

# Mapping Digital Sustainability Research in Europe: A Mini Scoping Review\*

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## Abstract

Digital Sustainability is an emerging field that integrates Information and Communication Technologies (ICT) with environmental, social, and economic responsibility. This study analyses the current state of the art regarding Digital Sustainability, capturing the evolution of the field in Europe. Over the past decade, research in this domain has increased significantly. The United Kingdom, Germany, Italy, France, and Spain are among the top contributing countries of European Digital Sustainability research, with the EU Commission serving as the largest funding body. By examining current research trends, this poster evaluates ICT's role in fostering a sustainable digital ecosystem.

## Keywords

Digital Sustainability, ICT for Sustainability (ICT4S), Environmental Impact, Energy Efficiency, Green Computing, Circular Economy

## 1. Introduction

Digital Sustainability, also known as ICT for Sustainability [1], has evolved alongside the rapid growth of Information and Communication Technologies (ICT). Initially focused on computational power and digital transformation, ICT development often overlooked energy consumption and resource efficiency. However, rising environmental concerns and policy interventions, such as the European Green Deal and Sustainable Digital Infrastructure frameworks, have pushed the sector toward more responsible digitalization.

Despite its increasing relevance, Digital Sustainability remains a fragmented multidisciplinary research domain with conceptual ambiguities [2]. Studies range from green IT and energy-efficient computing to broader topics like AI-driven sustainability, blockchain for carbon tracking, and circular digital economy models [3], [4]. While some emphasize reducing ICT's carbon footprint, others explore ethical computing, social and economic inclusion, and regulatory frameworks.

Several recent studies have explored the intersection of digital transformation and sustainability. For instance, a systematic literature review on digital competitiveness and sustainable development analysed 41 articles published between 2000 and 2023, highlighting both the positive and negative impacts of digitalization on sustainability [5]. Similarly, a scoping review of sustainable software models examined green ICT strategies, reviewing 41 works from an initial set of 178 query results [6]. Other studies have addressed specific aspects of Digital Sustainability, such as renewable energy integration in ICT [7], [8], and the role of digital technologies in aging societies [9]. However, there is rarely a scoping review of its evolution and current state in Europe. This work fills that gap by analysing key

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milestones and emerging research trends. By bridging technology and research, we provide an overview of Digital Sustainability's trajectory and future directions.

## 2. Materials and methods

Given the aim of this study, a scoping review was chosen as the primary research method. Scoping reviews are particularly useful for mapping key concepts, identifying research gaps, and synthesizing emerging topics in a field without the rigid inclusion criteria of systematic reviews. This study follows the standard five-step scoping review framework [10], comprising: (1) identifying the research questions, (2) identifying relevant studies, (3) study selection, (4) data extraction and charting, and (5) collating, summarizing, and reporting results. Our study addresses four key research questions:

RQ1: How has the concept of Digital Sustainability evolved?

RQ2: What are the dominant research fields contributing to it?

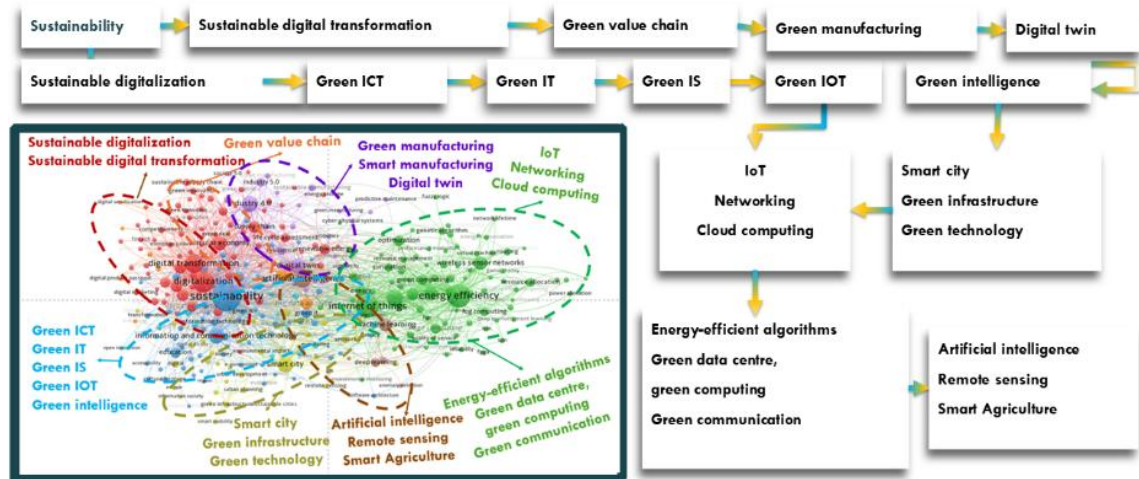
RQ3: What are key milestones and trends in European research?

RQ4: What are the major gaps and future directions?

To ensure that high-quality peer-reviewed papers were analysed, we focused on Scopus and Web of Science, renowned for indexing quality peer-reviewed research. It is however important to mention that this choice could have a significant impact on the results shown in this analysis, in particular regarding research outputs in the field of Computer Science (Informatics). It is well known that Computer Science papers, particularly from conferences, are not comprehensively covered in Scopus or Web of Science [11], [12], [13]. As this is a preliminary study, a more in-depth and exhaustive analysis would require the inclusion of more specialized databases such as DBLP and ACM Digital Library. In addition to conference papers, other literary output, such as books, is well covered in Google Scholar and not in SCOPUS and Web of Science, which should be included in a more extensive study. Nonetheless, the selected database still sampled a good number of conference papers and books even in the Computer Science domain.

Meanwhile, to explore relationships within Digital Sustainability research, we conducted co-occurrence analysis of keywords, mapping their connections to the broader field. The relationships follow a structured order (as visualized in Figure 1): Digital Sustainability → Sustainable Digitalization → Green ICT → ICT for Sustainability → Green IT → Green information system → Green IoT → Green intelligence → Green value chain → Green AI → Sustainable digital transformation → Twin sustainability → Sustainable cloud computing → IoT for sustainability → Low-carbon internet usage → Energy-efficient algorithms → Green data centers → Smart green world. This mapping highlights how technological and conceptual domains interconnect within digital sustainability research, reinforcing key trends and future directions.

A structured approach ensured relevant study inclusion, such as Deduplication – removing duplicates across databases; Title & Abstract Screening – Excluding unrelated studies; Full-Text Retrieval – Retaining accessible studies; Eligibility Assessment – Applying predefined inclusion/exclusion criteria. Relevant studies were categorized by publication trends, contributing disciplines, definitions, and geographical distribution (Europe-focused). Bibliometric keyword analysis tracked research evolution, terminology shifts, and emerging priorities in Digital Sustainability.



**Figure 1: Relationship between keywords in Digital Sustainability using co-occurrence analysis**

### 3. Our research findings

#### 3.1. Historical evolution of Digital Sustainability

Digital Sustainability research has grown significantly, with over 500% increase in publications from 2010 to 2023 (Figure 2). Initially centred on green IT and energy-efficient computing, it has expanded to AI-driven sustainability, circular digital economies, and policy-driven transformations. The key research phases:

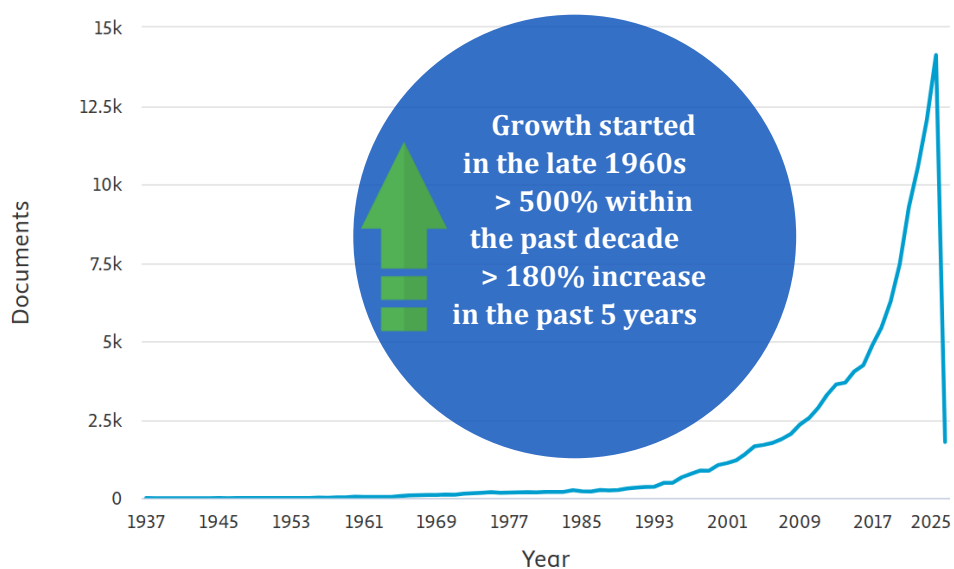
2000–2010: Focus on energy-efficient computing and e-waste management.

2011–2015: Growth in cloud computing sustainability and green software engineering.

2016–2020: Rise of AI, blockchain for carbon tracking, and circular digital economy models.

2021–2023: Major EU policies (e.g., EU Green Deal) drive Digital Sustainability adoption.

Documents by year



**Figure 2: Digital Sustainability research outputs timeline**

### 3.2. Comparison of research fields and subject areas

Digital sustainability spans multiple disciplines, with research articles being the leading form of contributions and significant input coming from fields such as Computer Science & Engineering (21%), Environmental Science (9%), and Agricultural and Biological Sciences (7%) (Figure 3).

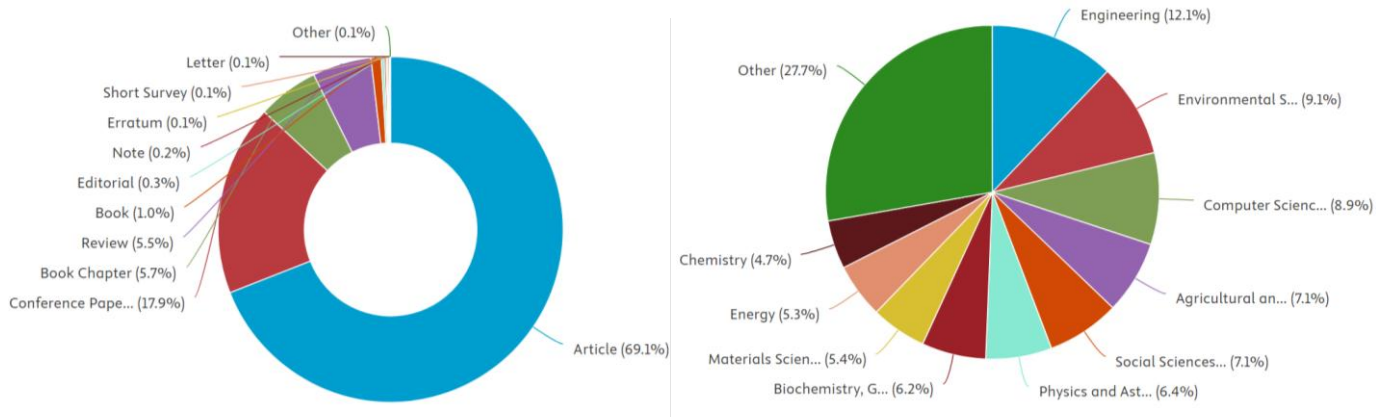


Figure 3: Digital Sustainability research outputs fields and sub-areas classification

### 3.3. Country and institutional contributions

From our analysis, the leading countries in Digital Sustainability research in Europe are as follows (Figure 4a): (1) United Kingdom, (2) Germany, (3) Italy, (4) France, and (5) Spain. The leading institutions in Europe include CNRS in France, the Russian Academy of Sciences, CNR in Italy, CSIC in Spain and the University of Cambridge in the UK (Figure 4b).

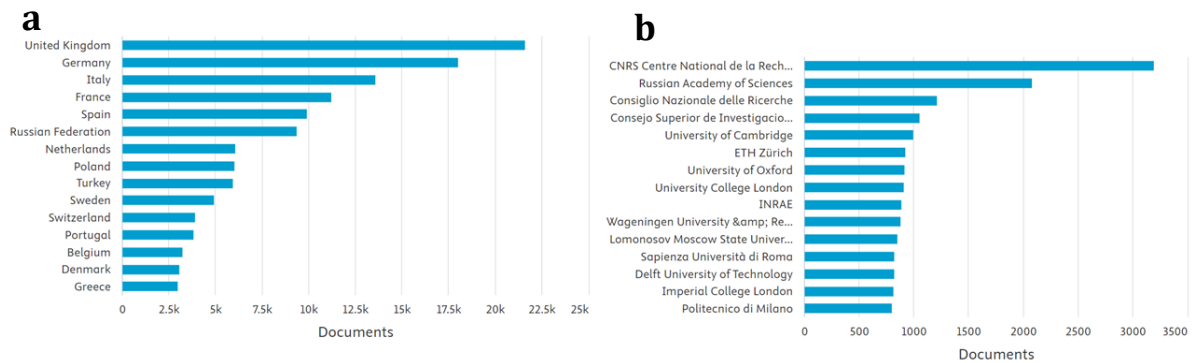


Figure 4: Digital Sustainability outputs countries (a) and institutions distribution (b)

### 3.4. Other trends, impact, and future directions in Digital Sustainability research

Digital Sustainability research has experienced significant growth in different journal publications. Leading journals in the field include *Sustainable Switzerland*, *Journal of Cleaner Production*, *Lecture Notes in Computer Science*, *Proceedings of SPIE The International Society For Optical Engineering*, and *E3s Web Conferences*. Most of the research analysed aligns with key Sustainable Development Goals (SDG), particularly SDG 9 (industry, innovation, and Infrastructure), SDG 12 (responsible Consumption and production), SDG 13 (climate action), SDG 7 (affordable and clean energy), and SDG 11 (sustainable cities and communities) (Figure 5). These were captured mostly in isolation, with very few studies simultaneously capturing the environmental, economic, and social dimensions of sustainability (Figure 6).

Insights from the analysed data and ongoing research highlight key future trends such as AI-driven sustainability (with projected energy efficiency gains of 25–30%), blockchain for

carbon tracking, smart cities, digital twinning, green cloud computing (targeting net-zero emissions by 2030), and policy-driven ICT decarbonization. By 2035, 80% of digital infrastructure investments are expected to align with carbon neutrality goals.



Figure 5: Digital Sustainability research output contribution to SDGs

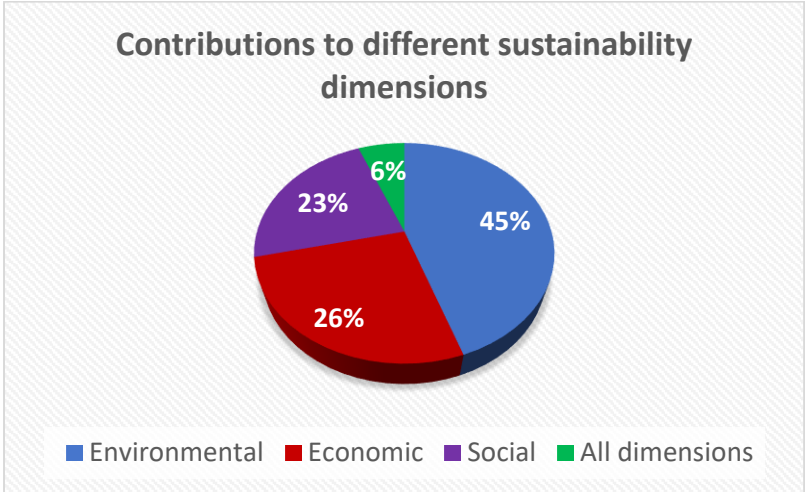


Figure 6: Digital Sustainability research outputs clustering according to the three sustainability dimensions

**4. Relevance and novelty**

Despite the rapid growth of Digital Sustainability research, there is no scoping review that maps the evolution of Digital Sustainability in Europe. This study is the first mini review to systematically analyse over 22,000+ scholarly articles, mapping research growth over two decades. We also compared Digital Sustainability research across fields, institutions, and countries to highlight regional and sectoral trends. We also show SDG alignment of Digital Sustainability research to assess its global relevance. By addressing these gaps, this research provides empirical evidence to guide decision-making in sustainable digital transformation.

## Declaration on Generative AI

During the preparation of this work, the authors used GPT-4 and Grammarly in order to: Grammar and spelling check. After using these tools/services, the authors reviewed and edited the content as needed and take full responsibility for the publication's content.

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