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Green fintech: Developing a research agenda

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Abstract

Digitalization and sustainability have been the core drivers of transformation of the financial industry in recent years. In this context, green fintech plays a major role, which, however, is still an unexplored field in business, information systems and finance research. This paper conducts a systematic literature analysis and develops a research agenda based on a framework, which is derived from clustering 74 academic research papers. The framework consists of the four clusters strategy, organization, technology, and potentials along nine dimensions. The research agenda reveals that green fintech is still a very premature field of research. The analysis shows that areas like customer- and government-related services, insurance-oriented approaches and SDGs which focus on life on land and life below water are still rare and that most of the approaches focus on blockchain technology, while other financial technologies like artificial intelligence are still underrepresented.

KEYWORDS
green finance, green fintech, research agenda, sustainable development goals, sustainable finance

1 | INTRODUCTION

Digitalization and sustainability have been the core drivers of transformation of the financial industry in recent years. What has been called the financial technology revolution or short "fintech revolution" has already led to a global redesign of the financial sector, mainly driven by startups like payment solutions from Stripe or investment platforms like Wealthfront as well as bigtech companies, such as Amazon and Google that provide these fintech solutions (The Economist, 2015).

In parallel, sustainability has emerged as another key transformation driver and again, startups realized that the potential for information technology (IT) to contribute to the United Nations Sustainable Development Goals (SDGs) is enormous. While the field of sustainability has been structured along environmental, social and governance goals, the environmental SDGs have gained an increasing importance as climate change has emerged as one of the greatest challenges for humankind over the next decades. In this context, green fintech emerged as a new field which has a specific focus on the use of fintech for the environmental SDGs 7 (Affordable and Clean Energy), 11 (Sustainable Cities and Communities), 12 (Responsible Consumption and Production), 13 (Climate Action), 14 (Life Below Water), 15 (Life on Land), and 17 (Partnerships for the Goals), as one SDG which generically has an impact on all SDGs (Nassiry, 2018). For example, in 2021, green fintech startups raised US$ 1.2 billion in venture capital funding and 68% of all funding rounds were in the pre-seed or seed stage (CommerzVentures, 2022). Among the examples of such green fintech startups are blockchain based peer-to-peer payment platforms for the optimization of energy exchange or crowdfunding platforms for agricultural supply chains. All these approaches have in common that they are using IT to provide financial services with the aim to contribute to the environmental SDGs. And, in addition, IT and the environmental SDGs are part of their "DNA" and not just a side effect. As the financial sector is relevant for all other sectors by providing payment infrastructures, allocating capital, etc. green fintech has not only an impact on the financial sector but also on the entire economy to create environmentally sustainable products and services.

However, a more detailed literature analysis of green fintech reveals that a comprehensive understanding of the term, its dimensions and the future research potential is a missing component in existing research. This paper aims to fill this gap by analyzing the

existing research in this field and developing a research agenda for green fintech by applying the following research question: *How can green fintech approaches be classified and what topics does a future research agenda include?*

The remainder of this paper is structured in six sections: first, it discusses the theoretical background in Section 2. This is followed by research methodology and a comprehensive literature analysis in Section 3. Section 4 outlines the research agenda and Section 5 draws some final conclusions.

2 | THEORETICAL BACKGROUND

2.1 | Fintech and green fintech

Fintech is an abbreviation of the two words "financial" and "technology" and focuses on the use of information technology (IT) in financial services and was most likely first mentioned in the 1990s John Reed, Citicorp's chairman, for the foundation of a new "Smart Card Forum" consortium (Puschmann, 2017). It encompasses innovative financial solutions enabled by IT and very often concentrates on start-up companies who deliver these solutions, although it also includes banks and insurers. Typical examples are peer-to-peer lending platforms, robo advisors, etc. The fintech sector has grown very fast over the past years attracting venture capital of 40.3 billion of all venture capital investments in the United States, which is almost half of the $98.2 billion IT-related venture capital investments (National Venture Capital Association, 2023).

However, the use of IT in financial services is not a new phenomenon. For example, already in 1950, Bank of America introduced the first computer called "ERMA" (Electronic Recording Method of Accounting). Later digitalization steps included processes between providers (e.g., outsourcing of applications) and customers (e.g., online banking), which in the 2010s culminated in the financial technology (fintech) revolution (The Economist, 2015). This transformation is based on at least three areas (Gomber et al., 2018). These are the evolution of novel technologies such as blockchain or artificial intelligence, the convergence of these technologies, and the enabling effect of them on new application areas and business models. An example is the blockchain-enabled transformation of energy management through decentralized peer-to-peer (p2p) platforms for the production and consumption of energy by using digital currencies and digital wallets as well as smart contract enabled payments, investments, and financing approaches. In addition to fintech, insurtech is often used as a separate term that describes insurance-related technological innovations (Chuang et al., 2016, p. 3), such as micro crop insurances in Africa delivered via mobile apps.

Most recently, many of the fintech startups started to focus on providing solutions for the United Nations environmental SDGs in the context of green finance approaches. Green finance has been discussed as a subcategory of "sustainable finance" (Dyllick & Muff, 2015; Schoenmaker, 2017) which specifically focuses on the environmental SDGs. Sustainable finance suggests that firms consider the SDGs not only in investing and lending decisions but include them as a core component in their business models. While sustainable finance has a very broad focus on all SDGs, the intersection of environmental protection and finance has been part of the discussion in the field of green finance. In this context, the term green finance frequently refers to "(…) financial investments flowing into sustainable development projects and initiatives, environmental products, and policies that encourage the development of a more sustainable economy" (Höhne et al., 2012). Hence, green finance addresses all environmental objectives, such as, industrial pollution control, water sanitation, or biodiversity protection. However, in practice, green finance does not only focus on investments, but does also includes all other financial services, such as payments, financing, and insurance.

While green finance approaches refer to financial activities related to the environment, the term "green fintech" as a sub field is specifically targeted at IT innovations in green finance with a clear focus on the environmental SDGs 7, 11, 12, 13, 14, 15, and 17.

3 | RESEARCH METHOD

This paper focuses on the development of a research agenda based on a comprehensive literature review. Literature reviews enable the identification of knowledge gaps (Denyer et al., 2003) as well as an understanding of the evolution of a certain field (Cassell et al., 2006). For this, various literature review methods have been developed.

The first category focuses on the literature review process. In this category systematic literature reviews use a precisely defined review process with distinct activities to analyze the existing literature in a specific research field (e.g., Konys, 2019; Bischoff & Volkmann, 2018). In addition, bibliometric reviews, which use statistical methods, are based on statistics for large amounts of data to visualize and cluster existing research (e.g., Capobianco-Uriarte et al., 2020; Hormiga et al., 2018). With this, a large number of literatures can be classified and visualized according to different criteria, so that an existing field can be analyzed comprehensively.

A second category focuses on the goal of the literature review. Here, critical literature reviews primarily focus on criticizing existing research (e.g., Cohen & Muñoz, 2018), while exploratory literature reviews (e.g., Kiefer et al., 2011) aim at deriving future research topics. These methods have proven to be beneficial for theorizing and conceptualizing an emerging field, as well as better understanding the distribution of publications (Cohen & Muñoz, 2018).

In this paper, a combination of both categories, the systematic literature review approach and the exploratory review approach is used. As the research field of green fintech is relatively new, with most publications from the last 4 years, a bibliometric research approach might not be suitable given the small number of papers. However, a precise review process seems necessary to make the literature review as repeatable as possible. For the development of the research agenda, an exploratory approach is used in a second step to derive potential areas for future research. Both approaches are outlined in more detail in the following two sections. The literature analysis was performed from February 2022 to March 2022 and updated between May 2023

TABLE 1 Literature analysis results.

Source databases	Search results final selection (intermediate; initial search results)
AIS Electronic Library	13 (53; 3196)
Business Source Complete	16 (27; 928)
ScienceDirect	29 (44; 1365)
Google Scholar	38 (93; 7095)
Total Sample with duplicate papers	96 (217; 12,584)
Final Sample without duplicate papers	74

to August 2023, taking into account all papers related to the green fintech topic from the business, information systems and finance disciplines.

3.1 | Systematic literature analysis

To analyze the existing theory in more detail, we first performed a systematic literature analysis process that included five steps (Furtmueller et al., 2013): (1) definition of the scope of the analysis, (2) literature search, (3) selection of the final sample, (4) corpus analysis and (5) presentation of the findings.

In the first step, we delineated and comprised the relevant search terms as part of the definition of the scope of analysis. We analyzed the abstracts and key words of published and working papers. The key words were: "green fintech," "green financial technology," "green digital finance," "climate," "environment," "sustainability," "clean energy," "biodiversity." We also searched for combinations of the above-mentioned key words to ensure to capture as many papers as possible, and we concentrated only on business, finance, and IT related literature. Literature from other disciplines like biology, chemistry, and so forth, were not included in the analysis.

As a part of the second step, we searched the online databases Association for Information Systems (AIS) Electronic Library, Business Source Complete, ScienceDirect, and Google Scholar. The AIS Electronic Library provides access to relevant literature of journals and conferences, which cannot be found in other databases such as Business Source Complete. Business Source Complete and ScienceDirect, on the other hand, provide access to and complement journals that are not part of AIS Electronic Library. With these four databases, a broad universe of academic literature from academic research can be covered and thus, the existing knowledge be identified. For the search itself, papers were excluded that provided work in progress papers from conference proceedings, panel introductions, papers that are not available in English, unavailable papers, teaching cases and pedagogical research papers. Each publication was downloaded and read through thoroughly.

In the third step, we chose the relevant papers for the analysis. The AIS Electronic Library delivered 3196 results, with 53 potentially relevant papers for further inclusion into the research procedure. After analyzing their abstracts and introduction, we identified 13 relevant papers. The same methodology was applied to Business Source Complete, ScienceDirect, and Google Scholar. The final sample comprised 217 papers, which we identified as potentially relevant for further analysis. After reading the papers' abstracts, analyzing keywords and after deleting duplicating papers from final samples, we obtained 74 papers (Table 1). In the literature search, all the following results were excluded: (1) green fintech was not the core part but the term was only mentioned; and (2) papers that could not be classified as research papers. In an additional step, we performed a backward search, which examined cited references, and a forward search, which identified articles that cite an original article after it had been published.

In the fourth step, each paper was classified according to descriptive elements like the title of the paper, author(s), publication outlet (journal or conference name), type of publication outlet (journal or conference), abstract, keyword, theories, methods (empirical), methods (non-empirical) and definitions.

In the fifth step, we evaluated the findings of the analysis. This led to the following findings:

First, most research has been conducted in the field of blockchain, tokens and cryptocurrencies, with fewer papers evaluating the effects on green finance in general or the use of the Internet of Things (IoT) and smart cities/homes more specifically. In this context, IoT is understood as an open and comprehensive network of intelligent objects that have the capacity to auto-organize, share information, data and resources, reacting and acting in the face of situations and changes in the environment (Madakam et al., 2015). For example, Nassiry (2018), among others, discusses the role of fintech in unlocking green finance at the example of policy insights for developing countries by outlining three areas for the possible application of fintech to green finance: blockchain applications for sustainability in general; specific blockchain use-cases for renewable energy, the decentralized electricity market, carbon credits as well as climate finance and innovations in financial instruments like green bonds. Another example is from Puschmann et al. (2020) who analyzes the impact of green fintech on alleviating climate change in Switzerland.

Second, among the identified papers that explore green fintech, most of them focus on specific, very often isolated aspects of green fintech. An example is electronic marketplaces, which are supported by fintech in the field of agricultural sustainability (Cornis van der Lugt, 2018) or the analysis of the feasibility of the fintech industry as an innovation platform for sustainable economic growth in Korea (Choi & Shin, 2019). Most of these papers specifically research single aspects of green fintech, such as electronic marketplaces, certain industries, countries, or technologies (e.g., IoT). Only a few papers develop a more comprehensive view like the paper on "sustainable supply chain finance: toward a research agenda," which conducts a literature analysis and shows future areas of research for the field of sustainable supply chain finance (Chen et al., 2020), which, however, concentrates on the specific field of supply chains.

Third, another category of papers provides cases for green fintech in certain areas. One example is a study on how a blockchain-enabled emission-trading framework can improve the fashion apparel

TABLE 2 Dimensions and characteristics of green fintech approaches.

Cluster	Dimension	List of characteristics					
Strategy	Business model	**Customer interaction** (Almeida et al., 2020; Baynham-Herd et al., 2019; Becker & Kirpes, 2018; Beer et al., 2018; Cunha et al., 2019; Mihaylov et al., 2016; Puschmann et al., 2020)	**Products** (Thompson, 2017; Hinson et al., 2019; Nassiry, 2018; Cunha et al., 2019; Becker & Kirpes, 2018; Cosby & Perrons, 2020; Evans et al., 2019; Chang et al., 2018; Orecchini et al., 2018; Ahl et al., 2019; Mihaylov et al., 2016; Sun & Zhang, 2020; Navickas et al., 2019; Beer et al., 2018; Sachin & Singh, 2019; Fu et al., 2018; Enescu et al., 2020; Patil et al., 2017; Puschmann et al., 2020; Scalise, 2023; Landi, 2023)	**Operations** (Anshari et al., 2019; Arner et al., 2020; Choi & Shin, 2019; Nassiry, 2019; Bechtis et al., 2019; Di Vaio & Varriale, 2020; Lim et al., 2020; Barmet et al., 2019; Almeida et al., 2020; Ahl et al., 2020; Vykoukal, 2010; Ahl et al., 2019; Navickas et al., 2019; Truby, 2018; Fu et al., 2018; Enescu et al., 2020; Deng et al., 2023; Mirza et al., 2023; Escrig-Olmedo et al., 2019)			
	Service	**Business service** (Anshari et al., 2019; Hinson et al., 2019; Arner et al., 2020; Choi & Shin, 2019; Nassiry, 2019; Bechtis et al., 2019; Di Vaio & Varriale, 2020; Cosby & Perrons, 2020; Lim et al., 2020; Barmet et al., 2019; Hopf et al., 2019; Ahl et al., 2019; Navickas et al., 2019; Fu et al., 2018; Enescu et al., 2020; Patil et al., 2017; Axelsen et al., 2023)	**Consumer service** (Thompson, 2017; Nassiry, 2019; Becker & Kirpes, 2018; Hopf et al., 2019; Baynham-Herd et al., 2019; Ahl et al., 2020; Evans et al., 2019; Chang et al., 2018; Orecchini et al., 2018; Mihaylov et al., 2016; Beer et al., 2018; Scalise, 2023)	**Government service** (Almeida et al., 2020; Cunha et al., 2019; Diestelmeier, 2019; Kostka et al., 2017; Lim et al., 2020; Sachs et al., 2019; Sun & Zhang, 2020; Tan et al., 2023; Truby, 2018)			
Organization	Network configuration	**Peer-to-peer network** (Ahl et al., 2019; Baynham-Herd et al., 2019; Becker & Kirpes, 2018; Beer et al., 2018; Chang et al., 2018; Deng et al., 2019; Hopf et al., 2019; Mihaylov et al., 2016; Thompson, 2017)	**Intra-organizational network** (Arner et al., 2020; Di Vaio & Varriale, 2020; Vykoukal, 2010; Enescu et al., 2020; Guang-Wen & Siddik, 2023)	**Inter-organizational network** (Nassiry, 2019; Sachs et al., 2019; Cunha et al., 2019; Bechtis et al., 2019; Lim et al., 2020; Barmet et al., 2019; Patil et al., 2017)			
	Stakeholder process	**G2G** (Kostka et al., 2017; Sachs et al., 2019; Sun & Zhang, 2020; Xu, Chen, et al., 2023; Xu, Zhang, et al., 2023)	**G2B** (Almeida et al., 2020; Cunha et al., 2019; Kostka et al., 2017; Sachs et al., 2019; Sun & Zhang, 2020; Truby, 2018)	**G2C** (Almeida et al., 2020; Cunha et al., 2019; Evans et al., 2019; Sun & Zhang, 2020; Tan et al., 2023; Truby, 2018; Udeagha & Muchapondwa, 2023)	**B2B** (Anshari et al., 2019; Hinson et al., 2019; Amer et al., 2020; Nassiry, 2019; Bechtis et al., 2019; Barmet et al., 2019; Hopf et al., 2019; Ahl et al., 2019; Enescu et al., 2020; Patil et al., 2017; Puschmann et al., 2020; Axelsen et al., 2023; Mirza et al., 2023; Kamble et al., 2020)	**B2C** (Arner et al., 2020; Nassiry, 2019; Ahl et al., 2020; Orecchini et al., 2018; Hopf et al., 2019; Ahl et al., 2019; Mihaylov et al., 2016; Patil et al., 2017; Puschmann et al., 2020; Mirza et al., 2023)	**C2C** (Thompson, 2017; Deng et al., 2019; Becker & Kirpes, 2018; Hopf et al., 2019; Baynham-Herd et al., 2019; Ahl et al., 2020; Chang et al., 2018; Ahl et al., 2019; Mihaylov et al., 2016; Beer et al., 2018; Puschmann et al., 2020; Scalise, 2023)

TABLE 2 (Continued)

Cluster	Dimension	List of characteristics						
	Business process	**Advice** (Sachs et al., 2019; Kang et al., 2020; Evans et al., 2019; Chang et al., 2018; Giungato et al., 2019; Beer et al., 2018; Sachin & Singh, 2019; Sulkowski, 2018; Truby, 2018; Enescu et al., 2020; Mathiyazhagan et al., 2018; Patil et al., 2017; Kostka et al., 2017; Puschmann et al., 2020)	**Payments** (Ahl et al., 2019; Arner et al., 2020; Diestelmeier, 2019; Mihaylov et al., 2016; Puschmann et al., 2020; Thompson, 2017)	**Investments** (Knuth, 2018; Hinson et al., 2019; Nassiry, 2019; Baynham-Herd et al., 2019; Puschmann et al., 2020)	**Financing** (Anshari et al., 2019; Cunha et al., 2019; Deng et al., 2023; Puschmann et al., 2020; Scalise, 2023)	**Risk management** (Arner et al., 2020; Bechtis et al., 2019; Di Vaio & Varriale, 2020; Vykoukal, 2010; Sun & Zhang, 2020; Navickas et al., 2019; Adams et al., 2017)	**Cross-process** (Almeida et al., 2020; Axelsen et al., 2023; Baynham-Herd et al., 2019; Di Vaio & Varriale, 2020; Hopf et al., 2019; Puschmann et al., 2020)	**Trading** (Arner et al., 2020; Nassiry, 2019; Becker & Kirpes, 2018; Lim et al., 2020; Barmet et al., 2019; Ahl et al., 2020; Chang et al., 2018; Mihaylov et al., 2016; Beer et al., 2018; Fu et al., 2018; Diestelmeier, 2019; Axelsen et al., 2023)
Technology	Application type	**Fintech** (Anshari et al., 2019; Knuth, 2018; Deng et al., 2019; Hinson et al., 2019; Arner et al., 2020; Choi & Shin, 2019; Vykoukal, 2010; Evans et al., 2019; Becker et al., 2019; Sasaki, 2018; Mathiyazhagan et al., 2018; Airehrour et al., 2016; Brauer et al., 2016; Patil et al., 2017; Kostka et al., 2017; Jia e al., 2020; Puschmann et al., 2020; Deng et al., 2023; Qu et al., 2023; Xu, Chen, et al., 2023; Xu, Zhang, et al., 2023; Nevanath & Mishra, 2023; Mirza et al., 2023; Lisha et al., 2023; Xu, Chen, et al., 2023; Xu, Zhang, et al., 2023; Cheng et al., 2023; Tan et al., 2023; Muganyi et al., 2023; Lu et al., 2023; Udeagha & Muchapondwa, 2023; Guang-Wen & Siddik, 2023; Jaiwant & Kureethara, 2023; Scalise, 2023; Landi, 2023)	**Insurtech** -	**Blockchain** (Nassiry, 2019; Vogel et al., 2019; Delliere & Grange, 2018; Cunha et al., 2019; Becker & Kirpes, 2018; Hopf et al., 2019; Bechtis et al., 2019; Marke & Sylvester, 2018; Baynham-Herd et al., 2019; Kang et al., 2020; Di Vaio & Varriale, 2020; Cosby & Perrons, 2020; Lim et al., 2020; Barmet et al., 2019; Almeida et al., 2020; Ahl et al., 2020; Chang et al., 2018; Orecchini et al., 2018; Hopf et al., 2019; Ahl et al., 2019; Mihaylov et al., 2016; Sun & Zhang, 2020; Fadeyi et al., 2020; Giungato et al., 2019; Navickas et al., 2019; Beer et al., 2018; Adams et al., 2017; Sachin & Singh, 2019; Sulkowski, 2018; Truby, 2018; Tran & Wu, 2018; John et al., 2018; Kouhizadeh & Sarkis, 2018; Fu et al., 2018; Kouhizadeh et al., 2018; Lee et al., 2020; Enescu et al., 2020; Diestelmeier, 2019; Patil et al., 2017; Puschmann et al., 2020; Axelsen et al., 2023; Kamble et al., 2020; Schuetz & Venkatesh, 2020)				

(Continues)

TABLE 2 (Continued)

Cluster	Dimension	List of characteristics	
	Application design	**Centralized** (Knuth, 2018; Sachs et al., 2019; Tan et al., 2023)	**Decentralized** (Cunha et al., 2019; Thompson, 2017; Deng et al., 2019; Hinson et al., 2019; Arner et al., 2020; Choi & Shin, 2019; Nassiry, 2019; Vogel et al., 2019; Becker & Kirpes, 2018; Bechtis et al., 2019; Baynham-Herd et al., 2019; Di Vaio & Varriale, 2020; Cosby & Perrons, 2020; Lim et al., 2020; Barmet et al., 2019; Almeida et al., 2020; Ahl et al., 2020; Vykoukal, 2010; Chang et al., 2018; Orecchini et al., 2018; Hopf et al., 2019; Ahl et al., 2019; Mihaylov et al., 2016; Sun & Zhang, 2020; Fadeyi et al., 2020; Giungato et al., 2019; Navickas et al., 2019; Beer et al., 2018; Adams et al., 2017; Sachin & Singh, 2019; Sulkowski, 2018; Truby, 2018; Fu et al., 2018; Kouhizadeh et al., 2018; Lee et al., 2020; Enescu et al., 2020; Becker et al., 2019; Mathiyazhagan et al., 2018; Brauer et al., 2016; Diestelmeier, 2019; Patil et al., 2017; Kostka et al., 2017; Deng et al., 2023; Axelsen et al., 2023; Nevanath & Mishra, 2023; Mirza et al., 2023; Lu et al., 2023; Chohan, 2017)
Potentials	Business benefit	**Efficiency** (Fu et al., 2020; Deng et al., 2019; Arner et al., 2020; Nassiry, 2018; Delliere & Grange, 2018; Becker & Kirpes, 2018; Bechtis et al., 2019; Venkatesh et al., 2020; Almeida et al., 2020; Ahl et al., 2020; Ahl et al., 2019; Fadeyi et al., 2020; Beer et al., 2018; Yadav & Singh, 2020; Sulkowski,	**Effectiveness** (Anshari et al., 2019; Thompson, 2017; Knuth, 2018; Hinson et al., 2019; Choi & Shin, 2019; Vogel et al., 2019; Cunha et al., 2019; Becker & Kirpes, 2018; Marke & Sylvester, 2018; Baynham-Herd et al., 2019; Di Vaio & Varriale, 2020; Cosby & Perrons, 2020; Lim et al., 2020; Barmet et al., 2019; Mihaylov et al., 2016;

TABLE 2 (Continued)

Cluster	Dimension	List of characteristics						
		2018; Truby, 2018; John et al., 2018; Fu et al., 2018; Enescu et al., 2020; Becker et al., 2019; Sasaki, 2018; Patil et al., 2017; Evans et al., 2019; Chang et al., 2018; Orecchini et al., 2018; Axelsen et al., 2023; Nevanath & Mishra, 2023; Xu, Chen, et al., 2023; Xu, Zhang, et al., 2023; Guang-Wen & Siddik, 2023)	Sun & Zhang, 2020; Krajnakova et al., 2019; Adams et al., 2017; Tran & Wu, 2018; Kouhizadeh & Sarkis, 2018; Kouhizadeh et al., 2018; Lee et al., 2020; Airehrour et al., 2016; Brauer et al., 2016; Diestelmeier, 2019; Kostka et al., 2017; Vykoukal, 2010; Hopf et al., 2019; Deng et al., 2023)					
	Environmental benefit	**7 (Affordable and clean energy)** (Knuth, 2018; Lim et al., 2020; Barmet et al., 2019; Ahl et al., 2020; Ahl et al., 2019; Mihaylov et al., 2016; Fadeyi et al., 2020; Krajnakova et al., 2019; Beer et al., 2018; Tran & Wu, 2018; Enescu et al., 2020; Becker et al., 2019; Airehrour et al., 2016; Kostka et al., 2017; Chang et al., 2018; Orecchini et al., 2018; Xu, Chen, et al., 2023; Xu, Zhang, et al., 2023; Tan et al., 2023)	**11 (Sustainable cities and communities)** (Fu et al., 2018; Cunha et al., 2019; Baynham-Herd et al., 2019; Almeida et al., 2020; Sun & Zhang, 2020; Fadeyi et al., 2020; Evans et al., 2019; Chang et al., 2018; Orecchini et al., 2018; Hopf et al., 2019; Cheng et al., 2023; Tan et al., 2023; Landi, 2023)	**12 (Responsible consumption and production)** (Anshari et al., 2019; Hinson et al., 2019; Vogel et al., 2019; Becker & Kirpes, 2018; Bechtis et al., 2019; Di Vaio & Varriale, 2020; Cosby & Perrons, 2020; Ahl et al., 2019; Krajnakova et al., 2019; Beer et al., 2018; Yadav & Singh, 2020; Kouhizadeh & Sarkis, 2018; Fu et al., 2018; Kouhizadeh et al., 2018; Enescu et al., 2020; Patil et al., 2017; Axelsen et al., 2023; Xu, Chen, et al., 2023; Xu, Zhang, et al., 2023; Tan et al., 2023)	**13 (Climate Action)** (Knuth, 2018; Deng et al., 2019; Amer et al., 2020; Nassiry, 2018; Delliere & Grange, 2018; Cunha et al., 2019; Marke & Sylvester, 2018; Venkatesh et al., 2020; Cosby & Perrons, 2020; Almeida et al., 2020; Mihaylov et al., 2016; Sun & Zhang, 2020; Krajnakova et al., 2019; Beer et al., 2018; Adams et al., 2017; Truby, 2018; Kouhizadeh & Sarkis, 2018; Fu et al., 2018; Kouhizadeh et al., 2018; Lee et al., 2020; Sasaki, 2018; Mathiyazhagan et al., 2018; Airehrour et al., 2016; Brauer et al., 2016; Patil et al., 2017; Vykoukal, 2010; Orecchini et al., 2018; Qu et al., 2023; Xu, Chen, et al., 2023; Xu, Zhang, et al., 2023; Mirza et al., 2023; Lisha et al., 2023; Xu, Chen, et al., 2023; Xu, Zhang, et al., 2023; Cheng et al., 2023; Sun, 2023; Muganyi et al., 2023; Lu et al., 2023; Udeagha & Muchapondwa, 2023; Guang-Wen & Siddik, 2023; Scalise, 2023)	**14 (Life below water)** -	**15 (Life on land)** (Baynham-Herd et al., 2019; Krajnakova et al., 2019; Patil et al., 2017)	**17 (Partnerships for the goals)** (Fu et al., 2018; Nassiry, 2018; Cunha et al., 2019; Becker & Kirpes, 2018; Marke & Sylvester, 2018; Cosby & Perrons, 2020; Lim et al., 2020; Almeida et al., 2020; Adams et al., 2017; Sulkowski, 2018; Truby, 2018; John et al., 2018; Kouhizadeh et al., 2018; Enescu et al., 2020; Sasaki, 2018; Diestelmeier, 2019; Kostka et al., 2017)

manufacturing industry (Kumar et al., 2020). Another example focuses on the question of how blockchain technology in irrigation systems can integrate photovoltaic energy generation systems (Enescu et al., 2020). Other cases are focusing on certain topics, such as smart cities or smart homes, and the potential of green fintech in these areas (Chang et al., 2018). Most of these case studies are only single research cases and do not focus on developing a framework that can be implemented in a multi-case study settings.

3.2 | Exploratory literature review

After the identification of these 74 relevant papers, each of them was analyzed thematically to identify clusters in a bottom-up analysis that helps to structure the domain in more detail. The coding was performed by assigning keywords to each of the papers. For example, the paper of Cunha et al. (2019) has a focus on customers (customer interaction) and novel financial products (products), for government related services (Government Services), for business-(G2B) and consumer-(G2C) networks (inter-organizational network), for financing forest credits on a (decentralized) platform based on a distributed ledger (blockchain). All these characteristics are presented in Table 2 in the column "List of Characteristics." Based on these characteristics, the process of clustering classes for all papers was performed. The classification technique used in this paper can be defined as an unsupervised technique based on grounded theory (Glaser & Strauss, 1967), since no one can know the ensuing classes prior to the process (Fisher & Yoo, 1993). Discovering a classification structure in initially unclassified data represents such an unsupervised task. Parsons and Wand (2008, p. 839), for example, state that "(…) classification holds that classes do not exist independently but are constructed as useful abstractions of the similarities of the classified phenomena." Based on this bottom-up approach, 9 dimensions and 36 characteristics were identified. The dimensions were assigned to the four clusters: strategy, organization, technology, and potentials (see Table 2). The strategy cluster is related to the literature area on the effects of green fintech on business models and services. The organization cluster lists papers that research effects on business networks, business processes, and the interactions among stakeholders involved in green fintech usage. For example, we distinguish that green fintech applications can be used both within an organization (intra-organizational) or between different organizations (inter-organizational). The technology cluster explores papers that concentrate on the application type and design of a green fintech application. Finally, the cluster potentials show which business and environmental-related potentials can be resolved through green fintech.

The outcome of this classification exercise is a framework that encompasses 36 unique individual classes related to different aspects of green fintech.

The results of this classification process show that customer interactions receive less attention in existing literature than products and operational approaches. This might be the case because the development of green fintech products is still in its early stages of development, and customer interaction can only follow at a later phase when these services are available and ready for access. From a

TABLE 3 Future research topics in the strategy cluster.

Dimension	Future research topics
Business model	*Development of green business models*: • Reflect on innovative blockchain for good applications that could help deliver environmentally beneficial outcomes, framed in terms of the SDGs (Adams et al., 2017). • Implementation of smart contracts to implement and execute token sales (Hopf et al., 2019). • Corporate green innovations (Deng et al., 2023). • Application of blockchains to enhance trading green bonds (Axelsen et al., 2023). • Explore the effects of green fintech on bank profitability in the Euro zone (Mirza et al., 2023). • Evaluate the performance of banks which adopted green fintech during the COVID-19 pandemic (Guang-Wen & Siddik, 2023). *Green ecosystems*: • Environment-focused information systems and technology (green IS/IT) as a crossing between sustainable ecosystems and business ecosystems research (Sasaki, 2018). • Fintech effects on carbon emission on city-level data (Cheng et al., 2023). • Fintech effects on carbon emission in Asian region (Sun, 2023). • Fintech and environmental protection in China (Muganyi et al., 2023). *Smart green cities*: • The role of smart big data platforms for the development of smart cities (Sun & Zhang, 2020). • How blockchain is used in different smart city business models to present a multi-layer taxonomy (Hopf et al., 2019). • Integration of innovative and multi-purpose blockchains in the smart city evolutionary process (Orecchini et al., 2018).
Service	*Product-life-cycle management*: • Implementation of fintech into product-service systems in product-life cycle models (Vogel et al., 2019). *Development of green products and services*: • Effects of fintech start-ups to create superior screening and monitoring technologies for sustainability (Beckamp & Floegel, 2019). • Opportunities for venture capitalists and entrepreneurs in the U.S. to foster clean energy fintechs (Knuth, 2018). • Development of a framework to illustrate how blockchain can enhance sustainability by providing information to consumers about products through the blockchain smart contract function (John et al., 2018).

stakeholder interaction perspective, the analysis reveals that approaches that focus on government interaction are still limited although governments play an important role in fostering environmental sustainability by providing data, etc. On the other hand, customer-to-customer (c2c) approaches based on blockchain-based models gained more interest in existing research. From a technology perspective, blockchain applications are clearly ahead of other fintech approaches (e.g., artificial intelligence), which is also reflected in the fact that most literature focuses on decentralized solutions rather than centralized ones. Green insurtech is an area which is not part of academic research so far. Regarding the environmental benefits, the SDGs 13 (climate action), 7 (affordable and clean energy) and 11 (responsible consumption and production) are the most researched ones, while the SDGs 14 (life below water) and 15 (life on land) are not widely considered yet. Taken together, the analysis shows that the identified 74 papers focus on various aspects of green fintech but also show gaps for future research. The clustering exercise also reveals that with these 36 classes green fintech touches many different aspects, allowing a more detailed understanding of the focus areas of this emerging field.

4 | RESEARCH AGENDA

As the topic of green fintech is only emerging, the analysis of the status quo of existing research in the previous section revealed that the approaches today primarily concentrate on the sectors energy (e.g., peer-to-peer renewable energy-trading systems), financial services (e.g., digital currency-enabled smart meters for water and energy supply), government/NGO (e.g., financial inclusion, corruption prevention, etc.), agriculture (e.g., supply chain finance for farming products), and waste management (e.g., digital currency incentivized waste management). The following sections outline the topics of a green fintech research agenda independent from a sector specific analysis.

4.1 | Strategy

One core field for future research is green business models (Table 3). Today, there is more research in operational and product-related areas rather than in customer-related ones. This reflects most of the

TABLE 4 Future research topics in the organization cluster.

Dimension	Future research topics
Network configuration	*Supply chain networks*: • Major implications of blockchain for operations management with a focus on the decision-making processes in supply chain networks from the perspective of sustainable performance (Di Vaio & Varriale, 2020). • Use of blockchain technology to develop efficient sustainable supply chain networks rather than the inefficient design of supply chain management (Yadav & Singh, 2020). • Novel concepts for sustainable supply chain finance (Chen et al., 2020). • Explore weaknesses of blockchain in the context of supply chains and its vaunted potential to help firms to reduce harms (Sulkowski, 2018). • How blockchain and smart contracts can be used to improve supply chain management (Kouhizadeh et al., 2018). • How can blockchain help to implement containerized supply chains (Bechtis et al., 2019). • Possible strategies of the players involved-incumbents and fintech and BigTech firms-and the role of regulation (Vives, 2019). *Local/regional networks*: • Market network design and simulation study about blockchain effects on sustainable local energy markets (Beer et al., 2018). • Explore the relationship between fintech and sustainable development in Chinese companies considering regional heterogeneity (Deng et al., 2019) *Urban networks*: • Develop concepts for urban smart-sustainability networks (Evans et al., 2019)
Stakeholder process	*User interaction*: • Acceptance of user-centric persuasive green information systems and positive potentials of persuasive design principles on the acceptance of them (Brauer et al., 2016). *Business interaction*: • Evaluate in demand-, supply-driven, and industry models the link between fintech and sustainable economic growth (Choi & Shin, 2019). *Government interaction*: • Examine government intervention choices to de-socialize negative environmental externalities caused by high-energy consuming blockchain technology designs (Truby, 2018). • Analyze how green fintech helps governments in clean energy transition (Xu, Chen, et al., 2023; Xu, Zhang, et al., 2023). • Explore how green fintech supports governments in management of natural resources (Tan et al., 2023).
Business process	*Supply chain processes*: • Link green fintech and supply chain technologies (Kouhizadeh & Sarkis, 2018). • Novel processes for risk management in supply chains (Kostka et al., 2017). *Industry specific processes*: • How can IoT transform energy processes with the use of smart energy products (Becker et al., 2019)

examples from the energy and financial sector which clearly dominate today's research. This might be because many green business models in this domain are still evolving (e.g., green supply chain finance, etc.) and many challenges have yet to be solved (e.g., taxonomies, data privacy, etc.), as are corporate green innovations (Deng et al., 2023). Another relevant question in this context is the integration of governments and regulatory supervision (e.g., in the context of energy or waste management where governmental authorities are involved).

Another important domain for future research is green ecosystems that are being developed around certain customer processes such as agriculture, mobility, etc. The core question for green ecosystems will be how such concepts can be implemented and what future business models will look like if environmental sustainability concepts are applied (e.g., business models for the circular economy) (Bai & Sarkis, 2020)?

A fourth relevant field in the service dimension is product-life-cycle management that analyzes how fintech could be used to improve or implement sustainable product-service systems and how it can be used to develop green products and services.

4.2 | Organization

New technologies often lead to changes in business networks. One core area of future research are networks on different levels such as supply chains, local/regional networks and urban networks. Especially, blockchain technology and smart contracts are one important fields of research to develop novel approaches for the design of such networks. This includes novel ways for supply chain finance, new processes for risk management in supply chains, operations management with a focus on the decision-making processes in supply chain networks, market network designs and simulations about blockchain effects on local energy markets and concepts for urban smart-sustainability networks.

Another important field for future research is digital public infrastructure, which not only includes consumers and businesses but also public institutions. For example, most research today is focused on b2b, b2c, or c2c approaches and not on government solutions (g2c, g2b), despite their important role in providing environmental data and other forms of support. From a consumer perspective, the acceptance of user-centric green information systems (e.g., citizen-led finance systems) becomes an important area, as consumers often do not have transparency about their behavior. For example, payment data could be used to analyze the carbon emissions. The interaction of the different stakeholders could also be reorganized by the concept of distributed autonomous organizations (DAOs) of green digital ecosystems. A DAO is an organizational form controlled by its members and not influenced by a central stakeholder. This would open an interesting link to research in common goods, where self-organization has proven

TABLE 5 Future research topics in the technology cluster.

Dimension	Future research topics
Application type	*IoT applications*: • Analyze the effects of IoT on environmental issues (Mathiyazhagan et al., 2018). • Analyze the capability of grid technology to reduce the environmental impact of IT hardware (Vykoukal, 2010). • Usage of blockchain technology in Internet-of-Things (Tran & Wu, 2018). *Energy blockchain applications*: • Analyze European cases of blockchain implementation to develop renewable energy production and their use in developing countries (Nassiry, 2018). • Analyze how China can employ blockchain technology to reform its energy sector (Lim et al., 2020). • Usage of blockchain technology to energize an innovative environmentally sustainable solution (Fu et al., 2018). • Analyze the applicability and prospects for blockchain-based technologies in the energy sectors (Barmet et al., 2019). • Analyze how blockchain can help framing industry to get liquidity to fund sustainable actions (Axelsen et al., 2023). *Environmental blockchain applications*: • Explore case studies of blockchain application in the management of the "Green Treasure Program" (Cunha et al., 2019). • Explore trends in the application of the blockchain in the cryptocurrencies market and its impact on environmental sustainability (Giungato et al., 2019). • Use of blockchains for waste management cities (Almeida et al., 2020). • Usage of blockchain technologies for irrigation systems (Enescu et al., 2020).
Application design	*System architectures*: • Develop a system architecture that integrates the use of blockchain, internet-of-things (IoT) and big data analytics for supply chain social sustainability efficiency and effectiveness (Venkatesh et al., 2020). *Security tokens*: • Assess the potential of blockchain-based security tokens to address high transaction costs for certification and monitoring, and high minimum investment sizes (Lee et al., 2020). *IoT architectures*: • Improvements in emerging energy infrastructures to revolutionize the IoT landscape (Airehrour et al., 2016).

to be beneficial. Table 4 summarizes the future areas of research in this field.

4.3 | Technology

A third field of research are applications and their design for green fintech. As the internet currently develops toward the "internet of value" (Andreessen Horowitz, 2021), a broad variety of new internet protocols, applications and integration middleware evolves. Amongst the most important areas are novel blockchains applications (e.g., decentralized finance (DeFi) applications) along all identified areas of environmental sustainability. Surprisingly, the use of artificial intelligence (AI) and other technologies such as application programming interfaces (APIs) to enable access to a wider spectrum of data are not well researched in the context of green fintech. Another important area linked to blockchains is crypto-assets, which could be used for various applications such as the funding of green fintech startups, etc. Table 5 summarizes the future research topics in this field.

4.4 | Potentials

Sustainability and profitability have long been opposing goals. Green fintech solutions can store financial and environmental data and thus contribute to both business and sustainability benefits (Bai and Sarkis, 2020). Most research today focuses on the sectors energy and agriculture, while others have not yet been explored in more detail. Other fields are economic development benefits, such as the influence of green fintech on economic growth in certain countries and regions, as well as climate and environmental benefits. Table 6 summarizes the future research avenues in the field of business and sustainability benefits.

TABLE 6 Future research topics in the benefits domain.

Dimension	Future research topics
Business benefit	*Energy*: • Potentials of blockchain to develop the geo-energy sector (Cosby & Perrons, 2020) • Benefits for stakeholders in the smart grid and for the renewable energy economy (Mihaylov et al., 2016). *Agriculture*: • Modeling of digital marketplaces with fintech-enabled, especially crowdfunding and payment systems to support agriculture's sustainability (Anshari et al., 2019).
Sustainability benefit	*Agriculture*: • Explore how fintech can foster the green footprint of agribusiness in developing countries (Hinson et al., 2019). • Blockchains in agriculture business (Axelsen et al., 2023). *Forests*: • Analyze how blockchain can help to address fundamental problems with market-based forest protection globally (Howson et al., 2019). • Identify benefits for Biomass blockchain use and for forest expansion and development of common energy systems (Krajnakova et al., 2019). *Energy*: • Explore the contribution of blockchain for sustainable energy production in Japan (Ahl et al., 2020). • Contextualize the energy-use in smart cities through mining of virtual currencies, to predict whether smart cities can truly be sustainable if crypto-mining is sustained (Fadeyi et al., 2020). • Find positive role of green fintech in clean energy transition (Xu, Chen, et al., 2023; Xu, Zhang, et al., 2023) • Analyze effects of green fintech and of renewable energy on climate change (Lu et al., 2023). *Economic development benefits*: • Anaylze the fintech effects on payment systems in terms of sustainability benefit distribution and economic development (Thompson, 2017). • Investigate the influence of green fintech on economic growth in India (Nevanath & Mishra, 2023). *Climate and environmental benefits*: • Introduce a measurement framework that offers a panoramic view of the environmental concerns associated with blockchain technologies in a cryptocurrency context (Delliere & Grange, 2018). • Explore novel ways to use blockchain to boost global climate finance flows and achieve the Paris Agreement goals (Marke & Sylvester, 2018). • Evaluate the influence of green fintech on environmental index (Qu et al., 2023) • Explore how fintech can significantly decrease carbon emissions intensity (Xu, Chen, et al., 2023; Xu, Zhang, et al., 2023). • Analyze how fintech and natural resources affect environmental sustainability in BRICS economies (Lisha et al., 2023; Udeagha & Muchapondwa, 2023). • Show effects of green fintech innovations on carbon emissions in China (Cheng et al., 2023). • Offer a comprehensive analysis for the impact of green finance policies in China (Muganyi et al., 2023). • Symmetric and asymmetric effects of green fintech on environment and renewable energy (Lu et al., 2023).

5 | CONCLUSION

For green finance, as a part of sustainable finance, green fintech can be a strong enabler. However, as this research has shown, the intersection of these two areas is still weakly explored. This research tried to shed light on the question: *How can green fintech approaches be classified and what topics should future research agendas include?*

To answer this question, the current state-of-the-art literature on fintech with a link to the environmental sustainability goals was identified and analyzed comprehensively, through which 74 academic papers were identified. By reading and coding all these papers, 36 characteristics in 9 dimensions and four clusters were identified in a bottom-up analysis based on grounded theory. The results obtained from the analysis of these relevant literature sources reveal at least four areas for future research.

First, green fintech is still a premature research field that needs further exploration by longitudinal studies, empirical analysis, etc. As only 74 papers could be identified in this area, more in-depth research is required to extend the knowledge in this emerging domain. While innovation and the number of start-ups in this field has been growing significantly over the past years, academic research has not yet caught up.

Second, the clustering of the literature showed that the 36 characteristics of green fintech cover different areas ranging from business model, service, network, stakeholder, business process, application type, application design, business benefit, and environmental benefit. However, the distribution of the different literature sources does not show the same picture, but rather indicates that some fields are underrepresented. Amongst the prominent examples are customer and government-related services or the use of other technologies other than blockchain. This opens a wide field for future research, not only in the areas where research has already started, but also in ones where research has not been conducted so far.

Third, the future fields of research show a broad variety of topics across all areas and provide researchers with a wide field for novel research in an emerging domain. This also includes cross-domain topics such as country-focused research or considering different ethics and cultures. This is very relevant, as especially interdisciplinary research is required in this field, where researchers from computer science, information systems, banking and finance, economics, law, and so forth can provide input.

Fourth, while this research provides a theoretical lens on green fintech, the application of these concepts in incumbent institutions as well as in startups and the research of these applications is another field of future importance. So far, we have only been able to research theoretical concepts rather than data on existing applications. This, however, would help to deepen our understanding of the benefits and use of such applications more broadly.

Although digitalization and green finance have been the core drivers of transformation of the financial industry over the past decade, their connection is still weak and remains an interesting field for future research.

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