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Assessment of permaculture integration into gray and mainstream scientific literature in four languages. A review

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Abstract

Permaculture, often described as a grassroots movement, philosophy, or set of progressive agricultural practices, is considered to have significant potential to revitalize degraded land, improve the robustness of ecosystems, reduce energy consumption, and lower operating costs while effectively sequestering carbon. Despite its growing international popularity and practical benefits, the term *permaculture* remains notably isolated from mainstream scientific discourse, limiting its broader integration and impact. Literature reviews on this versatile set of agricultural practices are uncommon, and this isolation from established scientific literature significantly hampers the potential of permaculture to influence and transform contemporary agricultural systems toward enhanced sustainability. Addressing this gap, this study compiles the most comprehensive collection of white and gray literature related to permaculture to date, analyzing 975 publications across four languages—English, Portuguese, Spanish, and French—through bibliometric analysis, qualitative content analysis, H-index, and citation counts. The findings reveal that permaculture retains a dynamic presence within academic discussions, being increasingly associated with critical concepts such as design, agriculture, and ecology. Notably, the use of *permaculture* in peer-reviewed technical publications has surged, particularly in recent study periods, marking a significant shift towards recognizing its value in mainstream scientific literature. This review aims to:

1. Gather white and gray literature related to the term *permaculture* across four languages.
2. Identify terms most commonly associated with permaculture using computational tools.
3. Describe the evolution of the term *permaculture* over time.
4. Examine whether the term *permaculture* is predominantly associated with philosophical or scientific perspectives in peer-reviewed literature.
5. Assess the increasing recognition of permaculture as a topic of interest in English peer-reviewed literature.

Keywords Bibliometric analysis · Permaculture · Qualitative content analysis · Semantic shift · Word cloud

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1 Introduction

Each year, 24 billion tons of fertile soil are lost worldwide (UNCCD 2017). More than 1.3 billion people, mostly in developing countries, live in areas with degraded agricultural lands and therefore have limited opportunities for economic growth (UNCCD 2017). Anthropogenic activities continue to degrade soils, adversely affecting human welfare, accelerating habitat loss for other species, and intensifying the impacts of climate change. In light of these challenges, experts emphasize the need to adopt innovative farming systems that foster sustainable, resilient, and self-sustaining ecosystems. For instance, permaculture practitioners and researchers, including Hathaway (2015), Krebs and Bach, (2018), and Toensmeier (2016), advocate for the application of permaculture principles to revitalize soil health and boost agricultural productivity. By fostering diverse plant communities, optimizing water management, and integrating animals to strengthen ecosystem vitality, degraded agricultural regions worldwide can recover productivity and restore ecological balance. This approach not only reverses soil degradation but also fortifies food security and fosters economically sustainable growth, all within an eco-friendly framework.

Agrifood systems employ 1.23 billion people worldwide, and about 3.83 billion people depend on agrifood systems for their livelihood (Porciello et al. 2024). Over the past century, the sector has involved remarkable transformations in technology, yield, and production (Mazoyer and Roudart 2006). A substantial portion of these transformative changes involve the adoption of industrial agricultural practices, defined as large-scale, energy-intensive, highly mechanized production of monoculture crops for commodity markets that are heavily dependent on chemical pesticides, mineral fertilizers, and irrigation for production (Moersdorf et al. 2024; Shanahan 2022; Woodhouse 2010). Although agricultural production has increased significantly worldwide, many researchers

suggest that the sustainability and efficiency of resource use in general have not increased proportionally (Badgley et al. 2007; Méndez et al. 2013; Reganold and Wachter 2016). According to Teague (2015), we can change current agricultural systems so that their negative effects on humans and natural resources can be reduced, while also meeting current and future food demands.

While industrial agriculture is highly productive, it can have detrimental effects on the environment, including soil degradation. Several alternative agricultural systems have been proposed as a means of reducing the problems associated with industrial agriculture. Many of these farming systems can be classified as agroecological (Ferguson and Lovell 2014; Gallardo-López et al. 2018; Wezel et al. 2009). Méndez et al. (2013) described an agroecological approach as one that is transdisciplinary, participatory, and action-oriented. Gallardo-López et al. (2018) wrote that agroecology is primarily applied at the level of farming systems, then at the regional level, then at the level of agroecosystems, and finally at the level of agri-food systems. One prevalent agroecological farming system is organic agriculture, but other farming systems, such as biointensive farming, biodynamic farming, and permaculture, are also regarded as part of the agroecological framework (Gallardo-López et al. 2018). Permaculture has been widely disseminated and is becoming increasingly popular throughout the world (Ferguson and Lovell 2014). Hathaway (2016) identifies permaculture as an ecological strategy for the design and management of agricultural systems that incorporates an ethical framework and guiding principles. It is a holistic approach that allows the design of diverse, sustainable production systems suited to a wide variety of cultural and ecological contexts (Hathaway 2016). Proponents of permaculture claim that this farming system can meet human needs for healthy and nutritious food, while generating less CO₂ emissions than industrial agriculture and sequestering more carbon from the atmosphere by restoring degraded soil (Toensmeier 2016). Furthermore, they claim that permaculture practices are less energy intensive than industrialized agricultural practices (Conrad 2010), promote a closed nutrient cycle (Altieri 1989; Conrad 2014), and significantly reduce the use of pesticides, mineral fertilizers, and irrigation water (Akhtar et al. 2016; Altieri 1998; Bhandari and Bista 2019; Hathaway 2016). Despite its widespread popularity, Ferguson and Lovell (2014) argue that permaculture studies remain largely disconnected from mainstream scientific research.

Farmers who aspire to change from industrial agriculture to permaculture face a complex project. If adopted as a broader social initiative, the transition away from industrial agricultural production toward permaculture would require the combined efforts of scientific institutions and

international communities of producers. Some researchers argue that such a transition should involve collaboration with communities of traditional producers, so that agricultural practices refined over millennia may be leveraged to develop a form of modern agriculture that is less harmful to the environment (Ferguson and Lovell 2014). Figure 1 illustrates permaculture designs developed for tropical regions. Permaculture fundamentals, such as zones, are illustrated on the left. This logic seeks to maximize the use of energy and resources by placing crops and processes (e.g. orchards) that require more maintenance near zone 0 (house), while those that require less maintenance (e.g. fruit forest) or are conservation zones are situated further away from the zero point. The design on the left also integrates Adaptive Multi-Paddock (AMP) grazing, which is a practice that integrates herbivorous animals into the permaculture system to produce numerous benefits, including diversifying product supply, accelerating soil regeneration, and improving carbon sequestration, among others. A permaculture design with a commercial approach can be seen on the right. It is based on the principles of permaculture and bio-intensive agriculture. As part of this holistic system design, the project is divided into zones. In general, the farther away from zone 0 (office and recycling collection center), the less resources and energy are required. A number of permaculture practices have also been incorporated, including windbreaks, fire barriers, and pollinator-attracting plants. Using Jeavons' (1982) crop percentage distribution ratio with a few minor modifications, we designed an agricultural system where 44% of the land was allocated to the orchard, 32% to high carbon and high calorie crops, and 24% to high calorie tubers (Jeavons 1982).

1.1 Historical background

The term *permaculture* was coined in the 1970 s by Bill Mollison and David Holmgren, who were working in

Tasmania, Australia (Tortorello 2011). The purported antecedents of permaculture vary according to author. Holmgren believed that the origins of permaculture were found in the environmentalist counterculture that arose during the 1970 s (Collins 2010). Events such as the publication of the study *Limits to Growth* by (Meadows et al. 1972), protests over the flooding of Lake Pedder, Tasmania, in 1972, and the 1973 oil crisis led to a paradigm shift in the way that people thought about the environment (Cohen 2018). During this period, current ideas about sustainability were also developed as part of the resurgent interest in intentional communities, organic agriculture, green architecture, and a self-reliant lifestyle (Collins 2010). Smith (2012), however, traces the antecedents of permaculture further back to the Garden City movement of the late 1800 s, Russell J. Smith's (1929) classic book *Tree Crops*, and later influences such as Carson (1962).

Permaculture, as conceptualized by Krebs and Bach (2018), is fundamentally a system for agro-ecological design. It is grounded in design principles and serves as a blueprint for mimicking and optimizing ecosystems. Other authors describe permaculture as a social movement organized around the nexus between permanent agriculture and permanent culture (Chakroun 2019). In accordance with Chakroun (2019), permaculture is not so much a method of farming as it is a framework for designing and implementing more sustainable socio-agricultural systems. Permaculture is viewed by some as a way to achieve a balance between the need for agricultural production and the principles of ethics and the protection of the environment (Bellacasa 2010; Brain and Thomas 2013). Meanwhile, Mollison describes it as the set of three fundamental ethical principles: 1) care for the land, 2) care for people, and 3) fair share (limiting population and consumption) (Akhtar 2016). Both humans and the environment can meet their essential needs through the maintenance and regeneration of healthy ecosystems, while sharing surpluses and protecting future generations' well-being.

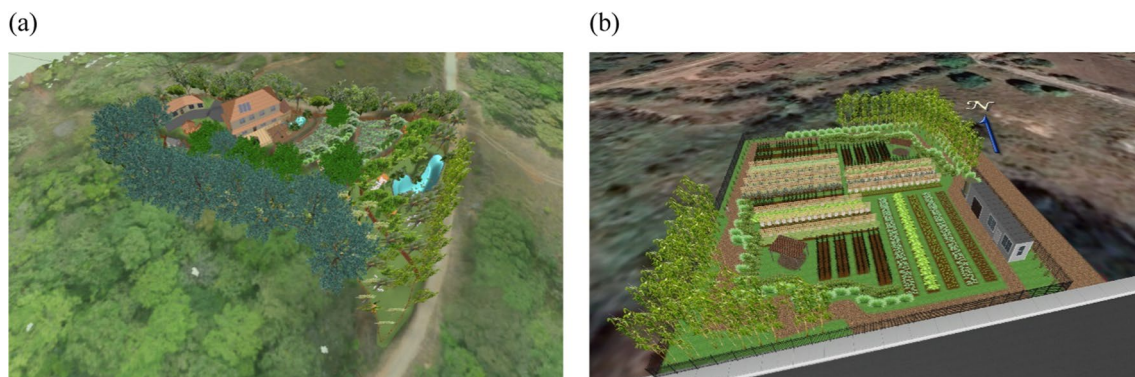


Fig. 1 Examples of permaculture designs for the tropics by Roberto Forte: (a) A 3500 m² farm in rural Panama; (b) Intercropping system of annual and perennial plants, based on permaculture principles, in Punta Chame, Panama. Photo credit: 2025 Roberto Carlos Forte Taylor.

Permaculture is considered by other authors, such as Krebs and Bach (2018), to be a more focused, technical practice; that is, an integral system for the design, implementation, and maintenance of resilient agroecological systems, which was developed in response to widespread concern about environmental degradation. As such, permaculture balances the necessity for agricultural production with principles of ethics and environmental well-being (Bellacasa 2010; Brain and Thomas 2013). Table 1 provides an overview of the early definitions of permaculture proposed by Mollison and Holmgren, highlighting their emphasis on sustainable design principles and the integration of human and natural systems.

1.2 Definition and principles

As we examine the early definitions of permaculture proposed by its founders, Mollison and Holmgren, we can infer their objective was to provide a design framework that mimicked the solutions provided by nature for the benefit of society. Holmgren and Mollison both provide insight into what they perceive to be the pressing needs of society, such as food, energy, fiber, and shelter. As a result of these early definitions of permaculture, they generally tend to involve a more technological, engineering, and ecological perspective, whereby permaculture is viewed as a means or tool to achieve a specific goal for the benefit of society. These definitions are quite in accordance with what we understand by ecological engineering today: "the design of sustainable ecosystems that integrate human society with its natural environment for the benefit of both" (Mitsch 1996). Both Mollison and Holmgren proposed in their early work that society should be integrated with landscapes and that the organization of local communities should be central to their design framework. Mollison takes it even further when he proposes a definition for this design framework. The initial permaculture definitions do not incorporate philosophical considerations. When Mollison outlines the ethics of permaculture—caring for the land, caring for people, and fair

sharing—the philosophical aspects of permaculture become apparent (Mollison 1988).

The principles of permaculture as articulated by Holmgren (2013) are paraphrased in Table 2. Similar to what was discussed in the previous paragraph about the initial definitions of the permaculture concept, Holmgren's principles tend to focus on the technical rather than the philosophical. It is in them that Holmgren makes reference to the importance of observation of nature and its ecosystems, design, self-regulation and functions of systems, energy flows, diversity, and a number of other considerations. Again, they are proposed as a means of achieving the social objective of providing abundant food, fiber, and energy.

1.3 Research question and objectives

Despite permaculture's high international public profile, few systematic literature reviews on the term and its associated concepts have been published in scientific journals. With a quick search of Scopus and Web of Science using the terms *permaculture* and *review*, there are fewer than 65 results for each database. The only literature review that we were able to identify as specifically addressing permaculture as a concept, practice, or movement is Ferguson and Lovell's (2014). Ferguson and Lovell (2014) carried out one of the most recent attempts, focusing on the potential contribution that this practice could have in the agroecological transition, its different strategies, and its potential as a grassroots movement.

However, a literature review focused on the semantic shift and associated concepts through time has not been carried out. For Ferguson and Lovell (2014), one of the barriers limiting permaculture's potential is its separation from the scientific community. This research is an exploration of the literature related to the term *permaculture* and related concepts. It examines whether the use of the term has moved from a philosophical, ethical, and social context to a technical one, or vice versa. Lastly, we examine whether the term *permaculture* has established itself over time as a scientific topic.

Table 1. Some early definitions of permaculture proposed by Mollison and Holmgren.

Author and Year	Definition
Mollison (1988)	Permaculture (permanent agriculture) is the conscious design and maintenance of agriculturally productive ecosystems which have the diversity, stability, and resilience of natural ecosystems. It is the harmonious integration of landscape and people providing their food, energy, shelter and other material and non-material needs in a sustainable way.
Holmgren (2013)	Consciously designed landscapes which mimic the patterns and relationships found in nature, while yielding an abundance of food, fiber, and energy for provision of local needs. People, their buildings and the ways in which they organize themselves are central to permaculture.
Mollison (1988)	Permaculture design is a system of assembling conceptual, material, and strategic components in a pattern which functions to benefit life in all its forms.

Table 2. List of permaculture principles adapted from Holmgren (2013).

Perspective of Elements	Principles	General description
Bottom – Up	Observe and interact	Careful observation and thoughtful interaction provide design inspiration and patterns. Continuous and reciprocal interaction with the land and its ecosystems is crucial.
	Catch and store energy	Capture local flows of renewable and non-renewable forms of energy (sun, wind, runoff water flows, and fossil fuels, amongst others).
	Obtain good yields	Elements that generate good and immediate yields will proliferate. Systems that obtain a yield and use it effectively tend to prevail over alternatives.
	Apply self-regulation and accept feedback	By designing self-regulated systems, the work involved in harsh corrective management can be reduced significantly.
	Use and value renewable resources and services	Permaculture design should aim to make the best use of renewable natural resources to manage and maintain yields.
	Produce no waste	There is waste or pollution when an output of one component of a system cannot be utilized productively by another component of the system.
Top - Down	Design from patterns to details	Complex systems that work in nature tend to evolve from simple ones that work. Finding the most appropriate pattern for the design in question is more important than understanding all the details of each component in a system.
	Integrate rather than segregate	In self-regulating design, elements should be placed in such a way that each serves the needs and accepts the products of other elements.
	Use slow and small solutions	Systems should be designed to perform functions at the smallest scale that is practical and energy-efficient for that function.
	Use and value diversity	Diversity is a result of the balance and tension in natural environments between variety and possibility on one hand and productivity and power on the other.
	Use edges and value the marginal	Value and contribution of the edges, as well as marginal aspects, should be recognized and conserved because the expansion of these aspects could increase productivity and system stability.
	Creatively use and respond to change	Change should be deliberately and cooperatively included in the design. The design should be capable of responding or adapting to large-scale system changes that are beyond control or influence.

To answer these questions, we propose the following objectives:

- (1) Gather white and gray literature related to the term *permaculture* in four different languages.
- (2) Use computational tools to identify the terms most commonly associated with permaculture.
- (3) Describe how the term *permaculture* has evolved over time.
- (4) Determine whether the term *permaculture* is mostly associated with philosophical or scientific perspectives in the peer-reviewed literature.
- (5) Examine whether over time, the term *permaculture* has gradually gained recognition as a topic of interest in English peer-reviewed literature.

The publication is organized as follows: Section 1 provides a historical background on the development of permaculture, including its definitions, principles, and early

implications for ecological engineering. Section 2 outlines the methodology, detailing the bibliometric and qualitative content analyses employed to examine the permaculture literature. Section 3 presents the results, highlighting the evolution of the term 'permaculture,' its growing incorporation into academic discourse, and its associated concepts. Section 4 discusses the implications of these findings for sustainable agricultural practices and scientific discourse. Finally, Section 5 concludes with a summary of the study's contributions and recommendations for future research.

2 Materials and methods

We used internet search engines and literature databases for this systematic literature review. A range of disciplines was represented by a broad selection of journals. The search engines and databases included Scopus (27,950

peer-reviewed journals supporting over 200 disciplines), Web of Science (over 21,000 peer-reviewed journals spanning more than 250 disciplines), McGill Library Catalog (a collection of millions of records), CAB Direct (more than 10 million international research records covering agriculture, environment, and applied life sciences), and Google Scholar (over 100 million scholarly documents spanning hundreds of disciplines), among other sources.

It is important to note that peer-reviewed articles and gray literature complement each other. Articles that are peer-reviewed undergo rigorous scrutiny before they are accepted for publication, ensuring a high level of credibility and reliability. Gray literature, on the other hand, includes papers that are not published or peer-reviewed, such as government reports, theses and dissertations, which may offer perspectives that are not readily available in peer-reviewed journals. Peer-reviewed articles provide rigor and reliability, whereas gray literature can provide broader and deeper coverage of a topic. When conducting a literature review, it is beneficial to combine peer-reviewed articles with gray literature in order to ensure that the review is comprehensive and balanced. The process allows for a broader range of perspectives and conclusions, mitigates publication bias, and enables a more nuanced understanding of the subject at hand.

It is therefore important to emphasize that, in the systematic literature review we present, some sources have a greater influence on the analyses than others. According to Figure 2, peer-reviewed articles account for 44% of English literature, whereas peer-reviewed articles account for 37% of French literature. However, out of the Portuguese and Spanish literature sets, theses and dissertations are most commonly found during searches, at 50% and 62% respectively.

In order to respond to the first objective of this research (Gather white and gray literature related to the term *permaculture* in four different languages), we adapted a

series of methodologies previously used in the generation of similar systematic literature reviews (Ferguson and Lovell 2014; Guitart et al. 2012; Peter et al. 2019; Wezel et al. 2009; Wezel and Soldat 2009). We applied these to the existing body of literature (1900 - 2023) related to the term *permaculture*. As we developed our search protocol, we encountered permaculture practitioners who linked permaculture with agriculture, holistic systems thinking, and social and ethical issues. During this analysis, we believe it is critical to analyze the origin of the term *permaculture*, to determine whether this collection of practices had already been promoted prior to its coining or conception. Accordingly, we proposed the search terms "permaculture", "permanent agriculture", and "permanent culture" as initial search terms. It is critically important for practitioners, farmers in transition, communities, decision-makers, and policy developers to have a solid understanding of the technical aspects, ideas, arguments, and concepts related to permaculture in order to effectively implement it. As part of these analyses, we reviewed a body of literature comprising 975 publications, including white and gray literature in four languages: English, Portuguese, Spanish, and French. Ferguson and Lovell (2014) report that queries to various Google Scholar language localizations for the term "permaculture" yielded primarily English-language literature. English results accounted for 59% of a total of 7,190 search results (Ferguson and Lovell 2014). In addition to English, the following languages strongly contribute to permaculture-related literature in descending order: Spanish, Portuguese, German, and French. To ensure a representative sample of our study, we selected English, Spanish, Portuguese, and French from the five most dominant languages identified by Ferguson and Lovell (2014). Inclusion of a diversity of languages in literature reviews is important to avoid overlooking important parts of the global scientific discourse (Malard-Adam 2023).

Fig. 2 The percentage breakdown of the documents analyzed by type and language

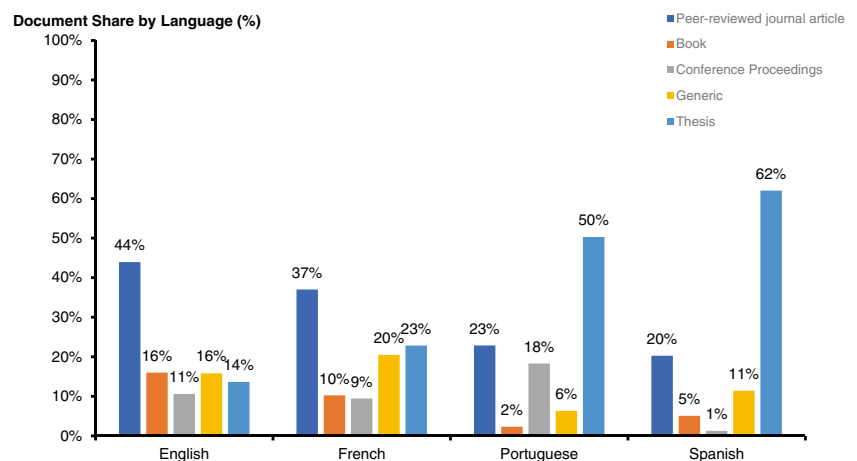


Table 3. The initial result of searches in several databases and four languages (English, Portuguese, Spanish and French)

Language	Navigator/Database	Search terms	No. of queries	
English	Google Scholar	Permaculture	1510	
		Permanent agriculture	141	
	Scopus	Permaculture	433	
		Permanent agriculture	88	
	Web of Science	Permaculture	363	
		Permanent agriculture	63	
	CATIE – Cab Direct	Permaculture	46	
		Permanent agriculture	15	
	Spanish		Permaculture	0
			Agricultura permanente	0
Google Scholar		Permaculture	607	
		Agricultura permanente	12	
SciELO		Permaculture	3	
		Agricultura permanente	4	
Portuguese		Permaculture	10	
		Agricultura permanente	4	
	Google Scholar	Permaculture	227	
		Agricultura permanente	2	
French	Archives HAL	Permaculture	54	
		Agriculture permanente	19	
	Érudit	Permaculture	12	
		Agriculture permanente	9	
	Google Scholar	Permaculture	127	
		Agriculture permanente	28	
			3777	

After conducting initial searches using the term "permanent culture" in databases such as Web of Science and Scopus, we discovered that the term was mostly associated with studies relating to the field of microbiology and the application of techniques for propagating microorganisms in growth medium. The search for literature was therefore limited to the terms "permaculture" and "permanent agriculture" and their respective translations in Portuguese, Spanish, and French. We performed searches in databases such as Web of Science (WOS), Google Scholar, Scopus, the Tropical Agricultural Research and Higher Education Center/Centro Agronómico Tropical de Investigación y Enseñanza (CATIE), SciELO, Érudit, Archives HAL, and GS. Searches in Google Scholar for the four languages were limited to publications with the term "permaculture" in the title. There are two search options available on Google Scholar: 1) "anywhere in the article" and 2) "in the title of the article." With the option "in the title of the article," the analysis was restricted to articles that explicitly addressed permaculture, excluding articles that may contain the term in some parts, but have nothing to do with the subject matter. For WOS, Scopus, SciELO, Érudit, Archives HAL, CATIE, and GS, we included only publications whose title and keywords contained the terms "permaculture" and "perm

anent agriculture". Searches were conducted in the different databases until November 2023.

Initial searches conducted on Google Scholar, Web of Science, Scopus, SciELO, Érudit, Archives HAL, GS, and CATIE yielded a total of 3,777 references. Of these, 2,659 were in English, 243 in Portuguese, 249 in French, and 626 in Spanish, as detailed in Table 3. It is imperative to note that these totals represent the entirety of the references returned by the search engines. This is without correcting for repetitions between databases or broken links. In order to complete our analysis, we conducted a thorough review and cleaning of the search results obtained, as many of them contained broken, duplicate, or inaccessible links from which the minimal information necessary for the analysis was not available (such as author information, keywords, and abstract). In the case of books, only those that included a digital file or online version of the book where the title, author(s) and introduction could be found were included.

After thoroughly reviewing our data, we verified the sources returned by the search string "permanent agriculture" in more detail. All of this was done with the intention of excluding sources that make references to conventional agricultural practices, or to shifting cultivation versus permanent systems of conventional agriculture, since

they are in no way related to permaculture. For the purposes of the subsequent analysis, the following nine sources were removed from the data set: (Bouwman 1989; Clark 1928; Gill 1962; Hopkins 1905, 1906; Israelsen 1943; Noble 2000; Puginier 1999; Thorne and Anderson 1942; Tugwell 1929). However, we retained the sources generated using the search string "permanent agriculture" that refer to practices or principles endorsed by permaculture. These include perennial crops, intercropping, native species integration, crop rotation, among others. The following ten sources were included in the analysis: (Akabane et al. 2017; Clark 1928; Eppig 2017; Molnar 2013; Paull 2006, 2011; Sati 2020; Suryatna and McIntosh 1982; Tower 1911). The initial set of literature sources included 984, but after eliminating those that did not mention the term *permaculture* or did not pertain to its principles and practices, we were left with 975.

The second objective (Use computational tools to identify the terms most commonly associated with permaculture) was achieved by using the four complete language data sets and analyzing them separately using a computational tool, ATLAS TI. The software was implemented in order to identify, quantify, and visually represent the most significant terms found in the titles of the analyzed literature as well as keywords (in the case of academic or scientific documents). ATLAS TI provides Word Cloud and Word List tools for this purpose. We divided the data into five periods in order to analyze the results of this research. Except for the period between 1900 and 1980, each period consists of a decade.

As a means of achieving objective three (Describe how the term *permaculture* has evolved over time), we created an Excel table that listed the terms that repeated most frequently during each period of time. Considering that we did not reach 15 terms that repeated at least once in some periods, we chose 15 as the cutoff for our analysis. As a final step, color coding was used to highlight the terms that had appeared in at least three periods.

We responded to objective number four (Determine whether the term *permaculture* is mostly associated with philosophical or scientific perspectives in the peer-reviewed literature) by categorizing only peer-reviewed publications published in the four languages. They were categorized into two main areas: those with a scientific/technical focus (engineering, natural sciences, finance, economy, agriculture, technology, ecology, environment, and others) and those with a philosophical emphasis (philosophy, religion, dance, art, politics, law, and social sciences). Consequently, an objective methodology was implemented across all four languages, as scientific journals and databases, such as WOS, Scopus, McGill Catalog, and other widely recognized databases, methodically and carefully classified these documents according to their research areas and fields.

During the process of categorizing the English dataset, information was gathered from databases that are life

sciences-oriented, such as WOS and SCOPUS, as well as databases that are more sociologically oriented, such as Age-Line (EBSCO), Social Work Abstracts (OVID), and Social Sciences Citation Index (SSCI, Web of Science). A total of 261 scientific publications were categorized according to their emphasis. Through WOS, we were able to categorize 141 publications. In WOS, the categorization was carried out by taking as a reference the "Research Areas" combined with the "Web of Science Categories" provided by the tool. At SCOPUS we were able to categorize 24 references using the "SciVal Topic Prominence", which according to the tool, represents "unique areas of research." It was not possible to classify the other 96 references through either WOS or Scopus. Therefore, we implemented a third and fourth method. The third method categorized publications based on keywords obtained from the digital versions of the publications or through the McGill Library Catalogue. Through this method, we were able to categorize another 33 references. Finally, the remaining 63 references were categorized based on the journal "Aim and Scope" or using the "Home or About" section for those who did not specify aim or scope.

The classification of the datasets in other languages was more challenging because we were not able to identify scientific databases or search engines that group and categorize publications by research area. In order to analyze the French language dataset, two methodologies were employed. As a first step, we relied on HAL specifically in the "Domain" section in order to classify a total of 24 publications. In addition, 18 other publications were categorized based on the abstract, title, and keywords used to describe the study's intent. The remaining five could not be classified. As for Spanish (16) and Portuguese (40) publications, all were classified using the abstract, title, and keywords as indications of the study's intent.

To address objective number five (Determine whether the term *permaculture* remains relevant in the peer-reviewed literature) of this research work, 261 scientific publications in English were reviewed. In order to conduct this analysis, we selected only the highly recognized databases Scopus and WOS. The limitation arises from the fact that there are no structured and organized databases or scientific search engines that enable researchers to download data on citations and H-indexes by authors in the other three languages. This analysis excluded self-citations from the number of citations considered. The analysis was limited to references that presented at least one citation. A list of 20 publications was compiled that could be accessed either through Scopus or WOS. To avoid the ambiguity inherent in the citation count indicator, we proposed combining it with the H-index. Citation counts and H-indexes are widely employed to evaluate the impact of authors, research groups, and scientific journals across a wide range of disciplines (Caulley et al. 2020; Hassan et al. 2020; King 1911; Kreinovich et al. 2021). We

used the H-index to summarize citation frequency rather than as a measure of scientific quality or success. Hirsch (2005) proposed the H-index as a research performance indicator for evaluating individual research outputs (micro level). The H-index, however, has been applied by researchers such as Van Raan (2006) to evaluate university research groups (meso level) (Bornmann and Daniel 2007). Hirsch (2005) states that "A scientist has index h if h of his or her N_p papers have at least h citations each, and the other $(N_p - h)$ papers have fewer or equal citations than h ". In contrast to other indices (for example, the total number of papers, the total number of citations, or citations per paper), the H-index is considered to provide a stronger indication of the citation footprint of a scientist's cumulative research contributions (Bornmann and Daniel 2007; Hirsch 2005). The H-index has been chosen in this analysis as it serves as a means of identifying the most influential researchers in the permaculture field, rather than evaluating the quality of their publications or their career trajectory. We recognize the limitations of the indicators themselves, as discussed by other authors (Bornmann and Daniel 2007; Hirsch and Buéla-Casal 2014; Van Raan Anthony 2006). However, the h -index continues to be recognized as a reliable and robust indicator of scholarly achievement, making it a valuable tool for assessing the productivity and impact of researchers, research groups, journals, and publishers (Shah and Jawaid 2023).

3 Results

3.1 Origins of the term permaculture (1900 - 1980)

According to Web of Science, the term *permanent agriculture* was used for the first time in 1910 in the book *Soil Fertility and Permanent Agriculture* by Cyril G. Hopkins. The book was published by *Boston and New York: Ginn and Company*. Two years later, the term appeared in the book *Farmers of Forty Centuries*, by F.H. King (1911). In Scopus, the first appearance of the term dates back to 1929 in the journal article "*Farm Relief and a Permanent Agriculture*" by R. G. Tugwell. The article was published by *Annals of the American Academy of Political and Social Science*. Later on, the term *permanent agriculture* appears in the peer-reviewed publication "The maintenance of soil organic matter under continuous cultivation at Samaru, Nigeria" by Jones, M.J. (1971). The article was published in *The Journal of Agricultural Science*. Interestingly, the term *permanent agriculture* was linked to the potential application and negative effects of continuous conventional practices of agriculture in savannahs in Africa where subsistence agriculture was traditionally practiced. The term *permanent agriculture*, however, has been associated with soil conservation practices such as the application of green manure and human/animal manure, as well as the

adoption of practices such as composting, multiple cropping, and the integration of perennial plants into orchards, including legumes (King 1911). Moreover, in *Soil Deterioration and the Growing World Demand for Food* (Brink et al. 1977) the term is used to propose alternative forms of agriculture in the United States as a way to combat the degradation of agricultural soils resulting from conventional agricultural practices. In Web of Science, the term *permaculture* appears for the first time linked to a peer-reviewed publication in the article "Permaculture - Practical Design for Town and Country in Permanent Agriculture" published in *Ecologist* (Strange 1983).

3.2 Literature distribution by language and document type

Some scientists have claimed that, despite the high public profile, international distribution, and unique approach of permaculture to system design, the concept remains isolated from scientific research (Ferguson and Lovell 2014; Krebs and Bach 2018). We implemented the search protocol described above to collect and pre-screen the bibliography for analysis. Table 4 illustrates the number of documents (594 English, 175 Portuguese, 127 French, and 79 Spanish) analyzed in the four different languages after eliminating duplicates and false results. Each reference in the bibliography was identified as a peer-reviewed journal article, book, thesis, conference proceeding, or other publication form. Each of the citations extracted from the different databases was thoroughly verified, especially those obtained from Google Scholar, to effectively classify and differentiate peer-reviewed publications from the grey literature.

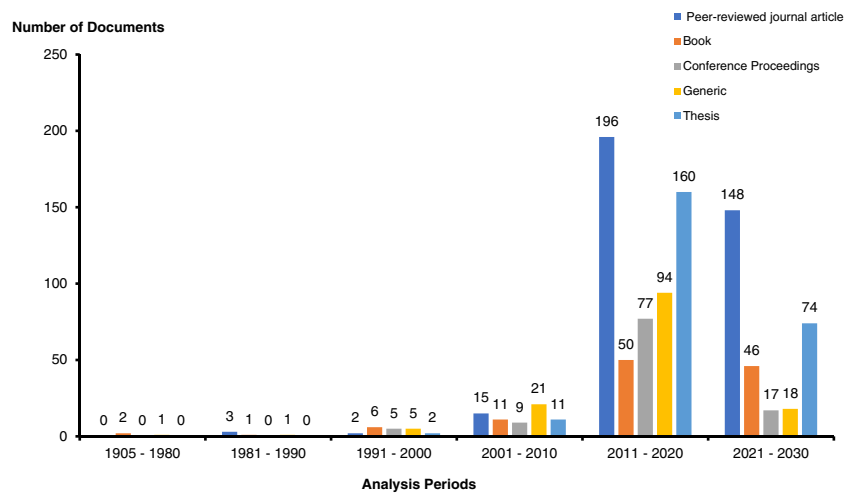
An overview of the distribution of documents by language and group, as well as their respective percentages within each language, can be found in Figure 2. This is intended to facilitate the reader's understanding of the influence that the number of documents in English may have in comparison to the other three languages and its implications for the comparative analyses developed throughout the study.

An analysis of the distribution of the 975 references by type over time is shown in Figure 3. Our references were grouped by decades, with the exception of the first period

Table 4. Final reference dataset breakdown by document type and language

Document type	English	Portuguese	French	Spanish
Peer-reviewed journal article	261	40	47	16
Book	95	4	13	4
Conference Proceedings	63	32	12	1
Thesis	81	88	29	49
Generic	94	11	26	9
All document types	594	175	127	79

Fig. 3 Total numbers of documents as grouped by type and period



from 1905 to 1980, in which we examined the origins of the term *permaculture* prior to its coining in the mid-1970 s. Literature collected from all types follows a similar pattern. Since 2000, there has been a rapid growth in publication generation (peer-reviewed journal articles, books, conference proceedings, generic documents, and theses), which has intensified significantly in the decade of 2011–2020, particularly for peer-reviewed articles.

3.3 Semantic shift of the term permaculture and associated terms over time

Figures 4 and 5 show the word clouds for each of the established periods in the English, French, Portuguese, and Spanish literature related to permaculture.

We also analyzed the 975 references in order to identify trends in the evolution of the term *permaculture* and its associated terms. The ATLAS TI tool was used to conduct a content analysis of titles and keywords. Trends in the evolution of terms associated with permaculture have been identified. Listed in the Supplementary Materials of this article are the 100 terms most commonly associated with permaculture practice in the literature examined (English, Portuguese, Spanish, and French).

Based on the data in Table 5, the following 15 key terms are most commonly associated with the concept of *permaculture* across the four languages (including all time periods). In order to generate this table, we eliminated variants of concepts that expressed similar meanings. As a result, we have presented in the table the 15 concepts with the highest occurrence among the different variants. Sustainability/sustainable, education/ecola/ensino, and ecology/ecological were among the pairs of similar elements that were combined into one with the highest occurrence. The same approach was used for concepts traditionally associated in the literature, such as agriculture/farming and community/social issues. In addition, we merged concepts formed from

compound words (such as climate change and urban farming) that had been separated throughout the analysis. As a general rule, we kept the word that appeared most frequently between the two single words of the compound word. This publication includes a much more comprehensive list of variants and their occurrences in the Supplementary Materials.

Figure 6 presents a color-coded analysis to identify which terms related to permaculture have been consistently used throughout the literature over the periods examined. As a result of this analysis, we identified the concepts that have persisted over three decades and those that have emerged in the last two decades. There are a number of concepts that have remained relevant for at least three decades, including agriculture, design, sustainability, education, soil, and food-related concepts. Over the past two decades, several new terms have emerged, including community, urban gardening, development, movement, and change (as related to climate change). This could be in response to advances in identifying, quantifying and communicating impacts of anthropogenic activities (climate change, desertification, biodiversity loss, eutrophication of the oceans, among others), and global efforts to mitigate the effects of these activities.

The color-coding analysis for the other three languages is presented in figure 7.

3.4 Changes in the nature of peer-reviewed permaculture literature in four languages

Figure 8 illustrates changes in the nature of literature related to permaculture in four languages. As shown in the graph about English publications (a), the publication of scientific literature related to this term increases significantly around 2010. In the first three years of the period 2021 - 2023, this trend continues with a very similar amount of scientific literature generated compared to the previous full period (2011 - 2020). The trend

Fig. 4 Word cloud analysis showing the most prominent terms in the English-language dataset. Note: **(a)** 1905–1980 ($n=3$), **(b)** 1981–1990 ($n=5$), **(c)** 1991–2000 ($n=19$), **(d)** 2001–2010 ($n=50$), **(e)** 2011–2020 ($n=314$), **(f)** 2021–2023 ($n=203$), **(g)** All years ($n=594$).



in French (b) and Portuguese (c) literature is that most of the works have been philosophical or political. Spanish (d) literature, however, does not exhibit a significant numerical difference between literature of a philosophical and political nature as compared with scientific and technical works.

3.4.1 Themes in English literature

The English-language literature highlights a variety of technical and philosophical contributions to the study of permaculture. Technical studies focus on the application of

permaculture principles in addressing practical challenges, while philosophical discussions explore the social and educational dimensions of the field. For example, studies by Bhandari and Lista (2019) and Brain et al. (2017) demonstrate how permaculture principles have been applied to improve soil health, enhance resource efficiency, and support food and economic security. In regional contexts, (2020) offer insights into the characteristics of permaculture systems, emphasizing their adaptability and relevance.

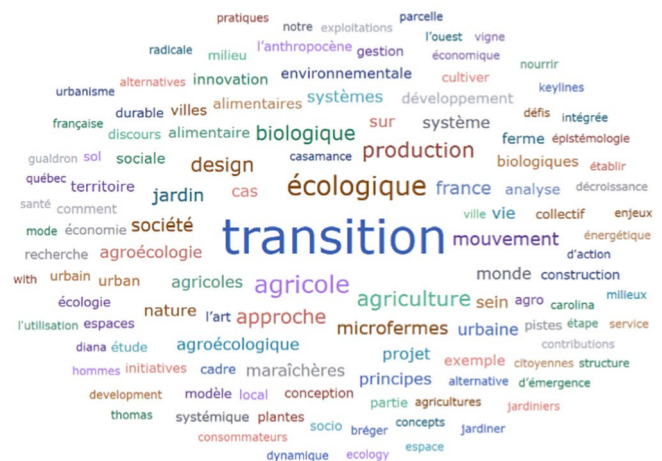
In the domain of design, Shi et al. (2022) describe innovative approaches to urban farming systems, while Kurtaslan

Fig. 5 Word cloud analysis showing the most prominent terms in the Portuguese, French, and Spanish datasets.

a. Portuguese



b. French



c. Spanish



(2020) evaluates the ecological underpinnings of existing permaculture systems. Additionally, Ismail and Affendi (2015) investigate how permaculture principles have been incorporated into urban residential landscapes in Malaysia.

Kruger (2015) expands on these themes by examining sustainability opportunities in energy and building systems.

Management practices are another focal point in English-language studies. Hinton et al. (2021) present

Table 5. The most prominent terms associated with permaculture by language (1900–2023)

Terms in English	Counts	Terms in Portuguese	Counts	Terms in French	Counts	Terms in Spanish	Counts
Sustainable	157	Educação	91	Transition	24	Desarrollo	22
Agriculture/Farming	143	Ambiental	57	Écologique	11	Diseño	19
Design	109	Sustentabilidade	49	Agricole	10	Arquitectura	11
Food/Organic	99	Agroecologia	29	Production	8	Sostenibilidad	11
Development	80	Agricultura	19	Approche	7	Comunidad	10
Community/Social	77	Design	19	Biologique	7	Alternativa	9
Urban/Garden	76	Desenvolvimento	18	Design	7	Centro	8
Ecological/Agroecology	55	Rural	18	France	6	Propuesta	8
Climate/Change	51	Experiência	14	Jardin	6	Social	8
Environmental	51	Planejamento	14	Microfermes	6	Alimentaria	7
Soil	45	Social	14	Mouvement	6	Educación	7
Systems	45	Vida	14	Société	6	Agricultura	6
Management	45	Caso	12	Cas	5	Ambiental	6
Education/Learning	44	Comunidade	12	Maraîchères	5	Bioconstrucción	6
Rural	35	Espaço	12	Monde	5	Cambio	6

1905 - 1980		1981 - 1990		1991 - 2000		2001 - 2010		2011 - 2020		2021 - 2023	
Term	#	Term	#	Term	#	Term	#	Term	#	Term	#
agriculture	9	agriculture	5	Food	4	sustainable	12	sustainable	70	sustainable	71
fertility	2	ecological	4	Tropics	3	environmental	11	agriculture	63	agriculture	64
Illinois	2	organic	4	Agriculture	2	agriculture	9	design	61	urban	45
Soil	2	crop	3	Cultivation	2	gardening	9	food	56	design	37
Arid	1	design	3	Design	2	education	8	community	48	development	37
centuries	1	decomposition	2	Ecology	2	Forest	8	development	39	food	35
China	1	family	2	Empowerment	2	management	7	organic	37	community	27
contribution	1	handbooks	2	Hope	2	Organic	7	management	31	agroecology	26
Crop	1	legumes	2	Land	2	Plants	7	ecological	29	regenerative	25
factors	1	Matter	2	Living	2	Design	6	change	28	systems	24
forestry	1	permanent	2	Permanent	2	woodland	6	urban	28	climate	23
Forty	1	soil	2	Personal	2	development	4	learning	24	land	23
foundation	1	sustainable	2	South	2	Ecology	4	garden	23	change	22
irrigation	1	tropical	2	Sustainable	2	Products	4	movement	22	education	19
Japan	1	Australian	1	Academic	1	Sciences	4	soil	20	rural	18

Fig. 6 A color-coded analysis of English terms associated with permaculture that have persisted through time. The color scheme highlights terms that have appeared in at least three distinct time periods,

emphasizing their sustained relevance. The number of occurrences of each term is provided by ATLAS TI.

borehole-garden permaculture as a method of sustainable water management. Chakroun and Droz (2020) and Hirschfeld and Van Acker (2019) explore innovative agricultural strategies, such as crop diversification, perennialization, and nature-sparing approaches.

Philosophical discussions delve into the social and educational dimensions of permaculture. Martín et al. (2023) emphasize the role of cooperatives in addressing inequities in science and education, while Suh (2014) explores how backyard gardening contributes to community development and livelihoods.

PORTUGUESE

2011 - 2020		2021 - 2023	
Term	#	Term	#
Educação	77	Educação	14
Ambiental	46	Ambiental	9
Sustentabilidade	38	Design	9
Agroecologia	21	agroecologia	6
Agricultura	15	sustentabilidade	6
Desenvolvimento	13	planejamento	5
Social	12	Horta	4
Experiência	11	Público	4
Rural	11	agricultura	3
Vida	10	Campo	3
Caso	9	Espaço	3
Cultura	9	Princípios	3
Design	9	Projeto	3
Espaço	9	Rio	3
Planejamento	8	Sul	3

FRENCH

2011 - 2020		2021 - 2023	
Term	#	Term	#
transition	17	Transition	7
Agricole	9	Ecologique	6
biologique	7	Jardin	3
agroécologie	5	l'anthropocène	3
approche	5	Production	3
design	5	Sol	3
monde	5	Villes	3
production	5	Alternatives	2
Vie	5	Analyse	2
alimentaires	4	Approche	2
environnementale	4	Cas	2
France	4	Design	2
nature	4	Enjeux	2
Sein	4	Etablir	2
société	4	Etape	2

SPANISH

2011 - 2020		2021 - 2023	
Term	#	Term	#
Desarrollo	14	Diseño	11
Sostenibilidad	10	Desarrollo	8
Comunidad	8	Sostenible	8
Alimentaria	7	Arquitectura	7
Alternativa	7	Bioconstrucción	5
Diseño	7	Agrícola	3
Cambio	6	Ambiental	3
Ecológica	6	Arquitectónico	3
Educativo	6	Propuesta	3
Innovación	6	Rural	3
Agricultura	5	Turismo	3
Arte	5	Comunidad	2
Ética	5	Conocimiento	2
Propuesta	5	Criterios	2
Ambiente	4	Ecológico	2

Fig. 7 An analysis of terms associated with permaculture that have persisted in three languages. The color scheme highlights terms that have appeared in at least three distinct time periods. ATLAS TI provided the number of occurrences for each term, indicating their relevance.

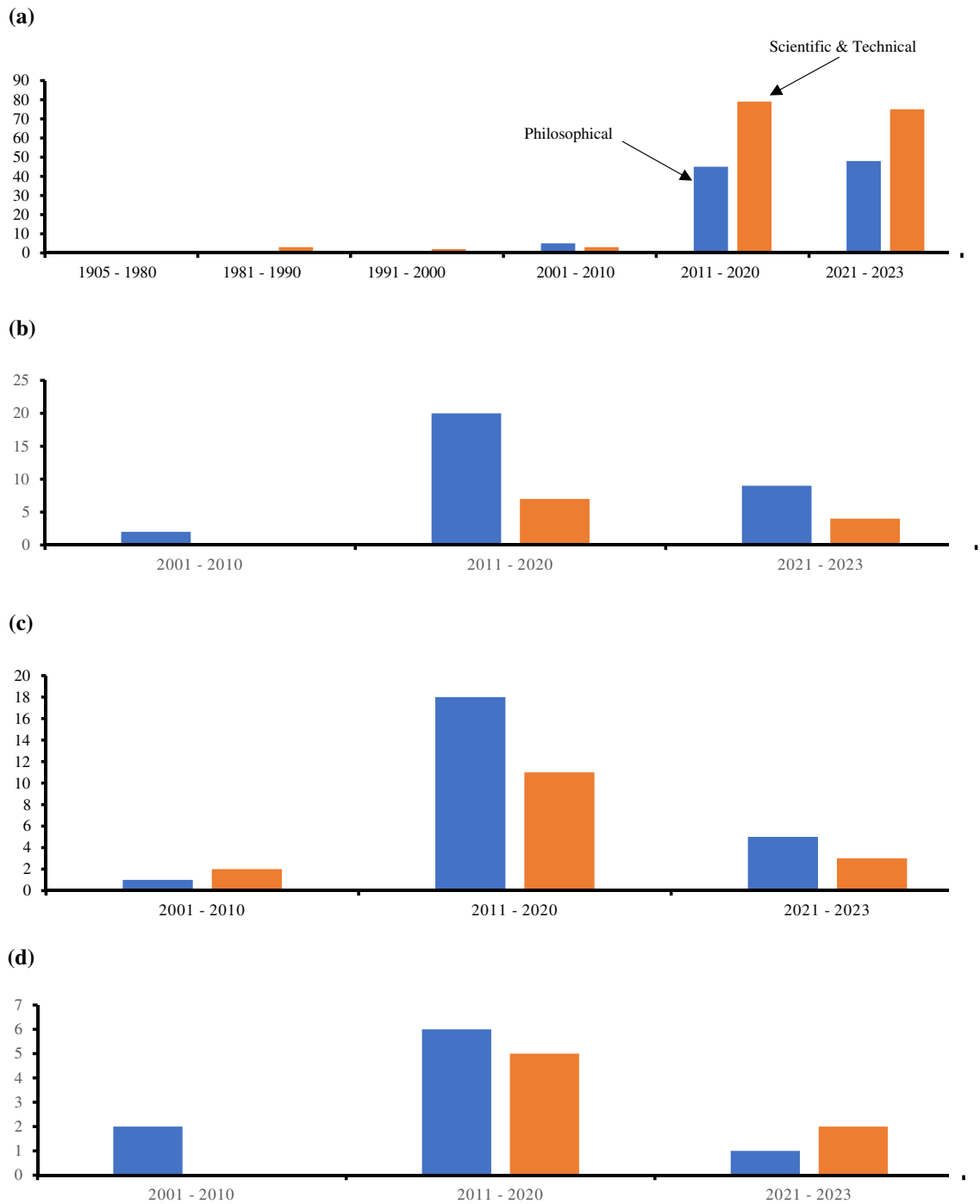


Fig. 8 An overview of the evolving nature of peer-reviewed permaculture publications in the four languages. Note: (a) English, (b) French, (c) Portuguese, (d) Spanish.

In terms of education, Krisdianto et al. (2021) highlight the significance of traditional knowledge and ecological attitudes in fostering sustainable practices. Similarly, Gashute and Hale (2023) discuss how permaculture serves as a bridge between indigenous agricultural practices and industrial technologies.

3.4.2 Themes in French literature

French-language studies often focus on the philosophical and political dimensions of permaculture, with a smaller but significant emphasis on technical applications.

Philosophical inquiries frequently explore the epistemological contrasts between conventional agronomy and agroecology. Cohen (2018) examines ecological and evolutionary dynamics in these systems, while Lesson (2021) positions permaculture as a cultural logic that influences human-environment relationships. Rigolot (2017) adopts an evolutionary perspective to investigate agricultural transformations and worldview shifts.

Policy and politics are also prominent themes. Chanez and Lebrun-Paré (2015) analyze citizen-led initiatives as responses to neoliberal globalization, illustrating how these efforts reshape political engagement. Chakroun (2020) discusses Swiss agricultural policy, focusing on the challenges of integrating permaculture into broader sustainability frameworks.

Technical studies in French literature often address urban agriculture. For instance, Pezrès (2010) compares permaculture designs with conventional urban planning, highlighting their potential to enhance sustainability. Similarly, Perrotti (2012) examines pilot projects and strategic planning tools designed to implement permaculture on a territorial scale.

3.4.3 Themes in Portuguese literature

Portuguese-language studies emphasize education and design, reflecting the philosophical and technical aspects of permaculture.

In the realm of education, de Castro Martins et al. (2021) and Santos et al. (2012) investigate the incorporation of permaculture into environmental education, particularly in schools. da Silva, Podewils et al. (2018) evaluate the outcomes of critical ecological education initiatives, emphasizing their role in promoting sustainable practices and awareness.

Technical studies focus on design and architecture. Azevedo (2022) highlights vernacular architectural techniques that prioritize local materials, reducing costs and improving comfort. Similarly, de Avila et al. (2022) describe participatory processes in implementing permaculture systems, offering valuable insights into community-driven approaches.

3.4.4 Themes in Spanish literature

Spanish-language studies provide a balanced perspective, addressing both philosophical and technical aspects of permaculture.

Philosophical discussions frequently examine social transformations and cultural frameworks. Pereira Salazar (2013) investigates how these frameworks support transformative social action, while Gutiérrez Pinto (2021) explores the integration of socio-anthropological and geographic perspectives in the development of sustainable habitats.

Technical contributions include García et al. (2016) who describe the use of rainwater in school gardens and the establishment of permaculture fruit forests. Muñoz (2019) highlights the application of permaculture in urban agriculture, while Herrera and Elizondo (2010) discuss ecological construction systems inspired by permaculture principles.

3.5 An analysis of how the term permaculture is received in peer-reviewed English literature

The results of our analysis of citation counts are shown in Figure 9. There is a more complete list of the citation count analysis of the main English-language publications available in the supplementary material. Based on this analysis, six publications were identified with high citation counts. Among these six papers, two are at the top of the list and both Scopus and Web of Science indicate that they have similar citation counts. These two publications are Regenerative Agriculture: An Agronomic Perspective (Giller et al. 2021) and Permaculture for Agroecology: Design, Movement, Practice, and Worldview. A review (Ferguson and Lovell 2014).

Our analysis based on the H-index is presented in Figure 10. The figure presents the 10 publications with the highest H-index, either in the first author, second author, or last author order. As a general rule, the top authors in scientific publications fall within these three positions.

4 Discussion

Despite its high profile and worldwide distribution, permaculture remains relatively isolated from scientific research, according to Ferguson and Lovell (2014). As far as we could tell, Ferguson and Lovell (2014) work is the only attempt at a literary review of permaculture. This study examines whether permaculture has moved from a philosophical, ethical, and social context to a technical one, or vice versa, for the first time in four different languages. A further question is whether permaculture has evolved over time into a scientific subject. Our analysis of 975 references indicates that there is a significant increase in interest in publishing literature on permaculture-related topics in a variety of audiences, primarily academics and scientists. This growth first began in each of the four languages examined in this literature review during the decade of 2000, and then became more prominent during the decade of 2010.

The initial promoters of the *permaculture* concept provided their visions of the term. These were Bill Mollison in 1988 in his book *Permaculture: A Designer's Manual* and David Holmgren in 2013 in his booklet *The Essence of Permaculture*. Their definitions are separated by 25 years and provide us with an initial and modern view of their conception. Terms such as *consciousness design*, *ecosystems*,

Publication title	Scopus	Web of Science
Regenerative Agriculture: An agronomic perspective (Giller, Hijbeek et al 2021)	143	126
Permaculture for agroecology: design, movement, practice, and worldview. A review (Ferguson and Lovell 2014)	142	110
Feeding and healing the world: through regenerative agriculture and permaculture (Rhodes 2013)	65	Not determined
Grassroots engagement with transition to sustainability: diversity and modes of participation in the international permaculture movement (Ferguson and Lovell 2015)	51	41
Agroecology and permaculture: addressing key ecological problems by rethinking and redesigning agricultural systems (Hathaway 2016)	47	Not determined
Permaculture—Scientific Evidence of Principles for the Agroecological Design of Farming Systems (Krebs and Bach 2018)	39	21
Examining Innovation for Sustainability from the Bottom Up: An Analysis of the Permaculture Community in England (Maye 2018)	38	Not determined
Integral estimate of the added value of agricultural crops in the synergetic agriculture on the example of vicia faba (Zhao, Cherkasov et al 2021)	37	27
The impact of growing legume plants under conditions of biologization and soil cultivation on chernozem fertility and productivity of rotation crops (Mukhametov, Bekhorashvili et al 2021)	33	5
Alternative visions: Permaculture as imaginaries of the Anthropocene (Roux-Rosier, Azambuja et al 2018)	33	26

Fig. 9 Comparison of citation counts for top English publications in different databases: Color coding: Green > 40, Orange 39–20, Red < 20. Excluding self-citations.

diversity, food, local, and energy are important in the visions of permaculture as described by those authors. The study results show that some of these concepts have persisted, while others were displaced (depending on languages and type of literature), and many are emerging. Since its inception, the *permaculture* concept has exhibited an adaptive nature that combines ancient traditional knowledge with modern practices and ecological principles. Various analyses presented in this study support the changing nature of the term *permaculture* over time. Many factors may contribute to this, including adaptation to changing environmental needs, the evolution of our society's challenges clearly defined by the United Nation's Sustainable Development Goals (Lee et al. 2016), as well as efforts to ensure that our society remains aware of pressing issues such as environmental degradation and climate change's detrimental effects.

4.1 Evolution of the term permaculture

Through an analysis of 230 permaculture publications, Ferguson and Lovell (2014) identified relevant terms related to permaculture, including design, agriculture, urban, sustainable, community, and system. We reaffirm some of the terms proposed by Ferguson and Lovell (2014); however, we have also highlighted other terms that have persisted through time, such as *soil, ecology, education, and food*. Further, in the years following Ferguson and Lovell's (2014) literature review, other terms have emerged as relevant to the English literature, including *organic, social, development, management, regenerative, climate change, urban gardens, and education*. Words such as *development, design, community, education, sustainability, alternative, food, and change*

Publication	Author 1	H-index	Author 2	H-index	Last Author	H-index
Regenerative Agriculture: An agronomic perspective	Giller, Ken E	77	Hijbeek, R.	13	Sumberg, J	23
Plant genus <i>Elaeagnus</i> : underutilized lycopene and linoleic acid reserve with permaculture potential	Patel, Seema	39				
Local scale water-food nexus: Use of borehole-garden permaculture to realise the full potential of rural water supplies in Malawi	Rivett, Michael O	28	Halcrow, Alistair W	1	Kalin, RM	33
Learning in the Permaculture Community of Practice in England: An Analysis of the Relationship between Core Practices and Boundary Processes	Julie Ingram	26	Maye, Damian	30	Kubinakova, Katarina	3
Permaculture for agroecology: design, movement, practice, and worldview. A review	Ferguson, Rafter Sass	5	Lovell, Sarah T	28		
Tree Crops, a Permanent Agriculture: Concepts from the Past for a Sustainable Future	Molnar, Thomas J	14	Kahn, Peter C	20	Funk, CR	7
Sustainable management models: innovating through Permaculture	Vitari, Claudio	12	David, Christophe	20		
Integral estimate of the added value of agricultural crops in the synergetic agriculture on the example of vicia faba	Zhao, Q	1	Cherkasov, Sergei, V	0	Mikhaylov, Alexey Y	20
“The right to food is nature too”: food justice and everyday environmental expertise in the Salvadoran permaculture movement	Millner, Naomi	6				
Environmental anthropology engaging permaculture: moving theory and practice toward sustainability	Veteto, James R.	9	Lockyer, Joshua	4		

Fig. 10 H-index analysis based on data from Web of Science

(*desarrollo, diseño, comunidad, educación, sostenibilidad, alternativa, comida, and cambio*) have significance in Spanish. A number of terms appear frequently in French literature, including *design, organic, ecological, transition, and society* (design, biologique, écologique, transition, and société). *Education, sustainability, agroecology, design, social, and development* (*educação, sustentabilidade, agroecologia, design, social, and desenvolvimento*) were the most prevalent terms in Portuguese literature. Permaculture is most commonly associated with three terms in the four languages: *design, agriculture, and ecology*. A number of other terms, such as *social/community, education, and sustainability*, are also very prevalent in at least three languages.

4.2 The term permaculture continues to be used more frequently in peer-reviewed technical literature

Considering Figure 3 of this study, we can conclude that permaculture research has increased significantly (when compiling all languages) during the decade 2011–2020 and in the most recent period studied (2021–2023) compared to previous periods. Based on the source distribution depicted in Figure 2, the three most common document types in English are peer-reviewed journal articles (44%), books and generics (16% each), and theses (13%). According to our analysis of the English data set, scientific publications tend to focus largely on technical issues relating to permaculture.

Contrary to this, philosophical aspects of permaculture emerge in 2000–2010. Nevertheless, the technical-scientific element continues to dominate the more recent philosophical aspect of permaculture. According to our analysis of scientific literature in English, the term has begun to appear in peer-reviewed publications of a philosophical nature in the 2000 s. On the other hand, Figure 8 (a) indicates that the term *permaculture* appears primarily in peer-reviewed papers of a technical nature. Over the last two periods, technical-scientific publications have outnumbered philosophical publications by more than 75% and 56%, respectively.

Based on the information depicted in Figure 2, the three most common document types in French are peer-reviewed journal articles (37%), thesis (23%), and generic (21%). Our study indicates that most of the literature in the French language has a philosophical orientation since its emergence in the 2000 s. Although reference to permaculture in French remained largely philosophical until the present day, technical literature in this language started to emerge in the 2010 s. The following are some of the most prominent topics in the literature studied according to their nature and the intended purposes of some of the publications in the French dataset.

Based on the source distribution depicted in Figure 2, the three most common document types in Portuguese are thesis (50%), peer reviewed journal article (23%), and conference proceedings (18%). The Portuguese database shows a similar tendency to the Spanish and French databases toward the development of philosophical-political literature. The Portuguese scientific-technical literature on permaculture emerged in the 2000 s, as opposed to the French and Spanish literature, which emerged in the 2010 s.

In accordance with Figure 2, the three most common document types in Spanish are theses (50%), peer-reviewed journal articles (23%), and conference proceedings (18%). Similarly to the Portuguese and French databases, the Spanish database shows a tendency toward the development of philosophical-political literature related to permaculture. Spanish literature of a scientific-technical nature began to emerge in the 2010 s, similarly to the French dataset.

4.3 Research and publications in peer-reviewed journals have embraced the term permaculture in recent decades

In both white and gray literature, it is evident that the number of publications related to permaculture is increasing. Based on the analysis of 364 scientific publications in four different languages, the literature has grown significantly over the past decade, especially between 2010 and 2023. Alternatively, our analysis, based on the H-index, indicates that various successful researchers have published on the concept of permaculture. Among the most prominent, we can list Ken Giller, Seema Patel, Damian Maye, Sarah Lovell, and Julie

Ingram, who have H-index values greater than the number of years they have of research work according to WOS records (Bornmann and Daniel 2007; Hirsch and Buéla-Casal 2014). Other researchers such as R.M. Kalim, Michael Rivett, and J. Sumberg exceed H-index values of 20.

As a result of our analysis, two publications have been identified as the most important regarding the concept of *permaculture: Regenerative Agriculture: An Agronomic Perspective* (Giller et al. 2021) and *Permaculture for Agroecology: Design, Movement, Practice and Worldview. A review* (Ferguson and Lovell 2014). Scopus shows that those publications have 143 and 142 citations, respectively.

Essential Science Indicators placed *Regenerative Agriculture: An Agronomic Perspective* among the top 1% of highly cited articles in the academic field of Agricultural Sciences in September/October 2023. Meanwhile, *Permaculture for Agroecology: Design, Movement, Practice and Worldview. A review* did not achieve this distinction. Giller et al. (2021), in their publication, delve into the concept of regenerative agriculture through an exhaustive review of the literature. According to them, this concept is nothing more than a re-framing of two other approaches widely discussed in the white and grey literature, such as agroecology and sustainable intensification. It was suggested by the authors that the introduction of a new concept such as regenerative agriculture created further confusion as to the challenges facing both predecessor concepts. Giller et al. (2021) even go so far as to suggest that it diverts attention from more fundamental challenges in the agricultural sector. A further claim made by Giller et al. (2021) is that permaculture is a niche practice with limited application in the production of various agricultural products. Meanwhile, Ferguson and Lovell (2014) conduct a systematic review of the literature of agroecology and argue that permaculture can be a significant contributor to the agroecological production industry.

5 Limitations of the study

- It is important to note that the exploration of the origins of the terms *permaculture* and *permanent agriculture* is hampered by the fact that several of the catalogs or databases used in this study do not permit searches prior to 1900. In view of this, it is possible that the term *permanent agriculture* was used prior to 1900, and we have not considered it in this literary analysis.
- In the study of the origins of the term *permaculture* and its associated term *permanent agriculture*, other influences on permaculture practice were not identified by the methodology implemented in this review, including Masanobu Fukuoka's (1978) work. Therefore, it is possible that other influences on the *permaculture* term, practice, or movement may not have been detected.

- c. A critical aspect of our methodology was to avoid considering the author's or co-author's perspective. As a consequence, the classification of each of the sources analyzed was carried out as much as possible based on taxonomies (Research areas, Categories, Topic Prominence, Unique Areas of Research) provided by the databases and catalogs used in the analysis. The use and combination of tools such as machine learning, artificial intelligence, and computer-assisted qualitative analysis is recommended as part of future literature reviews for the term for a deeper analysis of the references' content and for determine their technical or philosophical perspectives.

6 Conclusion

This study presents the most comprehensive analysis of permaculture literature to date, systematically evaluating 975 peer-reviewed and non-peer-reviewed publications in English, Portuguese, French, and Spanish. By examining bibliometric data, content (title and keyword) analysis, H-index, and citation counts, this work provides valuable insights into the evolution and impact of the term 'permaculture' within academic and non-academic contexts. Among the four languages analyzed, permaculture is most commonly associated with design, agriculture, and ecology, highlighting its interdisciplinary nature. Additionally, concepts such as social/community, education, and sustainability are prevalent across three languages, further demonstrating the term's broad applicability.

Several conclusions can be drawn from this analysis:

The term 'permaculture' remains prominent across various types of literature, particularly in scientific and academic contexts.

A general upward trend in publications related to permaculture has been observed, with significant growth over the past three years.

The concept of permaculture continues to evolve, driven by shifting social, environmental, and economic priorities.

In English-language peer-reviewed literature, permaculture is predominantly associated with technical applications, while its philosophical aspects are more prominent in Spanish, Portuguese, and French literature.

Permaculture has increasingly garnered attention in English peer-reviewed literature over the past two decades, including from internationally renowned scientists.

The findings of this study underscore the term's potential to contribute significantly to scientific discourse and sustainable agricultural practices. Despite this, the isolation of permaculture from mainstream scientific literature poses a challenge to its broader integration and impact. Addressing this gap is critical for maximizing its potential as a tool for ecological, economic, and social transformation.

The implications of this work are multifaceted. First, by systematically cataloging and analyzing permaculture literature, this review provides a valuable resource for researchers and practitioners seeking to understand the concept's evolution and current applications. Second, the interdisciplinary nature of permaculture highlights its potential to bridge gaps between scientific and practical knowledge, fostering collaborations that advance sustainability goals. Finally, this study emphasizes the importance of integrating permaculture into mainstream scientific discourse to enhance its credibility and applicability, ultimately supporting global efforts to create more resilient and sustainable food systems.

Future research should explore the practical applications of permaculture principles across diverse contexts, focusing on their measurable impacts on sustainability and resilience. Furthermore, fostering collaborations between scientists, practitioners, and policymakers will be crucial to ensuring that permaculture's principles and practices achieve their full potential in addressing the complex challenges facing contemporary agriculture and society.

Authors' contributions RCFT conceptualized the research, acquired funding, collected data (English, Portuguese, and Spanish), performed the data analysis, developed all figures and tables, and wrote the article. JJM-A collected data (French) and reviewed and edited the article. OGC provided funding, supervised the conceptualization and execution of the research, and reviewed and edited the article. The Center for Hydro-Environmental Innovation, Research, and Technology (CITEC) partially contributed to the open access publication cost.

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Data availability All data generated or analyzed during this study are included in this published article and its supplementary information files. The supplementary information files are hosted on eScholarship@McGill, McGill University's institutional digital repository featuring electronic, open access outputs of McGill researchers and students.

- **S1. Publication dataset.xlsx** (Table S1) List of publications related to permaculture included in the review of English, Spanish, Portuguese and French literature. This file is hosted at: https://escholarship.mcgill.ca/concern/file_sets/wm117v100?locale=en.

- **S2. Terms most associated with permaculture (English, French, Portuguese, and Spanish).xlsx** (Tables S2-A, B, C and D) The 100 terms most associated with the practice of permaculture in the English, Spanish, French, and Portuguese, respectively.

This file is hosted at: https://escholarship.mcgill.ca/concern/file_sets/td96k802j?locale=en

Code availability Not applicable.

Declarations

Conflicts of interest The authors have no conflicts of interest to declare that are relevant to the content of this article.

Ethics approval/declarations Not applicable.

Consent to participate Not applicable.

Consent for publication Not applicable.

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