frontiers | Frontiers in Environmental Science

TYPE Original Research
PUBLISHED 09 August 2022
DOI 10.3389/fenvs.2022.940526

Check for updates

OPEN ACCESS

EDITED BY
Magdalena Radulescu,
University of Pitesti, Romania

REVIEWED BY
Muhammad Usman,
Wuhan University, China
Gagan Deep Sharma,
Guru Gobind Singh Indraprastha University, India

*CORRESPONDENCE
Luis Seguí-Amortegui,
luisalberto.segui@unir.net

†These authors have contributed equally to this work and share first authorship

SPECIALTY SECTION
This article was submitted to Environmental Economics and Management, a section of the journal Frontiers in Environmental Science

RECEIVED 10 May 2022
ACCEPTED 18 July 2022
PUBLISHED 09 August 2022

CITATION
Rodriguez-Rojas MP, Clemente-Almendros JA, El Zein SA and Seguí-Amortegui L (2022), Taxonomy and tendencies in sustainable finance: A comprehensive literature analysis. *Front. Environ. Sci.* 10:940526. doi: 10.3389/fenvs.2022.940526

COPYRIGHT
© 2022 Rodriguez-Rojas, Clemente-Almendros, El Zein and Seguí-Amortegui. This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY). The use, distribution or reproduction in other forums is permitted, provided the original author(s) and the copyright owner(s) are credited and that the original publication in this journal is cited, in accordance with accepted academic practice. No use, distribution or reproduction is permitted which does not comply with these terms.

Taxonomy and tendencies in sustainable finance: A comprehensive literature analysis

Maria del Pilar Rodriguez-Rojas[1†], José Antonio Clemente-Almendros[2†], Samer Ajour El Zein[3] and Luis Seguí-Amortegui[2*†]

[1]Department of Civil and Environmental Engineering, Universitat Politècnica de Catalunya (UPC), Barcelona, Spain, [2]Faculty of Business and Communication, Universidad Internacional de La Rioja, Logroño, Spain, [3]Economics and Finance Department, EAE Business School, Barcelona, Spain

This study identifies the trends in the literature related to Sustainable Finance by means of an exhaustive literature review and a bibliometric analysis of publications taken from the Web of Science database (WoS). A search in WoS for the associated terms came up with a total of 9294 entries, showing a particularly noticeable growth in scientific production in the aftermath of the Paris Agreement of 2015. The analysis of the bibliometric networks was performed using VOSviewer (VOSviewer is a software tool for constructing and visualizing bibliometric networks), from which the analysis of key words was obtained. Using this analysis five cluster groups were identified, showing the main themes of research: Climate risk and adaptation, Low carbon energy economy or Low carbon economy, Environment, finance and governance, Low carbon emission technologies, Economic model and social cost. Further research is recommended into the themes of Low carbon energy economy and Environment, social and governance, considered key issues in the future.

KEYWORDS

sustainable finance, sustainable economy, low carbon economy, climate risk, ESG

Introduction

Sustainable development is a central concept nowadays (Roös, 2021). It is both a way of understanding the world and a method for solving global problems (Sachs and Schmidt-traub, 2015). The challenges of sustainability are becoming increasingly important, in the long-term strategy of companies, for their clients and for the external stakeholders, encompassing the increasing demand for natural resources, economic inequality and climate change (Baumann, 2009). Businesses must deal with their environmental impact without ignoring the finite resources of the planet and must contribute to a safe operating space for human development (Muñoz-Torres et al., 2019). The current environmental problems require more environmentally-friendly technology, but it is not clear if this technology alone will be enough to guarantee an environmentally

sustainable future (Kemp, 1994). That will depend on public and private support for environmentally beneficial technology and the measure with which world population growth and economic production lead to a reduction in per capita emissions and a more efficient use of natural resources (Kemp, 1994). One of the main challenges is financial mitigation and adaptation to climate change and sustainability (D. Zhang et al., 2019). Finance is generally considered an obstacle to a better world (Schoenmaker and Schramade, 2019), indeed it has always been an instrument of economic decisions (Ryszawska, 2018).

Sustainable finance (SF) is defined as the process of consider the environmental and social aspects when deciding to invest (European Commission, 2019). In other words, SF refers to the practice of sustainable principles in finance and emphasizes the environmental, development and institutional aspects of investment to promote sustainable development (Cheng et al., 2019). However, it is often difficult to distinguish between green finance, climate finance (Zhang et al., 2019), carbon finance, sustainable finance and other related terms.

The literature on the subject is far from complete. Research is still struggling to find an adequate grouping of financial methods to correlate with environmental and sustainable practices (Hahn and Figge, 2011; Shah, 2011; Endrikat et al., 2014). Finance may support sustainable development on three levels: (i) the economic level, optimizing financial performance and risk compensation. This financial orientation supports the idea of maximizing organizations' profits and the economic growth of countries (Schoenmaker and Schramade, 2019); (ii) on a social level, optimizing the impacts of commercial and financial decisions on society (Raworth, 2017; Schoenmaker, 2018; Schoenmaker and Schramade, 2019); and (iii) on an environmental level, optimizing the environmental impact (Schoenmaker and Schramade, 2019). The three levels are related; therefore, it is important to choose the right combination of financial, social and environmental aspects. The answer to dealing with the social and environmental problems is to include them in our economic models; however, these models are limited to capital and labor, without the goods and services of Nature (Schoenmaker and Schramade, 2019). The role of finance is changing from the deep-seated view of economic theory that maximizes earnings and wealth towards one that supports sustainable development, the green economy, the low-carbon economy and the adaptation and mitigation of climate change (Ryszawska, 2018).

The aim of this study is to identify the trends in SF literature and provide a better understanding of the main themes in current research, as well as identifying future research paths. These trends are identified from the literature using content analysis and the principles of the bibliometric method. Bibliometrics analyzes the development and growth of a specific field of research (Fu, Wang and Ho, 2013; van Eck and Waltman, 2014; Wang et al., 2016, 2017; Wang, Wei and Brown, 2017; Garrigos-Simon, Narangajavana-Kaosiri and Lengua-Lengua, 2018). The documents were extracted from the Web of Science (WoS) database and we used the VOSviewer software to visualize the bibliometric networks. The Web of Science (WoS) developed by Thomson Reuters, is one of the most-used databases, providing consistent results and the best graphics in the analysis of citations compared with other databases; it allows entire citation registers to be downloaded in ".txt" format, which is compatible with most literature analysis tools (Li et al., 2018). The results of this study will be useful for researchers, decision and policymakers in both the public and private sector, who need more information and academic support to understand the development of SF in different areas and sectors. For researchers it offers a concentrated view of the state of the art, trends and gaps in scientific research. It can guide the decision and policymakers in deciding upon their plan of action and assigning funds to the relevant areas. The study is also a means of researching SF theory in politics and practice, and vice versa, to obtain benefits in favor of sustainable development.

The document is organized as follows: Section 2 presents an up-to-date review of the literature referring to the specific theme of SF, showing the problems to be solved and questions to be answered. Section 3 shows the data and methods used. Section 4 shows the main results and Section 5 describes the principal conclusions and possibilities for future research.

Literature review

At an early stage in the research into SF, Feitelson (1992) suggested that economic instruments could be a source of specific funds for many environmental objectives. Until then, studies have identified a series of problems which impeded their use, considering that economic instruments might have an adverse effect on many companies and sectors. At the time, it was decided that as more analyses were carried out and more data accumulated, it would be possible to calculate the general contribution that economic instruments might have as SF tools for contamination control and environmental management (Feitelson, 1992). Since 2000, researchers have analyzed the relationship between financial performance and sustainability, concluding in most cases that sustainability does not harm, but improves, financial performance (Amato and Amato, 2012; Mă;nescu, 2011; Margolis and Walsh, 2003; Orlitzky et al., 2003; Paine LS, 2003; Vogel, 2005; Zeidan and Spitzeck, 2015). However, it is also said that bad sustainability management can lead to a loss in company value and the majority of financial reports do not contain environmental information (Nilsson et al., 2008; Noussia, 2011; Kling et al., 2012; Zeidan and Spitzeck, 2015). It also became evident that companies that incorporated sustainability in their strategies and management structure are better in both their accounting and stock performance (Zeidan & Spitzeck, 2015).

Soppe (2004) analyses the new concept of SF and concludes that finance as a discipline requires a multifaceted approach instead of a unidimensional focus on risk and performance. The author argues that, in the SF concept, the aim of the financial policy is sustainability. In this sense, the expected sustainable performance of companies is the result of optimizing the long-term financial, social and environmental variables; however, this multi-attribute focus may further complicate the financial modelling, while simultaneously supporting long-term financial objectives which convey a credible and trustworthy image of the company (Soppe, 2004). In 2008, Soppe went further in respect of the definition of SF, entering the discussion about the optimum ownership of a company, arguing that a sustainable company is one that belongs to a portfolio of stakeholders (Soppe, 2008). In 2006, Stern (2007) introduced interesting tools, from financial theory to the valuation of environmental investments (Stern, 2007; Gollier, 2008). The originality of Stern's report comes from the affirmation that in order to eliminate the consequences of the greenhouse effect, part of global consumption must be sacrificed (Gollier, 2008). The Stern report came in for criticism, such as from Gollier (2008), who questioned Stern's conclusions for being based on numerical suppositions. As most of the impacts of climate change were distant, Gollier considered it more logical that the effect would show as a permanent annual reduction of 0.1% in the growth rate of the Gross Domestic Product (GDP) (Gollier, 2008).

Zeidan and Spitzeck (2015), claim that there should be a relationship between a company's sustainable practices and its value. Using their own methodology, they suggest that integrating the scenarios and opportunities of Environmental, Social and Governance (ESG) may lead to significant changes in a company's value; they also show that sustainability reports can generate useful information. However, the SF shows that current ESG methodology does not consider exploring the opportunities to improve future cash flows. They conclude that more research is needed to analyze in detail how the innovations of sustainability improve future cash flows by improving income, reducing operation costs or reducing capital costs, as well as encouraging the spread of evaluation methods (Zeidan and Spitzeck, 2015). According to Ziolo, Fidanoski, Simeonovski, Filipovski and Jovanovska (2017), the SF can back up sustainable economic development, funnelling investment in such a way as to put the economy on a growth curve, which can solve the problems caused by negative externalities that might block achievement of a better quality of social wellbeing. An investment that helps to achieve sustainable growth may be considered a socially responsible investment (SRI), defined by the Investment Leader Group (ILG) as an investment that creates long-term social, environmental and economic value. In this respect, SF provide the financial instruments and the market structure that will assign the capital in such a way as to maximize the social benefits, adjusted by the financial and non-financial risks (Ziolo et al., 2017). From the institutional point of view, SF can be seen as the creation of institutional arrangements that can contribute to achieving sustainable economic development (Pisano et al., 2012; Ziolo et al., 2017).

Researching into the role of SF in guaranteeing sustainable development among the members of the Organization for Economic Cooperation and Development (OECD) in the period 2008–2013, Ziolo et al. (2017) provide details of the types of policies applied in compliance with the SF, in particular environmental (Usman and Balsalobre-Lorente, 2022) or social concerns. These include: civil and labor rights, indigenous peoples, climate and energy, biodiversity, forests, extractive industries, sustainable agriculture, chemical products, transparency, report presentations and social and environmental management systems. However, it seems there is no reliable, unified, standards for measuring and evaluating the risks and performance of sustainability in comparison to the financial ones, and with little attention paid to the combined performance related to the preservation of natural capital and socioeconomic wellbeing. Their model uses variables that represent the economic, social, environmental and institutional policies (Schwartz and Carroll, 2003). The results confirm that policies aiming at stricter financial regulation, better technology and improved intensified energy production create a solid base for sustainable development. One of the limitations of the study was the lack of available data and the relatively short amount of time used for an analysis of this type (Ziolo et al., 2017).

The group of experts on SF nominated by the European Commission (EC) at the end of 2016 published their final report at the end of 2018, in which they offered a global vision of how to prepare European Union (EU) strategy. The report states that SF is based on two urgent needs: (i) to improve the contribution of finances to sustainable economic growth, and (ii) to strengthen financial stability by incorporating environmental, social and governance (ESG) operators in investment decision-making (European Commission, 2018). According to an analysis of the publication "Sustainable Finance: paradigm shift", finance is adapting to the new economic trends with a transition to a green economy in converting the existing economic model towards new ones based on greater social and environmental responsibility, emphasizing elements such as: circular economy, low emissions, resource efficiency, clean technology, responsible consumption, social justice and equality (Ryszawska, 2018). This has led to increased public debate on taxonomy for finance: green finance (GF), climate finance (CCF), carbon finance (CF), sustainable finance (SF) (Ryszawska, 2018), the definitions of which are found in Table 1 of the SF taxonomy. All types of financing ease the transition to sustainability and give rise to the sustainable finance system (SFS), which creates, evaluates and carries out financial asset transactions, giving shape to real wealth to satisfy the long-term needs of an inclusive and environmentally sustainable economy (UNEP and Lehmann,

TABLE 1 SF taxonomy.

Type of SF	Author	Definition
GF	Bergedieck et al. (2017); G20 Green Finance Study Group, (2016); Ryszawska, (2018)	Supports green growth and the transition to a green economy and reduces negative environmental results. Means investment in renewable energy and the reduction of industrial emissions, sustainable transport, recycling, organic agriculture, waste management, water management, eco-innovation, clean technology used by public and private bodies
CCF	Ryszawska, (2018); Stewart et al. (2009)	The aim is to support adaptation and mitigation of climate change, as well as financing a shift to low emission and climate resistant development and is considered a critical element in global climate policy
CF	Labatt and White, (2007); Ryszawska, (2018); Ziolo *et al.* (2019)	Mitigates the impacts on health and climate of national carbon-based emissions. Presented as a solution to climate change

GF: green finance; CCF: climate change finance; CF: Carbon finance. Source (UNEP, and Lehmann, 2013; Ryszawska, 2018; Ziolo et al., 2019).

2013; Ryszawska, 2018). The change in the role of finance towards an approach that supports sustainable development, a low carbon green economy and the adaptation and mitigation of climate change is occurring as part of a process with multidimensional interaction between industry, technology, markets, politics, culture and civil society. Society and the economy expect finance to align itself with the transition to sustainability. Environmental transition needs money for mitigation and adaptation to climate change, protection of ecosystems and biodiversity. However, few experts work on the subject of SF (Ryszawska, 2018).

For Dörry and Schulz (2018) SF is less focused on the basic financial activities such as the relations between the company and its creditors. They explore the different understandings of the concept and seek to define them more clearly in order to deal with and complement the policies derived with different incentives (Balsalobre-Lorente et al., 2022) and impacts for sustainable economic activities at different levels of the economy, specifically in the context of the economy of Luxembourg at three levels: the private, public and financial sectors (Dörry and Schulz, 2018). For the researchers, the widest discussion was about GF and whether it consisted of innovative green investment strategies and the use of circumstances to create new markets for environmental or climate financing, or involved alternative small-scale local financing, environmentally respectful and socially inclusive, which would allow a more equitative sharing of profits and resources among the different social groups. According to the researchers, a much deeper understanding is needed in order to evaluate correctly the current transitional processes of finance towards greener economies and societies. The specific activities launched until now are considered too marginal or recent for their impact to be evaluated (Dörry and Schulz, 2018).

Zhan and de Jong (2018) examine the financial vehicles used in the Shenzhen International Low Carbon City (ILCC), how they contribute to sustainability and the implications of the lessons learned for other ecological and low carbon cities. ILCC is a demonstration program of collaboration between China and the EU in sustainable urbanization, which aims to show China's advances in low carbon emission technologies. The research into the practice of financing in ILCC, along with the participation of stakeholders (government) to explain the logic behind the financing of low carbon cities, contributes to the literature on the theory and practice of SF, studying whether the financial vehicles that ILCC use are sustainable in financial, social and environmental terms (Zhan and de Jong, 2018). Progress in the ILCC has up to now been due largely to the diversification of finance sources and the innovative changes in the organizational arrangements which group together a wider variety of stakeholders in the development process. The results of the study show that ILCC is environmentally sustainable, promoting low carbon transition, socially sustainable through the participation of residents and citizens, and financially sustainable by the diversification of sources of finance. However, it is considered that the concept of SF has not been fully exploited, especially in terms of social aspects (Zhan and de Jong, 2018).

Ziolo et al. (2017) explores the connection between SF and the three pillars of sustainable development. The document explains that sustainable development aims to mitigate the negative externalities and, up to now, conventional finance has offered no place for the environment and society. Therefore, SF has arisen. An attempt is made for the first time to examine the relationship between indicators of financial, economic, environmental and social development from the perspective of sustainability, with special attention to the negative externalities which must be managed. It is assumed that SF significantly undermines the negative externalities, and it is possible to assign special types of SF to the negative externalities affected (Ziolo et al., 2017). The literature still does not describe any concept for studying the links between the social, economic, environmental and financial development of the world's countries and, therefore, there are not enough completed databases, which is the main problem associated with analysis in these areas. On a global level, a common policy is

needed (Kamal et al., 2021) to help eliminate the effects of negative externalities and financial systems have a major role to play, especially in the social and environmental areas (Ziolo et al., 2017).

Since 2018 there has been an increase in scientific production regarding SF, dealing with the subject from different perspectives. Several authors mention the need to carry out projects on specific themes using SF tools (Galaz, Crona, Dauriachet al., 2018; Nadler and Nadler, 2018; Pueyo, 2018; van Brakel et al., 2018; Bohorquez, Dvarskas and Pikitch, 2019; Higgins, 2019; Negra et al., 2020). Nadler and Nadler (2018) analyze the political initiatives for sustainable investment in urban areas, such as the Joint European Support for Sustainable Investment in City Areas (JESSICA) project, which attempts to combine SF instruments with urban planning themes. There are several studies that present evidence to sustain the claim that sovereign debt is risky for the financing of public infrastructure if it exceeds certain limits; they make recommendations on the need to mobilize internal resources and innovate new financial models to promote sustainable development. They conclude that carrying out sustainable development projects by implementing unsustainable financial models will always produce unsustainable economic results (Heinemann, 2006; Minea and Villieu, 2009; Caneret al., 2010; Checherita et al., 2010; Reinhart and Rogoff, 2010). Ari and Koc (2021) reaffirm that investments in renewable energy always require a substantial amount of capital to provide accessible energy for all; finding the necessary capital is one of the biggest challenges faced by governments and private bodies (Ari and Koc, 2021). Galaz et al. (2018) analyze how the financial and capital operators play a key role in extractive economic activities all over the world, as well as current efforts to prevent climate change. They also explain how the financial actors affect the key biomes around the world. They combine the Earth system and sustainability sciences with finance (Mahendru, 2020; Sharma et al., 2021; Kaisar et al., 2022), linking the financial operators with the economic activities that alter the biomes necessary for stabilizing the Earth's climatic system, identifying a group of international financial operators with considerable global influence and explaining how incentives and disincentives currently influence their potential to strengthen or weaken the stability of the climate system (Galaz et al., 2018). Bohorquez et al. (2019) analyze SF management in protected areas (PA). The first work claims that the financial means to sustainably manage a representative network of PA on a global level do not yet exist; in particular, investment from the private sector is very modest. One option for increasing the flow of private investment in PA is the development of a market for the PA-emitted certificates for geographical areas managed in accordance with the best social and environmental practices (Bohorquez et al., 2019). The latter work repeats that achieving the goals of PA coverage falters at the lack of sufficient financial resources, and the gap in financing is particularly generalized in marine protected areas (MPA), adding that the quality and quantity of current data limits research into SF (Bohorquez et al., 2019).

From another perspective of SF research, authors such as Schaltegger et al. (2016), Mihalovits and Tapaszti (2018), Daszynska-Zygadlo et al. (2018), y Yip and Bocken (2018) state that the different initiatives launched to internalize the risks and threats of environmental degradation and climate change, such as carbon credits (CC), green bonds (GB), climate change bonds (CCB), social impact bonds (SIB) and carbon taxes, among others. For Mihalovits and Tapaszti (2018), the aim of the GB is to internalize to some extent the environmental externalities and increase environmentally friendly investment (Mihalovits and Tapaszti, 2018). Similarly, Daszynska-Zygadlo, Marszalek and Piontek, in their analysis of trends in the GB market and the nature of emitters, draw attention to the increasing recognition of this sector as the leading instrument of sustainable development (Daszynska-Zygadlo et al., 2018). Park (2018) analyses the implications of sustainable investment for human rights, which aims to create positive social and environmental impacts as well as financial benefits (Park, 2018). Schaltegger et al. (2016) y Yip and Bocken (2018) state that the business models for sustainability are relevant for researchers, given their orientation towards themes of sustainability; they claim that financial instruments with simultaneous financial, social and environmental goals may serve as efficient institutional mechanisms to support financing of the Sustainable Development Goals (SDG) (Schaltegger et al., 2016; Yip and Bocken, 2018).

Other research focuses on the role of the operators and financial markets, and how they may become a more positive part of society (Ziolo et al., 2017; Cash, 2018; Sandberg, 2018; Yip and Bocken, 2018; Contreras et al., 2019; Fioramonti, Coscieme, and Mortensen, 2019; Muñoz-Torres et al., 2019; Siri and Zhu, 2019; Urban and Wójcik, 2019; Monasterolo and de Angelis, 2020). According to Sandberg (2018) the current financial system is unable to deal with the great challenges of sustainability in our time, such as global poverty and climate change. They study the emphasis on social responsibility and the ESG factors in financial management, although they argue that the financial operators cannot be expected to become "substitute regulators", charged with the task of balancing financial and social obligations (Sandberg, 2018). Cash (2018) examines the recent entry of the credit rating agencies into the field of SF in the context of "rating addiction" and warns of the potentially negative effect these agencies might have on the SF sector, concluding that the credit rating agencies have shown that they are on the investor's side, i.e., those who pay them (Cash, 2018). The development of SF favors the rating agencies as providers of ESG information and tools for measuring the contribution of businesses to sustainable development (Muñoz-Torres et al., 2019). Muñoz-Torres et al. (2019) analyze whether these agencies contribute to promoting the creation of sustainable value, generating economic, social and environmental value, and comment that the ESG rating agencies

are promoting more sustainable business models that integrate ESG criteria holistically with a short to mid-term perspective (Muñoz-Torres et al., 2019). According to Urban and Wójcik (2019), the financial institutions have adopted the idea of SF as a business opportunity and have done no more than take advantage of investors' demands. Studying how the investment banks integrate sustainability in their services, the authors comment that they do not shun those companies who have been marked for their bad ESG conduct, and neither have they stopped investing in controversial sectors such as tobacco, coal and nuclear arms; they recommend that this problem should be dealt with in future research into responsibility, financial operators and commercial services in the transition towards sustainability (Urban and Wójcik, 2019). In additional research, Ziolo et al. (2017) ratify that adaptation to the design of the three-dimensional financial systems is based on incorporating the ESG risk in the decision-making of the institutions making up the financial sector and confirm that the principal hypothesis of research assumes that incorporating ESG factors in the decision-making processes of financial institutions will make those institutions more sustainable. Briefly analyzing recent developments in SF regulation worldwide, Siri and Zhu (2019) show a more detailed view of the establishment of a common regime in the EU, with special reference to the "Financing Sustainable Growth" plan, and examine recent proposals for SF regulation, in particular the barriers to integrating risks and sustainability factors in the investors' protection regulations. Monasterolo and de Angelis (2020) show that stock market investors have begun to consider low-carbon emission shares as an attractive investment opportunity since the Paris Agreement of 2015, but carbon intensive investments have not yet been penalized (Monasterolo and de Angelis, 2020).

The previous review of the literature has allowed coincidences in SF research to be identified: (i) the discipline and practice of finance are undergoing a paradigm shift from a unidimensional to a multifaceted focus which supports sustainable development, from only thinking of the economic benefits to rating and obtaining an environmental social benefit, defined as SF; (ii) the paradigm shift occurs on a multi-sectorial level, with interaction from the industrial and technological sectors, the markets, policies, communities, society and academia; (iii) the new approach to SF can support sustainable development by solving problems caused by negative environmental and social externalities; (iv) the development of the theory and practice of the SF concept still needs more analysis in order to evaluate the contribution of SF instruments to reducing negative environmental and social externalities; (vi) as can be seen, the main problem of research into this new area of knowledge is the lack of information, indicators, reliable and unified standards and complete data bases. A need to explore the concept and terminologies related to SF, with an exhaustive search in WoS, concentrating on the bibliometric network analysis shown in VOSviewer, has been detected in the literature. Classifying the journals by themes, and the development of a methodology that enables to measure this risk and its effect on the corporate vulnerability will intent to offer a quantitative approach which provides a better understanding of the characteristics and themes associated with SF until 2021.

Therefore, a quantitative approach based on the bibliometrics would seem advisable and would permit a more detailed analysis of the concept and the existing information about SF. Hence this article differs from the previous studies as: (i) it used a longer and broader time frame (1900–2021), (ii) it analyses more terminology associated with the study and practice of SF, and (iii) its methods and techniques are quantitative. Consequently, in this document we try to answer the following research questions: (i) how has scientific research developed regarding themes linked to SF? (ii) How are the research themes related? and (iii)What is the future of scientific research into themes related to SF and what might be the limits?

Data and methods

Source of data

Web of Science (WoS) is one of the most-used databases, providing consistent results and the best graphics in the analysis of citations compared with other databases; it allows entire citation registers to be downloaded in ".txt" format, which is compatible with most literature analysis tools (N. Li et al., 2018). According to a first search for the term SF, on 20 August 2021, only 270 publications have been included in WoS, which were reviewed in the literature analysis. To carry out a more exhaustive study, all the possible terms related to SF were identified in works contained in WoS. The search concentrated on related appellations and attributes, as shown in Figure 1, to obtain 16 terms associated with SF, which were used in the search. There was a total of 9294 results from the search, conducted in WoS on 13 August 2021, covering the period 1900–2021. The bibliographic data was downloaded as ".txt" files. In the WoS database, the bibliographic data of up to 500 publications can be downloaded at the same time. Therefore, downloading was done in batches. The result was a high number of WoS files downloaded, each one with bibliographic data for up to a maximum of 500 publications.

Performance and citation reports in WoS

Bibliometric indicators were used as an analysis method for carrying out the study, as they are considered suitable for analyzing and representing data (Zhang et al., 2019). The most

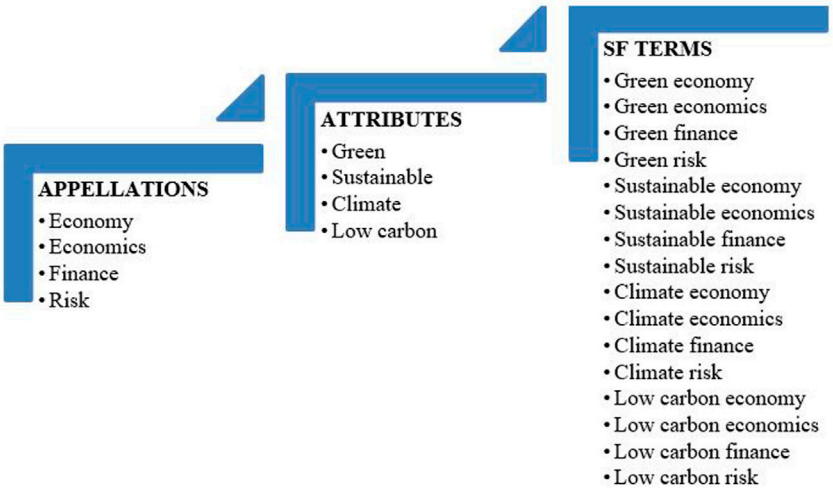

FIGURE 1
Appellations and Attributes combined to obtain terms associated with SF. Source: Own elaboration.

popular and accepted indicators in accordance with this methodology were used (Zhang et al., 2019), such as the total number of articles to measure productivity, the total number of citations to represent the incidence of an article and/or author, the h-index to indicate the quality of a series of documents and the impact factor to quantify the journal's spread of influence. According to information from WoS, the h-index is based on a list of publications classified in descending order according to the number of times they have been cited. The value of h is equal to the number of articles (N) in the list which has N or more citations. The impact factor (IF) is defined as the citations of a journal in the current year and of articles published in the previous 2 years, divided by the total number of academic articles published in that journal in the previous 2 years.

Bibliometric networks in VOSviewer

The method used in this document is a bibliometric analysis. This was used for the first time by Pritchard (1969) and has attained great popularity in helping the quantitative analysis to understand the literature (Zhang et al., 2019). This analysis focuses on the network of keyword frequency of the articles found in the search for the 16 terms associated with SF in WoS. The analysis of keyword frequency is a useful and effective method for analyzing content, a common approach in which important words or expressions that indicate the relevant content in the literature are taken as the object of research (Gao, Chen, Liu and Guo, 2015; Franceschini et al., 2016; Wang et al., 2016; Wang et al., 2017). Consequently, the represented keywords and clusters reflect the distribution of certain themes within the different fields of research.

VOSviewer is the tool used to view and analyze the bibliometric network resulting from the search. A bibliometric network is composed of nodes and lines. In a bibliometric network represented by VOSviewer the nodes are grouped in a bidimensional space in such a way that nodes with a strong relationship are grouped close together, while those with weak connections are farther from each other. By default, the tool assigns the nodes to colored clusters. A cluster is a group of closely related nodes. Each node in a network is assigned to a cluster, with the size of the node indicating its relevance (van Eck and Waltman, 2014).

Results

The results described in this article are based on five analyses. First of all, the development of the literature and the geographic origin of the publications dealing with SF are analyzed, according to the number of publications per year and the authors' countries of affiliation. In second place, the impact of the leading journals that publish the articles, according to the IF and the h-index. In the third case the total number of citations is analyzed and the articles with most citations are presented. The analysis of the co-occurrence of keywords is examined in the fourth section. Finally, the fifth section presents the principal research subjects according to prior analysis of the co-occurrence of keywords.

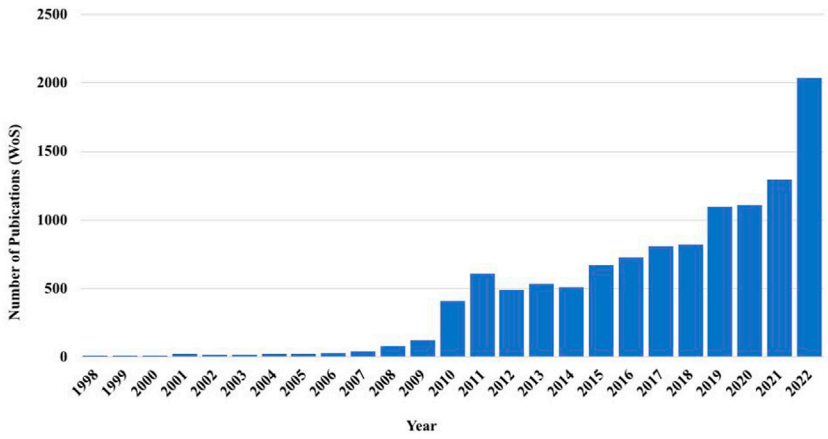

FIGURE 2
Annual publications in Web of Science (WoS) related to SF research. The value displayed for the years 2021 and 2022 corresponds to the estimated future value based on historical values, calculated on the date of data extraction in August 2021. Source: Own elaboration based on data from WoS 2021.

Development and geographic origin of the literature relating to sustainable finance

The annual number of publications from 1998 to 2021 is shown in Figure 2. The documents published in this period were analyzed emphatically as the data from before 1998, less than 10 registered per year (N. Li et al., 2018), was considered insufficient and less convincing. The values shown for 2021 and 2022 correspond to the estimated future value based on the existing (historic) values, calculated on the date of the WoS data extraction. To see the growth trends of the publications, two important events were taken as references: the Kyoto Protocol in 1997 and the Paris Agreement of 2015. Using the same 16 terms, three searches were made for the periods from 1900 to 1997, 1998 to 2015 and 2016 to 2021. The numbers of publications found, respectively, were 57, 3594 and 5643. The number of publications has risen almost 60% in the last 5 years, which shows an important increase in academic interest since the Paris Agreement of 2015.

Analyzing the country of origin of the publications, according to the country of affiliation of the authors registered in WoS, it can be seen that the themes relating to SF were studied mainly in China (2094 publications), the United States (956 publications) and England (665 publications), representing 28.67%, 13.09% and 9.01% respectively of all the publications related to SF. They are followed by Germany (438 publications) and Australia (341 publications), representing 5.92% and 4.62% respectively.

Impact of the journals

The 9294 articles have been published in more than 500 journals, of which 120 have published 10 or more articles, which corresponds to 37% of the total. Analyzing the IF quartile in journals with more than 10 publications, 54% are found in the first quartile (Q1), 22% in the second (Q2) and 9% in the third (Q3), according to the information in the Journal Citation Report (JCR). The journals are classified according to the number of articles published. The 10 most productive journals are shown in Table 2. The three journals with the highest number of publications are: Sustainability in first place, with 188 publications (2.55%), an h-index of 68 and IF of 2.576; in second place Journal of cleaner production, with 159 publications (2.15%), an h-index of 173 and IF of 7.246, and Advanced materials research in third place with 156 publications (2.11%), an h-index of 33 and IF of 0.39.

Citation analysis

With regard to analysis of the citation report from WoS, the 9294 publications have registered a total of 65,086 citations. The average number of citations per document published is 8.83. Figure 3 shows the evolution of the number of citations per year. The number shown for 2021 corresponds to the estimated future value based on historic values, calculated on the day of extraction from the WoS database. The articles with most citations are Naik (Naik et al., 2010) with 1456, Huber & Corma (Huber and Corma, 2007) with 949 and Binnemans (Binnemans et al., 2013) with 941. The 10 articles with most citations are shown in Table 3.

TABLE 2 Top 10 productive journals on SF topics. ESc: Environmental science; ESt: Environmental studies; GScT: Green and sustainable science and Technology; EE: Environmental engineering; Eng: Engineering; Che: Chemical engineering; Ec: Economics; EF: Energy and fuels; PA: Public administration; Eco: Ecology; MASc: Meteorology and atmospheric sciences; DS: Development studies. Source: Own elaboration based on data from WoS 2021 and JCR 2021.

Ranking	Journal	Publications	h-index	Impact factor	Category	Quartile
1	Sustainability	188	68	2.576	ESc;ESt;GScT	Q2;Q2;Q3
2	Journal of cleaner production	159	173	7.246	EE; ESc; GScT	Q1; Q1; Q1
3	Advanced materials research	156	33	0.39	Eng	Q4
4	Energy policy	105	197	5.042	Ec;EF;ESc;ESt	Q1;Q1;Q1;Q1
5	Climate policy	67	62	4.011	ESt;PA	Q1;Q1
6	Ecological economics	67	189	4.482	Eco;Ec;ESc;ESt	Q1;Q1;Q1;Q1
7	Climatic change	60	175	4.134	ESc;MASc	Q1;Q1
8	Renewable and sustainable energy reviews	57	258	12.110	EF;GScT	Q1;Q1
9	Climate and development	49	30	2.311	DE;ESt	Q1;Q2
10	Applied energy	39	189	8.848	EF;ChE	Q1;Q1

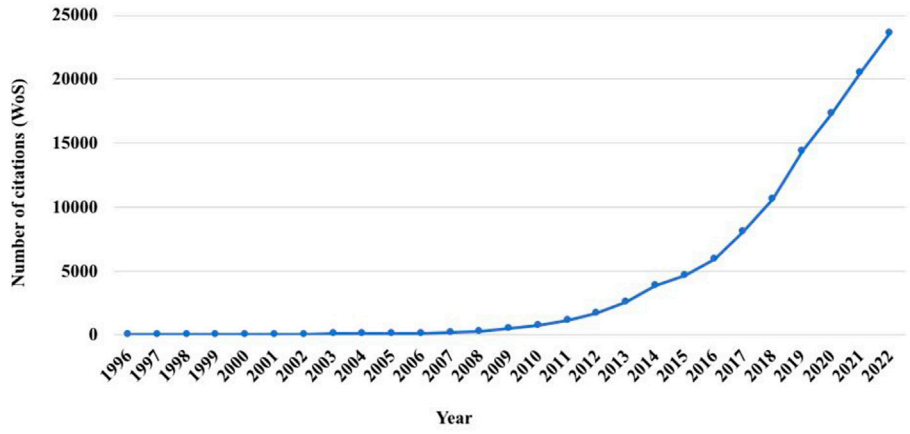

FIGURE 3
Evolution of the number of citations per year of publications related to SF resulting from the Web of Science search. The value displayed for the years 2021 and 2022 corresponds to the estimated future value based on historical values, calculated on the date of extraction of the WoS data in August 2021. Source: Own elaboration based on WoS 2021 data.

Keyword analysis

The analysis of the co-occurrence of keywords or phrases is a technique for analyzing the coincidence of terms, as well as identifying relationships and interactions between the themes researched and the emerging research trends (Molinillo, Ekinci, Whyatt et al., 2016). The keywords can be taken from the title and summary of a publication (van Eck and Waltman, 2014). VOSviewer was used to analyze the bibliometric network of keywords from publications relating to SF and identified 2728 keywords. Figure 4 shows the bibliometric network of the principal keywords represented by the nodes; the size of the node indicates the relevance of the term, i.e., the amount of documents it appears in (van Eck and Waltman, 2014). The tool calculates a score according to the relevance of each word. According to this score, the most relevant words are chosen and reflected in the network (van Eck and Waltman, 2014). The default option for VOSviewer chooses 60% of the most relevant terms for a total of 1637 keywords.

The words or terms that co-occur most often are located close to each other and VOSviewer has grouped them into five color-coded clusters. The most common keywords in each cluster are: (i) Blue cluster: climate risk, adaptation, agriculture, community, vulnerability; (ii) Green cluster: low carbon economy, carbon emission, economic development, energy consumption, construction; (iii) Red

TABLE 3 The 10 most cited publications related to SF terminology according to WoS search results. Source: Own elaboration.

Rank	Title	Authors	Journal	Citations	Key message
1	Production of first and second-generation biofuels: A comprehensive review	Naik et al. (2010)	Renewable and sustainable energy reviews	1456	Focuses on analysis of profitable technology and processes to convert biomass into liquid biofuels and useful bioproducts. Special emphasis on some concepts of bio-refining based on different raw materials, with the aim of fully using these materials to produce value-added chemical products
2	Synergies between bio- and oil refineries for the production of fuels from biomass	Huber and Corma (2007)	Angewandte chemie - International edition	949	Discusses the chemistry, catalyzers and challenges involved in the production of biofuels
3	Recycling of rare earths: A critical review	Binnemans et al. (2013)	Journal of cleaner production	941	Argues that Rare Earth Elements (REE) are becoming more important in the transition towards a green economy. The document provides a general view of the literature, emphasizing three main applications: permanent magnets, nickel-metal hydride batteries and lamp phosphors
4	Adapting agriculture to climate change	Howden et al. (2007)	Proceedings of the matinal academy of sciences of the United States of America	899	The authors argue that greater adaptation requires the integration of climate change-related problems with other risk factors, such as market risks and climate variability, as well as policy areas such as sustainable development. The multidisciplinary problems require multidisciplinary solutions, i.e. focusing on integrated rather than disciplinary science and strengthening the interface with decision makers
5	The politics and policy of energy system transformation - Explaining the German diffusion of renewable energy technology	Jacobsson and Lauber (2006)	Energy policy	513	To detain climate change, a transition to a low carbon economy must occur quickly. The spread of new technologies, such as electricity generation from renewable sources has become a central theme. The article explores the reasons for the rapid spread of two of these technologies in Germany, wind turbines and solar cells
6	Mesoporous materials for energy conversion and storage devices	Li et al. (2016)	Nature reviews materials	490	They argue that to satisfy the increasing energy demands of a low carbon economy, the development of new materials that improve the efficiency of energy conversion and storage systems is essential. The principal methods of preparing some materials are summarized. They describe the challenges that research, and development must overcome in order to increase the contribution of renewable energy applications
7	Robust adaptation to climate change	Wilby and Dessai (2010)	Weather	388	The article compares two different approaches to evaluating climatic risk in adaptation planning. It also describes a solid framework for adaptation decision-making, which differs from the traditional methods of 'predict and provide'. Examples of the water industry in developing and developed countries are used as evidence of how

(Continued on following page)

TABLE 3 (*Continued*) The 10 most cited publications related to SF terminology according to WoS search results. Source: Own elaboration.

Rank	Title	Authors	Journal	Citations	Key message
					significant progress can be made in most cases without the climate change projection
8	Clean energy new deal for a sustainable world: From non-CO2 generating energy sources to greener electrochemical storage devices	Poizot and Dolhem (2011)	Energy and Environmental Science	383	This article deals with the difficult energy question and the personal perception of the associated environmental problems. It particularly emphasizes the eminent role of the electrical energy produced from decarbonized sources in a future sustainable economy, as well as its storage problems
9	Geographies of energy transition: Space, place and the low-carbon economy	Bridge et al. (2013)	Energy policy	377	This article presents the case for studying energy transition as a geographic process, which implies the reconfiguration of the current patterns and scales of economic and social activity. The document is based on a series of seminars; "Geographies of energy transition: security, climate, governance" organized by the authors between 2009 and 2011, which started a dialogue between the disciplines of energy studies and human geography
10	Community level adaptation to climate change: The potential role of participatory community risk assessment	Van Aalst et al. (2008)	Global environmental change-human and policy dimension	377	This explores the value of community risk evaluation (CRA) in the adaptation to climate change. CRA refers to participative methods to evaluate dangers and vulnerabilities and the ability to support a reduction in the risk of community-based disasters, used by many NGOs, community organizations and the Red Cross

cluster: governance, climate finance, climate policy, green growth, green finance; (iv) Yellow cluster: water, fossil fuel, waste, biomass, plant; and (v) Purple cluster: climate economy model, climate economy, carbon price, social cost, integrated assessment model. Table 4 shows the principal keywords, their occurrence (frequency), relevance, the number of links (co-occurrences) and the cluster they belong to.

Principal themes of research

Several topics, trends and agendas relating to the study of SF were detected in the bibliometric analysis from the most commonly related keywords, which has led to five lines of research being suggested, described in table 5.

The first line of research suggested is identified as Climate risk and adaptation (blue cluster). Research has shown that the emission of greenhouse gases from human activity is already changing the Earth's climate. As a result, attention has increasingly been focused on how to combat climate change and give adaptation a more central role in the international response to his threat (van Aalst et al., 2008). The case for committing more financial and technical resources is gaining ground (Wilby and Dessai, 2010). Adaptation means being able to maintain current lifestyles in the face of the expected changes in climate trends and the intensity and frequency of major events that could affect people's living conditions. Adaptation to climate change has been receiving more attention, especially in the United Nations Framework Convention on Climate Change (UNFCCC) and among specialists in development and disasters. Many have noted the important role of disaster risk reduction in the adaptation to climate change (van Aalst et al., 2008). The challenges in researching vulnerability to climate change are to develop robust and reliable methods, to incorporate diverse methods that include perceptions of risk and vulnerability and to incorporate governance research about the mechanisms that measure vulnerability and promote adaptive actions and resilience (Adger, 2006). These evaluations, instead of using scenarios of future global models, should examine the vulnerability to variability and current climatic extremes as well as the strategies, policies and current methods of adaptation, based on real-life experience at different levels. Therefore, the initial step in the analysis is not theoretical and oriented to the future, but empirical and based on the real observation of the current climatic risks and how communities face them (van Aalst et al., 2008; Wilby and Dessai, 2010).

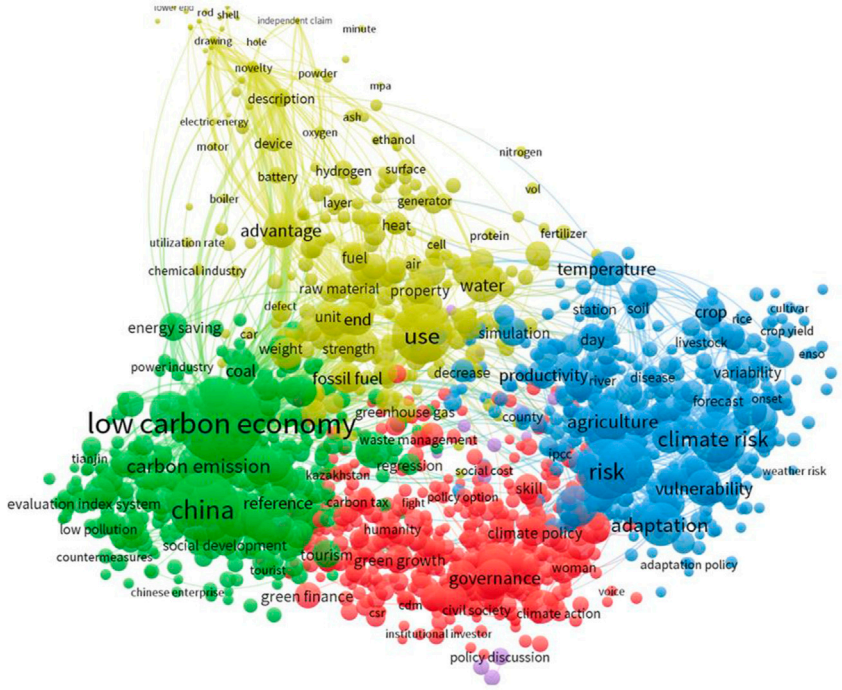

FIGURE 4
Co-occurrence network of author keywords for SF. Includes the 1637 keywords with the most frequent occurrences. Keywords are grouped into five clusters. The most common keywords for each cluster are: (i) Blue cluster: climate risk, adaptation, agriculture, community, vulnerability; (ii) Green cluster: low carbon economy, carbon emission, economic development, energy consumption, construction; (iii) Red cluster: governance, climate finance, climate policy, green growth, green finance. (iv) Yellow cluster: water, fossil fuel, waste, biomass, plant; and (v) Purple cluster: climate economy model, climate economy, carbon price, social cost, integrated assessment model. Source: Own elaboration.

The second line of research is identified as Low carbon energy economy (green cluster), or Low carbon economy. Currently more than 80% of world energy consumption comes from non-renewable fossil fuels such as coal, petrol and natural gas. Burning these fuels leads to CO2 emissions, the principal cause of climate change and other serious environmental effects (Jacobsson and Lauber, 2006; W. Li et al., 2016). One of the pillars of a low carbon economy would be a greater dependence on sources of renewable, environmentally friendly energy. In the coming decades the transition to a low carbon energy economy will continue to be the basis of national energy policies in those countries committed to the agreement on climate change (Guler, Çelebi and Nathwani, 2018). Although many governments claim to support the spread of renewable energy, the real diffusion rate of new technologies in the energy system varies considerably from one country to another (Jacobsson and Lauber, 2006). Enormous progress is being made in developing advanced technologies to face these challenges (Usman et al., 2021; Ramzan et al., 2022), although greater improvements in performance and efficiency will be needed to produce these technologies profitably on a large scale (W. Li et al., 2016). Equally, ensuring the availability and accessibility of energy services in a carbon-restricted world would mean developing new methods of producing, living and working with energy (Bridge et al., 2013).

The third line of research is identified as Environment, social and governance (red cluster). Companies should deal with their environmental impact while respecting the planet's limited resources and must contribute to a safe operating space for human development (Henriques and Sadorsky, 2010; Sachs and Schmidt-traub, 2015). In this context, the need arises for greater understanding of the business impact on global sustainability to help companies to create more sustainable value (Henriques and Sadorsky, 2010). The financial services sector is positioned to provide most of the financing for a green economic transition (Sharma et al., 2022). Long-term institutional investors are becoming aware of the increasing potential of minimizing environmental, social and governance risks (ESG) through the creation of "green" portfolios (Jain et al., 2019; Dutta et al., 2021), a measure that can be supported by defining a regulatory framework that promotes long-term investment, as well as integrated, sustainable, reports on progress in applying the ESG criteria (Kudinova et al., 2012).

The fourth line of research is identified as Low carbon emission technologies (yellow cluster). From the various options for reducing the environmental load, the technology is

TABLE 4 Main keywords of publications related to SF according to co-occurrence analysis. Source: Own elaboration.

Rank	Key word	Occurrences	Relevance	Links	Cluster
1	Low carbon economy	2172	0.61	1461	Green
2	China	1195	0.87	1296	Green
3	Use	1066	0.22	1500	Yellow
4	Risk	808	0.59	1351	Blue
5	Climate	649	0.58	1254	Blue
6	Climate risk	576	1.17	997	Blue
7	Advantage	462	1.07	993	Yellow
8	Economy development	434	0.66	285	Green
9	Carbon emission	412	0.92	999	Green
10	Adaptation	376	0.92	985	Blue
11	Construction	369	0.64	1007	Green
12	Enterprise	350	0.75	906	Green
13	Novelty	334	2.13	504	Yellow
14	Community	329	0.53	1061	Blue
15	Energy consumption	328	0.94	865	Green
16	Water	320	0.33	1050	Yellow
17	Agriculture	311	0.5	1038	Blue
18	Uncertainty	295	0.57	932	Blue
19	Temperature	263	0.59	843	Blue
20	Warming	246	0.14	922	Green
21	Governance	242	0.63	814	Red
22	Province	241	0.58	852	Green
23	CO_2 emission	233	0.71	784	Green
24	Vulnerability	229	1.22	780	Blue
25	Energy efficiency	226	0.55	25	Green
26	Low carbon	225	0.94	763	Green
27	Waste	221	0.52	851	Yellow
28	Pollution	214	0.3	829	Yellow
29	Environmental protection	211	0.61	791	Green
30	Climate finance	200	1.21	652	Red

widely considered the most attractive (Kemp, 1994). Technology will be crucial for the low carbon future. Evidently, this scenario will require not only the transformation of the energy system to fulfil global emission reduction targets, but also a rethink of household temperature regulation systems, transport systems, the use of more environmentally friendly materials, the manufacture of goods and waste disposal (Kemp, 1994; Sachs, 2016). Achieving the decarbonization of the different current systems requires new and better technologies. Researchers, scientists, engineers and technical experts play a crucial role

TABLE 5 Suggested lines of research in SF. Source: Own elaboration.

Lines of research	Description
Climate risk and adaptation	Related to the risks associated with climate and environment
Low carbon energy economy	Technological innovation and methods to finance and coordinate the transition to a low-carbon economy
Environment, social and governance	Develop standards, promote dissemination, encourage the integration of sustainable environmental, social and governance (ESG) concepts in investment and financial decisions
Low carbon emission technologies	Promote and generate innovation in the decarbonization process and low carbon emission technologies
Economic model and social cost	Incentives and market and social policies to reduce externalities and the social and environmental cost of current and future economic activities

in designing ways to decarbonize specific sectors, especially those of energy, heavy extraction and raw material transformation industries, transport and construction (Sachs, 2016).

The fifth line of research is identified as Economic model and social cost (purple cluster). The environmental impacts of current economic activity, intentional or not, are not visible on the market and therefore their cost is not evident. These costs are known as externalities or external costs. When externalities are generated the balance of the market is not socially efficient, i.e., a social cost is generated, equivalent to the cost of production plus the external cost (Pere Riera; Bengt Kriström, 2005). Existing policies and market incentives have contributed to this problem because they allow companies to incur negative social and environmental externalities, mostly unaccounted and uncontrolled. "Unregulated markets are not aimed at solving social problems", and so better public policies are needed, including price regulation, to change the perverse incentives of the market that ignore social and environmental externalities (Kudinova et al., 2012).

Discussion and conclusion

This article has analyzed the positioning of the concept and terminology relating to SF, mainly by means of a review of the literature according to the search in WoS and concentrating on the bibliometric network analysis shown in VOSviewer. The bibliometric method offers a quantitative approach which provides a better understanding of the characteristics associated with the body of literature relating to the research (Y. Wang et al., 2016), in this case, of SF. Although the literature does not contain a large amount of SF-specific publications (only 270 publications are found in WoS), the related literature has increased, especially since the signing in 2015 of international treaties such as the Paris Agreement and the 2030 Agenda for Sustainable Development.

Bibliometric methods were used to examine the characteristics of the literature and the development of scientific research into SF related themes from 1900 to 2021, based on the WoS database and using 16 terms associated with those used in the search. Two important events were also considered, the signings of the Kyoto Protocol in 1997 and the Paris Agreement in 2015. It was noted that the number of publications has risen considerably, especially in the 5 years since the Paris Agreement was signed.

We have identified the regions or countries where most of the research into SF has been carried out. The results show that China is a major contributor to SF-related literature, with the highest number of publications (2094), followed by the United States (956) and England (665). Regarding research quality and impact, we can see that most of the articles have been published in Q1 journals. The journals with most publications are Sustainability (188), Journal of Cleaner Production (159) and Advanced Materials Research (156). The three most-cited articles in SF research are Naik et al. (2010), Huber and Corma (2007) and Binnemans et al. (2013).

There was a noticeable trend towards classifying journals according to their themes: (i) journals related to cleaner production, including renewable energy; (ii) journals related to sustainability, also including energy and renewable energy; (iii) journals specialized in climate change and environmental policy; (iv) journals related to ecology and the environment; and (v) journals dealing with finance, business, strategy and their relationship with the environment.

The bibliometric analysis of keywords has allowed some research themes to be detected from the SF-related literature. The results of our study will be helpful for researchers as well as for decision-makers and policy planners in understanding developments, trends and interests in this field. We propose five lines of further research into: (i) Climate risk and adaptation; (ii) Low carbon energy economy; (iii) environment, social and governance (ESG); (vi) low carbon emission technologies and (v) Economic model and social cost. Future research into these themes could be considered a way of putting theoretical SF research into policy and practice and vice versa, with the objective being to obtain the maximum benefits for society and promote sustainable development.

What is more, our study help to draw significance conclusions with meaningful implications. An effective climate risk management involves the development of a methodology that enables to measure this risk and its effect on the corporate vulnerability, which results in the need of improving and creating corporate and institutional policies aimed in that way. However, the increasing attention of climate change and the role of SF, the actual implantation rate of these new technologies varies largely among countries, together with the necessity of improving it for an efficient diffusion. As a consequence, it is necessary to keep investing for a greater efficiency and its diffusion, which involves to develop institutional programs to foster and promote the improvement in the efficiency, scaling-up it accessibility and availability in a more equal way worldwide (Usman et al., 2021). Nevertheless, it is also important to address financial concerns (Lusardi, 2019) for investors and stockholders. In this vein, the presence of legislative regulation that fosters and takes into account their interest and concerns, in addition to standards that help to provide insight about the risk taken and sustainable value added by them, would encourage this type of investment, especially in the long-term (Yang et al., 2021). However, it also important to include in the transition household implementation (Jain et al., 2019. For that, it is compelling to develop a set of technologies, materials and mechanisms aimed to a real implementation of the climate transition. Financial support (Khan and Usman, 2021) from public institutions would accelerate the diffusion rate (Sharma et al., 2021), together with informative programs designed to increase the awareness of the citizenship (Bansal et al., 2022). Our last inference involves

changes in the current policies and market incentives (Sharma et al., 2021) that allow to generate externalities which costs are not reporting. Regulations addressing this harmful incentive would incentive corporations and financial markets to consider these externalities.

As a consequence, our inferences enable us to propose future lines of research. First, understanding and testing how the methodologies designed to measure the risk associated to sustainable policies and the stockholders' value generation may affect the decision-making process would help to improve them and develop more efficient methodologies, and as result, would promote sustainable issues in financial decisions and the normalization of sustainable transition. Additionally, as for financial markets the capacity of cash-flow generation is important, a deeper research on sustainable decisions and its effect in this corporate capability would encourage investors. Second, it is important to know whether the institutional policies aimed to scale-up the diffusion of sustainable technologies are really effective. In this vein, analyzing the co-existence of public policies with specific corporate governance mechanism would shed light on the necessity of coordinated efforts from public and private sectors. Third, to know to what extent the different attempts of sustainable externalizations regulations are effective, and its effect of market response would shed light on the right regulation to bring market and sustainable consequences together. In this line, a better understanding of which standards provide a more accurate sustainable and financial information would help investors and public institutions to be aware of the cause-effect relationship of their decisions and programs.

The analysis also shows the importance of the theme of energy in modern economic systems. More than 80% of the energy consumed worldwide comes from non-renewable fossil fuels such as coal, oil and natural gas. Burning these fuels leads to the emission of CO2, the main cause of climate change and other serious environmental effects (Jacobsson and Lauber, 2006; W. Li et al., 2016). To stop climate change, the transition to a low carbon economy must not be delayed (Jacobsson and Lauber, 2006; Khalid et al., 2021). The solutions involve decarbonizing the energy system, which means energy production and consumption systems that emit far less CO2 than now (Sachs and Schmidt-traub, 2015). This accords with two of the research lines identified: Low carbon energy economy and Environment, social and governance. The synergy between these two lines is important. It is considered that integrating the environmental, social and governance aspects is crucial and should be a priority in investment in technological innovation for the transition to a low carbon energy economy. (Stern, 2007; UNEP, 2011; Binnemans et al., 2013; Bridge et al., 2013; Sachs, 2016). Further analysis and deeper research is recommended into the themes of Low carbon energy economy and Environment, social and governance, considered key issues in the future.

Despite the advances in research and recognition of the study of SF as an important theme for the economic paradigm shift towards one seeking social and environmental benefits and a reduction of negative externalities, there are as yet no totally reliable indicators or standards for comparing the financial profits with environmental and social sustainability. Researchers emphasize the lack of available data, standards and indicators for performing this type of analysis, which they consider a limitation on research. A major challenge off of this research will be including other databases such as Scopus database, highlighting the major contributions to guide future researchers in this field and fill in any possible gaps.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Author contributions

MR-R—PhD student, data collection and analysis ofmdatabases JC-A—Specialist in finance, analysis of the analytical results of the databases and co-director of the MR-R thesis. SE—Economist and specialist in green finance, provides data analysis on green finance. LS-A—Director of research, Director of the MR-R thesis and main leader of the research line.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

References

Adger, W. N. (2006). Vulnerability. *Glob. Environ. Change* 16 (3), 268–281. doi:10.1016/j.gloenvcha.2006.02.006

Amato, L. H., and Amato, C. H. (2012). Environmental policy, rankings and stock values. *Bus. Strategy Environ.* doi:10.1002/bse.742

Ari, I., and Koc, M. (2021). Philanthropic-crowdfunding-partnership: A proof-of-concept study for sustainable financing in low-carbon energy transitions. *Energy* 222, 119925. doi:10.1016/j.energy.2021.119925

Balsalobre-Lorente, D., Ibáñez-Luzón, L., Usman, M., and Shahbaz, M. (2022). The environmental Kuznets curve, based on the economic complexity, and the pollution haven hypothesis in PIIGS countries. *Renew. Energy* 185, 1441–1455. doi:10.1016/j.renene.2021.10.059

Bansal, S., Jain, M., Garg, I., and Srivastava, M. (2022). Attaining circular economy through business sustainability approach: An integrative review and research agenda. *J. Public Aff.* 22 (1), e2319. doi:10.1002/pa.2319

Baumann, M. H., and Ahn, Y. H. (2009). The business case for sustainability. *Annu. Tech. Conf. - ANTEC, Conf. Proc.* 1, 489–540. doi:10.9774/gleaf.9781315562643_10

Bergedieck, L., Maheshwari, A., and Ugaz, F. A. (2017). *Green finance: A bottom-up approach to track existing flows*. Washington, DC: International Finance Corporation. doi:10.1186/1471-2164-11-360

Binnemans, K., Jones, P. T., Blanpain, B., Van Gerven, T., Yang, Y., Walton, A., et al. (2013). Recycling of rare earths: A critical review. *J. Clean. Prod.* 51, 1–22. doi:10.1016/j.jclepro.2012.12.037

Bohorquez, J. J., Dvarskas, A., and Pikitch, E. K. (2019). Filling the data gap - a pressing need for advancing MPA sustainable finance. *Front. Mar. Sci.* 6 (FEB). doi:10.3389/fmars.2019.00045

Bridge, G., Bouzarovski, S., Bradshaw, M., and Eyre, N. (2013). Geographies of energy transition: Space, place and the low-carbon economy. *Energy Policy* 53, 331–340. doi:10.1016/j.enpol.2012.10.066

Caner, M., Grennes, T., and Koehler-Geib, F. (2010). "Finding the tipping point: When sovereign debt turns bad," in *Sovereign debt and the financial crisis*. doi:10.1596/9780821384831_ch03

Cash, D. (2018). Sustainable finance ratings as the latest symptom of 'rating addiction. *J. Sustain. Finance Invest.* 8 (3), 242–258. doi:10.1080/20430795.2018.1437996

Checherita, C., and Rother, P. (2010). The impact of high and growing government debt on economic growth. *Empir. Investigation Euro Area. Frankfurt.*

Cheng, C., Hua, Y., and Tan, D. (2019). Spatial dynamics and determinants of sustainable finance: Evidence from venture capital investment in China. *J. Clean. Prod.* 232, 1148–1157. doi:10.1016/j.jclepro.2019.05.360

Contreras, G., Bos, J. W. B., and Kleimeier, S. (2019). Self-regulation in sustainable finance: The adoption of the Equator Principles. *World Dev.* 122, 306–324. doi:10.1016/j.worlddev.2019.05.030

Daszynska-Zygadlo, Karolina, Marszalek, Jakub, and Piontek, K. (2018). *Green bonds - sustainable finance instruments*. (March).

Dörry, S., and Schulz, C. (2018). Green financing, interrupted. Potential directions for sustainable finance in Luxembourg. *Local Environ.* 23 (7), 717–733. doi:10.1080/13549839.2018.1428792

Dutta, A., Bouri, E., Dutta, P., and Saeed, T. (2021). Commodity market risks and green investments: Evidence from India. *J. Clean. Prod.* 318, 128523. doi:10.1016/j.jclepro.2021.128523

Endrikat, J., Guenther, E., and Hoppe, H. (2014). Making sense of conflicting empirical findings: A meta-analytic review of the relationship between corporate environmental and financial performance. *Eur. Manag. J.* 32, 735–751. doi:10.1016/j.emj.2013.12.004

European Commission (2018). *ES*.

European Commission (2019). *Para una Europa Sostenible de aquí al 2030*. Brussels, Belgium: COM, 22. de 30 de Gener de 2019. Retrieved from https://ec.europa.eu/commission/sites/beta-political/files/rp_sustainable_europe_es_v2_web.pdf.

Feitelson, E. (1992). An alternative role for economic instruments: Sustainable finance for environmental management. *Environ. Manag.* 16 (3), 299–307. doi:10.1007/BF02400068

Fioramonti, L., Coscieme, L., and Mortensen, L. F. (2019). From gross domestic product to wellbeing: How alternative indicators can help connect the new economy with the Sustainable Development Goals. *Anthropocene Rev.* 6 (3), 207–222. doi:10.1177/2053019619869947

Forcadell, F. J., Aracil, E., and Úbeda, F. (2019). The influence of innovation on corporate sustainability in the international banking industry. *Sustain. Switz.* 11 (11), 3210–3215. doi:10.3390/su11113210

Franceschini, S., Faria, L. G. D., and Jurowetzki, R. (2016). Unveiling scientific communities about sustainability and innovation. A bibliometric journey around sustainable terms. *J. Clean. Prod.* 127, 72–83. doi:10.1016/j.jclepro.2016.03.142

G20 Green Finance Study Group (2016). *G20 green finance synthesis report 2016. G20 green finance synthesis report*.

Galaz, V., Crona, B., Dauriach, A., Scholtens, B., and Steffen, W. (2018). Finance and the Earth system – exploring the links between financial actors and non-linear changes in the climate system. *Glob. Environ. Change* 53, 296–302. doi:10.1016/j.gloenvcha.2018.09.008

Gao, W., Chen, Y., Liu, Y., and Guocheng, H. (2015). Scientometric analysis of phosphorus research in eutrophic lakes. *Scientometrics* 102 (3), 1951–1964. doi:10.1007/s11192-014-1500-7

Gollier, C. (2008). *Sustainable finance in the Stern review*, 1–9.

Guler, B., Çelebi, E., and Nathwani, J. (2018). A 'Regional Energy Hub' for achieving a low-carbon energy transition. *Energy Policy* 113 (10), 376–385. doi:10.1016/j.enpol.2017.10.044

Hahn, T., and Figge, F. (2011). Beyond the bounded instrumentality in current corporate sustainability research: Toward an inclusive notion of profitability. *J. Bus. Ethics* 104, 325–345. doi:10.1007/s10551-011-0911-0

Heinemann, F. (2006). Factor mobility, government debt and the decline in public investment. *Int. Econ. Econ. Policy* 3, 11–26. doi:10.1007/s10368-005-0043-z

Henriques, I., and Sadorsky, P. (2010). Can environmental sustainability be used to manage energy price risk? *Energy Econ.* 32 (5), 1131–1138. doi:10.1016/j.eneco.2010.01.006

Higgins, C. D. (2019). A 4D spatio-temporal approach to modelling land value uplift from rapid transit in high density and topographically-rich cities. *Landsc. Urban Plan.* 185 (3), 68–82. doi:10.1016/j.landurbplan.2018.12.011

Howden, S. M., Soussana, J.-F., Tubiello, F. N., Chhetri, N., Dunlop, M., and Meinke, H. (2007). Adapting agriculture to climate change. *Proc. Natl. Acad. Sci. U. S. A.* 113 (1–2), 19691–19696. doi:10.1073/pnas.0701890104

Huber, G. W., and Corma, A. (2007). Synergies between bio- and oil refineries for the production of fuels from biomass. *Angew. Chem. Int. Ed.* 46 (38), 7184–7201. doi:10.1002/anie.200604504

Jacobsson, S., and Lauber, V. (2006). The politics and policy of energy system transformation - explaining the German diffusion of renewable energy technology. *Energy Policy* 34 (3), 256–276. doi:10.1016/j.enpol.2004.08.029

Jain, M., Sharma, G. D., and Mahendru, M. (2019). Can I sustain my happiness? A review, critique and research agenda for economics of happiness. *Sustainability* 11 (22), 6375. doi:10.3390/su11226375

Jain, M., Sharma, G. D., and Srivastava, M. (2019). Can sustainable investment yield better financial returns: A comparative study of ESG indices and msci indices. *Risks* 7 (1), 15. doi:10.3390/risks7010015

Kaiser, T., Lusardi, A., Menkhoff, L., and Urban, C. (2022). Financial education affects financial knowledge and downstream behaviors. *J. Financial Econ.* 145 (2), 255–272. doi:10.1016/j.jfineco.2021.09.022

Kamal, M., Usman, M., Jahanger, A., and Balsalobre-Lorente, D. (2021). Revisiting the role of fiscal policy, financial development, and foreign direct investment in reducing environmental pollution during globalization mode: Evidence from linear and nonlinear panel data approaches. *Energies* 14 (21), 6968. doi:10.3390/en14216968

Karkowska, R. (2020). Business model as a concept of sustainability in the banking sector. *Sustain. Switz.* 12 (1), 111. doi:10.3390/SU12010111

Kemp, R. (1994). Technology and the transition to environmental sustainability. *Futures* 26 (10), 1023–1046. doi:10.1016/0016-3287(94)90071-X

Khalid, K., Usman, M., and Mehdi, M. A. (2021). The determinants of environmental quality in the SAARC region: A spatial heterogeneous panel data approach. *Environ. Sci. Pollut. Res.* 28 (6), 6422–6436. doi:10.1007/s11356-020-10896-9

Khan, N., and Abid Usman, M. F. J. (2021). The impact of investor's personality traits over their investment decisions with the mediating role of financial self efficacy and emotional biases and the moderating role of need for cognition and the individual mood in Pakistan stock exchange. *Multicult. Educ.* 7 (8), 766–775.

Kling, C. L., Phaneuf, D. J., and Zhao, J. (2012). From Exxon to BP: Has some number become better than no number. *J. Econ. Perspect.* 26, 3–26. doi:10.1257/jep.26.4.3

Kudinova, G. E., Rozenberg, G. S., and Yurina, V. S. (2012). "Towards a "green" economy: The way to sustainable development and poverty eradication,". *Principles*

of the ecology (Geneva (Switzerland), Moscow (Russia): Nai-robi (Kenya)UNEP), 738. doi:10.15393/j1.art.2012.1602

Labatt, S., and White, R. R. (2007). *Carbon finance : The financial implications of climate change*, 268.

UNEPLehmann, D. R. (2013). *Aligning the financial system with sustainable development*. Fo rth co m in g IJ Vo l um e Fo rth co m in g Vo l, (May).

Li, N., Han, R., and Lu, X. (2018). Bibliometric analysis of research trends on solid waste reuse and recycling during 1992–2016. *Resour. Conservation Recycl.* 130 (11), 109–117. doi:10.1016/j.resconrec.2017.11.008

Li, W., Liu, J., and Zhao, D. (2016). Mesoporous materials for energy conversion and storage devices. *Nat. Rev. Mat.* 1 (6), 16023. doi:10.1038/natrevmats.2016.23

Lusardi, A. (2019). Financial literacy and the need for financial education: Evidence and implications. *Swiss J. Econ. Stat.* 155 (1), 1–8. doi:10.1186/s41937-019-0027-5

Mahendru, M. (2020). Financial well-being for a sustainable society: A road less travelled. Qualitative research in organizations and management. *Int. J.*

Mănescu, C. (2011). Stock returns in relation to environmental, social and governance performance: Mispricing or compensation for risk? *Sust. Dev.* 19 (2), 95–118. doi:10.1002/sd.510

Margolis, J. D., and Walsh, J. P. (2003). Misery loves companies: Rethinking social initiatives by business. *Adm. Sci. Q.* 48, 268–305. doi:10.2307/3556659

Mihalovits, Z., and Tapaszti, A. (2018). Green bond, the financial instrument that supports sustainable development. Opportunities and barriers. *Public Finance Q.* 63 (3), 303–318.

Minea, A., and Villieu, P. (2009). Borrowing to finance public investment? The "golden rule of public finance" reconsidered in an endogenous growth setting. *Fisc. Stud.* 30, 103–133. doi:10.1111/j.1475-5890.2009.00091.x

Molinillo, S., Ekinci, Y., Whyatt, G., Occhiocupo, N., and Stone, M. (2016). "Private label management: Insights and research directions," in *Handbook of research on strategic retailing of private label products in a recovering economy*. doi:10.4018/978-1-5225-0220-3.ch001

Monasterolo, I., and de Angelis, L. (2020). Blind to carbon risk? An analysis of stock market reaction to the Paris agreement. *Ecol. Econ.* 170 (6), 106571. doi:10.1016/j.ecolecon.2019.106571

Muñoz-Torres, M. J., Fernández-Izquierdo, M. Á., Rivera-Lirio, J. M., and Escrig-Olmedo, E. (2019). Can environmental, social, and governance rating agencies favor business models that promote a more sustainable development? *Corp. Soc. Responsib. Environ. Manag.* 26 (2), 439–452. doi:10.1002/csr.1695

Nadler, M., and Nadler, C. (2018). Promoting investment in sustainable urban development with JESSICA: Outcomes of a new EU policy initiative. *Urban Stud.* 55 (9), 1839–1858. doi:10.1177/0042098017702815

Naik, S. N., Goud, V. V., Rout, P. K., and Dalai, A. K. (2010). Production of first and second generation biofuels: A comprehensive review. *Renew. Sustain. Energy Rev.* 14 (2), 578–597. doi:10.1016/j.rser.2009.10.003

Negra, C., Remans, R., Attwood, S., Jones, S., Werneck, F., and Smith, A. (2020). Sustainable agri-food investments require multi-sector co-development of decision tools. *Ecol. Indic.* 110 (9), 105851. doi:10.1016/j.ecolind.2019.105851

Nilsson, H., Cunningham, G. M., and Hassel, L. G. (2008). A study of the provision of environmental information in financial analysts' research reports. *Sust. Dev.* 16, 180–194. doi:10.1002/sd.363

Noussia, K. (2011). *The BP oil spill - environmental pollution liability and other legal ramifications*. Berlin, Heidelberg: European Energy and Environmental Law Review.

Orlitzky, M., Schmidt, F. L., and Rynes, S. L. (2003). Corporate social and financial performance: A meta-analysis. *Organ. Stud.* 24, 403–441. doi:10.1177/0170840603024003910

Paine, L. S. (2003). Value shift: Why companies must merge social and financial imperatives to achieve superior performance. *Choice Rev. Online*. doi:10.5860/choice.40-4099

Park, S. K. (2018). Social bonds for sustainable development: A human rights perspective on impact investing. *Bus. hum. rights j.* 3 (2), 233–255. doi:10.1017/bhj.2018.6

Pisano, U., Martinuzi, A., and Bruckner, B. (2012). *The financial sector and sustainable development: Logics, principles and actors*. European Sustainable Development Network Quarterly Report.

Poizot, P., and Dolhem, F. (2011). Clean energy new deal for a sustainable world: From non-CO2 generating energy sources to greener electrochemical storage devices. *Energy Environ. Sci.* 4 (6), 2003–2019. doi:10.1039/c0ee00731e

Pueyo, A. (2018). What constrains renewable energy investment in sub-saharan africa? A comparison of Kenya and Ghana. *World Dev.* 109, 85–100. doi:10.1016/j.worlddev.2018.04.008

Ramzan, M., Raza, S. A., Usman, M., Sharma, G. D., and Iqbal, H. A. (2022). Environmental cost of non-renewable energy and economic progress: Do ICT and financial development mitigate some burden? *J. Clean. Prod.* 333, 130066. doi:10.1016/j.jclepro.2021.130066

Reinhart, C. M., and Rogoff, K. S. (2010). Growth in a time of debt. *Am. Econ. Rev.* 100, 573–578. doi:10.1257/aer.100.2.573

Roös, P. B. (2021). "The importance of a sustainable future," in *Regenerative-adaptive design for sustainable development*. doi:10.1007/978-3-030-53234-5_3

Ryszawska, B. (2018). *Sustainable finance: Paradigm shift*, 219–231. doi:10.1007/978-3-319-92228-7_19

Sachs, J. D. (2016). *The age of sustainable development*. New York, NY: The Age of Sustainable Development. doi:10.7312/sach17314

Sachs, J. D., and Schmidt-traub, G. (20152013). *Sustainable development and planetary boundaries background research paper johan rockström and jeffrey D . Sachs with marcus C. Öhman and guido schmidt-traub submitted to the high-level panel on the post-2015 development agenda*.

Sandberg, J. (2018). Toward a theory of sustainable finance. *Des. a Sustain. Financ. Syst.*, 329–346. doi:10.1007/978-3-319-66387-6_12

Schaltegger, S., Hansen, E. G., and Lüdeke-Freund, F. (2016). Business models for sustainability: Origins, present research, and future avenues. *Organ. Environ.* 29 (1). doi:10.1177/1086026615599806

Schoenmaker, D., and Schramade, W. (2019). Principles of sustainable finance. *J. Sustain. Finance Invest.* 10 (1), 311–313. doi:10.1080/20430795.2020.1717241

Schwartz, M. S., and Carroll, A. B. (2003). Corporate social responsibility: A three-domain approach. *Bus. Ethics Q.* 13 (4), 503–530. doi:10.5840/beq200313435

Shah, K. U. (2011). Strategic organizational drivers of corporate environmental responsibility in the Caribbean hotel industry. *Policy Sci.* 44, 321–344. doi:10.1007/s11077-011-9130-x

Sharma, G. D., Sarker, T., Rao, A., Talan, G., and Jain, M. (2022). Revisiting conventional and green finance spillover in post-COVID world: Evidence from robust econometric models. *Glob. Finance J.* 51, 100691. doi:10.1016/j.gfj.2021.100691

Sharma, G. D., Talan, G., Bansal, S., and Jain, M. (2021). Is there a cost for sustainable investments: Evidence from dynamic conditional correlation. *J. Sustain. Finance Invest.*, 1–21. doi:10.1080/20430795.2021.1874215

Sharma, G. D., Tiwari, A. K., Talan, G., and Jain, M. (2021). Revisiting the sustainable versus conventional investment dilemma in COVID-19 times. *Energy Policy* 156, 112467. doi:10.1016/j.enpol.2021.112467

Sharma, G. D., Verma, M., Shahbaz, M., Gupta, M., and Chopra, R. (2022). Transitioning green finance from theory to practice for renewable energy development. *Renew. Energy* 119. doi:10.1016/j.renene.2022.06.041

Siri, M., and Zhu, S. (2019). Will the EU commission successfully integrate sustainability risks and factors in the investor protection regime? A research agenda. *Sustain. Switz.* 11 (22), 6292. doi:10.3390/su11226292

Soppe, A. (2004). Sustainable corporate finance. *J. Bus. Ethics* 53 (1–2), 213–224. doi:10.1023/B:BUSI.0000039410.18373.12

Soppe, A. (2008). *Sustainable finance and the stakeholder equity model*, 199–228. doi:10.1007/978-3-540-79472-1_8

Stern, N. (2007). *The economics of climate change: The stern review*. doi:10.1017/CBO9780511817434The economics of climate change

Stewart, R. B., Kingsbury, B., and Rudyk, B. (2009). *Climate finance: Cultures, histories, and representations*.Climate finance: Regulatory and funding strategies for climate change and global development

UNEP (2011). Pathways to sustainable development and poverty eradication - a synthesis for policy makers. *Towards a GREEN Econ.* 52.

Urban, M. A., and Wójcik, D. (2019). Dirty banking: Probing the gap in sustainable finance. *Sustain. Switz.* 11 (6), 1745. doi:10.3390/su11061745

Usman, M., and Balsalobre-Lorente, D. (2022). Environmental concern in the era of industrialization: Can financial development, renewable energy and natural resources alleviate some load? *Energy Policy* 162, 112780. doi:10.1016/j.enpol.2022.112780

Usman, M., Balsalobre-Lorente, D., Jahanger, A., and Ahmad, P. (2022). Pollution concern during globalization mode in financially resource-rich countries: Do financial development, natural resources, and renewable energy consumption matter? *Renew. Energy* 183, 90–102. doi:10.1016/j.renene.2021.10.067

Usman, M., Khalid, K., and Mehdi, M. A. (2021). What determines environmental deficit in asia? Embossing the role of renewable and non-renewable energy utilization. *Renew. Energy* 168, 1165–1176. doi:10.1016/j.renene.2021.01.012

van Aalst, M. K., Cannon, T., and Burton, I. (2008). Community level adaptation to climate change: The potential role of participatory community risk assessment. *Glob. Environ. Change* 18 (1), 165–179. doi:10.1016/j.gloenvcha.2007.06.002

van Brakel, M. L., Nahiduzzaman, M., Mahfuzul Haque, A. B. M., Golam Mustafa, M., Jalilur Rahman, M., and Abdul Wahab, M. (2018). Reimagining large-scale open-water fisheries governance through adaptive comanagement in hilsa shad sanctuaries. *Ecol. Soc.* 23 (1), art26. doi:10.5751/ES-09917-230126

van Eck, N. J., and Waltman, L. (2014). Visualizing bibliometric networks. *Meas. Sch. Impact*, 285–320. doi:10.1007/978-3-319-10377-8_13

Vogel, D. J. (2005). Is there a market for virtue? The business case for corporate social responsibility. *Calif. Manag. Rev.* 47, 19–45. doi:10.2307/41166315

Wang, L., Zhao, L., Mao, G., Zuo, J., and Du, H. (2017). Way to accomplish low carbon development transformation: A bibliometric analysis during 1995–2014. *Renew. Sustain. Energy Rev.* 68 (10), 57–69. doi:10.1016/j.rser.2016.08.021

Wang, Y., Lai, N., Zuo, J., Chen, G., and Du, H. (2016). Characteristics and trends of research on waste-to-energy incineration: A bibliometric analysis, 1999–2015. *Renew. Sustain. Energy Rev.* 66, 95–104. doi:10.1016/j.rser.2016.07.006

Wilby, R. L., and Dessai, S. (2010). Observations of a glaciating hole-punch cloud. *Weather* 65 (7), 176–180. doi:10.1002/wea.504

Yang, B., Jahanger, A., Usman, M., and Khan, M. A. (2021). The dynamic linkage between globalization, financial development, energy utilization, and environmental sustainability in GCC countries. *Environ. Sci. Pollut. Res.* 28 (13), 16568–16588. doi:10.1007/s11356-020-11576-4

Yip, A. W. H., and Bocken, N. M. P. (2018). Sustainable business model archetypes for the banking industry. *J. Clean. Prod.* 174, 150–169. doi:10.1016/j.jclepro.2017.10.190

Zeidan, R., and Spitzeck, H. (2015). The sustainability delta: Considering sustainability opportunities in firm valuation. *Sust. Dev.* 23 (6), 329–342. doi:10.1002/sd.1594

Zhan, C., and de Jong, M. (2018). Financing eco cities and low carbon cities: The case of Shenzhen International Low Carbon City. *J. Clean. Prod.* 180, 116–125. doi:10.1016/j.jclepro.2018.01.097

Zhang, D., Zhang, Z., and Managi, S. (2019). A bibliometric analysis on green finance: Current status, development, and future directions. *Finance Res. Lett.* 29 (1), 425–430. doi:10.1016/j.frl.2019.02.003

Ziolo, M., Fidanoski, F., Simeonovski, K., Filipovski, V., and Jovanovska, K. (2017). Sustainable finance role in creating conditions for sustainable economic growth and development. *World Sustain. Ser.*, 187–211. doi:10.1007/978-3-319-45081-0_11

Ziolo, M., Filipiak, B. Z., Bak, I., and Cheba, K. (2019). How to design more sustainable financial systems: The roles of environmental, social, and governance factors in the decision-making process. *Sustain. Switz.* (20), 5604. doi:10.3390/su11205604

Ziolo, M., Filipiak, B. Z., Bak, I., Cheba, K., Tîrca, D. M., and Novo-Corti, I. (2019). Finance, sustainability and negative externalities. An overview of the European context. *Sustain. Switz.* 11 (15), 4249. doi:10.3390/su11154249