; Shi, L.	35	2016	Environmental Monitoring and Assessment
8	The “royalties”' of technological applications of national genetic patrimony and associated traditional knowledge: the brazilian state in question.	Gomes Souza, A.L.; Santos Junior, A.A.; Da Silva, G.F.	29	2017	Revista Geintec - Gestão Inovação e Tecnologias
9	Predicting bird species richness and micro-habitat diversity using satellite data.	Ozdemir, I.; Mert, A.; Ozkan, U.Y.; Aksan, S.; Unal, Y.	26	2018	Forest Ecology and Management

Source: Prepared by the authors.

Among the publications, Nicholas C. Coops is the first author in three of the articles analyzed (Table 4). In the first article the author describes the development of the habitat index (DHI), calculated on the basis of satellite images and the absorbed radiation fraction (fPAR), describing the correlation of this index with the species diversity (COOPS et al., 2009a). The second one presents an environmental grouping classification, using several relevant factors as indirect indicators of biodiversity (physical environment, available energy, plant production, and habitat adequacy) obtained by remote sensing to carry out an environmental regionalization in Canada (COOPS et al., 2009b). And in the third, it presents the Normalized Difference Vegetation Index (NDVI) as an indirect indicator derived from satellite linked to the modeling of species distribution and biodiversity (COOPS et al., 2013). In relation to the methodologies used in the articles to measure biodiversity indicators, NDVI and DHI were the most found. The Normalized Difference Vegetation Index (NDVI) is calculated through satellite image analysis and used to analyze the condition of natural or agricultural vegetation by measuring the intensity of the emitted or reflected chlorophyll activity, ie texture measurements derived from red bands and infrared in images generated by remote sensing (COOPS et al., 2009a; HOU et al., 2014, OZDEMIR et al., 2018).

Other indicators found in the research related to the study of plant biodiversity were described in Table 5. Like the Shannon Diversity Index (SHI), based on habitat sub-functions, the Functional Attributes Diversity Index (FAD) to describe micro-habitat diversity (Ozdemir et al., 2018). Among others, such as: Improved vegetation index (EVI), Physical environment, Available energy indicators, Habitat suitability, Species richness, Shannon Equability Index (E), Beta diversity (β yes), Plant richness Diversity of ecosystem types, Number of endemic species, Proportion of forest, garden and pasture.

The dynamic habitat index (DHI) can be applied to a variety of species to help define relevant habitat conditions, recognizing that these relationships will change according to each species (COOPS et al., 2009 a; COOPS et al. 2013). The DHI is composed of three indices extracted from an annual sequence of monthly fPAR data (provided by NASA, based on MODIS data): the first index is the cumulative annual fPAR which indicates the total potential productivity of the vegetation; the second calculation is the annual minimum value of fPAR, which indicates the year-round provision of vegetation cover used to analyze food availability and habitat influence on the behavior of many herbivorous and carnivorous species; the third one summarizes the annual greenness variation, which is calculated as the coefficient of variation (standard deviation divided by the mean) (COOPS et al., 2009).According to Coops et al. (2009) fPAR, also called the absorbed photosynthetically active radiation fraction (fAPAR) intercepted by vegetation, can be used to estimate the rate of carbon dioxide and sunlight used during photosynthesis. In theory, the higher the fPAR observed, the denser the green leaf cover, the higher the productivity and the less disturbed the vegetation cover, and conversely, the lower the fPAR, the less productive the landscape (COOPS et al. al., 2013).

Table 5. Indicators of Plant Biodiversity described in the articles analyzed in the Systematic Review.

n	Citation	Indicators	Description
1	Coops et al., 2009 (a)	Index of vegetation of the normalized difference (NDVI)	Standard ratio of the reflectance channels (red and infrared), indicating the photosynthetic activity of the vegetation based on chlorophyll.
		Fraction of photosynthetically active radiation (fPAR)	Estimated plant cover, productivity and landscape degradation (vegetation) and carbon dioxide production.
		Improved vegetation index (EVI)	It estimates plant production, analogous to NDVI because it analyzes the reflectance in the images using the band of blue.
		Dynamic habitat index (DHI)	Tracks the productivity of the landscape and evaluates biomass as food and other habitat resources for wildlife.

2	Coops et al., 2009 (b)	Physical environment	Estimated by topography and land cover.
		Power indicators available	Measured by vegetation production (productivity or function)
		Habitat suitability	Related to spatial and structural arrangement.
3	Getzin et al., 2012	Species richness	Number of species in a specific region
		Shannon index (H)	Species diversity observed.
		Shannon Equability Index (E)	It is the diversity of species observed divided by the diversity of species under conditions of maximum equitability (Krebs 1994).
		Beta diversity (β sim)	Distribution of individuals calculated by one minus the similarity index Simpson ($\beta\ sim = 1 - S_{sim}$)
5	Coops et al., 2013	Dynamic habitat index (DHI)	Indirect indicator of habitat conditions over time.
6	Hou et al. , 2014	Indicator DPSIR (Driver-Pressure-State-Impact-Response)	It qualitatively describes the interrelations of cause and effect between social, economic and environmental systems.
		Wealth of native higher plants	Number of species of higher plants wild (mono and dicotyledons, gymnosperms and ferns).
		Diversity of ecosystem types	Number of ecosystem types (Wan et al.,2007; Wu,1980).
		Number of endemic species	Includes number of endemic plant and animal species
		Proportion of forest, garden and pasture	Quantity relating to land not cultivated by vegetation.
7	Ma, H. e Shi, L. (2016)	Ecological-environmental quality index (EQI)	Evaluates the regional eco-environmental status
		Fragmentation of vegetation	Patch density by year and area
		Vegetal Cover (Fc)	Coverage of vegetation in proportion to land area
		Biomass	Biomass per unit area
9	Ozdemir et al., 2018	Index of Vegetation by Normalized Difference (NDVI)	Analyzes texture measurements derived from red and infrared bands and predicts species richness.
		Shannon Diversity Index (SHI)	Measures the diversity of species.
		Functional Attribute Diversity Index (FAD)	Measures the diversity of microhabitats.

Source: Prepared by the authors based on the articles analyzed.

Therefore, the difficulty in assessing large-scale biodiversity loss and the impacts of land use on diversity requires new technological advances, it was based on this argument that Getzin et al. (Shannon index (H)), equability (E), soil moisture (E), soil moisture (E), soil moisture of Shannon (E) and beta diversity (βsim)) commonly applied in ecology. This paper proposes the interaction between biology and technology, as it presents a new method of assessing biodiversity in forests using unmanned aerial vehicles (UAVs) to capture the high resolution images and demonstrating potential to assess the biodiversity of the understory in forests.

HOU et al. (2014) published in the Science of the Total Environment the DPSIR indicators to analyze processes of interaction of human-environmental systems and to quantitatively describe influential socioeconomic factors of biodiversity. It was found that urbanization and industrialization positively influenced regional biodiversity, agricultural productivity, tourism services, and living standards. In contrast, agricultural land expansion and increased total food production were two factors that had a negative influence on biodiversity, ecosystem services capacity, regional tourism income, and population well-being (HOU et al., 2014).

According to Ozdemir et al. (2018), the effective management of biodiversity in forest ecosystems depends on the evaluation of surrogate environmental indicators to try to measure total biodiversity, so bird species richness (BS) and micro-habitat diversity (MH) are two characteristics- key indicators that can be used as substitutes for biodiversity. In his research he examined the possibilities of predicting SB richness and MH diversity using variables derived from satellite data in a pine forest ecosystem (*Pinus brutia* Ten.) Located in the southwestern region of the Mediterranean of Turkey. It concluded that texture measurements calculated from the images can predict and map species richness and microhabitat diversity and that this type of approach is potentially faster and less expensive compared to extensive field inventories (OZDEMIR et al., 2018).

Authors Ele Ma and Longyu Shi in 2016 presented a weighting method to determine the importance of each indicator and developed a system of indicators to assess the eco-environmental quality of the economic zone. It calculated the ecological-environmental quality index (EQI) of the administrative regions of Taiwan and found that plant cover and biomass indices are the two decisive factors of regional eco-environmental quality. Furthermore, the EQI can be used to assess the regional eco-environmental status and also to investigate the performance of current regional development policies (MA, SHI, 2016).

5. Threat to Validity

Threats to the validity of the systematic review are the influences that may limit the interpretation and conclusions from the data analyzed (PERRY, PORTER, VOTTA, 2000). Therefore, in this work, the threats were minimized by using three databases with scientific credibility for the areas of study of the environment and technological innovation (Web of Science, Scopus and ScienceDirect), guaranteeing the relevance of the articles in relation to the theme.

The validation of the search strings also made it possible to cross the three thematic dimensions (Genetic Patrimony, Plant Biodiversity and Technological Indicators) of the research to comprehensively capture the most relevant works. The relevance was calculated and defined by the Score attributed by the StArt program, thus avoiding the influence of the selection of the articles.

The academic specialties of the authors were also pertinent to better conduct the research and to approach the concepts and the methodology used, being, then, all the disagreements discussed collectively until reaching the consensus, and thus avoiding misinterpretations.

6. Final Considerations

The systematic review allowed us to observe important scientific advances and to identify relevant data on the subject studied, such as journals, authors and working areas. Therefore, developing this methodological strategy helped in the understanding of how science and technology can influence decision making and public policy management, also allowing to observe how technologies are being used in order to monitor biodiversity, and how the indicators of plant biodiversity are important for analyzing environmental, social, and industrial diagnostics.

Although it did not reveal the existence of an indicator or index that related the use of vegetal biodiversity to the production of technological innovation, in patents, the information obtained suggests the need to formulate these indicators, because it is through applied science that they are validated and can be used as parameters for evaluation and monitoring of the systems, as well as assisting the development of public policies in the areas of technological innovation and the environment.

Therefore, this research may be useful for guiding future work. An in-depth study on the use of plant genetic resources and their influence on technological indicators is recommended.

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