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REVIEW ARTICLE

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Defining and measuring the effects of digital technologies on social sustainability: A systematic literature review

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Abstract

The impact of digital technologies on the environmental and economic sides of sustainability has received considerable attention. In contrast, the societal implications are quite under-researched. Through a systematic literature review, we describe the current status of the research on the impacts that digital technologies have on social sustainability. We pay particular attention to methods used for assessing and measuring these impacts. One positive observation made from our descriptive (bibliometric) analysis is that there is an increasing interest in social sustainability. Our content analysis identified four categories, namely "Area of Impact," "Approach to technology," "Measured/Measurable Effect," and "Measuring Methods", accumulating 30 labels, which we use to classify the papers at study. A quite common label is "Jobs" as the area of impacts, whereas the least used label in the approach to technology category is "Cyber-security," signaling that few papers that investigate the impacts of digital technologies on social sustainability consider their security and privacy implications. Other gaps that we expose are the lack of empirical data as well as the lack of mathematical modeling when measuring the effects of digital technologies, with direct experiments appearing very seldom in the literature. In an attempt to provide a guide for future research, we identify five general research gaps, listing 20 specific research questions, and propose a structuring procedure for articles on social implications of digital technologies to be produce in a more systematic manner.

KEYWORDS
digital technologies, social sustainability, societal effects, sustainability measurement, sustainable development

1 | INTRODUCTION

Sustainability is one of the hottest topics of our time, and not without reason. Behind this growing interest lie several of the biggest issues that humanity is facing, such as the climate crisis (Pierrehumbert, 2019; Ryghaug, 2011; Tenali & McManus, 2022) and the wave of rising socioeconomic inequality (Elkjær & Klitgaard, 2021). Fortunately, this interest is not limited to academic circles, as consumers are progressively shifting their demand toward more sustainable products.[1]

In this paper, we adopt the definition of Sustainable Development from the World Commission on Environment and Development (WCED, 1987): "Development that meets the needs of the present

[1] https://www.worldwildlife.org/press-releases/search-for-sustainable-goods-grows-by-71-as-eco-wakening-grips-the-globe.

without compromising the ability of future generations to meet their own needs." When addressing Sustainability, it is common to identify three dimensions or pillars (Choi & Ng, 2011; Purvis et al., 2019): Environmental, Economic and Social. Of these three dimensions, the Social one stands out as the one that is the least understood (Afshari et al., 2022; Boyer et al., 2016; de Fine Licht & Folland, 2019; Dempsey et al., 2011), and as such, we believe it is important to add to the body of research of this particular aspect.

Social sustainability could be defined in several ways. We hereby present the following set of definitions as the conceptual basis for this work.

1. "Social sustainability is a vital cog of sustainable development which takes care of social aspects by giving importance to social values, equity and justice; addressing basic needs, safety and health; bringing sense of community, social capital and diversity; respecting human rights, and thereby paving the way to eliminate poverty, bringing higher quality of life and augmenting the standard of living." (Shaw et al., 2022)
2. "[A] positive condition within communities, and a process within communities that can achieve that condition" (de Fine Licht & Folland, 2019), including aspects such as equity in service access and between generations, defending labor rights, cultural integration, empowerment of minorities or widespread political participation of citizens.
3. "social goals [of sustainable development include] improving equal job opportunities, improving participation in creating community capacities, reducing impact on cultural and historical heritage." (Dalirazar & Sabzi, 2022)
4. "Social sustainability is perceived as a sustainable development principle aimed at achieving equality and reducing poverty through job creation and education, empowerment and freedom, preservation of diversity, protection and promotion of human rights, equity and health and safety." (Ipinnaiye & Olaniyan, 2023)

Motivated by the "exponential growth of information and communications technologies (ICT) in the last thirty years" (Walker & Brown, 2020), in this study, we aim to explore the relation between digital technologies and social sustainability via a systematic literature review. In particular, we want to address the following research questions:

R1: What are the areas of social sustainability where digital technologies can have an impact?
R2: What are the conceptions (i.e., the approaches) that authors have of digital technologies when describing an impact on social sustainability?
R3: What are the different types of measurable impacts that digital technologies can have on social sustainability, and how do authors proceed for measuring or assessing those impacts?

The concrete definition of the types of technology addressed in this study and the perspectives that authors use for approaching them are described in Section 2.2.

Even though relations of some aspects of technology and social sustainability are already present in the literature, it is still considered an under-researched topic (García-Muiña et al., 2021). For example, in (Grybauskas et al., 2022) a systematic literature review of the social implications of Industry 4.0 is conducted. However, the scope of (Grybauskas et al., 2022) is limited to Industry 4.0, so the areas of social sustainability studied are also constrained. Our research differs from previous work in that we apply a broader focus on the technological approaches we consider, while, at the same time, narrowing the scope of our review to the methodology that the authors used for assessing or measuring the impact of the technologies they study. Our approach is motivated by the lack of methodologies and tools for social sustainability (Papetti et al., 2018), and by the fact that the existing evaluation methodologies for this aspect are still considered to be "immature" (Balaman, 2019).

To clarify the scope of our review, we do not aim to study the value (positive or negative) nor the extent (big or small; local or global) of the impacts of digital technologies described in the literature. The opinions of the authors or the particularities of their results lie outside of the scope of this review.

The rest of this paper is structured as follows. Section 2 describes in detail the systematic literature review methodology that we followed. In Section 3 the results from a bibliometric (Section 3.1) and a content (Section 3.2) analysis of the literature are presented. In Section 4 we compile some cases of open research lines that arise from this systematic literature review as well as from specific calls for research from the literature. Finally, the concluding remarks and the implications of this study are described in Section 5.

2 | METHODS AND LABELING

This study has been conducted following the guidelines of the established method for performing systematic literature reviews (Kitchenham, 2004). In that fashion, we divide the study in two distinct stages: Collection of Study Material and Analysis of the Material we collected. A summary of the phases of each stage is presented in Figure 1.

2.1 | Collection of study material

In this section, we describe the strategy, the methodology and the criteria followed for collecting the relevant material for performing the systematic review.

2.1.1 | Sources and initial inclusion criteria

In order to follow a structured work plan, we begin by defining a set of clear research questions. These (three) questions, presented in Section 1, shape the criteria used for identifying, selecting and assessing the relevant studies. To start our search, we decided to use the

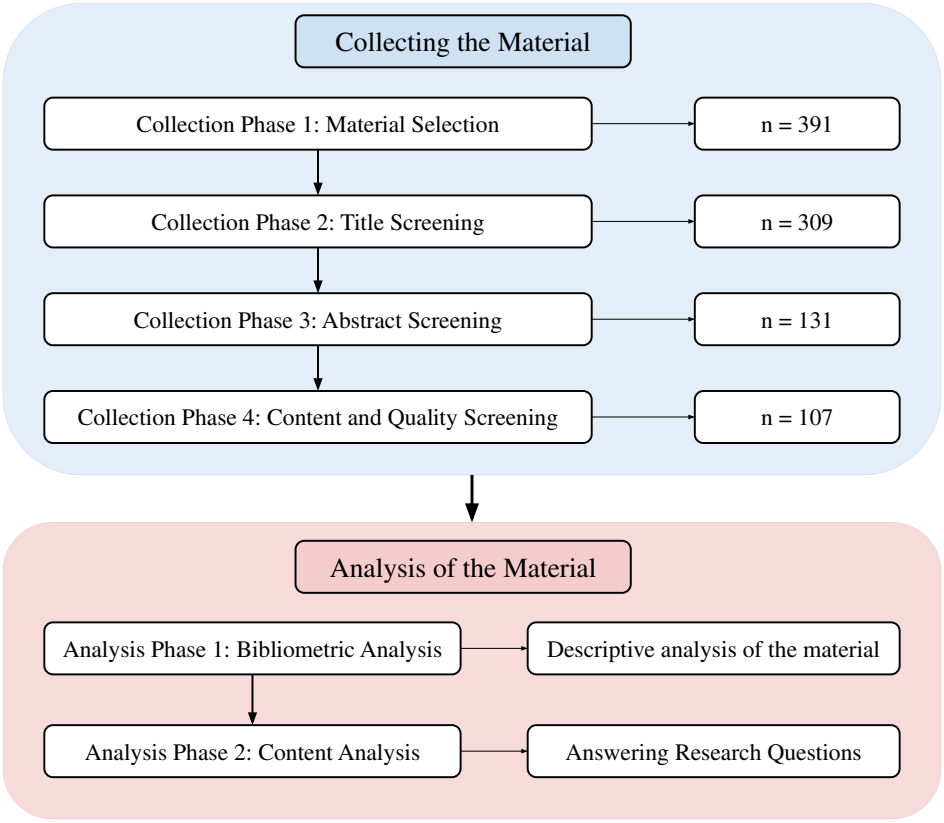

FIGURE 1 Summary of the systematic literature review methodology followed. The fields with $n = \#$ represent the size of the selected article sample.

Scopus database, as it compiles results from several databases, including Springer Link, Emerald Insight, and Science Direct. We limited our search to formal literature in the English language, so it excludes, for example, book chapters. As we believe that there could be valuable insights gained from the analysis of the yearly evolution of the number of publications, we did not impose any recency limits on the publication date for selecting the initial set of articles. The final set of articles analyzed ranged from 2008 to articles published until the end of 2022.

2.1.2 | Definition of search string

In order to retrieve a complete enough sample of literature that is relevant to our topic, but at the same time to limit the number of unrelated papers shown, we defined our search string as a combination of specific keywords. For that purpose, we distinguish between two topic groups: digital technologies and social sustainability. In order to find common and relevant keywords related to the technological perspectives that we address in this paper, we surveyed several systematic reviews such as Grybauskas et al. (2022), Cricelli and Strazzullo (2021), Rosário and Dias (2022). Furthermore, to better our initial understanding of the types of technologies studied in relation to social sustainability, we studied multiple articles by experts on the sustainability of digital technologies. These sources include selected articles from ICT for sustainability literature (Hilty & Aebischer, 2015; Hilty et al., 2011), digital sustainability literature (Stuermer et al., 2017), literature on the sustainability aspects of specific technologies like digital platforms (Zarra et al., 2019), articles on sustainability measurement (Wut et al., 2021) and digital economics literature (Martin, 2016).

TABLE 1 Summary of the parameters chosen for the initial search for relevant literature.

Search parameters	Chosen values
Database	Scopus
Language	English
Date of publication	January 2008–December 2022
Document type	Formal scientific literature (excluding books)
Search string	([“digital technologies” OR “digitalization” OR “ICT” OR “industry 4.0”] AND [“social sustainability” OR “societal sustainability” OR “societal impact” OR “socio-cultural needs” OR “social well-being” OR “social costs” OR “community well-being”])

From the initial pre-review, a set of keywords that represent a compromise between specificity and variety of results was proposed. These keywords are:

1. *Digital technologies keywords*: “digital technologies,” “industry 4.0,” “digitalization,” and “ICT.”

TABLE 2 Exclusion criteria for each of the literature selection phases.

Selection phase	Exclusion criteria
Title screening	• Articles that clearly have no relation to digital technologies and social sustainability. • Remove duplicates not found by the literature-management software. Some papers were indexed with slight variations in the title, or listed twice but one of them was missing the DOI. This, however, did not happen often.
Abstract screening	• Papers that do not include any type of assessment or measure of impact of digital technologies on an aspect related to social sustainability. • Papers with that explicitly mentioned that their main focus was on aspects related to the economic or environmental dimensions of sustainability. • Papers that did not have a technological focus. This includes papers that could have mentions to digital technologies, but the focus was on another thematic area.
Content screening	• Papers that were not accessible at the time of the review. For example, some papers were pre-publications not yet published. • Papers not related to assessing or measuring the impact of digital technologies on social sustainability, that were not previously excluded in the abstract screening phase. • Papers whose main focus was on aspects related to the economic or environmental dimensions of sustainability, and were not excluded in previous phases. • Paper that did not fulfill the standards of methodological robustness and validity of claims.

2. *Social sustainability keywords*: "social sustainability," "societal sustainability," "societal impact," "socio-cultural needs," "social well-being," "social costs," and "community well-being."

To find the relevant literature, we looked for papers that included in their title, abstract or keywords any combination of at least one of the keywords about digital technologies and one of the keywords on social sustainability. This can be summarized with the search string presented in Table 1. The search string provided initially 391 articles.

2.1.3 | Filtering process

As presented in Figure 1, we went through three progressive screening steps (phases 2–4). The list of exclusion criteria used in all three phases is presented in Table 2. First, we read the titles of all the articles we obtained from the initial query to determine their relevance for our research questions, removing from the list articles according to the criteria of Table 2. We then read the abstracts of the remaining 309 articles and, excluding based on the criteria for abstract screening from Table 2, we were left with 131 articles. Each article independently considered to be unrelated to our scope was removed.

Finally, a full-text quality assessment screening was performed by considering not only the relevance to the topic but also the scientific rigor of the publication. During this phase we found some articles that did not match our topic criteria, but the main reason for excluding the papers at this point was the critical assessment of the validity of the methodology of the authors as well as the degree of generalizability and confidence of the claims. We were left with 107 studies for further analysis.

2.2 | Analysis of the material and label generation

Based on a rigorous content analysis in relation to our three research questions, we identified four categories (or main themes), each one with a group of unique labels (or subcategories) for classifying the 107 papers in a systematic way. Instead of using predefined categories, we opted for an inductive approach (as done, for example, in Darko & Chan, 2017; Khizar et al., 2021).

The categories and their labels are defined as follows:

1. **Area of impact**: Answering research question R1, this category is dedicated to mapping the areas of social sustainability impacted by digital technologies as described by the authors. This could be thought of as defining the thematic area of the article at study in the context of the first research question. For this category, we have defined the following labels:
   i. *Jobs*: The focus of the article is on the impact that a technology or group of technologies can have on any aspect related to jobs, and professional lives of individuals or groups. For example, articles about social aspects of the gig economy (Loganathan, 2022).
   ii. *Education*: The focus is on effects that technologies may have on the education system or using technologies for educational purposes. For example, an article that measures the impact of informal educational YouTube videos (Bello-Bravo et al., 2021).
   iii. *Food and water*: Focus on access to clean water and food supply or the effects that technologies have on food production or water distribution. For example, a study on marketing technologies in the Agri-Food industry (Liao & Huang, 2021).
   iv. *Physical health*: Focus on the physical well-being of individuals. For example, a study on active aging aided by technology (Rosado et al., 2020).
   v. *Mental health*: Focus on mental health impacts (positive or negative) or managing mental conditions. For example, a study on a digital platform for supporting mental health for healthcare workers (Ye, 2021).
   vi. *Lifestyle*: Focus on the evolution of the general lifestyle of people due to digital technologies. This includes, for example, articles about the impact of adopting technologies in our

daily life (e.g., Young et al., 2019), or shifts in common practices as a result of technologies (e.g., Pathak et al., 2015).

vii. *Equality and inclusion*: Focus on promoting the inclusion and empowerment of minorities, reducing gender or socioeconomic inequalities, or governance practices (e.g., political participation, representation of citizens, etc.), such as "e-Government." An example would be Sultana et al., 2021, where the authors study women's access to computing in rural Bangladesh. This label also encompasses sources of increased inequalities as, for example, the Digital Divide (Van Dijk, 2006). An example would be Jauhiainen et al., 2022.

viii. *Safety and crime prevention*: Focus on the physical safety of individuals in a society, like using technologies for preventing crime, cybercrime, and the impacts of attacks on, or failure of, critical-infrastructure systems. For example, a study on the promotion of safety and security with ICT-based surveillance (Vogiatzaki et al., 2020).

ix. *Sustainable development goals (SDG) mapping*: Some of the articles analyzed describe multiple effects that a technology or a group of technologies have on society in several dimensions, mapping those effects onto the 17 Sustainable Development Goals of the General Assembly of the United Nations.[2] We found this label useful because several of the articles analyzed presented the societal impacts in this way. For example, the relation between 6G and the SDGs is studied in Matinmikko-Blue et al., 2021.

2. **Approach to technology**: This item aims to answer the second research question, categorizing the type of focus that authors have regarding technology that impacts an aspect of social sustainability. The different approaches were labeled as follows:

i. *Specific technology*: Studies that focus on a specific application or one type of technology. For example, an app to help men with HIV (Mathenjwa et al., 2020), or a study that focuses on 6G (Matinmikko-Blue et al., 2021).

ii. *Digitalization and digital transformation*: Studies that focus on the impact of Digitalization ("the way many domains of social life are restructured around digital communication and media infrastructures" (Brennen & Kreiss, 2016) and Digitization (sometimes called Digital Transformation, "the material process of converting analog streams of information into digital bits" (Brennen & Kreiss, 2016) on some aspect of social sustainability. These aspects are grouped together because of the strong conceptual connection between them. For example, a study on digital transformation in traditional Chinese enterprises (Xia et al., 2022)

iii. *Industry 4.0 and 5.0*: The focus on an impact related to Industry 4.0 (Lasi et al., 2014) or Industry 5.0 (Xu et al., 2021).

iv. *ICT and digital technologies in general*: Focus on the impact of digital technologies in general, without focusing on any specific technology. The present review could be categorized with this label. For example, a study on the relation between ICT use and mental health for distance learning students (Mc Donald Van Der Merwe, 2020).

v. *Circular economy*: Articles that explicitly conceive digital technologies as an enabler of circular economy, or how digital technologies fit into circular economy practices. For example, Bai et al., 2022.

vi. *Smart cities*: Explicit focus on Smart Cities (Batty et al., 2012).

vii. *Cyber-security*: Focus on cyber-security systems, cyber-attacks or risks associated with cyber-security on some aspect of social sustainability. For example, a study on the increase in cybercrime since the pandemic and its effects on mental health (Monteith et al., 2021).

3. **Measured/measurable effect**: This category arose as an answer to the first half of the third research question ("What are the different types of measurable impacts that digital technologies can have on social sustainability") by classifying the effects that digital technologies have on a particular aspect of social sustainability. The difference between this category and the first one is that, while the first one characterizes where some technology has some effect, this category focuses on how said technology impacts that specific area. As the primary focus of this study are the effects and how they are measured, we relate the specific effects identified with the SDGs. The identified labels are:

i. *Working conditions*: Articles that discuss or analyze the improvement (or worsening) of the working conditions of individuals or communities as a result of digital technologies. For example, how working conditions change due to a technology-enabled shift to gig labor (Rodrigues et al., 2021). Related to SDG 8.

ii. *Job opportunities*: Articles that analyze a change in job opportunities as a result of digital technologies (i.e., creation or loss of jobs for some group or population). For example, addressing youth unemployment through peer mobile groups (Klier et al., 2019). Related to SDGs 8 and 9.

iii. *Health risks*: Analysis of negative impact on human health (physical and/or mental) due to technology. For example, a study on how the increase in cybercrime since the pandemic affects mental health (Monteith et al., 2021) Related to SDG 3.

iv. *Health benefits*: Analysis of technologies used for improving aspects of the health of an individual or group. For example, a study about a platform for providing home care services (Isern et al., 2008). Related to SDG 3.

v. *Knowledge gains*: Technologies for facilitating education or access to culture, or achieving a deeper level of insight regarding a defined topic (e.g., democratizing knowledge, educational content sharing on online platforms (Bello-Bravo et al., 2021), understanding knowledge sharing in a specific community (Jatnika, 2019)). Related to SDG 4.

vi. *Safety and crime*: Variation in the crime rate due to digital technologies (e.g., reducing crime (Vogiatzaki et al., 2020),

[2] https://www.un.org/sustainable-development-goals.

new risks such as cyber-attacks, access to and resilience of critical infrastructure (Schaberreiter et al., 2013)). Mostly related to SDG 11. Also related to SDGs 9 and 16.

vii. *Inclusion, inequality and community formation*: Promoting through digital technologies, among other effects, the inclusion of minorities, empowerment of women, formation of communities and increase political participation of citizens. Some examples include analyzing eLearning systems from a gender-based perspective (Alharthi et al., 2018), and a study on the role of digital citizen participation for advancing social sustainability (Bouzguenda et al., 2019). Also measuring increases in inequalities due to technologies (e.g., the Digital Divide (Papadopoulos & Broadbent, 2009), digital technologies as enablers of new forms of discrimination). Related to SDGs 5 and 10, but it could also address SDG 16.

viii. *Lifestyle change*: Measuring or identifying trends in change of the lifestyle of individuals or populations. One possible measured effect could be the shift in the ways in which "people influence each other in their tastes and actions" (Chavalarias, 2016). Related to SDGs 3 and 11.

ix. *SDG mapping*: Studies that were categorized as SDG mapping for their area of impact are marked with this label.

4. **Measuring methods**: This category answers the second half of the third research question (How do authors proceed for measuring or assessing the impacts that digital technologies can have on social sustainability?). Each of the impacts of digital technologies presented in the papers is measured, assessed or described in some way by the respective authors. The existence, extent and nature of the effects described must be justified in some way. We classify the methods that the authors use for this purpose with the following labels:

   i. *Direct experiment*: Empirical studies where the data comes from a scientific experiment performed directly by the authors of the study. This could be developing and testing a specific technology for some aspect of social sustainability (e.g., an Internet of Things positioning system for dementia training), or studies that observe the behavior of a group of participants (e.g., Palm et al., 2020). This label does not include secondary data or studies of previous experiments performed by other researchers.

   ii. *Case studies*: Conclusions about the impacts of digital technologies based on one or more case studies (that are not direct experiments). For example, Ruoslahti & Davis, 2021 study the case of project ECHO.

   iii. *Mathematical model*: Results from a mathematical model developed, assessed, or presented by the authors. For example, modeling the risks of critical infrastructure services at run-time (Schaberreiter et al., 2013).

   iv. *Surveys and interviews*: Results from survey data, as well as based on one or more interviews with participants or experts. We decided to group both categories as in both cases this type of study gathers data from people describing their experience in a more or less guided manner. For example, Martín & Palomo Zurdo, 2021 conduct a series of interviews to "improve human performance and labor engagement in the face of digitalization."

   v. *Literature review*: Results that originate from reviewing literature. That is, authors review existing scientific literature to draw conclusions about impacts of digital technologies on social sustainability. For example, Grybauskas et al., 2022.

Although relationships exist between the categories Area of Impact and Measured/Measurable Effect, these are essentially distinct in the sense that the former refers to the general thematic area of a paper (e.g., a paper could be related to Jobs, to Education, etc.), whereas the latter describes how a paper measures the impact of digital technologies on a specific area of social sustainability. A thematic area, in contrast, does not carry information about the specific impact measurement methods. For example, a paper could focus on the impacts of a technology in the specific area of Jobs. This impact could be quantified by measuring some effect, such as the creation of job opportunities (e.g., by measuring the employment ratio in a sector), or change in working conditions (e.g., reduction of risk of injuries or decrease in strenuous manual labor).

Clearly these labels are not mutually exclusive. For each of the four categories, each article must have at least one label, but could have more. For example, one study could compare the health risks and benefits of one technology (i.e., labeled with (iii) and (iv)). Another study could, for example, analyze improvements in working conditions of the workers in one sector (label (i)) and the creation of new jobs ((ii)) in that same sector as a result of digitalization. When the boundaries are diffuse (for instance in studies, such as (Palumbo et al., 2022), that discuss both aspects of digitalization and an influence of ICT in general) we decided to apply both labels. This has implications that we detail in Section 3.2.

Finally, we identify two types of open questions that may help shape future research initiatives on social sustainability and digital technologies. First, we extract from the literature any future research directions explicitly suggested by the authors, for example, in their concluding sections. Second, and more importantly, we propose open questions resulting from our present review, that is, more general, meta-questions, stemming from our, now more comprehensive, understanding of this literature.

The process of labeling and classifying was done by creating a table that included, for each publication, the authors, title, year of publication, and name of the journal. To this table, we added five columns for, one for each category, and one for possible future research directions. This is in line with the common practice for this type of study (Bahman, 2023; Chourasiya et al., 2023). The table (in CSV format) is provided as a supplement to this study.

3 | RESULTS AND ANALYSIS

In this section we report both the results of a descriptive analysis of the literature as well as the outcomes of studying their content.

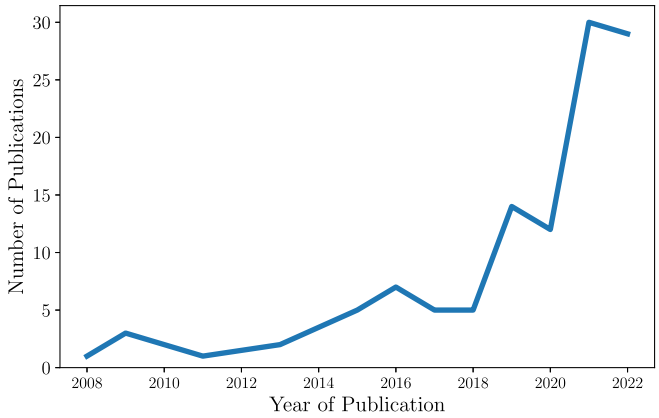

FIGURE 2 Number of published papers by year in the sample of 107 papers reviewed.

3.1 | Bibliometric results

By performing a quantitative analysis of the set of 107 articles selected for our final sample we can get valuable insights about the current state of the literature on our topic.

3.1.1 | Number of papers by year

The evolution of the number of publications with time inside our sample is presented in Figure 2. There we can see that the general interest in social sustainability in relation to digital technologies has grown over time. Even though our sample may not be fully representative, this observation is encouraging as it shows increased research productivity in an area that is considered to be under-researched (García-Muiña et al., 2021). The noticeable increase in publications starting from 2020 could suggest that the COVID-19 pandemic may have caused an increase in the general interest in social sustainability. The slight decline in the number of publications in 2022 could be then related to the decreasing impact of the COVID-19 pandemic.[3]

3.1.2 | Keyword frequency

We present in Figure 3 the frequency (i.e., the number of papers that use a specific keyword divided by the total number of papers in the sample) of the 10 most popular keywords used in the reviewed literature. All keywords, as they appear in the *Keywords* section, are converted to lowercase (keeping this convention also in our figures).

Unsurprisingly, "Social Sustainability" is the most frequent keyword by far, about a third of the papers use it, followed by "Industry 4.0," "Sustainability," and "ICT." One interesting fact is that approximately 5% of the papers had "COVID-19" as one of their keywords, suggesting that these were produced as a response to the COVID-19 pandemic.

[3]https://news.google.com/covid19/map.

It could also be interesting to look at the frequency of use of the most popular keywords with time. The time evolution of the four most popular keywords in the papers analyzed is presented in Figure 4. Taking the results from Figure 3 into account, the general tendency to increase in the frequency of all the keywords presented is not a surprise. However, it is interesting to see that the keyword "Sustainability" started to appear only relatively recently (2018),[4] which further verifies the rise in interest on Sustainability. Furthermore, even though the concept of Industry 4.0 originated in 2011 (Kagermann et al., 2011), these results suggest that it was not until several years later that its societal implications began to gain attention in the scientific literature.

3.1.3 | Number of citations

Finally, we can study the number of citations that the papers in the sample presented at the time of our review. The number of citations could be used as an indicator of the academic relevance of the field at study, as the more citations a set of papers gets, the more attention those papers have gained in the academic community. As we can see in Figure 5, the general trend in the number of citations is increasing over time, although this fact could be also due to the recency of most of the papers selected. When looking at Figure 5, one must take into account that recent papers (published in 2022) had not had time yet to receive a high number of citations.

We find that there have been two spikes in the number of citations of papers related to the impact of digital technologies on social sustainability. We argue that the conceptualization of social sustainability in relation to the UN Sustainable Development Goals played a role in the first one. It is reasonable to assume that, after the definition of the 17 SDGs in 2015, the research on social sustainability, in general, received more attention and more citations as a result.

The second peak could be due to the research on the social implications of the COVID-19 pandemic. Due to the pandemic, it is possible that recent (physical and mental) health research started to receive more attention. This new interest may explain the second increase in the number of citations. However, we do not have any empirical data to prove this claim, as it is outside the scope of the present study.

3.2 | Content analysis

The analysis of the content of this set of papers on the societal impact of digital technologies with the help of the four label categories described in Section 2.2 can provide valuable insights on several dimensions. Based on the thematic categories and their respective labels, we approach our research questions by analyzing how the reviewed literature fits into the context of this study (see Figure 6).

[4]Even though 2018 is not a recent date, relative to the earliest studies included in this review, dating back to 2008, and to the other keywords, the keyword "Sustainability" gained popularity relatively recently.

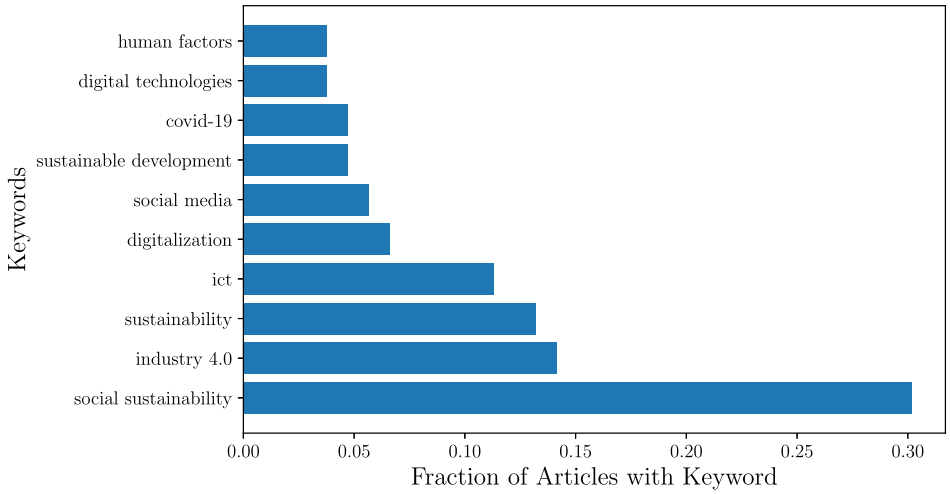

FIGURE 3 Frequency of the 10 most used keywords in the reviewed papers. We define keyword frequency as the number of papers that use a specific keyword divided by the total number of papers in the sample.

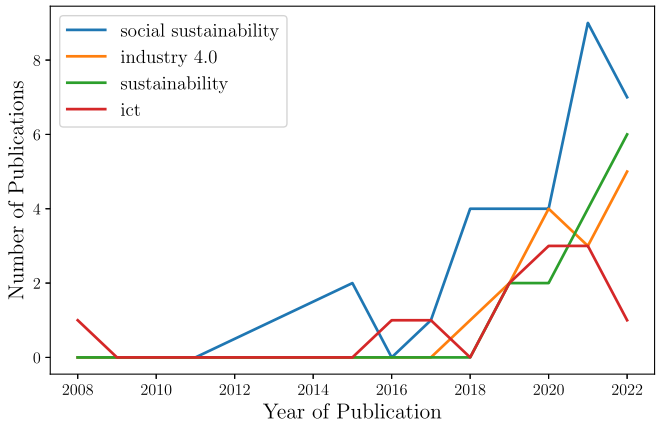

FIGURE 4 Number of publications by year in the review sample that use one of the four most popular keywords.

We present the results of the label frequencies, expressed as the fraction of papers that were categorized by a specific label, in Figure 7. Some of the papers of our set had been labeled with several labels for some of the categories. For example, one of the topics discussed in (Begum et al., 2022) is tools from Industry 4.0 as a response to the effect of the COVID-19 pandemic on workers in manufacturing firms, which means that the article studies the impact of Industry 4.0 on jobs. However, we cannot ignore its relation with the pandemic, and remarks such as "digitization in the pandemic [...] improves social distancing and social well-being" imply that a relation between Industry 4.0 and physical health is also discussed in the article. Thus, the area of impact of (Begum et al., 2022) would be both "Jobs" and "Physical Health." As there are several cases of multi-labeled articles, it is reasonable that the label frequencies in the sub-figures of Figure 7 do not add to 1.

3.2.1 | Area of impact

All the papers reviewed, classified by their Area of Impact are presented in Table A1 (in Appendix A) and the frequencies of those labels are presented in Figure 7a. This figure helps to shape the image that authors have about the meaning of social sustainability. The two labels that were used the most are "Equality and Inclusion" and "Jobs", followed by "Lifestyle" and the two health categories. Given that some articles studied both impacts on mental and physical health, the whole health category is smaller than the sum of both. Despite this fact, the total of health-related articles accounts for 35% of all the literature reviewed. Thus, according to this data, the three main areas of social sustainability where the impact of digital technologies is studied are:

1. Health
2. Equality and Inclusion
3. Jobs.

This data suggests that some areas of social sustainability are given less attention than the main ones. For example, the impact of digital technologies on Education or as a tool for providing Safety or preventing Crime are not very popular in the social sustainability literature. The less researched area of impact, however, is the access to food and water, including only about 3% of the articles reviewed. These insights could be an indication of the current gaps in knowledge for this area.

Another interesting fact is that physical health is usually given more attention than mental health with regard to the impact that Digital technologies can have. This resonates with the common fact that mental health is, in general, not given enough attention (Tomlinson & Lund, 2012).

3.2.2 | Approach to technology

A summary of the frequencies of the labels associated with the technological focus of the articles reviewed is shown in Figure 7b, and Table A2 (in Appendix A) presents the papers sorted according to said labels.

From Figure 7b we see that most of the authors study either a specific technology or the effects of ICT and digital technologies in general. These two main approaches are, as a general rule, inherently opposite, representing a narrow and a broad focus respectively. However, these two approaches are on the same line, treating technologies as a "thing," a static phenomenon. On the other hand, authors that focus on "Digitalization and Digital Transformation" and "Industry 4.0/5.0" study the impact of technologies as the result of a dynamic process, the shift toward a new way of performing our daily activities in our personal life and workplace. We see that this dynamic approach is less popular than treating the impact of digital technologies in the static sense.

In Section 3.2.1 we pointed out that the research on the impact of digital technologies on safety is not very popular in this type of literature. This fact is further accentuated by the scarcity of research we find on social sustainability in the context of cyber-security (only approximately 3% of the papers analyzed). This indicates a route for new potential lines of research.

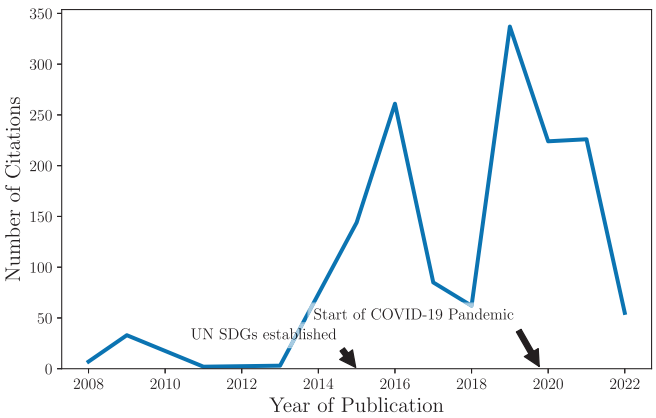

FIGURE 5 Number of citations by year that the papers of the sample had at the time of making this review (December 2022).

Finally, we argue that a reason behind the fact that the topics of "Circular Economy" and "Smart Cities" are not very researched in the context of social sustainability is that they could be thought of as having more relation to the Economic and Environmental aspects of Sustainability. Nevertheless, we believe that social sustainability should have an integral role in those technological areas too.

3.2.3 | Measured/measurable effects

In this section, we analyze the different types of effects that digital technologies can have on social sustainability. To consider the reviewed articles valid, the authors must have a description of the effects and their extent in terms of some form of data. After labeling the articles according to the different types of effects we identified in the literature (Table A3, in Appendix A), we can study the frequencies of these labels (Figure 7c). Relating the effects to the Sustainable Development Goals as explained in Section 2.2, the values of the label frequencies can be translated into a measure of the interest inside this research area on each of the SDGs (Figure 8).

The most frequently studied effects of digital technologies on societies we found is on "Inclusion, Inequality and Community formation," including both positive and negative aspects. On the positive side, we have promoting the inclusion of certain collectives, reduce inequalities in some area or help to form sustainable communities. On the negative, we have, for example, the digital divide, where technology reduces access of some collectives to certain services.

The second most prominent effect is the improvement or worsening of working conditions. Specific effects range from assessing ergonomics at the workplace to the reduction of physical workload. However, they can also create new ways of working that have their own problems, related to working conditions such as the phenomenon of video-conference fatigue (Döring et al., 2022).

Related to working conditions, we have the effects on Job Opportunities, related to the creation or loss of job positions as an effect of digital technologies. Even though this category is not as popular as

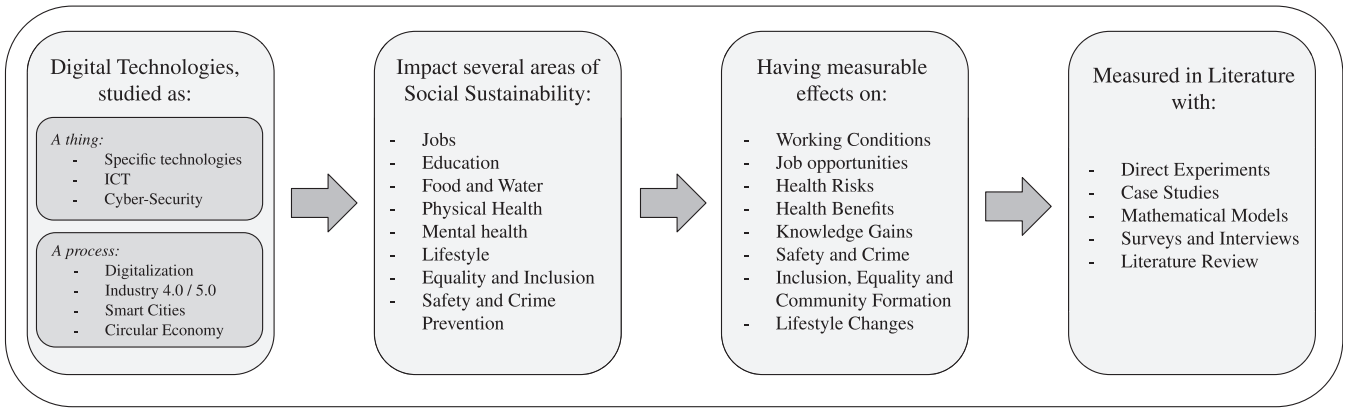

FIGURE 6 Conceptual foundation for reviewing the literature on the measurable effects of digital technologies on social sustainability.

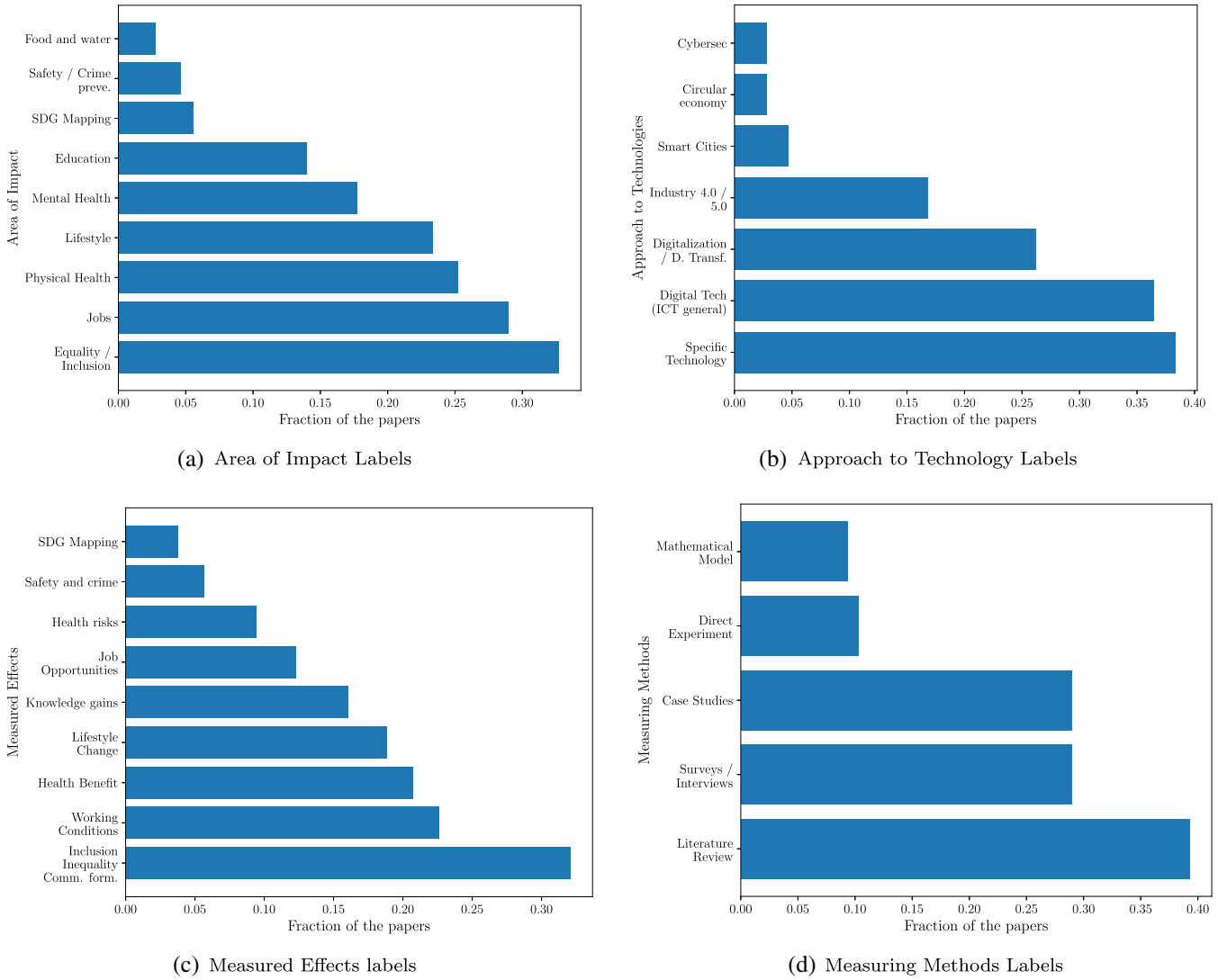

FIGURE 7 Label frequency for each of the four categories dedicated to answering the research questions about the impact of digital technologies on social sustainability.

the research on working conditions, both labels combined would account for about 31% of the reviewed papers.

Around 30% of the analyzed papers studied health-related effects. In fact, "Health Benefits" is the third most frequent label. This indicates that the view of the effects of technologies on human health is mostly positive, as very few papers (9.7%) were labeled as studies on "Health Risks." This could indicate the presence of a general bias in the literature, where the downsides of digital technologies might be downplayed and may need more research.

In the same fashion as before, the effects that digital technologies have on increasing or decreasing citizen safety or levels of crime seem to be a topic that needs more research.

Finally, a closer look at Figure 8 indicates that there are clear differences in the frequency of addressing the different SDGs in the selected literature. Given that SDG 9 is closely related to Economic Sustainability (apart from social sustainability), its relatively low popularity seems reasonable. However, Figure 8 shows clear deficiencies, especially in the research on the impact of Digital Technologies in Education from a social sustainability perspective. Aspects such as access to education and improvement of quality in education thanks to digital technologies should receive more attention. Apart from what is present in Figure 8, it is interesting to study what is not present there: in the analyzed sample, no study addressed the impacts of digital technologies on poverty (SDG 1) nor on contributing to ending World Hunger (SDG 2), issues that are related to social sustainability too.

3.2.4 | Measuring methods

When the impact of some technology on an aspect of social sustainability is described in a paper, the methods for assessing its nature and the extent the authors use change from study to study. Some authors choose to base their analysis on existing evidence in scientific literature and others take a more empirical approach. In this section, we classify the papers according to the methods they use (Table A4 in

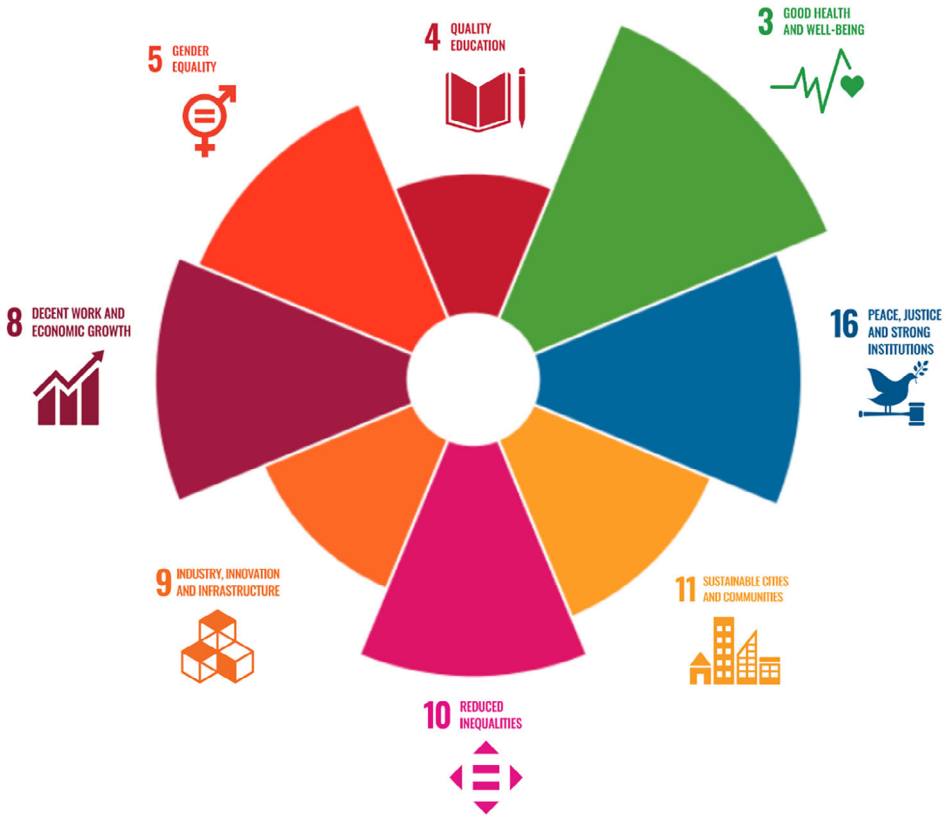

FIGURE 8 Research popularity of the effects of digital technologies on the different sustainable development goals.

Appendix A) and comment on the results from the frequency of use of these methods, presented in Figure 7d.

It is clear, from Figure 7d, that the preferred way of assessing an impact of technology on social sustainability is reviewing the existing literature. This label also applies to theoretical papers that describe some effects or some framework that the authors created using other articles to justify their claims. This is an indication of the difficulty of designing experiments or gathering data on specific impacts. In fact, only about 10% of the articles reviewed were based on an experiment, which suggests that there is a prominent need for empirical data on the Social aspect of Sustainability in relation to digital technologies.

Although case studies and interviews provide valuable data, it is not possible to systematize them. They are just isolated cases and personal experiences, embedded in the complexity of individual biases and external factors that are virtually impossible to account for completely. In order to discover more generalizable patterns and to achieve conclusions that could be applied in a broader context, more controlled experiments need to be performed.

Finally, we find that the research on mathematical modeling of the effects of digital technologies on society is scarce. This could point to new opportunities in social sustainability research.

4 | DISCUSSION AND FUTURE RESEARCH AGENDA

This section outlines several possible areas for future research, arising from this systematic review of the literature as well as frequent suggestions in the papers analyzed. We distil 20 sample research questions in Table 3, related to the five research gaps described below.

The first and most remarkable fact about the current state of research on the impacts of digital technologies on social sustainability is that there is a lack of empirical evidence. As explained in Section 3.2.4, direct experimentation is not very frequent, and most of the data used in the literature comes from surveys, interviews or case studies. In fact, we can find several calls for more empirical studies in the reviewed papers (e.g., Affolderbach & de Chardon, 2021; Ekener, 2019; Hervani et al., 2022; Hung et al., 2021; Palumbo et al., 2022; Tavares & Azevedo, 2022; Young et al., 2019), with specific examples such as "there is a need for more empirical studies and quantitative research" (in the context of Industry 4.0 and Sustainability) (Mastrocinque et al., 2022) or the remark from (Grybauskas et al., 2022) about the "sheer lack of empirical evidence on the positive or negative impacts of Industry 4.0 on social sustainability".

We also identify a need for more tools and metrics, mentioned in (Apaydin et al., 2018; García-Muiña et al., 2021; Grandi et al., 2021; Papetti, Gregori, et al., 2020; Somanath et al., 2021; Taj et al., 2019). This is in accordance with our findings, which indicate that the least common method used is mathematical modeling. Further research could develop applications based on mathematical modeling to quantify, evaluate and assess the impacts that digital technologies can have on different social sustainability aspects. Moreover, developing new or updated metrics is needed to feed the mathematical models and make these more comprehensive and precise.

Judging from the label-frequency results discussed in Section 3.2, the impact that digital technologies have on Safety and Crime needs

TABLE 3 Future research agenda for the impact of digital technologies on social sustainability.

Research gaps	Suggested research questions
Lack of empirical data on the impact of digital technologies on social sustainability.	1. Of the possible impacts that digital technologies have on societies and individuals, which can be assessed in an empirical way? 2. How can we gather data on social sustainability if it is not with surveys or interviews? 3. What experiments could be designed for measuring in a statistically significant way these impacts? 4. How could we convince researchers and institutions of the importance of gathering such data?
Lack of mathematical models and simulations.	5. How can we use mathematical modeling and simulations to assess, overall, if specific technologies have a positive or negative impact on (some aspect of) social sustainability? 6. What type of models could be used for studying social improvements or negative consequences of digital technologies? 7. What modeling approach is most suitable for the different technological approaches (Section 3.2.2)? 8. How could these models be assessed and tested? What kind of empirical evidence is needed for that purpose?
The impact on crime and safety is largely under-researched.	9. What are the specific negative consequences of the use of digital technologies and the transitions that we observe from such use on our general physical safety? 10. What could be the potential social impacts of cyber-attacks on critical infrastructure? Are the benefits of digitalization of critical infrastructure enough to accept the risk of suffering those impacts? 11. Since digital technologies can be used for crime prevention but also enable new types of crime (cybercrime), is it possible to assess the impacts of both types of crime and make a critical comparison? In other words, is the impact of the reduction in physical crime greater than the impact of the increase in cybercrime?
The benefits and drawbacks of digital technologies for Education are not given much attention in research.	12. In what ways can digital technologies be harnessed to provide universal quality education (SDG 4)? 13. Are there any negative impacts of digital technologies in the context of education? How do they compare to the positive ones? 14. What are the available technologies that could be used to reduce inequalities in access to education? 15. Digital technologies can help spread educational content to a wide audience instantly and without mobility requirements. Is there any change in the quality of the education received in this way with respect to traditional (*analog*) methods?
The negative impacts of digital technologies are often given less importance, especially when it comes to health.	16. Can digital technologies have noticeable negative health impacts? What areas of health, both physical and mental, could be affected? 17. How could the negative health effects of digital technologies be measured? 18. Do these effects change depending on the population segment studied? 19. What is the extent of these effects if the positive ones are taken into account? 20. Are digital technologies producing an increase in mental health issues?

more in-depth investigations. Several authors suggest this explicitly, with examples being: studying the societal implications of cyber-security (Ruoslahti & Davis, 2021), the risks of implementing digital technologies (Dobrolyubova, 2022), or the reasons behind cybercrime (Monteith et al., 2021).

Three more under-researched areas are made apparent by our study. First, the increase in access to education and recent shifts in teaching methods due to the use of digital technologies, need more studying from a social sustainability perspective. Furthermore, there is too little research that empirically measures the negative effects on mental health that digital technologies can have, especially when accounting for the high popularity of the research on the health benefits of digital technologies. More research is also needed on the societal impacts of the technology-enabled Circular Economy and Smart Cities. These topics are usually studied under the scope of Environmental Sustainability, but social sustainability should also be an integral part of these two research areas.

Finally, we identified several calls for interdisciplinary research initiatives (Begum et al., 2022; Ghobakhloo et al., 2022; Mabkhot et al., 2021), where experts from different fields address issues in this under-researched area.

To end this section, based on the results of this review, we propose a set of four steps that could help to develop future studies on the impacts of digital technologies on social sustainability in a systematic way (Figure 9). These steps are just intended as a possible procedure that arises from this study; it is not the goal of this paper to define a standard methodology.

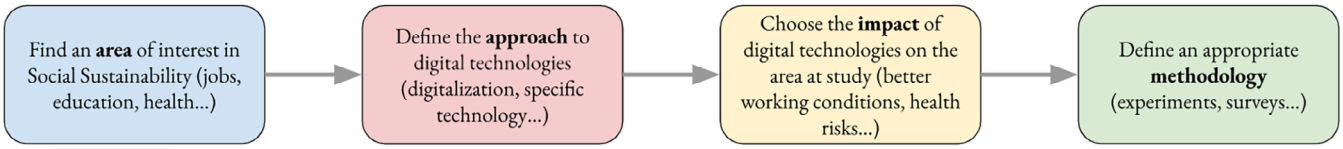

FIGURE 9 Proposed procedure for future research on the impacts of digital technologies on social sustainability.

For example, take the research question whether high usage of social media apps increases the incidence of insomnia in young adults. We define:

1. The area: Health;
2. The approach to technology: A specific set of technologies, namely social media apps;
3. The impact on Health: Health risks, concretely the increase in the incidence of insomnia;
4. The methodology: The study is restricted to a population of young adults. For example, it could be done through surveys and personal experience, or it could be done by tracking social media usage and sleep patterns of a sample of individuals from the population at study.

This procedure can help systematizing the production of social sustainability research in the context of digital technologies.

5 | CONCLUSION

Given that social sustainability is considered the least understood aspect of Sustainability, it is understandable that related research is scarce (even more if we consider measuring real impacts). We have analyzed the available literature on the impacts of digital technologies on social sustainability by addressing three research questions focused on the measurement of these impacts. In the process we have identified four categories of labels that we used to classify 107 papers.

The set of papers was first analyzed from a descriptive point of view, showing trends in the usage of keywords and possible explanations for the fluctuation in attention that social sustainability in the context of digital technologies had been given. As a result of this analysis, we found a growing interest in this research topic. Afterward, we answered the research questions by analyzing the content of the papers.

Regarding the first research question, we identified 9 areas of social sustainability where the effects of digital technologies are usually studied. The most prominent areas were "Equality and Inclusion" and "Health" (including both mental and physical health). The labor aspect of social sustainability is a frequent topic in the literature too.

For the second question, when studying the relationship between digital technologies and social sustainability, authors had two types of approaches: static (technologies "as a thing") and dynamic (technologies "as a process"). The static approach focused on the effects of a specific technology or digital technologies in general. In the dynamic approach, technologies are more in the background, understood as the foundation of a process, a type of evolution that has consequences on Society. This approach was less frequent and was characterized by the labels "Digitalization and Digital Transformation," "Industry 4.0/5.0," "Smart Cities," and "Circular Economy".

Answering the third question, the main impacts that were studied in the literature were differences in inclusion and levels of inequality as a result of digital technologies and the changes in working conditions. The impact on labor becomes more substantial when, together with "Working Conditions" we account for a variation in "Job Opportunities". The impacts on health were also given a reasonable amount of attention, focusing more on the benefits that digital technologies can bring, rather than on the risks they pose.

To finalize the answer to the third question, we found out that most of the studies are based on reviews of literature, followed by case studies and surveys or interviews. This shows a deficiency in empirical studies that could provide robust real-world data about several of the impacts described. There was also a lack of mathematical models for social sustainability.

5.1 | Implications for theory

With this paper, we add to the body of literature on the relationship between social sustainability and digital technologies. We portray the current state of the literature and identify trends in research in this area, as well as theoretical and methodological gaps that need to be addressed. By rigorously reviewing the available literature, we identified the main technological approaches, areas of social sustainability impacted, measurable effects of digital technologies, and measuring methods. Using these categories and their internal subcategories, we offer an organized view of the literature at study within a comprehensive framework (see Figure 6). Analyzing the prevalence of the internal subcategories, we identify the most common practices in the literature, revealing as well several research gaps and open problems (see Section 4). Two of the most prominent gaps reside in the scarcity of empirical studies and mathematical models, and the fact that quality education (SDG 4) is under-addressed in literature. We present a future research agenda in Table 3.

5.2 | Implications for practice

The practical contribution of this study is twofold. First, this paper provides practical guidelines for structuring research around the societal impacts of digital technologies (see Figure 9), in order to facilitate

addressing the several research gaps identified. The different stages of the process can be defined with the help of the subcategories resulting from this study, as shown in Figure 6.

A second contribution could come in the form of deciding what research to pursue and fund. As more research is needed in several areas (see Section 4), the decision to start, promote, and fund projects related to those areas could be guided in part by the results of this review. More research into the gaps identified, as well as focusing on the methodologies that are less used, can provide valuable tools for practitioners and policy makers, offering a more objective view of the pressing social issues related to digital technologies.

5.3 | Limitations of the study

The main limitation of this study is the review protocol. The results obtained when using a search string are always limited by the criteria used. Although we tried to be as inclusive as possible, narrowing the scope of the review with our choice of keywords necessarily limited the results of the search. Thus, it is possible that the sample of papers that had been reviewed could be highly influenced by our decisions while defining the search protocol, and there may be relevant studies that offer perspectives that had been left out unintentionally.

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REFERENCES

Abramova, S., Antonova, N., Campa, R., & Popova, N. (2022). Digital fears experienced by young people in the age of technoscience. *Changing Societies and Personalities*, *6*(1), 56–78. https://doi.org/10.15826/csp.2022.6.1.163

Affolderbach, J., & de Chardon, C. (2021). Just transitions through digitally enabled sharing economies? *Die Erde*, *152*(4), 244–259. https://doi.org/10.12854/erde-2021-569

Afshari, H., Agnihotri, S., Searcy, C., & Jaber, M. (2022). Social sustainability indicators: A comprehensive review with application in the energy sector. *Sustainable Production and Consumption*, *31*, 263–286. https://doi.org/10.1016/j.spc.2022.02.018

Alharthi, A., Spichkova, M., Hamilton, M., & Alsanoosy, T. (2018). Gender-based perspectives of elearning systems: An empirical study of social sustainability. In B. Andersson, B. Johansson, S. Carlsson, C. Barry, M. Lang, H. Linger, & C. Schneider (Eds.), *Designing digitalization (isd2018 proceedings)*. Lund University http://aisel.aisnet.org/isd2014/proceedings2018/Transforming/1

Apaydin, M., Bayraktar, E., & Hossary, M. (2018). Achieving economic and social sustainability through hyperconnectivity: A cross-country comparison. *Benchmarking*, *25*(9), 3607–3627. https://doi.org/10.1108/BIJ-07-2017-0205

Bahman, N. (2023). Airport sustainability through life cycle assessments: A systematic literature review. *Sustainable Development*, *31*(3), 1268–1277. https://doi.org/10.1002/sd.2498

Bai, C., Orzes, G., & Sarkis, J. (2022). Exploring the impact of industry 4.0 technologies on social sustainability through a circular economy approach. *Industrial Marketing Management*, *101*, 176–190. https://doi.org/10.1016/j.indmarman.2021.12.004

Balaman, Ş. Y. (2019). Chapter 4 – sustainability issues in biomass-based production chains. In Ş. Y. Balaman (Ed.), *Decision-making for biomass-based production chains* (pp. 77–112). Academic Press. https://doi.org/10.1016/B978-0-12-814278-3.00004-2

Barrett, M., Boyne, J., Brandts, J., Brunner-La Rocca, H.-P., De Maesschalck, L., De Wit, K., Dixon, L., Eurlings, C., Fitzsimons, D., Golubnitschaja, O., Hageman, A., Heemskerk, F., Hintzen, A., Helms, T., Hill, L., Hoedemakers, T., Marx, N., McDonald, K., Mertens, M., … Zippel-Schultz, B. (2019). Artificial intelligence supported patient self-care in chronic heart failure: A paradigm shift from reactive to predictive, preventive and personalised care. *EPMA Journal*, *10*(4), 445–464. https://doi.org/10.1007/s13167-019-00188-9

Batty, M., Axhausen, K. W., Giannotti, F., Pozdnoukhov, A., Bazzani, A., Wachowicz, M., Ouzounis, G., & Portugali, Y. (2012). Smart cities of the future. *The European Physical Journal Special Topics*, *214*, 481–518. https://doi.org/10.1140/epjst/e2012-01703-3

Begum, H., Abbas, K., Alam, A., Song, H., Chowdhury, M., & Abdul Ghani, A. (2022). Impact of the covid-19 pandemic on the environment and socioeconomic viability: A sustainable production chain alternative. *Foresight*, *24*(3–4), 456–475. https://doi.org/10.1108/FS-02-2021-0053

Bello-Bravo, J., Payumo, J., & Pittendrigh, B. (2021). Measuring the impact and reach of informal educational videos on youtube: The case of scientific animations without borders. *Heliyon*, *7*(12), e08508. https://doi.org/10.1016/j.heliyon.2021.e08508

Bensi, N., Bitelli, C., & Hoogerwerf, E.-J. (2011). Assistive technologies and other solutions for independence: Cost or investment? *Assistive Technology Research Series*, *29*, 270–277. https://doi.org/10.3233/978-1-60750-814-4-270

Bouzguenda, I., Alalouch, C., & Fava, N. (2019). Towards smart sustainable cities: A review of the role digital citizen participation could play in advancing social sustainability. *Sustainable Cities and Society*, *50*, 101627. https://doi.org/10.1016/j.scs.2019.101627

Boyer, R. H. W., Peterson, N. D., Arora, P., & Caldwell, K. (2016). Five approaches to social sustainability and an integrated way forward. *Sustainability*, *8*(9), 878. https://doi.org/10.3390/su8090878

Brennen, J. S., & Kreiss, D. (2016). Digitalization. In *The international encyclopedia of communication theory and philosophy* (pp. 1–11). John Wiley & Sons, Ltd. https://doi.org/10.1002/9781118766804.wbiect111

Brozzi, R., Forti, D., Rauch, E., & Matt, D. (2020). The advantages of industry 4.0 applications for sustainability: Results from a sample of manufacturing companies. *Sustainability (Switzerland)*, *12*(9), 3647. https://doi.org/10.3390/su12093647

Cappa, F., Rosso, F., & Capaldo, A. (2020). Visitor-sensing: Involving the crowd in cultural heritage organizations. *Sustainability (Switzerland)*, *12*(4), 1445. https://doi.org/10.3390/su12041445

Casal, J. P., & Ramos, A. C. (2017). E-government policies in health care: The social cost of digitalization. https://www.proquest.com/conference-papers-proceedings/e-government-policies-health-care-socialcost/docview/2213115242/se-2

Charmaraman, L., & Delcourt, C. G. (2021). Prototyping for social wellbeing with early social media users: Belonging, experimentation, and self-care. Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, 704. https://doi.org/10.1145/3411764.3445332

Chavalarias, D. (2016). The unlikely encounter between von foerster and snowden: When second-order cybernetics sheds light on societal impacts of big data. *Big Data & Society*, *3*(1). https://doi.org/10.1177/2053951715621086

Choi, S., & Ng, A. (2011). Environmental and economic dimensions of sustainability and price effects on consumer responses. *Journal of Business Ethics*, *104*(2), 269–282.

Chourasiya, R., Pandey, S., & Malviya, R. K. (2023). Sustainable manufacturing adoption in textile industries: A systematic state-of-art literature review and future research outline. *Sustainable Development*, *31*(2), 612–638. https://doi.org/10.1002/sd.2434

Chowdhury, G. (2013). Social sustainability of digital libraries: A research framework. Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics), 8279 LNCS, 25–34. https://doi.org/10.1007/978-3-319-03599-4_4

Cricelli, L., & Strazzullo, S. (2021). The economic aspect of digital sustainability: A systematic review. *Sustainability*, *13*(15), 8241. https://doi.org/10.3390/su13158241

Dalirazar, S., & Sabzi, Z. (2022). Barriers to sustainable development: Critical social factors influencing the sustainable building development based on swedish experts' perspectives. *Sustainable Development*, *30*(6), 1963–1974. https://doi.org/10.1002/sd.2362

Darko, A., & Chan, A. P. C. (2017). Review of barriers to green building adoption. *Sustainable Development*, *25*(3), 167–179. https://doi.org/10.1002/sd.1651

De Falco, C., & Romeo, E. (2021). ICT and social value co-creation during the Covid-19 emergency: The case of mascherinamica. In A. Visvizi, O. Troisi, & K. Saeedi (Eds.), *Research and Innovation Forum 2021* (pp. 3–12). Springer International Publishing. https://doi.org/10.1007/978-3-030-84311-3_1

De Felice, F., Travaglioni, M., & Petrillo, A. (2021). Innovation trajectories for a society 5.0. *Data*, *6*(11), 115. https://doi.org/10.3390/data6110115

de Fine Licht, K., & Folland, A. (2019). Defining "social sustainability": Towards a sustainable solution to the conceptual confusion. *Etikk i Praksis: Nordic Journal of Applied Ethics*, *13*(2), 21–39. https://doi.org/10.5324/eip.v13i2.2913

De la Calle, A., Pacheco-Costa, A., Gómez-Ruiz, M., & Guzmán-Simón, F. (2021). Understanding teacher digital competence in the framework of social sustainability: A systematic review. *Sustainability (Switzerland)*, *13*(23), 13283. https://doi.org/10.3390/su132313283

Dé, R. (2016). Societal impacts of information and communications technology. *IIMB Management Review*, *28*(2), 111–118. https://doi.org/10.1016/j.iimb.2016.04.002

Dempsey, N., Bramley, G., Power, S., & Brown, C. (2011). The social dimension of sustainable development: Defining urban social sustainability. *Sustainable Development*, *19*(5), 289–300. https://doi.org/10.1002/sd.417

Deng, X., Joshi, K., & Galliers, R. (2016). The duality of empowerment and marginalization in microtask crowdsourcing: Giving voice to the less powerful through value sensitive design1. *MIS Quarterly: Management Information Systems*, *40*(2), 279–302. https://doi.org/10.25300/MISQ/2016/40.2.01

Dobrolyubova, E. (2022). Evaluating digital government performance using surveys: International literature review and prospects for the future research. *Public Administration Issues*, *5*, 152–181. https://doi.org/10.17323/1999-5431-2022-0-5-152-181

Mc Donald Van Der Merwe, T. (2020). ICT use patterns, mental health symptoms and the well-being of the open distance learning student: A replication study with historically advantaged students. *International Journal of Learning Technology*, *15*(4), 360–383. https://doi.org/10.1504/IJLT.2020.113884

Döring, N., Moor, K. D., Fiedler, M., Schoenenberg, K., & Raake, A. (2022). Videoconference fatigue: A conceptual analysis. *International Journal of Environmental Research and Public Health*, *19*(4), 2061. https://doi.org/10.3390/ijerph19042061

Dula, A., & Güler, Ş. (2022). Exploring the role of digital social pressure on smartphone addiction [akıllı telefon bağımlılığı üzerinde dijital sosyal baskının rolünü keşfetmek]. *Cyprus Turkish Journal of Psychiatry and Psychology*, *4*(4), 306–314. https://doi.org/10.35365/ctjpp.22.4.01

Ekener, E. (2019). Social assessment of future scenarios: Developing and testing a new methodology covering consumption-related impacts with a focus on future ict societies. *Sustainable Production and Consumption*, *17*, 148–160. https://doi.org/10.1016/j.spc.2018.10.003

Elkjær, M. A., & Klitgaard, M. B. (2021). Economic inequality and political responsiveness: A systematic review. *Perspectives on Politics*, 1–20. https://doi.org/10.1017/S1537592721002188

García-Muiña, F., Medina-Salgado, M. S., González-Sánchez, R., Huertas-Valdivia, I., Ferrari, A. M., & Settembre-Blundo, D. (2021). Industry 4.0-based dynamic social organizational life cycle assessment to target the social circular economy in manufacturing. *Journal of Cleaner Production*, *327*, 129439. https://doi.org/10.1016/j.jclepro.2021.129439

García-Muiña, F., Medina-Salgado, M. S., González-Sánchez, R., Huertas-Valdivia, I., Ferrari, A. M., & Settembre-Blundo, D. (2022). Social organizational life cycle assessment (so-lca) and organization 4.0: An easy-toimplement method. *MethodsX*, *9*, 101692. https://doi.org/10.1016/j.mex.2022.101692

Genz, S., Janser, M., & Lehmer, F. (2019). The impact of investments in new digital technologies on wages – worker-level evidence from Germany. *Jahrbucher fur Nationalokonomie und Statistik*, *239*(3), 483–521. https://doi.org/10.1515/jbnst-2017-0161

Ghobakhloo, M., Iranmanesh, M., Mubarak, M. F., Mubarik, M., Rejeb, A., & Nilashi, M. (2022). Identifying industry 5.0 contributions to sustainable development: A strategy roadmap for delivering sustainability values. *Sustainable Production and Consumption*, *33*, 716–737.

Gordienko, Y., Stirenko, S., Alienin, O., Skala, K., Sojat, Z., Rojbi, A., López Benito, J., Artetxe González, E., Lushchyk, U., Sajn, L., Llorente Coto, A., & Jervan, G. (2017). Augmented coaching ecosystem for non-obtrusive adaptive personalized elderly care on the basis of cloud-fog-dew computing paradigm. 2017 40th International Convention on Information and Communication Technology, Electronics and Microelectronics (MIPRO), 359–364. https://doi.org/10.23919/MIPRO.2017.7973449

Grandi, F., Khamaisi, R., Peruzzini, M., Raffaeli, R., & Pellicciari, M. (2021). A reference framework to combine model-based design and AR to improve social sustainability. *Sustainability (Switzerland)*, *13*(4), 1–16. https://doi.org/10.3390/su13042031

Gregori, F., Papetti, A., Pandolfi, M., Peruzzini, M., & Germani, M. (2017). Digital manufacturing systems: A framework to improve social sustainability of a production site. *Procedia CIRP*, *63*, 436–442. https://doi.org/10.1016/j.procir.2017.03.113

Grybauskas, A., Stefanini, A., & Ghobakhloo, M. (2022). Social sustainability in the age of digitalization: A systematic literature review on the social implications of industry 4.0. *Technology in Society*, *70*, 101997. https://doi.org/10.1016/j.techsoc.2022.101997

Hervani, A., Nandi, S., Helms, M., & Sarkis, J. (2022). A performance measurement framework for socially sustainable and resilient supply chains using environmental goods valuation methods. *Sustainable Production and Consumption*, *30*, 31–52. https://doi.org/10.1016/j.spc.2021.11.026

Hilty, L., Lohmann, W., & Huang, E. M. (2011). Sustainability and ICT-an overview of the field. *Notizie di Politeia*, *27*(104), 13–28. https://doi.org/10.5167/uzh-55640

Hilty, L. M., & Aebischer, B. (2015). Ict for sustainability: An emerging research field. In L. Hilty & B. Aebischer (Eds.), *ICT innovations for sustainability*. Springer. https://doi.org/10.1007/978-3-319-09228-7_1

Hohn, M., & Durach, C. (2021). Additive manufacturing in the apparel supply chain—Impact on supply chain governance and social sustainability. *International Journal of Operations and Production Management*, *41*(7), 1035–1059. https://doi.org/10.1108/IJOPM-09-2020-0654

Hung, L.-P., Huang, W., Shih, J.-Y., & Liu, C.-L. (2021). A novel IoT based positioning and shadowing system for dementia training. *International Journal of Environmental Research and Public Health*, *18*(4), 1–21. https://doi.org/10.3390/ijerph18041610

Ihm, J., & Hsieh, Y. (2015). The implications of information and communication technology use for the social well-being of older adults. *Information Communication and Society*, *18*(10), 1123–1138. https://doi.org/10.1080/1369118X.2015.1019912

Ipinnaiye, O., & Olaniyan, F. (2023). An exploratory study of local social innovation initiatives for sustainable poverty reduction in Nigeria. *Sustainable Development*, *31*, 2222–2239. https://doi.org/10.1002/sd.2502

Isern, D., Moreno, A., Pedone, G., & Varga, L. (2008). An intelligent platform to provide home care services. Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics), 4924 LNAI, 149–160. https://doi.org/10.1007/978-3-540-78624-5_12

Jagemar, M., & Dodig-Crnkovic, G. (2015). Cognitively sustainable ICT with ubiquitous mobile services – Challenges and opportunities. Proceedings – International Conference on Software Engineering, 2, 531–540. https://doi.org/10.1109/ICSE.2015.189

Jatnika, R. (2019). Measurement of knowledge sharing in Jelekong Bandung Indonesia. *Humanities and Social Sciences Reviews*, *7*(5), 195–200. https://doi.org/10.18510/hssr.2019.7524

Jauhiainen, J., Özçürümez, S., & Tursun, Ö. (2022). Internet and social media uses, digital divides, and digitally mediated transnationalism in forced migration: Syrians in Turkey. *Global Networks*, *22*(2), 197–210. https://doi.org/10.1111/glob.12339

Kagermann, H., Lukas, W.-D., & Wahlster, W. (2011). Industrie 4.0: Mit dem internet der dinge auf dem weg zur 4. industriellen revolution. *VDI Nachrichten*, *13*(1), 2–3. https://www-live.dfki.de/fileadmin/user_upload/DFKI/Medien/News_Media/Presse/Presse-Highlights/vdinach2011a13-ind4.0-Internet-Dinge.pdf

Khizar, H. M. U., Iqbal, M. J., & Rasheed, M. I. (2021). Business orientation and sustainable development: A systematic review of sustainability orientation literature and future research avenues. *Sustainable Development*, *29*(5), 1001–1017. https://doi.org/10.1002/sd.2190

Kim, K.-J., Hassan, M. M., Na, S.-H., & Huh, E.-N. (2009). Dementia wandering detection and activity recognition algorithm using tri-axial accelerometer sensors. Proceedings of the 4th International Conference on Ubiquitous Information Technologies & Applications, 1–5. https://doi.org/10.1109/ICUT.2009.5405672

Kitchenham, B. (2004). Procedures for performing systematic reviews. *Keele, UK, Keele University*, *33*(2004), 1–26. https://www.inf.ufsc.br/~aldo.vw/kitchenham.pdf

Klier, J., Klier, M., Thiel, L., & Agarwal, R. (2019). Power of mobile peer groups: A design-oriented approach to address youth unemployment. *Journal of Management Information Systems*, *36*(1), 158–193. https://doi.org/10.1080/07421222.2018.1550557

Lasi, H., Fettke, P., Kemper, H.-G., Feld, T., & Hoffmann, M. (2014). Industry 4.0. *Business & Information Systems Engineering*, *6*(4), 239–242. https://doi.org/10.1007/s12599-014-0334-4

Liao, H.-T., & Huang, W.-Y. (2021). Marketing technologies in the agri-food industry: A scoping review of digital technologies for social and ecological sustainability. International Conference on Communication Technology Proceedings, ICCT, 2021-October, 829–833. https://doi.org/10.1109/ICCT52962.2021.9657939

Litsky, L., D'Antonio, S., & Bonnevie, E. (2022). An evaluation of the just five program, a flexible digital approach to adult substance use education. *PLoS One*, *17*(11), e0277112. https://doi.org/10.1371/journal.pone.0277112

Locatelli, P., Cirilli, F., Panno, E., Provenzano, S., Sanfilippo, R., & Casali, P. (2019). The role of the ict in process monitoring and system impact assessment of rare disease collaborative networks. Multi Conference on Computer Science and Information Systems, MCCSIS 2019 – Proceedings of the International Conference on e-Health 2019, 259–261. https://doi.org/10.33965/eh2019_201910p036

Loebach, J., Tilleczek, K., Chaisson, B., & Sharp, B. (2019). Keyboard warriors? Visualising technology and wellbeing with, for and by indigenous youth through digital stories. *Visual Studies*, *34*(3), 281–297. https://doi.org/10.1080/1472586X.2019.1691050

Loganathan, M. (2022). Assessing social sustainability in the gig economy. *The Indian Journal of Labour Economics*, *65*(3), 831–843. https://doi.org/10.1007/s41027-022-00399-1

Mabkhot, M., Ferreira, P., Maffei, A., Podržaj, P., Mądziel, M., Antonelli, D., Lanzetta, M., Barata, J., Boffa, E., Finžgar, M., Paśko, Ł., Minetola, P., Chelli, R., Nikghadam-Hojjati, S., Wang, X., Priarone, P., Litwin, P., Stadnicka, D., Lohse, N., & Lupi, F. (2021). Mapping industry 4.0 enabling technologies into united nations sustainability development goals. *Sustainability (Switzerland)*, *13*(5), 1–35. https://doi.org/10.3390/su13052560

Mark, B., Hofmayer, S., Rauch, E., & Matt, D. (2019). Inclusion of workers with disabilities in production 4.0: Legal foundations in europe and potentials through worker assistance systems. *Sustainability (Switzerland)*, *11*(21), 5978. https://doi.org/10.3390/su11215978

Marthick, M., McGregor, D., Alison, J., Cheema, B., Dhillon, H., & Shaw, T. (2021). Supportive care interventions for people with cancer assisted by digital technology: Systematic review. *Journal of Medical Internet Research*, *23*(10), e24722. https://doi.org/10.2196/24722

Martín, A., & Palomo Zurdo, R. (2021). Digital inability and social sustainability in the face of the fourth industrial revolution: A proposal of new non-financial indicators. *Sustainability (Switzerland)*, *13*(24), 13958. https://doi.org/10.3390/su132413958

Martin, C. J. (2016). The sharing economy: A pathway to sustainability or a nightmarish form of neoliberal capitalism? *Ecological Economics*, *121*, 149–159. https://doi.org/10.1016/j.ecolecon.2015.11.027

Mastrocinque, E., Ramírez, F., Honrubia-Escribano, A., & Pham, D. (2022). Industry 4.0 enabling sustainable supply chain development in the renewable energy sector: A multi-criteria intelligent approach. *Technological Forecasting and Social Change*, *182*, 121813. https://doi.org/10.1016/j.techfore.2022.121813

Mathenjwa, T., Adeagbo, O., Zuma, T., Dikgale, K., Zeitlin, A., Matthews, P., Seeley, J., Wyke, S., Tanser, F., Shahmanesh, M., & Blandford, A. (2020). Development and acceptability of a tablet-based app to support men to link to hiv care: Mixed methods approach. *JMIR mHealth and uHealth*, *8*(11), e17549. https://doi.org/10.2196/17549

Matinmikko-Blue, M., Yrjölä, S., Ahokangas, P., Ojutkangas, K., & Rossi, E. (2021). 6g and the un sdgs: Where is the connection? *Wireless Personal Communications*, *121*(2), 1339–1360. https://doi.org/10.1007/s11277-021-09058-y

Meneses Fernández, M., Santana Hernández, J., Martín Gutiérrez, J., Henríquez Escuela, M., & Rodríguez Fino, E. (2017). Using communication and visualization technologies with senior citizens to facilitate cultural access and self-improvement. *Computers in Human Behavior*, *66*, 329–344. https://doi.org/10.1016/j.chb.2016.10.001

Mesmar, S., Talhouk, R., Akik, C., Olivier, P., Elhajj, I., Elbassuoni, S., Armoush, S., Kalot, J., Balaam, M., Germani, A., & Ghattas, H. (2016). The impact of digital technology on health of populations affected by humanitarian crises: Recent innovations and current gaps. *Journal of Public Health Policy*, *37*, S167–S200. https://doi.org/10.1057/s41271-016-0040-1

Millard, J., Sorivelle, M., Deljanin, S., Unterfrauner, E., & Voigt, C. (2018). Is the maker movement contributing to sustainability? *Sustainability (Switzerland)*, *10*(7), 2212. https://doi.org/10.3390/su10072212

Mohideen, R. (2021). Technology for social well-being: Strengthening urban resilience in developing countries integrating infrastructure, energy, health and social inclusion. 2021 IEEE Conference on Norbert Wiener in the 21st Century (21CW), 1–9. https://doi.org/10.1109/21CW48944.2021.9532527

Mondejar, M., Avtar, R., Diaz, H., Dubey, R., Esteban, J., Gómez-Morales, A., Hallam, B., Mbungu, N., Okolo, C., Prasad, K., She, Q., & Garcia-Segura, S. (2021). Digitalization to achieve sustainable development goals: Steps towards a smart green planet. *Science of the Total Environment*, *794*, 148539. https://doi.org/10.1016/j.scitotenv.2021.148539

Monteith, S., Bauer, M., Alda, M., Geddes, J., Whybrow, P., & Glenn, T. (2021). Increasing cybercrime since the pandemic: Concerns for psychiatry. *Current Psychiatry Reports*, *23*(4), 18. https://doi.org/10.1007/s11920-021-01228-w

Ochara, N., & Mawela, T. (2015). Enabling social sustainability of e-participation through mobile technology. *Information Technology for Development*, *21*(2), 205–228. https://doi.org/10.1080/02681102.2013.833888

Okon, U. A. (2009). Information communication technology and sustainable communities in africa: The case of the niger delta region of nigeria. (Feb. 2009). 2009 International Conference on Information and Communication Technologies and Development (ICTD), 367–378. https://doi.org/10.1109/ICTD.2009.5426690

Ono, T., Iida, K., & Yamazaki, S. (2017). Achieving sustainable development goals (SDGs) through ICT services. *Fujitsu Scientific and Technical Journal*, *53*(6), 17–22.

Oruç, S., & Yeralan, S. (2020). A meta-study on future work in information and communication technologies. *Heritage and Sustainable Development*, *2*(2), 114–122. https://doi.org/10.37868/hsd.v2i2.52

Palm, K., Bergman, A., & Rosengren, C. (2020). Towards more proactive sustainable human resource management practices? A study on stress due to the ict-mediated integration of work and private life. *Sustainability (Switzerland)*, *12*(20), 1–13. https://doi.org/10.3390/su12208303

Palumbo, R., Casprini, E., & Montera, R. (2022). Making digitalization work: Unveiling digitalization's implications on psycho-social risks at work. *Total Quality Management & Business Excellence*, 1–22. https://doi.org/10.1080/14783363.2022.2055458

Papadopoulos, T., & Broadbent, R. (2009). Reducing the digital divide: An evaluation framework for the wired community@collingwood project. Creating Global Economies through Innovation and Knowledge Management Theory and Practice – Proceedings of the 12th International Business Information Management Association Conference, IBIMA 2009, 1–3, 701–709. https://vuir.vu.edu.au/4181

Papetti, A., Gregori, F., Pandolfi, M., Peruzzini, M., & Germani, M. (2018). Iot to enable social sustainability in manufacturing systems. *Advances in Transdisciplinary Engineering*, *7*, 53–62. https://doi.org/10.3233/978-1-61499-898-3-53

Papetti, A., Gregori, F., Pandolfi, M., Peruzzini, M., & Germani, M. (2020). A method to improve workers' wellbeing toward human-centered connected factories. *Journal of Computational Design and Engineering*, *7*(5), 630–643. https://doi.org/10.1093/jcde/qwaa047

Papetti, A., Pandolfi, M., Peruzzini, M., & Germani, M. (2020). A framework to promote social sustainability in industry 4.0. *International Journal of Agile Systems and Management*, *13*(3), 233–257. https://doi.org/10.1504/IJASM.2020.109243

Park, J., Kim, J., & Lee, B. (2016). Which tasks will technology take? A new systematic methodology to measure task automation. 2016 International Conference on Information Systems, ICIS 2016. https://core.ac.uk/download/pdf/301373552.pdf

Pathak, A., Issarny, V., & Holston, J. (2015). Appcivist – A service-oriented software platform for socially sustainable activism. Proceedings – International Conference on Software Engineering, 2, 515–518. https://doi.org/10.1109/ICSE.2015.185

Patón-Romero, J., & Jaccheri, L. (2021). Huge2: An interdisciplinary research program for sustainability. Proceedings – 2021 IEEE International Conference on Big Data, Big Data 2021, 4303–4306. https://doi.org/10.1109/BigData52589.2021.9671375

Pick, J., & Sarkar, A. (2016). Theories of the digital divide: Critical comparison. Proceedings of the Annual Hawaii International Conference on System Sciences, 2016-March, 3888–3897. https://doi.org/10.1109/HICSS.2016.484

Pierrehumbert, R. (2019). There is no plan b for dealing with the climate crisis. *Bulletin of the Atomic Scientists*, *75*(5), 215–221. https://doi.org/10.1080/00963402.2019.1654255

Pinzone, M., Albè, F., Orlandelli, D., Barletta, I., Berlin, C., Johansson, B., & Taisch, M. (2020). A framework for operative and social sustainability functionalities in human-centric cyber-physical production systems. *Computers and Industrial Engineering*, *139*, 105132. https://doi.org/10.1016/j.cie.2018.03.028

Prause, L. (2021). Digital agriculture and labor: A few challenges for social sustainability. *Sustainability (Switzerland)*, *13*(11), 5980. https://doi.org/10.3390/su13115980

Purvis, B., Mao, Y., & Robinson, D. (2019). Three pillars of sustainability: In search of conceptual origins. *Sustainability Science*, *14*(3), 681–695. https://doi.org/10.1007/s11625-018-0627-5

Ramvi, E., Gripsrud, B., Hellstrand, I., Gjerstad, B., & Vagli, Å. (2021). Caring futures: A study protocol for transdisciplinary qualitative research on technology-mediated care practices and theory development for ethics of care. *BMJ Open*, *11*(9), e054458. https://doi.org/10.1136/bmjopen-2021-054458

Regan, E. (2022). Changing the research paradigm for digital transformation in healthcare delivery. *Frontiers in Digital Health*, *4*, 911634. https://doi.org/10.3389/fdgth.2022.911634

Rodrigues, I., Schreier, C., Steiner, E., & Zemp, M. (2021). Shifting to gig labour: Perceptions of sustainability. *ABAC Journal*, *41*(4), 247–271. https://doi.org/10.14456/abacj.2021.12

Rosado, M., Abásolo, M., & Silva, T. (2020). ICT oriented to the elderly and their active aging: A systematic review. Communications in Computer and Information Science, 1202 CCIS, 134–155. https://doi.org/10.1007/978-3-030-56574-9_9

Rosário, A., & Dias, J. (2022). Sustainability and the digital transition: A literature review. *Sustainability (Switzerland)*, *14*(7), 4072. https://doi.org/10.3390/su14074072

Ruoslahti, H., & Davis, B. (2021). Societal impacts of cyber security assets of project echo. *WSEAS Transactions on Environment and Development*, *17*, 1274–1283. https://doi.org/10.37394/232015.2021.17.116

Ryghaug, M. (2011). Obstacles to sustainable development: The destabilization of climate change knowledge. *Sustainable Development*, *19*(3), 157–166. https://doi.org/10.1002/sd.431

Sá, M., Santos, A., Serpa, S., & Ferreira, C. (2021). Digitainability—Digital competences post-covid-19 for a sustainable society. *Sustainability (Switzerland)*, *13*(17), 9564. https://doi.org/10.3390/su13179564

Şad, S., Konca, A., Özer, N., & Acar, F. (2016). Parental e-nvolvement: A phenomenological research on electronic parental involvement. *International Journal of Pedagogies and Learning*, *11*(2), 163–186. https://doi.org/10.1080/22040552.2016.1227255

Scafà, M., Papetti, A., Brunzini, A., & Germani, M. (2019). How to improve worker's well-being and company performance: A method to identify effective corrective actions. *Procedia CIRP*, *81*, 162–167. https://doi.org/10.1016/j.procir.2019.03.029

Schaberreiter, T., Caldeira, F., Aubert, J., Monteiro, E., Khadraoui, D., & Simões, P. (2013). Assurance and trust indicators to evaluate accuracy of on-line risk in critical infrastructures. Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics), 6983 LNCS, 30–41. https://doi.org/10.1007/978-3-642-41476-3_3

Sendlhofer, T., & Lernborg, C. (2018). Labour rights training 2.0: The digitalisation of knowledge for workers in global supply chains. *Journal of Cleaner Production*, *179*, 616–630. https://doi.org/10.1016/j.jclepro.2017.12.173

Shaw, M., Majumdar, A., & Govindan, K. (2022). Barriers of social sustainability: An improved interpretive structural model of indian textile and clothing supply chain. *Sustainable Development*, *30*(6), 1616–1633. https://doi.org/10.1002/sd.2331

Somanath, S., Hollberg, A., & Thuvander, L. (2021). Towards digitalisation of socially sustainable neighbourhood design. *Local Environment*, *26*(6), 770–789. https://doi.org/10.1080/13549839.2021.1923002

Sparviero, S., & Ragnedda, M. (2021). Towards digital sustainability: The long journey to the sustainable development goals 2030. *Digital Policy, Regulation and Governance*, *23*(3), 216–228. https://doi.org/10.1108/DPRG-01-2021-0015

Stavdas, A. (2022). Networked intelligence a wider fusion of technologies that spurs the fourth industrial revolution-part I: Foundations. *World Review of Political Economy*, *12*(2), 220–235. https://doi.org/10.13169/WORLREVIPOLIECON.12.2.0220

Stojanova, S., Cvar, N., Verhovnik, J., Božić, N., Trilar, J., Kos, A., & Stojmenova Duh, E. (2022). Rural digital innovation hubs as a paradigm for sustainable business models in europe's rural areas. *Sustainability (Switzerland)*, *14*(21), 14620. https://doi.org/10.3390/su142114620

Stuermer, M., Abu-Tayeh, G., & Myrach, T. (2017). Digital sustainability: Basic conditions for sustainable digital artifacts and their ecosystems. *Sustainability Science*, *12*(2), 247–262. https://doi.org/10.1007/s11625-016-0412-2

Sultana, S., Mandel, I., Hasan, S., Alam, S., Mahmud, K., Sultana, Z., & Ahmed, S. (2021). Opaque obstacles: The role of stigma, rumor, and superstition in limitingwomen's access to computing in rural Bangladesh. Proceedings of 2021 4th ACM SIGCAS Conference on Computing and Sustainable Societies, COMPASS 2021, 243–260. https://doi.org/10.1145/3460112.3471960

Taj, F., Klein, M., & Van Halteren, A. (2019). Digital health behavior change technology: Bibliometric and scoping review of two decades of research. *JMIR mHealth and uHealth*, *7*(12), e13311. https://doi.org/10.2196/13311

Tavares, M., & Azevedo, G. (2022). Contribution of industry 4.0 technologies to social responsibility and sustainability. Iberian Conference on Information Systems and Technologies, CISTI, 2022-June. https://doi.org/10.23919/CISTI54924.2022.9820334

Tenali, S., & McManus, P. (2022). Climate change acknowledgment to promote sustainable development: A critical discourse analysis of local action plans in coastal Florida. *Sustainable Development*, *30*(5), 1072–1085.

Tomlinson, M., & Lund, C. (2012). Why does mental health not get the attention it deserves? An application of the shiffman and smith framework. *PLoS Medicine*, *9*(2), e1001178. https://doi.org/10.1371/journal.pmed.1001178

Trencher, G., & Karvonen, A. (2019). Stretching "smart": Advancing health and well-being through the smart city agenda. *Local Environment*, *24*(7), 610–627. https://doi.org/10.1080/13549839.2017.1360264

Tseng, S.-F., & Hsieh, Y. (2015). The implications of networked individualism for social participation: How mobile phone, e-mail, and im networks afford social participation for rural residents in Taiwan. *American Behavioral Scientist*, *59*(9), 1157–1172. https://doi.org/10.1177/0002764215580620

Van Dijk, J. A. (2006). Digital divide research, achievements and shortcomings. *Poetics*, *34*(4–5), 221–235. https://doi.org/10.1016/j.poetic.2006.05.004

Vogiatzaki, M., Zerefos, S., & Tania, M. (2020). Enhancing city sustainability through smart technologies: A framework for automatic pre-emptive action to promote safety and security using lighting and ict-based surveillance. *Sustainability (Switzerland)*, *12*(15), 6142. https://doi.org/10.3390/su12156142

Walker, R., Usher, K., Jackson, D., Reid, C., Hopkins, K., Shepherd, C., Smallwood, R., & Marriott, R. (2021). Connection to… addressing digital inequities in supporting the well-being of young Indigenous Australians in the wake of COVID-19. *International Journal of Environmental Research and Public Health*, *18*(4), 1–14. https://doi.org/10.3390/ijerph18042141

Walker, S. K., & Brown, R. L. (2020). Critical thinking on technology use: Higher education course design to promote personal, professional and societal change. 6th International Conference on Higher Education Advances, HEAd 2020, 1391–1398. https://doi.org/10.4995/HEAd20.2020.11300

WCED, S. W. S. (1987). World commission on environment and development. *Our Common Future*, *17*(1), 1–91.

Weber, R., Braun, J., & Frank, M. (2022). How does the adoption of digital technologies affect the social sustainability of small-scale agriculture in south-west Germany? *International Journal on Food System Dynamics*, *13*(3), 275–293. https://doi.org/10.18461/ijfsd.v13i3.C3

Webster, C., & Leleux, C. (2019). Searching for the real sustainable smart city? *Information Polity*, *24*(3), 229–244. https://doi.org/10.3233/IP-190132

Widdicks, K., Remy, C., Bates, O., Friday, A., & Hazas, M. (2022). Escaping unsustainable digital interactions: Toward "more meaningful" and "moderate" online experiences. *International Journal of Human Computer Studies*, *165*, 102853. https://doi.org/10.1016/j.ijhcs.2022.102853

Wut, T. M., Lee, D., Ip, W. M., & Lee, S. W. (2021). Digital sustainability in the organization: Scale development and validation. *Sustainability*, *13*(6), 3530. https://doi.org/10.3390/su13063530

Xia, H., Ye, P., Jasimuddin, S. M., & Zhang, J. Z. (2022). Evolution of digital transformation in traditional enterprises: Evidence from China. *Technology Analysis & Strategic Management*, 1–21. https://doi.org/10.1080/09537325.2022.2124909

Xu, X., Lu, Y., Vogel-Heuser, B., & Wang, L. (2021). Industry 4.0 and industry 5.0—Inception, conception and perception. *Journal of Manufacturing Systems*, *61*, 530–535. https://doi.org/10.1016/j.jmsy.2021.10.006

Ye, J. (2021). Advancing mental health and psychological support for health care workers using digital technologies and platforms. *JMIR Formative Research*, *5*(6), e22075. https://doi.org/10.2196/22075

Yoon, S., Goh, H., Nadarajan, G., Sung, S., Teo, I., Lee, J., Ong, M., Graves, N., & Teo, T. (2021). Perceptions of mobile health apps and features to support psychosocial well-being among frontline health care workers involved in the covid-19 pandemic response: Qualitative study. *Journal of Medical Internet Research*, *23*(5), e26282. https://doi.org/10.2196/26282

Young, A., Selander, L., & Vaast, E. (2019). Digital organizing for social impact: Current insights and future research avenues on collective action, social movements, and digital technologies. *Information and Organization*, *29*, 3. https://doi.org/10.1016/j.infoandorg.2019.100257

Zarra, A., Simonelli, F., Lenaerts, K., Luo, M., Baiocco, S., Shenglin, B., Li, W., Echikson, W., & Kilhoffer, Z. (2019). Sustainability in the age of platforms. https://ssrn.com/abstract=3610672

Zavratnik, V., Podjed, D., Trilar, J., Hlebec, N., Kos, A., & Duh, E. (2020). Sustainable and community-centred development of smart cities and villages. *Sustainability (Switzerland)*, *12*(10), 3961. https://doi.org/10.3390/SU12103961

SUPPORTING INFORMATION

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APPENDIX A: COMPLETE LIST OF REVIEWED ARTICLES CLASSIFIED

In this section, we present the tables containing the reviewed articles classified according to their labels for each of the four thematic categories analyzed.

TABLE A1 Reviewed articles categorized according to the studied area of social sustainability impacted by digital technologies.

Area of impact	Related papers
Equality and inclusion	Affolderbach & de Chardon, 2021; Alharthi et al., 2018; Apaydin et al., 2018; Bensi et al., 2011; Bouzguenda et al., 2019; Casal & Ramos, 2017; Charmaraman & Delcourt, 2021; Chavalarias, 2016; Chowdhury, 2013; Dé, 2016; Deng et al., 2016; Dobrolyubova, 2022; Ekener, 2019; Grybauskas et al., 2022; Ihm & Hsieh, 2015; Jauhiainen et al., 2022; Loebach et al., 2019; Mark et al., 2019; Mastrocinque et al., 2022; Meneses Fernández et al., 2017; Millard et al., 2018; Mohideen, 2021; Ochara & Mawela, 2015; Okon, 2009; Papadopoulos & Broadbent, 2009; Patón-Romero & Jaccheri, 2021; Pick & Sarkar, 2016; Rosário & Dias, 2022; Somanath et al., 2021; Stojanova et al., 2022; Sultana et al., 2021; Tseng & Hsieh, 2015; R. Walker et al., 2021; Webster & Leleux, 2019; Zavratnik et al., 2020
Jobs	Begum et al., 2022; Brozzi et al., 2020; De Falco & Romeo, 2021; Deng et al., 2016; García-Muiña et al., 2021, 2022; Genz et al., 2019; Ghobakhloo et al., 2022; Grandi et al., 2021; Gregori et al., 2017; Grybauskas et al., 2022; Hohn & Durach, 2021; Klier et al., 2019; Loganathan, 2022; Martín & Palomo Zurdo, 2021; Mastrocinque et al., 2022; Palumbo et al., 2022; Papadopoulos & Broadbent, 2009; Papetti et al., 2018, Papetti, Gregori, et al., 2020, Papetti, Pandolfi, et al., 2020; Park et al., 2016; Pinzone et al., 2020; Prause, 2021; Rodrigues et al., 2021; Scafà et al., 2019; Sendlhofer & Lernborg, 2018; Sparviero & Ragnedda, 2021; Stojanova et al., 2022; Tavares & Azevedo, 2022; Weber et al., 2022; Xia et al., 2022
Lifestyle	Affolderbach & de Chardon, 2021; Bensi et al., 2011; Charmaraman & Delcourt, 2021; Chavalarias, 2016; Chowdhury, 2013; De Felice et al., 2021; Dobrolyubova, 2022; Ghobakhloo et al., 2022; Hervani et al., 2022; Jagemar & Dodig-Crnkovic, 2015; Meneses Fernández et al., 2017; Ochara & Mawela, 2015; Okon, 2009; Oruç & Yeralan, 2020; Pathak et al., 2015; Şad et al., 2016; Schaberreiter et al., 2013; Sparviero & Ragnedda, 2021; Stavdas, 2022; Taj et al., 2019; Tseng & Hsieh, 2015; Webster & Leleux, 2019; Widdicks et al., 2022; Young et al., 2019; Zavratnik et al., 2020
Physical health	Abramova et al., 2022; Barrett et al., 2019; Begum et al., 2022; Casal & Ramos, 2017; Ekener, 2019; Gordienko et al., 2017; Gregori et al., 2017; Hervani et al., 2022; Isern et al., 2008; Kim et al., 2009; Liao & Huang, 2021; Litsky et al., 2022; Locatelli et al., 2019; Marthick et al., 2021; Mathenjwa et al., 2020; Mesmar et al., 2016; Mondejar et al., 2021; Papetti, Gregori, et al., 2020; Papetti, Pandolfi, et al., 2020; Pinzone et al., 2020; Ramvi et al., 2021; Regan, 2022; Rosado et al., 2020; Scafà et al., 2019; Taj et al., 2019; Trencher & Karvonen, 2019; R. Walker et al., 2021
Mental health	Abramova et al., 2022; Dula & Güler, 2022; Gordienko et al., 2017; Hung et al., 2021; Jagemar & Dodig-Crnkovic, 2015; Kim et al., 2009; Loebach et al., 2019; Marthick et al., 2021; Mc Donald Van Der Merwe, 2020; Monteith et al., 2021; Palm et al., 2020; Palumbo et al., 2022; Papetti, Pandolfi, et al., 2020; Pinzone et al., 2020; Şad et al., 2016; R. Walker et al., 2021; Widdicks et al., 2022; Ye, 2021; Yoon et al., 2021
Education	Alharthi et al., 2018; Apaydin et al., 2018; Bello-Bravo et al., 2021; Cappa et al., 2020; De la Calle et al., 2021; Grybauskas et al., 2022; Jatnika, 2019; Meneses Fernández et al., 2017; Okon, 2009; Papadopoulos & Broadbent, 2009; Ruoslahti & Davis, 2021; Sá et al., 2021; Şad et al., 2016; Sendlhofer & Lernborg, 2018; Sultana et al., 2021
SDG mapping	Bai et al., 2022; García-Muiña et al., 2021; Mabkhot et al., 2021; Matinmikko-Blue et al., 2021; Mondejar et al., 2021; Ono et al., 2017
Safety and crime prevention	Mohideen, 2021; Okon, 2009; Ruoslahti & Davis, 2021; Schaberreiter et al., 2013; Vogiatzaki et al., 2020
Food and water	Hervani et al., 2022; Liao & Huang, 2021; Mondejar et al., 2021

TABLE A2 Reviewed articles categorized according to the approach or aspect of digital technologies studied.

Approach to technology	Related papers
Specific technology	Affolderbach & de Chardon, 2021; Alharthi et al., 2018; Barrett et al., 2019; Bello-Bravo et al., 2021; Bensi et al., 2011; Cappa et al., 2020; Charmaraman & Delcourt, 2021; Chowdhury, 2013; De Falco & Romeo, 2021; Gordienko et al., 2017; Grandi et al., 2021; Gregori et al., 2017; Hervani et al., 2022; Hohn & Durach, 2021; Hung et al., 2021; Isern et al., 2008; Kim et al., 2009; Klier et al., 2019; Litsky et al., 2022; Loebach et al., 2019; Marthick et al., 2021; Mastrocinque et al., 2022; Mathenjwa et al., 2020; Matinmikko-Blue et al., 2021; Meneses Fernández et al., 2017; Mesmar et al., 2016; Ochara & Mawela, 2015; Palm et al., 2020; Papetti et al., 2018, Papetti, Gregori, et al., 2020, Papetti, Pandolfi, et al., 2020; Pathak et al., 2015; Ramvi et al., 2021; Ruoslahti & Davis, 2021; Sendlhofer & Lernborg, 2018; Somanath et al., 2021; Stojanova et al., 2022; Trencher & Karvonen, 2019; Vogiatzaki et al., 2020; R. Walker et al., 2021; Ye, 2021; Yoon et al., 2021
ICT and digital technologies in general	Abramova et al., 2022; Apaydin et al., 2018; Chavalarias, 2016; Dé, 2016; De Falco & Romeo, 2021; De la Calle et al., 2021; Dula & Güler, 2022; Ekener, 2019; Ihm & Hsieh, 2015; Jagemar and Dodig- Crnkovic, 2015; Jatnika, 2019; Jauhiainen et al., 2022; Liao & Huang, 2021; Locatelli et al., 2019; Mc Donald Van Der Merwe, 2020; Mesmar et al., 2016; Millard et al., 2018; Mohideen, 2021; Mondejar et al., 2021; Okon, 2009; Ono et al., 2017; Oruç & Yeralan, 2020; Palumbo et al., 2022; Papadopoulos & Broadbent, 2009; Patón-Romero & Jaccheri, 2021; Pick & Sarkar, 2016; Pinzone et al., 2020; Ramvi et al., 2021; Rosado et al., 2020; Sá et al., 2021; Şad et al., 2016; Somanath et al., 2021; Sparviero & Ragnedda, 2021; Sultana et al., 2021; Taj et al., 2019; Tseng & Hsieh, 2015; Widdicks et al., 2022; Young et al., 2019; Zavratnik et al., 2020
Digitalization and digital transformation	Affolderbach & de Chardon, 2021; Begum et al., 2022; Bouzguenda et al., 2019; Casal & Ramos, 2017; Chowdhury, 2013; Deng et al., 2016; Dobrolyubova, 2022; Genz et al., 2019; Hervani et al., 2022; Isern et al., 2008; Klier et al., 2019; Loganathan, 2022; Ochara & Mawela, 2015; Palumbo et al., 2022; Papetti, Pandolfi, et al., 2020; Park et al., 2016; Pathak et al., 2015; Patón-Romero & Jaccheri, 2021; Prause, 2021; Regan, 2022; Rodrigues et al., 2021; Rosário & Dias, 2022; Schaberreiter et al., 2013; Taj et al., 2019; Trencher & Karvonen, 2019; Weber et al., 2022; Webster & Leleux, 2019; Xia et al., 2022
Industry 4.0/5.0	Bai et al., 2022; Begum et al., 2022; Brozzi et al., 2020; De Felice et al., 2021; García-Muiña et al., 2021, 2022; Ghobakhloo et al., 2022; Gregori et al., 2017; Grybauskas et al., 2022; Mabkhot et al., 2021; Mark et al., 2019; Martín & Palomo Zurdo, 2021; Papetti et al., 2018, Papetti, Gregori, et al., 2020; Papetti, Pandolfi, et al., 2020; Scafà et al., 2019; Stavdas, 2022; Tavares & Azevedo, 2022
Smart cities	Bouzguenda et al., 2019; Pinzone et al., 2020; Trencher & Karvonen, 2019; Webster & Leleux, 2019; Zavratnik et al., 2020
Circular economy	Bai et al., 2022; García-Muiña et al., 2021; Rosário & Dias, 2022
Cyber-security	Monteith et al., 2021; Ruoslahti & Davis, 2021; Schaberreiter et al., 2013

TABLE A3 Reviewed articles categorized according to the described (measurable) effect that digital technologies have on some area of social sustainability.

Measured/measurable effects	Related papers
Inclusion, inequality and community formation	Affolderbach & de Chardon, 2021; Alharthi et al., 2018; Apaydin et al., 2018; Bensi et al., 2011; Bouzguenda et al., 2019; Casal & Ramos, 2017; Charmaraman & Delcourt, 2021; Chavalarias, 2016; Chowdhury, 2013; Dé, 2016; De la Calle et al., 2021; Deng et al., 2016; Dobrolyubova, 2022; Ekener, 2019; Grybauskas et al., 2022; Ihm & Hsieh, 2015; Jauhiainen et al., 2022; Loebach et al., 2019; Mark et al., 2019; Mastrocinque et al., 2022; Millard et al., 2018; Ochara & Mawela, 2015; Okon, 2009; Papadopoulos & Broadbent, 2009; Pathak et al., 2015; Patón-Romero & Jaccheri, 2021; Pick & Sarkar, 2016; Rosário & Dias, 2022; Stojanova et al., 2022; Sultana et al., 2021; Tseng & Hsieh, 2015; R. Walker et al., 2021; Webster & Leleux, 2019; Zavratnik et al., 2020
Working conditions	Begum et al., 2022; Brozzi et al., 2020; Deng et al., 2016; García-Muiña et al., 2021, 2022; Genz et al., 2019; Grandi et al., 2021; Gregori et al., 2017; Grybauskas et al., 2022; Hohn & Durach, 2021; Loganathan, 2022; Martín & Palomo Zurdo, 2021; Mastrocinque et al., 2022; Mondejar et al., 2021; Palumbo et al., 2022; Papetti et al., 2018, Papetti, Gregori, et al., 2020; Papetti, Pandolfi, et al., 2020; Pinzone et al., 2020; Prause, 2021; Rodrigues et al., 2021; Sendlhofer & Lernborg, 2018; Tavares & Azevedo, 2022; Weber et al., 2022; Xia et al., 2022
Health benefit	Barrett et al., 2019; Begum et al., 2022; Dula & Güler, 2022; Ekener, 2019; Gordienko et al., 2017; Hervani et al., 2022; Hung et al., 2021; Isern et al., 2008; Kim et al., 2009; Locatelli et al., 2019; Marthick et al., 2021; Mathenjwa et al., 2020; Mesmar et al., 2016; Mondejar et al., 2021; Ramvi et al., 2021; Rosado et al., 2020; Scafà et al., 2019; Taj et al., 2019; Trencher & Karvonen, 2019; Tseng & Hsieh, 2015; Ye, 2021; Yoon et al., 2021
Lifestyle change	Bensi et al., 2011; Charmaraman & Delcourt, 2021; Chavalarias, 2016; De Felice et al., 2021; Dobrolyubova, 2022; Dula & Güler, 2022; Ghobakhloo et al., 2022; Grybauskas et al., 2022; Hervani et al., 2022; Ihm & Hsieh, 2015; Jagemar & Dodig-Crnkovic, 2015; Meneses Fernández et al., 2017; Okon, 2009; Oruç & Yeralan, 2020; Pathak et al., 2015; Sá et al., 2021; Sparviero & Ragnedda, 2021; Stavdas, 2022; Widdicks et al., 2022; Young et al., 2019
Knowledge gains	Bello-Bravo et al., 2021; Cappa et al., 2020; Chowdhury, 2013; García-Muiña et al., 2021; Jatnika, 2019; Litsky et al., 2022; Martín & Palomo Zurdo, 2021; Meneses Fernández et al., 2017; Papadopoulos & Broadbent, 2009; Regan, 2022; Ruoslahti & Davis, 2021; Sá et al., 2021; Şad et al., 2016; Scafà et al., 2019; Sendlhofer & Lernborg, 2018; Somanath et al., 2021; Sultana et al., 2021
Job opportunities	De Falco & Romeo, 2021; De la Calle et al., 2021; Deng et al., 2016; Genz et al., 2019; Ghobakhloo et al., 2022; Grybauskas et al., 2022; Klier et al., 2019; Mark et al., 2019; Mastrocinque et al., 2022; Papadopoulos & Broadbent, 2009; Park et al., 2016; Tavares & Azevedo, 2022; Weber et al., 2022
Health risks	Abramova et al., 2022; Casal & Ramos, 2017; Jagemar and Dodig- Crnkovic, 2015; Liao & Huang, 2021; Mc Donald Van Der Merwe, 2020; Monteith et al., 2021; Palm et al., 2020; Palumbo et al., 2022; Şad et al., 2016; Widdicks et al., 2022
Safety and crime	Dobrolyubova, 2022; Mohideen, 2021; Okon, 2009; Ruoslahti & Davis, 2021; Schaberreiter et al., 2013; Vogiatzaki et al., 2020
SDG mapping	Bai et al., 2022; García-Muiña et al., 2021; Mabkhot et al., 2021; Matinmikko-Blue et al., 2021; Mondejar et al., 2021; Ono et al., 2017

TABLE A4 Reviewed articles categorized according to the methods the authors use for assessing, identifying or measuring the effect of digital technologies on social sustainability that they describe.

Measuring methods	Related papers
Literature review	Bai et al., 2022; Begum et al., 2022; Bouzguenda et al., 2019; Cappa et al., 2020; Chavalarias, 2016; Chowdhury, 2013; De Felice et al., 2021; De la Calle et al., 2021; Dobrolyubova, 2022; Ekener, 2019; Ghobakhloo et al., 2022; Gordienko et al., 2017; Grybauskas et al., 2022; Hervani et al., 2022; Jagemar & Dodig-Crnkovic, 2015; Liao & Huang, 2021; Loganathan, 2022; Mark et al., 2019; Marthick et al., 2021; Mastrocinque et al., 2022; Matinmikko-Blue et al., 2021; Mesmar et al., 2016; Mohideen, 2021; Mondejar et al., 2021; Monteith et al., 2021; Ochara & Mawela, 2015; Ono et al., 2017; Oruç & Yeralan, 2020; Pick & Sarkar, 2016; Regan, 2022; Rosado et al., 2020; Rosário & Dias, 2022; Sá et al., 2021; Somanath et al., 2021; Sparviero & Ragnedda, 2021; Stavdas, 2022; Taj et al., 2019; Tavares & Azevedo, 2022; Webster & Leleux, 2019; Ye, 2021; Young et al., 2019; Zavratnik et al., 2020
Case studies	Affolderbach & de Chardon, 2021; Bello-Bravo et al., 2021; Casal & Ramos, 2017; De Falco & Romeo, 2021; García-Muiña et al., 2021, 2022; Gordienko et al., 2017; Grandi et al., 2021; Gregori et al., 2017; Isern et al., 2008; Locatelli et al., 2019; Millard et al., 2018; Mohideen, 2021; Palumbo et al., 2022; Papadopoulos & Broadbent, 2009; Papetti et al., 2018, Papetti, Gregori, et al., 2020; Papetti, Pandolfi, et al., 2020; Pathak et al., 2015; Patón-Romero & Jaccheri, 2021; Pinzone et al., 2020; Prause, 2021; Ramvi et al., 2021; Ruoslahti & Davis, 2021; Scafà et al., 2019; Sendlhofer & Lernborg, 2018; Stojanova et al., 2022; Trencher & Karvonen, 2019; Vogiatzaki et al., 2020; Widdicks et al., 2022; Xia et al., 2022
Surveys/ interviews	Abramova et al., 2022; Alharthi et al., 2018; Barrett et al., 2019; Brozzi et al., 2020; Charmaraman & Delcourt, 2021; Dé, 2016; Deng et al., 2016; Dula & Güler, 2022; Ekener, 2019; Genz et al., 2019; Ghobakhloo et al., 2022; Hohn & Durach, 2021; Ihm & Hsieh, 2015; Jatnika, 2019; Jauhiainen et al., 2022; Litsky et al., 2022; Mabkhot et al., 2021; Martín & Palomo Zurdo, 2021; Mc Donald Van Der Merwe, 2020; Ochara & Mawela, 2015; Okon, 2009; Pinzone et al., 2020; Prause, 2021; Rodrigues et al., 2021; Şad et al., 2016; Sultana et al., 2021; Tseng & Hsieh, 2015; R. Walker et al., 2021; Weber et al., 2022; Widdicks et al., 2022; Yoon et al., 2021
Direct experiment	Bensi et al., 2011; Hung et al., 2021; Kim et al., 2009; Klier et al., 2019; Loebach et al., 2019; Mathenjwa et al., 2020; Meneses Fernández et al., 2017; Palm et al., 2020; Papetti, Gregori, et al., 2020; Papetti, Pandolfi, et al., 2020; Sultana et al., 2021
Mathematical model	Apaydin et al., 2018; Bai et al., 2022; Bensi et al., 2011; Chavalarias, 2016; De Felice et al., 2021; Genz et al., 2019; Mastrocinque et al., 2022; Park et al., 2016; Pick & Sarkar, 2016; Schaberreiter et al., 2013