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EDITED BY

Assoc. Prof. Dr. Kasman Ediputra
Universitas Pahlawan, Indonesia.

*CORRESPONDENCE

Margo Regalado
margo2n9hr@outlook.com

RECEIVED: May 15, 2026

ACCEPTED: August 12, 2026

PUBLISHED: August 27, 2026

CITATION

Regalado, M., Mashchenko, V., Sicilia, I., & Nolfu, A. (2026). Digital Finance and Green Finance in Sustainable Economic Growth: A Systematic Review of the DF–GF Nexus and Research Agenda. *Global Insights in Management and Economic Research*, 2(03), 109–127.
<https://doi.org/10.53905/Gimer.v2i03.13>

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Digital Finance and Green Finance in Sustainable Economic Growth: A Systematic Review of the DF–GF Nexus and Research Agenda

Margo Regalado^{1*}, Vladislava Mashchenko², Ivan Sicilia³, Anders Nolfu⁴

¹Department of Economics, University of Bonn's, Germany.

²National Research University Higher School of Economics, Russia.

³University of Granada, Spain.

⁴Faculty of Economics and Business Administration, University of Tartu, Estonia.

ABSTRACT

Purpose of the study: The convergence of digital finance (DF) and green finance (GF) has attracted increasing scholarly attention as a potential pathway toward sustainable economic growth (SEG). However, the evidence remains fragmented across financial mechanisms, geographical settings, outcomes, and methodological approaches. This systematic review synthesises evidence on the individual and joint relationships among DF, GF, and SEG, with particular attention to mechanisms, moderators, and the emerging DF–GF complementarity proposition.

Materials for Analysis: Following PRISMA 2020 and PRISMA-S principles, Scopus, Web of Science Core Collection, and ScienceDirect were searched for peer-reviewed English-language publications from January 2015 to 20 June 2025. Citation tracking and supplementary identification procedures were also applied. After deduplication and independent two-stage screening, 73 publications were included, comprising 61 primary empirical studies and 12 previous reviews. Methodological quality was assessed using MMAT 2018 and AMSTAR 2, and evidence was synthesised using descriptive, thematic, and framework synthesis.

Results: Digital finance was generally associated with financial inclusion, resource allocation, entrepreneurship, and sustainable or high-quality growth. Green finance was generally associated with renewable energy, energy efficiency, green innovation, and low-carbon transition. Innovation and financing-constraint reduction were recurrent mechanisms. However, findings were heterogeneous, nonlinear, and context dependent. Evidence on the joint DF–GF relationship remained limited and geographically concentrated, particularly in China.

Conclusions: The literature supports substantial individual associations of DF and GF with sustainability-related economic outcomes, while evidence for DF–GF complementarity remains preliminary. Future research should prioritise causal identification, cross-country evidence, measurement harmonisation, explicit interaction testing, and distributional outcomes.

Keywords

digital finance; green finance; sustainable economic growth; financial inclusion; green innovation; renewable energy.

INTRODUCTION

Global and Theoretical Context

Reconciling economic growth with environmental sustainability has become a central challenge for contemporary development policy (Shah et al., 2023, p. 600). The 2030 Agenda for Sustainable Development requires economic systems to generate productivity, employment, and welfare improvements while reducing environmental pressures and supporting a transition toward more resource-efficient and low-carbon economies (Adanma & Ogunbiyi, 2024, p. 965; Kara et al., 2022, p. 507). Finance is central to this challenge because financial systems influence the allocation, accessibility, and monitoring of capital across households, firms, sectors, and regions (Antunes et al., 2024, p. 15329; Boissinot et al., 2015). Within this broader transformation, digital finance and green finance have emerged as two increasingly important but historically distinct financial paradigms.

Digital finance refers broadly to the delivery of financial services through digital technologies and infrastructures, including digital payments, mobile financial services, digital lending, FinTech platforms, and data-driven credit assessment

(Alt et al., 2024, p. 3; Mpofu, 2024, p. 122). By reducing transaction and information costs, digital finance can expand access to financial services, particularly among households and firms previously underserved by conventional financial institutions (Basnayake et al., 2024; Tay et al., 2022). Improved financial access may facilitate savings, entrepreneurship, investment, and resource allocation, thereby creating conditions associated with higher-quality economic growth. However, digitalisation does not necessarily produce environmental benefits automatically. Increased financial access and economic activity may also generate additional consumption and energy demand, potentially creating environmental trade-offs under particular institutional and development conditions (Amaliah et al., 2024; Öztürk & Ullah, 2022).

Green finance represents a complementary financial paradigm concerned with directing financial resources toward environmentally beneficial activities (Fu et al., 2023, p. 18; Muganyi et al., 2021). Instruments include green credit, green bonds, green investment funds, and other forms of climate- and sustainability-oriented financing. The literature generally

associates green finance with renewable-energy development, energy efficiency, green innovation, and low-carbon transition, although the strength and direction of these relationships vary across countries, sectors, time periods, and institutional environments (Alharbi et al., 2023; Rasoulnezhad & Taghizadeh-Hesary, 2022; Wang et al., 2024).

The theoretical relevance of the two paradigms can be traced to finance-and-growth and Schumpeterian perspectives. Financial development can facilitate the mobilisation and allocation of capital, while financial innovation can support technological and productive innovation (Herrera & Ni, 2026, p. 643; Kapidani & Luçi, 2019, p. 86). When these mechanisms are considered within a sustainability framework, the relevant pathways extend beyond aggregate economic expansion to include financial inclusion, financing-constraint reduction, technological and green innovation, resource reallocation, and energy transition (Cevik, 2024; Feng et al., 2022; Liu et al., 2022).

An important unresolved issue is whether digital finance and green finance operate independently or whether their combination may generate complementary effects. Conceptually, digital financial infrastructures may reduce information, transaction, monitoring, and scaling frictions associated with green investment (perera et al., 2026; Tsybuliak et al., 2025). Digital technologies may therefore improve the identification of green investment opportunities and facilitate monitoring, while green-finance instruments may direct the additional financial capacity generated through digitalisation toward environmentally productive activities (Tan et al., 2024, p. 2; Wang et al., 2025, p. 10255). This proposition, however, should not be treated as an established causal relationship because the empirical literature on the joint nexus remains relatively small and is concentrated geographically.

The relationship may therefore be conceptualised through several distinct pathways. First, digital finance may have a direct association with sustainable-growth outcomes through financial inclusion and improved financial efficiency. Second, green finance may be directly associated with sustainable-growth outcomes through green investment and energy transition. Third, either financial paradigm may operate through mediating mechanisms, particularly technological and green innovation. Fourth, institutional quality, environmental regulation, infrastructure, and development stage may moderate these relationships. Finally, the joint DF–GF relationship can be formulated as an interaction or complementarity hypothesis, whereby the association between one financial paradigm and sustainable growth varies according to the development of the other.

Distinguishing these pathways is important because evidence of separate positive associations between digital finance and sustainable growth and between green finance and sustainable growth does not, by itself, establish an interaction effect between the two. The latter requires explicit empirical testing of the joint relationship.

Critical Overview of Existing Evidence

The empirical literature can be organised into several interconnected strands. The first examines the relationship between digital finance and the level or quality of economic growth. Studies using Chinese provincial and city-level panels generally report positive associations between digital inclusive finance and sustainable or high-quality growth, with financial inclusion, household financial activity, entrepreneurship, and resource allocation frequently identified as potential mechanisms

(Liu et al., 2023; Sun & Tang, 2022; Xi & Wang, 2023). Cross-country evidence from Asia-Pacific and Belt-and-Road economies similarly reports positive associations, although threshold effects and environmental trade-offs have also been documented (Amaliah et al., 2024; Basnayake et al., 2024; Öztürk & Ullah, 2022). The second strand examines green finance in relation to renewable energy and low-carbon transition. Evidence from country-level and cross-national studies generally indicates associations between green-finance development, green bonds, renewable-energy deployment, and energy efficiency (Alharbi et al., 2023; Li & Umair, 2022; Rasoulnezhad & Taghizadeh-Hesary, 2022; Wang et al., 2024). However, reported relationships differ according to technological capacity, emission intensity, regulatory environments, and time horizon. The third strand identifies innovation as a major transmission mechanism. Digital finance and green finance have been associated with green technological innovation through mechanisms such as financing-constraint reduction, improved access to capital, and increased research and development activity (Feng et al., 2022; Huang et al., 2022; Irfan et al., 2022; Liu et al., 2022, 2023). Some studies further suggest that these associations vary according to firm size, ownership, pollution intensity, and regional conditions.

The fourth strand, which is more recent, explicitly examines digital and green finance together. Emerging studies suggest that their joint development may be associated with sustainable development through new quality productivity, enterprise digital transformation, and energy transition (Gong & Zhang, 2024; Razzaq & Yang, 2022; Xu et al., 2024). Nevertheless, this evidence remains limited in volume and geographically concentrated, making broad generalisation premature.

Across these strands, substantial heterogeneity is evident. Digital finance has been operationalised using the Peking University Digital Financial Inclusion Index, FinTech indicators, ATM or debit-card penetration, and other bespoke measures. Green finance has been measured through green-credit ratios, green-bond issuance, investment measures, and composite indices (Chen et al., 2026, p. 11; Li et al., 2024, p. 6). Sustainable growth has likewise been operationalised through GDP-based measures, high-quality growth, green total-factor productivity, renewable-energy output, and carbon-emission indicators (Torre et al., 2023, p. 102218). Such variation complicates direct comparison across studies and provides an important explanation for apparently contradictory findings.

Previous Reviews and Unresolved Research Gap

Previous reviews have substantially contributed to understanding individual components of the broader nexus. Bibliometric and systematic studies have examined green finance, digital financial services, renewable energy, carbon-emission reduction, ESG, green innovation, and FinTech-related contributions to sustainable development. These studies generally describe a rapidly expanding interdisciplinary field with substantial geographical concentration in China and other Asian economies. However, most previous reviews examine either digital finance or green finance separately or connect one financial paradigm to a particular outcome. Consequently, the relationship between digital finance, green finance, and sustainable economic growth has not yet been sufficiently synthesised as an integrated analytical nexus.

The present review addresses this gap by distinguishing primary empirical evidence from previous review evidence. Specifically, 61 empirical studies constitute the primary evidence

base, while 12 prior reviews are treated separately as secondary contextual evidence. The prior reviews are therefore not considered independent empirical observations and are used primarily to contextualise the findings of the present synthesis and identify how the current review extends previous work.

Theoretical Contribution and DF–GF Complementarity Proposition

The central theoretical contribution of this review is the formulation of the DF–GF relationship as a complementarity hypothesis rather than as an assumed causal fact.

Proposition 1: DF–GF Complementarity

Digital finance and green finance may exhibit complementary associations with sustainable economic growth when digital financial infrastructures reduce information, transaction, monitoring, and financing frictions associated with environmentally oriented investment and when green-finance mechanisms channel financial resources toward environmentally productive activities. This proposition implies four analytically distinct relationships: 1) Direct relationship: $DF \rightarrow SEG$; 2) Direct relationship: $GF \rightarrow SEG$; 3) Mediated relationship: $DF/GF \rightarrow$ innovation, energy transition, or resource allocation $\rightarrow SEG$; 4) Interaction relationship: $DF \times GF \rightarrow SEG$

Institutional quality, environmental regulation, digital infrastructure, and development stage are subsequently conceptualised as potential moderators.

This distinction allows the review to separate pathways supported by existing empirical evidence from theoretically proposed pathways requiring further empirical testing.

Review Objective and Research Questions

The primary objective of this review is to systematically synthesise empirical evidence concerning how digital finance and green finance, individually and jointly, are associated with sustainable economic growth and sustainability-related growth outcomes. The review addresses six questions:

RQ1. How has the literature on digital finance, green finance, and sustainable economic growth evolved over time?

RQ2. What dominant themes and emerging research areas characterise this literature?

RQ3. What theoretical perspectives and conceptual mechanisms are used to explain the relationships among digital finance, green finance, and sustainable economic growth?

RQ4. How is digital finance associated with sustainable economic growth through financial inclusion, financial efficiency, technological innovation, and resource allocation?

RQ5. How is green finance associated with sustainable economic growth through green investment, renewable energy, environmental innovation, and low-carbon development?

RQ6. What contextual, methodological, geographical, and theoretical gaps remain in the evidence concerning the integrated DF–GF–SEG nexus?

MATERIALS FOR ANALYSIS

Review Design and Reporting Framework

This study employed a systematic literature review (SLR) with a configurative and theory-building orientation to synthesise empirical and review-level evidence concerning the relationships among digital finance (DF), green finance (GF), and sustainable economic growth (SEG). A configurative review design was considered appropriate because the existing literature is methodologically heterogeneous and encompasses quantitative observational studies, quasi-experimental designs, conceptual contributions, and previous systematic or bibliometric reviews, with substantial variation in constructs, measurements, populations, outcomes, geographical settings, and analytical strategies.

The review was reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 statement (Page et al., 2021). The search component was additionally structured in accordance with PRISMA-S to improve the transparency and reproducibility of information-source reporting, search strategies, search dates, limits, and retrieval procedures (Rethlefsen et al., 2021, p. 174).

An a priori review protocol was prepared specifying the review objectives, research questions, eligibility criteria, information sources, search strategy, screening procedures, data-extraction fields, methodological appraisal procedures, and evidence-synthesis strategy. The protocol was not registered in PROSPERO because the review addresses economics, finance, and sustainability rather than a health-related intervention. Any methodological decisions that emerged during the review process were documented and applied consistently across the included evidence.

A methodological distinction was established between primary empirical evidence and secondary review evidence. Empirical studies were treated as the principal evidence base for synthesising associations, mechanisms, moderators, and

contextual conditions, whereas previously published reviews were retained as contextual evidence for comparing prior syntheses, identifying established themes, and clarifying the contribution of the present review. Previous reviews were therefore not treated as independent empirical observations.

Review Scope and Population–Concept–Context Framework

The review examined how digital finance and green finance are individually and jointly associated with sustainable economic growth and related sustainability-oriented economic outcomes. The analytical scope distinguished four forms of evidence: (1) direct relationships between DF or GF and SEG-related outcomes; (2) mediated relationships involving mechanisms such as financial inclusion, financing-constraint reduction, innovation, entrepreneurship, resource allocation, and energy transition; (3) moderated relationships conditioned by institutional, technological, regulatory, or developmental characteristics; and (4) interaction or complementarity relationships in which the association between one financial paradigm and sustainable growth varies according to the level or development of the other.

The review question and eligibility criteria were structured using a Population–Concept–Context (PCC) framework. In addition, the principal outcomes were explicitly defined to ensure alignment between study selection, extraction, synthesis, and interpretation.

Table 1. Population–Concept–Context (PCC) Framework and Operational Definitions

PCC element	Operational definition
Population	Countries, regions, cities, firms, households, sectors, or broader economic systems examined in relation to sustainable-growth or sustainability-linked economic outcomes
Concept	Digital finance and/or green finance, including digital financial inclusion, FinTech, digital lending, mobile financial services, green credit, green bonds, green

Context	investment, climate finance, and related financial instruments	Language	English	Non-English publications
	Developed and developing economies, including national, cross-country, regional, city-level, sectoral, firm-level, and household-level settings	Date	January 2015–20 June 2025	Publications outside the prespecified period
Analytical outcomes	Sustainable/high-quality economic growth, green total-factor productivity, renewable-energy development, low-carbon transition, CO ₂ emissions or intensity, green innovation, and other clearly specified sustainability-linked growth outcomes	Accessibility	Full text retrievable after reasonable retrieval attempts	Full text unavailable after reasonable retrieval attempts
		Evidence role	Empirical studies classified as primary evidence; reviews classified as contextual secondary evidence	Publications that could not be classified or did not meet the conceptual eligibility criteria

The PCC framework defined the conceptual boundaries of the review rather than implying that all included studies employed identical populations, financial constructs, outcome definitions, or analytical designs.

Eligibility Criteria

Eligibility criteria were specified before screening and were applied consistently during title/abstract and full-text assessment. Publications were eligible when they satisfied all relevant inclusion criteria. Studies were included when they: (1) were peer-reviewed journal articles; (2) were published in English; (3) were published between January 2015 and 20 June 2025; (4) examined digital finance and/or green finance; (5) reported sustainable economic growth or a clearly specified sustainability-linked economic outcome; and (6) provided sufficient methodological information for meaningful interpretation. Empirical studies could employ quantitative, qualitative, mixed-methods, panel, cross-sectional, quasi-experimental, or other identifiable empirical designs. Review studies were eligible when they were systematic, bibliometric, structured, or otherwise clearly identifiable reviews addressing a component of the DF–GF–SEG literature.

Studies were excluded when they: (1) addressed finance without a relevant sustainability or growth outcome; (2) focused exclusively on technical FinTech engineering without an economic or sustainability dimension; (3) were editorials, commentaries, conference abstracts, book chapters, theses, working papers, or other forms of non-peer-reviewed grey literature; (4) were not published in English; (5) fell outside the prespecified publication period; (6) lacked sufficient methodological information for meaningful interpretation; or (7) substantially overlapped with another included study using the same dataset and research question without providing a sufficiently independent contribution.

Table 2. Eligibility Criteria for Inclusion and Exclusion of Studies

Criterion	Inclusion	Exclusion
Population/setting	Country, region, city, firm, household, sector, or economic system relevant to the DF–GF–SEG nexus	Context unrelated to DF, GF, or sustainable growth
Concept	Digital finance and/or green finance	Finance without DF/GF relevance; purely technical FinTech studies
Outcomes	Sustainable/high-quality growth, green TFP, renewable energy, CO ₂ emissions/intensity, low-carbon transition, green innovation, or SDG-related economic outcomes	Outcomes unrelated to economic growth or sustainability
Study design	Empirical quantitative, qualitative, mixed-methods, quasi-experimental studies; systematic, bibliometric, or structured reviews	Editorials, commentaries, conference abstracts, book chapters, theses, or working papers
Publication type	Peer-reviewed journal articles	Non-peer-reviewed publications

Information Sources

Three principal bibliographic databases were searched: Scopus, Web of Science Core Collection, and ScienceDirect. These sources were selected because the literature on digital finance, green finance, and sustainable economic growth spans economics, finance, environmental sciences, energy, technological innovation, and sustainability research. The final database search was conducted on 20 June 2025, with the eligibility window beginning on 1 January 2015. Database searching was supplemented by backward citation searching, forward citation tracking, hand-searching of selected relevant journals, and consultation with two subject-matter experts. Records identified through supplementary procedures were subjected to the same eligibility criteria as database-derived records. The reported retrieval was 1,527 records from database searches and 24 additional records from supplementary identification procedures, yielding 1,551 records before duplicate removal.

Search Strategy

The search strategy was developed around two conceptual components: (1) finance-related concepts covering digital finance and green finance, and (2) sustainable economic growth and sustainability-related outcomes. Free-text terms, truncation, Boolean operators, and database-specific field restrictions were used to maximise retrieval while maintaining conceptual relevance. The Scopus search strategy was:

TITLE-ABS-KEY (("digital financ" OR "digital inclusive financ" OR "digital financial inclusion" OR fintech OR "financial technology" OR "mobile money" OR "digital lending") OR ("green financ*" OR "green credit" OR "green bond*" OR "green investment" OR "climate financ*" OR "sustainable financ*")) AND ("sustainable economic growth" OR "sustainable development" OR "high-quality growth" OR "green growth" OR "green total factor productivity" OR "low-carbon" OR "carbon emission*" OR "renewable energy") AND (LIMIT-TO (PUBYEAR , 2015-2025)) AND (LIMIT-TO (DOCTYPE , "ar")) AND (LIMIT-TO (LANGUAGE , "English"))**

The strategy was piloted against known relevant publications and subsequently adapted to the search syntax and field structure of Web of Science Core Collection and ScienceDirect. The complete executed search strings for all databases, together with search dates, search fields, Boolean operators, truncation, filters, and retrieval counts, are provided in Supplementary File S1 to facilitate replication.

The search strategy intentionally used digital finance and/or green finance within the finance concept block. This design permitted the review to capture evidence on the individual DF–SEG and GF–SEG relationships as well as the smaller body of literature explicitly examining the integrated DF–GF relationship.

Supplementary Identification Procedures

Database searches were complemented by three supplementary identification procedures. First, backward citation

searching was conducted using the reference lists of eligible empirical studies and relevant reviews. Second, forward citation tracking was used to identify subsequent publications citing key eligible studies. Third, selected high-relevance journals in finance, economics, sustainability, energy, and technological forecasting were hand-searched. In addition, two subject-matter experts were consulted to identify potentially relevant publications that might not have been retrieved through database searching. All records identified through supplementary procedures were screened using the same eligibility criteria applied to database-derived records. These procedures were intended to improve retrieval completeness without changing the prespecified conceptual scope or eligibility criteria.

Study Management, Deduplication, and Screening

All retrieved records were exported to Zotero for reference management and duplicate detection. Duplicate records were first identified automatically and then checked manually to minimise the risk of erroneous deletion or retention of duplicate records.

Study selection was performed in two sequential stages. Stage 1 involved title and abstract screening against the predefined eligibility criteria. Stage 2 involved full-text assessment of potentially eligible publications. Two reviewers independently conducted both screening stages. Before full-text screening, a calibration exercise involving 50 records was conducted to harmonise interpretation of the eligibility criteria. Inter-rater agreement during the calibration stage was assessed using Cohen's kappa and yielded $\kappa = 0.81$, indicating substantial agreement. Disagreements were resolved through discussion and consensus; when consensus could not be reached, a third reviewer adjudicated the final decision.

The study-selection pathway comprised 1,551 identified records. After removal of 509 duplicates, 1,042 records remained for title and abstract screening, of which 869 were excluded. A total of 173 reports were sought for full-text retrieval; nine could not be retrieved, leaving 164 reports for full-text eligibility assessment. Ninety-one reports were excluded at the full-text stage for prespecified reasons, resulting in 73 included publications. The final corpus comprised 61 primary empirical studies and 12 previous reviews.

Data Extraction and Data Items

A structured data-extraction form was developed specifically for this review and piloted on eight studies before full extraction. The form was refined following the pilot process to improve consistency across heterogeneous study designs and financial constructs.

Two reviewers independently extracted data from the included empirical studies. A third reviewer verified a random 20% sample of extracted records. Discrepancies were resolved through discussion and consensus. Where important information was unclear or unavailable, corresponding authors were contacted where feasible. The extraction framework included the following domains:

Bibliographic characteristics: author(s), publication year, journal, DOI, and publication type.

Study characteristics: country or region, sector, unit of analysis, sample size, observation period, and research design.

Methodological characteristics: estimation strategy, econometric model, identification strategy, treatment of endogeneity, robustness analyses, and spatial or threshold specifications where applicable.

Financial constructs: definition and measurement of digital

finance and green finance.

Outcome characteristics: sustainable economic growth, high-quality growth, green total-factor productivity, renewable-energy development, CO₂ emissions or intensity, low-carbon transition, green innovation, and other sustainability-linked outcomes.

Mechanism characteristics: financial inclusion, financing constraints, innovation, entrepreneurship, resource allocation, digital transformation, renewable-energy development, energy transition, and new quality productivity.

Contextual characteristics: institutional quality, environmental regulation, governance, marketisation, development stage, technological capacity, and geographical context.

Relationship classification: direct, mediated, moderated, interaction/complementarity, spatial/spillover, or other/unclear.

Methodological Quality Appraisal of Primary Empirical Studies

The methodological quality of the 61 primary empirical studies was assessed using the Mixed Methods Appraisal Tool (MMAT), version 2018 (Hong et al., 2018). MMAT was selected because it provides design-appropriate appraisal criteria for qualitative, quantitative, and mixed-methods evidence and is suitable for systematic reviews containing heterogeneous study designs.

The appraisal procedure consisted of four stages: (1) screening the study using the relevant MMAT screening questions; (2) identifying the empirical study design; (3) applying the corresponding MMAT methodological criteria; and (4) independently recording judgements by two reviewers. Because the evidence base was predominantly quantitative, the appropriate quantitative MMAT criteria were applied according to the design of each study.

The appraisal considered methodological domains including appropriateness of the research question, sampling and data sources, measurement quality, outcome assessment, control of confounding, appropriateness of statistical analysis, potential selection or measurement bias, and coherence between study design and conclusions.

MMAT findings were not converted into an arbitrary overall numerical score. Instead, domain-level methodological strengths and weaknesses were incorporated into the interpretation of the evidence and the assessment of confidence in thematic findings.

Appraisal of Previous Reviews

The 12 previously published reviews were appraised separately using AMSTAR 2 (Shea et al., 2017). AMSTAR 2 comprises 16 methodological items covering important aspects of review conduct and reporting, including protocol development, comprehensiveness of the literature search, justification of exclusions, study-selection procedures, data-extraction procedures, risk-of-bias assessment, synthesis methods, consideration of heterogeneity, conflicts of interest, and publication-bias considerations.

AMSTAR 2 was used as a structured methodological appraisal framework rather than as a numerical scoring system. No total AMSTAR 2 score was calculated, consistent with the tool's methodological guidance. Because the included reviews span economics, finance, sustainability, bibliometrics, and related interdisciplinary fields, the appraisal was interpreted cautiously and was used primarily to identify methodological strengths, transparency, and critical limitations within the secondary review evidence.

Inter-Rater Agreement and Resolution of Appraisal Disagreements

Study selection and methodological appraisal were conducted independently by two reviewers. Inter-rater agreement during screening was quantified using Cohen's kappa, with $\kappa = 0.81$ obtained during the calibration exercise. Methodological appraisal disagreements were identified at the individual criterion level and resolved through discussion and consensus. When consensus could not be reached, a third reviewer adjudicated the final judgement.

Certainty of Evidence

Because the primary evidence base consisted predominantly of heterogeneous quantitative observational studies, the review did not treat certainty assessment as an indicator of causal identification. Instead, a structured certainty-of-evidence framework was applied at the thematic finding level.

The framework considered five dimensions: 1) Methodological limitations and risk of bias; 2) Consistency of findings across studies; 3) Directness and relevance to the review questions; 4) Strength and precision of the available evidence; and 5) Potential publication or reporting bias, where sufficiently assessable.

Four descriptive certainty categories were used: a) High certainty: findings were generally consistent and directly relevant, with relatively limited methodological concerns; b) Moderate certainty: findings were generally consistent but important methodological, contextual, or measurement limitations remained; c) Low certainty: evidence was limited, heterogeneous, geographically concentrated, or affected by substantial methodological concerns; and d) Very low certainty: evidence was sparse or highly uncertain, with substantial limitations affecting interpretation.

Evidence Synthesis and Analytical Strategy

A statistical meta-analysis was not performed because the included studies showed substantial heterogeneity in the definition and measurement of digital finance, green finance, and sustainable-growth outcomes, as well as in units of analysis, geographical settings, observation periods, econometric estimators, identification strategies, and reported effect specifications. Under these conditions, statistical pooling could produce apparently precise estimates that do not represent substantively comparable underlying relationships.

The review therefore employed a combined descriptive, thematic, and framework synthesis.

Descriptive Synthesis

The included evidence was first mapped according to publication year, geographical setting, research design, digital-finance measure, green-finance measure, outcome definition, theoretical framework, mechanism, moderator, direction of association, and methodological characteristics. This stage was used to identify the structure and distribution of the evidence base.

Thematic Synthesis

Empirical findings were subsequently coded and grouped into recurring analytical themes. The synthesis emphasised patterns, consistencies, contradictions, and contextual differences rather than simple counts of statistically significant results. This approach was intended to avoid equating statistical significance across studies with substantive consistency.

Framework Synthesis

The findings were mapped onto an a priori mechanism framework comprising five principal pathways: 1) Financial

inclusion; 2) Financing-constraint reduction; 3) Green and technological innovation; 4) Resource allocation; and 5) Energy transition.

Heterogeneity Analysis

Heterogeneity was examined across geographical setting, development stage, institutional quality, environmental regulation, financial measurement, outcome definition, model specification, unit of analysis, and time horizon. Particular attention was given to threshold effects, nonlinear relationships, spatial spillovers, environmental trade-offs, and differences between aggregate and firm- or household-level evidence.

Relationship Classification

Each reported relationship was classified according to the most appropriate analytical form: 1) direct association: DF or GF $\rightarrow$ SEG-related outcome; 2) mediated relationship: DF/GF $\rightarrow$ mechanism $\rightarrow$ outcome; 3) moderated relationship: moderator $\times$ finance $\rightarrow$ outcome; 4) interaction/complementarity: DF $\times$ GF $\rightarrow$ outcome; or 5) spatial or feedback relationship: geographically or dynamically interconnected effects.

This classification was used to ensure that evidence of separate DF–SEG and GF–SEG associations was not interpreted as evidence of an interaction or complementarity effect unless the primary study explicitly tested such a relationship.

Treatment of Evidence Overlap and Previous Reviews

The 12 previous reviews were kept analytically separate from the 61 empirical studies to minimise the risk of double-counting evidence. Previous reviews were used for five purposes: (1) identifying established themes; (2) comparing prior synthesis findings with the present review; (3) identifying populations and outcomes previously examined; (4) contextualising the evolution of the research field; and (5) identifying conceptual and methodological gaps. Where a primary empirical study was reported both independently in the present review and within an included previous review, the primary study remained the unit of evidence for the empirical synthesis. Review-level findings were used only as contextual evidence.

Treatment of Post-Search Publications

The systematic search was closed on 20 June 2025. Publications appearing after this date were therefore not eligible for inclusion in the prespecified systematic evidence base. Where post-search publications were identified during manuscript revision, they were treated solely as contextual literature and were excluded from the number of included empirical studies, the number of included reviews, thematic evidence counts, certainty assessment, and primary evidence synthesis.

This procedure preserved the temporal boundary of the systematic review and prevented post-search evidence from being retrospectively incorporated into the prespecified evidence corpus.

Data Management, Transparency, and Reproducibility

To support transparency and reproducibility, the review team retained the database search outputs, deduplication records, screening decisions, data-extraction records, methodological appraisal files, and evidence-synthesis matrix. These materials provide an auditable trail from information retrieval and study selection to appraisal and evidence synthesis.

Ethics and Research Integrity

This study synthesised previously published literature and did not involve human participants, identifiable individual-level data, animals, or interventions involving human subjects. Accordingly, institutional ethical approval and participant consent were not

required for the conduct of the review.

The review team accepts responsibility for the accuracy of study identification, screening, data extraction, methodological

appraisal, synthesis, and citation. No empirical appraisal judgement, search result, or study-level conclusion was intended to be generated independently of the underlying source evidence.

RESULTS

Search and Study Selection

After removal of 509 duplicate records, 1,042 records proceeded to title and abstract screening. Of these, 869 records were excluded because they did not meet the prespecified eligibility criteria. A total of 173 reports were sought for full-text retrieval; nine reports could not be retrieved, leaving 164 reports for full-text eligibility assessment.

At the full-text stage, 91 reports were excluded. The principal reasons were insufficient alignment with the DF–GF–SEG nexus ($n = 33$), absence of a sustainable-growth or sustainability-related

outcome ($n = 21$), publication type outside the eligibility criteria ($n = 14$), overlapping datasets without a sufficiently independent contribution ($n = 8$), non-English publication ($n = 9$), and insufficient methodological information ($n = 6$).

The final evidence corpus comprised 73 publications, consisting of 61 primary empirical studies and 12 previous reviews. The 12 reviews were retained as secondary contextual evidence and were not treated as independent empirical observations in the empirical synthesis. The complete identification, screening, eligibility, and inclusion pathway is presented in Figure 1.

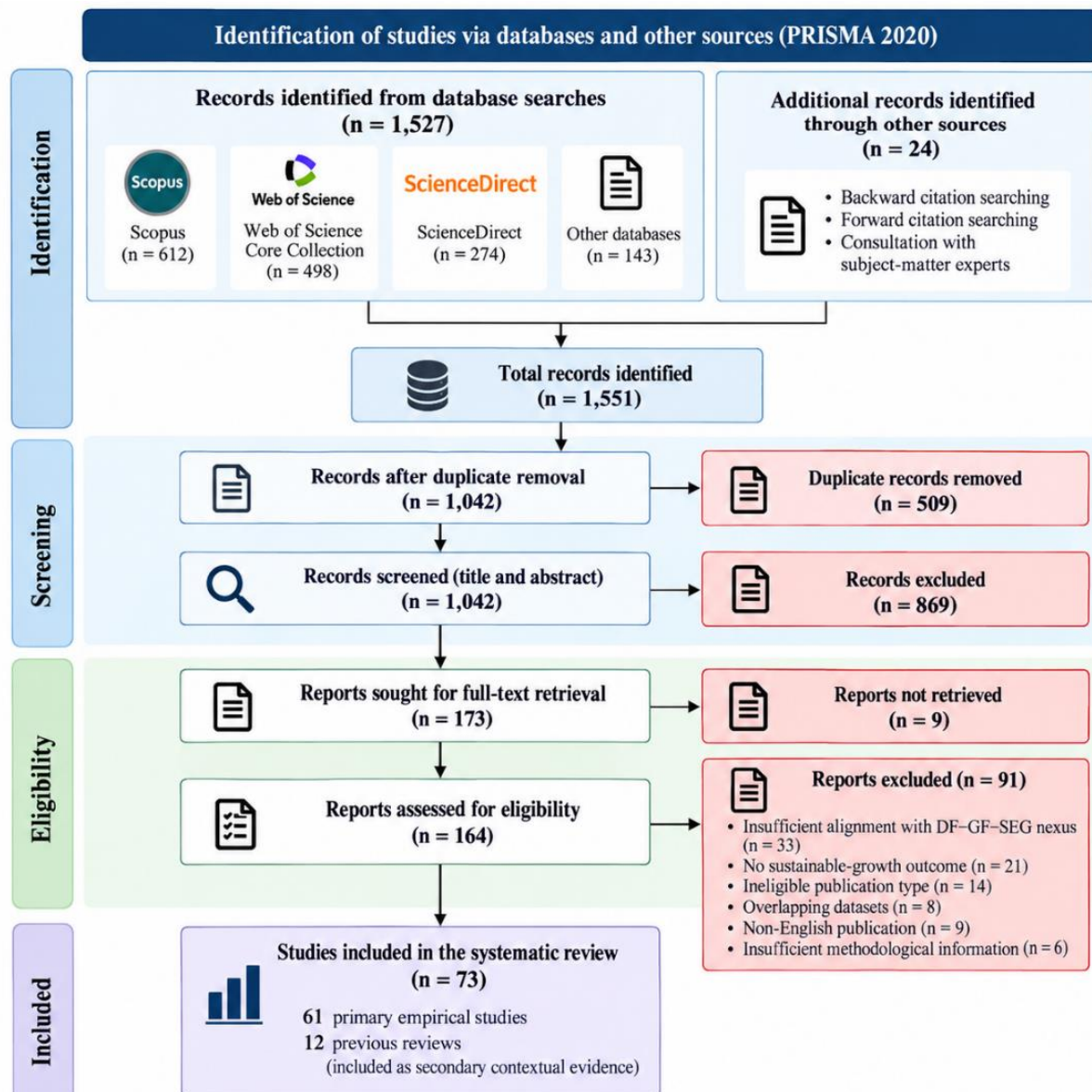


Figure 1. PRISMA 2020 flow diagram of the identification, screening, eligibility assessment, and inclusion of publications in the systematic review.

Table 3. Evidence classification of included publications

Evidence category	n	Role in synthesis	Appraisal framework
Primary empirical	61	Main evidence base for relationships, mechanisms,	MMAT 2018

studies	moderators, and outcomes	
Previous reviews	12	Contextual evidence for comparison and field development
Total	73	Integrated review corpus

AMSTAR 2

—

included
publications

Characteristics of the Included Evidence

The 73 included publications covered the period 2015–2025, with approximately 78% published from 2022 onward, indicating a substantial recent expansion of research on digital finance, green finance, and sustainability-oriented growth.

The geographical distribution was uneven. Approximately 55% of the included studies focused exclusively on China, particularly Chinese provinces, cities, firms, or regional panels. The remaining evidence included cross-country studies covering the Asia-Pacific region, BRICS economies, Belt-and-Road economies, G20 economies, and other emerging and developed economies. Evidence from Sub-Saharan Africa, Latin America, and low-income economies was comparatively limited.

The methodological profile was predominantly quantitative. The empirical corpus included fixed-effects panel models, dynamic panel estimators, generalized method of moments (GMM), spatial econometric models, threshold regressions, mediation models, and difference-in-differences designs. Quantitative observational studies substantially outnumbered

qualitative and mixed-methods studies.

The operationalisation of the principal constructs varied considerably across studies. Digital finance was measured using the Peking University Digital Financial Inclusion Index, composite digital-finance indicators, and other FinTech-related measures. Green finance was operationalised through green-credit indicators, green-bond issuance, green-finance indices, and related composite measures. Sustainable-growth outcomes included conventional economic growth, sustainable or high-quality growth, green total-factor productivity, renewable-energy development, energy efficiency, carbon emissions or intensity, and green innovation.

This heterogeneity indicates that the empirical literature has expanded rapidly while remaining diverse in geographical coverage, financial measurement, outcome operationalisation, and econometric specification. Consequently, findings were synthesised primarily by direction, mechanism, context, and methodological characteristics, rather than through a pooled effect estimate.

Table 4. Representative characteristics of included empirical studies

Study	Region/Sample	Design/Method	Finance construct	Main outcome	Reported direction
<i>Sun & Tang (2022)</i>	China	Fixed-effects panel	Digital inclusive finance	Sustainable growth	Positive
<i>Liu et al. (2023)</i>	China	Spatial Durbin model	Digital finance	Sustainable growth	Positive, including spatial spillovers
<i>Basnayake et al. (2024)</i>	Asia-Pacific	Threshold panel	Digital financial inclusion	Economic growth	Positive, nonlinear
<i>Öztürk & Ullah (2022)</i>	Belt-and-Road economies	GMM	Digital financial inclusion	Growth and CO ₂ emissions	Growth positive; emissions increase reported in sample
<i>Alharbi et al. (2023)</i>	44 countries	Panel analysis	Green bonds	Renewable energy	Positive
<i>Irfan et al. (2022)</i>	China	Difference-in-differences/mediation	Green finance	Green innovation	Positive
<i>Razaq & Yang (2022)</i>	Chinese cities	SBM/big-data analysis	Inclusive digital finance	Green growth	Positive
<i>Xu et al. (2024)</i>	Jiangsu, China	Mediation panel	Green and digital finance	Sustainable development	Positive through new quality productivity

Note: Table 5 presents representative studies rather than the complete 61-study empirical corpus.

Methodological Quality and Risk-of-Bias Findings

The methodological appraisal indicated that the 61 primary empirical studies showed generally sound but uneven methodological quality. Several studies demonstrated methodological strengths through the use of relatively large panel datasets and more advanced empirical strategies, including instrumental-variable approaches, difference-in-differences designs associated with green-finance policies, spatial econometric models, threshold models, and mediation analyses. These approaches provided stronger opportunities for examining identification, heterogeneity, spatial dependence, or potential mechanisms than conventional cross-sectional or basic fixed-effects specifications. However, recurring methodological concerns were identified. Some fixed-effects studies provided limited treatment of endogeneity and reverse causality. Measurement choices for digital-finance and green-finance constructs were not consistently justified, while alternative-indicator analyses and sensitivity tests were unevenly reported. Preregistration was uncommon across the empirical literature. The 12 previous reviews displayed additional methodological weaknesses, particularly the absence of registered protocols and formal risk-of-bias assessments of the underlying primary studies. Because these reviews served as contextual rather than primary evidence, their methodological limitations were

considered when interpreting broader statements concerning the evolution and consolidation of the field. No aggregate numerical MMAT or AMSTAR 2 score was calculated. Methodological quality was therefore considered at the domain level, with implications for interpretation incorporated into the thematic synthesis and confidence assessment.

Table 5. Summary of methodological quality appraisal

Appraisal domain	Low concern	Moderate concern	High concern
<i>Clarity of research question/aims</i>	Most studies	Some	Few
<i>Appropriateness of data and sampling</i>	Most studies	Some	Few
<i>Control of confounding/endogeneity</i>	Some	Most	Some
<i>Transparency of measurement</i>	Some	Most	Few
<i>Robustness/sensitivity reporting</i>	Some	Most	Some
<i>Protocol/preregistration among reviews</i>	Few	Some	Most

Thematic Synthesis of the Evidence

Five analytical themes emerged from the synthesis: (1) digital finance and inclusive, quality-oriented growth; (2) green finance, renewable energy, and low-carbon transition; (3) green and technological innovation; (4) the emerging joint DF–GF nexus; and (5) contextual moderators, thresholds, spatial spillovers, and

environmental trade-offs.

Theme 1: Digital Finance and Inclusive, Quality-Oriented Growth

The first theme concerned the association between digital finance and inclusive or sustainable forms of economic growth. Across a substantial proportion of the empirical literature, digital financial inclusion was associated with improved growth-related outcomes.

Frequently identified mechanisms included expanded access to financial services, increased lending, household savings and consumption, entrepreneurial activity, and improved allocation of financial resources. Evidence from Chinese provincial and city-level studies commonly reported positive associations between digital financial inclusion and sustainable or high-quality growth. Spatial analyses further indicated that these relationships may extend beyond the directly observed geographical unit. Studies using spatial econometric approaches reported positive spillover patterns, suggesting that financial development in one region may be associated with growth-related outcomes in neighbouring regions.

At the same time, cross-country evidence indicated that the relationship was not necessarily linear. Threshold-based analyses suggested that the magnitude of the association varied according to the level of digital-finance development. Overall, the empirical evidence showed a predominantly positive association between digital finance and growth-related outcomes, although the magnitude and functional form varied across geographical settings, levels of digitalisation, market conditions, and analytical specifications.

Evidence confidence: Moderate to high.

The relatively consistent direction of findings was tempered by the concentration of evidence in Chinese panel studies and by remaining concerns regarding endogeneity and measurement comparability.

Theme 2: Green Finance, Renewable Energy, and Low-Carbon Transition

The second theme concerned the relationship between green finance and renewable-energy development, energy efficiency, and low-carbon transition. Across country-level and cross-national studies, green bonds and broader green-finance development were generally associated with higher renewable-energy development. Several studies also reported relationships between green-finance development and improvements in energy efficiency.

The temporal dimension of these relationships varied across studies. Some evidence suggested that green-finance effects may become more observable over longer time horizons, whereas short-run relationships were not consistently significant. Other studies indicated that the transition toward low-carbon energy may operate partly through improvements in financing efficiency rather than solely through an expansion in financing volume.

Green finance was also associated in several studies with reductions in carbon-related outcomes and improvements in sustainability indicators, frequently through renewable-energy development and technological progress.

Overall, the evidence indicated a generally positive association between green finance and renewable energy, energy efficiency, and low-carbon transition, although the magnitude and persistence of these relationships varied according to technological capacity, emission intensity, time horizon, financial instrument, and measurement approach.

Evidence confidence: Moderate to high.

Theme 3: Green and Technological Innovation as a Principal Transmission Mechanism

Innovation emerged as the most frequently identified mechanism linking financial development with sustainability-oriented economic outcomes. Both digital finance and green finance were associated with improvements in green technological innovation. Frequently identified mechanisms included reduced financing constraints, improved access to capital, and increased research and development investment. Several studies further indicated that these relationships differed according to firm characteristics, including pollution intensity, firm size, ownership structure, and financing constraints.

The findings suggest that the contribution of financial development to sustainable growth cannot be understood solely through changes in the volume of finance. Instead, the evidence indicates that financial mechanisms may operate by modifying access to capital, the allocation of resources, and incentives for technological upgrading.

Spatial and nonlinear evidence additionally suggested that innovation-related effects may extend across regional boundaries and vary according to regulatory conditions. Overall, green and technological innovation represented a central intermediary pathway linking financial development with sustainability-oriented outcomes.

Evidence confidence: High for the direction of association; moderate for magnitude and boundary conditions.

Theme 4: The Emerging Joint Digital Finance–Green Finance Nexus

The fourth theme represented the most recent and least consolidated component of the evidence base: studies examining digital finance and green finance jointly. A relatively small but growing number of studies suggested that the two financial paradigms may operate through complementary mechanisms. Evidence included relationships involving digital inclusive finance, green finance, new quality productivity, enterprise digital transformation, energy transition, and sustainable growth.

The available findings are consistent with an analytical framework in which digital finance may improve financial accessibility, information processing, monitoring, and resource allocation, while green finance may direct financial resources toward environmentally oriented investments. However, the joint-nexus evidence was substantially narrower than the evidence concerning the two financial domains separately. Most joint-nexus studies were published during 2023–2025 and concentrated on China. Independent replication across countries and institutional environments remained limited. Therefore, the available evidence supports the existence of an emerging joint DF–GF research domain, but does not yet establish a general causal complementarity effect.

Evidence confidence: Low to moderate.

The lower confidence reflects the limited number of joint-nexus studies, geographical concentration, and limited independent replication.

Theme 5: Contextual Moderators, Thresholds, Spatial Spillovers, and Environmental Trade-offs

The fifth theme demonstrated that relationships between financial development and sustainable-growth outcomes were strongly conditioned by context. Threshold analyses indicated that the relationship may change once digitalisation or green-

finance development reaches particular levels. Several studies reported nonlinear relationships rather than constant marginal associations. Spatial econometric studies similarly identified spillover processes in which financial development in one geographical unit was associated with outcomes in neighbouring areas.

Institutional quality, governance, and environmental regulation also appeared to condition observed relationships. These findings indicate that the effect of financial development cannot be interpreted independently of the regulatory and institutional environment. Importantly, the empirical literature did not uniformly report simultaneous improvements in economic and environmental outcomes. A minority of studies reported positive growth-related outcomes alongside increases in CO₂ emissions under particular samples or model specifications. These findings indicate that increased financial access and economic activity may be accompanied by environmental pressures under conditions where additional financial capacity is not sufficiently directed toward low-carbon investment and technological transition.

Evidence confidence: Moderate.

Cross-Theme Synthesis and Evidence-Supported Pathways

Across the five themes, the evidence identified five principal

mechanisms connecting financial development with sustainable economic outcomes. First, financial inclusion was associated with expanded access to payments, savings, credit, and other financial services, particularly within the digital-finance literature. Second, relaxation of financing constraints represented an important pathway through which digital and green financial mechanisms may improve access to capital for financially constrained firms and households. Third, green and technological innovation emerged as a recurrent mechanism linking financial development with environmental and productivity outcomes. Fourth, resource reallocation and efficiency represented a pathway through which financial development may redirect capital toward more productive or environmentally efficient activities. Fifth, energy transition was repeatedly associated with green finance and, in selected contexts, with digital financial development. Additional mechanisms identified across the evidence included new quality productivity, enterprise digital transformation, threshold effects, spatial spillovers, institutional quality, and environmental regulation.

The resulting synthesis indicates that the DF–GF–SEG relationship cannot be adequately represented as a set of simple direct relationships. Instead, the evidence supports a network of direct, mediated, moderated, and spatial pathways, while the interaction/complementarity pathway between DF and GF remains comparatively underdeveloped empirically.

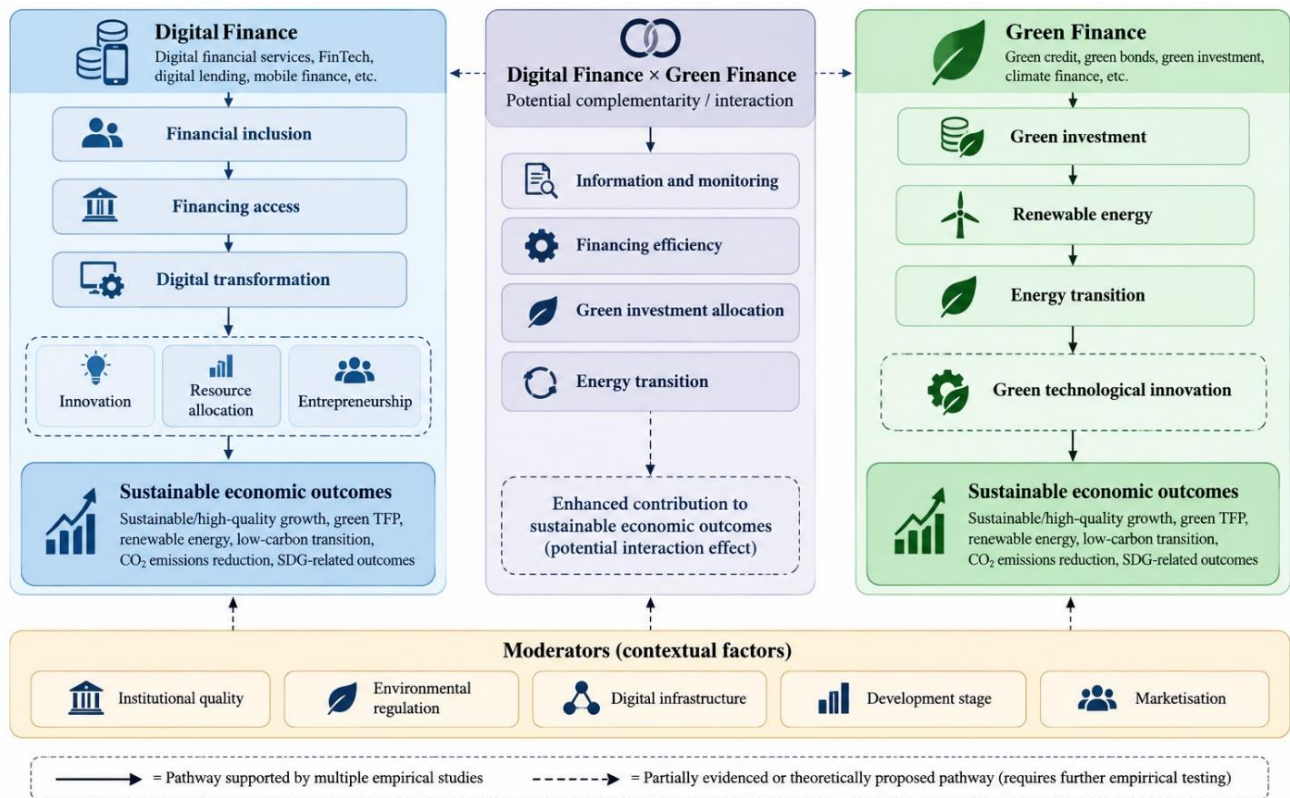


Figure 2. Evidence-informed conceptual synthesis of the DF–GF–SEG nexus

Heterogeneity and Contradictory Findings

Substantial heterogeneity was identified across geographical contexts, financial indicators, outcome definitions, units of analysis, and empirical specifications. Accordingly, apparently contradictory findings were not treated automatically as evidence of fundamentally opposing relationships. The most prominent contrast concerned the relationship between digital finance,

economic growth, and environmental quality. Several studies reported positive growth-related outcomes, whereas a smaller number reported increases in CO₂ emissions under specific samples or specifications. These findings indicate that economic and environmental outcomes may move in different directions under certain conditions. Nonlinear findings further indicated that the marginal association between financial development and

sustainability outcomes may vary according to the stage of digitalisation or green-finance development. Consequently, a universal statement that digital finance or green finance produces a constant positive effect would not accurately reflect the heterogeneity observed across the evidence base.

Table 6. Sources of heterogeneity in reported findings

Dimension	Pattern identified	Implication for interpretation
Geography	China dominates the evidence base	Generalisability beyond China remains uncertain
Development stage	Evidence concentrated in emerging and middle-income economies	Relationships may differ under different financial and institutional conditions
Digital-finance measurement	Peking University index, FinTech indices, access/usage indicators	Estimates may not be directly comparable
Green-finance measurement	Green credit, green bonds, composite indices	Different instruments may operate through different channels
Growth outcome	GDP growth, high-quality growth, green TFP, NQP	“Growth” is not a uniform outcome
Environmental outcome	CO ₂ emissions, intensity, renewable energy, energy efficiency	Economic and environmental outcomes may move in different directions
Estimation method	FE, GMM, DiD, spatial, threshold, mediation	Identification strength varies across studies
Time horizon	Short- versus long-run effects	Some relationships may emerge only over longer periods
Institutional context	Governance, regulation, marketisation	Institutional conditions may moderate observed relationships
Spatial structure	Local and neighbouring-region effects	National or regional estimates may overlook spillovers
Firm characteristics	Pollution intensity, size, ownership, financing constraints	Effects may differ substantially across firms

Geographic Distribution and Evidence Gaps

The evidence base was geographically concentrated. Approximately 55% of the included studies examined China exclusively, while additional studies used cross-country samples

involving Asia-Pacific, BRICS, Belt-and-Road, and G20 economies. By contrast, empirical evidence from Sub-Saharan Africa, Latin America, and low-income economies was limited. This distribution represents an evidence gap rather than evidence of the absence of effects in these settings.

The methodological distribution was similarly uneven. Observational panel designs dominated the corpus, whereas quasi-experimental approaches, policy-based natural experiments, instrumental-variable strategies, and spatial or threshold models were less frequent. Qualitative studies, firm-level implementation studies, and research examining the practical implementation of financial instruments were also comparatively limited.

Outcome coverage was concentrated on economic growth, green TFP, renewable energy, and carbon-related indicators. By comparison, distributional effects, equity, welfare, household-level sustainability outcomes, and implementation outcomes were less frequently investigated. These patterns indicate that the current literature provides comparatively stronger evidence concerning whether and through which mechanisms financial development is associated with sustainability-related outcomes than concerning how these relationships differ across institutional environments, regions, and population groups.

Evidence Synthesis and Confidence Assessment

Because the included studies differed substantially in financial constructs, outcome variables, units of analysis, estimation strategies, geographical contexts, and identification approaches, no formal statistical meta-analysis was conducted. The synthesis therefore evaluated the direction, consistency, mechanisms, contextual conditions, and methodological strength of the reported findings. The evidence showed relatively consistent associations between digital finance and financial inclusion or growth-related outcomes, and between green finance and renewable energy, energy efficiency, and low-carbon transition. Innovation was identified as a particularly recurrent transmission mechanism across the empirical literature. In contrast, evidence concerning the integrated DF–GF nexus, new quality productivity, explicit interaction effects, and feedback mechanisms remained comparatively limited.

Table 7. Thematic evidence synthesis and confidence assessment

Theme	Principal finding	Main mechanism	Key boundary conditions	Evidence confidence
Digital finance and inclusive growth	Digital finance is generally associated with improved growth and quality-growth outcomes	Financial inclusion; resource allocation; entrepreneurship	Digitalisation, marketisation, geography	Moderate–High
Green finance and low-carbon transition	Green finance is generally associated with renewable-energy development and energy efficiency	Green investment; financing efficiency; energy transition	Technology, emission intensity, time horizon	Moderate–High
Finance and green innovation	Both finance paradigms are associated with green technological innovation	Financing-constraint reduction; R&D	Firm size, ownership, pollution intensity, regulation	High for direction; Moderate for magnitude
Joint DF–GF nexus	Emerging evidence suggests complementary pathways toward sustainability	Digital transformation; NQP; energy transition	Geographic concentration; limited replication	Low–Moderate
Moderators and trade-offs	Effects vary by threshold, spatial structure, institutions, and regulation; some studies report growth–emission trade-offs	Thresholds; spillovers; institutional moderation	Development stage; environmental regulation; governance	Moderate

The overall evidence therefore supports a coherent but conditional pattern. Digital finance is primarily associated with financial inclusion, resource allocation, and growth-related outcomes; green finance is primarily associated with green investment, renewable energy, innovation, and low-carbon transition; and the emerging joint literature suggests potentially

complementary pathways involving overlapping financial, technological, and energy-transition mechanisms. At the same time, the empirical basis for the integrated DF–GF relationship remains substantially narrower than the evidence concerning the individual financial domains. Geographic concentration, heterogeneous measurement, predominantly observational

designs, and incomplete treatment of endogeneity limit the strength and external validity of inference.

DISCUSSION

Principal Findings

This systematic review synthesised evidence from 61 primary empirical studies and 12 previous reviews to examine how digital finance (DF) and green finance (GF), individually and jointly, are associated with sustainable economic growth and related sustainability outcomes. Four broad conclusions emerge from the synthesis. First, digital finance is generally associated with improved growth-related outcomes through financial inclusion, improved access to financial services, information efficiency, entrepreneurship, and resource allocation. However, the evidence does not support a uniform or unconditional positive relationship. Several studies identify nonlinear, threshold, and spatial patterns, while a smaller body of evidence reports simultaneous growth and environmental trade-offs. Second, green finance is generally associated with renewable-energy development, energy efficiency, green innovation, and low-carbon transition. These relationships appear to depend on institutional capacity, technological conditions, environmental regulation, the specific financial instrument employed, and the time horizon considered. Thus, the contribution of green finance appears to depend not only on the availability of capital but also on the capacity of financial systems to identify, monitor, and direct resources toward environmentally productive activities. Third, innovation represents one of the most consistent transmission mechanisms across the evidence base. Financing-constraint reduction, improved access to capital, research and development, green technological innovation, enterprise digital transformation, and energy transition repeatedly appear as pathways through which financial development is associated with sustainability-oriented outcomes. This suggests that the growth implications of financial development are better understood as a set of interconnected mechanisms than as a simple direct finance-to-growth relationship. Fourth, the evidence concerning the integrated DF–GF nexus remains substantially less mature than the evidence for the two financial domains separately. Recent studies suggest potentially complementary pathways through digital transformation, new quality productivity, energy transition, and environmentally oriented capital allocation. Nevertheless, the joint-nexus literature remains relatively small and geographically concentrated, particularly in China. The present evidence therefore supports DF–GF complementarity as an emerging theoretical proposition rather than an established causal relationship (An et al., 2024, p. 16008; Tan & Tao, 2026, p. 17).

Taken together, the findings indicate a coherent but conditional pattern: digital finance primarily contributes through financial access, information efficiency, and resource allocation; green finance primarily contributes through environmentally directed capital allocation, renewable energy, and green innovation; and the emerging literature suggests that the two may interact through overlapping mechanisms (Fan et al., 2025, p. 4184; Liu & Wu, 2023, p. 10). At the same time, heterogeneity in measurement, geography, institutional context, and identification strategy limits the strength of universal inference.

Comparison with Previous Reviews and International Evidence

The present synthesis extends previous review literature by

treating digital finance and green finance as analytically connected components of a broader sustainable-growth framework rather than as entirely separate research domains. Earlier reviews have substantially advanced understanding of green finance, digital financial services, renewable energy, carbon-emission reduction, ESG, green innovation, and FinTech-related sustainability (Bansal et al., 2024; Offiong et al., 2025), but much of this literature has examined either one financial paradigm at a time or linked one financial domain to a specific outcome. The present review therefore shifts attention from parallel literatures toward an integrated DF–GF–SEG analytical structure (Afjal, 2023, p. 3; Farah et al., 2026, p. 3).

This distinction is important because the evidence reviewed here demonstrates that the two financial paradigms operate through overlapping but not identical mechanisms. Digital finance primarily reduces financial, informational, and transactional barriers, whereas green finance provides an explicit environmental direction for capital allocation (Khan & Shahid, 2025; Ozili, 2021). Consequently, treating the two domains as interchangeable would obscure their different functions within the sustainable-growth process.

The synthesis is also consistent with the broader international evidence showing positive associations between digital financial development and growth-related outcomes, as well as between green-finance development and renewable energy or environmental innovation. However, the international evidence is unevenly distributed. A large share of the empirical literature originates from China and other Asian emerging economies, whereas evidence from Sub-Saharan Africa, Latin America, South Asia outside the major Asian economies, and low-income countries remains comparatively limited.

This geographical concentration provides an important qualification to interpretation. Findings from Chinese provincial, city-level, and firm-level studies offer substantial evidence for particular institutional and developmental settings, but they cannot automatically be generalised to countries with different financial systems, regulatory capacities, levels of digital infrastructure, governance structures, and development stages. The limited evidence outside China should therefore be interpreted as an evidence gap rather than evidence of no relationship.

Apparent contradictions across the international literature should likewise be interpreted cautiously. Differences between studies may result from the use of different outcome constructs, financial indicators, estimation strategies, temporal windows, or geographic units (Damaianti et al., 2023, p. 3582; Edison et al., 2002, p. 774). For example, green total-factor productivity captures a different dimension of sustainable growth than conventional GDP growth, while spatial models can identify regional spillovers that are not observable in conventional fixed-effects specifications. Therefore, statistical differences across studies do not necessarily represent substantive theoretical disagreement.

Theoretical and Conceptual Implications

The principal theoretical implication of the review is a shift from a conventional finance-and-growth perspective toward an integrated financial–technological–environmental framework. The conventional formulation can be represented as:

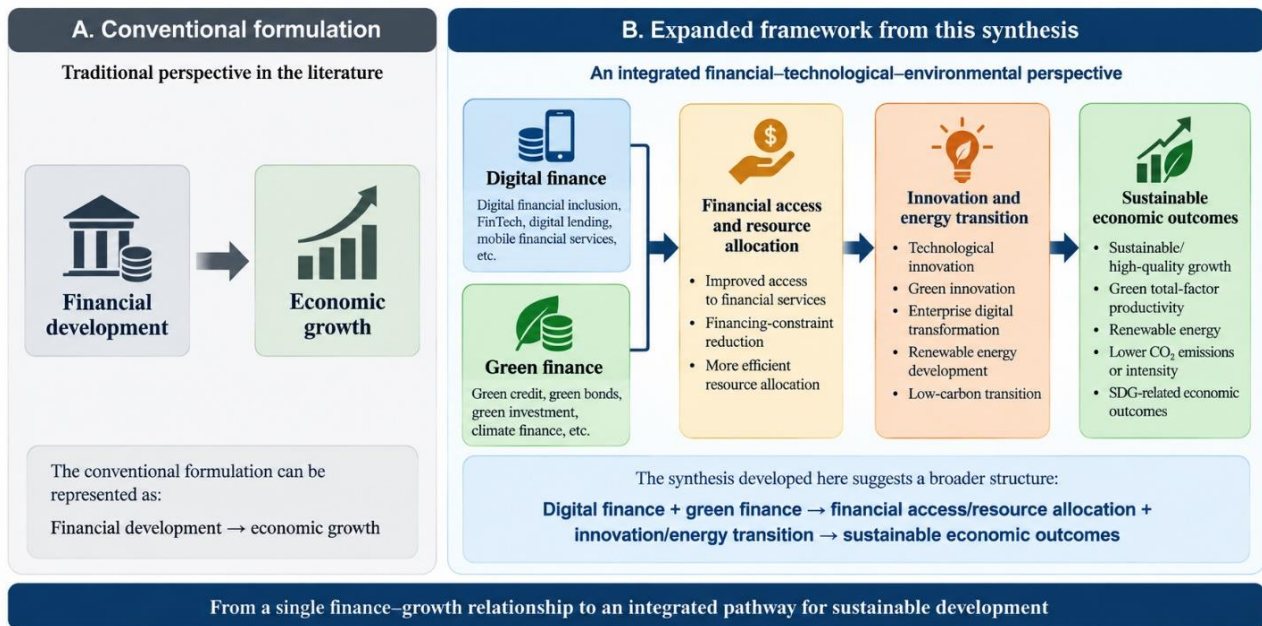


Figure 3. From Conventional Finance–Growth Theory to an Integrated Digital–Green Finance Framework for Sustainable Economic Outcomes

This framework integrates the financial-access function of digital finance with the environmental-allocation function of green finance. Digital finance can reduce information and transaction frictions, facilitate access to financial services, improve monitoring, and increase the efficiency of financial transactions. Green finance, in contrast, can channel financial resources

toward renewable energy, energy efficiency, and environmentally oriented innovation (Fan et al., 2025, p. 4184; Han & Gao, 2024, p. 4). The theoretical contribution is therefore not the claim that digital finance and green finance necessarily reinforce one another, but the formulation of testable conditions under which complementarity may emerge. The proposed interaction:

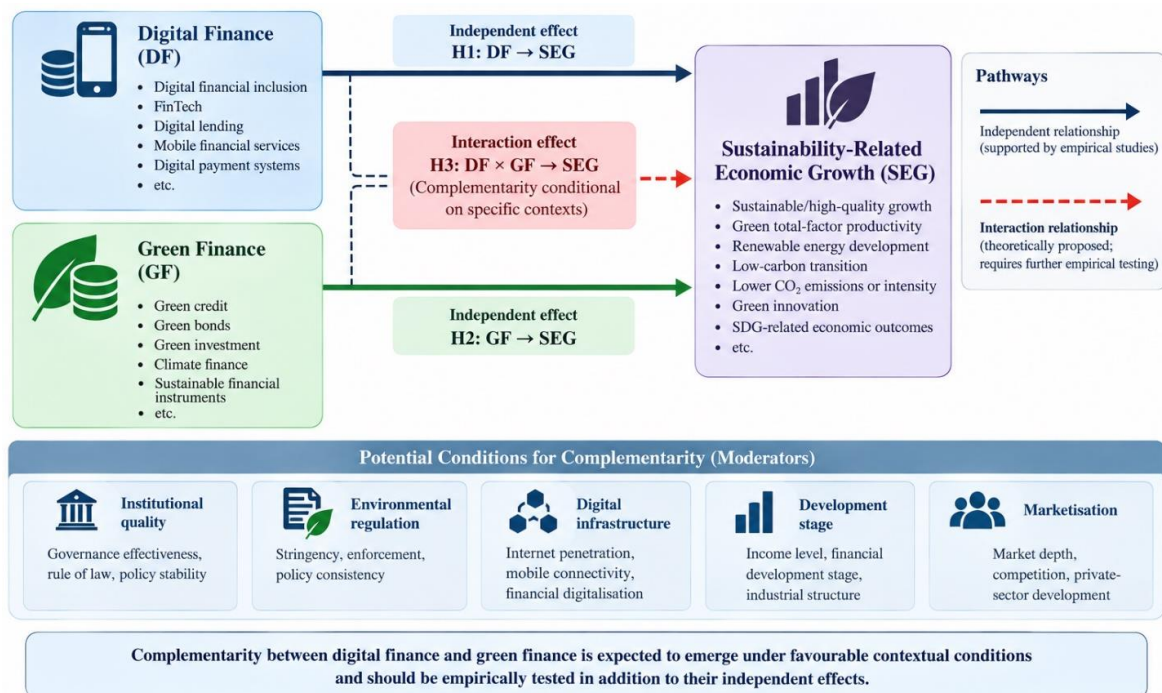


Figure 4. Independent and Interaction Effects of Digital Finance and Green Finance on Sustainability-Related Economic Growth

Positive coefficients for DF and GF separately do not constitute evidence that their interaction is positive. The complementarity proposition therefore requires direct empirical testing of the interaction term and examination of whether the marginal association between digital finance and sustainable-growth outcomes changes with the level of green-finance development (Tan & Tao, 2026, p. 5; Ureshova et al., 2023, p.

450).

The synthesis further identifies a set of potential mediators and moderators that help establish the theoretical boundary conditions of the DF–GF–SEG relationship. Mediators include financial inclusion, financing-constraint reduction, green innovation, technological innovation, enterprise digital transformation, renewable-energy development, energy

transition, and new quality productivity. Potential moderators include institutional quality, environmental regulation, digital infrastructure, marketisation, development stage, technological capacity, and regional characteristics.

This framework also helps explain why sustainability outcomes may not improve automatically with financial expansion. Digital finance can increase economic activity and financial access, but its environmental implications depend on how additional financial capacity is allocated and on whether environmental and technological institutions are sufficiently developed (Farah et al., 2026, p. 14; Mhlanga, 2022, p. 2). The resulting theoretical implication is that financial digitalisation should not be conceptualised as intrinsically green; its environmental contribution is conditional on the allocation and institutional use of financial capacity.

Methodological Implications

The synthesis identifies four major methodological priorities for future research.

First, stronger causal-identification strategies are required. Much of the evidence is based on observational panel designs, which are informative for documenting associations but remain vulnerable to reverse causality, omitted-variable bias, and unobserved heterogeneity. Future studies should therefore make greater use of credible quasi-experimental designs, policy discontinuities, instrumental variables, and appropriately specified difference-in-differences strategies. Second, measurement harmonisation is essential. Digital finance is measured using different indices, composite indicators, access measures, and FinTech proxies, while green finance is operationalised through green credit, green bonds, investment indicators, and composite measures (Fu et al., 2024, p. 18; Parveen et al., 2025). Sustainable growth is similarly represented by GDP-based indicators, high-quality growth, green TFP, renewable energy, carbon emissions, and related measures (Irfan et al., 2025, p. 197; Nauman et al., 2024, p. 29950). These differences make direct comparison of effect magnitudes difficult and may contribute to apparently inconsistent findings. Third, geographical and multilevel diversification is needed. The dominance of Chinese regional and firm-level studies creates substantial uncertainty concerning cross-country generalisability (Boschma, 2016, p. 357; Ouyang et al., 2022, p. 134974). Multi-country studies should be designed to account explicitly for institutional quality, development stage, environmental regulation, financial structure, and digital infrastructure rather than assuming homogeneous relationships across countries. Fourth, empirical models should distinguish direct, mediated, moderated, interaction, and spatial effects. Treating all statistically significant associations as equivalent obscures the mechanisms through which financial development operates. In particular, future studies examining the integrated DF–GF nexus should directly estimate interaction effects rather than inferring complementarity from separate coefficients. Finally, methodological reporting should improve reproducibility through more transparent data definitions, robustness checks, preregistration where appropriate, complete reporting of identification assumptions, and greater availability of research materials.

Practical and Policy Implications

The findings suggest that digital finance and green finance may be most productively understood as complementary components of a broader sustainable-finance architecture, while recognising that the empirical basis for their joint effects remains

limited.

For digital-finance development, expansion of access alone may not guarantee environmental improvement. Where increased financial access stimulates additional consumption, investment, or energy demand, complementary mechanisms for directing capital toward environmentally efficient activities may become important. This implies that digital-finance development and environmental-finance development should not necessarily be designed as isolated policy domains.

For green finance, the evidence suggests that the effectiveness of financial instruments depends partly on institutional and technological capacity. Financial systems require sufficient capability to identify eligible green investments, monitor environmental performance, and allocate capital toward projects capable of delivering measurable environmental and economic benefits (Lamperti et al., 2021, p. 100882; Volz, 2018, p. 26). Accordingly, institutional quality, environmental regulation, and digital infrastructure represent potentially important enabling conditions.

At the firm level, particular attention may be warranted for financially constrained firms and smaller enterprises because financing constraints appear repeatedly as part of the innovation mechanism. At the broader system level, policy frameworks should also consider the distributional consequences of financial digitalisation and green-finance expansion rather than focusing exclusively on aggregate GDP, investment, or emissions (Fu et al., 2023, p. 7; Hossain et al., 2024).

Because the evidence for DF–GF interaction remains limited, these implications should be interpreted as context-dependent rather than universal policy prescriptions. Their relevance is likely to vary with financial-system maturity, technological capacity, institutional quality, environmental regulation, and development stage.

Strengths and Limitations

This review has several strengths. First, it explicitly integrates two literatures that have often been examined separately while maintaining a clear distinction between primary empirical evidence and previous reviews. Second, the review combines systematic database searching, supplementary citation procedures, independent screening, structured methodological appraisal, and thematic and framework synthesis. Third, the synthesis explicitly addresses heterogeneity, geographic concentration, mechanisms, moderators, and the distinction between independent and interaction relationships.

Several limitations should nevertheless be considered. First, the restriction to English-language journal publications may have excluded relevant evidence published in other languages, potentially introducing language bias. Second, although Scopus, Web of Science Core Collection, and ScienceDirect provide broad disciplinary coverage, reliance on these principal databases may have resulted in omission of relevant studies indexed elsewhere. Third, the empirical literature is geographically concentrated, especially in China, which limits external validity. Fourth, substantial methodological heterogeneity prevented formal meta-analysis. Differences in constructs, measures, units of analysis, econometric approaches, identification strategies, and outcome definitions make quantitative pooling difficult to justify and limit direct comparison of effect magnitudes. Fifth, the predominance of observational designs constrains causal interpretation even where studies employ relatively sophisticated econometric models. Finally, the evidence concerning the integrated DF–GF

relationship remains relatively small and geographically concentrated. Consequently, the proposition of complementarity should be interpreted as a testable emerging framework, rather than as an established universal relationship.

Future Research Agenda

The synthesis identifies seven closely interconnected priorities that should guide the next generation of research on the digital finance–green finance–sustainable economic growth (DF–GF–SEG) nexus. These priorities arise directly from the methodological heterogeneity, geographical concentration, incomplete testing of mechanisms, and limited empirical evidence concerning the integrated relationship between digital and green finance. Rather than simply expanding the number of empirical studies, future research should strengthen causal inference, improve construct measurement, test the proposed interaction mechanisms explicitly, broaden geographical and distributional coverage, and enhance the transparency and reproducibility of empirical research.

Strengthening Causal Identification

A primary priority for future research is to strengthen causal identification in examining the relationships between digital finance, green finance, and sustainable economic growth. Much of the existing evidence is derived from observational panel studies, which provide important information about associations but remain vulnerable to reverse causality, omitted-variable bias, and unobserved heterogeneity (Aslam et al., 2025; Urekeshova et al., 2023, p. 450). Future studies should therefore make greater use of credible quasi-experimental designs, including natural experiments, policy discontinuities, instrumental-variable approaches, and carefully specified difference-in-differences models. Particular attention should be given to the validity of identification assumptions, treatment timing, parallel-trend requirements, and robustness to alternative specifications. Strengthening causal identification would enable researchers to distinguish more clearly between financial developments that are genuinely associated with changes in sustainable economic outcomes and relationships that may arise from simultaneous changes in economic, institutional, technological, or environmental conditions.

Explicit Testing of the DF–GF Interaction

A second priority concerns the direct empirical testing of the proposed complementarity between digital finance and green finance. The existing literature provides evidence that digital finance and green finance are individually associated with sustainability-related outcomes; however, separate positive associations do not, by themselves, demonstrate that the two financial domains generate an additional interaction effect. Future research should therefore explicitly estimate the interaction relationship $DF \times GF \rightarrow SEG$ and examine whether the marginal association of digital finance with sustainable economic growth varies according to the level of green-finance development. Such analyses should also investigate potential nonlinear relationships, threshold effects, and marginal effects across different levels of digital-finance and green-finance development (Gulzar et al., 2023; Wu & Cai, 2024, p. 3439). This approach would allow the complementarity proposition to be evaluated empirically rather than inferred from parallel evidence.

Diversifying Geographical Evidence

A third priority is to broaden the geographical scope of empirical research. The current evidence base is substantially concentrated in China and selected emerging Asian economies, creating important limitations for external validity. Future research

should expand systematically to Sub-Saharan Africa, Latin America, South Asia, low-income economies, and other institutional settings characterised by different financial structures, regulatory capacities, levels of digital infrastructure, and stages of economic development. Comparative cross-country and cross-regional research would be particularly valuable because it could determine whether the observed relationships are context-specific or demonstrate greater consistency across institutional environments. Such geographical diversification would also help distinguish the effects of financial innovation that are attributable to general mechanisms from those that depend on particular national policy and institutional configurations.

Harmonising Measurement and Operationalisation

Measurement harmonisation represents a fourth important research priority. The existing literature employs considerable variation in the operationalisation of digital finance, green finance, and sustainable economic growth, including composite indices, financial-access indicators, green-credit measures, green-bond indicators, renewable-energy measures, GDP-based outcomes, green total-factor productivity, and other sustainability-related indicators (Guo et al., 2022, p. 16310; Han & Gao, 2024, p. 3; Xiao et al., 2024, p. 4). This heterogeneity complicates comparison across studies and may contribute to variation in reported findings. Future research should therefore develop transparent and theoretically grounded operational definitions that facilitate comparability across countries, sectors, and periods. Where feasible, researchers should employ multiple indicators for the same construct and conduct sensitivity analyses using alternative measures. Greater consistency in measurement would strengthen cumulative evidence and facilitate more meaningful synthesis of effect directions, mechanisms, and boundary conditions.

Testing Mechanisms and Boundary Conditions

A fifth priority is to move beyond documenting statistical associations toward more rigorous examination of the mechanisms and boundary conditions underlying the DF–GF–SEG relationship. Future studies should clearly distinguish among direct effects, mediation, moderation, interaction effects, and spatial spillovers. In particular, researchers should examine whether financial inclusion, financing-constraint reduction, technological and green innovation, resource allocation, enterprise digital transformation, renewable-energy development, and energy transition function as genuine transmission mechanisms (Bergougui et al., 2026, p. 101614; Sun et al., 2026, p. 40). At the same time, institutional quality, environmental regulation, digital infrastructure, technological capacity, development stage, marketisation, and regional characteristics should be examined as potential boundary conditions (Bogari, 2025, p. 23; Xu et al., 2025, p. 10). Such an approach would provide a more theoretically precise explanation of **when, how, and under what conditions** digital and green finance are associated with sustainable economic outcomes, rather than treating statistically significant relationships as universally applicable.

Expanding Distributional and Welfare Outcomes

Future research should also broaden the definition of sustainable economic performance beyond aggregate measures of GDP growth, investment, and carbon emissions. Although these indicators are important, they provide an incomplete representation of the distributional and welfare consequences of financial digitalisation and green-finance development (Abdalla et al., 2025; Ghaffar et al., 2025). Subsequent studies should

therefore investigate income distribution, financial inequality, employment, household resilience, firm heterogeneity, welfare outcomes, and regional inequality (Fan et al., 2026, p. 16; Vojinović et al., 2024, p. 102). Particular attention should be given to whether improvements in aggregate economic or environmental indicators are accompanied by equitable access to financial opportunities and improvements in welfare across different population groups, firms, and regions (Demirgüç-Kunt & Levine, 2009, p. 335; Pachauri et al., 2022, p. 1059). Incorporating these outcomes would provide a more comprehensive assessment of whether financial innovation contributes to sustainability in economic, environmental, and distributional dimensions simultaneously.

Advancing Open and Reproducible Science

Finally, strengthening research transparency and reproducibility should become an important component of the emerging DF–GF literature. Future studies would benefit from preregistration where appropriate, transparent reporting of data construction and analytical procedures, open data when ethically and legally feasible, reproducible analytical code, and complete disclosure of model specifications, identification assumptions, robustness analyses, and sensitivity tests. Greater transparency would facilitate independent replication, systematic comparison across countries and institutional contexts, and more reliable accumulation of evidence over time. These practices are

particularly important in a rapidly expanding research field characterised by substantial variation in measurement and empirical design. Improving reproducibility would therefore contribute not only to methodological quality at the individual-study level but also to the development of a more coherent and cumulative international evidence base.

Integrated Research Direction

Collectively, these priorities suggest that the next stage of DF–GF–SEG research should move from descriptive expansion toward theoretically guided, causally credible, geographically diverse, and reproducible empirical investigation. The most important unresolved issue is whether digital finance and green finance merely exhibit parallel associations with sustainable economic outcomes or whether their combination generates measurable complementary effects under specific institutional and technological conditions. Addressing this question requires research designs that simultaneously consider causal identification, interaction effects, mechanisms, contextual moderators, distributional consequences, and cross-country variation. Such an agenda would provide a stronger empirical foundation for evaluating the DF–GF complementarity proposition and for understanding the conditions under which financial digitalisation and environmentally oriented finance can contribute to sustainable economic development.

CONCLUSION

This systematic review synthesised the international literature on digital finance (DF), green finance (GF), and sustainable economic growth (SEG), drawing on 61 primary empirical studies and 12 previous reviews treated as contextual evidence. The synthesis indicates that digital finance is generally associated with sustainable and high-quality economic-growth outcomes through financial inclusion, improved financial access, entrepreneurship, information efficiency, and resource allocation. Green finance is similarly associated with renewable-energy development, energy efficiency, green innovation, and low-carbon transition. Across both domains, innovation and financing-constraint reduction emerge as recurrent mechanisms linking financial development with sustainability-oriented outcomes.

The evidence is nevertheless heterogeneous and context dependent. Reported relationships vary according to geographical setting, measurement strategy, development stage, institutional quality, environmental regulation, estimation method, and outcome definition. A smaller body of evidence also indicates that financial expansion may coincide with environmental pressures, particularly where increased financial activity is not accompanied by sufficient environmental targeting or low-carbon transition. Accordingly, the findings should be interpreted primarily as evidence of reported associations, rather than as uniform causal effects.

A central contribution of this review is the formulation of DF–GF complementarity as a testable theoretical proposition. Digital finance may provide financial and informational infrastructure that improves access, information processing, monitoring, and resource allocation, whereas green finance may direct capital toward renewable energy, green innovation, and other environmentally productive activities. However, the current evidence remains insufficient to conclude that their combination

generates an additional causal interaction effect. Demonstrating such complementarity requires empirical studies that explicitly estimate the interaction between digital- and green-finance development rather than inferring complementarity from separate positive associations.

The generalisability of the evidence is constrained by its strong geographical concentration, particularly in China and other emerging Asian economies. Consequently, findings should not be assumed to apply uniformly across countries with different financial systems, institutional structures, technological capacities, regulatory environments, and development stages. The limited evidence from Africa, Latin America, and low-income economies represents an evidence gap rather than evidence of no relationship.

Three priorities follow directly from the synthesis. Future research should strengthen causal identification, expand cross-country and cross-context evidence, and improve measurement harmonisation. Additional priorities include explicit testing of DF–GF interaction effects, clearer separation of direct, mediating, moderating, and spatial relationships, and greater attention to distributional, welfare, and equity-related outcomes.

Overall, the available literature provides comparatively consistent evidence concerning the individual associations of digital finance and green finance with sustainability-related economic outcomes, while the integrated DF–GF nexus remains comparatively under-theorised and empirically under-tested. The next stage of research should therefore move beyond documenting parallel finance–growth relationships toward rigorous testing of the mechanisms, interaction effects, and contextual boundary conditions through which digital and green finance may jointly contribute to sustainable economic development.

DECLARATIONS

Ethical Approval

This study is a systematic review of previously published, publicly available literature and did not involve human participants, human data, or animals. In accordance with institutional research-ethics policy, formal ethics approval was not required. Authors should confirm this against their own institution's requirements.

Consent to Participate

Not applicable. The review did not involve human participants, and no primary data were collected.

Consent for Publication

Not applicable. The manuscript contains no individual-level or identifiable personal data, images, or details.

Author Contributions (CRediT)

Margo Regalado: Conceptualization, Methodology, Formal analysis, Writing – original draft, Supervision, Project administration.

Vladislava Mashchenko: Methodology, Investigation, Formal analysis, Visualization, Writing – review and editing.

Ivan Sicilia: Investigation, Data curation, Writing – review and editing.

Anders Noü: Writing – review and editing.

All authors: contributed to the interpretation of the findings, reviewed and approved the final manuscript, and agreed to be accountable for all aspects of the work.

Funding

The authors declare that no specific grant from funding agencies

in the public, commercial, or not-for-profit sectors was received for this research.

Conflict of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this manuscript.

Data Availability

All data supporting the findings of this review—search strategies, screening decisions, the data-extraction template, appraisal records, and the list of excluded studies—are included in the Supplementary Materials and/or will be openly available in a public repository (e.g., the Open Science Framework) with a citable DOI upon publication.

Acknowledgements

The authors thank the academic librarian who reviewed the search strategy and the subject-matter experts consulted during screening.

Generative AI Disclosure

Generative AI (a large language model) was used to assist with drafting, structuring, and language editing of this manuscript and with organising bibliographic material. The authors verified all scientific claims, methodological descriptions, numerical values, and references, and take full responsibility for the content, accuracy, and integrity of the final manuscript.

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